

INSTRUCTION No. 36

A STUDY OF ELECTRICAL STARTING AND GENERATING SYSTEMS: Pointers for Studying Electric Systems; Wiring Diagrams¹

POINTERS FOR STUDYING ELECTRIC SYSTEMS

The fundamental principle of the starting and generating systems has been treated in the preceding instructions. If the reader will master the principles as laid down in the foregoing pages, it will not be a difficult matter to understand any and all systems, because each system embodies one or more of the principles explained. Although the methods of operation or construction may vary, the purpose remains the same.

The external parts of the electric system consist of:

1. Battery.
2. Generator.
3. Ignition system.
4. Starting motor.
5. Switches: starting, ignition, and lighting.
6. Lamps.
7. Wiring system: the "single-wire" or the "two-wire" system.
8. Horn (electric), and push button.
9. Fuses.

The "single-wire" system is where one insulated wire is used and the frame of the car is used for the return circuit. This system is used most, and hence it will be noted in diagrams following.

The "two-wire" system is where there is no ground to the frame, but two insulated wires are used.

Although there are many different makes of cars, there are only a comparatively few different makes

¹ Note: It is impossible to show in this book wiring diagrams of the electrical systems of all cars. This requires a separate book and a very large one; see advertisements in the back of this book.

The diagrams that are selected for this book begin with the early electrical systems, and step by step the reader is shown the development from the very beginning, up to the point where electrical systems have become practically standardized. We advise those who intend to follow the automotive electrical trade to obtain a wiring diagram book.

of electric systems, and each of the different cars uses one or a combination of these systems.

The specifications of leading cars (see Index) will give the make of the particular electric systems that are used on the different cars.

The ignition system on a car is usually one of the following makes: Delco, Remy, Westinghouse, North East, Atwater-Kent, Connecticut, Auto-Lite, Bosch, and Wagner all of which employ the battery and coil system, as explained under the head of "Ignition."

If magneto ignition is used, it will be of one of the makes mentioned in the list of magneto manufacturers (see Index). Magneto ignition is more often found on trucks and tractors.

The ignition system most used is the battery and coil system. The interrupter is either an "open-circuit" or "closed-circuit" type, the latter being the most generally adopted system. Some few manufacturers of passenger cars use magneto ignition in addition to the coil and battery. Magnetos are used extensively on trucks and tractors.

Storage battery makes are the Exide, Vesta, Willard, Prest-O-Lite, U.S.L., Philadelphia, and several others. Some of the motor-coach manufacturers use 12-volt or 24-volt batteries, but most of the systems are 6-volt on passenger cars.

Electric starting motors and generators are usually of the Delco, Remy, Auto-Lite, Westinghouse, Bijur, North East, Dyneto, or other makes. The Delco and North East manufacture motor-generators as well as motors and generators separately.

The generator is either a plain shunt-wound generator, with an external electromagnetic principle of regulation, or a third-brush-regulated generator, or a combination of a third-brush and electromagnetic regulation.

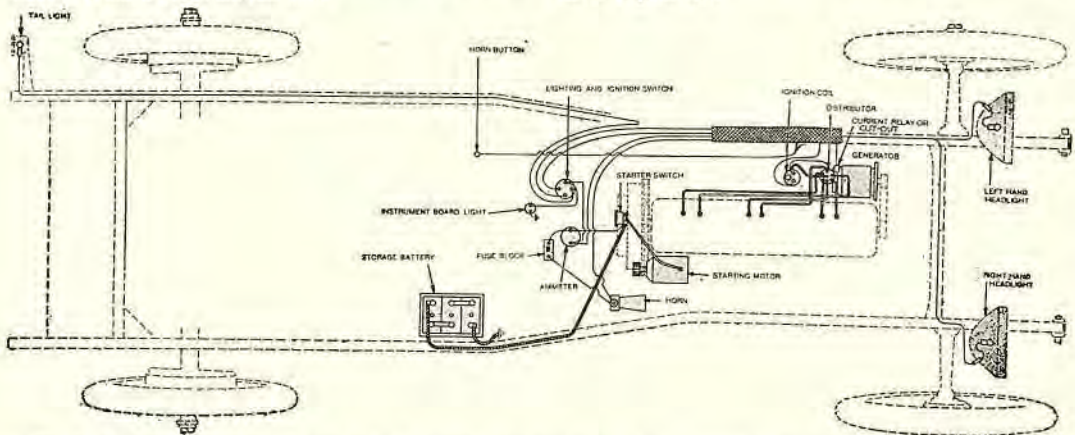


Fig. 1. Typical example of the location of the electric parts on a car. A "single wire" grounded system. The generator is driven by a silent chain (or by gears) from the crankshaft of the engine. The distributor and interrupter are mounted on the generator and are driven from the armature shaft. (Distributor is also often times driven from camshaft.) The starting motor is fitted with a Bendix drive (inboard type) and starts engine through flywheel.

The Remy and Delco use a thermostatic control (see pages 362, 395) in connection with the third-brush regulation on some of their systems.

Ground connection of generator and battery. If the positive (+) terminal of the battery is grounded to the frame of the car, then the (+) terminal of

the generator must also be grounded. Likewise, if the negative (-) terminal of the battery is grounded, then the (-) terminal of the generator must be grounded. Most manufacturers ground the negative (-) terminal of the battery and generator. The Westinghouse Co. grounds the positive (+) terminal in a number of its systems.

HOW TO STUDY WIRING DIAGRAMS

Electrical symbols: Before studying the different diagrams, the reader should become thoroughly familiar with the electrical symbols and abbreviations, as illustrated and described; for instance, the sign which denotes a "ground," or that which stands for a "storage battery," or for the point where "wires connect" or "pass over each other." They will be used quite freely in these instructions, as will also many of the other signs. The symbols vary slightly with the different manufactures of cars. It is also advisable to refer to page 415 for the addresses of the leading manufacturers of electrical systems. If the explanations are not clear, their catalogs will no doubt be of assistance.

In the illustration below, each symbol is numbered. The explanation of each is given with its appropriate number against it.

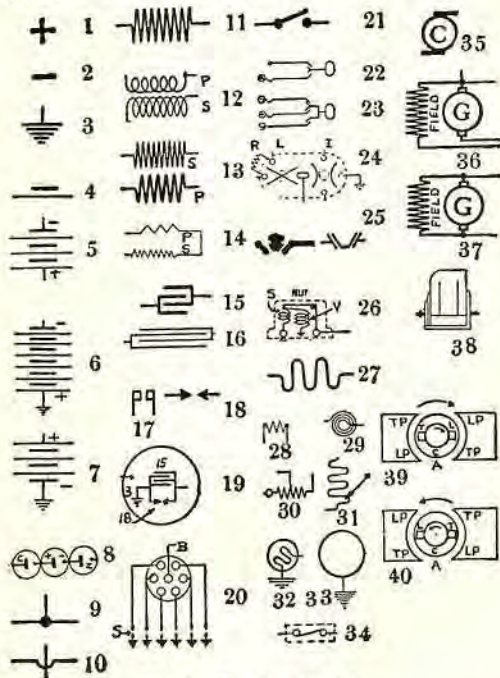


Fig. 2. Electrical symbols.

Electrical Symbols and the Terms Applied to Them

1. **Positive terminal**, the point at which the electric current starts to flow.
2. **Negative terminal**, the point to which the electric current returns.
3. **Ground**, where connection is made to metal, as the frame of the car, the engine or generator frame, etc.
4. **One cell of a battery**: A term usually applied to cells of a storage battery. The short black line represents the negative (-) terminal, and the

long line the positive (+) terminal. On a dry cell the positive plate is the carbon, and the negative, zinc. On a storage-battery cell there are usually several positive and several negative cells, but this symbol represents the terminals of each group. Each storage-battery cell gives 2 volts when charged.

5. **Three cells of a storage battery connected in series**: Note that there are three sets of negative and positive terminals or cells. Thus this would represent a 6-volt storage battery.
6. **Six cells of a storage battery connected in series**: 12 volts. Note the (+) terminal of this battery of six cells grounded at the end cell.
7. **Three cells of a storage battery connected in series**: 6 volts. Note that the terminal of one end of this battery is grounded.
8. **Dry cells**: The illustration shows three connected in series. (C) is the carbon or (+), and (Z) is the zinc or (-).
9. **Wires connected**.
10. **Wires crossing, but not connected**.
11. **Coil**: Could represent a field-coil, or ignition coil. Supposed to surround an iron core.
- 12, 13, 14. **High and low-tension ignition coil windings**: There are several methods of showing the primary winding (P) and the secondary winding (S), as, for instance, those shown by 12, 13, and 14. The two windings are usually shown separate, although they are wound on one core. The current is induced into the secondary by lines-of-force produced by the primary winding, and there is no metallic connection between the primary and secondary windings. The secondary is a much finer wire, and consists of several thousand turns, whereas the primary has only a few hundred turns of heavy wire.
- 15, 16. **Condenser**: Placed across the coil points to absorb the spark when the points separate, and to permit the discharge back through the primary coil to demagnetize the core.
17. **Contact-points**: Usually refers to the cut-out or regulator points; also refers to the contact-breaker points.
18. **Interrupter or contact points** (as used by Delco): The Remy Co. uses this symbol to designate the spark jumping a gap at the spark-plug points, or at the safety-gap on an ignition coil.
19. **Interrupter or contact-breaker**: A method used by Delco. Note the "interrupter points" (18); also the "condenser" (15), and the "ground" (3).
20. **Distributor of high-tension ignition current to spark plugs**: (B) connects with the secondary terminal of the coil, and a high-tension current is distributed to the spark plugs and jumps the gap of the spark plugs (gap represented at S), then flows through the metal part of the engine back to the grounded secondary terminal.

21. Lighting switch.
22. Delco ignition and lighting switch, as used on some of the Delco systems.
23. Double switch, of the same type.
24. Remy lighting and ignition switch of the "pole-changing" type. Lighting switches (L) at left, with dimming resistance (R). Ignition switch (I) at right represents a "pole-changing" type of switch (see Index. Note the "ground" on the side of the switch case.
25. Starting-motor switches.
26. Cut-out: Also called a relay, with two windings. The "voltage or shunt" winding (V) is a winding, and is always placed across the circuit. The "voltage winding" of a cut-out can be found by noting that it has more turns of wire than the "series" or "current winding." The series or current winding (S) has a less number of turns and is a coarser wire and is always placed in series with the charging circuit. Cut-out windings are often on one core. Sometimes they are on two cores. The illustration shows two coils, or windings, on two separate cores (model 264-D Remy).
Regulator winding: This is usually on one core and is a single winding. It is always placed in series with the "shunt-field winding." If it consists of a coarse heavy wire, this indicates that it regulates the current output; if it consists of a fine wire winding, this indicates voltage regulation.
27. Resistance coil.
- 28, 29. Resistance coil for dimming lights.
30. Resistance divided into two paths.
31. Resistance which can be varied.
- 32, 33. Lamp bulbs: Note that one side is grounded.
34. Fuse mounted on a fuse block.
35. Commutator and brushes for either a generator or a motor.
36. Series-connection of field-coils, with commutator and brushes of a motor or generator (internal circuit). The series connection is generally used on motors. If (G) appears as shown, it means that the connection is for a generator; if (M) appears in place of (G), the connection is for a motor.
37. Shunt-connection field-coils, with commutator and brushes (G) of a motor or a generator. (Internal circuit.) Shunt windings are generally used on generators; they are seldom used on motors for automobile work. (G) indicates generator, and (M), motor.

38. Magneto.
39. Trailing pole tips are indicated by (TP). Leading pole tips are (LP).
40. Same as 39; but since the armature (A) and the commutator (C) are in opposite positions, the order is changed.
The "trailing" pole tip is the one (A) or (C) moves from.
The "leading" pole tip is the one (A) or (C) moves to.

Abbreviations Commonly Used to Represent Electrical Terms

- A: Ampere or Ammeter.
AC: Alternating current.
B: Brush; also used for Battery
BAT: Battery.
C: Current.
C or COM: Commutator.
CARB: Carburetor.
C.E.M.F.: Counter-electromotive force.
DC: Direct current (usually written d.c.).
DIS. or DIST'R: Distributor. The word "distributor" is often used to express the inclusion of the interrupter and distributor in one unit.
E.M.F.: Electromotive force.
GB: Generator brush; also grounded brush.
G or GEN: Generator.
G or GRND or GR: Ground.
HL: Headlights or lamps.
H.P.: Horse power (746 watts) (usually written h.p.).
I or IG: Ignition.
IS. or IG.S: Ignition switch.
INT: Interrupter.
KW: Kilowatt (1,000 watts).
L: Light, or lamps.
LS: Lighting switch.
M: Motor.
MB: Motor brush; also main brush.
N: North.
RES: Resistance.
S: South.
S or Sec: Secondary.
ST.M.: Starting motor.
SEF: Series field winding.
SHF: Shunt field winding.
3B: Third brush.

TRACING CIRCUITS OF WIRING DIAGRAMS

The electric system should be divided into circuits as follows:

1. Starting-motor circuit.
2. Generator circuit.
3. Ignition circuit.
4. Lighting circuit.

When tracing circuits, remember that the positive (+) terminal at the source of current is where to start. If a battery supplies the current, start at the (+) terminal. If the generator supplies current, start at the (+) brush or brushes of the generator.

Tracing Starting-Motor Circuits

See Fig. 3: The battery supplies the current, therefore start with the battery (+) terminal, thence to starting switch, to terminal (T) on the motor, to the field-circuit. In this instance the field-coils or windings on the four field-poles are connected in "series parallel." The current divides when passing into the field-coils, and flows through the two field-coils on each side, then to the (+) main brushes, through the armature, through the grounded (-) main brushes, to the grounded (-) terminal of the battery, thus completing the circuit.

Sometimes the (+) brushes are grounded instead of the (-) brushes. In this case, the (+) terminal of the battery would be grounded instead of the (-) terminal, and the flow of current would then be from the (+) grounded terminal of the battery to the (+) grounded terminal of the motor brushes.

Sometimes the fields are grounded. In every instance, however, start with the (+) terminal of the battery where the source of current for the motor starts.

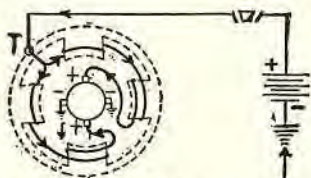


Fig. 3. Starting motor of the four-pole type, with the field-coils connected in "series parallel."

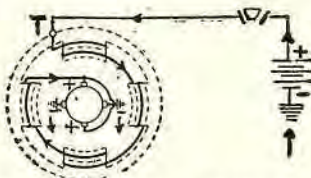


Fig. 4. Starting motor with the field-coils connected in "series."

See Fig. 4: This represents a four-pole motor with straight "series" field-winding. If the (-) brushes are grounded (they are, in this example), then start with the (+) terminal of the battery. The (+) brushes are sometimes grounded. The usual method, however, is to have the (+) current flow to the field-windings in a motor, although this is not always the case.

Tracing Generator Circuits

There are three circuits to consider always:

1. Field-circuit.
2. Voltage coil cut-out circuit.
3. Battery charging circuit.

The field-circuit is the winding around the field-poles, and is the circuit through which current passes to build up the magnetic lines-of-force around the field-poles. There is a slight amount of magnetic lines-of-force in the iron poles to start with (called "residual magnetism"); therefore as the armature revolves, it generates current from the lines-of-force and part (about 10 per cent) of the armature current flows through the field-windings. The faster the armature revolves, the greater the strength of the current in the field-coils; therefore the regulation of the field-circuit at high speed by cutting down the current in the field-coils is important, otherwise the armature would generate too great an output.

Under the subject of "generator regulation" this subject is fully treated. Three principles are involved:

1. Compound field (two windings and inherent regulation).
2. Shunt field, with external regulation system.
3. Shunt field with a third-brush or inherent regulation.

1. The compound-field regulation is explained on pages 354, 355, 356. There would be two field-circuits to trace.

2. The straight "shunt-field" generator with an electromagnetic type of voltage¹ regulator is shown in Fig. 5: The "shunt-field-circuit" would start with the source of current, which is the (+) main brush of the generator, to the regulator blade (H), to points (E), through the field-coils, to the (-) brush of the generator. If the generator speed is high, the points (E) will open and resistance (M) will be cut into the field-circuit, thus weakening it, through the generator speed producing a high voltage through the voltage winding (H).

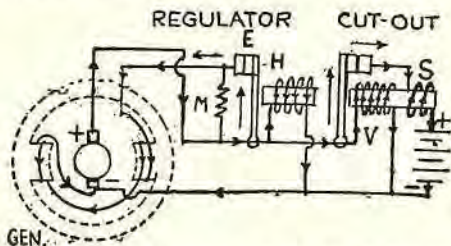


Fig. 5. Shunt-field generator using an electromagnetic voltage regulation.

The cut-out "voltage winding" circuit (V) is from the (+) main generator brush, back to the (-) main brush. This would be the next circuit. This builds up magnetism around the cut-out core.

The charging circuit to the battery is the next circuit, which is from the (+) main brush of the generator, through the blade and points of the cut-out, to the cut-out series or "current" coils (S), to the (+) terminal of the battery, to the (-) terminal of the battery, to the (-) main brush of the generator. At high speeds the voltage increases. Thus the regulator winding (H) exerts a magnetic pull on the blade, opening points (E). The shunt-field-circuit then has resistance (M) inserted in its circuit which reduces its strength.

3. A third-brush regulated generator with a cut-out on top of the generator would have its circuits as follows:

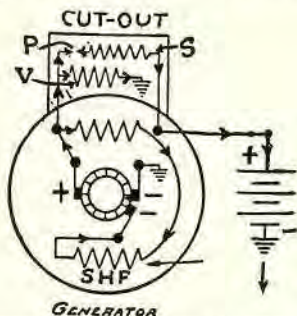


Fig. 6. Shunt-field generator using a third-brush regulation.

Shunt-field-circuit: Start with the (+) main brush of the generator, through the shunt-field-windings (SHF), to the (-) third brush. The third brush is always connected to one end of the

¹ You can instantly tell when an electromagnetic regulator controls the voltage, because its winding is finer, and it is placed across the circuit, as at (H) (Fig. 5). When the regulator winding is in series with the circuit, it controls the amperage or current, and is usually of heavier wire.

field-windings and regulates the output of the generator at high speeds. It is sometimes on the (+) side of the armature.

The cut-out voltage winding circuit (V) is from the (+) main generator brush, to the cut-out fine wire voltage winding (V), through the grounded end of this coil (V), back to the (-) grounded main generator brush.

Charging circuit to battery: When the generator voltage reaches about 6.5 volts, or above battery voltage, the voltage coil (V) has sufficient magnetism in its core to close cut-out points (P). The charging circuit will then be from the (+) main generator brush, through cut-out points (P), through the cut-out series, or current winding (S), to the ammeter (not shown), to the (+) terminal of the battery, to the (-) grounded terminal of the battery, to the (-) grounded main brush of the generator.

If the (+) main brush of the generator was grounded, then the circuit would start at the grounded (+) brush of the generator, which would be the reverse of the circuit described. The (+) terminal of the battery would then be grounded.

Tracing Ignition Circuits

This circuit includes:

1. Ignition coil.
2. Interrupter.
3. Distributor.

Coil windings: There are two windings, the primary and the secondary (Fig. 7). The current must first flow through the primary winding.

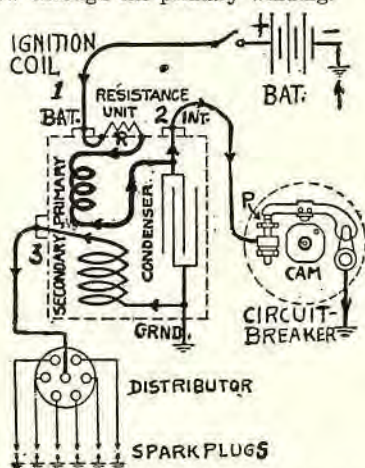


Fig. 7. A simplified diagram explaining how to trace the ignition system.

Coil terminals: Some coils have 3 or 4 terminals (see page 209). Most of the coils use 2 terminals as in Fig. 7.

Note. When referring to the number of the coil terminals, the secondary terminal is not considered.

Primary and interrupter circuit: Suppose the (-) terminal of the battery and generator was grounded. The flow of current would then be from the (+) side of the ignition switch, which is usually connected to the circuit at the ammeter. The current path would then be from (+) of the battery (or the generator if running fast enough to charge the battery), to the switch, through ignition resistance (R) on the coil, through the primary winding, out terminal (2), through the insulated and stationary interrupter point, through the grounded interrupter point and arm, to the (-) grounded terminal of the battery or generator.

If the (+) terminal of the battery and generator was grounded, then the circuit would be from (+) of the battery, to the grounded arm of the interrupter, through points (P), through the primary winding and resistance (R), to the switch, to the (-) terminal of the battery or generator.

Note that the interrupter is for a four-cylinder engine, because there are four high points on the cam. Thus it will raise the arm four times during one revolution.

The condenser is across the circuit of the interrupter points, as one end of the condenser is also grounded. (See Index for the construction and purpose of the condenser.) Condensers are often placed in the interrupter housing.

The secondary circuit is an induced current in the secondary winding from the primary winding, and would flow from the secondary terminal (3) to the distributor, through the spark-plug points, through the engine frame which would be termed a ground, to the grounded end of the secondary fine wire winding (GRND.).

Note. In Fig. 7, owing to an error in drawing, a 6-cylinder distributor is shown. It should be a 4-cylinder distributor.

The primary and secondary coil windings are supposed to be on one soft iron core.

The foregoing explanation will give an idea as to the method of procedure in tracing wiring diagrams. All wiring diagrams do not have arrow points showing the path of the circuits. It is therefore necessary to make a point of starting with the source of supply of electric current which is (+) of the battery or generator. If (+) is grounded, then start at (+) just the same, and go to the grounded end of the part of the circuit you are tracing.

Tracing the Lighting Circuits

See Index under "Wiring diagrams."

REMY ELECTRIC SYSTEM ON STUDEBAKER "EM"

Studebaker (Model "EM") Circuits (The "EJ" is Similar; See Under Fig. 8 Below)

Starting motor: From the (+) ground of the battery to the (+) grounded motor brushes, to the (-) brushes, to the field coils, to the starting switch, to the (-) of the battery. A Bendix drive is used.

Generator field-circuit: From the (+) brush of the generator, to ground (G) of the thermostat, to the field coils, to third brush (3B).

Cut-out voltage circuit: From the (+) grounded brush of the generator, to ground (G) of the voltage coil (V), through cut-out series coil (S), to the (-) main generator brush.

Generator charging circuit: From the (+) grounded brush (G) of the generator, to the (+) ground of the battery (GB), to the starting switch,

through the ammeter, to cut-out points (P), to cut-out series coil (S), to the (-) main brush of the generator.

Regulation of the shunt field of the generator is by means of a third brush.

Ignition primary circuit: From the (+) ground of the battery (GB), or the (+) ground of the generator (G), to ground (G) of the contact-breaker, to arm (A), to points (P), to primary coil winding (PR), through ignition resistance unit (RES), to the switch, to the ammeter, to the generator (-) brush, through the cut-out if the generator is supplying current, or from the ammeter to the (-) terminal of the battery, if the battery is supplying current for ignition, as is the case when starting.

The secondary circuit is from the secondary winding of coil (SC), to the distributor, to the spark plugs, to ground, to the grounded end of the secondary winding.

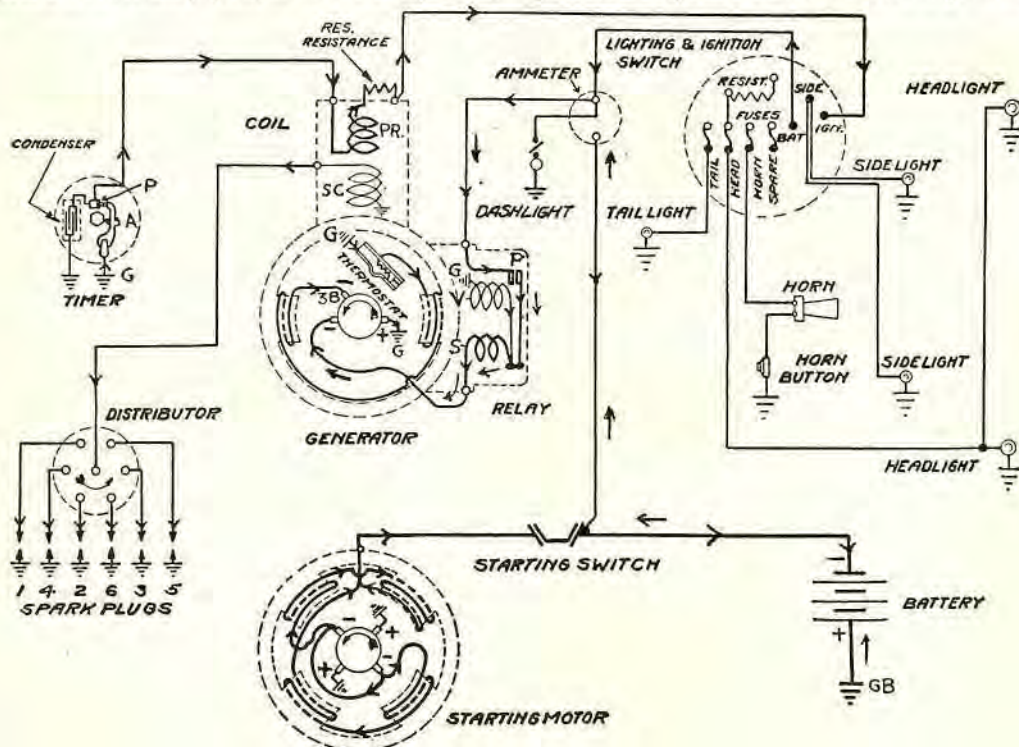


Fig 8. Wiring diagram of the Remy-Studebaker model "EM" 1923 electric system. The "EJ" is similar, except has slightly different switch and connections and a separate fuse block.

STUTZ SERIES "K": REMY GENERATOR AND MOTOR; DELCO IGNITION

Remy generator and starting motor with Delco ignition together constitute the system used on this car. The distributor principle is similar to that on the Pierce-Arrow, explained on page 216.

Stutz (Series "K") Circuits

Starting-motor circuit: From (+) ground (GB) of the battery, to (+) ground (G) of the starting motor brushes, through the field coils, to the starting switch, to the (-) terminal of the battery.

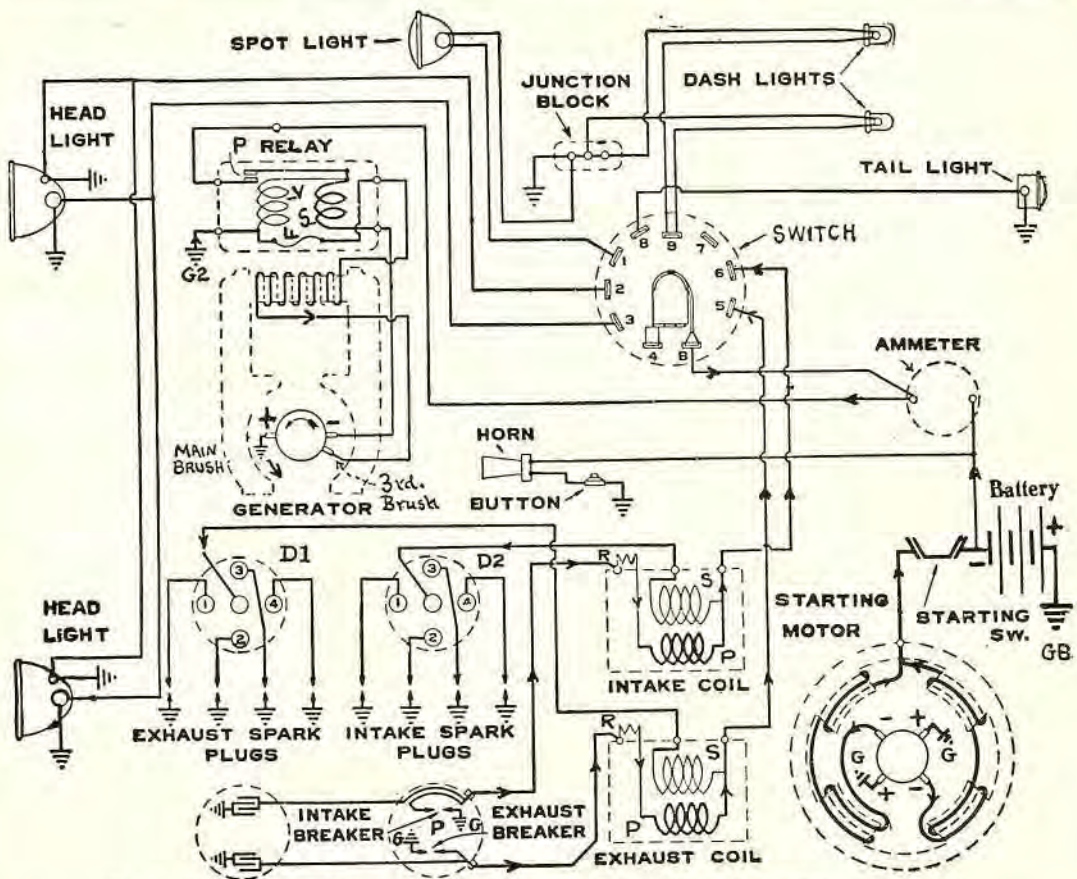
Generator field circuit: From the (+) main brush of the generator, to ground (G2) of the cut-out (relay), through fuse (F), through the shunt-field winding, to the third brush.

Cut-out voltage circuit: From the (+) generator brush, to ground (G2), through cut-out voltage

coil (V), to cut-out series coil (S), to the (-) main brush.

Generator charging circuit: From the (+) main brush of the generator, to the (+) grounded terminal of battery (GB), through the ammeter, to cut-out closed points (P), through series coil (S), to the (-) main brush of the generator.

Ignition primary circuit (intake coil): From (+) ground of the battery, if starting, or (+) ground of the generator, if the generator is running at proper speed, to ground (G) of contact-breaker points at top, through points (P), through ignition resistance unit (R), through primary coil (P), to switch (S), to (B), to the ammeter. If the current is from the battery, then through the ammeter, which will show "discharge," to (-) of the battery. If the current



is from the generator, then from the ammeter, to the cut-out, to the (-) brush of the generator.

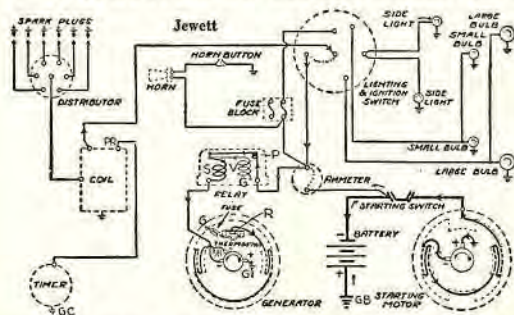
Ignition primary circuit (exhaust coil): The circuit is exactly the same as for that of the intake coil, except that contact-breaker points for exhaust coil are at the lower part of the interrupter, and circuit is through the lower, or exhaust coil, to (5) on switch. From this point it is the same as previously described.

The secondary circuit from the secondary coil (S) on both coils can easily be traced to the center terminal of the distributor, to the spark plugs, to ground, to ground of the battery or generator, to (B)

on the switch, then to (5) and (6), to the other end of the secondary winding. (The contact points on the interrupter are open when the secondary spark occurs at the spark plugs. The circuit could not, therefore, pass back through this side.)

The Stutz engine is a dual-valve engine. The intake valves are on one side of the cylinder and the exhaust valves on the other.

JEWETT: REMY GENERATOR AND STARTER AND ATWATER-KENT IGNITION



Starting motor circuit: From (+) ground battery (GB), to (+) grounded motor brushes, to (-) main brushes, through field circuit, to starting switch, to (-) battery terminal.

Generator field circuit: From (+) grounded generator brush (G1), to (G) ground of thermostat, through closed points, or through resistance (R), through field windings, to (-) third brush (3B).

Cut-out voltage circuit: From (+) grounded main brush (G1), to ground (G) of voltage coil (V), through series coil (S), to (-) main generator brush.

Generator charging circuit: From (+) grounded generator main brush (G1), to (+) ground (GB) of battery, through battery to ammeter, through ammeter to (closed) cut-out points (P), through series coil (S), to (-) main generator brush.

Ignition primary circuit: (Atwater-Kent ignition system used). From (+) ground of generator (G1), to ground (GC) of timer, through interrupter points to primary coil (PR), through primary coil winding, to switch, to ammeter, through cut-out points (P) and winding (S) to (—) main generator brush. Condenser is in interrupter. If current for ignition is from battery, as when starting, it is from (+) of battery (GB).

OAKLAND "6-44" ELECTRIC SYSTEM (REMY)

Starting motor circuit: From (+) of battery, to starting switch, through the series parallel windings, to (+) motor brushes, to (-) grounded motor brushes, to (-) ground (GB) of battery.

Generator field circuit: From (+) third brush (3B), through shunt field windings, through (closed) thermostat points (P), to ground (G), to generator (-) ground (GG), to (-) main brush.

Cut-out voltage circuit: From (+) main generator brush, to cut-out coil (C), to voltage coil (V), to ground (G), to (-) main grounded brush (GG).

Generator charging circuit: From (+) main generator brush, through cut-out series coil (C), through (closed) cut-out points (P), to ammeter (A), through ammeter to (M), to (+) of battery, to (-) ground (GB) of battery, to (-) ground of generator (GG), to (-) grounded main brush.

Ignition primary circuit: From (A) on ammeter, which takes current direct from generator without passing through ammeter, if generator is supplying current, or from (M) to (A) through ammeter, which would show "discharge," if current is taken from the battery, to switch (Bat), to (Ign), to ignition resistance unit, to primary winding (PR), to insulated interrupter terminal, through interrupter points (P), through arm (A), to ground (G), to (-) ground of generator (GG), to generator main brush, or to battery ground (GB).

Secondary ignition circuit: From secondary terminal of ignition coil (S), to distributor, to spark plugs, to ground, to grounded end of secondary coil winding (G).

Condenser (CD) is in the interrupter housing and is connected across the points (P) of contact-breaker.

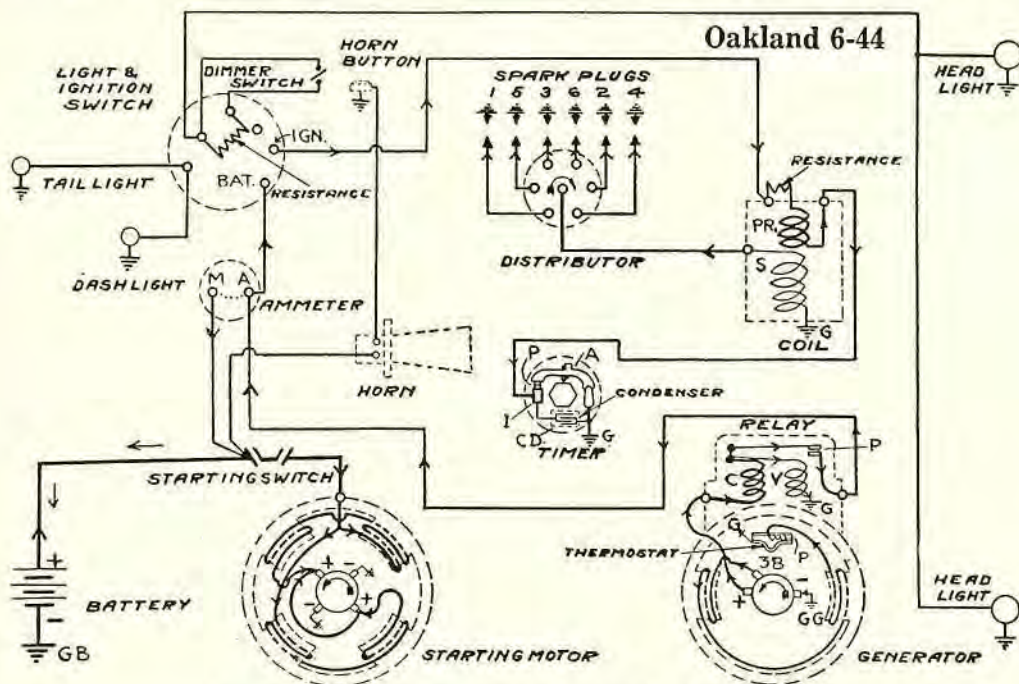


Fig. 10. Wiring diagram of Oakland "6-44" (Remy electric system).

OVERLAND "4" ELECTRIC SYSTEM

Electric system: Auto-Lite two-unit, 6-volt starting and lighting system, with Bendix drive. U.S.L. Battery, 6-volt, 80-amp. hour. Model GK 1001 generator with third-brush regulation. Starting motor model MG 1001.

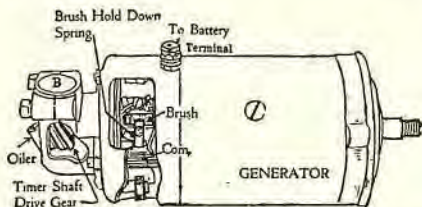


Fig. 12. Generator, driven from the right side of the engine, by helical gears, from the crank shaft.

Ignition: Connecticut (Auto-Lite on Models 91 and 92) timer and distributor driven from the armature shaft of generator (Figs. 12 and 13). See page 40 for engine illustration and description.

Ignition timing Overland Models "4, 91 and 92": Advance spark lever; crank engine until No. 1 piston is starting up on compression stroke and until the ignition timing mark on flywheel is in line with the mark on housing (this ignition timing mark is located $2\frac{1}{2}$ " ahead, or to the left of the mark "T-C-1-4" on flywheel, looking at it from the rear; the piston is then $15/64$ " from top of cyl. block); at this position interrupter points should just start to open; the distributor rotor should be in line with secondary terminal to spark plug of No. 1 cylinder.

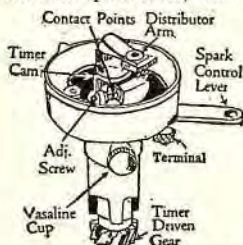


Fig. 13. Timer, driven from the armature shaft through opening (B, Fig. 12) by helical drive gear.

Overland "4" Circuits

Generator field-circuit: From the (+) third brush of the generator, through the field windings, to the (-) main brush.

Cut-out voltage circuit: From the (+) main brush, to the fine wire voltage winding (V) on the cut-out (circuit-breaker), to ground, to the (-) main grounded brush of the generator.

Generator charging circuit: From the (+) main brush of the generator, through cut-out points (P), to cut-out series coil (S), through the ammeter, to the (+) terminal of the battery, to the grounded (-) terminal of the battery, to the (-) grounded brush of the generator.

Starting-motor circuit: From the (+) terminal of the battery, through the closed starting switch, to the terminal on the starting motor, through the two "series parallel" windings on each side, to the

(+) brushes, through the armature, to the (-) grounded brushes, to (-) ground of the battery.

Primary ignition circuit (from battery when starting): From (+) of the battery, to (D), to the ignition button switch, to the thermostat switch,¹ through wire (I) to the primary winding of the ignition coil, to the timer (contact-breaker of the closed-circuit type), through the timer points, to the ignition coil where the primary and secondary windings are grounded, thence to ground (G1), to (-) ground of the battery. On the circuit just described, the ammeter would not indicate, as the current is flowing from the battery, but not through the ammeter.

¹The "Connecticut ignition thermostat switch" is illustrated and described elsewhere. See Index.

Overland Models "91 and 92" use Auto-Lite ignition. Thermostat switch is not used. See pages 1058-1059 for Specifications.

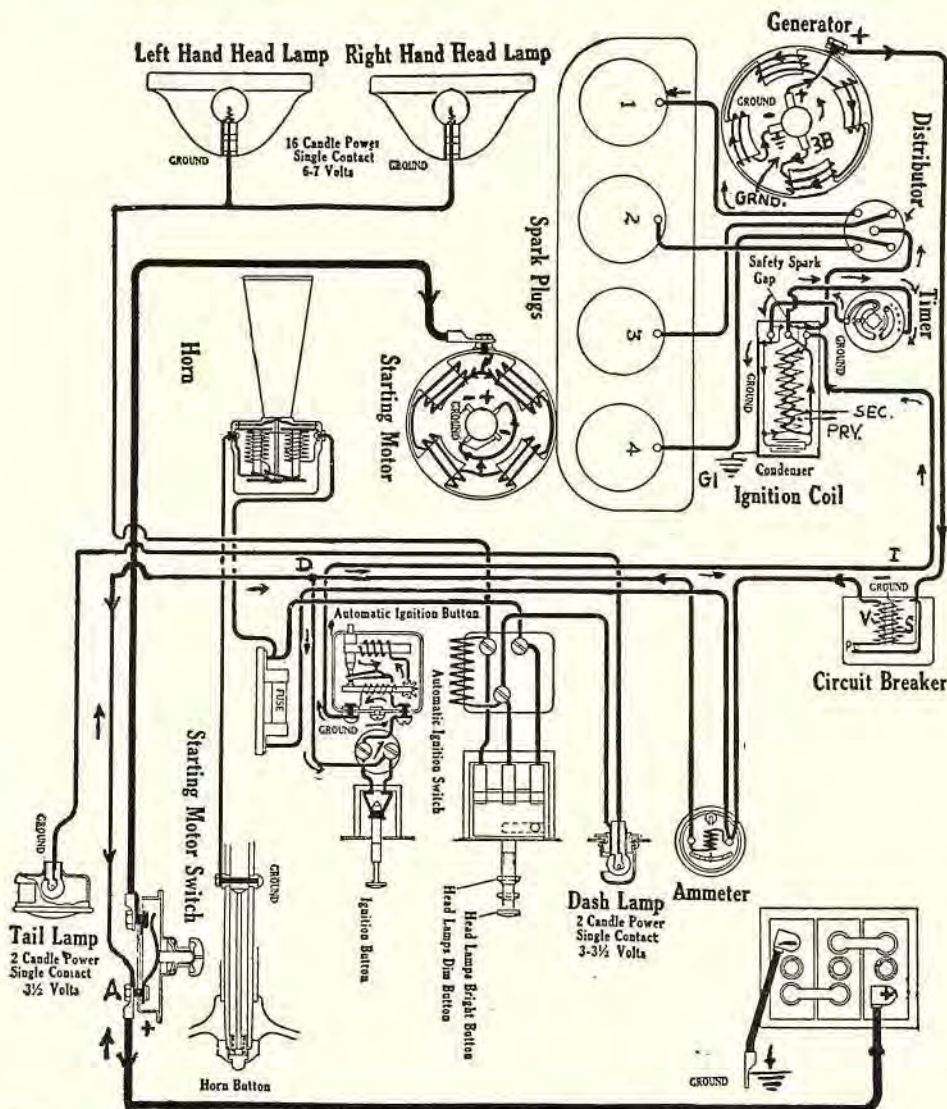


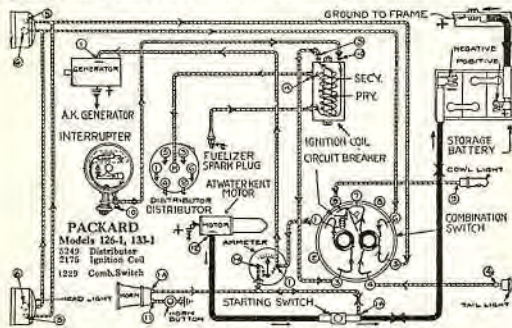
Fig. 11. Wiring diagram of the Overland "4"; Auto-Lite electric system. Connecticut ignition. Models 91, 92 Overland use Auto-Lite ignition. Thermostat switch not used.

Primary ignition circuit (from generator): From point (D), which takes current from the generator which must pass through the ammeter. Thus the ammeter would read on the "charge" side, because the current would be flowing from the generator to the battery, and the ammeter is between point (D), where the ignition is taken, and the generator. The rest of the circuit would then be the same from point (D), as explained above.

Light circuits, if from battery, would be from (+) of the battery, to the ammeter, then through the ammeter, to the inside wire at the right-hand connection of the ammeter, to the fuse, thence to the lighting switch, through the different lighting circuits. The ammeter would read on the "dis-charge" side.

DELCO ELECTRIC SYSTEM ON PACKARD "SIX," MODELS 116 (1921, 1922), 126-1, 133-1 (1923)

The Delco ignition is used on this car, but Atwater-Kent starting motor and generator are provided for generating current and for starting.



Packard (Model 126-1, 133-1) (Above)

The wiring diagram of the Model 116 (1921, 1922) is shown in Fig. 15. Models 126-1, 133-1 (1923) (shown in smaller

If current for lights comes from the generator, then start with (+) of the generator, to the cut-out, to the ammeter (but not through the ammeter), to the wire from the same connection on the ammeter, to the fuse, and from this point on, as before. In this instance, the current for lights would not pass through the ammeter, but the generator would be charging the battery and supplying current for lights and ignition also. Thus the ammeter would read on the "charge" side, indicating the amount of current flowing to the battery and used for ignition.

Overland "4" electric equipment data: Auto-Lite generator third-brush regulated; Auto-Lite starting motor; Connecticut ignition. See also page 40.

Lamps: Four; head lamps, single-bulb, single-contact, 6-volt, 16-candle power; dash and tail lamps, single-contact, 3-volt, 2-candle power. (See page 1058 for later specifications.)

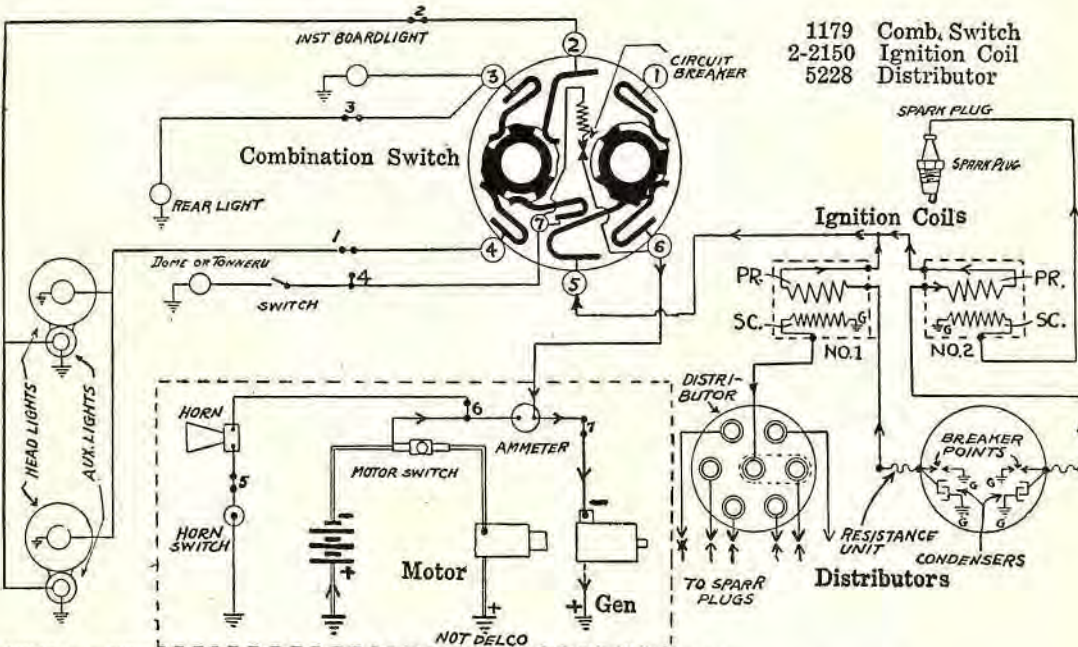
Packard (Model 116) Circuits (Below)

Starting motor: From (+) ground of the battery, to (+) ground of the starting motor, to the switch, to (-) terminal of the battery.

Generator charging circuit: From (+) ground of the generator, to (+) ground of the battery, to (6), through the ammeter, to (7), to (-) terminal of the generator.

Primary ignition circuit (battery): From (+) ground of the battery, to grounded (G) contact-breaker points (on the left), through the ignition resistance unit, to primary winding (PR) of the ignition coil No. 1, to (5) on the switch, to (6), through the ammeter, to (-) terminal of the battery.

Primary ignition circuit (generator): From (+) ground of the generator, to contact-breaker-point ground (G) on the left, and through the same path, but to the (-) generator terminal instead of to the battery.



NOTE: - - - INDICATES JUNCTION BLOCK TERMINALS NUMBERED LEFT TO RIGHT

Fig. 15. Wiring diagram of the Delco-Packard (model 116) (1921, 1922) electric system.

Secondary circuit to ignition spark plugs: From secondary winding (SC), on coil No. 1, to the distributor rotor, to the spark plugs in the engine, to ground, to ground (G) of the secondary winding.

Fuelizer ignition coil is No. 2. This coil is used for the single spark plug used in the Fuelizer. (See pages 108 and 140 for an explanation of the Fuelizer.)

PACKARD "TWIN-SIX" MODELS "325-335" (1921, 22, 23) ELECTRIC SYSTEM

The Delco ignition is used on this car. Bijur generator and starting motor are used. See also pages 217, 84, 85, 86, for other illustrations pertaining to the Packard "Twin-Six."

Packard "Twin-Six" (Models 325, 335) Circuits

Charging circuit: Start with the generator (+) grounded terminal, to (+) ground of the 6-volt, 120-ampere-hour battery, to combination switch (6), through the ammeter, to (-) terminal of the generator.

Ignition circuit: Start with (+) ground of the battery if the engine is running slow, or with (+) ground of the generator if the generator is charging the battery, to ground of interrupters (CP), but first through the resistance units.

Note that there are three interrupter points (CP), 1, 2, and 3. The Nos. 1 and 2 are for the No. 1 and No. 2 coils and distributors, and 3 is for the No. 3 coil and spark plug (3P) for the fuelizer. See also, pages 140, 217, giving an explanation of "Fuelizer" and "Distributor."

The engine ignition primary circuit of No. 1 distributor is through ignition resistance unit (R1), through contact points (CP-1), through primary coil (1), to junction (J), to the ignition switch, to 5 and 6, to (-) of the battery or generator. Note condenser (1) is connected across the points (CP-1).

The primary circuit is the same as for the other coil, except that the contact-breaker points on the right of the contact-breaker are used.

The contact-breaker and distributor for this system are shown on page 219. Note that two sets of interrupter contacts are provided, each set being connected in series with a separate ignition coil.

If the current is from the battery, it will not pass back through the ammeter. If current is coming from the generator, it will pass through the ammeter, but as the generator would then be charging the battery, the ammeter would indicate the current flowing from generator to battery and the ignition, and would indicate on the "charge" side of the ammeter.

Secondary circuit of No. 1: From the secondary winding on coil (1), to the distributor arm or rotor, to the spark plugs, to ground, to grounded secondary terminal (G) on No. 1 coil.

Engine ignition primary circuit of No. 2 distributor is similar, except that the circuit is through resistance (2R), through points (CP-2), through primary winding (P) of coil 2, to junction (J).

The secondary circuit of No. 2 is similar to that of No. 1, except that it passes to No. 2 distributor.

The fuelizer ignition primary circuit is from (+) of the battery or generator, to ground (G3) of the interrupter, through points (CP-3), through resistance (R3), to primary winding (P) of coil 3, to junction (J), to switches (5 and 6), to (-) terminal of the battery or generator.

The secondary circuit for the fuelizer spark plug is from (S), coil 3, to spark plug (3P), to ground, to ground (G) of coil 3.

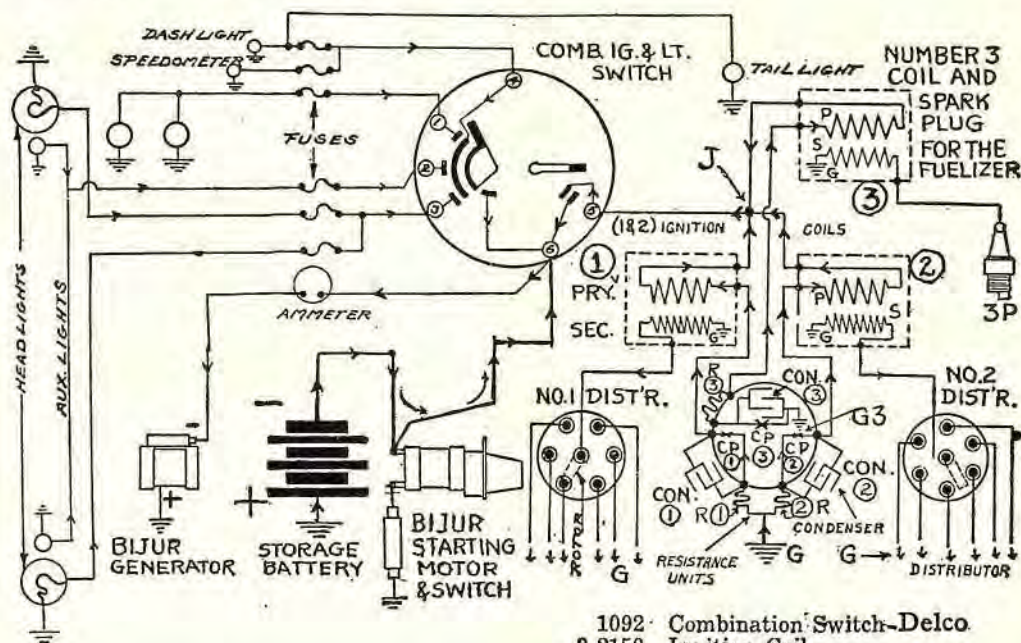


Fig. 16. Packard "Twin-Six" wiring diagram: Note the twin or dual set of interrupters. The breaker arms are operated by one three-lobe cam. There are three high-tension coils, one used for ignition for the right block of the cylinders, and the second, for the left block. The third coil (3) is used in connection with a spark plug (3P) in the fuelizer. An auxiliary contact-breaker mechanism, mounted on top of the distributor, is connected with the latter.

Starting-motor circuit: From (+) of the battery, through ground, to the ground terminal of the starting-motor switch, through the starting switch, through the starting motor, to (-) terminal of the battery.

The automatic gear-shift principle, connected with a flywheel is used. The starting motor is a 4-pole, series-wound motor.

Regulation of the output of the generator consists of a constant voltage electromagnetic device which cuts resistance into the shunt-field circuit. The generator regulator keeps a constant electrical pressure or voltage, slightly higher than the voltage maintained by a fully charged battery, this pressure being maintained regardless of speed.

The voltage being constant, the current generated naturally varies, being small when the battery is fully charged and increasing as the lights are turned on or the battery is partially discharged.

The cut-out is a reverse-current electromagnetic type of the usual cut-out principle. The generator field-winding is a straight shunt winding.

The cut-out and regulator are wound on separate cores and mounted on top of the generator. The circuit is not shown but is shown in the Wiring Manual, details of which will be found in the advertising pages of this book.

REMY ELECTRIC SYSTEM ON OAKLAND "32" AND McLAUGHLIN "D-60"

The Remy "relay-regulator" system, described on page 350, was used on these cars (1916). The system is shown here in order to give an example of the Remy relay-regulator in connection with a plain shunt-wound four-pole generator using an "electromagnetic current regulation" of the shunt-field circuit. See Fig. 17 on the next page.

Circuits

Generator: Plain shunt wound, with an electromagnetic vibrating-current type of regulator (see also page 350). This regulator is operated by the amount of current flowing from the generator to the battery through the regulator winding (D). It would thus be termed an electromagnetic "constant-current" regulation method.

Generator shunt-field circuit: From the (+) main brush of the generator, to the fuse, to (Y), to closed regulator points (E), to (H), to the shunt-field windings, to (-) main brush (G) of the generator.

Note. This is not a third-brush regulated generator, although there are three brushes. The brush on the left is used for grounding purposes. All brushes bear on neutral points of the commutator, and are therefore "main brushes." See, also, page 359.

Cut-out (relay) voltage circuit: From the (+) main brush of the generator, to the fuse, to (Y), to cut-out voltage coil (J), to ground (G1), to the (-) grounded generator brush.

Generator charging circuit: From the (+) main brush, to the fuse, to (Y), to closed cut-out (relay) points (A), through cut-out series coil (C), through regulator winding (D) (note that the charging circuit flows through the regulator winding), to (K), to the fuse block, through the ammeter, to (+) terminal of the battery.

When the generator speed is high, the regulator comes into action by cutting resistance (F) into the shunt-field circuit of the generator, thus reducing

Fuse Board

All lamp circuits and the horn circuit pass through the fuse board on the front side of the dash. When the horn or lamps fail, examine the fuses. If the fuse is in proper order, then look for loose wires.

Fuses are of the glass-tube type. If fuses continually blow, look for a short circuit as the cause.

Ammeter

The ammeter is located on the instrument board. It is connected between the generator and battery through the switch; thus, with the engine idle, the ammeter does not indicate whether the lights are on or off. Should it register to the left of zero with the engine idle, remove the disconnect plug from the regulator, to prevent discharging the battery.

When the engine is running, the ammeter registers the amount of charging current passing from the generator to the storage battery and lights.

If the ammeter fails to register when the engine is running at about 750 revolutions, or over 20 miles per hour, look for loose connections or broken wires between the generator and battery; also see that the generator commutator is clean and that the brushes are making good contact.

If the ammeter shows a high current continuously of 25 or 30 amperes, it indicates a heavy ground or short circuit in wiring or battery. Disconnect the battery to prevent discharging, and examine the wiring for short circuits.

Electric Lighting

Light circuits can be traced by starting with (+) of the battery or generator, to ground of the lamps, through the fuses, through the switch terminals, to (-) of the generator or battery.

Auxiliary headlights are smaller than the headlights. They are placed in front, to be used in place of headlights. The headlights are 24 c.p., 7-volt and the auxiliary headlights are 6 c.p., 7-volt. See diagram of wiring. They are sometimes called dimmer lights.

the magnetic strength of the field, and consequently also the output of the generator. The action is as follows: from the (+) brush, to (Y). Points (E) are now open, because of the high charging current value flowing through regulator coil (D), drawing points (E) apart. Thus the field circuit must then pass from (Y), through resistance (F), to (H), to the other end of the field winding.

Note. It will be noted in the diagram that half of the resistance coil (F) is shunted across one set of regulator points, and half across the other set (there are two sets of regulator points). It is essential that the two sets be adjusted equally, so that the same current through regulator coil (D) will separate both points at the same time; otherwise the generator output will be high. See Index for Remy "relay-regulator" adjustments, etc.

Ignition primary circuit (from battery, when starting): From (+) of the battery, to the ammeter, to the fuse block, to switch (Z), to (I), to primary winding (P) of the coil, to the contact-breaker (closed-circuit type), to the right terminal on the coil, to the switch, to ground (G3), to (-) ground of the battery.

The ammeter would now read on the "discharge" side, as the current is coming from the battery.

Note. This switch is termed a "pole-changing" switch. If switch blades (B) and (B1) were reversed, the current would flow through the contact-breaker points in the opposite direction. See page 203, explaining this type of switch.

Ignition primary circuit (from generator): The current would be taken from the fuse block, to (Z), and the same path would be followed. The ammeter would not indicate the ignition current, but would indicate the amount of current going to the battery.

Starting-motor circuit: From the (+) terminal of the battery, to the starting-motor straight-series field-winding, through the field-windings, to the (+) brushes, through the armature, to the grounded (-) brushes, to (-) ground of the battery (G2).

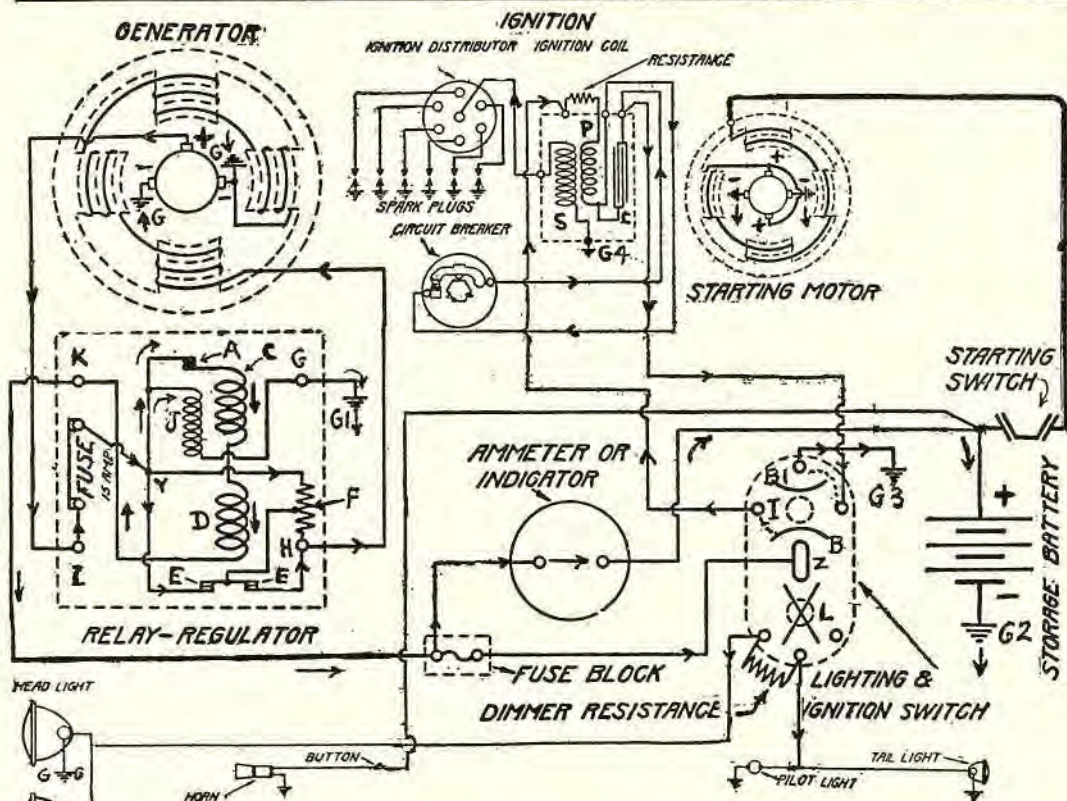


Fig. 17. Wiring diagram of the Oakland 32 and McLaughlin "D-60" explaining the Remy "relay-regulator" and the "pole-changing" switch (see Index for these subjects).

FRANKLIN (Up to July, 1921) ELECTRIC SYSTEM

The Franklin air-cooled, six-cylinder engine automobile electric system used on models "9A" and "9B" until July, 1921, is shown in the illustration (Fig. 18). Note that the ignition system is the Atwater-Kent open-circuit type. A master vibrator is used for starting purposes.

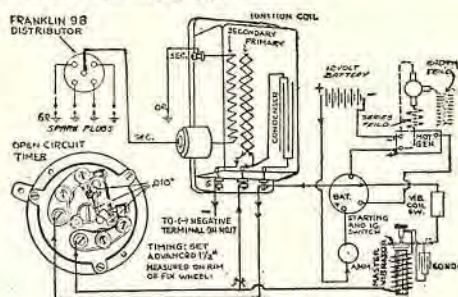


Fig. 18. Franklin electric system.

On later models, the Atwater-Kent closed-circuit ignition system is used, and the master vibrator is dispensed with. Instead, the switch is so arranged that on starting position, it cuts out a part of the primary coil winding, thus lowering the resistance of the coil, so that in cold weather, when the battery is used excessively for starting and is more or less weak during these periods, the ignition coil resistance is cut down, as mentioned above, and the spark is

sure to occur. After starting, and when the battery is "boosted up" by the generator, the switch movement cuts in the full primary coil winding.

Motor-generator: The 12-volt single-unit Dyneto motor-generator is used. The motor-generator is directly connected to the crank shaft of the engine. The motor-generator acts as a generator at car speeds over $8\frac{1}{2}$ m.p.h., and as a motor at speeds below this point.

The current output is regulated by a compound winding "differential in action," consisting of a series and a shunt-field winding which oppose, or "buck," each other, as a generator. This is termed "differential action," and the windings assist each other as a motor, or "cumulative action."

The regulation is also by a "third brush," which reduces the voltage through the shunt-field winding, which, in turn, is caused by "armature reaction" at high speeds.

Starting motor: A Dyneto motor-generator connected to the crank shaft of the engine by a silent chain; operated from the cowl board by the same switch that controls the ignition.

Generator: A Dyneto motor-generator; shunt winding, and a series-field winding are both used for the generator.

Ignition: Atwater-Kent open-circuit timer and distributor, using a box type of coil, with a condenser in the coil. A master vibrator is used for starting, which gives a continuous series of sparks

instead of a single spark operated by a switch on dash. The distributor rotor takes care of the time at which the spark occurs. This device is used only for starting purposes.

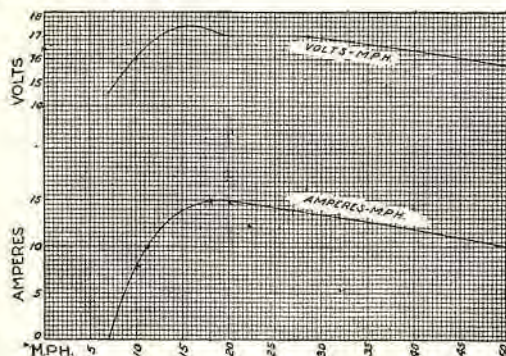


Fig. 19. The diagram or curve shows the voltage and amperage at various speeds of the car.

For instance, at a speed of 10 m.p.h. (lower line of figures), the amperage is 8 amperes; the voltage is 16 volts. At 18 m.p.h., the highest amperage peak is reached, which is 15 amperes, and at this speed, the voltage is 17 volts. The highest voltage is reached at 18 m.p.h.

The voltage begins to drop at a car speed of 28 m.p.h. (from 17 volts to slightly below 16 volts at 50 m.p.h.). The amperage begins to drop at 20 m.p.h., from 15 amperes to 10 amperes, at 50 m.p.h.

Circuits

Starting motor: From (+) of the battery, to the indicator,¹ through the indicator, to the switch, to the (+) terminal on the motor-generator, through the field-windings, to the (+) brush, through the armature, to the (-) brush, to the (-) terminal of the battery.

Generator shunt-field circuit: From the (+) main brush, or terminal of the motor-generator, to the switch, to the connection on the lower right of the switch, through a fuse (not shown), to the terminal on the motor-generator connecting with the shunt-field winding, to the (-) main brush of the generator. A 10-ampere fuse is in series with the shunt-field circuit.

Generator charging circuit: From the (+) main brush, to the switch, through the current indicator marked (AMM), to (+) of the battery, through the battery, to the (-) battery terminal, to the (-) brush of the motor-generator.

Ignition master-vibrator circuit: This ignition system is equipped with a master-vibrator coil which is used for starting. There is only one winding (primary) on this coil. When the switch or starting circuit is closed, the current is from (+) of the battery, to the switch, to the right-hand switch terminal, to the vibrator blade of the master vibrator, to the vibrator screw, to the primary winding of the master vibrator, to the lower center terminal of the coil, through the coil primary winding, to junction block (No. 17) which connects with (-) of the battery. This master vibrator gives a continuous succession of sparks to start with, and the distributor takes care of the time of the spark to the engine. The switch is thrown to the regular ignition after the engine is under way, and when the generator is "boosting" the battery.

The primary ignition circuit of the ignition coil is from the battery or generator at the right-hand switch terminal in the illustration, to the left, to the first terminal on the coil, to the timer, through the points, to the center coil terminal, to the

¹ An ammeter of the usual construction generally used, cannot be connected in series with a starting-motor circuit. An "indicator," however, which is used on the Franklin, is so designed that it is capable of carrying the starting current. See pages 469, 468 for explanation of the construction of an "Indicator" and also of an "Ammeter."

Note: It has long been an established fact that in all branches of mechanical instruction work it is necessary to go back to the earliest examples and trace their developments and work with fundamentals. These wiring diagrams show different early principles; for example, the purpose of the wiring diagram of the early Franklin electric system is to explain how the master-vibrator ignition coil was used to assist in starting the engine. See *Specifications*, pages 1060-62A, for specifications of later cars.

Examples of later wiring diagrams are shown on pages 424B, C, and D, and also in the Addenda. Attention is called to the fact that to keep wiring diagrams up to date is beyond the scope of this book. For those who propose to follow automotive electrical work, the *Standard Auto-Electrician's Manual* is recommended. It shows the wiring diagrams, factory electrical specifications, data for electrical tests, and adjustments of the various electrical units of all cars. This is a loose-leaf book and can be kept up to date yearly by purchasing *Supplements* from the publishers of this book. See advertisement in this book on page preceding the Index.

primary winding of the coil, to the left-hand coil terminal, to No. 17 on the junction block, to (-) of the battery.

The secondary ignition circuit is from the secondary winding, to the distributor, to the spark plugs, to ground, to ground of the secondary.

The ignition timing (Atwater-Kent open-circuit type): The timer is set so that it fires at $1\frac{1}{2}$ " advance, measured on the rim of the flywheel.

To check timing: Remove the distributor cover and turn the engine over slowly until the click of the contact-maker is heard. Stop exactly at this point, raise the toe-boards, and see if any center line corresponds to the position of "C. L. 1-6" shown on the flywheel.

To reset timer: Turn the flywheel until No. 1 cylinder completes its compression stroke and the 1-6 center line is $1\frac{1}{2}$ " ahead of the center point in the diaphragm (Fig. 20). Loosen the clamp screw in the aluminum base plate of the timer, so that the body can be turned in its bearing. For accurate setting, the body should be clamped tight enough to turn hard.

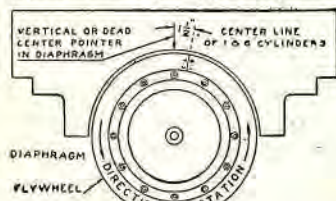


Fig. 20. Flywheel markings for spark setting.

Turn the distributor-timer body in a clockwise direction until the distributor arm is opposite the terminal on the cover leading to No. 5 spark-plug wire. Then turn the body slowly and steadily counter-clockwise until the click of the contact maker is heard. Stop exactly at this point, and tighten the clamp screw.

Adjustment should then be checked by moving the flywheel backwards about 16° on the flywheel rim, so that it is off the firing point. Then move ahead to the firing point again, and stop the moment a click is heard. If "C. L. 1-6" is then $1\frac{1}{2}$ " ahead of the center pointer on the diaphragm, the timer is set right. Rewire the clamp-screw in the base plate.

Timer contact points are set .010" apart on the open-circuit type, and .007" on the closed-circuit type. To adjust the contact screw, take it out of the holder and remove one of the thin steel washers from under its head. This brings the points a little closer together (see also page 203). The points should be examined every 3,000 miles. The spark-plug gap should be set at .031".

Firing order: 1, 4, 2, 6, 3, 5.

Master vibrator adjustment: When operating properly, the vibrator should buzz on an 8-volt circuit, i.e., on 4 cells of a fully charged storage battery. A more accurate way of setting the vibrator is to turn the ignition switch to "neutral" (the engine should not be running), take out whichever spark plug is firing at that time, and set the adjusting screw on the vibrator so that a spark of the highest possible frequency can be observed at the plug points. When the vibrator draws about 1.1 amperes on a fully charged battery, it will give the hottest spark.

For Franklin gear shift and controls, see Index. See the Index also for the Franklin engine.

Changes on Franklin Series 10

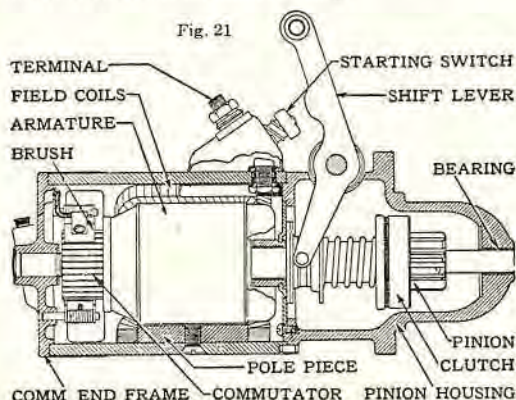
On the "Series 10" car, the Atwater-Kent type "R" interrupter and type "N7" coil are used (see page 207). Interrupter gap is .015".

Ignition timing "Series 10." Advance spark. Turn crank until No. 1 piston comes up on compression stroke—stop when the Δ slot in fanwheel rim is $1\frac{1}{2}$ " from center line of engine. Straighten the spark control wire inserted in the ball clevis; put ignition switch "on," and with center wire of distributor cover removed and its terminal held $\frac{1}{8}$ " from engine, turn distributor counter-clockwise slightly, then clockwise, until interrupter points open and spark jumps. At this position secure spark control wire in ball clevis. Spark timing should now be $1\frac{1}{2}$ " advanced.

BUICK SERIES 8-50, 8-60, 8-80 AND 8-90 ELECTRICAL SYSTEM¹

The Delco-Remy starting, lighting and ignition system is used on all models. See page 307A for ignition system.

Starting motor, Fig. 21: The same starting motor is used on all series 1931 models, except that used on series 8-50 has no inner bearing.



These motors are of the **mechanical shift over-running clutch type**, and for this reason it is important to release the pedal as soon as the engine is running, to avoid excessive speed which may cause the over-running clutch to seize.

The flywheel teeth are cut in a heat-treated steel ring shrunk on the flywheel and welded to it. Number flywheel teeth 8-50 series: 118; 8-60, 8-80 and 8-90 series: 123. Number pinion teeth 8-50, 8-60, 8-80 and 8-90 series: 9. Ratio 8-50 series: 13.11 to 1; 8-60, 8-80 and 8-90 series: 13.66 to 1. The starter pedal should not be depressed while the engine is running as this may result in **burring the flywheel teeth**. If this occurs it may be possible to remove the burrs by filing. However, if the teeth have been badly burred it may be necessary to replace the flywheel.

The 1931 starting motors do not have an adjustment on the switch stem. This adjustment has been eliminated by holding closer manufacturing limits.

The starting motor brushes are of a composition having sufficient abrasive action to ordinarily keep the commutator clean.

If an examination indicates that commutator should be cleaned (can be inspected by removing cover band), it can be done by holding a narrow strip of No. 0 sand paper against the commutator with the finger and operating the starting motor by pressing on the starter switch button, or with engine running at idling speed. Any excessive grease or oil should be cleaned from the commutator surface and brushes with a clean cloth.

Starting motor lubrication: A few drops of engine oil should be placed in the oil cup on the commutator end bearing approximately every 1,000 miles. No further lubrication is required.

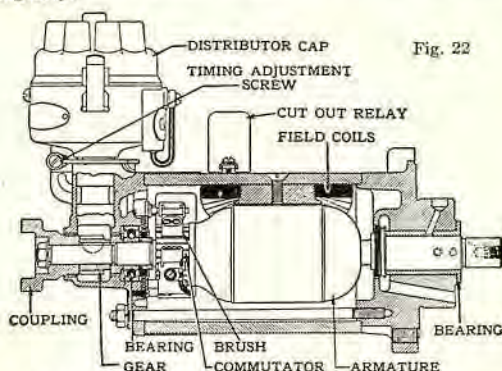
The starter shift pedal should work freely at all times. If the pedal does not completely return to the disengaged position, it may be necessary to place a few drops of oil on the starter pedal cross shaft bearing, also on the various pins in the linkage.

Generator: The same generator (Fig. 22) is used on all models, and is similar in performance to preceding designs. The direction of the spiral on the distributor drive gear has been reversed to drive the distributor in opposite rotation to all previous models. This was required for proper operation of the Bowden wire spark control.

Generator lubrication: The distributor and distributor drive gears are lubricated by grease inserted through a Zerk fitting on the distributor well. This should be done each 500 miles, using a good grade of cup grease.

In order to make certain that a sufficient quantity of grease has been inserted, an overflow has been provided at the top of the distributor well; this overflow is restricted and will not permit the passage of grease until the gear housing and distributor bearing has been filled.

The commutator end of the generator shaft is supported by a ball bearing which should be lubricated with a few drops of engine oil, inserted in the oil cup located on top of the end bearing, each 1,000 miles. An excess of oil at this point should be guarded against to prevent the commutator surface from becoming dirty.



The drive end oil ring used on previous models has been eliminated, but ample lubrication is provided by the overflow of oil from the valve rocker arm shaft.

Generator charging rate: The generator starts charging at car speeds of 8 to 10 m.p.h., and is maximum (16 to 19 amperes at ammeter on instrument panels) at approximately 25 m.p.h. The charging rate should never be adjusted unless the generator frame feels cool. This adjustment can be made by loosening the adjustment screw at commutator end of generator and moving the third-brush in the direction of rotation of the armature for increasing the rate, and in the opposite direction for decreasing. If the generator is functioning normally the proper charging rate will ordinarily be obtained without bringing the third-brush closer than two commutator bars from the adjacent main brush.

Generator thermostat: The action of the thermostat (Fig. 23) is as follows: If the engine is started cold, and the car is operated at approximately 25 m.p.h., the charging rate as indicated by the dash ammeter, should be approximately halfway between the 15 and 20 ampere points for a period of time depending on outside air temperature, after which the charging rate will automatically reduce to approximately 10 amperes. This reduction in charging rate results from the heat inside the generator becoming sufficient to separate the thermostat points, which allows the field current of the generator to pass through a resistance coil mounted on the thermostat frame. This makes it unnecessary to frequently regulate the output for varying driving conditions and seasonal changes. The charging rate will be reduced in summer after a very short period of driving, whereas in winter the rate will remain high for a much longer period of time.

Caution: The adjustment of the thermostat is sealed and must not be changed. Never pry the thermostat points apart or clean the contacts, as this will alter the calibration. The wiping action obtained by expansion of the thermostat metal automatically cleans the points. The resistance unit mounted on the thermostat frame, in addition to controlling the charging

¹ These pages, 424A, B, C, D, E and F, exemplify later construction and were added since the preceding pages were prepared. Although it will be noticed that improvements and refinements have been made, the fundamental principles of operation are similar in many respects.

rate, also acts as a fuse and will not burn out unless subjected to severe overload, such as produced by an open circuit, loose or dirty connection in the charging circuit. A burned-out resistance unit will be indicated by the dash ammeter showing charge when the engine is cold, and discharge after operating a short period of time.



Whenever it is necessary to replace a thermostat resistance unit, the car wiring, particularly connections to the cutout relay, ammeter, starting motor and battery posts, should be carefully inspected to see that they are clean and tight.

Cut-out relay: The cut-out relay (Fig. 24), which is mounted on top of the generator, automatically connects the generator with the battery whenever the car speed is sufficient to cause the generator to charge, and likewise disconnects the generator from the battery when the car speed is below that required for charging. This prevents the battery from discharging through the generator windings.

CUT IN & CUT OUT ADJUSTMENT

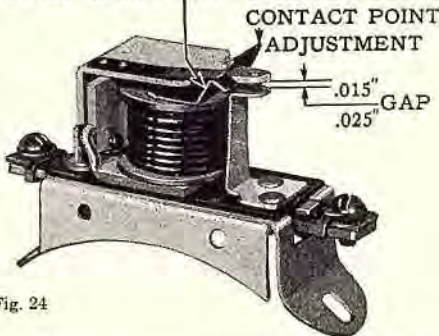


Fig. 24

Cut-out relay adjustments: The relay points should close between voltages of 6.7 and 7.5, and should open when the generator discharge current is not more than $2\frac{1}{2}$ amperes. If the relay requires adjustment, first see that the contact point opening is from .015" to .025". The point opening can be changed by bending the brass stop, which bears against the relay arma-

ture when the points are in open position. If the points are in proper adjustment and the relay still does not operate satisfactorily, the armature spring tension can be varied by bending the brass support for the flat steel spring which is riveted to the relay armature. If the relay cuts in at a voltage above 7.5, the cut-in can be lowered by bending down the brass support. If the discharge current required to open the points exceeds $2\frac{1}{2}$ amperes, the spring tension should be increased by bending the brass support upward. See Fig. 24. This will require an ammeter connected between the generator feed wire and cut-out relay because the dash ammeter includes the ignition current.

The current limit relay (Fig. 25) is mounted on the inside of the dash. The function of this unit is to protect the lighting system from damage due to short circuits. The horn and ignition circuits are not protected by the relay. The normal lighting current is not sufficient to operate the relay, but a short circuit in any of the lighting circuits, or the addition of too many electrical accessories, will cause the relay to function, giving forth a buzzing sound, which provides a distinctive warning. This will continue until the trouble is remedied, or the battery completely discharged.

In addition to the foregoing, the current limit relay on the 1931 models has been provided with automatic wiping contacts. This action is obtained by a strip of thermostat metal which causes the contact to slide whenever there is a change in temperature. The thermostat metal also reduces the current flow when a short circuit occurs by lessening the contact pressure as the relay heats up.

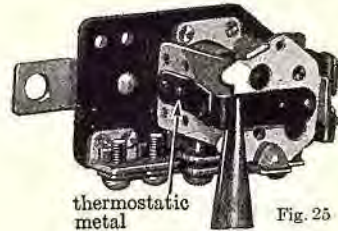


Fig. 25

Current limit relay adjustment: The relay should start to vibrate at a load of from 30 to 35 amperes, and on a dead short circuit the current should not exceed 15 amperes. The contact spring pressure measured directly above the plunger should not be less than 5 ounces. If it is necessary to change the spring tension, this can be done by grasping the contact spring with a narrow pair of pliers and bending in a direction to give the required tension. See Fig. 25. Never bend the thermostatic metal to obtain this adjustment.

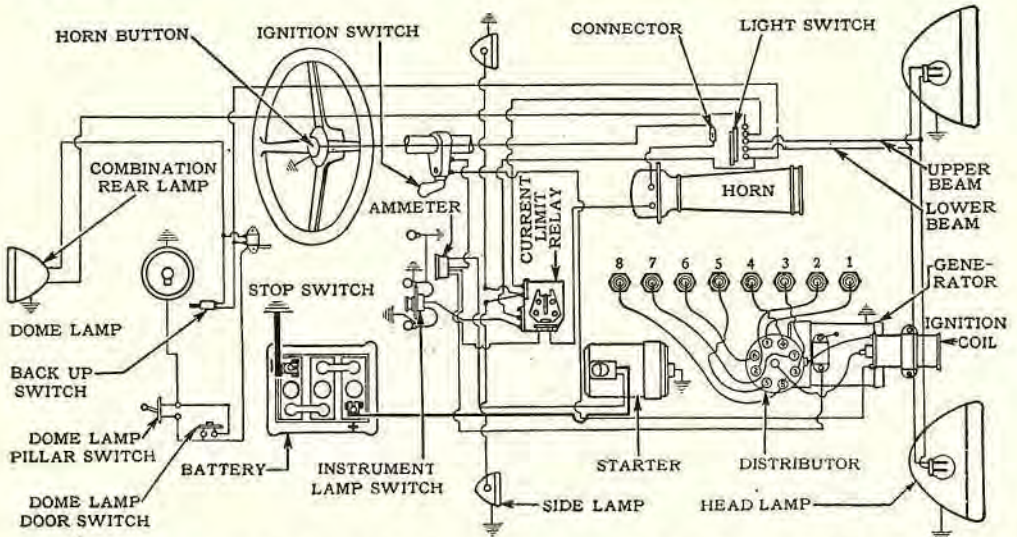


Fig. 26. Wiring diagram of the Buick 8-60, 8-80 and 8-90 series car. With the aid of this diagram, each circuit through the various units can be traced. See specifications, pages 1055-1062, for the Buick and other cars.

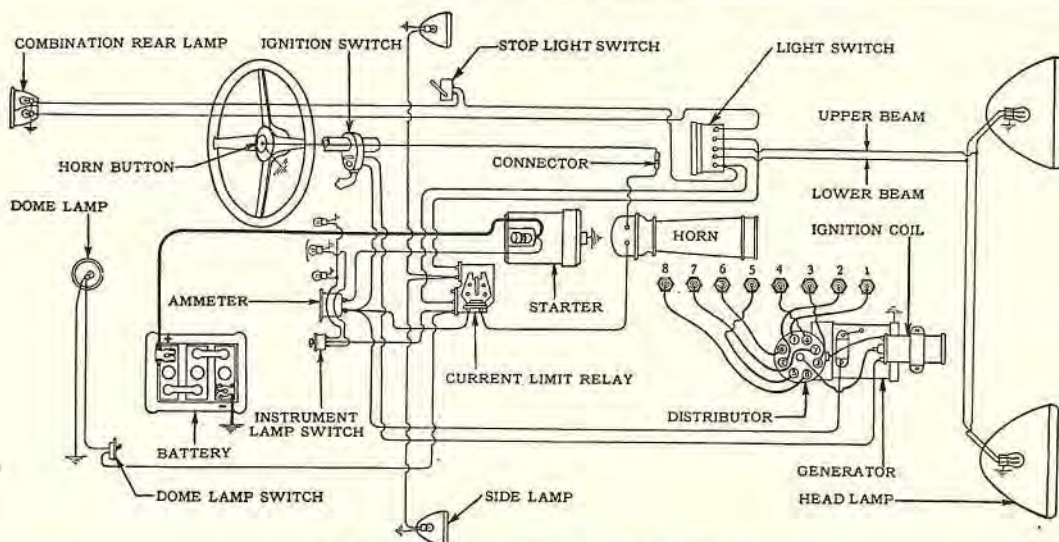


Fig. 27. Wiring diagram of the Buick 8-50 series car.

CADILLAC V-16, SERIES "452" ELECTRICAL SYSTEM

The electrical system consists of a Delco-Remy generator, starting motor and ignition system. The cylinder blocks are mounted at 45° .

Ignition system: Delco-Remy. Consists of two almost entirely separate circuits controlled by the same switch. Each circuit has a separate coil, breaker-contact points, condenser, and a separate set of distributor terminals. One circuit provides ignition for the right-hand cylinders, the other for the left-hand cylinders.

There are two sets of breaker-contact points, both breaker-arms being operated by a single eight-lobe breaker-cam. The V-16 breaker-contact gap is .014" to .018". Each set of points has its own condenser mounted inside the distributor. The breaker-arms operate alternately and are mounted at an angle of $22\frac{1}{2}^\circ$. The right-hand breaker-arm and the left-hand coil furnish ignition for the left-hand or odd-numbered cylinders. This arm pivots on the stationary post and is timed by turning the cam. The left-hand breaker-arm and right-hand coil furnish ignition for the right-hand or even-numbered cylinders. This arm pivots on a post anchored

to an adjustable plate and is timed by an eccentric adjustment which must be synchronized with the other arm.

The high-tension distributor has a special double-end rotor which distributes the high-tension current to the right-hand cylinders from one end and to the left-hand cylinders from the other end. The end which takes care of the right-hand cylinders is connected to a contact in the center of the rotor, which in turn is continually in contact with a brush in the center of the distributor head. The end of the rotor which provides for the left-hand cylinders is connected to a brush making continual contact with a ring in the distributor head. This ring is connected to a separate terminal in the head.

Firing order V-16: The cylinders are not numbered according to the same system as previously used on Cadillac cars. The cylinders of the V-16 are numbered according to the location rather than firing order. The numbering system is as follows: Front R.H.: 2-4-6-8-10-12-14-16; front L.H.: 1-3-5-7-9-11-13-15. The firing order is as follows: 1-8-9-14-3-6-11-2-15-10-7-4-13-12-5-16. See Fig. 31.

CADILLAC V-12, SERIES "370" ELECTRICAL SYSTEM

The electrical system on the V-12 is very similar to the V-16 except that it is arranged for a twelve-cylinder engine instead of a sixteen. The cylinder blocks are mounted at 45° .

Ignition timer-distributor: Similar to the V-16 type and has the same type of automatic advance mechanism.

The contacts at the end of the distributor rotor are not exactly 180° apart, because of the alternate 45° and 75° firing intervals of this engine. A 45° interval (on the crankshaft) comes after each of the right-hand cylinders fires and a 75° interval comes after each of the left-hand cylinders fires.

Firing order: Front R.H.: 2-4-6-8-10-12; front L.H.: 1-3-5-7-9-11. This firing order is: 1-4-9-8-5-2-11-10-3-6-7-12.

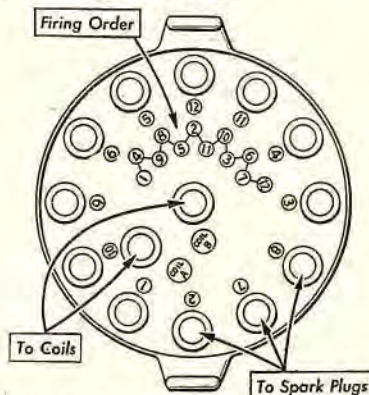


Fig. 28. The firing order as well as the high-tension connections are shown on the distributor head.

Breaker mechanism: The breaker-cam has six lobes instead of eight, as on the V-16. The breaker contacts are arranged the same as on the V-16 and operate alternately. The right-hand arm and left-hand coil furnish ignition for the left-hand or odd-numbered cylinders. This arm is on the stationary post while the left-hand arm which, with the right-hand coil furnishes ignition for the right-hand cylinders, is carried on the adjustable plate. The gap between the breaker-contact points is .018" to .024". The condensers and breaker contacts are interchangeable with those on the V-16.

Ignition timing: Before attempting to time the ignition, see that the contacts are in good condition and properly adjusted for a gap of .018" to .024". The distributor should be removed from the engine and the breaker-contacts synchronized. Synchronizing tool No. 109224, for the eight-cylinder engines, can be adapted to the V-12 as well as to the V-16, by marking the quadrant properly.



Fig. 29. The markings shown on this sketch are for the V-12 and the V-16 as well as for the V-8 engines.

When synchronizing the points on the V-12, adjust the synchronizing fixture so that the right-hand or stationary breaker-contacts just separate when the pointer is moved away from the farthest indicating point on the quadrant. Synchronize the left-hand contacts so that they separate just as the pointer passes the "12 L.H." mark, which is 37 1/2°

from the point at which the right-hand contacts separate. Moving the pointer still further, the right-hand contacts should separate again at the "12 R.H." mark, just below the center indicating point on the quadrant, Fig. 29. This mark is 60° from the farthest point.

To insure accuracy in the synchronizing operation the test lamp should be used, connecting one lamp to the ground and the other to the binding post for the contacts being timed.

After synchronizing the points, reinstall the distributor and time the ignition in the same manner as on the V-16. The IG/A marks on the V-12 flywheel do not specify the cylinder numbers to which they apply. Each IG/A mark is 1 27/32" ahead of center and in bringing the IG/A mark for No. 1 cylinder in line with the indicator at the timing inspection opening, turn the engine until the mark 2-12 can be seen in the opening and No. 1 piston is coming up on the compression stroke. The IG/A mark for No. 1 cylinder is 3 11/16" beyond this mark. Continue to turn the engine very carefully until this IG/A mark appears in line with the indicator.

When timing the ignition, the distributor should be at the fully advanced position. Be sure that the control rod is properly adjusted so that when the spark control button on the dash is pushed all the way in, the rear stop screw on the distributor is at the extreme right-hand end of its slot in the quadrant. Loosen the set screw in the middle of the breaker cam and turn the cam clockwise until the right-hand contacts just separate, with the terminal from the center of the rotor in line with No. 1 insert on the distributor head.

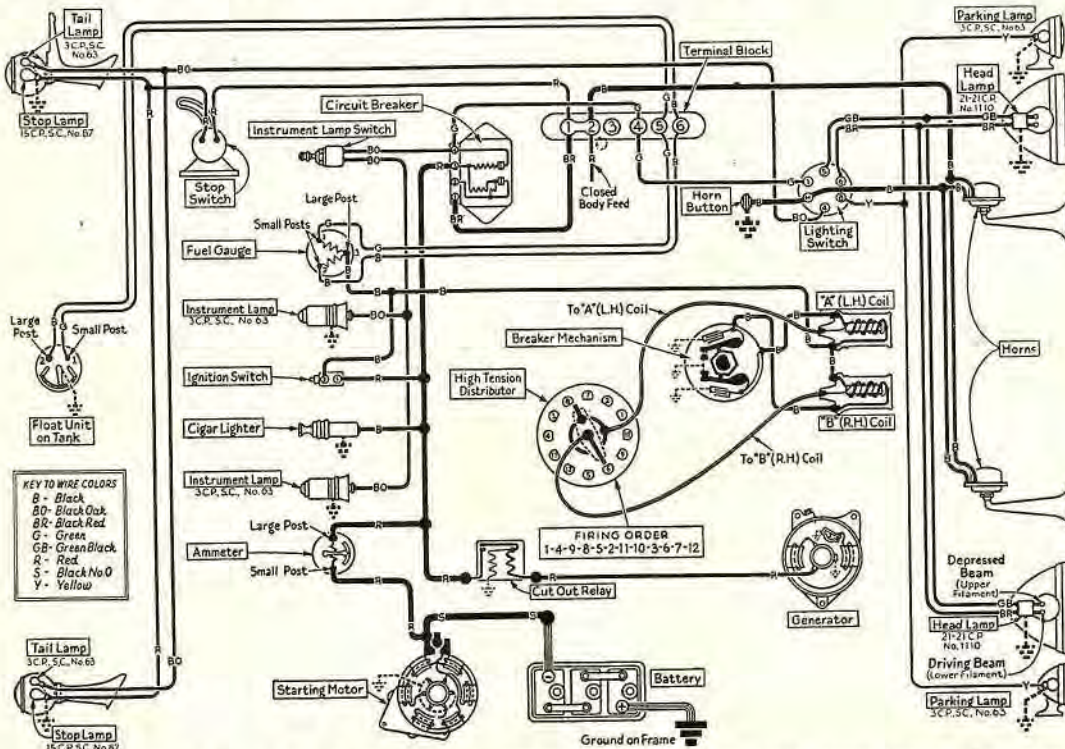


Fig. 30. Wiring diagram of the Cadillac V-12, series "370," twelve-cylinder car showing the electrical circuits. The arrangement of the V-16 chassis wiring circuits is similar except for the horn circuits, the fuel gauge and the connections at the terminal block on some of the earlier V-16 cars. See specifications, pages 1055-1062, for the Cadillac and other cars.

The two ignition coils are mounted in recesses in the upper tank of the radiator, where they are protected from moisture and excessive heat. They are of the same type as those on the V-16 but are not interchangeable with them because of the difference in the high-tension connections.

Spark control: The manual control is the same as

on the Cadillac V-16 and is operated by a rod and rocker arm mounted on the dash.

The spark plugs and wires are concealed by a cover plate over the "V" between the cylinder blocks, in the same manner as on the V-16. The same spark plugs, AC type G-8, are used as on the V-16. The standard spark plug gap for these plugs is .025" to .028" on both cars.

CADILLAC V-16, SERIES "452" FIRING ORDER AND POWER LAP CHART

The firing order is shown in the upper illustration (Fig. 31) and also on both sides of the power-lap chart. Note that odd numbers represent the cylinders on the left-hand side and the even numbers represent the cylinders on the right-hand side. Also observe that the cylinders are staggered because the connecting rods are placed side-by-side.

The power-lap chart is shown below the firing order chart (Fig. 32). By laying a straight edge in a vertical position on the power-lap chart one can observe just what takes place in each of the 16 cylinders at any instant during a complete cycle or 720°.

Abbreviations: See illustration at extreme bottom: P, power stroke represented by dark zone; PE, power and exhaust done while the valve is opening. There is considerable pressure on the piston at the begin-

ning of exhaust valve opening, but this pressure is gradually tapered down or reduced to zero by the time BDC has been reached. The dark zone representing the power stroke begins to taper down after 141° travel, where the exhaust valve starts to open, and comes to a point at BDC. Just at the beginning of exhaust valve opening, four cylinders are working under full power but one gradually loses power for a distance of 39°; E, exhaust; EI, exhaust and intake at the same time; both valves being open at the same time, due to the 5° valve lap. Inertia of the mixture flowing through the intake manifold causes it to enter the cylinders before suction begins. S, suction; II, inertia intake caused by inertia of the mixture due to its high velocity in the manifold; C, compression; EO, exhaust opens; IO, inlet opens; EC, exhaust closes; IC, inlet closes.

Valve timing of the V-16 Cadillac engine is as follows: intake opens TDC and closes 44° ABDC. Exhaust opens 39° BBDC and closes 5° ATDC.

During the four strokes, or two revolutions, of crankshaft (720°), four cylinders are delivering power at all times. Prepared by Mr. P. J. McCullough.

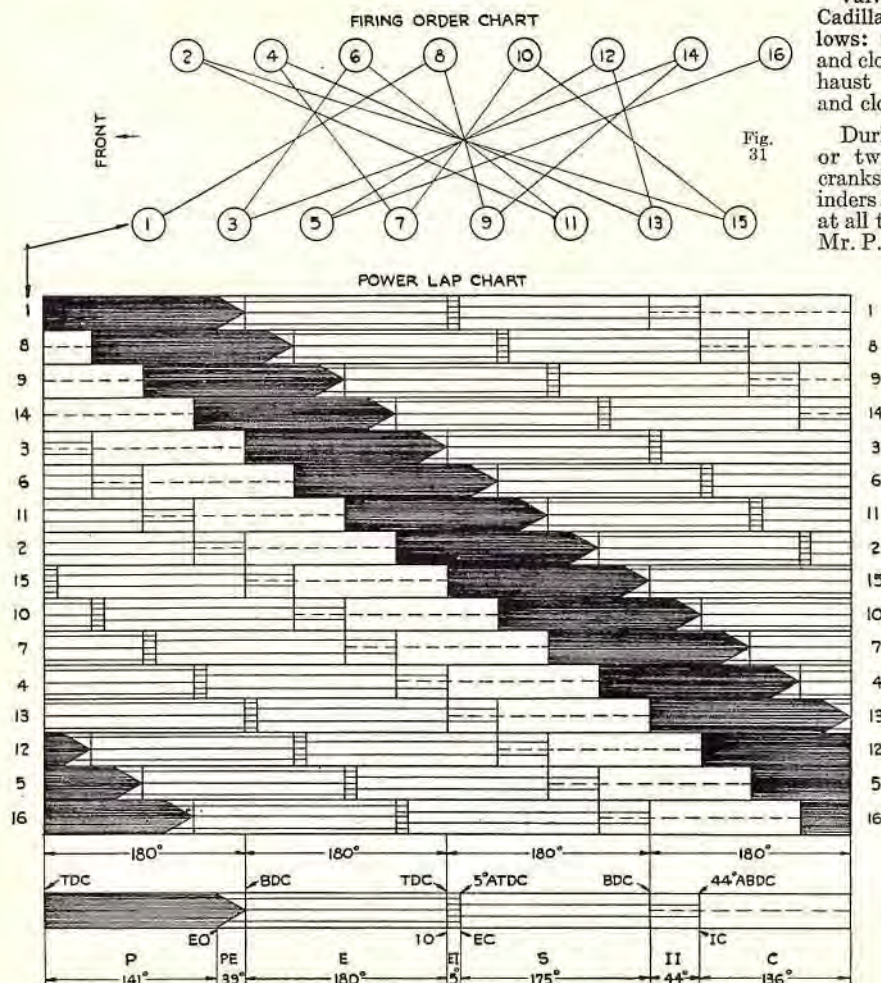


Fig. 32

CHRYSLER "70" (1930) STARTING MOTOR AND GENERATOR

The starting motor (Delco-Remy) is of reduction gear type and is mounted on the left side of the fly-wheel housing. It is held in place by a heavy set screw and lock nut. The starting motor pinion is shifted into mesh with the gear teeth on the flywheel by a foot-operated mechanism. In connection with this gear-shifting mechanism is a switch which closes the electric circuit for the starting motor just after the gears have been meshed.

The commutator should be kept clean and free from oil and grease; if it appears dirty or rough, it should be cleaned with number 00 sandpaper. Emery paper should never be used for this purpose. If this treatment does not smooth the commutator, the armature should be removed and the commutator turned in a lathe. The mica should not be undercut on motor commutator. The brushes should move freely in the brush holders and the full contact area should bear on the commutator. The locations of the brushes should never be changed as they are properly set when the instrument is built.

The oilers in each end of the starting motor housing should receive a few drops of light engine oil every 2,000 miles. Medium cup grease should be forced into the gear case at the pipe plug hole (12, Fig. 33) at rear end of starting motor body. Grease should be inserted here about every 10,000 miles. The commutator should never be oiled. The connections of the gear-shifting mechanism should receive a few drops of oil each 2,000 miles to maintain free action.

The starting motor is removed by first disconnecting the cables. Then the cotter pin and clevis pin, connecting the gear-shifting lever with the foot rod, should be removed. The lock nut should be loosened and the set screw, entering the fly-wheel housing above the starting motor, removed. The starting motor may then be pulled straight out of the fly-wheel housing toward the front of the car.

The generator is mounted on the left side of the engine at the front and driven by the fan belt. It generates current for the entire electrical system and feeds it to the storage battery. The generator may be easily and quickly removed by removing the mounting bolts. The oil reservoirs at each end of the armature shaft should be filled with light engine oil every 2,000 miles.

The generator (Delco-Remy) begins charging at 8 to 10 miles per hour and reaches its maximum output of 16 amperes (with cold generator) at 20 to 22 miles per hour. For ordinary driving the rate should never exceed 12 amperes. The charging rate may be regulated by rotating the "third" brush holder. This is made accessible by removal of the commu-

tor end cover band. The "third" brush rocker ring clamp screw may then be loosened and the "third" brush holder rotated in the direction of armature rotation to increase the rate or against armature rotation to decrease.

If the generator charging rate is not up to the proper figure the difficulty may be due to a loose generator and fan drive belt. The belt should be adjusted.

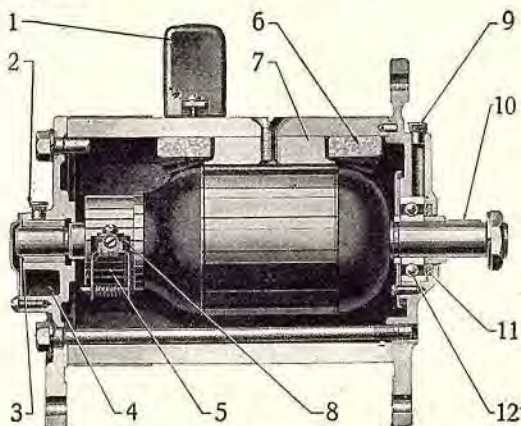


Fig. 34. Generator. Name of parts: 1, relay; 2, oiler; 3, bearing; 4, oil reservoir; 5, commutator; 6, field coil; 7, field pole; 8, brush; 9, oiler; 10, pulley key; 11, oil seal; 12, bearing.

The relay, assembled on the top of the generator body, automatically breaks the circuit between the generator and the battery when the engine speed is too low for the generator to charge the battery. It automatically closes the circuit at the proper engine speed so the generator can charge the battery. The relay requires no lubrication or other attention. The adjustment of the movable arm should not be disturbed.

For ignition system and wiring diagram of the Chrysler "70" see pages 307C and 307D. For specifications of Chrysler and other cars see pages 1055-1062.

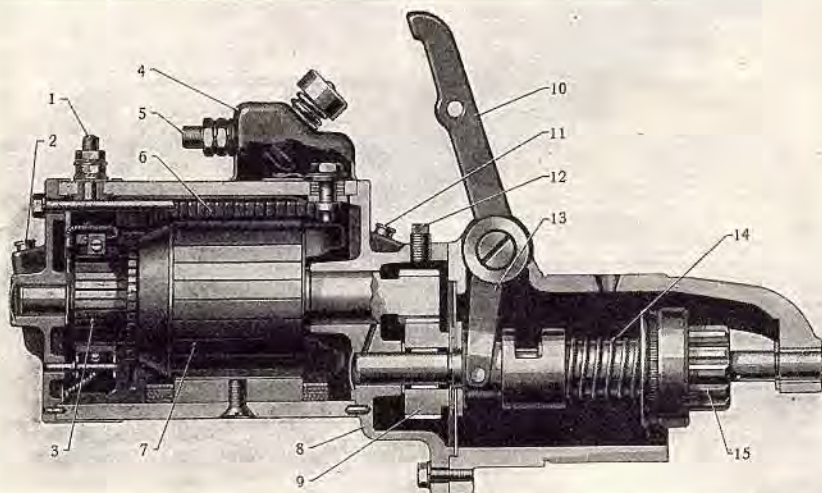


Fig. 33. Starting motor. Name of parts: 1, fumer cable terminal post; 2, oil cup; 3, commutator; 4, starter switch and plunger; 5, starter cable terminal post; 6, field coil; 7, armature; 8, reduction gear or center housing; 9, oil cup; 11, oil cup; 12, lubricant hole plug; 13, shift yoke; 14, shift spring; 15, pinion.

INSTRUCTION No. 37

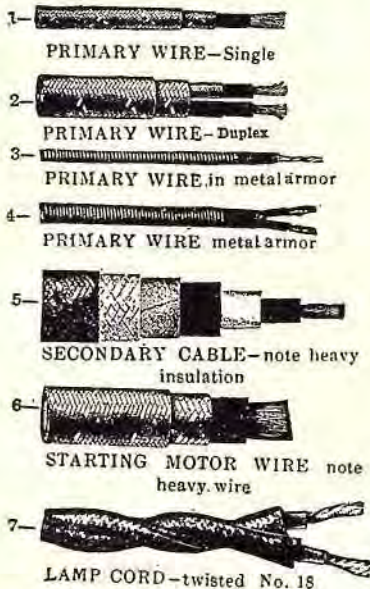
WIRING OF A CAR: Ignition, Starting, Generating, and Lighting

KINDS OF WIRE USED FOR AUTOMOBILE ELECTRIC SYSTEMS

Wire for connecting the different electrical units of a car is usually called cable. There are five general classifications: low-tension or primary ignition cable; lighting cable; high-tension or secondary ignition cable; starting-motor cable; portable cord.

Low-tension, or primary ignition cable is used for low tension (voltage) work, such as for the ignition circuit, from switch to coil, and from coil to timer. See 1 below and Fig. 8, page 426. It is flexible, consisting of several fine strands covered with a waterproof insulation and is usually Nos. 14 and 16. It can also be had in duplex form; see 2.

Lighting cable is used from the switch to the headlights, side, dash, tail and dome lights, etc. It can be obtained in four sizes: 16, 14, 12 and 10. The amount of current to be carried determines the size. No. 16 gauge will answer for small tail and dash lights; No. 14 for headlights on small cars (see Fig. 8, page 426). Sometimes where there are very large lamp bulbs, No. 12 is used. Usually this lighting cable is of the armored type (3 below, and Fig. 15, page 428). Sometimes duplex cable is used (4 below), and is usually encased in metal armor, or even as many as four cables can be together in one metal armor.



High-tension, or secondary ignition cable (see 5 above) is used for high-tension ignition current from coil to distributor and from distributor to spark plugs. The wire itself is small and flexible, but the insulation (usually rubber) is very heavy, as it carries a high voltage, but a low amperage. It is made usually in two sizes: 7 mm. and 9 mm., the 7 mm. being used most.

Starting-motor wire, or cable (see 6 above): This wire must be very large, because it carries a very heavy current. No. 1 size is generally used on small and medium-sized cars, and No. 0 is used if the distance is greater; as on a large car. The No. 0 measures .32" diameter. This wire is flexible, being made up of a large number of copper wire strands heavily insulated with rubber and with a braided cover over the rubber. This wire is much heavier than the secondary cable, as it carries a high amperage, but a low voltage.

For example, the wire running from the storage battery to the starting motor, when it is first starting, must carry from 80 to sometimes 400 amperes (the quantity of current depends on the size of the motor and condition of the engine). This is used only for a few seconds. But large wires must necessarily be used to carry this great quantity, even for a few seconds. Compare the size of the starting-motor wire (6) with that of (5). Note the difference in size of the wire and insulation. (5) carries a high voltage and low amperage, whereas (6) carries a high amperage and low voltage.

The wires running from the generator to the storage battery are much smaller than (6) (see 3 and 4), as the quantity of current which passes through this wire is only 5 to 25 amperes. See Fig. 8, page 426 and note that No. 10 is generally used and is armored.

By way of a comparison, imagine water pipes. If you desire to pass 150 gallons of water through a pipe in one hour it would require a larger pipe than one through which you passed only 25 gallons in an hour.

Note: On most cars and as shown in Fig. 8, page 426, the live or feed wire which supplies current for ignition, lights and horn from battery to ammeter is taken from the battery side of the starting switch and should be heavier than the other lighting circuits, or No. 10. This wire also carries the current from generator to battery when the battery is being charged; therefore the entire circuit from generator to battery should be No. 10 and armored.

Portable cable is similar to lamp cord, but is heavier and better insulated. It is used for extension or trouble lamps, small portable drills, etc. Lamp cord (7) should not be used for wiring any part of a car.

Voltage Drop and Wire Size

When current flows through a wire (conductor), a certain amount of pressure (voltage) is lost in overcoming the resistance that the conductor offers to the flow of current (amperage).

The greater the distance that current flows through a conductor, the greater the loss of pressure. This is known as "voltage drop."

The resistance of a wire depends upon two things: (1) the kind of metal in the wire (copper offers less resistance to the flow of current than iron); (2) the area or size of the wire. The resistance of a small copper wire is greater than the resistance of a large wire; that is, the resistance decreases as the size increases.

The size of wire to use depends upon the amount of current that must flow through it, and the length of the wire. The longer the wire, the greater the resistance offered to the flow of current. Therefore there will be too much drop in voltage at the wire terminus, if the wire is not of sufficient size.

A conductor must be large enough to carry the required amount of current to a certain point with less than 5 per cent drop.

Ohms multiplied by Amperes equals Voltage Drop.

Voltage Drop divided by Ohms equals Amperes.

Voltage Drop divided by Amperes equals Ohms.

Almost all automobiles are using a single wire with a grounded return system of wiring, and the length of wire in one direction is seldom over 12 feet.

Voltage Drop and Connections

All connections should be bright and clean, for a dirty connection will add resistance, and consequently will cause a voltage drop. Binding posts, screws, and the ends of the wire must be scraped clean before the wire is attached—this is very important, especially on low-voltage wiring.

Grounded connections should be filed or scraped bright before attaching the wire, and the connection when made should be firm in position—and tightly drawn up, otherwise resistance will be added, thus resulting in a voltage drop.

Ampere Capacity of Copper Wire

The carrying capacity of copper wires (B & S gauge)¹, as given by the National Board of Underwriters for rubber-covered wire, is shown opposite.

The higher the number, the smaller the wires. No. 0 is many times larger than No. 18. No. 18 is .04 or 3/64" diameter; No. 0 is .32 or 5/16" diameter.

¹ B & S gauge means Brown & Sharpe gauge, and is a recognized standard.

Carrying Capacity of Copper Wire

No. 18	B & S gauge.	3 amperes.
No. 16	B & S gauge.	6 amperes.
No. 14	B & S gauge.	15 amperes.
No. 12	B & S gauge.	20 amperes.
No. 10	B & S gauge.	25 amperes.
No. 8	B & S gauge.	35 amperes.
No. 6	B & S gauge.	50 amperes.
No. 4	B & S gauge.	70 amperes.
No. 3	B & S gauge.	80 amperes.
No. 2	B & S gauge.	90 amperes.
No. 1	B & S gauge.	100 amperes.
Nos. 1 & 0	B & S gauge.	125 amperes.
Nos. 2 & 0	B & S gauge.	150 amperes.

AVERAGE LENGTH AND SIZE OF WIRE USED FOR WIRING A CAR

An example of the size of wire used for wiring a car and the length for the different circuits of an average car is shown in the accompanying illustration, which is the wiring diagram of the Lexington Series "S" model (Fig. 8). Connections of the wires to the fuse block and other details are also shown.

Generator: Third-brush regulated Gray & Davis; Starting motor: Gray & Davis; Ignition: Connecticut system using type 96Y switch; Wiring system: Single wire, grounded return.

Eight External Circuits of an Electric System

The diagram (Fig. 8) clearly shows the eight external circuits. The internal circuits of the generator, and its field-winding circuit and cut-out circuit are not shown. The cut-out is mounted on the generator, but is not shown.

Starting-motor circuit: From the grounded (+) terminal of the battery, to the grounded terminal of the motor, through the starting switch, to the (-) terminal of the battery.

The ignition circuit, when starting, is from ground (G) of the ignition coil, to coil terminal (A), through the primary wire, to contact-breaker terminal (T), through the closed contact-breaker points, to (B), through the coil primary winding, to (C), through a jumper (J) on the fuse block, through ignition thermostat (H) on the switch, to switch (IG), to ammeter (I), through a jumper on the fuse block, to the (-) terminal of the battery at the starting switch.

Note: Current for ignition and lights is taken from the battery side of starting switch. This wire should never be connected with the terminal on the battery, as it will corrode and offer resistance to current.

If the generator is supplying the ignition current, the circuit is then from (+) of the generator, through

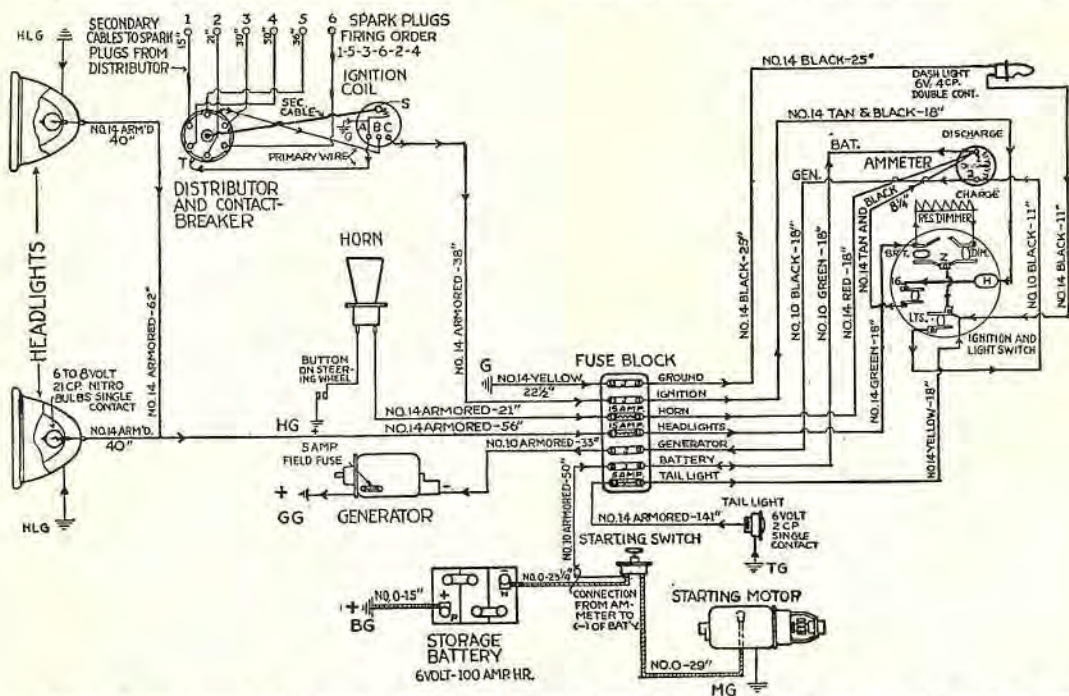


Fig. 8. Wiring diagram of the Lexington (Series "S"), showing the size of wire used, length of wire, size of lamp bulbs, fuse block, and the various circuits. Note where armored cable is used; also how the connections are made to the ammeter, and where secondary cable is used. Note also the starting-motor cable and the size of it.

Note, too, that No. 10 wire is used in the generator and battery circuit; No. 14 is used in ignition and lighting circuits, and No. 0 in the starting-motor circuit. The live or feed wire for lights, ignition and horn from battery, is the wire connecting to the battery side of starting switch. Note that it leads to the ammeter, thence to switch, and also serves for connection from generator to battery when the generator is charging the battery, and is No. 10 wire, or lighting cable. This is an important wire and should never be connected to the battery terminal direct for reasons stated in the note above.

NOTE: Refer to page 690 under "Re-Wiring a Car" for a booklet entitled "The Certified Re-Wiring Manual." This booklet not only gives valuable information on checking the electrical system of a car but also gives the proper size of cable to use for re-wiring cars, buses, trucks, tractors and trailers.

the same circuit to (1) on the ammeter, through the ammeter to (2), to jumper (J) on the fuse block, to the (-) terminal of the generator. The condenser is in the coil.

The secondary circuit is from the coil of the secondary terminal (S), through the secondary cable to the center, or rotor of the distributor, to the spark plugs, to ground, to ground (G) of the coil, to the grounded end of the secondary at (A).

Generator charging circuit: From the (+) ground of the generator, to the (+) ground of the battery, to the fuse block, through jumper (J) on the fuse block ("jumper" means that instead of a fuse, a straight connection is made), through No. 10 size green wire (BAT.), to (1) on the ammeter, through the ammeter to (2), through (GEN.) black wire (No. 10 size), to the fuse block, through jumper (J), to the (-) terminal of the generator.

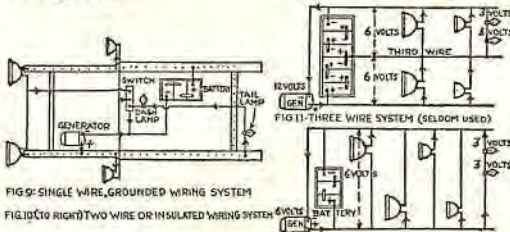
Headlight circuit: From the (+) battery ground or (+) generator ground (whichever is in service), to ground of the headlights (HGL), through the lamp bulbs in parallel, to the fuse block, through a 15-ampere fuse, through green wire (No. 14) size, to

one side of the dimmer resistance. If connections are made at (BRT.), then resistance is cut out. If made at "Dim," then current must flow through the resistance and bright would be "off"; then to (Z), to (LTS), to (2) on the ammeter, and through the ammeter to (1), to the (-) battery through wire (BAT.) (if the battery is supplying the current), or, if the generator is supplying the current, not through the ammeter but direct through wire (GEN.), to the (-) terminal of the generator.

The other circuits, such as those of the horn, the tail light, and the dash light, can be traced in the same manner, starting with the (+) ground of the battery, if engine is not running, or is running very slow; or at the (+) ground of the generator, if the engine is driving the generator at sufficient speed to charge the battery, at which time all current is taken from the generator. (The starting-motor current, of course, is never taken from the generator.) From the (+) of the generator, or battery, it is then necessary to start with (+) ground of all circuits because the (+) of the battery is grounded. For this reason the (+) of the generator must be grounded, and the "lead" is from (+) to all grounds, back to (-) of battery or generator.

WIRING METHODS

There are three methods for wiring a car: (1) the single-wire, or grounded, return system; (2) the two-wire, or fully insulated, system; (3) the three-wire system.



The single-wire or grounded return system (Fig. 9): One insulated wire is insulated from the frame and is termed the "lead" wire. The frame serves as the return wire. However, when the (+) terminals of the generator and battery are grounded, then the frame serves as the lead. The ground connection from the battery wire or cable to the frame is usually a heavy copper connection which is tightly bolted to a cleaned surface with copper or brass washers on each side. This connection, as well as all other grounded connections, must be clean and secure, so that vibration will not jar it loose. This is the system in general use.

The two-wire, or insulated, system (Fig. 10): In this system, both insulated wires—the lead wires and return wires—are kept away from the frame and from all metal parts of the car.

The three-wire system (Fig. 11): This system consists of three wires, one being known as the "neutral." Note in this illustration that the storage battery is a 6-cell or 12-volt battery and the third wire divides the three cells to a circuit, making 6 volts for each side of the third wire.

It is important that the lights or load be equalized, for if three of the six cells are worked more than the other three, and both sets are charged from the same source and at the same rate, one set would get more charge than the other. When the load is properly balanced, there will be no flow of current through the neutral, which is the reason for so calling it. This system is now seldom used.

Wire Connections

The connections in electric wiring should be soldered. The unsoldered connection may work as well as a soldered connection at the time of being made, but the resistance always increases.

Soldering paste: Do not use acid when soldering electrical apparatus or wiring, as acid is an electrical conductor and destroys the insulation. It is much better to use a non-corrosive soldering paste.

Tape: Do not use friction tape on high-tension wiring or on other wiring where the grease or oil can get to it. It is much better to use linen tape and shellac. Friction tape will not insulate ignition current, neither will it hold when oily. Repairmen often burn the alcohol out of the shellac after coating with it. This causes it to harden, and makes a hard-coated insulation.

When placing a wire terminal under a terminal nut, twist the wire in the direction in which the nut turns, as shown in Fig. 12.

When connecting a wire under a screw or nut, use a brass washer.

Note. When stranded wire is used on any part of a car, sometimes one strand will play loose from the others and cause a short circuit. Always twist and solder the ends of stranded wires. Use wires with different colored insulation when wiring the car; then they can easily be traced.

Starting-Motor and Battery-Cable Connections

Short circuits: Fuses, which will melt on a dead short circuit and open the circuit, are usually provided on all parts of the electric system, except from the battery to the starting motor. The current here is too great for a fuse.

It is plain, therefore, that if the insulated cable (1, Fig. 14) should become frayed and touch the frame or any metal part of the car, a dead short circuit would result. If this were left shorted for several hours, the plates would be likely to become buckled inside of the battery and touch each other and cause an internal short circuit which could not be repaired. A battery is on practically a dead short circuit each time the engine is started, but only for a moment.

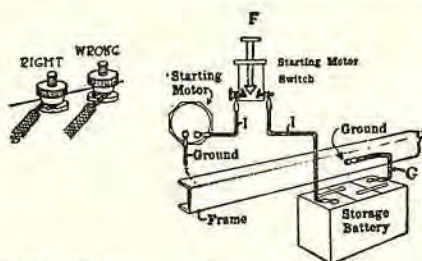


Fig. 12 Fig. 13 Fig. 14 (See text, page 427)

Result of Open Connections between Generator and Battery

Open circuits: If, on the other hand, the ground terminal (G) of the battery to the frame, or the wire from the battery to the generator, in fact all wires in the circuit from the generator to the battery and ground, are not in perfect contact, there will either be a resistance set up which will reduce the charge going to the battery and the discharge from the battery, or a complete open circuit.

If a complete open circuit should exist between generator and battery, especially on a constant-current-regulated generator, such as a third-brush-regulated generator, then this would have the same effect as if the battery were disconnected from the circuit. The result would be that the generator would build up a high-current value at high speeds and burn out the lights and possibly the cut-out winding, and might also damage the field windings.

How to Make Connections

Good connections from generator to battery and battery ground connection are, therefore, very important. The battery ground connection is not only used for the starting-motor circuit, but is used for the generator and all other circuits.

WIRES AND ACCESSORIES FOR LIGHTS, HORN, ETC.

These wires should be protected from oil and dampness and from the frame. There are two methods, either or both of which may be used. One method is to use armored wire (Fig. 15), where the wire remains permanently in the metal armor. The other method is to use a conduit, where it is possible for the wire to be withdrawn.

Conduits (Fig. 16) provide a complete enclosed runway for wires from which they can be withdrawn if necessary and through which new wires can be installed. A conduit affords protection from mechanical injury, such as bruises, etc. The conduit is made of galvanized steel and is flexible. Conduit is now seldom used.

Flexible-steel armored cable is very popular. It can be purchased containing one or more wires. The wire cannot be withdrawn.



Fig. 15

Fig. 16

Fig. 15. Armored cable.

Fig. 16. Showing wires run through metal, flexible tubing or conduit.

The coupling box (Fig. 17) provides a convenient and easily separable means for connecting together the wiring on the chassis and on the car body (seldom used).

The ends of wires or cables should be "tinned" by dipping them in molten solder and then cleaned, and strong copper terminals should then be soldered thereto for attaching to the motor and to the switch. The terminals themselves should also be cleaned before soldering.

If the battery terminals are sulphated with a green corrosion, wash them off, as well as all surrounding parts, with carbonate of soda or some other alkali.

Clean the battery terminals inside with a round file and the terminal itself with a flat file. The acid of the battery tends to corrode the terminals, and after cleaning, a little vaseline will help to prevent this (on the lead terminals and the lugs of the battery).

The ends of wires connecting with the battery are fitted with copper terminals which are lead coated. On the cable leading from the battery to ground on the end of the cable which grounds to the frame, a heavy copper terminal is used. It is important that these lugs be properly scraped, cleaned, and soldered, and that all connections be drawn tight.

The frame, where the ground is made, should be scraped clean, and the connection should be drawn tight with a bolt.

Poor connections at battery terminals, or ground, will often result in slow cranking of the starting motor, in dim lights, and in a weak current supply in general from the battery.

Wiring Troubles

Wiring troubles are numerous if the wiring is not properly done. All connections must be soldered. Oil and grease destroy insulation. Moving parts must not touch wires. Protect wires from chafing. Avoid frayed ends. Tape all connections. Connections and terminals must be kept tight. Vibration often jars them loose.

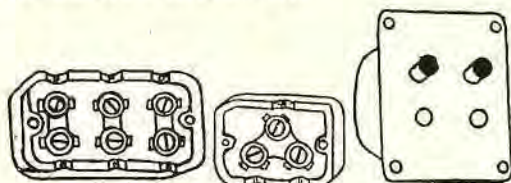


Fig. 17

Fig. 18

Fig. 19

Fig. 17. Coupling box; Fig. 18. Junction box; Fig. 19. Lighting switch.

The junction box (Fig. 18) is for use wherever a branch circuit is tapped off the main wiring. If it is used, no taping of joints is required, and proper connection is assured without soldering. It also affords a junction from which to make tests. (Now seldom used.)

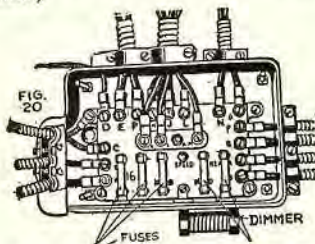


Fig. 20. A junction box, as used on the Studebaker "Big Six" car, is shown in Fig. 20. Note that the fuses are included in the junction box.

Ignition switches are made in many different forms and are usually placed on the cowl (dash) of the car, and are operated with a key. The ignition switch must be "on" when the engine is started.

Starting motor switches are usually operated by the foot. See Index.

Lighting switches are usually placed on the cowl (dash) of the car, and are of the "push-button" type, usually termed "gang" switches as in Fig. 19 (a "two-gang" type), or of the "arm" type (Fig. 20D).

A touring switch is sometimes provided on a car for the purpose of allowing the operator to discontinue the charge from the generator to the storage battery when the car is on a long tour, running mostly during the day.

Delco Combination Switches

There are three types in general use: the "knife-blade type" (Fig. 20A); "drum and spring type" (Fig. 20B); the "finger contact type" (Fig. 20C). Although the appearance may vary, their internal construction and operation in controlling the current from battery or generator, to ignition and lighting circuit is quite similar (see also, page 409 and different Delco wiring diagrams for connections).

A circuit-breaker (see pages 391, 392, 409) is carried on the back of the majority of switches.

Switch lock: A Yale or Sargent lock is provided which locks the switch levers I and L (Fig. 20D).

Switch levers (I) and (L) are shown as a front view in Fig. 20D. These levers move the parts marked (I) and (L) in Figs. 20A, B, C; (I) being the ignition switch lever and (L) for lights.

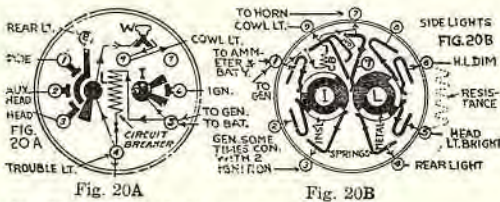


Fig. 20A. Delco "knife-type" switch.

Fig. 20B. Delco "drum and spring-type" switch (both "off").

Points to bear in mind when tracing switch connections: First start with the source of current. In Fig. 20A, this is at (5), thence to (1). If (I) is turned to the right, the current would then flow from (5) to (6), to ignition.

Note that current flows from (5) through circuit-breaker, to (L), thence to a separate switch (W) for the dash or cowl light. If (L) is turned clockwise (note that there are three positions, 3, 2, 1), then the different light circuits are "on."

In Fig. 20B the source of current is at (1), thence to (1, black metal part). If I is turned clockwise, this would connect (1) with ignition (3).

Note that current flows from (1) through circuit-breaker (CB) to (7) and (9) which are the horn and cowl light, which have separate switches; (S) is switch for cowl light (9) and a push button on the steering column is for the horn. Also note that current flows from (1) through circuit-breaker, to (L) at all times. If (L) is turned to first position counter-clockwise this would connect (1) with (4) and (5). If turned to the second position this would connect (1) with (4) and (6). If turned to third position it would connect (1) with (4) and (8).

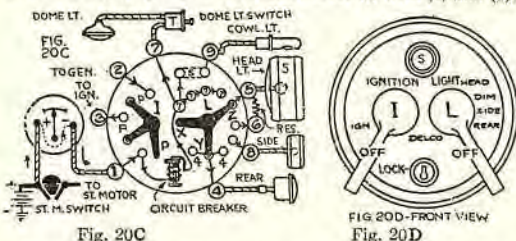


Fig. 20C

Fig. 20D-FRONT VIEW

Fig. 20C. Delco "finger-contact type" switch. Interior view from seat.

Fig. 20D. Front view of 20C showing ignition switch lever (I) and light switch lever (L). (I) moves to left and turns (I) (Fig. 20C). (L) moves to the right and turns (L) (Fig. 20C), in a counter-clockwise direction. (This is the Buick model switch.)

In Fig. 20C, the source of current is at (1); note that on almost all wiring systems the ammeter is between battery and

switch; also that in almost all instances the lead wire from battery to ammeter and switch is invariably connected to the battery side of the starting motor switch.

If (I) is turned to the left, the fingers (P) would connect with (1), (3), and (2); thus the battery would supply current for ignition (3) and for motorizing generator (2) to start, and after starting, the generator (2) would supply current and charge the battery, and the ammeter would of course read in the opposite direction.

Note that current flows from battery at (1) through circuit-breaker to (7), to dome and (9) cowl light which have separate switches (S) and (T).

If (L) is turned to the right, the connections are as follows:

First position, finger (Z) will then connect to (7) for current supply, and (Y) with (4); thus the rear light is on.

Second position, (Z) to (7), (Y) to (8) (side lights) and (X) to (4) (rear light).

Third position, (Z) to (7), (Y) to (6) (dim head lights) and (X) to (4) (rear light).

Fourth position, (Z) to (7), (Y) to (5) (bright head lights) and (X) to (4) (rear light).

Fuses

Fuses are used on many systems, particularly when the "grounded" or "single-wire system" is used. The purpose of a fuse is to melt and open the circuit in case of a short circuit, and thus to prevent discharge of the battery.

A fuse is never placed in the circuit between battery and starting motor, as the current consumption is too great.

Note. When a fuse "blows," it should not be replaced with a new one until the cause of its blowing (usually a short circuit or overload) is found.

Fuse wires are made in different diameters. The fuse is made of lead alloy and will melt at a given temperature.

If a lighting circuit required 10 amperes of current, then a 15-ampere fuse would be placed in the circuit. Therefore current up to 15 amperes could pass safely; but if more attempted to pass, which would naturally be the result if a short circuit existed, the fuse would melt and open the circuit.

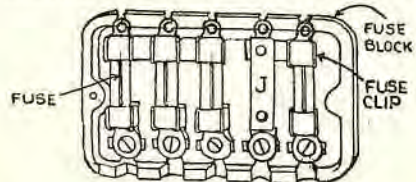


Fig. 21. Fuse block.

Fuse blocks (Fig. 21) are usually placed inside of the cowl (dash), under the hood of the engine, or in the form shown in Fig. 22, which is placed on the cowl, and to which the different wires of different circuits are connected.

The fuse is placed in series with the circuit. If a fuse melts, or "blows," it is then an easy matter to insert another fuse, of which extras should be carried. Extra fuses are usually carried in a fuse clip on the fuse block provided for the purpose, and to which there are no wires connected.

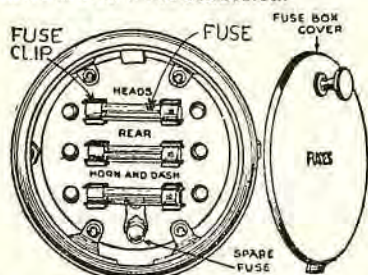
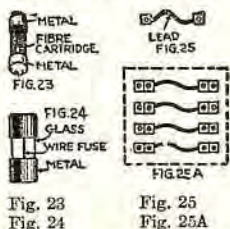


Fig. 22. Fuse box (round type) used on the Studebaker "EJ." It is placed on the cowl and contains three fuses: one for the headlights, one for the tail light, and one for the horn, and the dash lamp. It is also arranged to hold one spare fuse.

There are three types of fuses: (1) The cartridge, or enclosed type (Fig. 23) which consists of a fiber tube with the fuse enclosed, and which connects with



the metal ends. The metal ends are then slipped into the metal fuse clips which should make good contact. With this type of fuse, when it blows, a hole is usually blown in the thin fiber shell.

(2) The visible type (Fig. 24) is the type most used. The fuse is enclosed in a small glass tube, and connects with metal ends which are slipped into the fuse clips.

(3) The open type (Fig. 25) is seldom used. The fuse block to accommodate this type is shown in Fig. 25A. A screwdriver is necessary to connect or to disconnect a fuse of this type.

Capacity of Fuses

The size of fuse to use is determined by the amount of current that is to pass through it. If the fuse is to be placed in the headlight circuit and $5\frac{1}{2}$ amperes are required, then a 10-ampere fuse would be ample protection.

On an average, a fuse of about 10-ampere capacity is used in the ignition circuit, if one is used in this circuit at all, which is seldom.

Fuses in the lighting circuit are used on almost all cars, unless a circuit-breaker is used instead, as on the Delco systems. The capacity for headlight fuses is 15 to 20 amperes. The tail-light fuse is usually of a 5-ampere capacity, and the horn circuit of a 15-ampere capacity.

On many cars where fuse blocks are used, it will be found that, although there are fuse clips provided for fuses, a "jumper" (J) (Fig. 21) of copper wire is placed in the clips instead of fuses, in all circuits except the horn and lighting circuits.

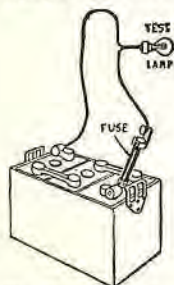


Fig. 26. Testing a fuse.

Testing a Fuse

The enclosed type of fuse, if suspected of being blown, or the visible type, if connection of the fuse with the metal part is suspected of being loose, can be tested with a test light (2 c.p.), and battery, as in Fig. 26. If the fuse is blown or the connection is loose, the light will not light, as the circuit is open.

Fuse Clip Connections

The importance of good contact and clean fuse clips is very great. If the clips are corroded, or if the fuse is not making good contact in the fuse clips, resistance will be offered to the flow of current.

Fuse Between Generator and Battery

If a complete open circuit should exist between fuse clip and fuse, and this fuse should be in series with the main charging circuit, between the generator and battery, this would have the same effect as

disconnecting the battery from the generator.¹ And if the generator regulation was by means of a third brush, the result would be, at high speeds of the generator, that the generator would build up a high value and burn out the lamps and possibly the cut-out voltage winding and shunt-field windings, if the generator was run for a long period of time at a high speed. Thus the importance of occasionally examining the fuse clips to see if they are clean and if they retain tight connection, must not be forgotten.

If a fuse should blow in the "main charging circuit," between generator and battery, the same result would probably occur. For this reason the fuse is omitted in the main charging circuit on many of the electric systems using a third-brush regulated generator, unless there is a fuse in the "field-circuit" of the generator.

Shunt-Field Fuse

On almost all third-brush regulated generators, a fuse is placed in the "shunt-field circuit" of the generator, in order to protect the generator in case an open circuit occurs in the "main charging circuit."

In other words, if an open circuit¹ should occur in the "main charging circuit" when the generator was running at high speeds, the generator would build up a much higher output than normal. If a fuse is placed in the "shunt-field circuit," then the fuse will "blow" and open the "shunt-field circuit," thus preventing the generator from reaching an abnormal value—providing the "shunt-field fuse" is of the proper capacity. If the fuse should be of a much higher value than required, it would not blow in time to prevent the generator building up, and the lights would be burned out. Hence the importance of using the correct capacity of fuse in the generator "shunt-field winding," and a fuse of a large enough capacity, or none at all, in the "main charging circuit." As already stated, a fuse is seldom placed in the main charging circuit from the generator to the battery where a third-brush regulation system is used, and seldom in the ignition circuit. See Fig. 8, page 426.

Thermostat Resistance

A thermostat resistance (pages 362, 363) is also used to protect the generator field winding in case the battery becomes disconnected when the generator is in operation. The excessive current forced through the field winding causes the temperature of the generator to rise rapidly, opening the thermostat in a very short while, and this excessive current burns out the resistance, thus opening the field circuit and preventing the generator from producing current. After the generator cools down, the thermostat points (X) (Fig. 37, page 362) close and the generator will deliver current again until a temperature is reached where they open, at which time no current is delivered. If resistance (R) is burned out, it should be replaced as soon as possible to prevent burning of contacts when they separate.

Delco Circuit-Breaker

A circuit-breaker is used on Delco electric systems in place of fuses. This device opens the circuit when the current is above normal, as, for example, when a short circuit occurs. The circuit-breaker is not placed in the generator "main charging circuit," however, but is usually placed in series with the lighting or horn circuit. See Index, "Delco circuit-breaker."

Westinghouse Compensator

A small cylindrically wound resistance unit is sometimes incorporated with the fuse block in some of the Westinghouse systems, and is termed a "compensator" or "ballast-resistor." Its purpose is to protect the side lights from over-voltage, when the headlights are not lighted.

¹Loose or corroded battery terminals are often the cause of an open circuit in the charging circuit, and if there is no shunt field-fuse the generator would build up and burn out the lights. A short circuit would also cause the fuse to blow.

SWITCHES

These pages, 430A, B, C and D are added to point out to the reader briefly, the development in switches now being generally used on cars since the preceding pages were prepared.

Lighting switches on most all present-day cars are mounted on the lower end of the steering gear and operated by a lever in the center of the steering wheel. See wiring diagram, page 424B.

In this example the switch has four positions, and from left to right are: parking, off, dim, bright. The parking position lights the cowl lamps and tail lamp. The dim position lights the headlamp upper filament (lower beam) and tail lamp. The bright position lights the headlamp lower filament (upper beam) and tail lamp.

Signal-lamp switch is usually mounted underneath the car and actuated by a rod connected with the brake pedal. See Fig. 26A. The signal-lamp should light when brake pedal is depressed about one or two inches.

Note: On some cars the combination of a signal-lamp, backing-lamp and tail-lamp are mounted in one unit at the rear. The signal-lamp and backing-lamp operate when the foot-brake pedal is applied and also when the gear-shift lever is placed in reverse position. The steering column lighting switch usually controls the tail-lamp and license plate lenses. Some cars are equipped with two tail-lamps, one on each side, in which there are two lamp bulbs, one for the tail-lamp and one for the signal-lamp.

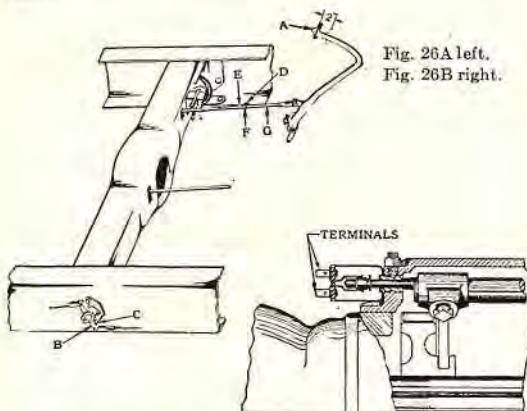


Fig. 26A left.
Fig. 26B right.

Backing-lamp switch, for example, on the Buick 8-60, 8-80 and 8-90 is mounted on the rear of the transmission cover. A vellumoid gasket is placed between the switch housing and transmission cover

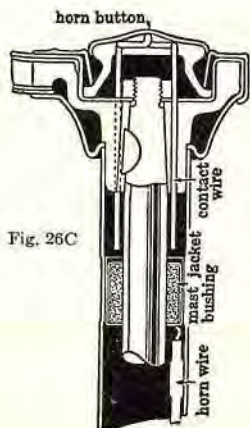


Fig. 26C

to prevent oil leaks. The back-up switch is connected in parallel with the signal switch so that both the signal and back-up lights are provided when the gear-shift lever is placed in reverse position. See Fig. 26B:

Horn switches are usually placed on the top of the steering column. As an example, Fig. 26C illustrates the horn button connections on the Chevrolet "AD." Pressing the horn button closes the circuit, the horn button contact wire making the electrical contact against the mast jacket bushing, the lower end of which is connected to the horn wire.

The ignition switch on many cars is of the switch-lock type. On some cars the ignition switch is in combination with the steering gear, or transmission lock.

The ignition switch is provided with a key lock built into the ignition coil, or separated from the coil in such a way that it is impossible to short-circuit the switch without short-circuiting the coil also. Examples of this type of switch follow.

The Ignition Switch Lock

As an example, the Electrolock, types 9-A, 9-B, 5-A and 5-B, are used to explain the principle of operation.

Description and operation of the type 9-A and 9-B: The Electrolock is a coincidental ignition switch lock approved by the Underwriters' Laboratories. When the key-way is in a vertical position, the ignition is shut off, and the car locked. To unlock, turn key $\frac{1}{4}$ turn to right, which closes the ignition switch. The key is not required to lock the car, and should be removed after the operation of unlocking is completed. To lock, turn locking cylinder back with the handle so that the key-way is in a vertical position, after which try the handle to be sure that it cannot be turned to the unlocked position.

When the cylinder is in a locked position the ignition circuit is not only broken, but also grounded. Mechanical protection to the wire between the Electrolock and the timer-distributor is accomplished by enclosing this wire in a steel cable. The cable is attached to the distributor in such a way that it is difficult to remove. The grounding of the ignition switch takes place both through the lock casing and through the attachment at the distributor.

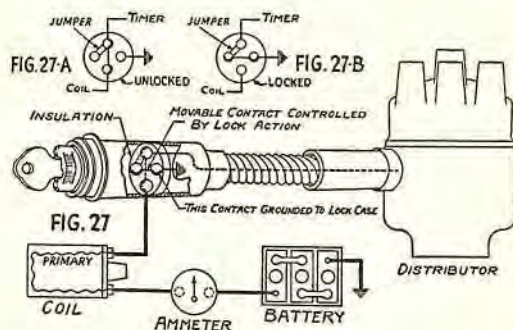


Fig. 27. Type 9-A Electrolock wiring diagram with one terminal on the side of the lock case. Fig. 27-A shows the switch in the unlocked position and Fig. 27-B, in the locked position.

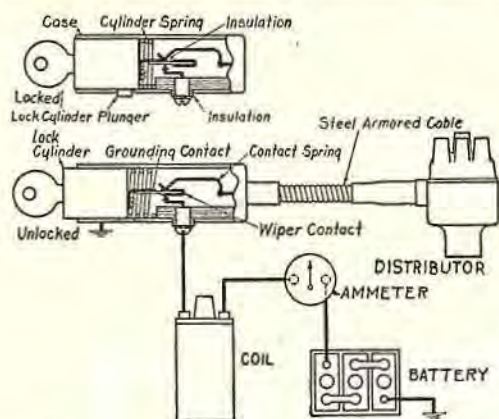


Fig. 29. Type 5-A Electrolock wiring diagram with one terminal on the side of the lock case. Lower illustration shows the switch in the unlocked position; upper illustration in locked position.

The type B is similar to type A, except it employs a switch mechanism which provides a double break required by a different wiring circuit, which is necessary when the car is equipped with an electric gasoline gauge operated from the ignition switch. The circuit can be traced in the same manner as in Fig. 28, starting at the + terminal of battery.

Tests for 5-A lock are practically the same as the 9-A test, except the following: Should the tests (first and second tests) indicate some trouble in the Electrolock switch, the lock should then be unlocked and removed from the mounting. The wire should then be disconnected from the terminal. The lock cylinder then can be removed by taking out the small set screw on the side of the lock casing. Remove the coil spring which is directly behind the lock cylinder and pull out the metal wedge which holds the bakelite terminal block in position. With the terminal screws removed, that part of the bakelite piece in which the terminal screws are located can be pushed into the lock casing and the lock casing can then be slid back on the cable, allowing the switch to be inspected.

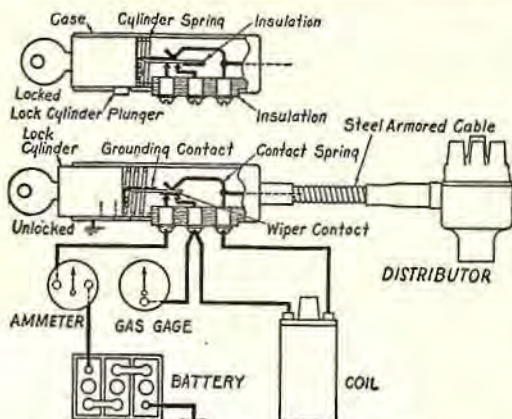


Fig. 30. Type 5-B Electrolock wiring diagram with three terminals on the side of the lock case. Lower illustration shows the switch in the unlocked position; upper illustration in locked position.

Tests for 5-B lock are practically the same as the 9-B test, except the following:

Second test: Place one test point on the insulated terminal inside the distributor as in the first test and the other test point on the No. 2 terminal on the switch. Unlock the switch, push the lock barrel in about half way and release it. The light should not burn or flash in, thus operating the lock barrel.

Third test: Place one test point on the No. 3 terminal, and the other test point on the lock casing. With the switch locked, the lamp should burn. With the switch unlocked the lamp should not burn. If the lamp burns either there is a ground in Electrolock or the distributor condenser is shorted or grounded. It will be necessary to disconnect condenser from distributor to determine whether the trouble is in Electrolock or condenser.

If the above tests show up satisfactorily and there is still ignition trouble evident, this ignition trouble must be located elsewhere in the ignition circuit.

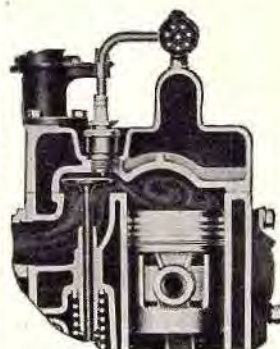
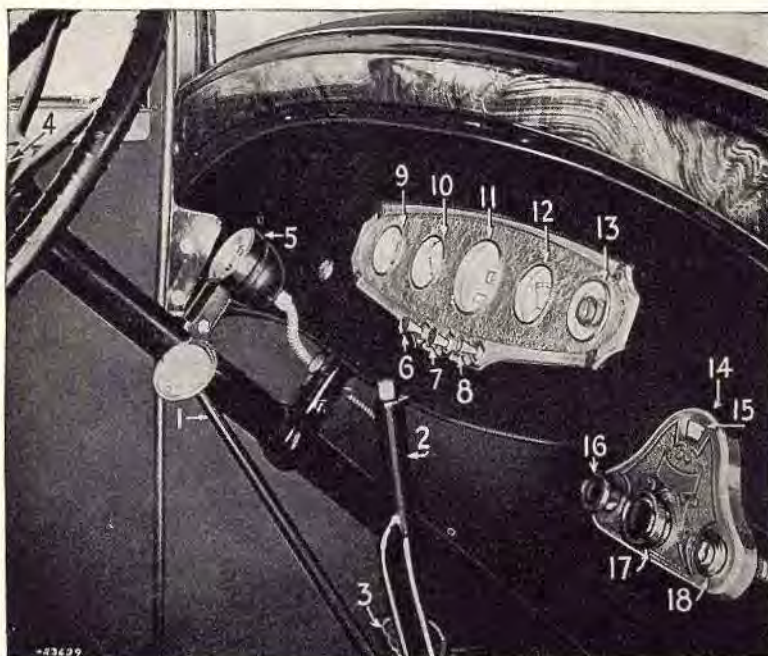
Should the tests indicate trouble in the Electrolock it should be unlocked and removed from the mounting, wires disconnected from the terminals and lock cylinder removed as explained under 5-B above. The Electrolock is manufactured by Mitchell Specialty Co., Holmesburg, Philadelphia, Pa.)

RADIO FOR AUTOMOBILES

Radio receiving equipment for automobiles is a desirable accessory and has reached a stage of perfection where it is reliable and efficient. The outfits being offered are compact and easily installed, usually under the cowl or hood out of sight. The control assembly is conveniently located on the instrument panel. The speaker is located to give best reception. The aerial is arranged so that reception is not affected by the direction in which the car may be traveling. Many automobile manufacturers are installing aerial wires (usually in the roof of car) as standard factory equipment. The

current is taken from the automobile storage battery

Ignition interference is overcome by shielding, thus grounding the static from the high-tension leads, which improves reception while engine is running.



The engine on all models of Marmon cars mentioned below is of the L-head, eight-in-line cylinder type. The double-dome high turbulence combustion chamber providing high compression without detonation is shown above. The compression ratio is 5.5 to 1 on all models except the "Eight-69" which is 5.25. See specifications on pages 1055-1062 for other engines.

As an example of a car equipped with radio receiving equipment the Marmon "Roosevelt" is shown above. Note the radio control assembly (16) on the instrument panel. Radio receiving equipment is available for installation on each of the four models of Marmon cars: "Eight-69," "Eight-79," "Roosevelt" and "Big Eight."

The driving compartment of the Marmon "Roosevelt" is also shown in the illustration above. The gear shift is the S.A.E. standard, three-speeds forward and one reverse (also on the 69, 79 and Roosevelt). The "Big Eight" has four-speeds forward and one reverse, termed a four-range transmission-direct drive in fourth speed. Silent internal gear drive in third insures super-acceleration. Second gear used for starting under all normal driving conditions. First speed for extreme road conditions. Three-speed or four-speed (the latter at extra cost) is optional on the "Eight-79."

Names of parts shown in above illustration are: 1, gear-shift lever; 2, hand-brake lever; 3, clutch pedal (the foot-brake pedal is to the right of clutch pedal, as is also the accelerator pedal, both of which are not shown); 4, center of steering wheel spider. The lights, horn and starter are all operated by the button in the center of the steering wheel. Turning the button to the right operates the various lights. Pressure on this button operates the horn and, by pulling out on same, operates the starting motor. The switch assembly is at the base of the steering device: 5, heat indicator; 6, choke; 7, spark (pulling this out retards the timer-distributor); 8, hand throttle control; 9, ammeter; 10, oil pressure gauge; 11, speedometer; 12, gasoline gauge (electric); 13, ignition lock switch of the Electrolock make; 14, radio control assembly; 15, radio dial; 16, radio volume control; 17, radio station selector control; 18, radio lock on switch.

INSTRUCTION No. 38

LIGHTING A CAR: Electric Lighting; Gas Lighting; Oil Lighting

LIGHTING METHODS

There are three methods for lighting a car: By acetylene gas, by electricity, and by kerosene oil.

The gas light can be produced from carbide in a "generator," or it can be stored in a "gas tank" and carried on the car.

Electric lights are supplied with electricity from a storage battery. When the storage battery runs down, it can be recharged from an outside source, or from a dynamo, run from the engine.

The old-style "carbon filament" in the electric

globe consumed so much current that it was difficult to obtain a storage battery of a reasonable size and weight which would supply current for any length of time. The carbon filament lamp used a filament chemically treated and in a vacuum. The gas-filled lamp increases brilliancy and uses less current and is now the approved type.

Lights on the car may be divided into those which are required by law, namely: head, parking, tail and signal lamps and those which add to convenience and comfort.

AUTOMOBILE ELECTRIC LIGHTING SYSTEMS

There are three methods of furnishing electric current for car lighting:

- (1) By independent storage battery system.
- (2) By the generator and battery system.
- (3) By an independent generator system.

(1) Where an independent storage battery system is used, the capacity of the battery must be great enough to run the headlamps and rear lamps for a reasonable time before the battery has to be recharged.

A current consumption of approximately 7.85 amperes is required for headlamps and for rear and dash lamps, the equipment of the average car.

A 100-ampere-hour lighting battery would run these lights for about twelve hours of steady burning. Under average conditions this would mean that the battery would have to be recharged about once a week. A 120 or 150-ampere-hour battery will not cost much more than a 100-ampere hour and will give longer service.

(2) Generator and battery system: The advantage of this system is that it automatically keeps the battery charged, and permits more current to be used for lighting without danger of running down the battery while on the road. This is the method now generally used. The generator is driven by the engine and charges the battery. The battery supplies electric current for the starting motor, ignition for starting, and also for lights, if the generator is not charging the battery. In such a case, current is supplied for ignition and for lights by the generator.

(3) Independent generator system: The Ford Model "T" for example: The generator delivers alternating current which is used for both lighting and ignition. The battery cannot be charged with alternating current, and on this account the lights can be run only when the generator is running. Thus the strength of the light varies with the speed of the engine unless some type of regulator is installed.

Another type of magneto which, if run fast enough, will light electric lamps, is the inductor type of magneto, shown in Fig. 12, page 246. The "shuttle" type of armature magneto will not light lamps.

Nomenclature for Automobile Lamps¹

Head-lamp.—A lighting unit on the front of a vehicle intended primarily to illuminate the road ahead of the vehicle.

NOTE: Since this instruction was written many improvements have been made, such as, *prefocused lamp bulbs* which eliminate adjusting the focus; instead the headlamp itself (or the reflector) is moved to properly "aim" the light beams. A foot switch is used to shift to "passing" beams. The asymmetrical type headlamps which came into general use in 1938, applies to light beams that are not parallel to each other—not symmetrical, for example, one system provides that the beam from the left lamp projects or "toes-in" toward the right side of the road, and the beam from the right lamp projects slightly toward the left side of the road. The latter is depressed on passing to minimize glare. The sealed beam headlight system came into general use in 1940. With this system, the reflector, lens and light source are hermetically sealed as an assembled unit. When the filament burns out the whole unit is replaced. The life is said to be approximately two years of average driving service. The lamp provides two beams; the "traffic beam" rated at 30 watt and "country beam," rated at 40 watt. A foot switch is used to select either. There are no focussing adjustments as the light source is precision focussed at the factory. The only adjustment is to assure correct aiming of the beam. By removing the headlamp door rim two adjustment screws are accessible from the front of the lamp. One screw is for lateral and the other for vertical adjustment. The headlight relay is another development now in general use. See footnote 5, p. 555, also "Lighting," p. 690.

Side-lamps.²—A lighting unit mounted on either side of a vehicle and intended primarily as a marker to indicate the location of the vehicle.

Tail-lamp.—A lighting unit used to indicate the rear end of a vehicle by means of a ruby light.

Backing-lamp.—A lighting unit mounted on the rear end of a vehicle and intended to illuminate the road to the rear.

Spot-lamp.—A lighting unit, mounted on a manually operated adjustable bracket which has one focusing type reflector and one focusing type light source.

Instrument-lamp.—A lighting unit mounted on the instrument board and intended to illuminate the instruments.

Dome-lamp.—An interior lighting unit mounted in the top of a vehicle.

Panel-lamp.—A lighting unit mounted either in the rear panel or in the corners of a closed vehicle.

Tonneau-lamp.—A lighting unit mounted in the back of the front seat in open or closed vehicles.

Signal-lamp.—A device used to indicate the intention of the operator of a motor-vehicle to diminish speed, stop, or change direction.³ A stop-signal indication shall be either red or amber, etc. (extracts from S.A.E. Specifications for laboratory tests of optical characteristics of electric signal lamps for motor-vehicles).

Step-lamp.—A lighting unit mounted on the exterior of a vehicle and intended primarily to illuminate the step or running-board.

Hood-lamp.—A lighting unit mounted under the hood of a vehicle to illuminate the engine compartment.

Inspection-lamp.—A portable lighting unit connected by an extension cord to the lighting system of a vehicle

Electric incandescent lamp bulbs of 21 cp. (gas-filled) are commonly used for head-lamps; 15 or 21 cp. for the signal-lamp and backing-lamp; 6 cp. for dome-lamp; 3 cp. for tail-lamp, side-lamps, instrument-lamps, panel-lamp, tonneau-lamp and step-lamp. The selection of candle powers, aside from the head-lamps, rests largely with each car manufacturer. The nominal voltage of electric incandescent lamps is usually 6-8, and in some instances 12-16.

The tail-lamp and instrument-lamp are sometimes connected in series. If tail-lamp should burn out, the instrument-lamp would not burn, and vice versa. The law requires that the tail-lamp burn during the night. Since it is impossible to tell from the seat if the tail-lamp should fail, this method is used. The voltage is just one-half of that of the regular lighting circuit when connected in series. A lens giving a white light to illuminate license number is usually provided on tail-lamp.

It is advisable to use the best grade of lamp, of as low a candle power, and with as few lights as possible, if the battery does not get sufficient charging from the generator.

¹ From S.A.E. Handbook, 1930. ² Head-lamps may be divided into three general types: single-socket, a lamp having one focusing type reflector and one focusing type light source; two-socket, a lamp having one focusing type reflector and one focusing type and one auxiliary light sources; and duplex, a lamp having two focusing type reflectors and two focusing type light sources. ³ Side-lamps cover such types as are generally known as bullet, cow, fender or parking, pillar or windshield lamps.

Candlepower, Voltage, and Amperage of Electric Lamps

The candle power of a lamp is expressed as c.p. Although we speak of a lamp as being 21 c.p., we really refer to the spherical c.p. This means that 21 c.p. is sent out in every direction.

A reflector does not increase the brilliancy of the light from the filament. It simply takes the total amount of light which is thrown in all directions, and concentrates it in one direction (see Figs. 20 and 21, page 436). For instance, with a "spreading beam," the brilliancy is not as intense as from a "straight beam" (see page 436).

The voltage is usually that of the battery, but quite often, to save the lamp from burning out, a lamp of one or two volts higher is used. For instance, if a 6-volt lamp is used on a lighting circuit using a 6-volt battery, the light would be bright as long as the battery was fully charged. If a generator is used to charge the battery and supply current for the lights when the car is running over 10 or 15 m.p.h., then the probabilities are that the generator would develop a slightly higher voltage than the battery. The result would be that the higher voltage would increase the brilliancy of the lamps and cause them to burn out quicker than if the voltage was the same as or less than that of the lamp. For this reason lamps of a voltage of, say, 1 or 2 volts higher than the battery voltage are used.

The amperage, or quantity of current consumed, is governed by the candle power of the lamp—the c.p. averages from 2 to 32. The higher the candle power, the more voluminous is the light—if voltage or pressure is in accordance with that of the lamp—therefore the higher the c.p., the more current or amperes consumed per hour.

Watts: If you multiply the volts by the amperes the result is expressed in "watts." For instance: 6 volts multiplied by 2 amperes gives 12 watts (there are 746 watts to a horsepower).

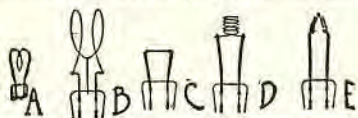
Automobile Electric Lamp Bulbs

Two types of lamps are used for car lighting: the vacuum type, usually known as Mazda B, and the nitrogen-gas-filled lamp, known as the Mazda C.

The vacuum lamp uses a "Tungsten" filament instead of a "carbon" filament. The carbon filament lamp requires more current and is now seldom used. The air is withdrawn from the bulb of a vacuum lamp, hence a vacuum.

The gas-filled lamp also uses a Tungsten filament, but the bulb is treated with nitrogen gas which increases the brilliancy by increasing the heating intensity of the filament.

The source of light is the fine wire at the center of the lamp bulb, known as the "filament." The current heats this wire white hot. If a bulb was designed for 6 volts, and the circuit was 12 volts, then this wire would become so white it would burn up. If designed for 12 volts and the circuit was 6 volts, the filament would be yellow and dim.



Filaments of lamps are made in different shapes: (A) is the type used for house lighting, and is not suitable for automobile use on account of vibration. (B) is an old type, and (C) is the present type used

for rear, speedometer, side, and auxiliary lights, as the Mazda B, 62, 63, 64, 81 and 82. This lamp does not require focusing. (D) is a type used for headlight lamps, as Mazda B type lamps. (E) is of the V-type construction, and is the type of filament as that shown in the Mazda C lamps. All bulbs for headlight lamps must be focused.

Mazda B lamps usually have this wire or "filament" made up in the form of a spiral about $3/16$ " long, and $1/8$ " in diameter. This gives a uniform distribution of light all around the spiral.

Mazda C lamps usually have the filament made up in the form of an inverted "V." In most types of C lamps the V is about $1/8$ " high and about the same distance across the base. Some makers of type C lamps make the V about $3/16$ " long and $1/8$ " across the base. This form gives a much better distribution of light than the short V.

The voltage lamp to use depends upon the voltage of the system. If you do not know this, count the cells of the storage battery. Each cell gives 2 volts.

Use of the Mazda B and C Lamps

The Mazda B lamp is designed for all lights, such as rear, side, and headlights. It is made in 6 to 8-volt, 12 to 16-volt, and 18 to 24-volt.

The Mazda C lamp is designed for headlight lamps and spot lights, and is made in 6 to 8-volt, 12 to 16-volt, and 18 to 24-volt.

The candle power of these lamps is given in tables farther on.

The Mazda C lamp is brighter and gives more c.p. for the same amperage consumption. Not only is a gain realized initially, but the advantage increases throughout the life of the lamp, for the candle-power of a gas-filled or Mazda C lamp is maintained close to the initial value, whereas the vacuum or Mazda B lamp gradually blackens.

Note. As the lamps become older, the current consumption increases. If the glass of the lamp bulb is blackened or the filament bends down, and if less than its rated c.p. is being used, it will be best to replace the lamp bulbs.

In order to tell what class of base of lamp bulb is required on a car: If the wiring of the car is a single-wire grounded system, then an "SC" base is required. If the wiring is a two-wire system, a "DC" base is required. (See page 1055, giving type lamp bulbs used on different cars.)

To ascertain the voltage: Count the cells of the storage battery. If there are 3 cells, a 6-volt lamp is required; if 6 cells, a 12-volt lamp is required. Each cell is counted as 2 volts. The candlepower of an incandescent lamp varies materially with the voltage applied. Increasing the candlepower by operating the lamp above its normal or rated voltage, however, reduces the life materially.

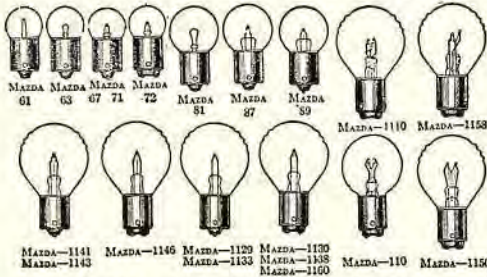
To determine the candle power to use: First determine the voltage. Then refer to the tables on next page. For instance, if there are three cells to the battery, then the voltage is 6 volts; refer to the table "6-8 volts." If six cells, the voltage is 12-volts; refer to table "12-16 volts" (see page 434 explaining).

Refer to table on next page and note that head lamp and spot lamp bulbs are all Mazda C and are 21 and 32 c.p.

Rear, instrument and step lamp bulbs are Mazda B and are 3 c.p. Side and auxiliary head lamp bulbs are both of the B and C type and are 3 and 12 c.p. Dome and panel lamps are of the B and C type and are 6 c.p. If rear and instrument lamp are in series, they are 3 volts (see Nos. 61 and 62). Double filament lamps are Nos. 1158 used on the Ford and 1110 used on Cadillac, Buick, etc. (see next page).

Mazda Automobile Lamps

How to read tables: There are four tables shown below. See heading above each, which gives the subject. Next, read sub-headings above each column. Where abbreviations appear in some of the columns, the meaning is given under each table. The meaning of other abbreviations is also given on page 434.



Lamp bases: All odd numbers denote a single contact (SC) bayonet base, and all even numbers denote a double contact (DC) bayonet base.

The corrugated glass bulb is now used on head lamps for the purpose of breaking up filament secondary reflections. The plain glass bulb is used on tail, side, and instrument lamps. The illustrations are approximately one-fourth actual size.

Voltage: Practically all cars now use 6-8 volts with SC base except the Ford. The Ford uses 6-8 volts in the battery circuit and 18-24 in magneto circuit. The 1158 head lamp used on Fords has a DC base. The Dodge and Stearns-Knight use 12 volts in the lighting circuit. See page 1055 for the numbers of lamps used on different makes of cars.

Mazda Lamps for Automobile Service
(Excluding Lamps for Ford Cars)

Mazda Lamp Number	(a) Position	Mazda B or C	Bulb	Volts	Candle-power	Amps.
★ 61	R-I	B	G-6	3-4	2	0.84
62						
★ 63	R-I-St	B	G-6	6-8	3	0.80
★ 64						
★ 67	R-I-St	B	G-6	12-16	3	0.5
68						
71	R-I	B	G-6	18-24	3	0.2
72						
★ 81	D-P	C	G-8	6-8	6	1.2
82						
87	Si-A	C	G-8	6-8	12	
88						
89	D-P	B	G-8	12-16	6	0.86
90						
1110	H	C	S-11	6-8	{ 21 21 }	2.81
★ 1129	H-Sp	C	S-11	6-8	21	2.81
★ 1130						
1133	H-Sp	C	S-11	6-8	32	4.16
1134						
★ 1141	H-Sp	C	S-11	12-16	21	1.16
★ 1142						
1143	H-Sp	C	S-11	12-16	32	1.77
1144						

★ Represents over 90% of the demand.

- (a) H—Head Lamp.
R—Rear Lamp.
Sp—Spot Lamp.
Si—Side Lamp.
St—Step Lamp.
Se—Side Car.
A—Auxiliary Head Lamp.
I—Instrument Lamp.
D—Dome Lamp.
P—Panel Lamp.

Mazda Lamps for Automobile Service
(For Ford Cars)

Mazda Lamp Number	(a) Position	Mazda B or C	Bulb	Volts	Candle-power	Amps.
★(b) 63	R-I-A	B	G-6	6-8	3	0.6
(c) 72	R	B	G-6	18-24	3	0.2
★(b) 1129	H	C	S-11	6-8	21	2.81
★(d) 1130						
(c) 1138	H	C	S-11	9	27	2.14
(c) 1146	Sp	C	S-11	18-24	27	0.98
★b } 1158	H	C	S-11	6-8	{ 21 2 }	{ 2.81 0.47 }
★f }						
★(e) 1160	H	C	S-11	9	21	

★ Represents over 90% of the demand. See bottom of left column for meaning of abbreviations.

- (b) For cars equipped with 3-cell (lead type) storage battery-generator lighting system.
(c) For use on magneto lighting system.
(d) To insure satisfactory service, Mazda 1130 should be operated two in series on magneto lighting system equipped with reactance coil.
(e) To be burned two in series on magneto lighting system not equipped with reactance coil.
(f) For use on Ford and other cars wired for two filament lamps.
Note: A reactance or dimmer coil (Ford No. 8892) sells for 50 c. It is used with two 6-8 volt bulbs in series. Better results are obtained by using two 9-volt lamps in series.

Mazda Lamps for Motorcoach Service

Mazda Lamp Number	(a) Position	Mazda B or C	Bulb	Volts	Candle-power
★ 67	(b)	B	G-6	12-16	3
89	(c)	B	G-8	12-16	6
★ 1141	(d)	C	S-11	12-16	21
★ 1142	(e)	C	S-11	12-16	21

★ Represents over 90% of the demand.

- (b) Tail, Instrument, Side, Running or Marker, Fare Box, Signal Indicator.
(c) Auxiliary Head, Sign.
(d) Head, Signal, Spot, Backing, Trouble, Step.
(e) Interior, Spot.

Mazda Lamps for Motorcycle Service

Number	(a) Position	Mazda B or C	Bulb	Volts	Candle-power
★ 63	A-R	B	G-6	6-8	3
★ 64	SC	B	G-6	6-8	3
★ 1129	H-Sp	C	S-11	6-8	21
★ 1130	Sp	C	S-11	6-8	21

★ Represents over 90% of the demand. See bottom of left column for meaning of abbreviations.

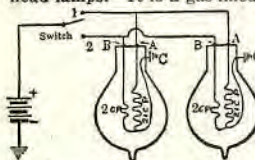
Double-Filament Mazda Head Lamps

The purpose of this lamp is to dispense with two lamps in the head lamps, and thus do away with the separate "dimmer," or auxiliary head lamp.

The No. 1158 double filament lamp is used on Ford cars for head lamps. It is a gas-filled Mazda C built in the S11 type bulb. It has a corrugated glass bulb and is a 6-8 volt lamp.

One filament is 2 c.p. serving as a "dimmer" light, and the other is 21 c.p. serving as a bright head lamp. It has a DC base. Both filaments pass through the focal area of the reflector. (This type lamp is also made special with 21 c.p. and 6 c.p.; also 32 c.p. and 6 c.p. filament and with a D.C. base.)

Circuit diagram is shown in Fig. 6, an explanation being as follows: Two wires are used for connecting to the lamp socket from switches. (A) and (B) are terminals of the base and are insulated; (C) is grounded.



When the 2 c.p. filament is used, the circuit is through (B) insulated, and (C) grounded, and the switch is connected on terminal 2.

When the 21 c.p. filament is used, the circuit is through (A) insulated, and (C) grounded, and the switch is connected on terminal 1.

The No. 1110 double filament lamp is used on several popular makes of cars for head lamps. It is a gas-filled Mazda C built in the S11 type bulb. It has a corrugated glass bulb and is a 6-8 volt lamp with DC base.

Both filaments are 21 c.p. and each take 2.81 amperes. Both filaments are out of the focal center of the reflector. One is above this center and the other is below, there being a 9/64" separation between the filaments.

The lower filament is used as a long-range driving light, and being below the focal center, it tends to bend the light rays upward. The upper filament is a courtesy light which is used when passing another car, and, being above the focal center, depresses or bends down the light rays for a short distance which keeps the light out of the eyes of the passing driver and yet gives a safe driving light.

Mazda Lamps for Electric Vehicle Service

There are only two lamps listed for electric vehicles as follows:

Number	Position	Mazda B or C	Bulb	Volts	Cp.
110	R-I	B	G-10	40-44	6
1150	H-Si	C	S-11	40-44	21

Meaning of Abbreviations of Mazda Automobile Lamps

The abbreviations used with the lamps, such as "G-6," "G-8," and "S-11," refer to the shape and size of the bulb.

For instance, "G" indicates that the bulb is round or globular; 6 means that many eighths of an inch, or 6/8" or 3/4" diameter. "G-8" would be a round bulb, 8/8" (or 1") in diameter.

Where the designation "S-11" appears, the "S" indicates "straight side," and the 11 designates the diameter in eighths of an inch, or $11/8 = 1\frac{3}{8}$ " diameter.

Formerly all of the bulbs were round, but now only some are round, such as "G-6" and "G-8." The other bulbs are pear shaped and designated as "S." They are not really straight, but this term is used in order to distinguish them from the round bulb.

Where figures appear under the "voltage" of the lamp bulbs, as "6-8," or "12-16," this means that the lamp is intended for electric systems using a 6-volt battery, but will stand a voltage up to 8 volts for a small period of time, as it is designed to operate at a voltage of 6.35 volts for maximum efficiency. The lamp sometimes gets this—or near it—when the generator is charging the battery, as the generator voltage is slightly higher than the battery voltage.

The "12-16" lamp is for a 12-volt system, such as a Dodge, and the lamp is capable of withstanding a generator voltage as high as 16 volts for a small period of time. It is designed to operate at 14.5 volts for maximum efficiency.

Lamp Bases

There are four types of these: (1) double-contact bayonet candelabra; (2) single-contact bayonet candelabra; (3) candelabra screw base; (4) miniature screw base. Each of these is shown in the illustrations.

The lamp base is that part which is fitted to the end of the bulb and fits into the socket. Only two of the types mentioned above are in general use for automobile work: the "S.C.," meaning "single contact," and the "D.C.," meaning "double contact." The "S.C." is used most.

The double-contact base (D.C.) (Fig. 7) has two contacts (note the top) insulated from the metal base. These contacts are connected with the ends

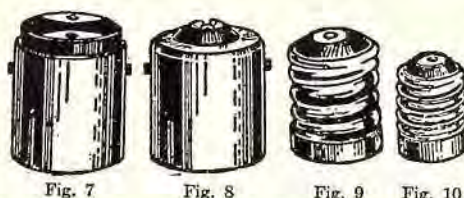


Fig. 7

Fig. 8

Fig. 9

Fig. 10

of the lamp filament; and when connected to the socket they make contact in the socket with the circuit. The "D.C." base and socket are used only for a "two-wire insulated" system of wiring.

The single-contact base (S.C.) (Fig. 8) has one contact in the center which is insulated from the metal base. One filament of the lamp connects with this center contact, and the other end of the filament connects with the metal base. When placed in the socket the center contact connects with an insulated terminal in the socket, which connects with the single insulated wire of the light circuit, and the rest of the socket and outside part of the base are grounded. The "S.C." base and socket are used only for the "single-wire, grounded" system of wiring.

The words "Bayonet" and "Candelabra," which appear in the tables to designate the type of base, are explained as follows:

Bayonet base: The "Candelabra" screw type base (Fig. 9) was originally used on miniature lamps, but owing to the vibration of the automobile, the lamps would loosen. A type of base was then designed as shown in Figs. 7 and 8, the single contact (Fig. 8) being used most and arranged as shown in the illustration (Fig. 11). The base (B) is thrust into the socket (S) through slot and is then given a turn or twist which locks (T) in place. The thrusting effect was what gave the base its name: "bayonet type." The word "candelabra" is also used with the word "bayonet," the candelabra base originally was a screw type, as shown in Fig. 9.

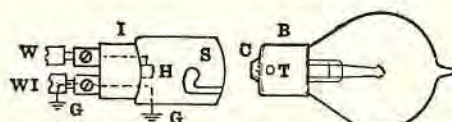


Fig. 11. (B) is the base, S. C. Type. The tip (T) locks in the opening of (S). Contact is made by (C) at (H), which conducts the current from (W) to one end of the filament, back to the grounded base, thence to ground (G), or to (WI) which is grounded. (I) is insulated from the socket (S), and (C) is insulated from the base (B).

The candelabra screw base (Fig. 9) is not used for automobile work, because of the vibration. This type is often used on trouble lamps, flash lamps, etc.

The miniature screw base shown in Fig. 10 is a smaller size, used principally for decorating purposes.

Lamps must be selected according to the type of sockets used on the car. On a single-wire grounded system, use an "S.C." base. On a double or two-wire system, use a "D.C." base.

Head Lamp Adjustment

The light you get on the road will depend on the candle power you get from the lamp in the reflector; on the focus or adjustment of the lamp in relation to the reflector; and on the direction in which the headlamp itself points.

Every device designed to prevent glare and properly distribute the light from head lamps is entirely dependent upon the proper focal position of the bulb in relation to the reflector and the proper inclination of the beam of light itself by adjustment of the head lamp.

Different Focusing Adjustments

Getting the lamp bulb in the proper relation to the reflector to give the best light on the road is called "focusing." All headlamps are provided with some means of moving the lamp bulb back and forth along the center line of the reflector, which line is called the axis. The four types of adjustments (Figs. 12, 13, 14 and 15) shown, should cover practically all of the headlamps used.

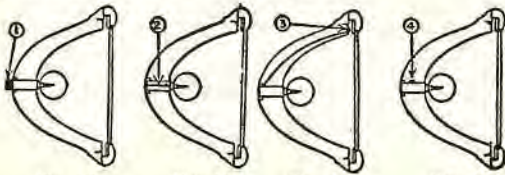


Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 12 has an adjusting screw or knob near the center, on the rear of the headlight shell. The lamp bulb is moved forward by turning the screw or knob (1) to the left, and backward by turning it to the right.

Fig. 13. The lamp is held in place by a ratchet device (2). The lamp is moved forward or back by grasping the bulb and either turning the bulb to the right or pressing it to one side or the other to disengage the ratchet, and then pulling or pushing the lamp in its socket to the next notch in the ratchet. If the lamp does not move easily, remove the reflector and see how the ratchet works.

Fig. 14. The adjustment is made by turning the large screw (3) in the rim of the headlight front just at the edge of the reflector. By turning this screw to the right, it will move the lamp forward in the reflector. Turning it to the left moves it backward in the reflector.

Fig. 15. The lamp is held in place by a set screw (4) in back of the reflector. When the set screw is loosened, the lamp may be moved backward or forward. The set screw must be tightened securely to hold the lamp in place.

Examples of Headlamp Adjustments

Observe the two methods of adjustment (Figs. 16, 17); also the manner in which the door or rim is removed, etc.

TO REMOVE LAMP DOOR: PRESS IN ON RIM & TWIST TO LEFT

TO FOCUS: TURN FOCUSING SCREW WHICH MOVES LAMP BULB IN OR OUT

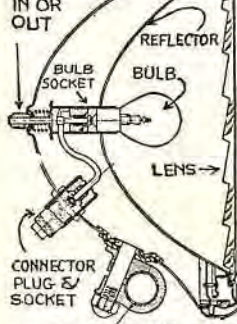
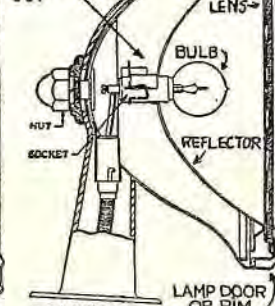


Fig. 16 ADJUSTING CLAMP

TO FOCUS: PRESS DOWN ON BULB AND SLIDE BULB AND SOCKET IN OR OUT

BRACKET TO FASTEN TO FENDER
Fig. 17

To remove the door (Fig. 16): Press in hard against the rim of the lamp, and twist in a counter-clockwise direction. The same applies to Fig. 17.

To replace burned-out bulbs: Remove the door; then remove the bulb by pressing it into the socket and twisting it one way until it is released from the catch. See Index, for lamp sizes for various cars.

If a lens breaks, and a new one has to be ordered, the name and size will usually be found moulded into the lens.

The "door" to the headlamp on various makes may be fastened on in one of several ways. There may be a hinge at the top and a screw clamp at the bottom, or the hinge may be at one side and the clamp at the other. If no hinge shows, and the "door" overlaps the shell of the headlamp, the "door" can probably be removed by pressing it in, and at the same time turning it to the left, as described above.

In some headlamps, the glass is held in place by a retaining spring, which slips in between the headlamp shell and the glass.

In other headlamps, the rim which holds the glass is held up against the shell by a band which fits over shoulders on both rim and shell, and is drawn up by a screw at the bottom of the headlamp.

Tilting Reflectors

On some makes of lamps the reflectors are arranged so that the reflectors can be tilted. One method is as shown in Fig. 18, and another (Fig. 19). There is also an electric method (not shown).

Bellows for Tilting the Reflector

The operation of the reflectors (Fig. 18) is controlled by a small three-way valve located on the instrument board, the partial vacuum created in the engine by the suction stroke of the piston being utilized to exhaust the air from the metal bellows connected to the reflectors when it is desired to illuminate the road for a long distance.

When it is desired to lower the reflectors to their tilted, or normal, position, the handle is turned to the letter (L) on the dial, which breaks the communication of the bellows with the engine and allows air to enter the bellows through a port in the valve. Communication is maintained between the inside of the headlights and the engine by $\frac{1}{8}$ " O.D. annealed copper tubing, and between the end of the tubing and the bellows by rubber tubing, in order that reflector unit may be easily removed.

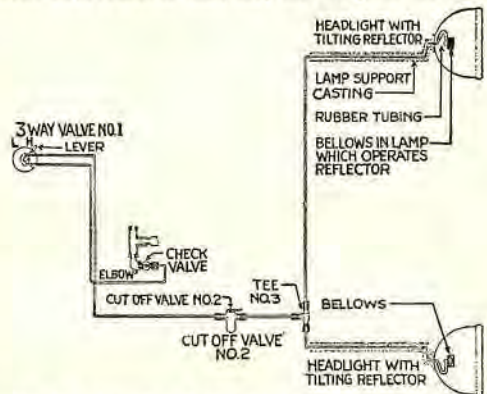


Fig. 18. Operation of tilting reflectors, shown above: The bellows has the appearance of a coil spring, and is just back of the center of the reflector. The bellows expands and pushes the reflector forward at the top, giving the focal point of the lamp a deflection of five degrees. This is what happens with the control lever at (L). When the lever is at (H), the bellows contracts by action of the engine piston and thus deflates the bellows and pulls the reflector back at the top, giving to the focal point of the lamp an elevation of five degrees.

A check valve is placed in the vacuum line between the three-way valve and engine to prevent a quick change to the tilted position when the throttle is opened quickly. A cut-off valve is provided to render the system inoperative from the driver's seat when necessary.

If the system should become inoperative at any time, it may be the result of a break in the line, a leaky connection, a break in the rubber tube connection to the bellows, or the three-way valve may have become dry, permitting air to leak in, destroying the vacuum. The three-way valve may be taken apart for inspection and lubrication. Care must be used in reassembling not to disarrange any of the parts. Use a small amount of commercial vaseline for lubrication.

Mechanical Shifting Method of Tilting the Headlamp Reflectors

The reflectors are pivoted, in order that they may be tilted by means of a button on the instrument board connected with an arm (A) projecting from the bottom and connected with the reflector (R). The lever pulls the reflector down (as indicated by dotted lines), thus tilting the reflector (Fig. 19).

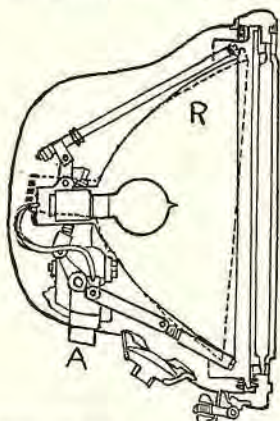


Fig. 19. Tilting reflector as used on model V-63 Cadillac

The advantage of tilting headlights is explained as follows:

When there is a clear road ahead, the illumination of the road for a distance is desirable. Thus the reflector is so focused that the light is projected ahead for the greatest distance.

If a vehicle is approaching in an opposite direction, the reflector (R) can be tilted down by movement of the lever on the steering column connected to the arm (A), thus tilting the reflector at an angle as shown in the dotted lines. This deflects the rays below the level of vision of the occupants of the approaching car, and at the same time increases the illumination in front of the car, where it is needed most.

Reflectors: Principle of

A parabolic type of reflector, made of metal with a polished silver surface, is used in most head-lamps.

If a lamp were used without a reflector, the light which leaves the lamp filament would be thrown in every direction (Fig. 20).

When a reflector is used, the light from the lamp filament is concentrated all in one direction (Fig. 21). See also "Candle power" (page 432).

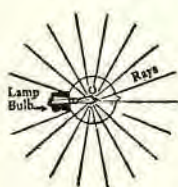


Fig. 20

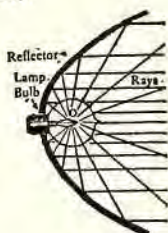


Fig. 21

A ray of light is the light which falls on any one point of the surface of the reflector, and is sent off from that point.

A beam is the total mass of light rays leaving the opening in the reflector.

One of the fundamental laws of light is, that the angle at which light leaves a surface is the same as the angle at which it strikes the surface. By referring to Figs. 22, 23, and 24, the angles which are made by the rays of light leaving the surface of the reflectors at (H), (M), and (N) will be seen to be the same as the angles made by the rays of light striking the reflector at the same point. The angles at which the rays strike the reflector are called "angles of incidence," and those leaving the reflector are called "angles of reflection."

X—Focus Point O—Light Source

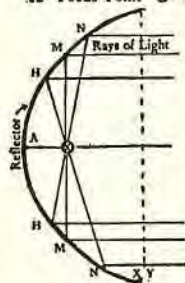


Fig. 22. Straight beam.

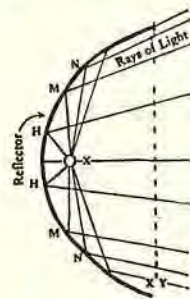


Fig. 23. Spreading beam.

The distribution of light leaving the opening of the reflector when lamp filament (O) is at the focal point (X) of the reflector is shown in Fig. 22. The rays which start from point (X) and strike the reflector at (H), (M), and (N) must be reflected parallel to each other to make the reflecting angles equal the striking angles. This gives a cylindrical or "straight beam." The beam is theoretically the same size (XY, Fig. 22) throughout its entire length. A "straight beam" gives a very narrow streak of light down the center of the road, like a spotlight; but no light is thrown to the side of the road.

The form of beam leaving the reflector when the filament (O) is back of the focal point (X). The rays spread or diverge from one another, and form a "spreading beam," with its narrowest point at the opening of the reflector (XY). Note that the light rays which leave the headlamp at a rising angle are those which come from the upper half of the reflector.

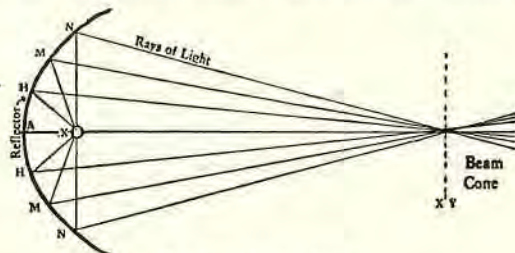


Fig. 24. Crossed beam.

The effect of bringing the filament (O) ahead of the focal point (X) is shown in Fig. 24. This forms what is termed a "crossed beam." Note that the light rays which leave the headlamp at a "rising angle" are those which come from the lower half of the reflector.

Anti-Glare Devices

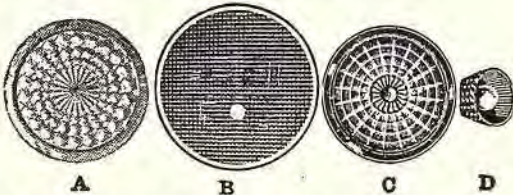
In most states, laws are being enforced to prevent glare. The light which produces glare is that part which leaves the headlamp at a "rising angle" and so never hits the road, but does hit the eyes of approaching drivers or pedestrians. These rays may come from either the top or bottom of the reflector, depending upon the position of the lamp in the reflector.

Methods for Reducing Glare

- (1) By using a very low candle-power lamp, or dimming the headlamps; using whitening, semitransparent paint, or colored glass. Low-candle-power lamps reduce the brilliancy, and colored glass or paint absorb part of the light and reduce the lighting effect desired, and are unsatisfactory.
- (2) By tilting the reflector down enough to bring the upper edge of the beam below the average eye level (42 inches is the usual legal limit).¹ The distance along which the road will be lighted is very much shortened. If the reflector can be tilted back to normal position, as shown in Figs. 18 and 19, then the distance will be greatly increased.
- (3) By diffusing the light by means of ground glass, office-partition glass, or by a specially designed "diffusing" lens, having its surface covered by a large number of small lenses or pyramids. With diffusing lenses there is a tendency to glare if the candle power of the lamp is sufficient to light the road, as the light is thrown in all directions.
- (4) By using "deflecting lenses" which bend or deflect that part of the beam which leaves the headlamp at a rising angle and direct this part of the beam back to the road level. Devices of this kind have the advantage of being able to limit the glare without cutting down the distance along which the light will be thrown on the road. Some of the deflecting lenses which are constructed so as to affect all of the light leaving the headlamp make it hit the road nearer to the car than it would with clear glass, and are not desirable.

Classification of Some of the Anti-Glare Lenses

In the accompanying illustration, A, B, C, and D, are "diffusing" type lenses. As these devices scatter the light in every direction, the adjustment of the headlamp has little effect on the road illumination. Both the light and the glare will be a little stronger if the focus is for a straight beam.



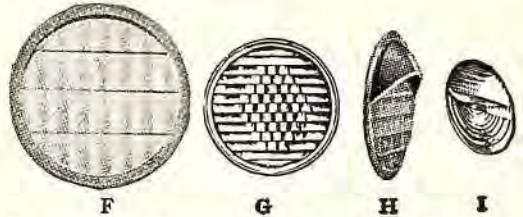
A, Warner: Both sides of glass covered with small lenses; adjust focus for straight beams for best lighting.

¹ The most common "glare height" regulation in regard to headlamps is that, at a point 75 feet or more ahead of the car, the concentrated beam from the headlamp shall not rise more than 42 inches above the road level, when the car is standing on a level. In the latest headlamp regulations, the height has been raised to 60 inches from the road surface, and the intensity of the light is limited to a maximum of 800 candle power above this point.

² See page 442 for Bausch and Lomb lens.

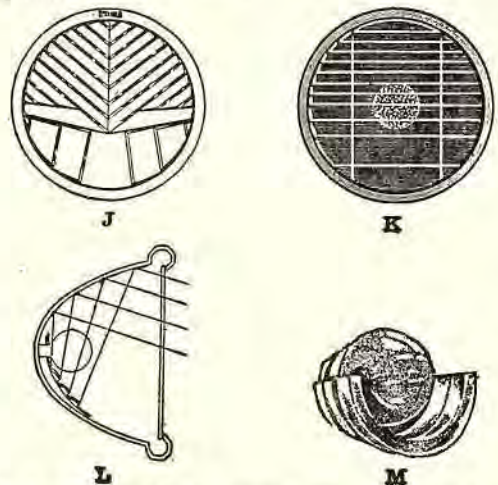
- B, Prismolite: Front of glass covered with small pyramids except small spot near center; adjust focus for straight beam.
- C, Morelight: Front of glass covered with short cylinders, arranged in circles; adjust focus for straight beam.
- D, Stewart: Cup fitting around bulb; outside covered with small lenses; inside with ribs; adjust for straight beam.

F, G, H, I, shown below, are "deflecting" type of lenses, which are intended to be used with a straight beam. In making adjustments, adjust in accordance with directions for plain glass adjustment, page 438, except that the lamp must be moved to the point in the reflector which gives the smallest point of light on the screen or wall, instead of making the spot 3 ft. in diameter.



- F, Patterson: Horizontal prisms deflect rays of light downward on the road, bringing entire light below parallel of the headlamps. The cylindrical services on the back produce a spread of light over the entire road. Adjust focus for straight beam.
- G, Conaphore: Horizontal prisms throw light on the center of the road; cylinders in the center throw a soft light along the sides of the road. Adjust for straight beam.
- H, Macbeth: Horizontal prisms throw light on the center of the road, and cylinders on the inside spread the light to the side of the road. The hood at the top cuts off the light from that part of the lens. Adjust for straight beam.
- I, Holophane: Circular prisms at bottom throw light on the road and give quite a spread. Horizontal prisms and vertical cylinders at the top throw diffused light along the sides of the road. Adjust for straight beam.

J, K, L, M, are "deflecting" type lenses designed to be used with a spread or crossed beam, depending on whether a part of the lens which bends the glare rays down is located at the top or bottom of the lens. The focus is adjusted to give a beam having some spread.



- J, Roadlighter: A deflecting type of lens. Adjustment is for a spreading beam.
- K, Osgood: Horizontal prisms on the back of the lens throw light down on the road. The cylindrical section on the center of the front of the lens is intended to add to the spread of the light. Adjust focus for spreading beam.
- L, Letts deflector: A deflecting device. The corrugated reflector is placed below the lamp and changes the angle of

the light striking the reflector so that all the rays are sent down on the road. Adjust focus for crossed rays.

M, Fractor: A deflecting device. The prisms on the glass cup which is placed below the lamp change the angle of the light striking the reflector, so that all of it is sent down on the road. Adjust for crossed beam.

With any of the deflecting devices it is best to make the adjustment for either spread, crossed, or straight beam, while the plain glass is still in place in the headlamp.¹

Note: State headlight laws do not require or specify types or makes of lens, but in most states they specify a distribution of light which cannot be met by a diffusing lens and which can only be met by certain types of deflecting lenses.

An Ideal Light

An ideal light is one which will meet the following requirements: (1) sufficient light to illuminate the road such a distance ahead that the driver would have ample time to stop before reaching an object, and so that it would have penetrative powers in dust and fog; (2) very bright light at the edge of the road and close to the car so that the road could be clearly seen and followed in spite of glare from an approaching car; (3) full width of the road from fence to fence lighted for at least 200 feet ahead of the car.

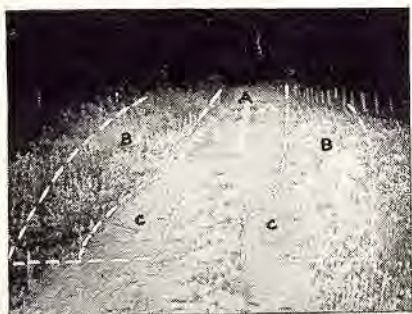


Fig. 25. One make of lens designed to meet these conditions is shown. This illustration was furnished by the manufacturers who claim that this lens meets the ideal requirements mentioned above and have corroborated the statement with a photograph of the lens in use. Note that the prisms in the lower half of the lens (see J, page 437) concentrate the distance light, at (A). The diagonal prisms in the upper half of the lens bend the light, which would otherwise cause glare, to light the sides of the road from fence to fence (BB), and give the bright light on the edge of the road as shown at (CC).

How to Focus Headlight Lamps

In order to secure the best lighting effects, headlight or spotlight lamps should be carefully adjusted in their reflectors every time new lamps are inserted, or, better still, at regular intervals.

Focusing may easily be accomplished by standing the vehicle on level ground not less than 25 feet, and preferably 50 feet, from a flat vertical surface, such as the wall of a house, a garage, or a fence. For an automobile, two points should be marked on the wall the same distance apart and at the same, or slightly less, height above the ground as the centers of the headlamps on the car. The cover glasses of lenses should be removed from the headlamps and the beams (preferably one at a time) trained on to the marked points on the wall. The lamps should then be adjusted in the reflectors by means of the focusing devices until the smallest possible spots of

light are obtained. The headlamps should then be so set that the centers of these spots coincide with the marked points on the wall.



The appearance of the spot from a well-focused headlamp is shown in Fig. 30.

The spot from the same headlamp when the bulb is either drawn too far back into the reflector or not far enough, i.e., is behind or ahead of the focal point (either condition produces a similar effect), is shown in Fig. 31.

The same effect as shown in Fig. 30 is shown in Fig. 31, except that the glare-reducing lenses are now supposed to be placed in the lamp door. The illustration in Fig. 32 shows how the upward rays of light are turned down below the horizontal.

What actually happens to the light rays from the light source in a parabolic reflector, such as is generally used for automobile headlamps, is shown in Fig. 33.

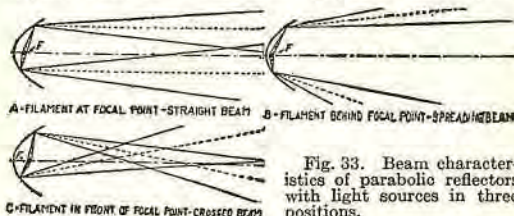


Fig. 33. Beam characteristics of parabolic reflectors with light sources in three positions.

When that source is as shown at (A), (Fig. 33) the lamp bulb is at the focal point of the reflector. When the source is in position (B), the lamp bulb is behind the focal point. When the source is in position (C), the lamp bulb is ahead of the focal point.

Position (A) is the correct position for the lamp filament, and produces the smallest spot of light, or the most highly concentrated beam, as in Fig. 30.

When focusing headlamps with plain lenses, adjust to get the result shown in Fig. 30.

Lights on the Road, C.P., and Lamp Brackets

In some states the law requires that headlamps be tilted so that the brightest part of the light strikes the road about 50 to 75 feet ahead of lamp.

If lamp brackets cannot be tilted by loosening the clamp bolts, then use a large monkey wrench and bend cold (if of wrought iron or steel). If of malleable iron, they cannot be bent at all, and the only course is to file the holes larger and to wedge. One can tell steel or wrought iron because it files soft, and malleable iron is hard, brittle, and uneven castings.

In some states the headlamp bulbs must be of sufficient candle power to reveal objects 200 feet ahead, but the candle power of a lamp bulb must not exceed 36 c.p. for the diffusing type lens etched or ground; 32 c.p. for the diffusing type lens which are moulded (such as A, B, and C, page 437), and 21 c.p. for the deflecting type lens.

In some states the law requires lights to be dimmed when passing vehicles going in opposite direction on highways at night, and 6 c.p. dim, and 21 c.p. bright lights are generally used. Write to the Secretary of your State and obtain a copy of the state automobile laws.

¹ Addresses of some of the lens manufacturers:

The Warner-Patterson Co., 914 So. Mich. Ave., Chicago; Macbeth, by Macbeth-Evans Glass Co., Pittsburg, Pa.; Legalite, by The Legalite Corp., Boston, Mass.; Sun Ray, by Standard Corp., Columbus, Ohio; Conaphore, by Corning Glass Works, Corning, N.Y.; Holophane, by Holophane Glass Co., New York City; Bausch & Lomb by Bausch & Lomb Optical Co., Rochester, N.Y.

This instruction has not been revised for some time.

NOTE: Instead of moving the lamp to adjust the focus, the beam is now "aimed". See Note, page 431.

Focal Adjustment for Different Lenses

There are three general types of anti-glare or glare-reducing lenses:

- (1) The diffusing type, as A, B, C, and D, page 437, which requires a focal adjustment for a "straight beam," or where the lamp filament is at the focal point, as shown in Fig. 22, page 436.
- (2) The deflecting type of lenses which require a focal adjustment for a "straight beam," the same as the diffusing type, are F, G, H, and I, page 437.
- (3) The deflecting type of lenses which require a focal adjustment for a "crossed beam," as in Fig. 24, page 436, where the filament is ahead of focal point, are J, K, L, and M, page 437.

Therefore, when fitting lenses of either of these types, it is necessary to adjust the focal point accordingly, after first making the adjustments with the lenses removed, as shown in Figs. 30 and 31.

When a "diffusing" type of lens is used it makes no difference whether you have a crossed beam, a spreading beam, or a straight beam, except that where a straight beam is used there will be less diffusion, and consequently a stronger light ahead of the car.

When a "deflecting" type of lens is used it is absolutely necessary to know whether it is intended for use with a spreading, a crossed, or a straight beam, before the focus can be made to insure satisfactory results. Therefore the manufacturer's instructions should be followed carefully.

If that part of the deflecting lens which is designed to bend the "glare rays" down towards the road is located in the upper half of the lens, a "spreading beam" must be used; if located on the lower half, a "crossed beam" must be used.

If the device is made of prisms having a uniform angle on both upper and lower halves of the device, a "straight beam" must be used.

Checking Lamp Adjustment

To find out whether the lamp is set for a "spread" or a "crossed beam" pass a screen, such as a piece of board or paper, down in front of the headlamp. If the shadow caused by the screen moves up as the screen moves down, the filament of the lamp is in front of the focal point (Fig. 34), and you have a



Fig. 34

"crossed beam." If the shadow moves down with the screen, the lamp is set for a "spreading beam."

Another method of testing whether the light is a crossed beam or a spreading beam: Let the light from the headlight shine on a wall or screen 10 or 15 feet ahead of the lamp. Then move the lamp bulb back in the reflector.

If the spot on the wall grows larger as the lamp bulb is moved toward the back of the reflector, the lamp is adjusted for a spreading beam and the filament is back of the focal point.

If the spot on the wall grows smaller as the lamp is moved back towards the reflector, the adjustment is for a crossed beam, and the filament is ahead of the focal point.

If the filament is moved from as far back in the reflector as it will go, to a point as far ahead as it will go, you will find that the spot of light will first

grow smaller and then grow larger, as the filament passes the focal point. The point where the spot is smallest is the point where the filament is practically at the focal point (X), and the adjustment is for a straight beam.

These tests are, of course, made with plain lenses.

To Clean Reflector

Do not forget that dust or dirt on the reflector or on the glass lens may cut down the light on the road by more than half. The reflectors of head and side lamps are plated with pure silver.

To clean reflector, use a very soft, clean cloth, or powdered dry rouge and a chamois skin, without using pressure and rub in a circular motion. Never rub a reflector with a cloth or chamois skin which is covered with dust or grit. It will scratch the reflector and ruin it for service.



Fig. 35

If a reflector becomes tarnished or scratched, take it to a silver plater and have it buffed. It cannot be properly polished in any other way. An improvement can be made, however, where reflectors are tarnished, by moistening the rouge with alcohol and applying with a soft chamois. Do not use the chamois for any other purpose. Putz pomade applied with a very soft, clean chamois may also be used.

To Clean the Glass Lens.

Absorbent cotton, dipped in alcohol and lightly rubbed in a circular motion over the surface, will be found efficient. See also page 646 for cleaning glass, polishing nickel and brass, etc.

Dimming Headlights

There are four methods for reducing the brilliancy of headlights, which is required by law in most cities.

One method is to use resistance wire which is in series with the circuit, as shown in the Lexington (Fig. 8, page 426). See also Fig. 14 of Hudson, page 390.

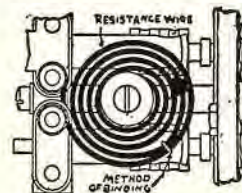


Fig. 36

To vary the intensity of the headlights when the dimmer is in circuit (Delco Hudson system) is merely a matter of shortening the path of the flow of current (the dimmer "resistance" wire, Fig. 36), which can be done by tying one coil together. This will make considerable difference.

To do this, it is necessary to remove the switch. Remove the four bolts passing through the housing at the back of the switch. The housing will then come apart. Remove No. 1 wire which connects with the generator, before dismantling the switch, otherwise a short circuit will result.

Another method (seldom used) is to have the switch connections so arranged that the two headlights which are always connected in parallel will be connected in series, thus reducing the voltage of each lamp one-half.

For instance, if the two lamps are connected in parallel on a 6-volt circuit, each lamp would get 6 volts. If connected in series, each lamp would get 3 volts, thus dimming lamps.

The method in general use is to use auxiliary headlight bulbs (also called dimmer bulbs). They are placed in the headlamps in addition to the regular headlight bulbs. See Olds diagram, page 402, and note that (5) are bright headlight bulbs, usually 21 c.p., and (6) are dim, or auxiliary headlight bulbs of 2 c.p. See also pages 400 and 407.

In some states the law requires that lights be dimmed when passing vehicles on the highway at night, and 6 c.p. auxiliary and 21 c.p. bright headlight bulbs are generally used.

Headlamps also come equipped with three lights: parking lights (2 c.p.), driving lights (21 c.p.), and bright lights (32 c.p.). All three are in each headlamp, and are operated by movement of the switch lever, so that either set of lights can be used. Figs. 5, 6, 8 in the Packard diagram, page 407, show the three lights in each headlamp and switch connections. The driving and parking lights are not in focal point of reflector.

A double-filament lamp bulb (Fig. 6, page 433) is another method of dimming. These bulbs can be had in 2 c.p. and 21 c.p., also 6 c.p. and 21 c.p.

A headlamp lens can be frosted with epsom salts dissolved in a teacup of water and then used on the inside of the headlight

glass, where it is allowed to evaporate. This produces a diffusing type of lens which, however, in some states is prohibited.

A "Spot-Light"

The spot-light is a type of lamp which can be placed on the wind-shield, and turned in any direction by hand. Where a great deal of night driving is done, or where a cross-country trip is made, a spotlight is of great convenience. It is fastened close to the driver's hand, and can be directed at any spot desired.

Adjustment is for a "straight-beam," with the filament exactly at focal point. On the Fyrac spot-light (made by Fyrac Manufacturing Co., Rockford, Ill.) there is a screw back of reflector in the neck. Loosen screw and slip reflector backward or forward on tube until a bright small clear spot appears. There is a point in the focusing where several black spots appear; focus so that the black spots are eliminated.

Spot-lights are prohibited in some states, and in others the law requires that the light be thrown on the ground, not more than 60, 75, or 100 feet ahead of the car, and it must not be directed in the faces of persons approaching.

Electric bulbs used with spot-lights are usually of the nitrogen type, and 21 and 32 c.p. The limit allowed in some states is 21 c.p.

Stop Light

In most states the law requires that a stop light be placed at rear of car so that a red or yellow light be flashed when slowing down or stopping. This light is usually operated by a switch connected with foot-brake pedal. The lamp is usually 21 c.p. See Nash diagram, page 402, and Packard, page 407, showing circuit. See also page 654.

GAS LIGHTING (ACETYLENE)

Gas lighting is now seldom used,¹ but it is explained here for the benefit of the reader. There are two methods of supplying the acetylene gas to the gas burners. One method is by means of a carbide gas generator, and the other by means of a tank containing compressed acetylene gas. The method whereby the gas is supplied to the gas jet by a gas generator is shown in Fig. 37.

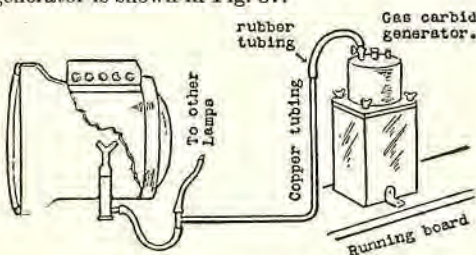


Fig. 37. Showing how small $\frac{1}{8}$ " copper tubing and rubber tubing connects from generator to lamps. Note that the rubber tubing connected from the copper tubing to the lamp drops in a curve. This places the rubber tubing at the lowest point. The gas condenses and turns to water, and the water clogs the pipes and gas tips. If this rubber tubing is disconnected occasionally, the condensed water will drain out.

It is always necessary that the line or leads from the gas generator to the lamps be on as much of an incline as possible. In fact, a draincock could be placed at the lowest point to advantage. Pipes to each lamp should be independent if possible.

There are two types of gas or carbide generators: the "drip" type, and the "automatic" type.

With the "drip" principle of generation, the water is usually arranged to drip directly on the carbide, and the amount of gas formed is regulated by a tap which allows more or less water to come in contact with carbide (Fig. 38).

A modification of this system allows the water to drip down a perforated metal tube, surrounded with carbide, and thus the water gradually soaks through the carbide.

¹ The Prest-O-Lite gas tank is used considerably for truck and motorcycle lighting and automotive shop use, such as soldering, brazing, etc.

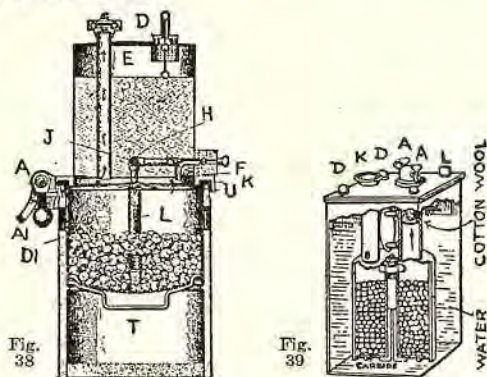


Fig. 38. Explanation of the "drip" type of carbide generator: The tank (E) being filled with water at (D), the water saturates the cotton wick (H) in the tube (J) and the valve (F) being turned on, it drops into the screen tube (L), passing out of the holes at the bottom. As it comes in contact with the carbide, it forms gas which passes out at the top of the generator through pipe. The unused carbide held in the cage is separated by the screen in the bottom, and the dust or used carbide falls to the bottom (T) perfectly dry. Consequently the charge is always fresh while it lasts and is ready to light or extinguish. Cleaning simply means emptying the dry dust at the bottom and refilling the cage with carbide, and the tank with water. To shut off the light turn the valve (F) off. (F) being a two-way valve on the side (not lettered), the gas then contained in the generator passes out of the two-way valve into the air, thus insuring perfect safety.

Fig. 39. The automatic type of generator: In some respects this is simpler and gives a better regulation of the gas, but it does not seem to be always reliable.

The operation is as follows: The carbide is contained in a bell or chamber with perforated sides and bottom, to admit water freely. This bell has a suitable outlet for the gas. It is supported inside an outer vessel or tank to hold the water. Immediately the water comes in contact with the carbide, gas is generated and, if the supply tap (A) is open, this gas will pass on to the lamps. Should the tap be closed, the pressure exerted by the gas then acts inside the bell, and drives the water away from the carbide.

Should the generation of gas still continue, it will force its way through the water and escape into the atmosphere, through a small vent hole (L), so that no dangerous pressure can develop within the generator.

It will be seen that an automatic regulation of the gas is thereby obtained, because immediately that more is being

generated than can be used, the water is driven away from the carbide, but as soon as there is a demand for more gas the pressure inside the bell falls and water re-enters.

The gas outlet pipe and cotton wool or horsehair filter, whence the gas reaches the top, or to which the tubes are connected to the lamps is shown at (AA).

A gas bag is provided on the gas outlet pipe inside the generator to steady the pressure.

The carbide container lifts out of the tank by unscrewing the nuts (DD).

The tank is filled from the aperture (K), in the plug of which is a small vent acting as a safety valve. In this, as in other forms, the gas can be turned on and off any number of times till the carbide is all used up.

Gas Burners—Also Called Gas Tips

The gas burner is made up in various styles, and consumes from .25 to 1.5 cubic feet of gas per hour. By referring to Figs. 40 and 41, the reader will observe the construction.

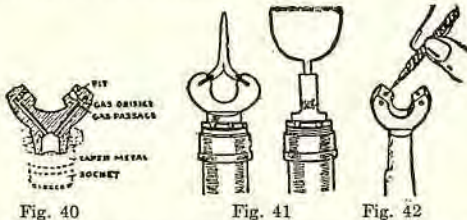


Fig. 40. Interior of a gas tip or acetylene burner. Tips are generally made of lava. Two small holes are in each end, only one of these being discernible to the eye. The hole, however, which becomes clogged is the small hole inside the large one.

Fig. 41. Showing end and side view of the flame when burner is in good order. Fig. 42. Showing how to clean a gas tip.

If acetylene gas was used with an ordinary jet, it would have a yellow tint, but the oxygen drawn into the tip through the large hole raises the temperature of the flame to a point where a white blaze is obtained. It is therefore necessary that the smaller hole in the burner be kept clean.

If the flame is yellow and dim, the lack of oxygen is probably the cause, or the pipe line needs blowing out, or the generator needs cleaning.

If the independent generator is used, it is important that all parts be perfectly clean and fresh carbide be added daily, using whatever quantity is required.

The average gas tip consumes one-half foot of gas per hour. Gas tips are made in standard sizes as follows: $\frac{1}{4}$ foot; $\frac{1}{2}$ foot; $\frac{3}{4}$ foot, and 1 foot.

Lighting the Gas

The usual method for lighting the gas is to turn on the gas at the generator or tank, and to light the gas at the burners with a match.

Another method is to turn on and light the gas from the seat. This is accomplished by a valve and electric spark (Fig. 43).

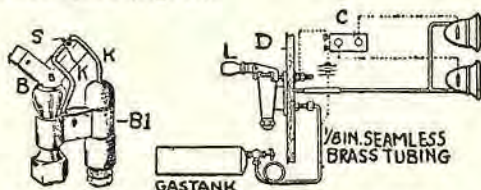


Fig. 43. Lighting the gas by an electric spark: This system consists of a special valve and switch placed on the dash-board (D), a high-tension coil (C), and a special gas lighting attachment shown in the cut.

The connections are as follows: The gas tank is piped to the valve and connected to a union under it. After gas passes through the valve it is then carried to the lamps. A wire runs from switch to coil and from there through primary winding to battery; through battery to ground.

An attachment (B1) is placed on each gas tip to be lighted. When lever (L) is pressed down, this opens the gas and also makes a temporary electric contact, and a spark jumps across points (S) and lights the gas. An ignition battery or dry cells will do this work.

Non-Freezing Solution for Gas Generators

Use plain alcohol in the proportion here given. Alcohol is a fuel, but not explosive. It will, therefore, probably give a slightly stronger gas than water, and for this reason less will be required. Do not use glycerine, as this is an explosive.

Percentage of alcohol to water: At 18 degrees, 10 per cent; at 5 degrees, 20 per cent; at -2 degrees, 25 per cent; at -9 degrees, 30 per cent; at -15 degrees, 35 per cent; at -24 degrees, 40 per cent. Note: The - in front of the figures are minus signs, meaning below zero.

Carbide—Used in the Generators

The chemical formula for Acetylene is C_2H_2 (i.e., a compound of carbon and hydrogen). It has a characteristic pungent odor—which at once gives evidence of any leakage—and is a poison if inhaled in any quantity.

Approximately one pound of good quality calcium carbide will generate six cubic feet of acetylene gas. It can readily be liquified or compressed, but in this state it is highly explosive, and its use finds no favor in this country. What is known as dissolved acetylene, however, is safe.

The gas in a moist or impure state attacks copper or brass, forming acetylene of copper, which is exceedingly explosive; so much so that it will go off by slight friction or a blow. This accounts for the small explosions that are sometimes experienced when cleaning a generator.

The Pressure-Gas (Acetylene) Storage Tank

This tank is used instead of a gas generator, and is charged at the factory. When the tank is exhausted it is taken to the local agent and exchanged for a fully charged tank.

The gas used in the tank is acetylene gas, made from carbide—the same kind of gas used in a generator. Fig. 44 illustrates the Prestolite gas tank. The amount of gas in the tank is indicated by the pressure gauge. In this way the motorist can tell the quantity of gas in the tank. A key opens the valve which allows only a low pressure of gas to feed the lamps.

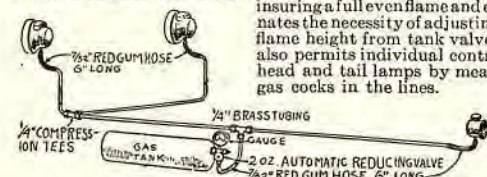
Piping of gas from gas tank to lamps is similar to that used with generator.

The Prestolite gas tank is made in three styles: Style E, which weighs 23 lbs.; style B, 30 lbs., and style A, 50 lbs.

The pressure inside the tank (E) is based on a pressure of 15 atmospheres, or about 50 cubic feet of gas, which will supply gas for two $\frac{1}{2}$ -foot burners for 50 hours.

Fig. 44. The pressure gas tank is used considerably for truck lighting, and also some motorcycles. The fact that a great share of the truck hauling is done at night makes it very desirable and dependable for this class of work. The tank is usually suspended from frame or supported on running board.

Fittings and tubing used are usually of the size shown on illustration. The reducing valve can be used or not. It reduces the pressure to the proper burning pressure of 2 ounces, insuring a full even flame and eliminates the necessity of adjusting the flame height from tank valve and also permits individual control of head and tail lamps by means of gas cocks in the lines.



The tank should be placed on the car in such a way that it can be easily removed. The running board is a convenient place. Always place the tank top side up.

Prestolite Gas Tank Pointers

Prestolite gauges, how to read them: Several styles of gauges are used. Some register in atmospheres, some in pounds and some in both (see Figs. 45, 46, 47). If you wish to determine the number of pounds of pressure in your tank, reading from a gauge showing only atmospheric pressure, multiply the number of atmospheres shown by 14.7, which is the number of pounds to which one atmosphere is equal. The result will give you the number of pounds of pressure in your tank. All atmosphere gauges are marked "ATM." An atmosphere equals 14.7 lbs. at sea-level.



Fig. 45



Fig. 46



Fig. 47

Fig. 45. Gauge reading in atmospheres.

Fig. 46. Gauge reading in pounds.

Fig. 47. Combination gauge reading in pounds and atmospheres.

Prestolite tanks are charged to a pressure of 225 pounds (equal to approximately fifteen atmospheres) at 65° Fahrenheit. If the temperature of a tank be increased 10° to 20° F., the pressure will be raised 25 to 50 pounds. If the temperature be lowered, the pressure will be reduced in about the same ratio. This accounts for the rapid fall in the gauge pressure when a tank is taken from a warm garage into the cold air of the street. Change in temperature does not affect either the quantity or the quality of the gas. Consequently, when the outside temperature

is 65° F., a properly filled Prestolite tank will show a pressure of about 15 ATM (atmospheres) when using the atmospheric type of gauge, and 225 pounds when using the gauge reading in pounds, while the gauge showing both pounds and atmospheres will indicate a pressure of 221 pounds, or 15 ATM, with corresponding variations according to the outside settled temperature, despite the fact that the first two mentioned gauges show a capacity of 40 ATM and 500 pounds, respectively.

Where to look for leaks: Rub soap-suds along the pipe lines and over all joints and connections. Do not use a match any more readily than you would use one to hunt for a gas leak in your cellar.

The following may be the source of a leak: (1) union where attached to tank; (2) rubber hose connecting union with brass piping of car; (3) joints where rubber hose connects with union and with piping of car; (4) joints, T's, or crosses where piping branches; (5) where rubber hose connects piping with lamps; (6) part of lamp to which burners are attached; (7) any point on piping where there is a liability of chafing.

Sizes and capacities of Prestolite tanks: "A"—22 inches long, 7 1/4 inches in diameter; contains 70 cubic feet of gas.

Using two 1/2-ft. burners, 70 hours lighting

Using two 3/8-ft. burners, 56 hours lighting

Using two 3/4-ft. burners, 46 hours lighting

"B"—20 inches long, 6 inches in diameter; contains 40 cubic feet of gas.

Using two 1/2-ft. burners, 40 hours lighting

Using two 3/8-ft. burners, 32 hours lighting

Using two 3/4-ft. burners, 26 hours lighting

"E"—16 inches long, 6 inches in diameter; contains 30 cubic feet of gas.

Using two 1/2-ft. burners, 60 hours lighting

Using two 3/8-ft. burners, 30 hours lighting

Oil Lighting

Inasmuch as electricity for lighting is now the adopted standard, and is almost universally used, it is hardly worth while to deal with the kerosene oil lamp. The oil lamp, when used in place of electric lights, is generally placed as a tall or rear lamp, to illuminate the license number and as required by law for protection of the fire department.

The brilliancy of oil lights can be improved by using a hard wick and placing cotton in the bowl of lamp. Then use gasoline or half gasoline and light cylinder oil instead of kerosene.

BAUSCH & LOMB LENS FOR AUTOMOBILE ELECTRIC LAMPS

The diagrams (Figs. 1 and 2) illustrate the path of light from a lamp fitted with the Bausch & Lomb deflecting type of lens.

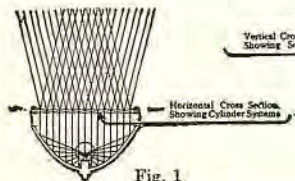


Fig. 1

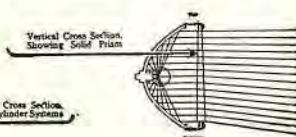


Fig. 2

The illustration in Fig. 1 shows a horizontal cross-section and how the vertical cylinders (placed in front and rear of lens) throw or spread rays outward sufficiently to illuminate a lateral area of about 50 feet at a distance of 100 feet.

Note: The word "cylinders" used above refers to the flutings which are in both the front and back of the lens. The whole lens is in reality a "prism," and in this example it is somewhat thicker at the bottom than it is at the top.

The illustration in Fig. 2 shows a single or solid vertical prism which deflects the light downward, or below the level prescribed by law.

In order to secure maximum satisfaction from these lenses it is necessary to adjust them properly, and this is explained as follows:

The adjustment of a lamp consists in moving the lamp bulb forward or backward (see pages 435, 436). Some lamps have external adjustments whereby the adjustment can be made with the lens in place, and others where the lamp door must be opened. Adjustment should be made each time the lamp bulbs are changed.

For adjustment with the lens in the lamp, have the light on a wall 25 or 50 feet away. Cover or disconnect the other light.

Cut out a circular piece of light-weight cardboard as in Fig. 3, with holes in it 1/8" in diameter and 4 1/2" from center to center of holes. Hold it in front of the lamp so that the centers of the two holes in the card lie in a vertical line as shown.

If the bulb is properly set (focused or adjusted), the light on the wall will appear as one solid band, as shown in Fig. 4.

If the lamp bulb is too far away or too close from the reflector, two bands will appear, and the lamp bulb should be moved forward or backward until a single band is obtained as shown in Fig. 4.

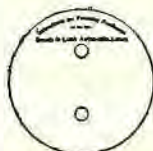


Fig. 3



Fig. 4



Fig. 5

For adjustment with lamp doors open, which is necessary when the adjustment is inside of the lamp, the same procedure is followed. If the lamp bulb is properly focused with the reflector, a solid spot or patch of light will appear, as shown in Fig. 5.

If the lamp bulb is not properly focused, two images or spots will appear, and adjustment of the bulb should be made until only a single patch of light appears, as in Fig. 5. This adjustment is for a straight beam.

Next, place the lens in place in the door and then close it, and see if the adjustment is now as in Fig. 4.

The tilting of the lamps should be made in accordance with local requirements.

(Manufacturers are Bausch & Lomb Optical Co., Rochester, N.Y.)

INSTRUCTION No. 39

SIGNAL ALARMS; SPEEDOMETERS

SIGNAL ALARMS

There are a variety of devices properly designated as signal alarms, including: bells, bulb horns, electric horns, exhaust whistles, compression whistles, etc.

In the early days the mechanical electric bell, operated by the foot, was the applied method for warning the pedestrian—although possibly this was not necessary, as the cars in those days made sufficient noise to give warning a block ahead.

Then came the bulb horn, but the old-style bulb horn has about seen its day. It is seldom used, because of its difficult method of bulb operation and because of a tendency to get out of adjustment at the reed.

The compression whistle is the type shown in Fig. 1. It is desirable for use where there is no battery, or where the battery is not of sufficient size to operate an electric horn, or where it is desired to save battery current. It is screwed into the cylinder instead of into the relief cock. The pressure is obtained from the compression in the cylinder.

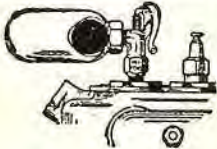


Fig. 1

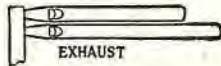


Fig. 2

The exhaust horn or whistle (Fig. 2) was used extensively at one time, but is now seldom used. It is connected to the exhaust pipe by means of a valve which is opened and closed by a foot pedal connection, which when depressed admits the exhaust gases to the horn. See Index, for "Fitting an exhaust horn."

The hand-operated horn (Figs. 3, and 3A) is not altogether desirable because it is operated by hand at an inconvenient place. It is usually placed too near the driver, whereas it ought to be nearer the front of the car.

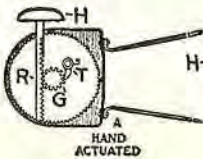


Fig. 3

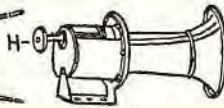


Fig. 3A

Fig. 3A. Klaxon type 3, hand-actuated horn. Klaxon S-3 type is similar, except that it has a vertical push rack.

The hand-actuated horn is operated by pressing on the knob (H) (Fig. 3) connected with a toothed rod (R), thus actuating gear (G). This type of horn is used extensively on motor trucks.

Horn brackets for automobile use, as shown in Fig. 3B, are arranged so that the horn can be mounted at different angles. (M) and (S3) are for motor-boat use. American Electric Co., Chicago, supplies the brackets.

Handles for hand-actuated horns (Fig. 3C) can be had of some of the horn manufacturers. They are suitable for long-continued blasts when used on boats.



Fig. 3B

Fig. 3C

The Electric Horn

The electric horn is the most popular type, and is classified under two types of general construction: (1) vibrating type; (2) motor type.

The Vibrating Type of Electric Horn

The vibrating type of electric horn produces a sound resulting from the action of a vibrating armature (B) (Fig. 4) magnetically operated by the magnet cores (R). The vibrations are transmitted through rod (A) to a diaphragm (D), thus producing a sound which is greatly magnified by having a horn or trumpet attached as in Fig. 4B.

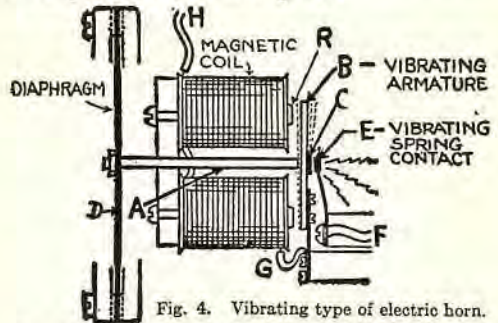


Fig. 4. Vibrating type of electric horn.

The electric circuit is to (F), from (+) of the battery (or generator), through the blade, through platinum iridium points (E and C), through armature (B), to lower connection (G) of the lower magnet coil, through the upper coil, to (H), to the push-button, to the (-) connection of the battery. When the push-button is depressed, the circuit is closed, and armature (B) is drawn to coil (R), striking against rod (A). The moment this occurs, the circuit is opened and armature (B) is released; thus contact is made again at the points (E and C), and the armature vibrates back and forth as long as the push-button closes the circuit. The action is similar to that of a vibrating type of ignition coil or electric bell. The consumption is from 4 to 6 amperes.

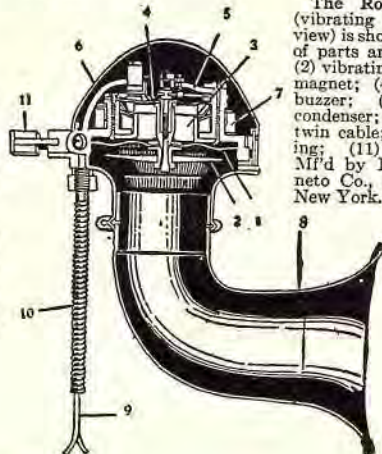
Points (EC) should be of iridium platinum, otherwise they will wear down and stick. (On the Bosch horn a condenser is connected parallel to the breaker points.)

Adjustment is made by adjusting the rod (A) (Fig. 4) in relation to (B), to obtain a greater or less number of vibrations, which increases or decreases the sound transmitted through diaphragm (D). This adjustment on Fig. 4B is made by screwing (S) in or out with current on until the sound is as desired.



Fig. 4B

The Robert Bosch horn (vibrating type, sectional view) is shown below. Names of parts are: (1) diaphragm; (2) vibrating disk; (3) electro-magnet; (4) pole pieces; (5) buzzer; (6) housing; (7) condenser; (8) trumpet; (9) twin cable; (10) flexible tubing; (11) fastening strap. Mfd by Robt. Bosch Magneto Co., 123 W. 64th St., New York.



The Motor Type of Electric Horn

The motor type of electric horn also produces a sound transmitted through a diaphragm, but in a manner different from that of the vibrating type.

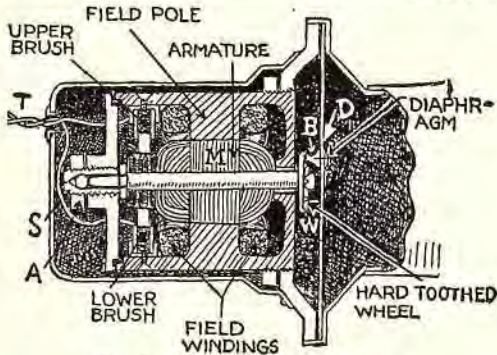


Fig. 5. Motor type of electric horn.

Construction: An electric motor (M) (Fig. 5) of small size is enclosed in one end of the horn. On the right end of the armature shaft a case-hardened steel-toothed wheel (W) operates against a case-hardened steel button (B) securely attached to the metal diaphragm (D) (see also Fig. 6). The sound produced by the wheel (W) operating against (B) is transmitted through the diaphragm (D) and greatly magnified through the horn which encloses the diaphragm.

The intensity of this sound can be increased or decreased by moving the armature shaft so that (W) will make closer contact with (B) to increase the sound, or so that they will back away from each other, to reduce the sound.

This adjustment is made by loosening the locknut (A) and screwing the adjusting screw (S) in or out, which moves the armature, as explained above. Do not adjust too tight at (B) and (W).

The motor is a series-wound motor. Note the field-windings (shown in section), also the armature and brushes and the commutator on which the brushes rest.

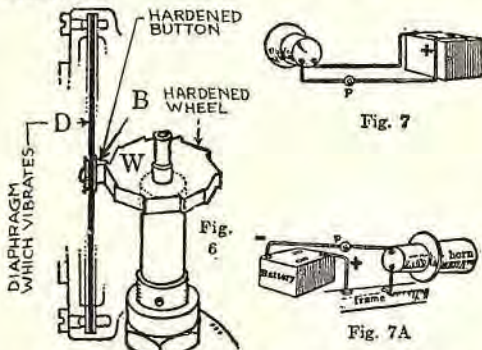


Fig. 6. Explaining how the wheel (W) actuates (B) on the diaphragm, and thus produces the sound.

Fig. 7. A "two-wire system" horn circuit.

Fig. 7A. A "single-wire grounded-return" horn circuit; the frame is used as a ground or return.

The circuit is from (+) of battery (or generator) to ground, to one end of the field-winding, through the two field-windings to one of the brushes, through the armature, out the other brush, through push-button (P) (Fig. 7A), to (-) of the battery or generator.

Fitting an Electric Horn to Car

When fitting the electric horn to a car, the horn should be placed on the opposite side from the driver and as far away in front of the car as possible. The reason for this is that the noise is then away from the occupants of the car, and the signal is placed where it is most effective, usually under the hood, to the front. Being under the hood, it is protected from water when car is washed, and from rain.

Klaxon Electric Motor Horn¹

The Klaxon is used extensively on various makes of leading cars, and its principle of construction is that explained in Figs. 5 and 6. Several different types of Klaxon horns are manufactured. Some of the leading types for automobile use are shown in Figs. 8, 9, 10, and 11.

Klaxon horns are made for various voltages. If the battery is a 6-volt battery, the voltage of the horn should be 6 to 8 volts. Dry cells can be used if necessary, about 6 to 8 dry cells being required.

The amperage, or current consumption, is fixed for each size horn see under illustrations.

To adjust Klaxon 20L (Fig. 8): Loosen the locknut (A), and start the current by pressing the push-button. While it is sounding, twist the motor case until no sound is heard except the buzzing of the motor. Continue twisting, in either direction, until the note is loud and clear. When the note is as desired, tighten the locknut.

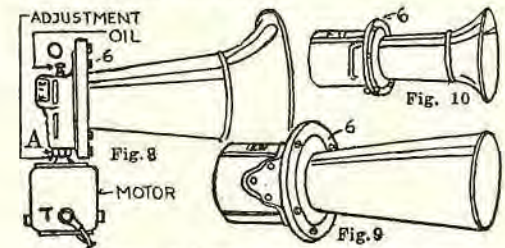


Fig. 8. Klaxon 20-L uses 7 amperes. It is a large, deep-toned horn; Fig. 9. Klaxon 12L uses 8 amperes. A medium-sized and popular type; also a deep-toned horn; Fig. 10. Klaxon-6 uses 5 amperes; Klaxette, (not shown) 3 amp.

To adjust the Klaxon 12-L and Klaxon-6 (Figs. 9 and 10): Loosen the screws and remove cover. You will find a locknut (A) (Fig. 5). While the motor is running adjust screw (S) until the note is as desired. This action forces the armature shaft with its wheel (W) against the button (B). Replace cover and tighten screws.

Care of Electric Horn

Clean and lubricate commutator once a month, as follows: With a dry cloth wipe the commutator clean. Apply a little vaseline with a clean cloth. Use thin oil in winter. Apply this to the commutator. The slightest film is all that is necessary. Every three or four months a little vaseline should be applied to the toothed wheel (W). Oil the shaft bearing once a month.

¹ Write the Klaxon Co., Anderson, Ind., for instruction pamphlet on adjusting and caring for the Klaxon.

Write the Sparks-Withington Co., Jackson, Mich., for instruction pamphlet on adjusting and caring for the Sparton motor horn (a popular make). Adjustment of tone of Sparton horn is made by turning adj. screw in rear of motor cover. To oil, remove motor cover in rear and drop in a few drops of light oil at each end of the armature shaft in oil groove.

The LeClaire electric horn vibrates a tuning fork against a violin spruce wood diaphragm. The manufacturers state that there are no parts to adjust or oil. New Era Spring & Specialty Co., Grand Rapids, Mich.

On the Klaxon 20-L, oil once a week through oil hole (O) (Fig. 8). Give two drops of "3 in 1" oil.

If the horn starts with the right tone and suddenly jumps to a higher pitch or screech, it indicates too light a contact between rotor and diaphragm. This can usually be remedied by tightening screws (6).

If the tone falls off, look to voltage of battery first, then to adjustment, then to lubrication, and clean and lubricate commutator.

Electric Horn Adjustments

As an example, the North East electric horn (Fig. 11) will be used.

Tone adjustment: First be sure that the horn needs adjustment; trouble may be due to other causes (see "Troubles"). Adjust by turning the tone adjusting screw slightly in or out, as the case may require.

The speed at which the motor can revolve is also an important factor in producing a loud clear tone—this is dependent upon the condition of the motor and horn.

When replacing diaphragm, always fit a new gasket on each side. Tighten nuts and bump horn (projector end down) on soft felt or waste, then draw up slack by again tightening nuts.

Horn Trouble Diagnosis

Tone irregular or weak: (1) battery weak; (2) loose connections at switch, horn, or grounded connection, or ground or partial open circuit; (3) diaphragm screws or nuts loose; (4) bearings need oil; (5) brushes gummy or worn, not making good contact; (6) armature thrust spring too stiff or weak; (7) out of adjustment.

Horn fails to operate: (1) battery weak; (2) ground or open circuit in wiring, button, or horn; (3) brushes not making good contact; (4) field-coil lead broken; (5) armature binds; (6) ground in brush-holder, field coil, or armature; (7) open or short circuit in armature; (8) out of adjustment; (9) oil on commutator.

Horn blows continuously: (1) horn switch or button stuck, (2) short circuit in horn button or wiring; (3) ground in horn or in wiring between horn and button.

For testing electric horn, see pages 453, 451, 485.

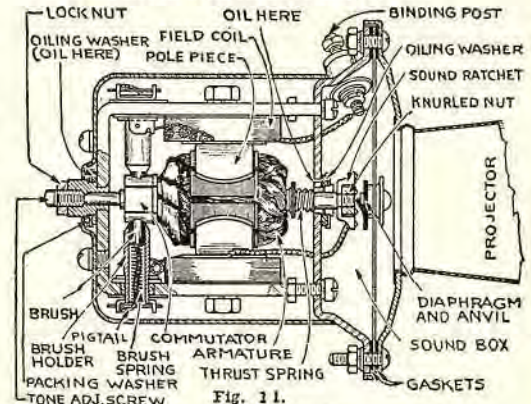


Fig. 11. Sectional view of the North East electric horn.

SPEEDOMETERS AND ODOMETERS

Purpose of a speedometer: The speedometer for automobiles is an instrument for measuring and indicating—in miles per hour—the exact speed at which a car is being driven. The number of miles per hour shown at the dial of the speedometer is the actual speed at which the car is traveling at the instant of indication. For this reason the numbers shown constantly change as the car is driven faster or slower.

Necessity of a speedometer: A speedometer is necessary in testing a car, to learn its speed capabilities under various conditions: in order to time trips over various distances, or to avoid violation of the speed limit laws, the penalty for which is arrest and fine.

Purpose of an odometer: The odometer (combined with the speedometer) is an instrument for measuring and recording—in miles and tenths of miles—the distance a car travels in making a trip. It also records the entire or total distance traveled during an entire season.

Necessity of an odometer: The odometer is usually embodied in the same case with the speedometer. It is necessary in auditing the cost of operating and maintaining a car. It enables the owner to tell how much gasoline is used per mile; how much his tire expense per mile amounts to; how much mileage he gets out of his car. Thus it enables the owner to make comparison of the cost of operating and maintaining his car, with the cost of operating and maintaining a car of another make. The recording and resetting features of the trip-register part of the odometer are a necessity in following a guide book when touring.

Speedometer Principles

The magnetic principle (Fig. 1), as employed in Stewart-Warner instruments, utilizes a revolving magnet positively driven from the car wheel or other part. The magnet exerts its influence on a metal part which is separated from it by an air

gap, which in turn is connected with the indicating mechanism. The metal part is generally aluminum, as the inertia of the part must be kept as low as possible to make the speedometer quickly sensible to speed changes. A feature of the magnetic design is that the travel of the dial bears a direct ratio to the speed of travel of the magnet, and in order to compensate for changes in the drag, due to temperature differences, a compensating unit is fitted.

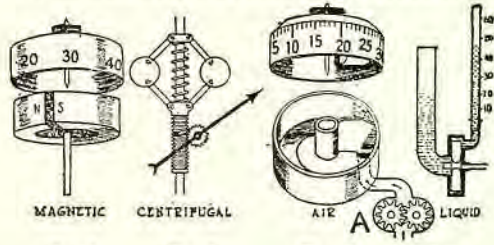


Fig. 1

Fig. 2

Fig. 3

Fig. 4

The four principles of speedometer operation: magnetic, in which a revolving magnet exerts its drag on the dial; centrifugal, in which revolving weights supply the energy due to centrifugal force; air, in which a current of air flows against a vane carrying the dial, and liquid, in which a column of liquid is lifted a height proportional to the speed of the pump drive.

Centrifugal control (Fig. 2), as utilized in speedometers, is very much the same as that on a fly-ball engine governor. Standard, Johns-Manville, Sears-Cross, Corbin-Brown, Hoffeker and Garford use this principle. Weights are mounted on the revolving shaft by bell crank levers which allow them to travel farther from the axis of the shaft as the speed of the drive increases. The centrifugal force of the weights increases as the square of the velocity of the shaft, meaning that at four times the speed the force doubles.

This tendency of the weights to fly from the axial center of the shaft under the influence of centrifugal force furnishes the basis of the indicating needle movement. An ingenious feature in centrifugal

design is that although the movement of the weights would naturally vary as the square of the speed, the levers or cams governing the movement are so calculated that calibrations on the dial are uniform, or nearly so. Another feature which is carefully watched is the balance of the weights. The governors are made very sensitive, so that even at low speeds the correct rate of travel may be indicated.

The air principle (Fig. 3) is an instrument which calibrates an air current and translates the result into miles per hour. The air circulator (A) consists of two intermeshing aluminum gears housed in a chamber in which there are two openings, one from the outside and away from which the gears rotate, the other opening conducting the air into the speed dial chamber where the air is directed against a light vane attached to the inside of the speed dial.

The speed dial is an inverted aluminum cup (C) mounted on a pivot set in jeweled bearings. The amount of air directed against the vane in the speed dial is governed by the speed at which the air circulator (A) is driven by the flexible shaft. The speed dial, when the car is at rest, is held at zero by the action of a nicked steel hairspring.

The liquid or hydraulic principle (Fig. 4): One instrument, the Veeder, which employs the hydraulic system, uses a centrifugal pump which is connected with the drive and which lifts a liquid to a height proportionate to the speed of the drive. The tube in which the colored liquid is lifted is calibrated to register speed. See illustration. (*Motor Age.*)

Speedometer Drive Methods

Front wheel drive: The speedometer can be driven from the front wheel (Fig. 5), or off the propeller or transmission shaft, as in Fig. 6. The usual plan is to drive with gears.

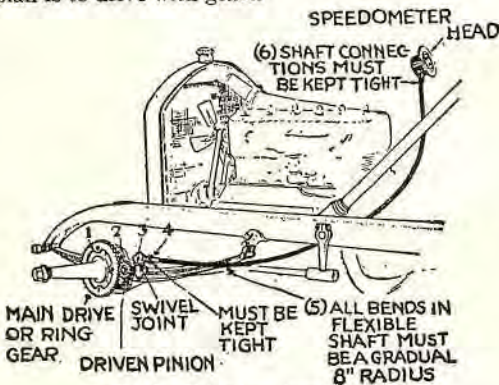


Fig. 5. Drive from front wheel.

Transmission drive: Instead of placing the speedometer drive on the front wheel, which has been the standard former method, it is now quite often placed just in the rear of the transmission, on the

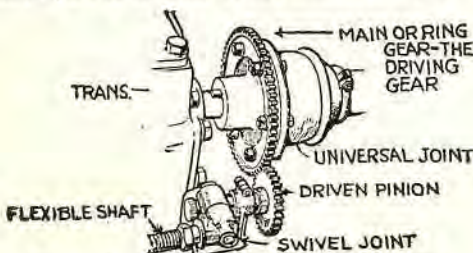


Fig. 6. Stewart speedometer, propeller-shaft drive.

transmission main shaft. Fig. 6 shows how the driving gear is attached to the front of the forward universal joint. The swivel joint and gear section are clearly depicted. Other manufacturers are now adopting a set of gears inside of the transmission case, to drive the speedometer shaft.

The speedometer flexible shaft is shown in Fig. 7.

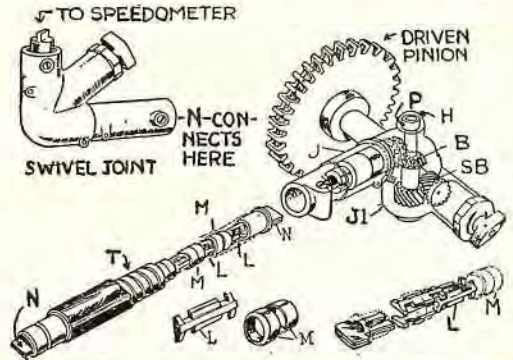


Fig. 7. The speedometer flexible shaft (Waltham, as an example) is made up of a series of links (L), which are held in position by a series of steel collars (M). The links (L) are covered with flexible tubing (T). The illustration shows the flexible shaft together with other fittings, including swivel and angle joints.

Ratio of Gearing

The ratio of gears for a speedometer when driven from front wheels is found by doubling the diameter of the tire. This gives the number of teeth necessary in the large driving or road wheel gear. For example, a 30 x 4 tire would require a 60-tooth gear, etc. **Driven pinions** (small) on all Stewart-Warner speedometers, for front axle drive, have the same number of teeth, viz., 16, and drive through a 2½ to 1 swivel-joint reduction.

The gear reduction in the swivel joint is mounted close to the driven pinion, as shown in Figs. 5 and 7. When installed on the left-hand wheel, a swivel joint is used which reverses the direction of rotation.

Calibration: The Stewart-Warner speedometer flexible shaft travels 1,009 revolutions per minute when the car is traveling 60 miles per hour.

On all Stewart speedometers the space between the main gear (1, Fig. 5) and the pinion gear (2), should be 1/16". Also note that the main gear should have twice the number of teeth that there are inches in the diameter of the tire.

When tires are changed to oversize, the car should be taken to the speedometer service station and gears changed.

Speedometer Care and Troubles

The following matter refers to the Stewart speedometer, some of the instructions and illustrations being taken from the Studebaker instruction book.

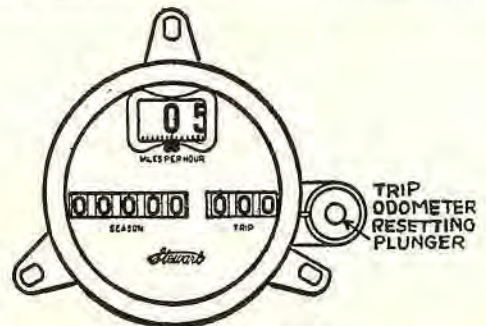


Fig. 8. Front view of speedometer.

Resetting odometer: Pull out the trip odometer, resetting the plunger (Fig. 8), after which turn to right or left as much as necessary to show the figures you desire to have appear. After resetting the odometer, do not fail to push the resetting plunger in as far as possible, or else the trip odometer will not register. The speedometer is a very delicately adjusted instrument, and must be handled carefully to insure continued satisfactory service.

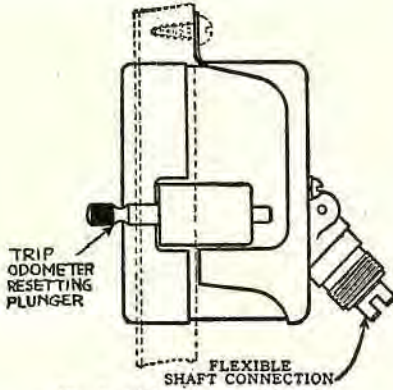


Fig. 9. Side view of speedometer.

Lubrication: Do not attempt to lubricate the speedometer head under any circumstances.

To lubricate the shaft, disconnect upper end tip, and pull chain out of casing from lower end. Cover the links liberally with Stewart Lubricant, and insert lubricant which can be obtained of Stewart service stations or Stewart-Warner Corp., Chicago, Ill.

Speedometer Troubles

If the speedometer is not operating satisfactorily, look over the installation and see if it is in accordance with the following instructions:

Flexible shaft connection: Make sure that the clutch in the flexible shaft enters the slot in the neck of the speedometer (shown in Fig. 9, "Flexible Shaft Connection"). The sliding bar on the other end of the flexible shaft enters the slot in the driving shaft at transmission.

Speedometer Adjustments

Dial vibration results in failure to indicate speed and mileage. Noisy instruments are caused by any of the following:

1. Loose union connection between speedometer and flexible shaft connection.
2. Loose union connection between driving shaft at transmission and flexible shaft. (These unions on flexible shaft should always be kept as tight as possible.)
3. The flexible shaft may be bent at a sharp angle. This condition causes the shaft at times to bind, making the dial unsteady.
4. The worm gear and pinion at the drive end may be either meshed in part only or entirely out of mesh, due to speedometer pinion gear sleeve at the rear of the transmission being loose. The shaft should be shoved in the housing as far as possible, and the nut tightened.
5. The flexible shaft may not be well lubricated, which causes erratic shaft movement and unsteady indication. The manufacturer has a special grease for this purpose.
6. The chain in the flexible shaft may have broken. If so, it can be quickly repaired by replacing the

broken link. If the chain breaks, unscrew both shaft connections and remove the chain from the outer casing. Then repair the break by hooking into place a new link—a very simple operation—replace the chain, and screw both shaft ends into place. Extra links may be obtained from Stewart-Warner Corporation branches or service stations at a nominal cost.

When speedometer pointers vibrate, look for loose unions, connection, flexible shaft bent too sharp, lack of lubrication, gears not properly meshing.

Failure to indicate speed: Look for the same causes as above; also for a broken link in the shaft.

Noise may be due to lack of lubrication or any of the causes described above.

Checking a Speedometer

A simple test worked out by Mr. S. T. Williams of the *Motor World* is shown in the table below, and is as follows:

When the drive is from the front wheel, jack up the wheel. A chalk mark is then placed on the rim of the wheel, and the wheel is turned as fast as possible.

At a signal, one person reads the speedometer, and another counts the revolutions for one minute, as timed by a stop watch, or the second hand of a watch. The number of revolutions of the wheel, and the speedometer reading at the start and finish are noted. (By adding the two speedometer readings, and dividing them by two, the average speed as recorded by the speedometer is determined.)

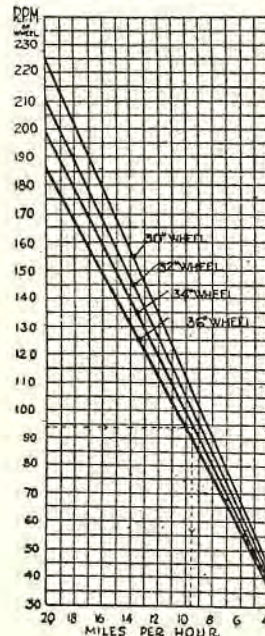


Fig. 10

The actual speed may be obtained from the chart in Fig. 10. Supposing the revolutions in the minute to have been 94, a horizontal line is followed until it meets the slanting line representing the diameter at the front wheel, assume it to be 34". Dropping down vertically, the speed is seen to be 9.6 miles per hour—which should correspond to the speedometer readings. If carefully made, this test is quite accurate, and requires little time.

INSTRUCTION No. 40

ELECTRIC PARTS OF A CAR: Preliminary Instructions for Locating Troubles of the Electric System

DIVIDING THE ELECTRIC SYSTEM INTO PARTS AND TROUBLES THAT COULD OCCUR

Before it is possible to diagnose properly, or to test for any trouble in the electric system of a car, it is first necessary to know the fundamental principles underlying all the parts, their location, and the relation of one part or another.

The fundamental principles of all parts of the electric system have been dealt with in preceding instructions. We shall now deal with the division of the parts, the troubles that are likely to occur in each part, together with the effect that these may have on some other part, and also with the devices, instruments, and tools necessary to locate troubles and to remedy them.

Electric troubles may be in the external parts, or in the internal parts. If trouble occurs in the ignition system, then the point to begin at would be the source of electric supply of the ignition system, tracing through the external parts of this system. Then if the trouble is not located, the test should extend to the internal parts, such as the winding of the ignition coil, the condenser, etc. The same procedure would apply to the starting motor, the generator, the battery, the cut-out, etc.

Hence the necessity of dividing the electric system into component parts and testing the circuits of each part, and at the same time considering the relation of that part to some other part. In other words, intelligently to diagnose electric troubles requires a knowledge of the fundamental principles of all the parts and their relation to each other. The importance of separating the parts, in order definitely to be able to locate the trouble is the point to consider in this instruction.

If we separate the electric system of a car into its main external parts, we have:

1. The storage battery.
2. The generator.
3. The starting motor.
4. The wiring system.
5. Dash ammeter.

(1) Storage Battery

If we take the storage battery and divide it into its component and internal parts, we have:

- (a) The storage battery plates.
- (b) The storage battery separators.
- (c) The storage battery jars.
- (d) The storage battery electrolyte.
- (e) The storage battery connectors and lugs.
- (f) The storage battery ground connection.
- (g) The storage battery terminals.

Any of the parts of a storage battery mentioned above could cause trouble, such as plates being internally short-circuited, separators becoming rotted, jars leaking, electrolyte falling below the level of the plates, connectors or lugs not being burned properly and thus making poor contact or open circuits, ground connection loose, and making poor contact or open circuits, and terminals also.

The construction, care, troubles, tests, and repairs of storage batteries are treated under the storage battery subject.

Usually, when automotive electrical troubles occur, the battery is tested first (the source of electrical supply). If in good condition, then attention is directed to the current-consuming devices. If not in good condition, then the next step is to determine if the trouble is due to discharged or defective

battery. Tests on pages 545-553 will determine this. If discharged, then the next step is to determine if the discharged condition is due to the generating system, or excessive current consumption, and thus step by step to locate the cause of the trouble.

(2) Generator

If we take the generator and divide it into its component and internal parts, we have:

- (a) The field poles and frame.
- (b) The shunt-field windings.
- (c) The regulation of the shunt-field winding circuit.
- (d) The armature
- (e) The commutator.
- (f) The brushes.
- (g) The cut-out.

Any of the parts mentioned, if defective, would interfere with the proper operation of the generator, for instance:

- (a) The field poles, if loose where they are held to the frame by screws, would probably result in damage to the armature. The proper clearance between the ends of the field poles and the armature is a point to consider.
- (b) Field windings, if grounded with the field pole, or if one coil is grounded with another, or if short-circuited, would either carry no current at all, or, at best, a weak current.
- (c) The regulation system, such as the electromagnetic "voltage regulator," or the "current regulator," may not be properly adjusted. These regulators are usually connected with the shunt-field winding of the generator, and if not properly adjusted, they would permit too high or too low an output of the generator.

Furthermore, the regulator windings may be open-circuited or short-circuited, thus necessitating a test of the windings. Or the points of the regulator may be burned together and fail to open, or the resistance, usually connected with the points, may be burned out.

If the regulation is of the "third-brush" type, the brush may not be seating properly, or the brush may be worn too short, or there may be poor connection of the brush with the wire connecting with it, or an improperly adjusted brush.

All or any one of these troubles in the regulation system would prevent the shunt-field winding from building up lines-of-force properly and would thus affect the output of the generator.

- (d) The armature troubles are principally either in a short-circuited or in a grounded armature coil; that is, one wire may be shorted to another wire internally of the armature, or one wire may be grounded with the core of the armature, or there may be open circuits, where the wire is broken, or loose at the commutator.
- (e) The commutator gives more trouble than any other part of the generator. Eighty per cent of the generator troubles are indicated by the condition of the commutator.

A commutator blackened over its entire surface indicates too much grease and carbon dust. Rough commutators require turning down in a

lathe or being sanded. Mica insulation, which is placed between each commutator segment, will protrude in time, as the copper, being soft, wears. As a consequence, the mica protrudes and prevents the brushes from making good contact, thus causing arcing at the brushes which, in turning, burns the commutator. There are other causes of commutator troubles, such as loose segments, loose wires to segments, etc., all of which will be taken up farther on. Oil should never be placed on a commutator.

- (f) The brushes are a source of trouble, principally when they fail to make good contact, when there is improper spring pressure, when the brushes are stuck in the brush-holder or are worn short, when the brush-holder is loose or when there are loose connections. All these affect the operation of a generator. When new brushes are fitted, it is important that they be seated to the curvature of the armature (explained farther on).
- (g) The cut-out has two windings: a "voltage winding" and a "series winding." The voltage fine wire winding connects across the main circuit of the generator. In some instances the cut-out points burn together and permit the current to flow back through this fine wire winding, which burns it out.

The cut-out series winding is connected in series with the charging circuit from the generator to the battery, and is a larger wire. It seldom burns out, but may become short-circuited, or open-circuited. The windings can be tested for open circuits, short circuits, and grounds, just the same as the generator field-windings, the armature coil windings, and the regulator windings; explained farther on.

The cut-out points sometimes stick together, thus permitting the battery to discharge back through the generator, which is usually indicated in the ammeter on the "discharge" side. This necessitates cleaning and adjusting points.

(3) Starting Motor

If we take the starting motor and divide it into its component and internal parts, we have:

- The field poles and frame.
- The field windings: straight "series" or "series parallel."
- The armature.
- The commutator.
- The brushes.
- The bearings.
- The starting switch.
- The ground connections.

(a) Field pole troubles are not common, but it is well occasionally to tighten the screws holding field poles to the frame, with a screwdriver.

(b) The field windings, like the generator field-windings, can be tested for open circuits, short circuits, or grounds, explained farther on.

(c) The armature troubles of a starting motor are usually due to the bearings giving way and permitting the armature to strike the pole pieces, thus injuring the armature windings.

The armature windings can be tested for open circuits, short circuits, and grounds, in the same manner as a generator armature, as will be explained farther on.

The armature shaft is sometimes bent or twisted, because of the back firing of the engine and hard strains. How to test and straighten this is explained farther on.

(d) The commutator on starting motor is subjected to a great amount of current passing through it. Thus if it is roughened, it should be turned down in a lathe. It is seldom that the mica protrudes, as in a generator commutator, because the starting motor is not used as much as the generator. Loose wires from the armature coils to the commutator segments sometimes come loose and require soldering.

(e) Brush troubles on a starting motor are usually due to poor contact on commutator, or to loose brush-holders. Brushes should seat properly.

(f) Bearings of a starting motor are usually plain bronze bearings which may become worn from the lack of oil and long service. Thus when a heavy charge of current (150 to 300 amperes) passes through the armature and the field-windings, as the armature revolves, it is forcibly drawn to the pole pieces, since the air-gap or clearance is very slight, with the result that the armature strikes the pole pieces and damages them. This usually necessitates a new armature and end-plates with new bearings.

(g) Starting switch troubles usually result from poor connections, loose parts, or burned contacts.

(h) The ground connection from battery to frame, which is a part of the starting circuit, should occasionally be examined. If not properly made when first installed, the connections will corrode and cut down the current supply, not only to the starting motor, but to all of the other circuits. Vibration often causes this contact to become loose.

(4) Wiring System

If we take the wiring system and divide it into its various circuits, we have:

- The starting-motor circuit.
- The generator charging circuit.
- The ignition circuit.
- The lighting circuit.
- The horn circuit.
- The ground connections.

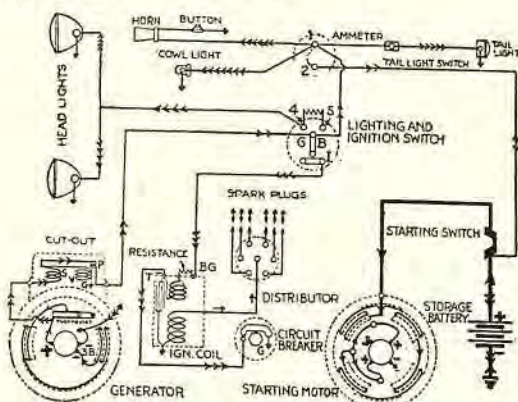


Fig. 1. Diagram of a Remy electric system as an example. The object of this diagram and the explanations is to point out where to start when tracing different circuits in order to locate troubles intelligently. Note the arrow points.

Single arrow: starting-motor circuit.

Two arrows: generator charging circuit.

Three arrows: ignition circuit (primary).

Four arrows: headlight circuit.

Five arrows: tail-light circuit.

Six arrows: horn circuit.

Seven arrows: cowl-light circuit.

Single arrow to the side of wires: secondary ignition circuit.

Where to Start Tracing When Trouble Occurs

(a) **The starting-motor circuit:** The circuit in this example would start from (+) of the battery, thence to the starting switch, to the motor, to ground, to (-) ground of the battery, as shown by single arrows on the wires.

If the (+) terminal of the battery is grounded, then the starting of the circuit would be at the grounded (+) terminal of the battery, to the (+) grounded brushes of the starting motor.

The parts included, therefore, in the starting-motor circuit are the battery, the heavy wire, the starting switch, the motor field-windings, the brushes, the commutator, the armature, the ground connection of the motor, and the ground connection of the battery.

(b) **The generator charging circuit:** The point at which to start in the example (Fig. 1) is with the (+) brush of the generator, to the cut-out series winding, through the closed cut-out points, to the ammeter, as shown by two arrows on the wires.

If the (+) brushes are grounded, then the (+) terminal of the battery would also be grounded, and the start would be from the (+) grounded brushes, to the (+) grounded battery terminal, thence to the starting switch, where the main charging wire usually connects, to the ammeter.

Thus the parts of the generator main charging circuit include the generator armature, the brushes, the cut-out, the ammeter, the connection to one side of the starting switch, the battery, and the battery ground connection.

Troubles which are common in this circuit are open circuits, grounds, short circuits, and poor connections; and the poor connections would include poor brush contact, loose terminals, and loose or corroded battery terminals and ground connections. It is very important that the third brush of a third-brush-regulated generator be properly seated.

(c) **The ignition circuit** takes its current from the battery, at switch connection (B), when the engine is first started, or when it is running slow. When the engine is speeded up, the generator generates sufficient voltage to charge the battery, and the current for ignition is then taken from the generator at switch connection (G).

In the example shown in the illustration (Fig. 1) the (-) terminals are grounded; therefore the start for the ignition circuit is at the (+) terminal of the battery or at the (+) terminal of the generator, to the switch at (B) or (G), to (I), to the resistance unit on the coil, through the primary winding, to (T), to the contact-breaker, to ground (G), to the (-) ground of the battery or generator.

If the (+) terminal of the battery and generator are grounded, then the start would be from (+) of the battery or generator to the grounded terminal of the contact-breaker.

The ignition circuit is divided into two circuits, the primary low-tension circuit and the secondary high-tension circuit.

The primary or low-tension circuit includes the ignition switch, the ignition resistance unit, the primary winding and the contact-breaker, and also the condenser, which is always placed across the contact-breaker points.

The condenser is sometimes placed in the coil, and sometimes on or in the contact-breaker housing, but in every instance it connects across the contact-breaker points.

The resistance unit is sometimes placed on the coil and sometimes on the contact-breaker housing, and is always in series with the primary circuit.

The secondary circuit is an independent circuit, termed the "high-tension" circuit. It starts with the secondary winding in the coil, through a very heavy terminal, thence to the center of the distributor, to the rotor, thence to the segments or points, where it is distributed to the spark plugs in their regular firing order, thence to ground, to the grounded terminal of the secondary.

The parts therefore include the secondary winding, the distributor, and the spark plugs.

The primary ignition circuit usually takes its current supply from the switch (if (-) terminal is grounded). Note in the diagram that the connection to the switch is from the ammeter. If the battery supplies the current, then the current must pass through the ammeter on the "discharge" side, whereas, if the generator supplies the current, it is taken direct at switch terminal (G), and thus does not pass through the ammeter.

Troubles which are common with the ignition circuit are: open circuits, grounds, short circuits, poor connections, both externally and internally of the coil, also burned-out resistance units, loose condenser connections, defective or short-circuited condensers, incorrect adjustment of contact-breaker points, burned or pitted points, incorrect timing or opening of points of contact-breaker, defective distributor, incorrect spark-plug gap, leaky spark plugs, fouled spark plugs.

(d) **The lighting circuit** includes the headlight circuit, the dimmer or auxiliary light circuit, the tail-light circuit, the cowl board or instrument light circuit, and, in a closed car, there will probably be a dome light and tonneau light. In this example a dimmer resistance is thrown in series with the headlights to dim the headlights. If switch connection is made at (5) (Fig. 1), the dimmer resistance is in series with headlights. If connection is made at (4), the dimmer is not in circuit, and headlights are bright.

The lighting circuit starts at the ammeter (1), to switch (B), if the battery supplies the current, and from the switch at (G) if the generator supplies the current; that is, on the assumption that the (-) terminal of the battery and generator are grounded, which they are in the example shown on page 449.

If the (+) terminals are grounded, then the circuit would start from the (+) ground of the battery and generator to ground of the lamps.

If current for lights is taken from the battery, the current in the example (Fig. 1) (and on many other systems) must pass through the ammeter (2) to (1), and thus it shows "discharge."

If current is being taken from the generator for lights, it is taken from (G) on the switch for the headlights, and one side of the ammeter (1) for the other lights, but does not usually pass through the ammeter.

The current passes through ammeter, however, from (1) to (2) (or in the opposite direction to that in which it passed when the battery was discharging). When the generator is charging the battery the needle will show "charge."

If the (+) of the battery and generator are grounded, then the start would be from this ground to the ground of all light circuits, as shown in Fig. 8, page 426.

Either a fuse (page 426, Fig. 8), or a circuit-breaker (see Delco system, Fig. 15, page 392) is always placed in the lighting circuit. A fuse or circuit-breaker is seldom in any of the other circuits except the horn, which always has a fuse or circuit-breaker in series with the circuit.

Troubles which are common in the lighting circuits are open circuits, grounds, short circuits, poor connections, burned-out bulbs, and blown fuses.

If all of the lights fail to burn, the indications are a blown fuse. Therefore the first place to look is at the fuse; if the fuse is not blown, then an open circuit exists.

If only one of the lights fails to burn, the indications are that the bulb is burned out or an open circuit exists on that line.

If the ammeter shows "discharge" with all switches off, then the indications are a "ground." If the discharge is heavy, a short circuit in the wiring exists at some point, and the fuse should "blow" if there is one in the circuit.

When troubles of this nature occur, the trouble should be located before a new fuse is installed.

(e) The horn circuit is usually taken from the ammeter (1), in the same manner as described under the subject of lights. A push-button is usually placed in the top of the steering column. A fuse is always connected in the horn circuit, or else in the circuit-breaker circuit, as on Delco systems.

Troubles of the horn circuit are open circuits, grounds, short circuits, push-button defects, and also troubles internally of the horn. See Index for "Electric horns."

(f) Grounded connections: By referring to Fig. 1, and to Fig. 8, page 426, and to all other wiring diagrams of the single-wire, ground-return systems, it is to be observed that the grounded connection of the battery not only serves for the generator charging circuit, but is also a return path or lead for all circuits. Hence the importance of seeing that this and all ground connections are tight.

(5) The Dash Ammeter

The dash ammeter might more properly be termed the cowl ammeter, as it is placed on the cowl or instrument board of the car.

The purpose of this instrument is to indicate the amount of current passing from the generator to the battery, and indicates on the "charge" side of the zero (0) of the ammeter.

When current is being taken from the battery for lights and ignition (not for the starting motor), the current is from (2) to (1), and the needle of the ammeter indicates on the "discharge" side (see also page 334). Thus it is clear that if the ammeter shows "discharge" when it should show "charge," or if it shows "discharge" when all switches are off, it indicates something is wrong. This subject is treated on pages 471 and 472.

On some cars, for instance the Franklin, an indicator is used instead of an ammeter. This device indicates when the battery is "discharging" or being "charged." Unlike the ammeter in one respect, although it serves the same purpose, it can be placed in the circuit of the battery to the starting motor. Owing to its construction, it will show "charge" or

"discharge" on 2 amperes of current, yet it is capable of withstanding 300 amperes and any voltage. The ammeter, however, is universally used.

If the ammeter should be connected wrong, or if the battery is connected wrong, the ammeter needle will read in the opposite direction.

The point to note is this: Usually the ammeter is the point from where the ignition, lighting circuits, and horn derive their source of electric supply for either the battery or generator, and that the current runs thence to the switch.

Summary

The various parts and circuits of the electric system have now been fully dissected. The reader should bear in mind that the only successful method of diagnosing electric trouble is to locate the circuit or the part the trouble is in, and to eliminate one possible cause after another, until the probable cause is arrived at. We could fill this book with an enumeration of possible troubles, their cause and remedy, but the simplest method is to learn the fundamental principles of each part, the circuits, and the relation of one circuit and part to another, and then to THINK—and to use intelligent thought before deciding, or even starting to locate a trouble.

When making tests, first determine which one of the parts or circuits the trouble is in, and then test that part from the beginning to the end.

For instance, if the generator fails to show "charge" on the ammeter, start at the (+) of the generator, then the fuse (field fuse), then the cut-out, then the circuit. If the fuse is blown, there must be a short circuit. Find the cause.

If lights fail to burn, first examine the lamp-bulb to see if it is burned out; if not, then the lamp-socket, then the fuse; then start at the switch, and then test the wiring. If the fuse is blown, find the cause.

Points to Remember

Remember this same principle applies to a two-wire system.

Remember that when a fuse-block is used in a circuit, the fuses are merely cut into each circuit, which will melt and open the circuit if a wire or part becomes short-circuited. The cause of the "blowing" should always be learned.

Remember that a fuse is never used in the starting-motor circuit, but a fuse is used in the field-circuit in nearly all third-brush regulated generators. If the fuse is blown, the generator will not generate current. Also remember that the ammeter is never connected into the starter circuit unless it is connected with a "shunt."

Remember that the cut-out is often placed integrally with the generator. For instance, on the illustration, page 364, the cut-out is in the generator housing and is connected internally with the generator.

Remember that the regulation of the output of a third-brush generator does not have a separate mechanism to regulate the current, and that it is important that the third-brush, as well as all other brushes, should be properly seated to the commutator.

Remember that a generator which has a voltage regulation system does have a mechanism called a "voltage regulator," which controls the output.

Remember that a Wiring Diagram Book will tell you just what kind of a regulation system a generator has, and will also show the external and internal circuits.

OPEN CIRCUITS, POOR CONNECTIONS, GROUNDS, AND SHORT CIRCUITS

Throughout the preceding instructions, frequent reference is made to the subjects in this heading. We shall now analyze the meaning of these and their relation. In fact, practically all of electric troubles are due to open circuits, poor connections, grounds, or short circuits in some part of the electric system.

Open Circuits

Open circuits, as the name indicates, is a point where any part of a circuit is opened. It is an incomplete circuit, and thus it does not offer a passage for the current.

Low-tension (voltage) direct current is used in all circuits of the automobile, except in the secondary ignition circuit, which is an independent circuit of a high tension. The secondary circuit, however, is dependent upon the low-tension primary circuit for its existence.

In order that electricity may flow, it must have a complete circuit to flow in, even though it is not a copper path all the way. For instance, the steel frame of the car can be, and is, used for a part of the path.

Electricity starts at the positive or (+) terminal of the generator or battery, and returns to the negative or (-) terminal.

Thus if the circuit or path is open, the low-tension current cannot pass or jump across a gap, and this is termed an "open circuit."

Causes of open-circuits may be said to be loose connections or blown fuses, broken wires, or the fact that brushes on the generator or motor do not make contact; also open circuits may occur at the commutator where the armature coils are soldered to the commutator segments, or possibly on the armature coils themselves, or in the field windings, or in loose or poor connections at the battery or ground wire.

Indications of open circuits are: Lamps failing to light, ammeter failing to indicate "charge" or "discharge," the starting motor failing to start, absence of spark at the spark-plug points. In fact, an open circuit could exist in any one of the circuits, but seldom in all circuits at one time; hence the importance of knowing the different circuits and their relation one to the other.

There are several methods of testing for open circuits, all of which will be explained farther on. A few pointers are given below.

If any one lamp fails to light, it indicates an open circuit in that line. "Blown" fuses, a broken lamp filament, or a broken lamp wire may be responsible.

If all lamps fail to light when the engine and dynamo are speeded up, the open circuit is most likely located between the battery and the dynamo, or between the dynamo and the lighting switch.

The "blowing" or melting of a fuse opens the circuit and disconnects from the system the short-circuited wire which caused the fuse to blow. Therefore the cause should be located, before replacing a fuse.

An open circuit that often occurs, and that is difficult to find, is a broken wire inside of the insulation of the lighting wiring. The easiest way to find the break is first to determine which one of the wires is open and then temporarily to run another wire in its place and note if it remedies the trouble.

Testing current flow: Whether or not current is flowing in a given circuit may be determined by removing one of the wires forming the circuit, and then touching it to its terminal. If a spark occurs, current is passing through the line.

Loose and Poor Connections

It is also well to notice the close relation of open circuits and loose connections. If connections are poorly made, but not completely loosened from the terminal, then there will very likely be an "intermittent open circuit," that is, the circuit will be complete at times, and at times open.

Grounds

There are two kinds of grounds: one which is intended to ground the circuit, as from the battery to the frame of the car, and one which is not intended to ground, but does so for various reasons. It is with this latter ground that we shall deal here.

In speaking of an intended ground, bear in mind that it has no connection whatever with the ground or earth. It is merely a term used to indicate that a part of the circuit is connected to some metal part of the car, thus saving the necessity of using two wires for a circuit.

Wires that are grounded, but not intended to be grounded, can be the result of numerous causes. For instance, if the insulation on one or more of the armature coils is in such a condition that there is a leak of current through the insulation to the metal core of the armature, it would be termed "grounded."

Or if two wires are oil-soaked and close together, and if they leak current from one to the other, the circuit may not be completely short-circuited, but it will be "grounded," and thus reduced in value, owing to the leak, which results in a weak current supply.

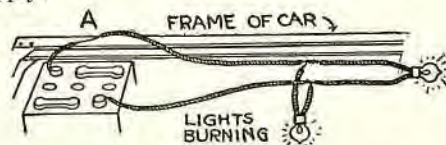


Fig. 2. A ground.

Another example of a ground is shown in Fig. 2, where a two-wire system from a battery is shown connected to two lights. If the wire was grounded to the frame at (A), the current could still flow to the lamps. Therefore, a "ground" might be termed an electrical "leak."

Short Circuits

A short circuit means that two conductors of current are in metallic contact when they should not be.

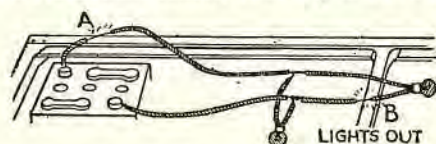


Fig. 3. A short circuit with wires which are supposed to be insulated from the frame.

For example, on a two-wire system, as in Fig. 3, if one wire was "grounded" to the frame of the car, as at (A), and the other wire of the circuit was grounded at (B), a "dead short circuit" would be the result, and the lights would not burn at all. The path of the current from the battery would be shortened, and as electricity takes the path of least resistance,* it would flow freely through the frame of the car instead of through the lamps, which are of higher resistance. The result would be that the battery would discharge at a very high rate. In fact, the effect in this instance would be the same as connecting a wire across the terminals of the battery, and unless the wire was of very large size, it would get very hot, or burn into and thus damage battery internally. For this reason fuses or circuit-breakers are used in some of the circuits such as the lighting and horn circuits, which are longer and are more exposed, and nearer to the frame, to dampness, etc.

* See footnote, p. 237.



Fig. 4. A short circuit where one wire is insulated and the other grounded.

An example of a short circuit on a single wire or grounded return system of wiring is shown in Fig. 4. Under these conditions we should have the same result as in Fig. 3.

Note, for instance, that the circuit (when not short-circuited) is from the positive terminal of the battery, to the grounded connection to the frame, to the grounded connection at the end of the frame (which is intended), through the lamp, to the negative terminal of the battery.

Suppose the wire, as shown, becomes short-circuited or in contact with the frame at (A): the result is that the path is shortened and the current would flow from the positive terminal of the battery, through the ground connection, to the frame, through the wire in contact with the frame at (A), to the negative of the battery. Thus the current is short-circuited and would not pass through the lamp, since the easier path is through the wire where it makes contact with the frame. The effect on the battery would be the same as placing a wire directly across the battery terminals, which would be termed a "dead short circuit" across the battery terminals.

Indications of Grounds

If there is an ammeter on the car, it will show a "discharge" with all switches off. The needle should stand at "0" when all switches are "off."

Lamps when turned on will burn dimly, in case of a ground.

TESTING ELECTRIC HORN AND CIRCUIT

Testing horn circuit: Test with ammeter, using 30 ampere shunt (Fig. 6). Adjust horn to take least amount of current. The average horn takes from 3 to 8 amperes, depending on size. If amperage is very high, it is probably due to dry or dirty bearings, commutator, brushes, or short circuits or grounds internally (see also pages 451, 485, for other tests, and page 445 for "Horn trouble diagnosis").

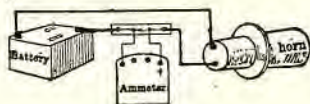


Fig. 6

Testing Horn Motor

Use a test light and look for indications as mentioned below. Before making test, disconnect

Testing for a ground is made by several different methods, but if the ammeter shows "discharge" with the switches "off," then it is a matter of finding which wire is grounded. This will be explained farther on.

If there is no ammeter on the car, and a ground is suspected, then turn all switches "off" and disconnect the wire at the terminal of the battery (as in

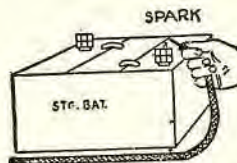


Fig. 5. One method of testing for a ground.

Fig. 5), and strike the terminal in quick succession. If a spark occurs, even though very slight, it indicates a "ground." Grounds will cause the battery to discharge. The rate of discharge will depend upon the intensity of the ground.

Indications of Short Circuits

If there is an ammeter on the car, the needle will probably go to the limit of the scale on the "discharge" side.

Fuses will blow repeatedly.

If a short circuit exists in the starting-motor circuit, it will probably be indicated by the wires getting very hot, and the smell of burned insulation can be noticed. In fact, a "dead short circuit" would cause the insulation to burn and smoke. This would seriously injure the battery internally if permitted to continue for a long period of time.

As previously stated, grounds, short circuits, and open circuits may exist in any part of the circuit, even to the armature and field-windings. The indications and appropriate tests will be taken up in their respective order farther on.

Before taking up the subjects of electrical tests and tools and devices to test with, a Digest of Troubles will be given in the next instruction, which is to be used as a reference.

wires from horn terminals (see Fig. 11, of the North-East horn, page 445).

Testing for ground in brush holder or field coil: (1) insulate brushes from commutator (in grounded type, remove ground connection first); (2) test from each brush holder to frame. Light indicates a ground.

Testing for ground in armature: (1) insulate brushes from commutator; (2) test from commutator to frame. Light indicates a ground.

Testing for short circuit in armature: (1) use a growler (see page 499).

Testing for open circuits in field coils: (1) insulate brushes from commutator; (2) test from positive terminal to positive brush holder and from negative terminal to negative brush holder. Failure of test light indicates open circuit between parts tested.

INSTRUCTION No. 41

DIGEST OF TROUBLES: Electrical Troubles; Engine Troubles; Miscellaneous Troubles

MAKING A DIAGNOSIS

Diagnosing automobile troubles requires thought and reasoning. If a person understands the principle and construction of the various parts of a car and one of the hundreds of possible troubles occurs, then simply reason it out; ask yourself what the trouble is, what could cause that trouble, and why the trouble is there. Find out if it is ignition, carburetion, cooling, or just what the trouble is, and then figure it out the best you can before proceeding.

It is of little use to turn the engine over and over by the starting handle or by means of the engine starter, in an effort to get it going. If the engine will not start with a few turns, the chances are that there is something radically out of order, requiring intelligent attention. With the carburetor giving a correct mixture, the ignition system affording a hot and effective spark, and everything else apparently all right, it should be as easy to secure an explosion on the second stroke as on the sixtieth. So if the engine will not start with the second or third attempt, it is not likely to start with three or four hundred attempts; consequently it is better to find out the cause of the trouble than to turn the engine over indefinitely and run the battery down.

To Make an Engine Run Two Things Are Essential

Always remember, when diagnosing troubles, that there are two essentials to the running of an engine: first, gasoline; second, a spark.

The gasoline must reach the inside of the cylinders, and the spark must be there at the proper time to ignite the gas. If you have both, something is bound to happen, even though it is but a single explosion.

Next, remember that even though you have a spark and gasoline—the engine will not run properly if the gas does not enter the cylinder at the right time “and stay there,” and be in a proper gaseous form.

The gas cannot be ignited regularly if there is not a good, hot spark at the correct time.

Next, remember that if an engine is not properly lubricated and cooled it will heat. If the engine is too cold, heat must be applied for proper carburetion.

Therefore, speaking generally, we find that most troubles are found to originate in ignition, carburetion, and lubrication.

If trouble occurs, first find which of the three headings the trouble comes under and then reason it out.

The object of this digest or condensed account of troubles and remedies is simply to give you an idea of what would be likely to cause certain troubles and what would be likely to remedy them. The reader will then decide which one is most probably the trouble confronting him, and if he does not know

the meaning of certain adjustments called for, he will then turn to the Index, find the subject mentioned, and read up on that subject.

Systematic Trouble Hunting by a Process of Elimination¹

In dealing with engine troubles, one should always try to figure out the possible cause of a trouble before starting to adjust something that does not need adjusting.

An adjustment never should be changed without a knowledge of why the change is made, the effect the change should have, and how to restore the mechanism to its original adjustment.

If one will first reason out the probable causes of a trouble, the real cause can be quickly located. For instance, if a single lamp fails to burn, you will know that the trouble is not in the battery or the generator if all the other lamps burn. Therefore the cause must be in that particular lamp, in the socket, or in the wiring of that particular lamp.

Similarly, if the starting motor fails to start the engine, yet you know that it is turning the engine crank shaft, and your lights burn brightly, you would not look to the battery for the trouble, but you would know that the trouble must be with the ignition or carburetion. It is then a matter of applying the process of elimination—that is, test each of the remaining probable causes until the final cause is the only one left.

When the possible cause of trouble cannot be imagined, then begin with a careful examination of all the features of the engine that are likely to give rise to the trouble.

If nothing out of order is found, then begin testing out the various features, beginning with the easiest and most accessible, and thoroughly complete each test before starting on another possible cause.

For example: If your ignition system is suspected, the easiest thing to test would be the spark plugs. First find the faulty plug; then proceed from the spark plugs to the wiring between the plug and the distributor; then examine the battery connections, the switch connections and, last of all, the adjustments of either the timer, the coil, or the magneto.

Do not examine a spark plug and then leave it and try a few carburetor adjustments, and later come back for another spell of tinkering with the ignition, etc.

If you suspect the ignition system, go to it from beginning to end in a systematic manner before proceeding with the carburetor, and likewise with all other parts.

¹ See Index for “Digest of lighting troubles” and see Index for “Storage battery troubles” and “Tire troubles,” as well as for subordinate subjects involving “troubles.” See also pages 512 to 519.

DIGEST OF GENERATOR TROUBLES:

When troubles occur in the electric system of a car, remember that the electric system is divided into four parts: the lighting circuit, the generating circuit, the starting-motor circuit, and the ignition circuit. The idea is then to determine in which of the circuits the trouble is, and then to test it from beginning to end, as previously explained.

The troubles and the indications and causes of generator troubles can be classed under two heads: those which are due to mechanical defects and those due to electrical defects.

Mechanical Generator Troubles

Indications: Noise; low current generated, or no current at all.

Causes: (1) Broken bearing (examine by turning armature by hand. If it sticks or turns hard, look to ball bearings and replace); (2) loose driving gear or pinion (if loose, key to shaft); (3) armature off center (may be due to loose pole pieces. See that the screws with counter-sunk heads on outside of generator are tight); (4) shaft bent (this is more common on starting motors than on generators. A new armature is required if shaft is bent); (5) commutator burst (when this happens the brushes and brush-holders, etc., are also damaged. A new armature, brushes and brush-holders are required).

Electrical Generator Troubles

Electrical troubles can be classified as: (a) open circuits; (b) grounded or short circuits; (c) defective regulation system; (d) defective cut-out.

(a) **Open-circuit indications** would be a low current generated, or none at all.

Causes: (1) Brush connections poor; (2) brushes stuck; (3) brushes worn too short; (4)

brush spring broken, with consequently no spring pressure to hold brush to commutator; (5) dirty commutator; (6) if the armature is open by connection being loose at commutator, or owing to a broken coil, it would cause intense blue sparking at commutator and flattened commutator bars; (7) field coils, if open, will show no current at all, or if partially open, a low current generated.

(b) **Ground or short circuits** may be (1) at main terminals; (2) at brush connections; (3) at brush holders; (4) armature, if short-circuited, will cause excessive heating of armature, burned insulation, and low current; (5) field coils, if short-circuited, will cause field coils to heat and low current to be generated; (6) commutator, if short-circuited, will produce no current at all, or a low current output.

(c) **Regulation:** In this instance we shall deal with the "third-brush" system of regulation. If a "voltage-regulated" system is used, see Index.

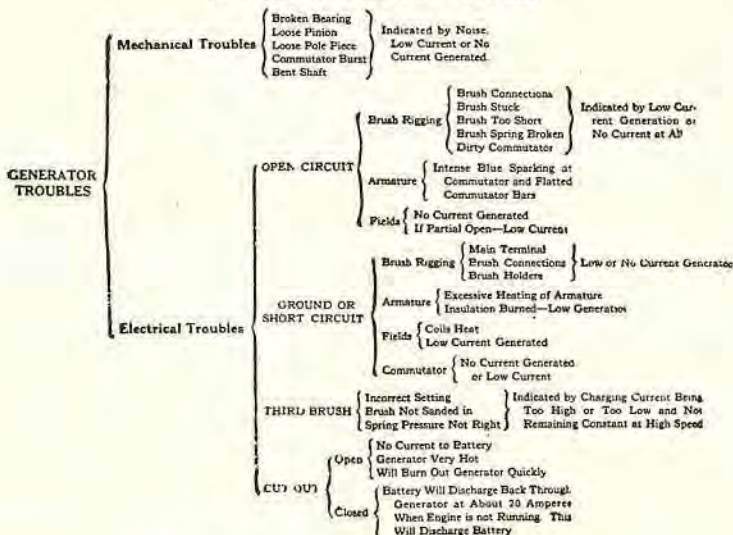
Indications will be that the charging current is too low or too high, and does not remain constant at high speeds.

Causes: (1) Incorrect setting of third brush; (2) brush not sanded in; (3) spring pressure on brush not sufficient.

(d) **Cut-out remaining open at all times:** Result will be: (1) no current to battery; (2) generator will get very hot; (3) generator will burn out.

(e) **Cut-out remaining closed at all times:** Result will be: (1) battery will discharge back through generator at about 20 amperes (on the Ford), when the engine is not running or not running fast enough. This will discharge the battery.

GENERATOR TROUBLE CHART



DIGEST OF STARTING-MOTOR TROUBLES:

Starting-motor troubles, their indications and causes may also be classified under two heads:

those which are due to mechanical defects and those due to electrical defects.

Mechanical Starting-Motor Troubles

Indications: Excessive current draw, slow cranking or complete failure to crank, and excessive noise.

¹ The "Generator Trouble Chart" is reproduced here through courtesy of the Service Station Equipment Co.

² The "Motor Trouble Chart" (page 456) is reproduced through courtesy of Service Station Equipment Co.

Causes: (1) Worn bearings; (2) shaft bent; (3) commutator burst; (4) loose pole-pieces; (5) broken Bendix drive system; (6) armature off center (may be due to loose pole-pieces, in which case tighten screws).

Gummed oil on Bendix drive: It sometimes happens that oil has come in contact with the Bendix drive shaft and becomes gummed, thus preventing the drive pinion from moving to its position and engaging the fly-wheel gear. This condition can be remedied by squirting some gasoline with an oil gun upon the Bendix drive shaft through the opening at the rear of the starting motor.

Electrical Starting-Motor Troubles

Electrical troubles are classified under (a) open circuits; (b) ground or short circuits.

Open-circuit indications would be suggested by low current or no current, and by failure of starting motor to operate. If a partially open circuit is

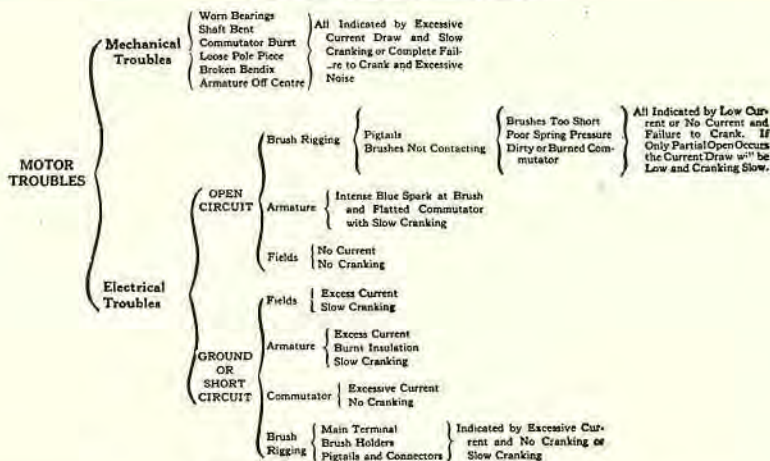
found to exist, the current draw will be low and cranking slow.

Open-circuit causes: (1) Brush pigtails loose; poor brush-spring pressure; brushes too short; dirty or burned commutator; (2) armature commutator blue sparking, or flattened commutator with slow cranking; (3) fields open; (4) starting switch open; (5) loose connections at battery, ground, or switch.

Ground or short-circuit indications are excessive current required, no cranking, or slow cranking.

Grounds or short-circuit causes: (1) Shorted fields cause excessive current and slow cranking; (2) armature shorted causes excessive current, burned insulation, slow cranking; (3) commutator shorted causes excessive current, no cranking; (4) when the brush rigging is shorted, the causes may be in the main terminal, in the brush holders, or the pigtails may be loose.

MOTOR TROUBLE CHART



STORAGE-BATTERY TROUBLES

This subject is treated under the discussion on the "Storage Battery." See Instruction No. 49: "Digest of Storage Battery Troubles; External and Internal."

See also, Instruction No. 48: "Testing Storage Batteries."

LOCATING TROUBLES OF THE ELECTRIC SYSTEM IN GENERAL

In addition to the electrical troubles enumerated above, the following data, graphically presented, will assist in quickly locating troubles in the electric system.

Assume That Battery Is Fully Charged

Trouble: Motor will not crank engine.

Possible causes:

1. Bendix drive or starting mechanism out of order.
2. Engine too stiff.
3. Open circuit in wiring.
4. Ground in wiring.
5. Defective starting motor.
6. Broken or loose wiring connection in starting-motor circuit or ground.
7. Starting switch does not close, or contacts burned out.
8. Open circuit internal to the motor: field, armature, or brush rigging.

9. Ground or short in motor: field, armature, or brush rigging.

10. See Motor Trouble Chart, under "Electrical Troubles."

11. See Motor Trouble Chart, under "Mechanical Troubles."

Assume That Battery Is in a Discharged Condition

Trouble: Battery not being charged at proper rate.
Possible causes:

1. Generator not working properly.
2. Generator charging at a low rate, or not at all.
3. Open generator circuit.
4. Grounded generator circuit.
5. Defective cut-out; will not close.
6. Broken or loose connection on generator line.
7. Shorted or open coil in cut-out windings.

8. Cut-out contact points defective, or improper spring tension.
9. Low charging rate.
10. Third brush not set properly.
11. No charging current.
12. Generator may be new, or perhaps has been operated for some time with field fuse removed. Field can be excited by momentarily connecting one side of the fuse clip with the metal part of the generator when the engine is running slightly above idling speed.

Trouble: Battery being charged at proper rate, but will not hold charge.

Possible causes:

1. No water over plates.
2. Battery has internal or external ground.
3. Excessive use of current in starting and for lights; very little day driving with lights off; mostly night driving with lights on.
4. Cut-out stuck.
5. Wiring defective.
6. Added electrical equipment using too much current.
7. Bulbs with too high a candle power.
8. Bulbs old and using too much current.
9. Stiff engine, using excess current, especially during cold weather.

Starting-Motor Trouble Tests

Trouble: Motor will not start:

Turn on the lights and try the starter. If the lights do not dim, then the battery is probably charged, as the condition of the battery is the first thing to test when the starting motor does not operate. Then examine:

- (1) For an open circuit in the starting switch.
- (2) For an open circuit at the motor terminals.
- (3) For an open circuit at the ground connection to the frame of the car.
- (4) The commutator; examine, and see if glazed.
- (5) The brushes; see if they are bearing on the commutator, and if they are seating properly.
- (6) The brushes; remove and inspect—they may be worn or stuck, or one of the brush-holders may be loose.
- (7) The brush material; it may be of too high a resistance.

Trouble: If the ammeter shows no reading when lights are switched on; if the starting motor kicks over spasmodically or not at all; or if the lights do or do not dim when the starting button is depressed, examine the inside of the motor as follows:

- (1) For a short circuit in the field or armature coils. This will cause the lights to dim, or the ammeter will show no reading when the starting switch is closed. The ammeter referred to is in the lighting circuit, not the starting-motor circuit.)
- (2) For an open circuit in the armature where the coils are soldered to the commutator segments. (This will cause the motor to kick over spasmodically or not at all.)

Next, check the external motor circuit:

- (1) To the frame. (If open, slow cranking or none at all will result.)
- (2) To the switch. (If open, the lights will not dim; if grounded, the lights will dim excessively or the ammeter will show no reading when the starting switch is closed and lights are turned on.)
- (3) To the battery. (Same indications as 2.)

Trouble: Starting motor starts, but not enough to turn engine over

- (1) Crank the engine by hand to see if it is unusually stiff.
- (2) If the engine will not start readily by hand cranking, then look for engine trouble.
- (3) Bendix drive may be stuck, or there may be a broken Bendix spring.

Next, if the engine, the ignition, the carburetion, etc., are in order, then look for:

- (1) Poor contact at battery terminals.
- (2) High resistance contact at brushes.
- (3) Poor connection between brush and shunt-field.
- (4) Poor connection between brush and brush-holder.
- (5) All brushes not bearing on commutator.
- (6) Brushes stuck in brush-holder.
- (7) Grounded brush-holder.
- (8) Loose ground connection (if car has a ground-return system).
- (9) Battery below cranking capacity.
- (10) Open circuit in armature coils.

Next, disconnect battery, and make a temporary connection to a fully charged storage battery. If the starting motor will then turn the engine over, the battery in the car is at fault.

Test storage battery with hydrometer. If the storage battery is low, look to the generator. (Note. Always make a hydrometer reading before adding distilled water. See "Storage Battery" instruction.)

If battery is low or lights are dim, test out the ampere charging rate of the generator. (Do not rely upon the ammeter on the car.)

Trouble: Lights and ignition are cut off entirely when the starting switch is depressed.

- (1) Starting switch may be loose, where the wire connects from one side of the starting switch to lead to the ammeter, ignition, and lighting switch.
- (2) A short circuit may exist at the switch, which will short this circuit.

Generator Trouble Tests

The following will explain where to test a generator for open circuits, short circuits and grounds.

Test for open circuit in:

- (1) Generator terminals.
- (2) Battery connection.
- (3) Ground connection to car frame (if car has a grounded return system).
- (4) Fuse.

- (5) "Cut-out" or ignition and lighting switch.
- (6) Field windings and armature coils.

Test for short circuit in:

- (1) Generator itself; field windings and armature coils.
- (2) In external wiring.

Examine brushes and commutator for:

- (1) Pitted or burned segment surfaces and brush seats.
- (2) Dirty or glazed commutator, high wired, rough commutator.
- (3) High resistance contact at brushes.
- (4) Worn-out brushes.
- (5) Poor connections.

- (6) Brushes not bearing on commutator (faulty spring or holder).

Examine generator for:

- (1) Worn bearings causing unequal air-gap.
- (2) Reversed polarity. (Storage battery is sometimes reversed in position in car.)

Examine regulator and cut-out for:

- (1) Dirty or pitted contact points.
- (2) Contacts out of adjustment.
- (3) Regulator cuts out too soon or not soon enough, owing to gummed mechanical parts.
- (4) If in a third-brush regulation, see brush connection or look for defective mechanism. The third brush failing to seat properly is a common cause of an open circuit and a low charging rate.

DIGEST OF ENGINE TROUBLES: CAUSE AND REMEDY¹

Ordinary engine troubles are generally of three kinds:

- (1) Engine will not start.
- (2) Engine starts but misses.
- (3) Engine starts and runs regularly but has no power.

The following matter refers principally to ignition and carburetion troubles.

ENGINE FAILS TO START.

- (1) **Lack of gasoline:** See that there is gasoline in the tank and that the shut-off cock is open. Make sure that gasoline is flowing to the carburetor by priming or pushing down the carburetor float. If the carburetor is too full, the gasoline will drip. If the carburetor is not full enough, look for a stoppage in the gasoline pipe and see that the vent hole in the tank cap is open.

- (1A) **Carburetor needs priming:** Either prime carburetor or close air intake valve.

- (2) **Poor quality of gasoline:** Some of the gasoline offered for sale is of such poor quality that it will not vaporize when the engine is cold.² The gasoline may contain water, which will freeze in cold weather and clog the gasoline pipe. Old or stale gasoline may also cause difficult starting.

- (3) **Too much gasoline:** The cylinder may be flooded with gasoline; the spark plug may be soaked. Open the relief cocks, cut off the throttle, and crank the engine until the excess is eliminated and an explosion occurs. Then close relief cocks, open throttle only partially and try cranking again; engine ought to start. Float may be loose; or a grain of dirt may be under the needle valve.

- (4) **No pressure in fuel tank:** If the system is a pressure fuel system, then use the hand pump and try priming carburetor. See that the gasoline tank filler cap is tightly screwed on.

- (5) **Lack of ignition current:** If battery ignition, see if battery is strong. Remove one of the spark-plug wires and hold it about $\frac{3}{8}$ " away from plug and terminal, and see if the spark

jumps the gap when the engine is cranked. If there is no current at all, then look for broken or loose wires at the switch and on the battery and the battery ground connection; Also on the connections on the coil and distributor and timer. If the spark is very weak, then look to the battery and test coil and the ignition resistance unit and the condenser.

- (6) **If starting motor fails:** See Index under "Starting motor fails to start."

- (7) **Spark plugs:** Spark plugs may have become sooted from over-lubrication, or if they have seen considerable usage the points may be burned and corroded. If water has been splashed on the engine when it was hot, the porcelain of the plugs may be cracked. See that the sparking points are perfectly clean and that the gap does not exceed .020" to .031".

ENGINE STARTS BUT MISSES.

- (8) **Carburetion adjustments:** If on a cold day and engine has just been started, wait a few minutes for engine to warm up—closing air intake.

If missing still occurs, with popping back or "sneezing," this indicates that the mixture is too lean; give the needle valve of the carburetor a slight opening until the engine runs smooth. If no needle valve is provided, give less air in the auxiliary air valve.

- (9) **Ignition:** If missing continues after engine is warmed up, and more gasoline is fed as directed in (8), examine the spark plugs and test as suggested in (7). Weak battery may be the cause, if coil and battery ignition.

ENGINE STARTS, BUT "POPS" AND "SNEEZES" IN CARBURETOR.

- (10) **Carburetion:** See Index under "Carburetion troubles."

ENGINE STARTS, BUT WILL NOT PULL.

- (11) **Carburetion:** See (8); or there may be an over-rich mixture. This would be indicated by black smoke.

- (12) **The valves:** May be leaking, and there might be poor compression.

- (13) **Ignition:** The spark may be weak. This, however, would be indicated by missing. Test battery.

¹ See "Digest of Lighting Troubles," and "Storage Battery Troubles."

² Very common in cool weather. See Index under "Carburetion troubles."

ENGINE RUNS REGULARLY FOR A FEW MINUTES AND THEN STOPS.

- (14) **Carburetion:** In cold weather this is more liable to occur until engine is warm; give slightly more gasoline by closing air valve (if one is provided); gasoline may not be flowing freely to carburetor. Prime carburetor and see if it drips. There may not be enough gasoline; closing air valve will determine. May be too much gasoline (see 3).
- (15) **Ignition:** Battery may be weak. Ignition may be retarded too much. If there are two systems of ignition, try the other one.

ENGINE STOPS SUDDENLY.

- (16) **Carburetion:** Lack of gasoline. Stoppage of gasoline pipe (prime carburetor, and if no gasoline, examine tank, then fuel strainer). See (73).
- (17) **Ignition:** Loose wire. Short circuit, loose switch connection. If magneto ignition, switch to coil and battery. Weak battery. Points of interrupter may be closed by pitting.
- (18) A sudden stoppage is almost always due to ignition trouble, for gasoline trouble will stop engine slowly.

ENGINE STOPS SLOWLY WITH MISFIRING.

- (19) **Carburetion:** See (16). The needle valve sometimes jars itself closed.
- (20) **When an engine stops slowly, the explosions becoming weaker and weaker until they cease, it is likely due to gasoline trouble.** The fault will be found in the failure of the mixture to reach the cylinder. (See 73.)
- (21) **Ignition:** Batteries exhausted; plugs fouled through over lubrication.

ENGINE LOPES OR LOADS UP.

- (22) **Carburetion:** When the engine slows down irregularly, speeding up and then slowing down again as though fitted with a governor, and if throttle be closed further in order to slow down more, engine stops. Air has leaked in between carburetor and cylinders. Examine gaskets around the joints of inlet pipe or where carburetor is attached to intake manifold. Too much gasoline will also cause "loping." Cut down on the carburetor gasoline feed.
- (23) **Ignition:** The spark may be set too far advanced. If this is the case, loping is likely to occur when spark is fully advanced. Therefore test the time of ignition.

LACK OF FLEXIBILITY.

- (24) **Carburetion:** This trouble is almost exclusively a carburetor fault, and is due to the fact that the auxiliary air intake is so constructed that it furnishes an abundance of air on high speed, and is not sensitive enough on low. When the throttle is nearly closed the engine stalls; or when the throttle is suddenly opened there is no "get away," because the auxiliary air inlet valve allows an inrush of air forming a mixture good enough for high speed running, but too weak for "pick up" purposes. This calls for careful adjustment of the auxiliary air valve and gasoline needle valve, or for more gasoline.

ENGINE MISSES EXPLOSION.

- (25) **Defective or dirty spark plug:** With the engine running idle, short-circuit the spark plugs one at a time by touching a screw-driver from the metal of the cylinders to the terminals of the plugs. (See page 238.) This prevents the plug from firing, and when one is short-circuited—that makes no difference in the running of the engine—you have probably located the plug at fault. If the spark-plug wire is properly connected to the distributor, either clean or install a new plug in place of the one that has been found defective. If a vibrator coil, see page 222 (also see 17).
- (26) **Spark-plug gap too wide:** The distance between the spark-plug points should not exceed .025". (See 7.)
- (27) **Examine interrupter points.** Weak battery.
- (28) **Too lean a gasoline mixture:** If the engine misses with a popping noise in the carburetor, the indications are that too much cold air is being admitted through the air-regulating valve; the carburetor jets have become clogged with dirt, or there is a partial stoppage somewhere in the gasoline pipe connections. See that carburetor intake header gaskets are perfectly tight, and do not admit air, which would thin the mixture.
- (29) **Look for gasoline trouble:** Dirt in gasoline tank over outlet; dirt or water in carburetor; float leaking; jet in carburetor clogged up; supply cock loose; inlet valve sticking or leak in inlet pipe; weak exhaust valve spring; may be a leak of air in inlet pipe.
- (30) If the engine misses, and the following explosion is accompanied by an explosion in the muffler, ignition is at fault, for the charge has reached the cylinder correctly, but has been exhausted without being exploded.

ENGINE MISSES ON HIGH SPEED.

- (31) **Ignition:** Weak battery (if coil and battery ignition). If the engine misses at high, but not on low, or on a hard pull, then it is evident the spark plugs are in proper order but the contact-breaker needs adjusting.

A word of explanation on this: the engine may fire all right at lesser speeds, because the speed is slow enough and the contact is long enough to allow the coil to build up, but at high speeds the time of contact is so short that the coil does not have sufficient time to build up, thus indicating that the contact-breaker gap is too wide. See pages 296-303.

Try switching to the other ignition system, if a dual system is provided. This will determine which ignition system is at fault.

The coil may be defective internally, in its winding, or the resistance unit or condenser may be defective. See Index for "Testing a coil."

- (32) **Carburetion:** The carburetor may have been adjusted for slow speed, but requires more gasoline on high speed, or it may be getting too much gasoline. Proper adjustment of carburetor ought to suffice.

ENGINE MISSES ON LOW SPEED.

- (33) **Ignition:** If magneto ignition, the cause may be the slow speed of magneto, and weak cur-

rent generated. Try advancing the spark more. Also examine the interrupter points.

Examine spark-plug points (see 7). If not remedied, try switching to the other system of ignition. If missing still occurs, there are two other points to consider: loose connection, or a broken-down coil, if one coil is used for both systems, such as a low-tension magneto.

- (34) **A spark plug may be fouled:** It has been known that often a bad plug will not cause missing at all speeds, but will miss at high speeds.
- (35) **Carburetion:** Mixture at fault—readjust low-speed adjustment. The float may be too low, giving over-rich mixture.
- (36) **There may be a leak in the intake pipe:** This is a very common cause for missing at low speeds, and is best detected by allowing the engine to run at the missing speed. Take a squirt can full of gasoline and squirt around all the intake pipe joints. If you detect any difference whatsoever in the running, there is a leak. The remedy is obvious.

ENGINE MISSES AT ALL SPEEDS.

- (37) **Ignition:** Defective spark plug (see 7 and 25). Loose connection. Weak battery. Loose switch parts. Broken wire. Slight short circuit. Defective coil, ignition resistance unit or condenser, pitted or incorrectly adjusted breaker points.
- (38) **Carburetion:** See Index under "Carburetion mixture."

ENGINE DOES NOT DELIVER FULL POWER.¹

- (39) **Compression:** Leaky exhaust valves, scored cylinder, worn or loose rings, cause loss of compression. Timing of valve may be wrong. Exhaust and inlet may not open at correct time. See Index, under "Checking valve timing," "Valve grinding," "Valve clearance." Weak inlet or exhaust springs. Examine cams for wear.

The spark plugs will indicate condition of engine, as follows: If the end of the spark plug is oily it indicates too much lubricating oil or leaky piston rings. If black soft soot, like that which accumulates in a lamp chimney, this indicates that too much gasoline is being fed to the cylinder through intake, causing too rich a mixture. This may come from improper carburetor adjustment or an air leak in intake manifold. If the ends of the plugs are oily and sooty, this would indicate that the valves leak, as this permits burned gases being drawn into the mixture, which would result in poor combustion and lack of pressure in cylinder, which would permit oil to pass and foul plug.

- (40) **Carburetion:** Too rich a mixture (see Index under "Carburetion mixture.")
- (41) **Overheating of engine:** Lack of oil. Circulation system defective (see Index under "Engine overheats; cause of.")
- (42) **Ignition:** Timing of ignition may be wrong—set too far retarded or too far advanced. Weak ignition. Defect in distributor.

- (43) **Miscellaneous causes:** Dragging brakes, leaky piston rings, lack of lubrication. Tight bearings. Flat tires. If new piston rings fitted, they may be not fully set. Use plenty of oil.

ENGINE OVERHEATS.¹

- (44) **Valves:** The exhaust valve may not open early enough to permit the burned gas to pass out.
- (45) **Carburetion:** Too rich a mixture (see Index under "Carburetion mixture"), or driving with throttle open too far and spark retarded too much.
- (46) **Ignition:** Running on retarded spark invariably causes heating. Test the ignition timing.

The spark lever should be raised up or advanced as far as possible at all times without causing the engine to knock. See Index "Spark control and over-heating."

- (47) **Lack of lubrication:** Examine the oiling system.
- (48) **Cooling:** Constricted water circulation; examine the water circulation and pump. Under-sized radiator.
- (49) **Carbon deposit:** See Index under "Relation of carbon deposit to lubricating oil." Choked exhaust.
- (50) **Slipping fan belt:** Tighten the belt.
- (51) **Brakes dragging:** Examine the brakes with rear wheels jacked up.
- (52) **Bearings:** If engine is new or just overhauled, the bearings may be too tight. Put in plenty of oil and run the engine until loosened up.
- (53) **Driving too long on low gear:** This is bad practice and should be avoided.

Note. Refer to page 148 and note the "motometer." This is an excellent device to assist in diagnosing overheating troubles. Overheating is always manifest when engine begins to run slow and pounds.

ENGINE KNOCKS.

- (54) **Ignition:** The most common knock is the ignition knock, caused by too much advance of spark. Back lash in timing wheel teeth. See Index for "Knocks."
- (55) **Bearings:** The connecting rod or main bearings may be loose. Lubrication may be poor. (See Index for "Testing," also "Tightening bearings.")
- (56) **Carbon deposit:** This is also a frequent cause of knocking; see Index for "Carbon troubles."
- (57) **Loose or worn pistons:** Will cause a "piston-slap." See Index. Loose piston pin also causes knocks.
- (58) **Carburetion:** Too rich a mixture will cause a gas knock.
- (59) **Engine overload on hill:** Shift to lower speed.

¹ When the engine overheats by steaming, owing to frozen water, feel the radiator at bottom. If cold, it is frozen; if warm, then the circulation is right, and the trouble is due to lack of water or something else. See also pages 154, 150, 153.

¹ See Index under "Engine. Why It Loses Power."

ENGINE WILL NOT STOP WHEN SWITCHED OFF.

- (60) **Ignition:** If firing is regular, the switch is defective. If firing is irregular, pre-ignition is the cause. Caused by poor oil. This carbon hardens and becomes red hot, hence "pre-ignition." (See Index under "Pre-ignition.")

Stop engine by closing throttle, and as soon as the engine cools, locate the cause.

- (61) **Miscellaneous other causes:** Overheating, as explained from (44) to (53), may be the cause.

DIGEST OF ENGINE AND CHASSIS TROUBLES: CAUSE AND REMEDY**ENGINE RUNS WELL, BUT CAR DRAGS.**

- (62) **Clutch is probably slipping:** The spring needs tightening. If leather-faced cone type, too much oil on the leather. Clean with gasoline squirted on with an oil gun. If this does not hold, use Fuller's earth (last resort). If multiple disk type, clutch spring at fault or plates worn.

A slipping clutch is detected by the engine speed not conforming with speed of car when throttle is opened. This ratio between car and engine is soon learned by experience.

Brakes may be dragging. See test, page 338.

CLUTCH DRAGS.

- (63) **If cone type:** The clutch may not clear the flywheel when thrown out. If multiple disk type, the oil may be too heavy and sticks to plates.

CLUTCH GRABS, OR IS FIERCE.

- (64) **If cone type:** Leather too dry. Clean with gasoline (see 62); then put on castor oil or neats-foot oil to soften.

If multiple disk, use lighter oil after cleaning. Spring may be too tight (see repair subject, "Care of clutch," and Index under "Borg & Beck clutch").

CLUTCH SLIPS (Ford)

- (65) See Ford instruction and Index. See also (62).

CLUTCH BRAKE WORN, CAUSES TROUBLE IN SHIFTING GEARS

- (66) See Index: "Borg & Beck, single-plate clutch."

OIL ON CLUTCH LEATHER (cone type). See Index "Clutch repairing."

- (67) **Cause:** Too much oil in crank case—oil works out of engine bearing.

ENGINE BACK FIRES IN MUFFLER.

- (68) **Ignition:** Usually occurs when coasting with spark off and retarded, and suddenly throwing on switch, thereby firing charges which have entered muffler unfired.

- (69) **Carburetion:** Mixture too weak to fire, or mixture right but sparking wrong. One cylinder missing fire and pumping explosive charges into muffler which ignites from heat of the next exhaust charge. Missing of ignition, valves leaking. Gasoline supply failing.

Remedy: (1) Examine as in sections (25) to (30); particularly see if the plug points are too far apart. (2) See that all cylinders are firing regularly. (3) Adjust carburetor. (4) See if plenty of gasoline is in tank.

CRANK CASE BECOMES VERY HOT AND ENGINE WEAK.

- (70) **Cause:** Serious leak of exploded gas past piston rings; rings worn or broken; crack in head of piston; piston pin loose in piston and allowing gas to escape along bearing. See Index under "Testing piston ring leaks."

OVERHEATING OF EXHAUST PIPE AND MUFFLER.

- (71) **Cause:** Carburetor trouble; over-rich mixture; valves out of time; very late spark; running too long on low gear; using too much gas; exhaust throttled; insufficient lift on valve or choked muffler.

This condition is the result of the mixture not being completely burned in the combustion space, but continuing to burn in the exhaust pipe and muffler.

A mixture that is too rich or too poor, usually the former, will burn slowly and will still be burning during the exhaust stroke.

If the exhaust valve opens too soon, the charge will escape before it has done its work.

Very late ignition will not give enough time to permit the charge to be burned before the exhaust valve opens.

ENGINE MAKES AN UNUSUAL HISSING NOISE.

- (72) **Cause:** Spark-plug porcelain broken; joint between engine and exhaust pipe loose; exhaust pipe cracked; compression cock worked loose; spark plug not tightly screwed into cylinder; valve caps may be loose; cylinder head may be loose. Probabilities are that the exhaust pipe or a spark plug is loose.

GASOLINE FAILS TO REACH THE CARBURETOR.

- (73) **Cause:** Gauze strainer in base of carburetor choked; obstruction in the supply pipe; air lock at a bend in supply pipe; pressure leakage from tank, or, if a gravity tank, it may be air-bound; floating obstruction in gasoline tank covering the gasoline outlet; gasoline pipe near exhaust pipe causing a vapor lock; vent hole in filler cap clogged. See Index: "Vacuum-tank troubles."

CONTINUAL EMISSION OF SMOKE FROM MUFFLER.

- (74) **Cause:** Engine veing over-lubricated. Re-adjust lubrication to give a slower rate of oil flow. The emission of black smoke indicates that the carburetion is too rich. Piston rings leak. Cylinders may be "scored."

CRACK IN CYLINDER.

- (75) **Effect:** Water in combustion chamber or in crank chamber; air bubbling through radiator on pulling engine over compression. (See Index.)

CARBURETOR DRIPS.

- (76) **Cause:** Float-valve mechanism out of order. Examine float and reseal the float needle valve. Usual cause is dirt under needle valve, or float set too high. (See also Index.)

ABNORMAL NOISE FROM TRANSMISSION GEAR.

- (77) **Cause:** (Other than unskillful changing of the gears)—want of lubrication of gears in change-gear box or bevel drive on back axle; pinions damaged; teeth broken or worn down; nut loose in gear box and fouling gears; clutch drum or flywheel loose; universal joints on transmission shaft badly worn or damaged; bearings in gear box worn, allowing shafts to rock about; sliding member of clutch out of alignment with cone (sets up harsh grating noise); wear of jaws of positive clutch in gear box.

SQUEAKS AND SIMILAR NOISES.

- (78) **Cause:** Fork actuating the clutch throw-out collar needs lubrication; one or more bearings overheating and want of lubrication; one or more of the brakes partly on; bearings of spring shackles want lubricating (on some cars the spring ends work in a slide, which requires occasional lubricating); valve stems running dry in the guides. Fenders and hoods are usually the cause of most noises. Spring leaves require lubrication between them. Spokes in wheels loose. (See pages 3 and 1138); rim bolts loose, producing rim squeaks (see page 610).

A rattling noise can often be traced to the hood where it rests on its seat. Strips of rawhide or other anti-friction material should be installed to prevent any squeaks or rattle.

Brakes squeaks may be due to causes such as exposed rivets (re-rivet or reline); eccentric drum (true up drum on lathe); eccentric brake band (true

up band); points of band touch first (bend out points); glazed or hood lining (reline. Glazed lining should not be treated with compounds as the cure is only temporary); unequal brake adjustment (adjust brakes); loose rear anchor bolt (tighten or replace); band frozen on rear anchor (lubricate so that band moves freely); scored drums (renew or refinish drums); metal or grit imbedded (remove); imperfect rounding of bands (round to equal clearance—use feeler gauge).

Brakes chatter: This may be due to such causes as weak rear springs (cannot be cured except by adding extra leaves or stronger springs. Install hard lining. On some cars with weak rear springs and strong leverage chatter will result just before the car comes to a stop. Decreasing the leverage by some method helps in certain cases); loose rear anchor bolt (tighten or replace); worn rear anchor (build up by brazing or shim); loose dust shield and brake supports (re-rivet); lining loose on rivets (reline); eccentric drum (turn drum); weak release springs (replace with stronger spring or insert washer below it to increase tension). This material on brake troubles is from *Silver Edge*, published by the Raybestos Company, Bridgeport, Conn.

LUBRICATOR STOPS WORKING.

- (79) **Cause:** Oil pipe choked; feed nipples choked; pump shaft may be broken, usually due to clogged pipes—may need priming; loose connections.

OIL-FEED GAUGE DOES NOT SHOW FLOW OF OIL.

- (80) See if oil in crank case. Clean strainer. Air leak. Examine pump and pipe connections. Oil may be too cold to flow (see page 164). Oil pump may need priming. When testing an oil-feed pipe for an air leak, remove and test with air pressure, submerging pipe in water to make the test.

OIL LEAKAGE FROM ENGINE.

- (81) **Cause:** Bearings badly worn and passing out bearing journal; gaskets not tight; screws loose; crank case flooded with oil (lubricator working too rapidly); cap screws holding lower crank case not tight; gaskets leaking.

For "Ignition troubles," "Magneto troubles," "Carburetor troubles," "Starting-motor troubles," "Cooling troubles," "Generator troubles," "Carbon troubles," "Storage-battery troubles," "Miscellaneous repairs and adjustments," "Tire troubles," "Lighting troubles," see Index.

INSTRUCTION No. 41 A

DYKE'S TROUBLE-SHOOTING CHARTS: Relation Between Ignition and Carburetion; Ignition Trouble-Shooting Chart Explanation and Key; Fuel and Carburetion Trouble-Shooting Chart Explanation and Key; Generator, Battery, Cut-Out Trouble-Shooting Chart; Starting-Motor Trouble-Shooting Chart.

RELATION BETWEEN IGNITION AND CARBURETION

For an engine to start easily, pull at low speeds, and develop maximum power at high speeds, three major factors are necessary as follows:

1. A good spark
2. A combustible mixture
3. Good compression

1. A good spark is a hot, voluminous, and intense spark, as explained on page 286.

To insure a good spark, the primary, or low-tension circuit (shown in black and dark shade on the ignition chart, page 462-D) and the secondary, or high-tension circuit (shown in red) must function properly. The cause and effect of either circuit not functioning properly can be determined by referring to the Ignition Chart Key, page 462-E.

2. A combustible mixture is a mixture of gasoline vapor and air in the proper proportions (usually 14 to 17 parts air to 1 of gasoline by weight) which is drawn into the cylinder. It is the heat (which is energy) from combustion which expands the gas between the head of the cylinder and piston and produces pressure on the head of the piston. The more combustible the mixture and the hotter the spark, the greater the expansion and pressure, because more heat is produced in a given time and all of the charge is burned.

3. Good compression applies to the mixture being compressed in the cylinder as the piston ascends on its compression stroke, and the power produced depends upon the amount of pressure which is exerted upon the piston head. The more highly the gas is compressed, the more quickly and completely it will burn. Good compression is dependent upon the combustion chamber being air tight at this time. Factors which would prevent good compression are: loose or worn piston rings, leaky valves, scored cylinders, air leaks at spark plugs, valve guides, valve stem bushings and cylinder head gaskets, and last, but not least, proper opening of the valves, termed valve timing.

The volumetric efficiency of an engine refers to the quantity of gas drawn into the cylinder; the greater the quantity, the greater the compression and power. Consequently, if the valves do not open and close at the proper time, the volumetric efficiency is correspondingly less, as is also the mean effective pressure (see page 765). Compression pressure is an important factor, but there is of course a limit. The only reason all engines are not of the high-compression type is that such engines are likely to self-ignite, detonate, or pre-ignite the mixture and cause knocks.

Relation of Spark, Mixture, and Compression

It is thus clear that a close relation exists between the following factors that determine the power efficiency of an engine, assuming that the mechanical features, such as proper bearing adjustment, cooling, and lubrication are correct:

- (a) A good spark, correctly timed.
- (b) A combustible mixture, which enters the cylinder at the correct time.
- (c) Good compression, with valves properly timed.

If we should have a good spark and a non-combustible mixture, or a combustible mixture and a weak spark, the effect is a loss of power.

Likewise if we have a good spark and a combustible mixture and poor compression, the effect is a loss of power.

Likewise if we have a good spark, combustible mixture, good compression and the spark occurs too early or too late, the effect is a loss of power.

Likewise if we have a good spark occurring at the correct time, a combustible mixture, good compression, but the valves do not open at the correct time, the effect is a loss of power.

If, however, we have a good spark at the correct time, a combustible mixture entering the cylinder at the correct time, and good compression, the result is rapid flame propagation, or spread of the flame (see pages 290, 304), and a maximum of power.

The three chief factors which make rapid flame propagation possible are a good spark, combustible mixture and good compression.

If the spark is weak and the mixture non-combustible, the flame propagation will be slow, with the result that a greater portion of the mixture will pass out of the exhaust valve port unburned, or into the crank case, diluting the lubricating oil, with the result of a greater loss of power as well as of fuel.

We have defined the meaning of a good spark (page 286) and rapid flame propagation (page 290). We will now consider the combustible mixture, which is a very important factor.

Factors Which Help Produce a Combustible Mixture

We stated under 2 above that a combustible mixture of gasoline vapor and air in the proper proportion was desired. Therefore, the point now to consider is how to obtain this vapor and air in the proper proportion. We cannot measure it. How, therefore, are we going to tell? There is no method of determining this accurately, outside of a laboratory; therefore we must depend upon the adjustment of the carburetor. But first it is well to mention the fact that all other factors should first be checked as follows:

First, see that there is a good hot spark, which of course includes the battery being in good condition.

Second, see that the ignition is properly timed (see pages 301-303, 232).

Third, see that the interrupter points make a smooth, firm contact and that they are adjusted properly.

Fourth, see that the compression is good (see pages 765, 767).

Fifth, see that the valves are opening and closing properly by checking the valve timing (see page 67), and also by checking the valve clearance (see page 775).

Sixth, adjust the carburetor when the engine is warm. Make the adjustment both with the engine idling and at high speeds. See Index for "Carburetor adjustments."

The chief factors in producing a combustible mixture are gasoline vapor and air. The air absorbs the gasoline vapor like a sponge absorbs water, but if the gasoline is not vaporized, the air cannot absorb it rapidly enough. Gasoline vapor depends upon the heating of the gasoline and the quality of the gasoline. The present-day gasoline requires heating, especially during cold weather, and this can be accomplished by quickly heating the engine, or heating the air drawn into the carburetor, or heating the mixture as it is drawn from the carburetor, or a combination of all three methods, so that it will give off a vapor which will more readily be absorbed by the air, or will more readily mix with the air.

The engine can quickly be heated by covering the radiator to prevent cold air being drawn through the radiator core until the motometer indicates about 150° and by means of a water thermostat (page 149), which prevents the water circulating until it is heated to about 150° F. See also pages 149, 150, 105.

The air drawn into the carburetor can be heated, as explained on page 106; the mixture can be heated by methods explained on page 106. See also the Franklin method (page 142).

There is, however, a possibility of overheating. The mixture entering the cylinder should be heated until it is in the first stages of a cool vapor, or, in other words, heated until it will enter the cylinder, not in a liquid state, but as a vapor.

Too much heat produces a dry, lean mixture which produces a knock, due to detonation, or too sudden an explosion, and also to self-ignition due to the extremely heated gas and pre-ignition from red-hot particles in the combustion chamber, whereas in a mixture properly heated, while flame propagation should be rapid, the burning of the mixture will take place during the time the piston is traveling down on power stroke.

Why More Gasoline on a Cold Day

On a cold day, when the engine is cold, a very large quantity of gasoline must be drawn into the cylinder in order that the engine start at all. This is accomplished by closing the air-valve choker (page 462-H). The reason for this is the fact that a certain proportion of vapor must be in the cylinder in order that it can be ignited. Cold gasoline gives off a very small percentage of vapor, and that percentage is further decreased as the vapor comes in contact with the cold cylinder walls, causing it to condense back to a liquid state of heavy particles of gasoline which is non-combustible. Thus a very great quantity of gasoline is necessary under these conditions.

The result is that only the vapor is ignited and a part of the raw gasoline, or the heavy particles drawn into the cylinder, settles in the inlet manifold; part passes into the cylinder out the exhaust valve

in an unburned state; part also passes down the cylinder walls, washing off the oil lubrication, into the crank case, diluting the lubricating oil. Thus the importance of quickly heating and vaporizing the gasoline and the opening of the choker valve as soon as it is possible to do so without back-firing.

Cause of Back-Firing in Carburetor

Often, when starting, back-firing in the inlet manifold and carburetor takes place. This is due to an insufficient amount of gasoline to produce the proper proportion of vapor (lean mixture), which burns slowly, with the result that the flame continues until the opening of the inlet valve again at which time the flame enters the inlet manifold, heats the heavy particles of gasoline, which on the previous stroke settled there unburned, and is ignited and thus fires back through air opening of carburetor.

To Reduce Excessive Fuel Consumption

1. Use the "choke" valve sparingly; make economical "choke" adjustments. For extremely cold weather, when starting, close the "choke" valve entirely, but open it gradually and as quickly as the engine will run without missing until fully open.

For fairly warm weather, close the "choke" only two-thirds of the way, and open as soon as the engine will run without missing. (At least 100 per cent more gasoline is consumed when the choke valve is closed. A percentage of this passes into the crank case thinning the lubricating oil, see page 104 and "dilution test" page 1075.)

Note: Don't open throttle too wide in either case, and retard spark. When starting with hand crank in cold weather fully close choker with throttle barely open for two or three turns of crank, then set choker $\frac{1}{2}$ to $\frac{3}{4}$ open and crank two or three times until engine starts.

2. For extremely cold weather, when starting the engine, keep the radiator cover over the entire front of the radiator until the motometer shows about 150°. Then place the cover on the lower part of the radiator, and keep it there, providing the temperature as shown by the motometer does not rise above 170° to 180°. When leaving the car standing, cover the entire front of the radiator (see p. 650; automatic temperature regulator).

If a denatured alcohol mixture is used as a non-freezing solution, the alcohol begins to evaporate readily above 175°.

3. The "heating of the mixture," or "heating of the air" drawn into the carburetor main air inlet, will reduce fuel consumption.

4. A good hot ignition spark will cause more rapid flame propagation and thus assist in reducing fuel consumption. Keep the battery voltage up by keeping the battery fully charged, either by increasing the generator charging rate or by having it charged at an outside source occasionally.

5. Running on a retarded spark at high speeds consumes gasoline, due to part of the unburned mixture passing out the exhaust valve, not having time for complete flame propagation.

6. See that the brakes do not drag (to test, allow the car to coast to a standstill and see if hot).

7. Test the compression of the engine. Leaks past the piston rings and leaky valves allow a large percentage of gasoline and power to escape.

8. Avoid unnecessary variation in speed or racing of the engine. Strong acceleration is usually obtained by an unduly rich mixture, with a consequent increase of gasoline consumption.

9. Disengage clutch when coasting.

10. When approaching a heavy grade, obtain sufficient momentum to carry vehicle a considerable distance up the grade before making it necessary to change gears.

IGNITION TROUBLE-SHOOTING CHART—EXPLANATION

See Index for Principles, Tests, Adjustments, and Repairs.

The ignition system is divided into two major circuits (see page 462-D): (1) the primary low-tension circuit (black and dark shade); (2) the secondary, or high-tension circuit (red). The secondary circuit is entirely dependent upon the condition of the primary circuit.

Major tests: If the engine fails to start, try test 57B. If a good spark occurs, both primary and secondary circuits are in proper condition, and the trouble is in the spark plug, providing the ignition is at fault.

If no spark at 57B, try test 42T. If a spark occurs at 42T but not at 57B, the secondary circuit is grounded or there is a static leak between spark plug cables 56.

Now disconnect the terminal of wire 42 from coil terminal 41; take a wood handle screwdriver and touch its point to ground (G) (of any part of the engine), at the same time bringing the metal part to within a $\frac{1}{4}$ " gap from 41, as shown at 41T. If a spark occurs in test 41T, but not 42T, the primary circuit and the secondary winding of the coil are in proper shape, but the secondary circuit is open somewhere between 41 to 62.

Use of a 6-volt test light in shooting wiring troubles: A handy test light may be constructed as shown on page 464, Fig. 10.

To find an open circuit in a wire lead, disconnect one end of the wire lead (the end farthest from the battery); connect one end of the test light to this end of the wire and the other end of the test light to ground.

For example, consider testing wire 14 in the ignition chart (page 462-D). Disconnect at 15; attach one end of the test light to the free end of 14 and the other end of the test light to ground. Turn on the ignition switch. If the lamp lights, there is no open circuit. If the lamp does not light, connect one end of the test light to terminal 20 and the other end to ground (wire 14 being disconnected); if the lamp now lights, this proves conclusively that there is an open circuit or ground in wire 14, but if the lamp still fails to light, the open circuit or ground is nearer to the battery.

To test the ignition coil primary circuit to see if it is open-circuited, with a 110-volt A.C. test light: Place one test lead on terminal 24, the other on terminal 20. If the lamp lights, the primary circuit of the coil is not open.

If the lamp does not light, place one lead on 22, the other on 20. If the lamp lights, the primary winding 21 is in proper shape, but resistance unit 23 is burned out or open. If the lamp does not light, primary 21 is open.

To test the ignition secondary circuit with a 110-volt A.C. test light: Place one test lead on 41, the other on the grounded base of coil 66. If the lamp lights, the secondary is short-circuited, because part of the winding is cut out and the resistance of the winding is thus decreased.

If the lamp does not light, try moving the test lead by rubbing it on 66. A very faint spark should occur, because, if the secondary winding is in proper condition, the fine wire winding offers considerable resistance. If no spark at all, secondary is open circuited.

Ignition Interrupter Troubles

Factors which produce ignition missing due to the ignition interrupter, as used on the non-vibrator coil type of ignition (see page 462-D), are as follows:

1. Resistance at the points
2. Sparking or arcing at the points
3. Improperly set and uneven contact of points
4. Mechanical troubles

1. Resistance at the points (10), is caused by dirty points, burned, oxidized, or pitted points, or poor surface contact of points, all of which tend to offer resistance to the flow of the primary current, thus weakening the spark (see page 225 for cleaning and dressing points).

Appearance of Tungsten points: A silver gray appearance with pitted surface at point of contact is O.K. New points may show only a small spot, usually near the edge; when in this condition do not disturb. If points are blackened, clean and adjust.

2. Sparking or arcing at the points, which pits and burns them and increases the resistance of the primary current and causes weak or missing spark is due to: (a) points set too close; (b) condenser (18) connections loose, or defective condenser (see page 191 for the reason why the condenser prevents arcing at the opening of the primary circuit at the points); (c) the secondary winding (40) being shorted, it will lack intensity enough to jump the spark-plug gap (61), especially at high compression, with the result that it reacts through the primary circuit, the

easiest path, and arcs across the interrupter points; (d) the spark plug gap being too wide will sometimes cause the same effect; (e) spark overloaded, that is, a coil or magneto system, designed for a medium compression engine, will not produce a spark of sufficient intensity or voltage for an extremely high-compression engine. Thus the spark will be overloaded, and will react through the primary circuit and arc at the interrupter points and cause missing. The missing will be noticeable at low speeds with hard pulling with the throttle well opened, and at high speeds with the throttle well opened, at which time the compression is very high.

3. Improperly set interrupter points means that they are either too close or too far apart, or not making full-face, flat, even contact.

Points set too far apart cause missing, probably more at high than low speeds because the points do not have time to make good contact for the coil to build up; thus flame propagation is retarded. Contact is broken early with wide points.

Points set too close together cause missing, probably at low speeds more than at high speed. Contact is broken late, as cam (9) must travel to its highest point before making contact with bumper (8), or roller. Sparking or arcing occurs at the points when set too close.

Where condensers are placed in a coil at a distance away from the interrupter points, the sparking is more pronounced, and usually a greater condenser capacity is provided. In this instance the contact points are usually placed farther apart. When the condenser is defective, as being loose, open, or short-circuited, the sparking will be excessive at points (10) and will be blue, and a milky white corrosion will form on the points.

4. Mechanical troubles of the interrupter are: (a) worn fibre (8), or roller on the contact arm which does not permit sufficient opening of the points and causes late opening; (b) looseness in the contact arm due to worn bearing at the pivot pin (6); (c) looseness in contact screw or lock nut (11, 16); (d) looseness in cam (9), or cam-shaft bearing, permitting wobbling (give the gap slightly more play in this instance if not remedied by putting in new bearing); (e) lack of sufficient spring tension (5) for good contact at the points. Noisy distributors are sometimes due to wear from lack of lubrication. See pages 219 and 307 about grease to be carried in lower part of distributor housing of certain types.

Pointers on Adjusting Interrupter

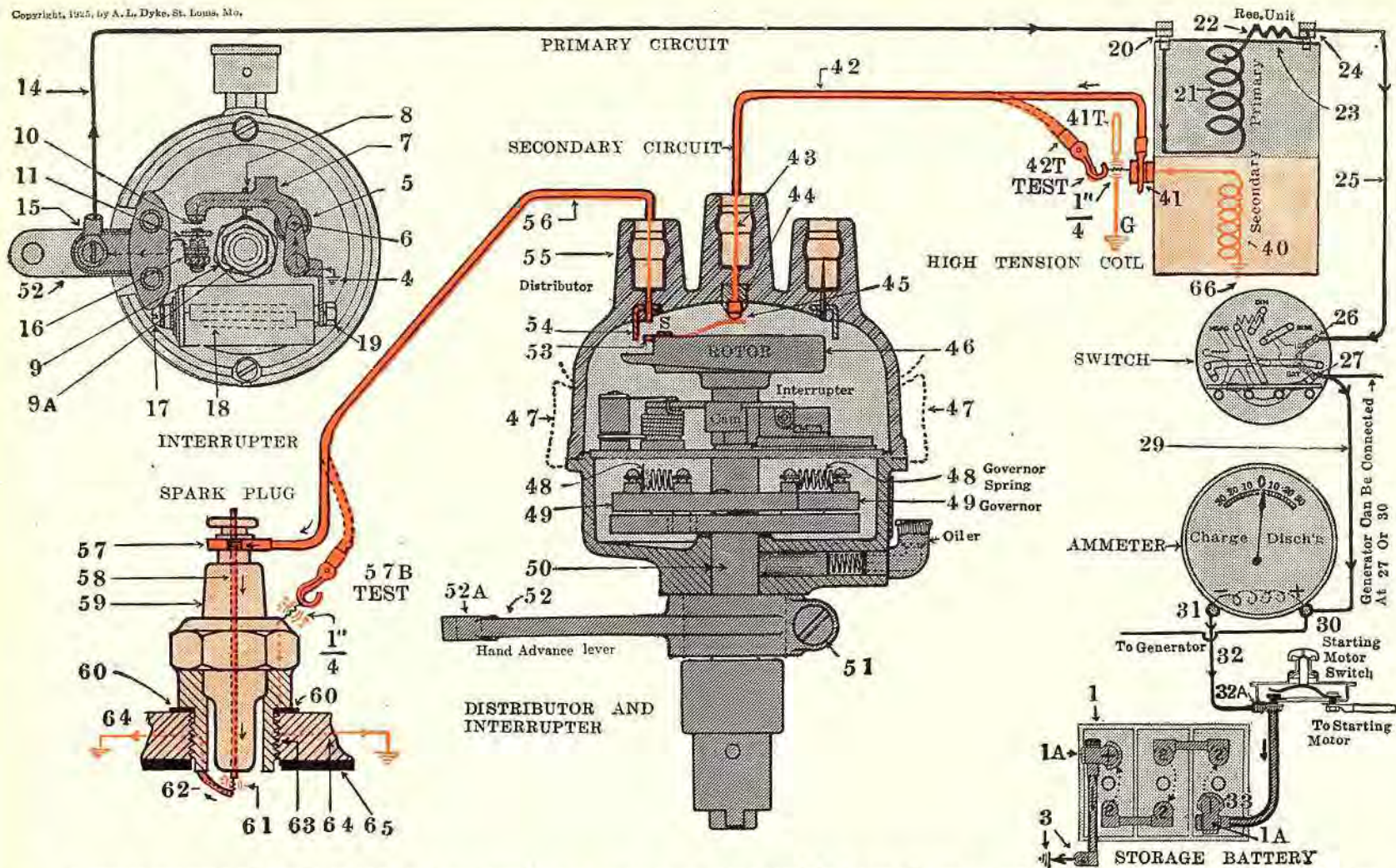
Adjustment of interrupter points is made by moving the adjustable screw on the stationary contact point (11) in or out. Never bend the arm.

When setting interrupter points, the main object is to set the gap as close as possible just so that it does not spark across the points (10), and to have a good smooth and full flat-face surface contact, with sufficient spring tension (5) to close the contact points firmly so that this contact will allow time for the primary circuit to build up.

See pages 238, 239 for testing ignition system for missing; page 227 for testing interrupter for grounds; page 241 for distributor troubles; page 232 for testing coils, and pages 230, 231 for testing condenser.

If the engine will not start, this may be due to any cause in the following chart key which will prevent a spark occurring at spark-plug points; or if the spark is so weak that it fails to ignite the gas (see Index for "Carburetion troubles" and "Starting motor troubles").

The engine missing explosion may be due to any cause in the following chart key which will cause a weak spark or an irregular spark or incorrectly timed spark at spark plug points (61), which of course would be caused by a weak battery, generator, defective coil, improperly adjusted contact points, etc., as given in the chart key.



IGNITION TROUBLE-SHOOTING CHART. The chart shows a modern ignition system using a closed-circuit type of interrupter and a non-vibrating type of ignition coil. There are two circuits: the primary low-tension or voltage circuit shown in black and dark shading, from 3 to 4, to 14, to 20, to 26, to 27, to 32A, to 33, to 3. The secondary high-tension or high-voltage circuit is shown in red, from 41, to 45, across gap 53 to 54, through 56, to 57, through 58, through 52, through 61, through 62, through engine ground 64, to secondary coil winding 66; through secondary coil winding 40, to 41. Note: Although the interrupter is shown separate at the upper left corner, it is a part of the distributor and interrupter shown in center illustration.

IGNITION TROUBLE-SHOOTING CHART—KEY

See Index for principles, tests, adjustments, and repairs.

1. Battery—Trouble: (a) discharged. **Effect** (a) weak or no primary current. **Test** (a) test with hydrometer, or use voltmeter. See pages 531, 545, 547. **Remedy** (a) recharge battery.

1A. Battery terminal—Trouble: (a) loose; (b) corroded. **Effect:** (a) low reading at dash ammeter when switch is turned on, weak spark or none at all; (b) low reading at dash ammeter when switch is turned on and interrupter points are together. **Test:** (a) examine; (b) green, yellow, or white corrosion appears at terminals. **Remedy:** (a) tighten terminal clamps; (b) clean terminals with wire brush, wash with ammonia solution, coat with vaseline, and tighten terminals.

2. Battery cell connectors—Trouble: (a) loose. **Effect:** (a) low reading at dash ammeter. **Test:** (a) examine. **Remedy:** (a) burn connectors on again.

3. Battery ground connection—Trouble: (a) loose; (b) corroded; (c) broken. **Effect:** (a) irregular spark or none at all; (b) (c) no primary current; dash ammeter fails to indicate. **Test:** (a) examine; (b) examine for rust at connection to frame; (c) examine for broken wire cable. **Remedy:** (a) tighten bolt, or, if riveted, install new rivet; (b) file off corrosion and tighten connection at frame; (c) install new ground cable.

4. Interrupter arm ground—see 7.

5. Interrupter spring—Trouble: (a) weak; (b) broken. **Effect:** (a) (b) interrupter points will not make firm contact. **Test:** (a) (b) separate interrupter points with finger, thus feeling spring tension. **Remedy:** (a) (b) install new interrupter spring.

6. Interrupter pivot—Trouble: (a) worn; (b) stuck. **Effect:** (a) wobbly interrupter arm; thus points do not meet squarely; (b) interrupter points fail to close. **Test:** (a) examine for looseness; (b) examine. **Remedy:** (a) install new breaker plate; (b) dress pivot with fine file.

7. Interrupter grounded movable contact arm—Trouble: (a) wobbly; (b) stuck. **Effect:** (a) points do not meet squarely, and pit; (b) interrupter points fail to close. **Test:** (a) examine for looseness; (b) examine. **Remedy:** (a) install new interrupter arm; (b) remove rust, clean, lubricate.

8. Interrupter fibre cam contact—Trouble: (a) worn too far; (b) loose. **Effect:** (a) if points are set at correct gap they will remain in contact too long, thus causing pitting; (b) imperfect opening of interrupter points. **Test:** (a) examine, (b) examine for looseness. **Remedy:** (a) install new movable arm (7), and adjust points; (b) reset clamps and rivet or install new arm (7), and adjust points.

9. Interrupter cam—Trouble: (a) worn; (b) wobbly; (c) loose; (d) out of time. **Effect:** (a) if set at correct gap, point will not remain in contact long enough; therefore weak spark; (b) timing irregular; (c) continually shifts out of time; (d) ignition knock if too far advanced; lack of speed and overheating of engine if too late. **Test:** (a) examine cam for wear; (b) (c) examine for looseness; (d) check timing. **Remedy:** (a) install new cam; (b) tighten adjusting screw (9A); if this does not overcome difficulty, a new cam must be installed, or perhaps the timer shaft bearing is worn from lack of oil; (c) tighten adjusting screw or nut (9A); (d) re-time.

9A. Cam nut or screw—Trouble: (a) loose. **Effect:** (a) cam shifts out of time. **Test:** (a) examine. **Remedy:** (a) re-time and tighten.

10. Interrupter points—Trouble: (a) worn; (b) too far apart; (c) too close; (d) pitted; (e) poor contact; (f) oxidized (white); (g) uneven; (h) burned or oxidized (black). **Effect:** (a) weak spark at plugs; (b) engine misses at all speeds; (c) engine misses at low or idling speeds; (d) engine fails to start or misses at all speeds; (e) (f) (g) (h) engine misses. **Test:** (a) examine to see if sufficient amount of tungsten is on points; (b) measure gap when points are fully separated and compare with manufacturer's specifications; (c) measure gap when points are fully separated; (d) examine surface of points for pits; (e) see that surfaces meet squarely; (f) look for milky white substance on surface of points; (g) see that points line up; (h) see that generator voltage is not too high, and test condenser. (Be sure the proper type of ignition coil is being used. Cases have been known where a coil has been substituted with a coarse primary winding, which draws a high amperage, thus burning the points. A coil which draws over 5 amperes may be suspected). **Remedy:** (a) renew interrupter points; (b) set gap to manufacturer's specifications; (c) set points farther apart; (d) dress points on oil stone, and test condenser; (e) dress points on oil stone until surfaces meet squarely; (f) remove oxide with file or oilstone; test condenser; (g) bend interrupter points to line up evenly; (h) remove oxidation with file or oilstone; locate open in generator circuit; install new condenser.

11. Interrupter insulated stationary contact—Trouble: (a) loose; (b) grounded. **Effect:** (a) engine misses, owing to incorrect gap; (b) no spark at spark plug. **Test:** (a) examine for looseness; (b) ammeter registers discharge when interrupter points are open. **Remedy:** (a) tighten lock nut on stationary contact; (b) re-insulate and clean.

14. Interrupter lead to coil primary winding—Trouble: (a) open; (b) grounded; (c) loose at 15. **Effect:** (a) no current in primary; engine fails to start; (b) primary current will not be broken by interrupter; battery runs down; (c) irregular primary current; engine misses. **Test:** (a) disconnect at 15; connect test light, which should burn when the other lead is touched to ground; if light burns from 20 to ground, but not from 14 to ground, lead is open; (b) ammeter reads discharge when points are separated; (c) examine. **Remedy:** (a) fix break in wire or install new wire; (b) install new wire or re-insulate at bare spot; (c) tighten.

15. Connection to insulated contact of interrupter—Trouble: (a) loose; (b) grounded. **Effect:** (a) engine misses; (b) engine will not start. **Test:** (a) examine; (b) ammeter registers discharge when interrupter points are open. **Remedy:** (a) tighten; (b) insulate.

16. Adjustment screw for insulated contact (11)—Trouble: (a) loose; (b) grounded, not insulated. **Effect:** (a) engine misses owing to incorrect gap; (b) no spark at spark plug; battery runs down. **Test:** (a) examine for looseness; (b) ammeter registers discharge when interrupter points are open. **Remedy:** (a) adjust to correct gap and tighten lock nut; (b) re-insulate and clean.

17. Condenser lead—Trouble: (a) loose at 15; (b) grounded; (c) open. **Effect:** (a) engine fails to start or misses; interrupter points become pitted; (b) same as 16(b); (c) same as 17(a). **Test:** (a) examine for looseness; (b) same as 16(b); (c) examine for break in lead. **Remedy:** (a) tighten; (b) same as 16(b); (c) solder break in lead.

18. Condenser—Trouble: (a) open; (b) short-circuited internally. **Effect:** (a) pitting of interrupter points; weak spark at spark plug; engine misses; (b) primary circuit will not be broken by interrupter. **Test:** (a) try new condenser (see Index for "Condenser test"); (b) disconnect condenser leads and test with test light; if light burns, condenser is shorted. **Remedy:** (a) (b) install new condenser.

19. Condenser ground connection—Trouble: (a) poor ground connection. **Effect:** (a) pitting of interrupter points; weak spark at plugs. **Test:** (a) examine for dirt, rust, looseness, or dampness. **Remedy:** (a) clean connection and tighten.

20. Coil terminal—Trouble: (a) loose connection. **Effect:** (a) no primary current. **Test:** (a) examine for looseness. **Remedy:** (a) tighten.

21. Coil primary winding—Trouble: (a) open; (b) shorted; (c) water soaked. **Effect:** (a) no primary current; engine fails to start; (b) (c) weak spark or none at all. **Test:** (a) (b) see ignition coil tests; (c) examine coil for moisture. **Remedy:** (a) (b) install new coil; (c) dry out coil.

22. Coil primary connection to resistance unit—Trouble: (a) loose. **Effect:** (a) no primary current; no spark; engine fails to start. **Test:** (a) examine for looseness. **Remedy:** (a) tighten connection.

23. Resistance unit—Trouble: (a) burned thin; (b) open. **Effect:** (a) low primary current; engine misses; (b) no primary current; engine fails to start. **Test:** (a) resistance wire appears thin; (b) examine resistance wire for break, (see also ignition coil test). **Remedy:** (a) install new resistance unit; (b) install new resistance unit; in emergency, connect wire 25 to terminal 22.

24. Coil terminal—Trouble: (a) loose. **Effect:** (a) no primary current. **Test:** (a) examine for looseness. **Remedy:** (a) tighten.

25. Wire lead—Trouble: (a) open; (b) grounded. **Effect:** (a) no primary current; (b) no current through primary of coil; battery runs down. **Test:** (a) disconnect at 24; attach test light from wire to ground; if light burns lead is all right; if light fails to burn, but will burn from 26 to ground, the lead is open; (b) dash ammeter reads excessive discharge. **Remedy:** (a) install new wire; (b) insulate from ground, or install new wire.

26. Ignition switch terminal—Trouble: (a) open; (b) grounded to base of switch. **Effect:** (a) no primary current; (b) no current through primary of coil; battery runs down. **Test:** (a) test light will not burn from 26 to ground, but will burn from 27 to ground; (b) dash ammeter reads excessive discharge. **Remedy:** (a) clean switch contacts and bend to make firmer contact; see that switch is turned on; (b) insulate from base of switch.

27. Ignition switch terminal—Trouble: (a) open; (b) grounded. **Effect:** (a) no primary current; (b) no current through primary of coil. **Test:** (a) test light will not burn from 26 to ground, but will burn from 27 to ground; (b) dash ammeter reads excessive discharge. **Remedy:** (a) clean switch contacts and bend to make firmer contact; (b) insulate from base of switch.

28. Switch handle—Trouble: (a) loose. **Effect:** (a) fails to turn switch on or off. **Test:** (a) examine for looseness. **Remedy:** (a) fasten to switch by set screw or other means.

29. Wire lead—Trouble: (a) open; (b) grounded. **Effect:** (a) no primary current; (b) no current through primary of coil; battery runs down.

Test: (a) test light will not burn from 27 to ground, but will burn from 30 to ground; (b) dash ammeter reads excessive discharge. **Remedy:** (a) install new wire; (b) insulate wire from ground or install new wire.

30. Ammeter terminal—Trouble: (a) loose; (b) grounded. **Effect:** (a) irregular or no primary current; (b) no current through primary of coil; battery runs down. **Test:** (a) examine for looseness; (b) examine for ground; ammeter reads excessive discharge. **Remedy:** (a) tighten; (b) insulate from ground.

31. Ammeter terminal—Trouble: (a) loose; (b) grounded. **Effect:** (a) irregular or no primary current; (b) no current through primary of coil; battery runs down. **Test:** (a) examine for looseness; (b) examine for ground. **Remedy:** (a) tighten; (b) insulate from ground.

32. Wire lead—Trouble: (a) open; (b) grounded. **Effect:** (a) no primary current; (b) no current through primary of coil; battery runs down. **Test:** (a) test light will not burn from 31 to ground, but will burn from 32A to ground; (b) examine for worn insulation. **Remedy:** (a) install new wire; (b) insulate or install new wire.

32A. Ignition and lighting wire connection with battery at starting motor switch—Trouble: (a) loose; (b) corroded. **Effect:** (a) irregular or no primary current; (b) low primary current or none at all. **Test:** (a) examine for looseness; (b) disconnect and examine for corrosion. **Remedy:** (a) tighten; (b) file, clean, and tighten.

33. Battery terminal—Trouble: (a) loose; (b) corroded. **Effect:** (a) (b) same as 1A. **Test:** (a) (b) same as 1A. **Remedy:** (a) (b) same as 1A.

40. Secondary winding—Trouble: (a) open; (b) shorted; (c) water soaked. **Effect:** (a) no spark at plug; (b) (c) weak or no spark at plug. **Test:** (a) (b) see ignition coil tests page 462-C; (c) examine coil for moisture. **Remedy:** (a) (b) install new coil; (c) dry out coil.

41. Coil secondary terminal—Trouble: (a) loose. **Effect:** (a) may cause missing; **Test:** (a) with engine running; look for sparks at 41. **Remedy:** (a) tighten connection.

41T. Coil secondary winding test—see major tests and explanations page 462-B.

42T. Coil secondary terminal test—see major tests and explanations page 462-B.

42. Cable lead from secondary terminal to center part of distributor—Trouble: (a) open; (b) grounded. **Effect:** (a) no secondary current to distributor; (b) high-tension current leaks here; therefore no spark at plug. **Test:** (a) test with screwdriver; when engine is cranked, spark will jump from 41 to ground, but not from 44 to ground; (b) examine for worn or rotted insulation. **Remedy:** (a) (b) install new high-tension wire.

43. Distributor center terminal—Trouble: (a) loose connection. **Effect:** (a) may cause missing. **Test:** (a) examine for looseness. **Remedy:** (a) tighten.

44. Distributor contact to 45—Trouble: (a) loose; (b) shorted, owing to dirt or moisture in distributor cap. **Effect:** (a) may cause missing; (b) engine misses. **Test:** (a) examine for looseness; (b) examine for dirt and cracks in distributor cap. **Remedy:** (a) if brush type, replace brush and spring, otherwise replace distributor cap; (b) clean distributor cap; if cracked, replace.

45. Rotor spring contact—Trouble: (a) poor contact with 44; (b) weak tension; (c) broken

Effect: (a) (b) may cause missing; (c) no spark; engine fails to start. **Test:** (a) examine spring contact for dirt; (b) examine spring; (c) examine. **Remedy:** (a) clean contact and bend spring upwards; (b) bend upwards or tighten screw (S); (c) install new rotor 46, or new spring 45.

46. Rotor—Trouble: (a) shorted; (b) wobbly. **Effect:** (a) no spark; engine fails to start; (b) irregular spark. **Test:** (a) examine rotor for cracks and dirt; (b) examine for looseness on distributor shaft; may be due to distributor shaft bearing 50 being worn from lack of lubrication.¹ **Remedy:** (a) clean rotor; if cracked, replace with new rotor; (b) install new rotor, or rebush shaft if bearing is worn, or replace housing.

47. Distributor cap spring—Trouble: (a) loose; (b) broken. **Effect:** (a) distributor cap wobbles; (b) too large a gap between 53 and 54. **Test:** (a) examine for looseness; (b) examine. **Remedy:** (a) bend to tighten; (b) install new spring.

48. Automatic governor spring—Trouble: (a) weak; (b) loose. **Effect:** (a) spark advances at low speed and causes pre-ignition, knock, or kick-back; (b) same as 48(a). **Test:** (a) (b) examine spring. **Remedy:** (a) install new spring; (b) tighten.

49. Automatic governor spider—Trouble: (a) tight; (b) rusty and stuck. **Effect:** (a) (b) does not advance spark; engine will not develop power at high speed. **Test:** (a) (b) examine spider. **Remedy:** (a) (b) clean, loosen, and lubricate.¹

50. Distributor-interrupter shaft and bearing—Trouble: (a) worn. **Effect:** (a) interrupter shaft wobbles and causes missing. **Test:** (a) examine. **Remedy:** (a) install new bearing and shaft if both are worn.¹

51. Advance arm clamp screw—Trouble: (a) loose. **Effect:** (a) advance arm shifts to improper ignition timing position. **Test:** (a) examine to see if advance arm is tight on distributor. **Remedy:** (a) check ignition timing and tighten screw.

52. Advance arm—Trouble: (a) improperly set. **Effect:** (a) ignition out of time. **Test:** (a) check ignition timing. **Remedy:** (a) loosen screw 51; reset advance arm 52, and tighten screw (see also pages 301, 302 for other timing methods).

52A. Advance arm hole—Trouble: (a) worn. **Effect:** (a) too much play in ignition rod. **Test:** (a) examine for looseness. **Remedy:** (a) replace arm, or bush hole.

53. Rotor secondary point—Trouble: (a) burned; (b) gap too wide; (c) poor contact with 45. **Effect:** (a) weak spark at plug; engine misses; (b) spark thin; engine misses; (c) no spark at all. **Test:** (a) (b) (c) examine. **Remedy:** (a) install new rotor spring; (b) adjust 54 closer to 53 (about .010"); (c) install new rotor spring.

54. Spark plug terminal—Trouble: (a) loose; (b) gap too wide. **Effect:** (a) may strike 53, or have too wide a gap; (b) same as 53(b). **Test:** (a) examine for looseness; (b) same as 53(b). **Remedy:** (a) install new terminal or new distributor cap; (b) same as 53(b).

55. Spark plug cable terminal—Trouble: (a) loose. **Effect:** (a) poor contact; irregular spark at plug. **Test:** (a) examine for looseness. **Remedy:** (a) tighten terminal.

56. Spark plug cable—Trouble: (a) open, (b) grounded; (c) static discharge. **Effect:** (a) irregular or no spark at plug; (b) no spark at plug; (c) missing. **Test:** (a) see major tests; (b) (c) notice spark jumping through insulation or bare wire. **Remedy:** (a) (b) install new wire; (c) separate wires; if this does not remedy trouble, the rubber insulation may be hard and porous; install new wires.

57. Spark plug cable connection to plug—Trouble: (a) loose; (b) spark plug cables not connected according to firing order of engine. **Effect:** (a) irregular firing of plug; (b) engine misses, sometimes backfires. **Test:** (a) examine for looseness; (b) check cable connections. **Remedy:** (a) tighten; (b) connect properly according to firing order.

57B. Spark plug terminal test—see major tests and explanations.

58. Electrode—Trouble: (a) cement loose; (b) broken; (c) shorted with moisture. **Effect:** (a) irregular firing and air leak; (b) no spark at plug; (c) no spark at gap 61. **Test:** (a) hissing sound; (b) examine electrode; (c) examine for moisture. **Remedy:** (a) install new porcelain or plug; (b) install new porcelain or new spark plug; (c) dry the spark plug.

59. Porcelain—Trouble: (a) broken or cracked; (b) carbonized; (c) air leak in shell. **Effect:** (a) spark jumps through crack, termed an electrical leak; no spark at 61; (b) short circuits high-tension current; cylinder misfires; (c) compression leak; loss of power, perhaps misfiring. **Test:** (a) examine plug; (b) examine for carbon deposit; (c) hissing sound. **Remedy:** (a) replace porcelain or spark plug; (b) clean with muriatic acid or alcohol; (c) tighten lock nut or install new gasket, if of separable type; if a one-piece type of spark plug, as shown in illustration, replace plug.

60. Spark plug gasket—Trouble: (a) air leak. **Effect:** (a) same as 59(c). **Test:** (a) hissing sound. **Remedy:** (a) tighten spark plug or install new gasket.

61. Spark plug gap—Trouble: (a) too wide; (b) too close; (c) burned; (d) carbonized. **Effect:** (a) missing at high speed; (b) missing at low speed and when idling; (c) engine misses; (d) no spark at 61. **Test:** (a) (b) measure gap with thickness gauge (should be about .025"); (c) examine; (d) examine for carbon. **Remedy:** (a) set closer; (b) set farther apart; (c) install new spark plug; (d) remove carbon.

62. Spark plug shell electrode—Trouble: (a) loose; (b) burned. **Effect:** (a) gap changes; (b) engine misses. **Test:** (a) examine for looseness; (b) examine. **Remedy:** (a) (b) install new shell or plug.

63. Spark plug shell threads—Trouble: (a) air leaks; (b) too long. **Effect:** (a) compression poor; loss of power; (b) preignition causing knock. **Test:** (a) hissing sound; bubbles will appear if oil is squirted around threads; (b) compare length of plug to thickness of cylinder wall; should be about the same (see page 235). **Remedy:** (a) tighten spark plug; (b) install proper length of spark plug.

64. Valve cap into which spark plug is sometimes screwed—Trouble: (a) cracked; (b) air leak. **Effect:** (a) (b) loss of compression and missing, usually at idling speed. **Test:** (a) (b) examine. **Remedy:** (a) replace with new cap; (b) tighten cap and replace gasket 65, if necessary.

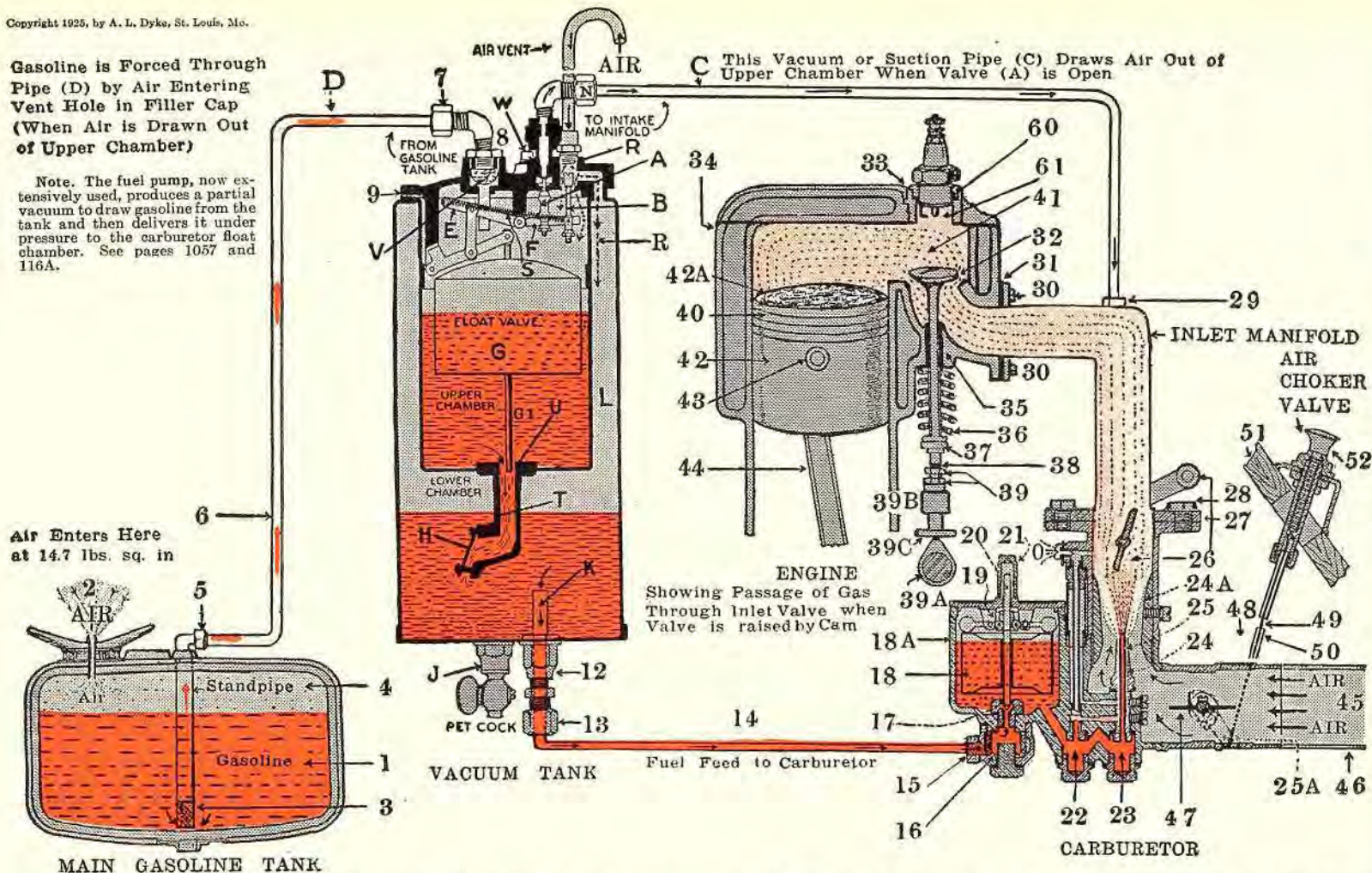
65. Valve cap gasket—Trouble: (a) valve cap not drawn down tight; (b) gasket leaks. **Effect:** (a) (b) loss of compression and missing. **Test:** (a) (b) examine. **Remedy:** (a) draw valve cap tight; (b) replace gasket.

66. Secondary ground to base of coil—Trouble: (a) open. **Effect:** (a) no spark at plugs. **Test:** (a) see coil and examine connection from base of coil to ground. **Remedy:** (a) if open in coil, replace coil; clean base of coil and coil bracket.

¹ See "Noisy distributor," page 462-C.

Gasoline is Forced Through Pipe (D) by Air Entering Vent Hole in Filler Cap (When Air is Drawn Out of Upper Chamber)

Note. The fuel pump, now extensively used, produces a partial vacuum to draw gasoline from the tank and then delivers it under pressure to the carburetor float chamber. See pages 1057 and 116A.



FUEL-FEED AND CARBURETION TROUBLE-SHOOTING CHART. The red color represents gasoline; light grey color represents air. In the chart, gasoline is being fed to the carburetor by gravity from the lower chamber of the vacuum tank. The upper chamber of the vacuum tank is feeding gasoline by gravity to the lower chamber because air valve (B) is open and suction valve (A) is closed, owing to the float being at its highest position. See page 113, showing how the gasoline is drawn from the main gasoline tank to the upper chamber of the vacuum tank when the gasoline level in the upper chamber lowers, causing the float to open valve (A) and close valve (B). The piston of the engine is just starting down on suction stroke, and the inlet valve is open. (Note that cam 39A is raising the inlet valve.) The carburetor throttle valve is fully open, and a rich mixture is being drawn out of the main jet spray nozzle (25) and a leaner mixture is being drawn in at (45), mixing with the gasoline mixture, producing a combustible mixture shown in light red, which is drawn into the cylinder through the open inlet valve (Zenith type "U" triple jet carburetor, page 131, and Stewart vacuum tank, page 113, are used in this chart).

FUEL FEED AND CARBURETION TROUBLE-SHOOTING CHART—EXPLANATION

(See page 462-H)

The fuel feed system is divided into four major parts:

1. The vacuum feed (D) from main gasoline tank to the upper or vacuum chamber (see page 113 for principle of operation).
2. The gravity feed (14) from lower or gravity chamber to carburetor.
3. The suction line (C) from inlet manifold to vacuum tank.
4. The inlet manifold leading from carburetor to inlet valve ports of engine.

The major troubles which are usually the result of defects in the fuel system are:

1. Engine fails to start.
2. Engine slows down, lacks power, and back-firing or popping occurs in the carburetor.
3. Engine stops, with back-firing or popping in carburetor.

1. Engine Fails to Start

Cause of engine failing to start may be lack of gasoline, due to: (a) no gasoline in tank; (b) choker valve (47) not being closed; (c) fuel line clogged.

Test (a): See if there is gasoline in the main gasoline tank (do not depend upon the gasoline gauge; it does not always indicate correctly). If there is gasoline, the next procedure is to see if gasoline reaches the float chamber (18A) of carburetor, by unscrewing cap (21) and lifting needle valve (20), and seeing if gasoline drips at (25A). If so, you know that gasoline is reaching the carburetor, as it must run out of jet (25) in order to reach (25A).

Test (b): If on test (a) gasoline drips at (25A) then by closing choker valve (47), by pulling button (52) out, the engine should start, assuming that ignition is good.

If gasoline does not drip out at (25A), then open drain cock (J) at the bottom of the vacuum tank to see if there is gasoline in the lower chamber. If so, then the trouble lies between (K) and the carburetor.

If gasoline does not drip out at (25A) on making test (a), then run a wire through (J); if gasoline does not then flow, there is probably no gasoline in the lower or gravity chamber, and the trouble is either in the vacuum tank (see chart key), or the fuel line is clogged. (See also "Vacuum gauge test," page 1041.)

Usually, when there is no gasoline in the vacuum tank, the first place to look is at the air vent in the filler cap (2), to see if it is clogged. Next, examine strainer (V) in vacuum tank. Next, examine flapper valve (H); it may be held open by sediment which

can be removed by shaking. Next, see if connections at unions (5) (7) (8) and union (N) on pipe (C) and at (29) are loose; or valves (A) and (B) may be leaking.

Test (c): If pipes are suspected of being clogged, remove and blow them out or run a wire through.

If gasoline drains from drain cock (J), but does not drip at (25A) when the float needle valve is lifted, then remove the pipe at union (15) and see if gasoline runs out of pipe (14); if so, then the trouble is either in the carburetor strainer (16) being clogged, or the openings, or jets (24) (25) are clogged.

2. Engine Slows Down; Back-Fires in Carburetor

When the engine slows down, lacks power, and popping occurs in the carburetor, it is usually due to lack of gasoline and may be caused by the vacuum tank strainer (V), or carburetor strainer (16), or fuel pipes being partially clogged, or air or gasoline leaks in the fuel pipe lines (sometimes an incorrect valve clearance will cause back-firing; see pages 57-59, 61, 118, 765). (See also pp. 1041, 114-115.)

3. Engine Stops; Back-Fires in Carburetor

When the engine slows down, lacks power, and popping occurs in the carburetor and the engine stops, the trouble is likely due to lack of gasoline, either in the main gasoline tank, to clogged strainers (V) or (16), or the vacuum system is out of order or there are clogged or leaky pipes, or clogged openings in the carburetor. (See also pages 114, 115, 122, 1041.)

Indications that the gasoline supply is less than normal are the slowing down of the engine, lack of power, and popping in the carburetor.

Indications that the gasoline supply is completely cut off, or that the supply is running out, are first, as above; then the engine stops.

If it is impossible to get gasoline from the main gasoline tank to the vacuum tank, draw some gasoline from the main tank, either at the drain cock or by means of an oil gun or rubber tube syphon, and remove plug (W) and put it into the vacuum tank (see page 115). This will get the car home or to a garage, where time can be taken to locate the trouble properly. (See also pages 1041, 115.)

A simple test, when the engine will not idle properly, is to close the choker valve slightly, giving the engine more gasoline, and to note if this improves the running conditions. If so, cut down slightly on the air adjustment; if not, try opening the air adjustment slightly. Make this test when the engine is warm.

FUEL FEED AND CARBURETION TROUBLE-SHOOTING CHART—KEY

(See page 462-H)

1. Gasoline in main gasoline tank—Trouble: (a) poor grade; (b) old; (c) no gasoline; (d) leak in tank; (e) water in gasoline. Effect: (a) engine fails to start or lacks power; (b) volatility lost; will not vaporize; engine fails to start or lacks power; (c) engine fails to start; (d) fuel consumption appears unduly high; (e) popping back through carburetor. Test: (a) gasoline smells like kerosene; (b) gasoline has very little odor; (c) examine fuel tank; (d) examine tank for leak; (e) slightly open drain plug in bottom of tank; water will emerge. Remedy: (a) refill with good grade of gasoline; (b) refill tank with fresh gasoline; (c) fill tank with gas-

oline; (d) solder leak in tank; (e) drain water from bottom of tank through drain plug.

2. Air vent in filler cap of main gasoline tank—Trouble: (a) clogged (a common trouble); (b) too small. Effect: (a) gasoline will not flow to vacuum tank; engine stops; (b) flow of gasoline to vacuum tank retarded. Test: (a) examine hole in filler cap; (b) examine hole (should be $\frac{1}{8}$ " diameter). Remedy: (a) clean out hole; (b) drill out with $\frac{1}{8}$ " drill.

3. Strainer at end of standpipe in main gasoline tank—Trouble: (a) clogged. Effect: (a) gasoline fails to reach vacuum tank. Test: (a) examine.

Remedy: (a) clean strainer (not all standpipes have strainers on them; in fact, only a few tanks have strainers at all in the gasoline tank; the strainers are usually in the vacuum tank and the carburetor).

4. Standpipe in main gasoline tank through which gasoline is drawn to vacuum tank (upper chamber)—

Trouble: (a) clogged; (b) seam cracked. **Effect:** (a) gasoline fails to reach vacuum tank; (b) gasoline fails to reach vacuum tank when level of fuel is below crack. **Test:** (a) (b) remove standpipe and examine. **Remedy:** (a) remove the obstruction with wire or compressed air; (b) solder up crack in seam. (This standpipe can usually be removed by unscrewing the nut and drawing it out from the top. Sometimes rubber from the filler hose gets into the tank and is drawn to the standpipe opening, closing it.)

5. Union and connection—Trouble: (a) loose; (b) air leak; (c) clogged. **Effect:** (a) (b) admits air, thus reducing flow of gasoline to vacuum tank; (c) gasoline fails to reach vacuum tank. **Test:** (a) examine for looseness; (b) squirt gasoline around union; crank engine, and see if gasoline is sucked in through union; (c) disconnect union and examine. **Remedy:** (a) tighten; (b) unfasten union, coat with soap, then tighten; (c) remove obstruction.

6. Pipe from main gasoline tank to vacuum tank—Trouble: (a) clogged; (b) bent; (c) cracked or perforated; (d) frozen, owing to water in gasoline. **Effect:** (a) (b) (c) (d) gasoline fails to reach vacuum tank. **Test:** (a) disconnect at 7 and blow through pipe to see if free; (b) examine for bends or kinks; (c) disconnect at 5 and 7; have someone hold finger over end at 5, then blow at 7 and examine for leaks; (d) same as 6 (a). **Remedy:** (a) blow out with compressed air; (b) install new pipe; (c) solder up leaks or install new pipe; (d) remove pipe and thaw out in hot water.

7. Union and connection—Trouble: (a) loose; (b) air leak. **Effect:** (a) (b) leaks air; gasoline fails to reach vacuum tank. **Test:** (a) examine for looseness; (b) disconnect at 8; squirt gasoline around 7, and blow at 8; bubbles indicate leak. **Remedy:** (a) tighten; (b) tighten pipe D at 7; coat threads of union with soap.

8. Nut—Trouble: (a) loose; (b) air leak. **Effect:** (a) (b) leaks air; gasoline fails to reach vacuum tank. **Test:** (a) examine for looseness; (b) squirt gasoline around 8; crank engine; if gasoline is sucked in, a leak exists. **Remedy:** (a) tighten; (b) coat threads with soap and tighten.

9. Vacuum tank gasket—Trouble: (a) loose, causing air leak; (b) torn. **Effect:** (a) gasoline fails to reach vacuum tank; (b) air leak; gasoline fails to reach vacuum tank. **Test:** (a) examine for looseness of vacuum tank head; (b) remove vacuum tank head and examine. **Remedy:** (a) tighten screws in vacuum tank head; (b) install new gasket. Do not shellac (see page 114).

A. Vacuum tank suction valve—Trouble: (a) leaks; (b) valve seat bushing loose. **Effect:** (a) (b) gasoline is drawn to inlet manifold through pipe C. **Test:** (a) see page 1041, or loosen pipe C at 29; remove head of vacuum tank, raise float, and blow through pipe C; (b) see page 1041. **Remedy:** (a) have new valve installed at Stewart-Warner service station; (b) tighten bushing.

B. Vacuum tank air valve—Trouble: (a) leaks. **Effect:** (a) gasoline fails to reach vacuum tank. **Test:** (a) remove head of vacuum tank, lower float, stop passage to L with finger, and try to blow through air vent. **Remedy:** (a) have new valve installed at Stewart-Warner service station.

C. Vacuum tank suction pipe to inlet manifold—

Trouble: (a) loose at N or at 29; (b) clogged. (c) gasoline passing through pipe C. **Effect:** (a) air leak; gasoline fails to reach vacuum tank; (b) no suction; gasoline fails to reach vacuum tank; (c) engine loads up. **Test:** (a) with engine running, apply light oil at these points; if oil is drawn in, a leak exists; (b) disconnect at N and 29, and blow through pipe; (c) see page 1041, or disconnect at 29; hold finger over opening, if engine ceases loading up, this is the trouble. **Remedy:** (a) tighten or apply soap to threads; (b) blow out with compressed air; (c) fix valve A or float G.

D. Same as 6. (See also "Vacuum gauge test," page 1041.)

E. Vacuum tank lever to which the two coil springs (S) are attached—Trouble: (a) out of order. **Effect:** (a) valves A and B do not operate properly. **Test:** same as A and B. **Remedy:** (a) take head of vacuum tank to Stewart-Warner service station for repairs.

F. Vacuum tank lever operated by springs attached to E—Trouble: (a) out of order. **Effect:** (a) same as E. **Test:** (a) same as A and B. **Remedy:** (a) same as E.

G. Vacuum tank float—Trouble: (a) leaks and fills up. **Effect:** (a) fails to close A or open B; gasoline is drawn through C. **Test:** (a) examine float for leaks by immersing in hot water. See page 114. **Remedy:** (a) see page 114.

G1. Vacuum tank float guide rod—Trouble: (a) bent. **Effect:** (a) float sticks, causing same trouble as G. **Test:** (a) examine rod. **Remedy:** (a) straighten.

H. Vacuum tank flapper valve—Trouble: (a) dirt under valve. **Effect:** (a) gasoline fails to reach vacuum tank. **Test:** (a) plug up air vent; disconnect at 13; hold finger over opening while cranking engine; suction at 13 indicates H is leaking. **Remedy:** (a) tap on side of tank to remove dirt, or remove upper chamber and clean.

J. Petcock for draining or cleaning tank—Trouble: (a) clogged. **Effect:** (a) will not drain. **Test:** (a) open. **Remedy:** (a) run wire through opening.

K. Outlet of lower chamber or gravity tank to carburetor—Trouble: (a) clogged. **Effect:** (a) gasoline fails to reach float chamber 18A. **Test:** (a) disconnect at 13; gasoline fails to run out freely but will run out of J. **Remedy:** (a) clean with wire.

L. Space between outer shell and vacuum tank—Trouble: (a) air vent clogged. **Effect:** (a) gasoline fails to flow from lower chamber to carburetor. **Test:** (a) remove air vent tube and try to blow through it. **Remedy:** (a) blow out air vent with compressed air, or run wire through it.

N. Union—Trouble: (a) see C.

R. Air vent—Trouble: (a) overflows regularly. **Effect:** (a) too rich mixture in engine, which loads up. **Test:** (a) examine for overflow. **Remedy:** (a) clean out air vent (2) in main gasoline tank; (b) vacuum tank may be too close to hot engine; (c) bottom of vacuum tank must be at least 3" above carburetor; (d) attach length of tubing to air vent, and run up higher under hood.

S. Two coil springs—Trouble: (a) loose; (b) broken. **Effect:** (a) (b) valves A and B not properly operated. **Test:** (a) (b) see test on page 1041, and also examine springs. **Remedy:** (a) tighten; (b) install new springs.

T. Outlet passage from upper to lower chamber.

U. Washer for float guide rod (fibre or metal).

V. Vacuum tank wire screen strainer—Trouble: (a) clogged. **Effect:** (a) gasoline fails to flow to vacuum tank. **Test:** (a) this is one of the first places to examine when vacuum tank fails. **Remedy:** (a) loosen nut 8; remove strainer, and clean. (See also "Vacuum gauge test," p. 1041.)

W. Flushing plug—to be used for filling tank when vacuum fails. Remove and pour gasoline through opening; engine can be run to garage by repeated fillings. Also used for flushing sediment from H. See also, page 115.

Vacuum tank empty—Trouble: (a) carburetor throttle valve 26 opened wide for too long a period. **Effect:** (a) engine receives lean mixture or no gasoline. **Test:** (a) engine misses or gradually stops. **Remedy:** (a) operate engine for a short time with closed throttle (see also page 115).

12. Connection from lower gravity tank—Trouble: (a) loose; (b) clogged. **Effect:** (a) gasoline drips out; (b) gasoline fails to reach carburetor properly. **Test:** (a) examine for looseness; (b) gasoline runs out of J when opened, but no gasoline in 18A, or gasoline flows very slowly to 18A. **Remedy:** (a) tighten; if necessary, coat threads with soap; (b) remove connection, and clean.

13. Union connecting pipe 14 with connection 12—Trouble: (a) loose; (b) clogged. **Effect:** (a) same as 12(a); (b) same as 12(b). **Test:** (a) (b) examine. **Remedy:** (a) tighten; (b) remove and blow out, or run wire through it.

14. Feed pipe from gravity chamber to carburetor—Trouble: (a) clogged or bent at sharp angle; (b) cracked seam or perforations; (c) frozen, as a result of water in gasoline. **Effect:** (a) gasoline fails to reach carburetor properly; (b) gasoline leaks; (c) gasoline fails to reach carburetor. **Test:** (a) gasoline runs out of J, but does not flow freely into 18A; (b) examine for leaks; (c) gasoline runs out of J, but does not enter 18A. **Remedy:** (a) disconnect at 13 and 15, and blow out with compressed air or tire pump, or straighten; (b) solder leaks or install new pipe; (c) remove pipe and thaw out in hot water.

15. Union connection at carburetor—Trouble: (a) loose. **Effect:** (a) gasoline leaks. **Test:** (a) examine for looseness. **Remedy:** (a) tighten; if necessary, coat threads with soap.

16. Carburetor strainer—Trouble: (a) clogged. **Effect:** (a) gasoline fails to reach carburetor properly. **Test:** (a) gasoline runs out of J, but enters 18A slowly or not at all. **Remedy:** (a) remove strainer and clean.

17. Carburetor float needle valve seat—Trouble: (a) sediment collected on seat; (b) out of adjustment; (c) rough; (d) burr on seat. **Effect:** (a) float valve fails to cut off flow of gasoline; (b) causes float valve to cut off too quickly or too late; (c) (d) float valve fails to cut off flow of gasoline. **Test:** (a) overflowing of gasoline in 18A or at 25A; (b) check gasoline level, which should be slightly below jet 25; (c) (d) overflowing of gasoline in 18A or at 25A. **Remedy:** (a) remove cap 21 and raise and lower valve 20 in its seat several times to dislodge sediment; (b) readjust valve seat by screwing

in or out (see pages 123, 144); (c) replace with new valve seat; (d) remove cap 21 and tap gently on float needle valve 20.

18. Carburetor float—Trouble: (a) hole in it; (b) stuck due to mechanism. **Effect:** (a) fills up and sinks, therefore does not cut off flow; (b) either will not fill up or will overflow, owing to position where float sticks. **Test:** (a) overflowing of gasoline in 18A or at 25A; immerse float in hot water, and bubbles will appear at hole. **Remedy:** (a) punch another hole, drain out gasoline, solder hole (see pages 122, 123); (b) examine mechanism.

18A. Carburetor float chamber—Trouble: (a) frozen, owing to water in gasoline; (b) sandholes in casting. **Effect:** (a) gasoline fails to reach engine; (b) gasoline leaks. **Test:** (a) remove float chamber cover, and examine; (b) examine. **Remedy:** (a) thaw out with hot water; (b) renew float chamber.

19. Carburetor float needle valve mechanism—Trouble: (a) cuts off too late; (b) cuts off too early; (c) stuck. **Effect:** (a) gasoline level too high; engine loads up as mixture is too rich; (b) level too low, mixture too lean, engine misses; (c) will cut off too late or too early, owing to position when stuck. **Test:** (a) overflowing of gasoline at 18A or at 25A; (b) test level of gasoline; (c) examine. **Remedy:** (a) adjust to cause proper level of gasoline slightly below level of jet 25; (b) adjust to proper level; (c) adjust, or put in new parts.

20. Carburetor float needle valve—Trouble: (a) loose from collar; (b) bent. **Effect:** (a) mechanism fails to operate valve; (b) fails to cut off flow of gasoline. **Test:** (a) examine for looseness; (b) examine to see if it operates freely. **Remedy:** (a) refasten to collar; (b) straighten.

21. Carburetor needle valve cap—Trouble: (a) binds against needle valve 20. **Effect:** (a) needle valve 20 fails to admit gasoline or fails to cut off flow. **Test:** (a) no gasoline to engine or overflowing at 18A or 25A; trouble stops when 21 is removed. **Remedy:** (a) straighten 20 or put washers under 21.

22. Carburetor fuel passage to compensator jet (compensator is above 22, p. 462-H; see also p. 131)—Trouble: (a) water in gasoline or clogged compensator; (b) compensator jet too large; (c) compensator jet too small. **Effect:** (a) mixture lean, backfiring; (b) too rich a mixture on a hard pull (see page 132); (c) too lean a mixture, missing and jerky motion of car on a hard pull (see pages 131, 132). **Test:** (a) unscrew plug below 22 and drain. Compensator may be clogged; unscrew and clean; (b) (c) see page 131. **Remedy:** (a) (b) (c) see page 132 and 462-I.

The influence of the compensator jet is strongest at low speeds and hard pulls. A hard pull on high gear on a hill with the throttle well open taxes the efficiency of the compensator and will readily indicate the correctness of its size.

23. Carburetor fuel passage to main jet (main jet is directly above 23 and is Fig. 25)—Trouble: (a) water in gasoline. **Effect:** (a) mixture lean, backfiring. **Test:** (a) unscrew plug below 23 and drain.

24. Carburetor cap jet. This is an outside cap surrounding the spray nozzles (not clearly shown), or passages leading from the idling well and compensator jet. **Trouble:** (a) passages to the side of main jet may be clogged. **Effect:** (a) engine will not pick up on accelerating and misses at high speed. **Test and Remedy:** (a) unscrew and clean.

Note. On the Model "U" Zenith, shown in the chart, and page 131, there are two passages to the side of the main jet (not clearly shown), whereas on the Model "L" (older model) there is one passage to the side of the main jet.

¹ The carburetor used in the chart is the Zenith Model "U" as explained on page 131. In the Zenith carburetor, adjustment of the mixture for high speeds is made by means of replacing jet with one of another size. The various adjustments of other makes of carburetors are given on pages 117-144.

24A. Carburetor choke tube or venturi—Trouble: (a) too large; (b) too small. **Effect:** (a) (b) see pages 131 and 132.

Bear in mind that when inside diameter of the choke tube is increased, more air is admitted and the mixture is correspondingly thinned, and vice versa.

25. Carburetor main jet—Trouble: (a) clogged; (b) too large; (c) too small. **Effect and Remedy:** (a) unscrew and clean; (b) (c) see page 131.

The influence of the main jet is mostly felt at high speeds. **Note.** When testing: First determine the size of the choke (the size is stamped on each part), then of the main jet, then of the compensator.

O. Carburetor idling adjustment. **Note.** Although air is shown to enter at the screw on the chart, the air really enters through an adjusting screw (O, Fig. 21, page 131) directly below and to the side of the screw shown on the chart.—**Trouble:** (a) mixture too rich at idling speed; (b) mixture too lean at idling speed. **Effect:** (a) engine runs in a jerky or irregular manner; (b) same as (a) and will also miss, and in extreme cases the engine will stop. **Test and Remedy:** (a) open throttle to clear the passages of the rich mixture, and then bring back to idling position, and screw out idling adjusting screw (O, Fig. 21, page 131) to lean the mixture, until regular running is attained. If it is necessary to screw this out more than four or five turns from its seat, put in a smaller idling tube; (b) screw in on idling adjusting screw to enrich the mixture until missing stops and engine idles properly. If it is necessary to screw O in to within 1 to 1 turn from its seat, put in a larger idling tube.

Note. When making idling adjustment, have it on the "rich" side; that is, have the adjusting screw O adjusted to a point where a slight "turn in" would result in a rich mixture.

25A. Gasoline dripping from carburetor—Trouble: (a) gasoline level in float chamber 18A too high; (b) needle valve 20 does not seat at 17. **Effect:** (a) (b) overflows at 25 and 25A. **Test:** (a) (b) examine for drip. **Remedy:** (a) adjust level of gasoline (see 19(a); (b) see 17(a), 17(b) and 17(c).

26. Carburetor throttle valve—Trouble: (a) screw loose on pin; (b) lever loose (see T1, Fig. 21, page 131); (c) stop screw not adjusted properly (this stop-screw can be seen on Fig. 21, page 131, at "T2"); (d) spring which pulls throttle valve closed, weak, or broken; (e) rods from throttle lever to accelerator or hand throttle on steering wheel out of adjustment; (f) connection between throttle shaft and body of carburetor worn. **Effect:** (a) (b) does not open and close properly; (c) engine does not idle properly; (d) throttle does not close properly; (e) throttle does not open and close properly; (f) admits air giving lean mixture. **Test:** (a) remove carburetor and examine for looseness; (b) examine for looseness; (c) idle engine; if it stops, screw in; if it runs too fast, screw out; (d) accelerator pedal does not rapidly return to proper position when released; (e) examine for looseness. **Remedy:** (a) tighten screw; (b) tighten; (c) readjust; (d) increase tension of spring or install new one; (e) lengthen or shorten rods; (f) replace parts with new ones.

27. Carburetor gasket—Trouble: (a) loose; (b) air leak into inlet manifold; (c) projects into inlet manifold. **Effect:** (a) (b) admits air and causes too lean a mixture; (c) obstructs passage of mixture. **Test:** (a) examine for looseness; (b) with engine running, squirt gasoline around gasket; if engine speeds up, there is an air leak; (c) remove carburetor and examine fit of gasket. **Remedy:** (a) tighten bolts 28; (b) install new gasket or shellac old gasket, being sure to scrape clean first; (c) cut opening to fit, or install new gasket.

28. Carburetor manifold bolt—Trouble: (a) loose. **Effect:** (a) admits air; too lean a mixture. **Test:** (a) examine for looseness. **Remedy:** (a) tighten.

29. Vacuum tank suction pipe connection to inlet manifold—Trouble: (a) loose (see also C); (b) air leak. **Effect:** (a) gasoline fails to reach vacuum tank; (b) gasoline fails to reach vacuum tank; lean mixture. **Test:** (a) examine for looseness; (b) with engine running, squirt gasoline around 29; if it is drawn in, a leak exists. **Remedy:** (a) tighten; (b) coat threads with soap and tighten.

Inlet manifold—Trouble: (a) carburetor too small or too large an opening. **Effect:** see pages 109, 115, 1050.

30. Inlet manifold cap screw—Trouble: (a) loose. **Effect:** (a) admits air; mixture too lean. **Test:** (a) examine for looseness. **Remedy:** (a) tighten.

31. Inlet manifold gasket—Trouble: (a) loose; (b) air leak; (c) projects into inlet manifold. **Effect:** (a) (b) admits air; too lean a mixture; (c) obstructs passage of mixture. **Test:** (a) examine for looseness; (b) whistling sound when engine is running; (c) remove manifold and examine fit of gasket. **Remedy:** (a) tighten cap screw 30; (b) install new gasket, or shellac old one; (c) cut opening to fit, or install new gasket.

32. Inlet valve head and seat—Trouble: (a) dirt or carbon under seat; (b) pitted. **Effect:** (a) valve does not seat; poor compression; loss of power; (b) valve leaks compression; loss of power. **Test:** (a) unequal compression noticed when cranking engine by hand. (b) unequal or poor compression noticed when cranking engine by hand. **Remedy:** (a) (b) grind valves.

33. Inlet valve cap—Trouble: (a) loose; (b) gasket leaks. **Effect:** (a) (b) leaks air and compression; loss of power. **Test:** (a) examine for looseness; whistling sound; (b) whistling sound; remove cap and examine gasket. **Remedy:** (a) tighten; (b) install new gasket.

34. Cylinder head gasket—Trouble: (a) leaks air and compression; (b) leaks water. **Effect:** (a) loss of power; (b) water enters cylinder. **Test:** (a) whistling sound; (b) popping back through carburetor. **Remedy:** (a) (b) tighten cylinder head bolts, or install new gasket.

35. Inlet valve guide—Trouble: (a) worn. **Effect:** (a) leaks air on suction stroke; mixture too lean. **Test:** (a) with engine running, squirt gasoline around 35; if engine speeds up a leak exists. **Remedy:** (a) install new guide or ream out and install oversize valve.

36. Inlet valve spring—Trouble: (a) weak tension; (b) broken; (c) same troubles with exhaust valve spring. **Effect:** (a) (b) valve does not seat properly; loss of power popping through carburetor; (c) exhaust valve sucked open admits burned charge back into cylinder; engine misses. **Test:** (a) twist screwdriver between coils of spring to increase tension; if operation is improved, this indicates weak tension; spring tension can also be increased by adding washers (see also page 776); (b) examine spring; (c) same as (a) and (b). **Remedy:** (a) stretch spring or install new one; (b) install new spring; (c) same as 36(a) and 36(b). **Note:** When increasing spring tension, if the tension is increased too much the valve will be very noisy.

²¹ The illustration shows both a valve cap (33) as used with non-detachable cylinder head, and a gasket (34) used when the cylinder head is detachable. Both are not used on the same engine, but are shown here to cover both types of engines.

37. Inlet valve spring retainer washer—Trouble: (a) loose. Effect: (a) same as 36(a) and 36(b). Test: (a) examine for looseness. Remedy: (a) install new pin or collar under washer.

38. Inlet valve clearance—Trouble: (a) none at all; (b) too much clearance; (c) not enough clearance; (d) no clearance at exhaust valve. Effect: (a) valve fails to seat; back-fires through carburetor; (b) valve opens late, closes early; noisy, loss of power; (c) valve does not seat when engine is hot; loss of power; (d) exhaust valve becomes red hot; pre-ignition knock (see also pages 170, 820). Test: (a) (b) (c) (d) test clearance with thickness gauge (pages 58, 775). Remedy: (a) (b) (c) (d) adjust valve tappet (page 775).

39. Inlet valve clearance adjusting nuts—Trouble: (a) loose. Effect: (a) same as 38(a), 38(b), 38(c). Test: (a) examine for looseness. Remedy: (a) adjust valve tappet and tighten.

39A. Cam—Trouble: (a) out of time; (b) worn contour. Effect: (a) loss of power; engine may fail to start; (b) valve lift too short; loss of power. Test: (a) check valve timing (pages 65-67); (b) measure valve lift after checking clearance 38. Remedy: (a) remesh timing gears properly; (b) install new camshaft (see Index under "Valve lift").

39B. Valve tappet guide—Trouble: (a) worn. Effect: (a) when cam nose strikes the tappet (39C), a tapping noise will be produced, owing to the side thrust of tappet against its guide. Test: (a) examine tappet and see if it fits snugly in its guide. Remedy: first try lubricating; if too badly worn, ream guide and put in an oversize tappet, or install a new guide and tappet.

39C. Valve tappet—Trouble: (a) worn. Effect: (a) same as with 39B. Test: (a) same as with 39B. Remedy: (a) same as with 39B.

40. Piston rings—Trouble: (a) worn; (b) too loose a fit. Effect: (a) (b) compression leaks to crankcase; gasoline dilutes oil; oil enters combustion chamber 41, forming carbon. Test: (a) (b) smoke emerges from crankcase, whistle heard from oil filler or breather pipe when engine is cranked; smoke is also emitted from exhaust, owing to excessive oil in combustion chamber, and spark plugs wet with oil, which causes missing. Remedy: (a) install new rings (sometimes a smaller ring gap clearance is necessary; see page 827); (b) install oversize rings (see pages 825-834).

41. Combustion chamber—Trouble: (a) carbon-coated, owing to poor grade of fuel; (b) carbon-coated, owing to piston pumping oil; (c) carbon-coated, owing to excessive use of choker 52; (d) carbon-coated owing to compression leaks. Effect: (a) (b) pre-ignition knock (see pages 170, 780, 820); loss of power; (c) pre-ignition knock; loss of power; high gasoline consumption; (d) pre-ignition knock; loss of power. Test: (a) remove spark plug and examine for carbon; (b) remove spark plug and examine for oil deposits; (c) examine combustion space for carbon; (d) examine for leaks at 32, 33, 60, 34, 40. Remedy: (a) remove carbon and use better grade of fuel; (b) remove carbon and install new piston rings; (c) remove carbon and use choker moderately; (d) remove carbon and fix leak (see page 763 for removing carbon by scraping, and page 764 for removing with oxygen decarbonizing outfit).

42. Piston—Trouble: (a) too loose; (b) carbon accumulation on head. Effect: (a) piston slap; excess oil in combustion chamber; (b) carbon knock; loss of power. Test: (a) see pages 778, 779; (b) examine for carbon. Remedy: (a) install new or oversize piston (see page 809); (b) remove carbon.

42A. Carbon accumulation on piston, combustion chamber walls, and valves—Trouble: (a) mixture too rich; not enough air; (b) poor grade of fuel; (c) piston pumps oil. Effect: (a) excess gasoline forms carbon; (b) unvaporized fuel forms carbon; (c) see 41(a), 41(b), 42(a), and 42(b). Test: (a) see 24(b) and 25(b); (b) see page 103; (c) test compression of each cylinder and see if piston rings leak (see also pages 168, 169). Remedy: (a) adjust mixture leaner and remove carbon; (b) use better grade of fuel or heat thoroughly; (c) see pages 168, 169.

43. Piston pin and bushing—Trouble: (a) worn or loose. Effect: (a) noisy operation. Test: (a) dull metallic knock, more noticeable when idling (see also page 777). Remedy: (a) renew bushing, or piston pin, or both.

44. Connecting rod—see page 796.

45. Carburetor main air inlet—see pages 131, 106, 107 for methods of heating the air drawn into the carburetor.

46. Carburetor hot-air pipe (this pipe extends to exhaust pipe, to draw in warm air)—Trouble: (a) too much hot air after engine is warm; (b) disconnected; (c) obstructed. Effect: (a) expands charge; loss of engine power (see also page 106); (b) insufficient heat; spitting through carburetor (see also page 118); (c) not sufficient air to absorb the gasoline vapor; mixture too rich. Test: (a) try colder air and see if operation improves; (b) examine connections; (c) examine pipe for obstruction. Remedy: (a) open temperature regulator (Figs. 21, 22, page 131); (b) connect hot-air pipe to exhaust stove and to carburetor; (c) clean out pipe or remove obstruction.

47. Carburetor air valve (choker valve)—Trouble: (a) loose. Effect: (a) does not open and close properly. Test: (a) examine for looseness on shaft. Remedy: (a) tighten.

48. Carburetor air valve (choker) lever—Trouble: (a) loose. Effect: (a) does not open and close valve properly. Test: (a) examine for looseness on shaft. Remedy: (a) tighten.

49. Carburetor choker valve wire (runs inside tube 50)—Trouble: (a) sticks. Effect: (a) choker button (52) hard to operate. Test: (a) see that choker button (52) moves freely. Remedy: (a) lubricate with oil.

50. Carburetor choker valve tube—Trouble: (a) too sharp a bend. Effect: (a) binds on wire 49. Test: (a) button 52 hard to operate; examine tube for sharp bend. Remedy: (a) make bend more gradual.

51. Dash or cowl.

52. Carburetor choker valve button—Trouble: (a) loose; (b) stuck; (c) pulled out when engine is warm. Effect: (a) does not pull wire 49; (b) will not pull out or push in; (c) too rich mixture, engine loads up; excess gasoline dilutes lubricating oil. Test: (a) examine for looseness; (b) examine to see if bent or if rusted from the lack of oil; (c) see if valve 47 is fully open when choker button 52 is pushed in. Remedy: (a) refasten to wire 49; (b) straighten or loosen and oil; (c) push button "in" as soon as engine will operate without missing (see page 462-B).

60. Spark plug gasket—Trouble: (a) loose; (b) leaks air. Effect: (a) (b) leaks air and compression; missing and loss of power. Test: (a) (b) squirt oil around gasket; bubbles indicate leak. Remedy: (a) tighten spark plug; (b) install new gasket.

61. Spark plug point gap—Trouble: (a) incorrectly set. Effect: (a) see ignition chart key, 61(a), 61(b).

NAMES OF PARTS AND TROUBLES WHICH COULD OCCUR IN THE GENERATOR AND ITS CIRCUIT.

The generator circuit consists of:

1. Generator
2. Drive method
3. Cut-out
4. Ammeter
5. Storage battery

Generator Troubles Electrical and Mechanical

1. **Fuse:** usually in field circuit; (a) blown, thus opening circuit; (b) poor connection; (c) wrong capacity. A corroded or loose battery connection will permit the generator output to increase and to blow the fuse, thus protecting the generator and lights. See also page 430.

2. **Third brush:** (a) adjustment for output not enough or too much; (b) brush not making good contact; (c) worn short; (d) loose brush spring; insufficient tension; (e) loose pig tail connection

to brush; (f) brush stuck in holder; (g) charging rate too high causes sparking.

3. **Main brush:** (a) poor contact; (b) worn short; (c) loose spring, insufficient tension; (d) loose pig tail connection; (e) brushes stuck in holder.

4. **Brush-holder assembly:** (a) loose; (b) grounded.

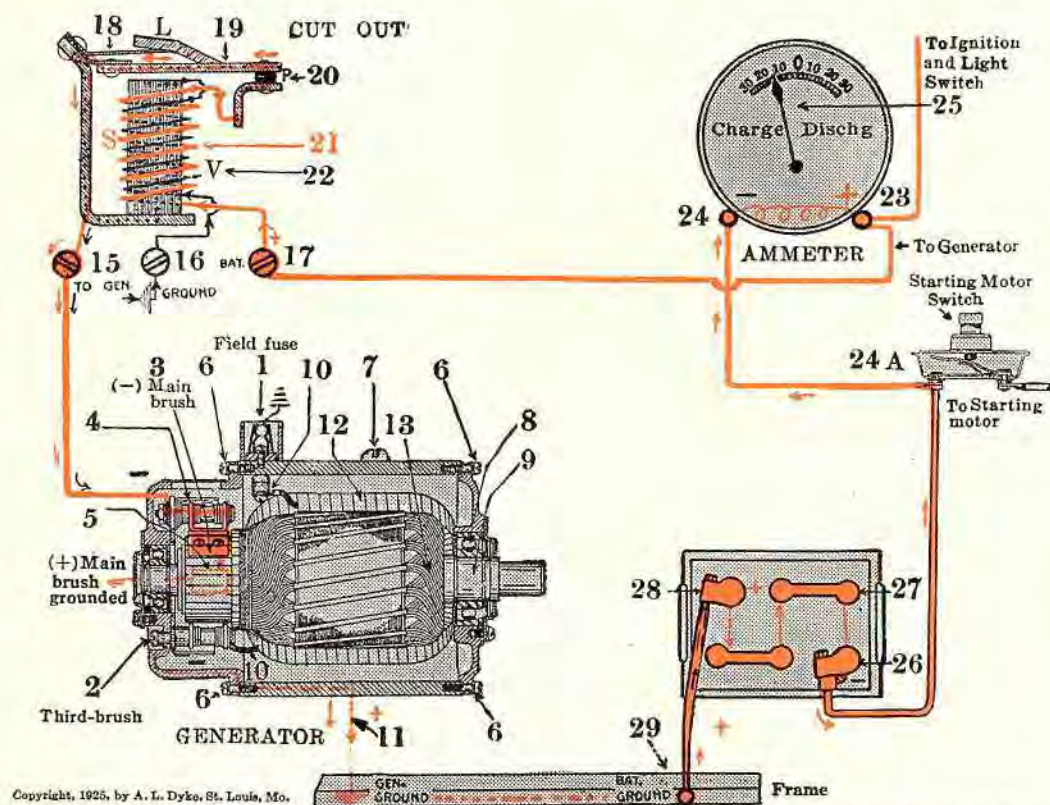
5. **Commutator:** (a) dirty; (b) pitted; (c) high mica; (d) segments loose; (e) armature coil leads to segments loose; need soldering (see also, pages 491, 480); (f) out of round.

6. **Housing end-plate screw:** (a) loose.

7. **Field pole screws:** (a) loose.

8. **Bearings:** (a) worn; (b) ball broken; (c) dry; lack of lubrication; (d) out of alignment.

9. **Armature shaft:** (a) scored or cut from lack of lubrication; (b) bent.



GENERATOR, BATTERY, CUT-OUT TROUBLE-SHOOTING CHART. The chart above shows two circuits of the generator electrical system: (1) the cut-out voltage or shunt winding circuit; (2) the "generator charging circuit."

The cut-out voltage winding causes cut-out points (P) to close when the generator armature attains a speed of usually 6 to 8 m.p.h. car speed. Sufficient current at this speed is produced through this winding (V-22) to cause the cut-out core to become magnetized, which draws the cut-out armature (19) toward the core, closing points (P), thus closing the generator charging circuit (red) to battery.

The cut-out voltage winding circuit starts at (+) main brush, which is grounded, thence from (11) to ground, to ground of cut-out winding (18), through the fine wire voltage winding (V-22), to core, through core and cut-out frame (insulated from ground), to (15), to (-) main generator brush.

The generator charging circuit (shown in red) charges the storage battery when cut-out points (P) are closed by action of cut-out winding (V-22), as stated above; the generator then charges the battery and the ammeter needle should indicate on the "charge" side.

The generator charging circuit starts at the (+) grounded generator main brush, to ground (11), to (29), to (26), to 24A, to (24), to (23), to (17), through cut-out series or coarse wire winding (S-21), through closed cut-out points (P), through cut-out armature (19) and cut-out frame, to (15), to (-) main generator brush. See also, page 333.

10. Field lead: (a) loose; (b) grounded.
11. Ground: (a) oil soaked; not good contact.
12. Field winding: (a) grounded, shorted, or open.
13. Armature windings: (a) grounded, shorted, or open (see pages 496-504).

See pages 563 and 506 as to when a battery needs charging, and when to adjust generator output.

Cut-Out Troubles Electrical and Mechanical

15. Cut-out terminal: (a) loose; (b) grounded; (c) connected to wrong lead (see page 506).
16. Cut-out terminal: (a) loose; (b) fails to ground; (c) connected to wrong lead.
17. Cut-out terminal: (a) loose; (b) grounded; (c) connected to wrong lead.
18. Cut-out spring tension: (a) weak; does not open points; permits current to discharge to generator from battery (bend lug L down to increase tension); (b) weak; does not open points early enough; (c) too strong; does not permit points to close fully; (d) too strong; does not close early enough (bend lug L up to decrease tension).
19. Cut-out armature: (a) bent up; closes late; (b) bent down; closes early.
20. Cut-out points: (a) pitted; do not make good contact; (b) stuck, owing to too much current or not opening quickly and arcing; (c) points do not close fully owing to open shunt winding (V-22), or too strong a spring (18) tension (see that points make a full, even surface contact).
21. Cut-out series winding: (a) grounded; (b) open; (c) loose connection (see pages 505, 519, to test).
22. Cut-out shunt winding: (a) grounded; (b) open; (c) loose connection (see page 505 to test).

Dash Ammeter Troubles

23. Ammeter connection: (a) loose.
24. Ammeter connection: (a) loose.
- 24A. Generator wire connection with battery at starting motor switch: (a) loose; corroded.
25. Ammeter needle: (a) bent; (b) out of calibration; (c) spring broken.

It is advisable to check the dash ammeter with one known to be accurate, as, for instance, a testing ammeter, by placing the two in series and observing if both read alike (see also, page 471).

Storage-Battery Troubles

Troubles of a storage battery are explained on pages 448, 532, 542, 559, 562, 556-559, 563, 506.

Tests of a storage battery are explained on pages 531, 545.

26. Terminal: (a) loose; (b) corroded.

27. Connectors: (a) loose, not burned properly, grounded, owing to acid-soaked battery box (see page 557).

28. Terminal: (a) loose; (b) corroded.

29. Ground connection: (a) loose; (b) corroded (see also page 428).

Generator Circuit Trouble Tests

(First test on car.) (1) With the engine idle, the ammeter should be at zero with all switches off. If the ammeter indicates anything at all with all switches off, then the cut-out points (P) are probably stuck together. Open them and see if the ammeter needle goes back to zero; if not, the ammeter is defective, or there is a ground in the circuit.

2. If the ammeter needle is at zero, turn on the light switch. The ammeter should then indicate the amount of current the lights draw from the battery, and should indicate on the "discharge" side.

3. Next, start the engine, by turning on the ignition switch, and crank the engine and run it slowly. With lights and ignition "on," the ammeter should indicate on the "discharge" side, as current is being taken from battery.

4. Next, speed the engine up, and at about 6 to 10 m.p.h. car speed of the engine, the cut-out points should close and the ammeter should indicate on the "charge" side.

If it does not, then the cut-out points (20) are not closed, owing to defects in the generator or cut-out. A good method of procedure is as follows:

- (a) Keep the engine running at about 20 m.p.h. car speed; close the cut-out points by hand; if the ammeter now reads "charge" from 9 to 20 amperes (according to the type), the generator is in good order but the cut-out is defective. See pages 504-506 for cut-out tests.

- (b) If the ammeter fails to read "charge" when cut-out points (20) are closed, the generator is at fault and must be examined.

- (c) Examine all connections in the generator circuit and see that they are tight and clean, and that no grounds exist.

- (d) Shift third brush (2) in the direction of the commutator rotation and see if the difficulty is overcome; also examine the third brush for wear, poor contact, weak spring tension, stuck in holder, loose brush holder.

- (e) Examine all brushes for items listed under (d). See also pages 430, 506, 563, 363.

- (f) Examine for dirty commutator (5).

- (g) Examine for worn bearings (8).

- (h) If the trouble has not been located by this time, the generator should be removed from the car and tested as explained in the text. See Index under "Testing generator."

NAMES OF PARTS AND TROUBLES WHICH COULD OCCUR IN THE STARTING MOTOR AND ITS CIRCUIT

1. Battery terminal: (a) loose; (b) corroded.
2. Connector from cell to cell: (a) loose; not burned tightly (b) internal short circuit in one cell (see also page 558).
3. Battery ground to frame of car: (a) loose; (b) corroded (see also page 428).
4. Starting motor ground: Usually grounded through frame of motor: (a) rusty; not good contact.

5. Brush: (a) brushes worn short; do not make good contact; (b) stuck in brush holder; (c) brush holder grounded; (d) loose pig tails; (e) weak spring tension (see also pages 493, 494, 496, 329).

6. Commutator: (a) high mica; (b) loose or pitted commutator segments; (c) loose armature wires to commutator; (d) commutator out of round (see also page 449).

7. Brush: (a) brushes worn short; do not make good contact; (b) stuck in brush holders; (c) brush holder grounded; (d) loose pig tails.

8. Field winding: (a) open; (b) shorted; (c) grounded (see also pages 486, 518).

9. Terminal: (a) loose; (b) grounded.

10. Lead to switch: (a) open; (b) grounded; (c) terminal to wire loose.

11. Switch terminal: (a) loose; (b) grounded.

12. Switch contact spring: (a) broken; (b) burned; (c) grounded; (d) open.

13. Switch plunger: (a) stuck; (b) grounded with (14).

14. Switch terminal and contact: (a) loose; (b) burned; (c) grounded.

14A. Ignition, light and generator connection to battery at starting motor switch: (a) loose; corroded.

15. Wire lead to battery: (a) open; (b) grounded.

16. Battery terminal: (a) loose; (b) corroded.

A. Bendix inertia gear (travels toward flywheel; in this example, termed "in-board" type): (a) meshes too tight or too loose with (D); (b) counterweight loose; (c) improper tension of anti-drift pin.

B. Thread for A: (a) oil gummed; (b) rusty (see also page 320).

C. Bendix spring: (a) broken; (b) loose at K or R; (c) flexibility lost owing to engine back-firing and wrapping spring tightly around shaft S.

D. Flywheel gear: (a) broken teeth; (b) teeth not chamfered; (c) improper backlash; should be about $\frac{1}{16}$ ".

F. Chamfered edge of inertia gear: (a) worn; (b) broken.

K. Bendix spring bolt: (a) broken; (b) loose.

L. Bolts supporting motor: (a) loose, thus throwing gears A and D out of alignment.

M. Screws holding pole pieces: (a) loose; may damage armature winding.

P. Stop collar for checking travel of gear A.

R. Bendix spring bolt: (a) broken; (b) loose.

S. Motor armature shaft: (a) bent; (b) rusty.

The starting motor troubles are either electrical or mechanical (see also pages 330, 449, 456, 563).

Mechanical troubles would refer to the Bendix drive, to bent armature shaft, worn bearings, etc. (see also pages 456, 517, 320).

Note: Sometimes when pinion A meshes too tight with flywheel ring gear D, it will cause jamming, difficult engagement, and wear of teeth.

If engagement of the teeth is too tight and there is no backlash it will be necessary either to file out the bolt holes L, or to shim up the motor so that the starting motor can be moved slightly away. The backlash between the teeth of the gears A and D is about $\frac{1}{64}$ " clearance.

Worn bearings, resulting from lack of oil, will also cause improper engagement of gear teeth. Drive pinion A can be checked by noticing if, when motored, it spins freely and does not stick or bind in its travel and meshes freely with about $\frac{1}{64}$ " backlash.

Starting Motor Circuit Trouble Tests

1. If the "whir" of the starting motor is heard, but the engine is not cranked, examine for gummed or rusty threads B, broken spring C, or a broken bolt R (a Woodruff key is sometimes in the end of the shaft S, under R and it may be sheared off), gears A and D may not be meshing owing to incorrect alignment.

2. If the starting motor fails to turn when gear A is engaged with gear D examine for:

(a) Discharged battery (try another charged battery if available).

(b) Engine too stiff (try cranking by hand to determine).

See also page 320.

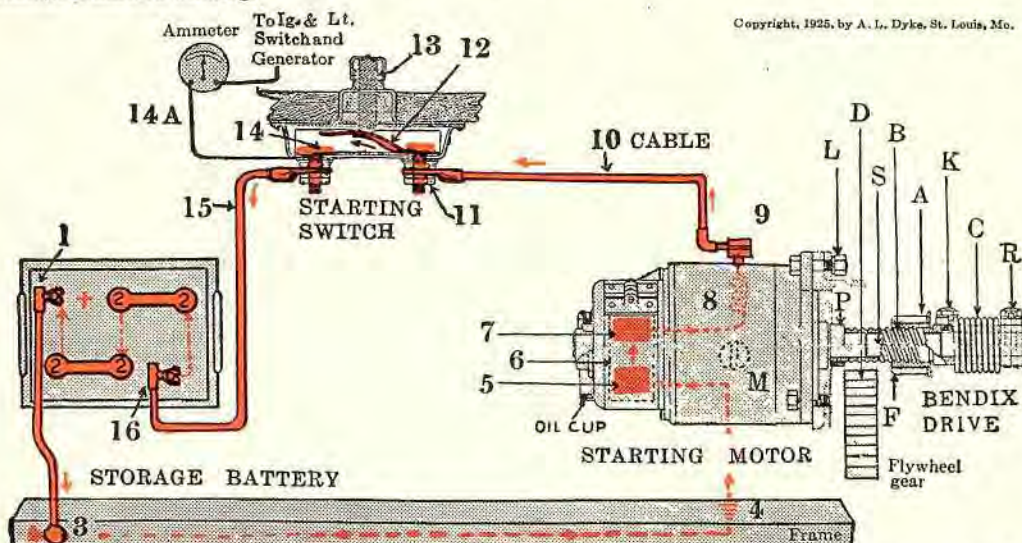
(c) Loose connections, open circuits or accidental grounds at (1), (2), (3), (4), (9), (10), (11), (12), (14), (15), (16).

(d) Brushes (see 5 and 7).

(e) Commutator (see 6).

3. If the trouble has not been located by this time, the starting motor must be removed from the car and tested (see Index under "Testing starting motor"). (See also, pages 319-320, and 834-837.)

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STARTING MOTOR TROUBLE-SHOOTING CHART. The above chart of the starting motor electrical system shows two principal parts: (1) the "starting motor circuit" (in red); (2) the "Bendix drive mechanism," as shown on the end of the starting motor armature shaft.

The starting motor derives its current solely from the storage battery and has no direct connection with the generator.

The starting-motor circuit (red) starts at the (+) terminal of battery (1), to ground (3), to ground (4) of starting motor, to (+) main grounded starting motor brush (5), through commutator (6), through armature coil, to main (-) brush (7), through field windings (8), to terminal (9), to starting motor switch terminal (11), through spring contact (12) (shown open), to (14) to (-) terminal of battery (16). (Note: There are usually four field poles and windings and four brushes on a starting motor, see pages 326-328, 400, 1125.)

The Bendix drive construction and principle are explained on page 320. See also, pages 834-837.

INSTRUCTION No. 42

TESTING DEVICES FOR ELECTRICAL TESTS: Ammeter and Voltmeter Construction and Tests

ELECTRICAL TESTING DEVICES

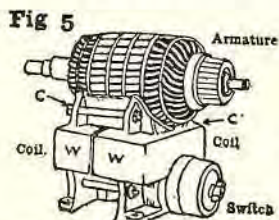
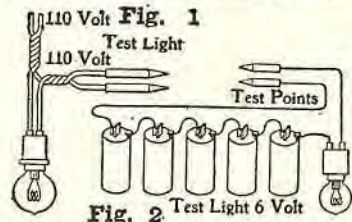
To test the electrical part of a car, or "trouble shooting," requires the proper instruments and devices to locate the trouble, and it is also desirable to follow a logical order or system of testing, instead of guessing. See also pages 448, 482, 507, 545-553.

Some of the concerns supplying volt and ammeters and electrical testing devices are mentioned at the bottom of page 464 and on page 481.

Most tests of any part of an electric system are for "open circuits," "grounds," or "short circuits"—that is, electrical troubles. There are, of course, many mechanical troubles which are not tested with instruments.

Devices used for testing circuits can be classified under two headings:

1. Visible circuit-testing devices.
2. Audible circuit-testing devices.



Visible circuit-testing devices include such devices as are mentioned below:

- (a) Test-light and test-points in series with a 110 or 220-volt lighting circuit (Fig. 1), termed a "high-voltage test-light."
- (b) Test-light and test-points in series with a set of dry cells or a storage battery (Fig. 2), termed a "low-voltage test-light."

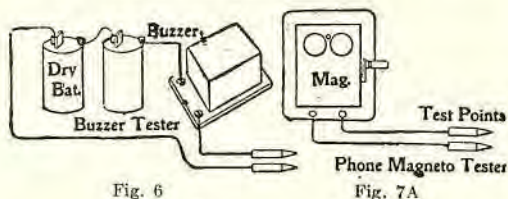


Fig. 6

Fig. 7A



Fig. 7

(c) A voltmeter (Fig. 3).

(d) An ammeter (Fig. 4).

Frequently the voltmeter and ammeter are combined in one instrument.

Audible circuit-testing devices include such devices as a growler (Fig. 5) for testing armatures; a buzzer and test-points (Fig. 6); a phone receiver and test-points (Fig. 7); a magneto and test-points (Fig. 7A).

Test-Lights

The test-light and test-points can be used for testing for open circuits, grounds, and short circuits in the lighting, the horn, ignition, the generator, and, in fact, in all circuits, including the field-windings and armature. Tests will be explained farther on.

Next to the combination volt-ammeter, the most important testing arrangement for the electric mechanic is a set of "test-points," to use in connection with the electric light circuit. This is very easily made by tapping one wire of an ordinary extension lamp, and splicing the wires on to suitable points with insulated handles, in order that these may be handled with no danger of electrical shock, as explained below.

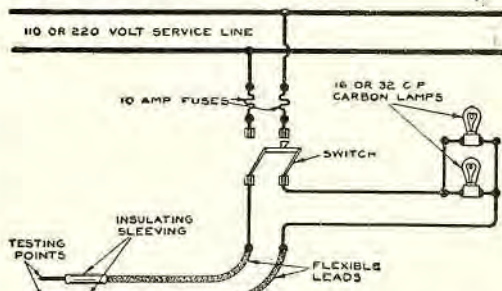


Fig. 8. High-voltage test-lamp with fuses in the circuit

High-voltage test-lamp: The circuit shown in Fig. 8 is for a 110 or 220-volt circuit. Carbon filament lamps are used as they stand more vibration.

With a set of test-points as described, the lamp will burn when the test-points are together, or when there is an electrical connection between the points.

This will give more satisfactory results for testing for grounds, leaks, or open connections than will a bell or buzzer used with dry batteries, as the voltage is higher and it requires a small amount of current to operate the lamp.

With a bell or buzzer, a ground may exist, but the resistance is so high that enough current will not be forced through it by the dry batteries, to operate the bell or buzzer.

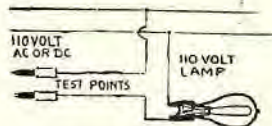


Fig. 8A. High-voltage test-lamp without fuses.

No harm can be done to any part of the apparatus by test-points as described above, when the ordinary carbon or tungsten lamp is used for testing purposes.

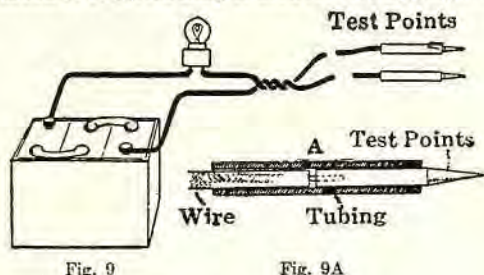


Fig. 9

Fig. 9A

Fig. 9. Low-voltage testing lamp.

Fig. 9A. Construction of the test-points.

A low-voltage test-lamp is shown in Fig. 9. In many instances it is advisable to use a small 2 c.p. lamp and a storage battery. Note that the lamp is in series with the circuit. The voltage of the lamp is the voltage of the battery used. Usually, a 2 c.p. lamp is used.

Test-points: An example of how the test-points can be made is shown in Fig. 9A. The end of the wire is scraped clean and inserted into a hole drilled

into a brass rod about 6" long, and soldered securely. The rod must have a very sharp point, so that it will make good contact. A fiber tube is then tightly fitted over the pointed brass rod and wire (Fig. 9A.)

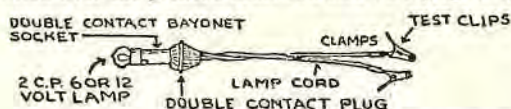


Fig. 10. Test-lamp for timing the ignition, or for making other electrical tests.

A test-lamp for testing the opening and closing of the contact-breaker points of the primary ignition circuit when timing the ignition is shown in Fig. 10. See page 371 for directions for use. See also page 301.

Buzzer, Phone Receiver, and Magneto Tester

The buzzer or bell (Fig. 6) and the phone receiver (Fig. 7) can be used with the test-points for testing out different sections of the armature coils.

The magneto tester (Fig. 7A) generates a high voltage and is adapted for tests which will force a current through a high degree of insulation, such as poor connections or a leaky path and coil windings. This device is nothing more than a telephone magneto generator with a bell, test-cords, and test-points. It is cranked by hand (seldom used).

AMMETER AND VOLTMETER FOR DIRECT CURRENT TESTS¹

The ammeter and voltmeter can be used in many instances where a test-light can be used, and vice-versa. In fact, the voltmeter and ammeter are more often used for all general electric tests than any other type of testing device. Therefore, before taking up the subject of tests of the various parts and circuits, an explanation of these will be given.

A voltmeter is always placed **across**, or parallel with, a circuit to be tested, as in Fig. 12A.

An ammeter is always placed in series with a circuit to be tested, as in Fig. 13.

The positive (+) terminal of each instrument is placed on the (+) side of the line, otherwise the instrument would read backwards.

Combination Voltmeter and Ammeter for Electrical Testing Purposes

Instead of having a separate voltmeter and ammeter, it is possible to combine both in one instrument using the same scale and moving coil. The Weston model 280 garage testing voltammeter will be used as an example (Fig. 12).

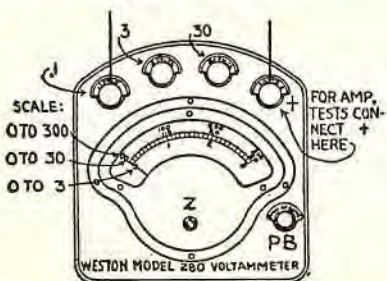


Fig. 12. Showing the three scales on the volt ammeter. The contact button (PB) is pressed when making readings. If it is desired to obtain a continuous deflection, the key (Z) should be given a turn, which locks it. When starting to use the instrument, see that the needle is at zero; if not, adjust with (Z).

As a Voltmeter

When using the instrument for voltage tests: See Fig. 12, and note terminals are marked .1, 3, 30, +.

The positive (+) terminal of the instrument is always connected with the positive (+) wire of the circuit being tested. When making connections where the polarity is not known, the needle will deflect to the left if wrongly connected—reverse connections.

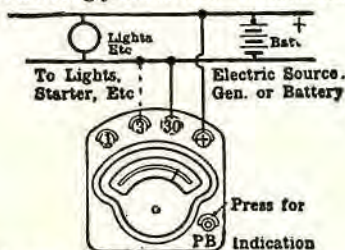


Fig. 12A. When used as a voltmeter, the connections are always made across the line. The circuit of this is from (+) of the battery, to lights, to (-) of the battery. Note that (+) of the meter is connected to the (+) side of the line. Thus if the circuit is 3 to 30 volts, connect the other side of the line with meter terminal 30. If the voltage is from 0 to 3 volts, connect with terminal 3.

If the voltage to be tested is known to be between 3 and 30 volts, then connect the other, or negative (-) wire to terminal marked 30, and use the scale 0 to 30, the divisions of the scale being 0.5 volt for each line (the scale has 60 divisions).

If the voltage is known to be between 1 and 3 volts, connect the negative wire with terminal marked 3, and use scale 0 to 3, the divisions of the scale being 0.05 volt for each line.

If the voltage is known to be less than 1 volt, connect the negative wire with terminal marked .1, and use scale 0 to 3.

¹ Manufacturers and distributors of volt and ammeters are: Weston Electrical Inst., Corp., Newark, N.J.; Mann & Briggs (Jewel "Hyrate" instruments), Chicago, Ill.; Burton & Rogers (Hoyt instruments), Boston, Mass. (see also page 481).

When making voltage or ampere tests, the button (PB) is pressed for indication.

The zero adjustment (Z), is merely used to line up the needle with zero or O, when starting to use the instrument.

A voltmeter is always connected across the line, as shown at (V1) and (V2), page 470, and in Fig. 12A. It is used to indicate the voltage pressure of an electric circuit.

As an Ammeter

When using the instrument for measuring amperes, it is connected in series (that is, the shunt is in series) with the circuit, and is intended to indicate the quantity or rate of flow of current.

It is important to note that a "shunt" (Fig. 14) must be connected as shown in Fig. 13. The reason for this is explained farther on. A shunt is not used with the voltage tests.

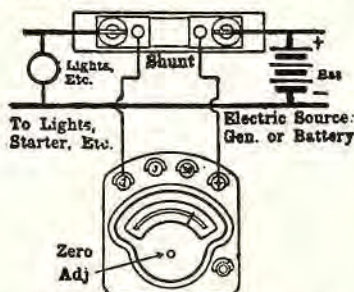


Fig. 13. When used as an ammeter, a shunt is placed in series with the line and the meter is connected to the shunt. The circuit is from (+) of the battery, to shunt, to light, to (-) of the battery. Note that the ammeter is connected to each side of the shunt.

An ammeter is a millivolt meter, adjusted to a known drop in the shunts used with it.

Shunts

Construction: A shunt consists of a special alloy, called manganin (Fig. 14), which, in this instance, is placed between two copper bars mounted on a wood or hard rubber base. The shunt is placed in series with the circuit being tested.

The meter is connected at each end of the manganin at (M) and (M1) (Fig. 14). Thus the manganin is shunted across the meter terminals, and this is why it is termed a "shunt." A shunt is used with the meter for ampere tests and not for voltmeter tests.

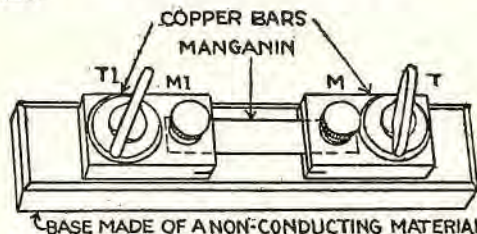


Fig. 14. A shunt used in connection with the Weston ammeter.

The manganin alloy was discovered by Dr. Weston. It possesses the faculty of holding a constant resistance, whether it is hot or cold, and directly proportional to the current flowing through it.

It is a well-known fact that other metals which are used for resistance purposes, when cold, offer less resistance than when hot. In other words, other

resistance metals when heated offer greater resistance to the flow of current (some metals more or less than others).

The shunts which are used with this model 280 instrument are designed to give a 100-millivolt drop between the terminals (M) and (M1), (Fig. 14A).

Explanation of Millivolt Drop

A millivolt is a one-thousandth part of a volt. One hundred millivolts would then be one hundred times more, or one-tenth of a volt, expressed decimally as .1. The terminal of the meter (Fig. 12), at the left, which is marked .1, is then, the one-tenth of a volt, or 100-millivolt terminal of the meter.

The moving coil of model 280 voltmeter and ammeter is designed for a passage of 100 millivolts (or .1 of a volt) through the coil. If this amount of voltage passes through the moving coil (K) (Fig. 15), it will cause the coil to move its maximum distance of travel across the scale. As the needle moves with the coil, it would give a full-scale deflection of the needle, that is, the needle would move from 0 at the left of the scale, to the extreme right. Thus it will be noted that one-tenth of a volt (.1), or 100 millivolts, which is the same, is the voltage required to cause the needle to give its maximum or full-scale reading. This voltage is used for the instrument when it is used as an ammeter or as a voltmeter.

If less than one-tenth of a volt (.1) (or 100 millivolts) is passed through the coil of the meter, then the needle will not move as far on the scale. The scale is graduated to show in volts or amperes, although the actual voltage which is permitted to pass through the coil of the meter is only 100 millivolts, or one-tenth (.1) of a volt, or less.

This drop in voltage depends on the size or quantity of the manganin used in the shunt, when the instrument is used as an ammeter.

When the instrument is used as a voltmeter, the shunt is not used, but resistance is used as shown in the figure of the meter in Fig. 15.

For example: Let us assume that the instrument is to be used as an ammeter to test the rate of flow of amperes passing from the (+) brush of the generator to the (+) terminal of the battery, as shown in Fig. 14A. We will also assume that 30 amperes will

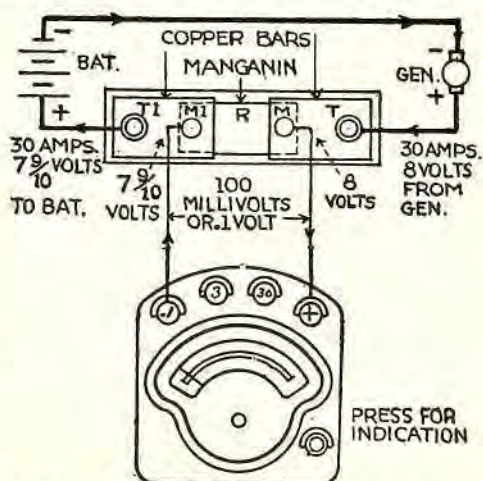


Fig. 14A. Illustrating how the voltage is dropped one-tenth of a volt (100 millivolts), when 30 amperes are passed through the shunt. Only one-tenth (.1) of a volt, or 100 millivolts, or less, passes through the meter—never any more.

pass from generator to battery when the former is generating its maximum current output,¹ and about 10 amperes when it is generating its minimum output.

A 30-ampere shunt is then placed in series with the main charging circuit, as shown in Fig. 14A. We use the 30-ampere size because we know the maximum current is not over 30 amperes, or is less. If it was more, then a shunt with a greater capacity should be used.

The main circuit is then as follows: The (+) current starts at (+) of the generator brush, to a copper bar terminal (T), through the manganin, to the other copper bar terminal (T1), to the (+) terminal of the battery, through the battery, to the (-) terminal of the battery, to the (-) brush of the generator.

Thus we have, say, 30 amperes flowing in the main circuit and through the shunt. Therefore, 30 amperes will flow through the manganin from the (+) brush of the generator, and will not be reduced, and thus 30 amperes reach the battery.

The ammeter circuit: The meter terminals (when used as an ammeter) are always connected from one terminal (M) of the shunt, which is the (+) side, where the connection of the copper bar makes contact with the manganin, thence to the (+) terminal of the meter, through the moving coil in the meter (Fig. 15), to the 100-millivolt terminal, or .1 terminal, of the meter, to the terminal (M1) on the shunt (Fig. 14A) which is the (-) or other end of the manganin.

We will now see what would cause the needle to deflect a full-scale deflection and show 30 amperes. The reading is made on the second scale, 0 to 30 (Fig. 15), because we are using a 30-ampere shunt.

In the preceding paragraphs, it was stated that if one-tenth (.1) of a volt, or 100 millivolts, passed through the meter coil, this would cause the coil to travel such a distance in the direction of rotation as to cause the needle to make a full-scale deflection. Therefore we must now pass .1 of a volt (or 100 millivolts) through the coil, which is the purpose of the shunt.

For instance: If the voltage was 8 volts from the generator, then 8 volts would start into the manganin at (M), but after passing through the manganin, the voltage would have dropped 100 millivolts, or one-tenth (.1) of a volt, or to 7 9/10 volts at (M1).

Therefore, as the meter terminals are connected with the manganin at each end (M) and (M1), this difference of one-tenth (.1) of a volt, which represents the millivolt drop, would pass through the coil of the meter, and the needle would have moved to the extreme right and would read 30 amperes on the scale (Fig. 15).

Thus the shunts used with this meter are designed for a 100-millivolt drop, and it is this voltage drop which is used to operate the meter. It will be clear, therefore, that if the meter was connected in series with the circuit without the shunt, the full voltage (8 volts) would pass through it and damage it.

We will now assume that the output of the generator is but 10 amperes, instead of 30 amperes.

If it required 30 amperes of current to pass through the shunt to cause a drop in voltage of 100

millivolts, or one-tenth (.1) of a volt, then if only 10 amperes passed through the shunt, the millivolt drop would be proportionately less. Therefore, as only one-third of the current is passing through the shunt, only one-third of the 100 millivolts would drop. Instead of the voltage dropping to 100 millivolts at (M1), it would drop only one-third as much, and only one-third of 100 millivolts would pass through the coil of the meter. Thus the coil of the meter would move but one-third of the distance, and as the needle moves with the coil, it would move but one-third the distance on the scale, or to the reading of 10 amperes, as calibrated on the scale.

The same rule applies to all the other shunts. If a 3-ampere shunt is used, only 3 amperes must pass through it, and consequently it contains a proportionately less amount of manganin. If full 3 amperes pass through the shunt, the result will be a voltage drop of 100 millivolts, or one-tenth (.1) of a volt. The same applies to the 300-ampere shunt, or to any shunt designed for this instrument.

The point to bear in mind is that one-tenth (.1) of a volt, which is 100 millivolts, is what is required to give a full deflection of the needle on the scale, and that a shunt must be used, which will give a drop of 100 millivolts if the full amperage for which it is designed, is passing through it, or that it will give a proportionately less drop, if less amperage than that for which it is designed is passing through it.

Thus the shunt, which is shunted between the two terminals (+) and .1 of the meter, when used as an ammeter, is for the purpose of giving this 100-millivolt, or one-tenth (.1) of a volt drop, or less, in proportion to the current passing through it.

Internal and external shunts: Where currents are small, as on a dash ammeter, the shunts are usually internal, or contained in the meter case. But for large currents or for testing instruments, external shunts are used, so as to keep the heat developed in the shunts outside of the meter as well as for convenience, as the shunt can be located in the circuit wherever it is easiest, and can be connected with the meter by a small cable, thus saving the running of heavy wires to the instrument.

Note. When testing amperes, use the testing cables which come with the instrument, from the meter to the shunt, as the cable is figured out for the exact length and size. From the shunt to the part being tested, use a wire of sufficient size to carry the load or amperes which will pass through it; for instance, if 30 amperes, use No. 10 or 8 wire.

Capacity of Shunt to Use with the Model 280 Instrument, and Range of Scale

Shunts to use with this instrument:² There are three external shunts figured on a 100-millivolt drop between terminals.

1. A 300-ampere shunt with which use the scale 0 to 300. Each division or mark on the scale represents 5 amperes (see Figs. 12 and 15).
2. A 30-ampere shunt, with which use the scale 0 to 30. Each division or mark represents 0.5 amperes.
3. A 3-ampere shunt, with which use the scale 0 to 3. Each division or mark represents 0.05 amperes.

When testing where you do not know what the amperage is likely to be, as when testing for short circuits, it is advisable to assume that the highest possible amperage is to pass through the meter. In such cases use the 300-ampere shunt. If the deflection obtained is less than 30 amperes, then use the 30-ampere shunt and scale, to gain a more accurate

¹ A generator seldom delivers more than 20 or 22 amperes maximum. We have arbitrarily taken 30 amperes to illustrate our explanation of how the needle will make a full-scale deflection from 0 to 30 when a 30-ampere shunt is used and 30 amperes are passing through it.

² Other sizes can be obtained.

reading. Should the indication now be less than 3 amperes, use the 3-ampere shunt.

The 3-ampere shunt and range are convenient for measuring small lights and ignition.

The 30-ampere shunt and range are convenient to measure current delivered by a generator to the battery as shown at (A1), page 470; for measuring current required by the lights, horn, etc., and also for testing short circuits and open circuits.

The 300-ampere shunt and range are convenient for measuring the current required by the starting motor, as shown at (A2) page 470 and also for testing for short circuits.

Shunts Not Used with Instrument as a Voltmeter

When the instrument is used as a voltmeter, the same coil winding as shown in Fig. 15 is used, and it is necessary to have the same 100 millivolts or .1 volt drop, just the same as when it is used as an ammeter, but the shunts are not used to obtain this drop. Resistances (C), (B), and (A) are used (Fig. 15). This resistance is in series with the meter circuit and its connections to the main circuit being tested. Note, however, that the voltmeter connections are across the line of the main circuit.

The (+) terminal of the meter is always connected to the (+) side of the circuit being tested, and the terminal .1, 3, or 30 is connected to the other side of the circuit.

This instrument is designed for testing the voltage of a circuit, from 0 to .1 volt (100 millivolts); 0 to 3 volts; and 0 to 30 volts.

By means of a multiplier, used in conjunction with the 30-volt range, the range is extended to 150 volts. This multiplier can be obtained of the Weston Electrical Instrument Co., Newark, N.J. (or of A. L. Dyke, Electrical Dept., St. Louis, Mo.).

Millivolt Reading

When testing a circuit of 100 millivolts or less, the connections are made for the (+) side of the circuit, to the (+) terminal of the meter, through the moving coil, to the .1 (100-millivolt) terminal on the extreme left.

If 100 millivolts (1/10 volt) pass through the moving coil, then the needle will deflect from 0 to the extreme right.

If 50 millivolts pass through the meter coil, then the needle will deflect half-way of the scale, and so on.

The millivolt connections are used for testing the voltage drop in armature and field coils.

The scale 0 to 30 is used, and it will be noticed that this scale has 60 divisions. The scale, however, is not calibrated for millivolt readings. Therefore a comparative test is usually made when using it.

For example: If each armature coil is being tested for short or open circuits, the procedure would be to test an armature coil that is known to be in good condition, and then to note where the needle goes on the scale. Then test all of the other armature coils, which should compare with the good coil in the reading. There will, of course, probably be a slight variation in the readings of the different coils, owing to the fact that they may not all be exactly the same length, but the variation should be very slight.

If there is a noticeable difference, where the reading is greater than in the good coil, then the coil is

probably open-circuited. If the reading is noticeably less, then there is probably a short circuit in the coil.

As previously stated, the scale is not calibrated for readings in millivolts, but if the needle moves from 0 to the right of the scale, then we know that 100 millivolts are passing through the meter coil. The scale has 60 divisions, therefore one division would equal one-sixteenth of one hundred, or $1\frac{2}{3}$ millivolt.

Purpose of resistance in the circuit when testing armature or field-coils: It will be observed by referring to the subject of: "Testing armature or field coils with a meter" (page 488), that resistance, termed a resistor, is used in series with the circuit.

If the millivolt connections of the meter were made to an armature coil in good condition, the drop would be very slight and difficult to read, unless a meter with a millivolt scale was used.

The object is to place enough resistance in the armature or field-coil circuit to cause a voltage drop sufficient to obtain a millivolt drop which will be easy to read. A good armature coil is then tested, and the needle is deflected to a certain distance on the scale. This reading is then taken as a standard to go by; then the tests of all the other coils should compare with it, as previously explained.

This resistance is variable, that is, more or less can be used, in order to obtain the deflection of the needle to a distance on the scale where it can most easily be read.

This resistor can be purchased of Ward-Leonard Electric Co., Bronxville, N.Y., at a cost of \$5.00. It is designated as "Weston Special 6-10." (It can also be obtained of A. L. Dyke, Electrical Dept., St. Louis, Mo.)

Sometimes a lamp is used in series with a 6-volt battery for the same purpose.

Readings 0 to 3 Volts

When testing a circuit of 3 volts or less, the connection is made at the (+) of the meter with the (+) side of the circuit, then from terminal 3, to the (-) side of the circuit.

The lower scale 0 to 3 is used, and if 3 volts are passing through the circuit, then 100 millivolts, or .1 of a volt will pass through the meter coil, because the resistance (C) and (B) will reduce the 3 volts to one-tenth (.1) of a volt. Therefore the needle would make a full-scale deflection from 0 to 3.

If less than 3 volts is passing through the circuit being tested, then the voltage passing through the meter coil would be proportionately less.

Readings 0 to 30 Volts

When testing a circuit of 30 volts or less, the same connections are made as in the 3-volt test, except that the 30-volt terminal of the meter is used instead of the 3-volt terminal, and the scale 0 to 30 is used.

The resistance (C), (B), and (A) would be in the circuit, and it would therefore be reduced to .1 of a volt, which amount would pass through the meter coil; and this amount would be required to give a full-scale deflection of the needle from 0 to 30.

If less current than 30 volts is passing in the circuit, then a proportionately less voltage than .1 of a volt will pass through the meter coil.

Internal Connections of Model 280 Combination Volt-Ammeter

Note on Fig. 15: When button (PB) is pressed down, the circuit is from the (+) terminal of the meter, through the moving coil (K), to the terminal being used.

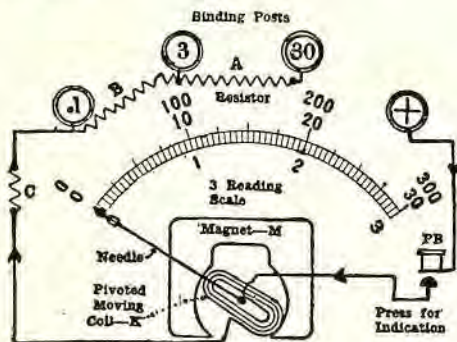


Fig. 15. Internal connections of the Weston model 280. The D'Arsonval or moving-coil principle.

Resistance (C) is the adjusting resistor for the 100-millivolt range; (C) and (B) are in series for the 3-volt range, and (C), (B), and (A) in series for the 30-volt range.

The scale is divided into three sections, and, unlike the dash ammeter, the 0 (zero) is placed at the extreme left, instead of being in the center. Therefore the needle and coil move to the right. It is well to mention that the scale of this instrument is carefully drawn and calibrated by hand. In order to do this and check the instrument with a master meter, three weeks' time is required. This instrument is guaranteed to be accurate within 1 per cent.

When connecting the meter, care must be taken to see that the connections are correctly made; that is, the (+) terminal of instrument should be connected with the (+) side of the circuit being tested, otherwise the needle will deflect to the left, indicating that the (+) terminal of the meter is connected with the (-) side of the circuit.

Cadmium scale: A scale for making cadmium tests of a storage battery, as explained in the storage battery instruction, has been added to the Weston model 280 instrument. This is not shown in the illustration (Fig. 15).

The scale in Fig. 15 has added to it four lines to the left of "0," the first line being one-half of one-tenth of a volt, or .05 of a volt, or 1/20 volt. The second line would be .1 (one-tenth) of a volt; the third line would be .15, or 3/20 volt, and the fourth line would be .2 or 1/5 volt. This scale is used for cadmium readings when testing a storage battery, and is explained in the storage battery instruction.

Principles of the Ammeter

Two principles are in general use: one is the "D'Arsonval type," which is termed a "moving-coil type," and which is the principle on which the Weston model 280 instrument is constructed.

The other type is the "polarized vane" type, which has a "stationary coil."

Moving-Coil Principle

D'Arsonval type: Refer to Fig. 15. Note the permanent magnet (M) which has a permanent N and S pole polarity. A fine, light spiral spring (not shown) serves to lead the current into and out of the moving coil (K), and also to keep the coil in its zero position and to provide a force against which the magnetic action of the current in the coil acts.

The electric current to be measured is passed through the moving coil (K) and magnetic lines-of-force are set up around the coil which becomes an electromagnet,¹ with the N pole at one end and the S pole at the other, depending upon the direction of flow. Therefore, as a N pole will attract a S pole, or repel the N pole,¹ this principle is utilized. The coil endeavors to place itself in line with the magnetic circuit flowing from N to S from the permanent magnet. The coil is pivoted so that it can move, and the needle, being connected with the coil, moves with it.

The D'Arsonval, or moving-coil principle, is the type of ammeter and voltmeter in general use, especially for testing purposes, where close accuracy is required. This type of instrument is designed for only a fraction of a voltage to pass through it, and if a greater amount than a 50 per cent overload is passed, it will damage the instrument.

Stationary-Coil Principle

The polarized vane type of ammeter uses a fixed or "stationary coil." This type is more rugged and will withstand severe strains and shocks without damage, but it is not as accurate in its readings. This principle is often used for dash ammeters and indicators, but not for testing purposes.

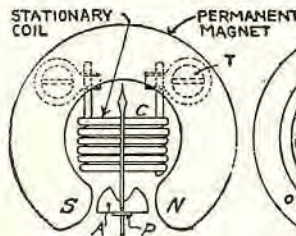


Fig. 16

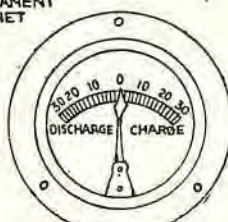


Fig. 17

The principle of its operation is shown in Figs. 16 and 17. A piece of soft iron, rigidly attached to a steel pivot placed equally distant from the poles of a permanent magnet, is attracted or repelled by the passing of an electric current in one direction through the coil of wire (C) fixed or stationary in the plane of the iron. The magnet, being of the permanent-magnet type, holds the piece of iron (called the armature) exactly in position, so that the pointer attached to the pivot is held at zero.

As current is admitted to the coil, it becomes an electromagnet, the N pole being at one end and S pole at the other, dependent on the direction of flow.

When the end nearer the armature is North, it repels the North end of the armature and attracts the South end, with the result that the needle moves across the scale.

As a result of the manner of the construction of this instrument it is capable of withstanding the current from the battery to the starting motor without damage, as the coil (C) is of very heavy construction.

Dash Ammeter

The dash ammeter of the moving-coil type (for direct current) is similar in principle to that shown in Fig. 15, except that it has internal shunts and its dial is calibrated to read in two directions. That is, the zero (0) is placed in the center of the dial, as shown in Fig. 18.

¹ Why the N pole attracts the S pole and repels the N pole is explained on page 179. See also, page 183, explaining how a coil becomes an electromagnet with a N and S pole polarity.

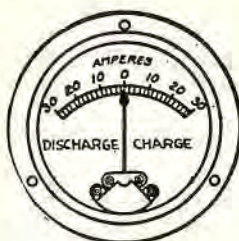


Fig. 18

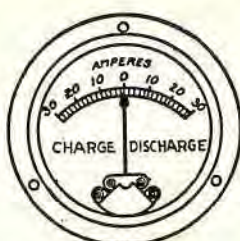


Fig. 18A

If the moving-coil type of instrument is used on a circuit of more than 30 amperes, it will be damaged. The starting-motor current is never taken through a dash ammeter of this type. The generator charging current is carried through it and as the generator seldom delivers over 22 amperes, the 30-ampere range is sufficient.

Meaning of Zero Center

Note that the "0" is in the center, and when no current is flowing the needle will remain at 0 or zero. The needle can read up to 30 amperes on the "charge" side, to the right, or to 30 amperes on the "discharge" side, to the left, and is termed a "30-0-30" scale.

If the generator is running at sufficient speed to charge the battery, the cut-out points will close and connect the generator with the battery and charge the battery. Then the needle will move to the right or "charge" side of 0—if correctly connected.

If the engine slows down, and the cut-out points open, then the battery is disconnected from the generator, and as ignition is being consumed from the battery the needle will move slightly to the left of 0, or "discharge" side of zero—as the battery would be discharging instead of taking a charge. If lights were on, then the needle would go farther on the discharge side, as more current will be discharging from the battery.

This shows that the needle moves in one direction when current is flowing from the positive connection (+) of the generator to (+) of the meter, to (+) of the battery. But the needle operates in an opposite direction, when current is flowing back from the battery to the meter, as connection is with the negative side (-) of the meter in this instance. This is the reason for zero (0) being in the center on the dash ammeter.

Note. The instrument just described, as is the case also with the other instruments illustrated in these instructions, shows the "charge" side on the right of "0" and the "discharge" side on the left of "0."

The standard now adopted by manufacturers of dash ammeters is to have the "charge" side on the left and the "discharge" side on the right of "0" (see Fig. 18A). There are many instruments which came into use before this recent standard was adopted, which read as shown in the illustration (Fig. 18). This makes no particular difference, however.

An Indicator

A battery indicator (Fig. 19) is used for the same purpose as a dash ammeter, that is, to show when the battery is being "charged" by the generator and when it is being "discharged." Instead of showing the rate of charge or discharge, it merely indicates what is taking place, by the movement of a cylinder



Fig. 19. Battery indicator showing its three indications.

inside of the instrument bearing the wordings, "off," "charge," and "discharge," which appear at an opening in the dial of the instrument.

This instrument will operate on as low as 2 amperes and, unlike the dash ammeter of the moving-coil type, it is capable of withstanding any voltage or amperage without damage.

This type of instrument can be placed in series with even the starting-motor circuit without injury, and will show "discharge" when current is flowing to the starting motor from the battery.

This type of instrument is used on the Franklin (see footnote bottom of page 424), and is placed in the motor circuit as shown in this diagram. The same type was also formerly used on the Dodge.

This type of indicator is termed the "polarized vane" type, with a "stationary coil" (of a principle similar to that shown in Fig. 16).

The Roller-Smith Co., Woolworth Bldg., New York, manufactures a dash-type ammeter of the polarized vane type which can be placed in the starting-motor circuit. The same concern also manufactures instruments of the moving-coil type. Another concern manufacturing the moving coil or rotary type, as well as stationary-coil type instruments, is the Hoyt Co., the instruments being sold by Burton-Rogers, Boston, Mass.

HOW THE VOLTMETER AND AMMETER ARE USED FOR TESTING THE ELECTRIC SYSTEM OF A CAR; EXTERNAL TESTS

As an example we shall use the Weston, model 280 combination volt-ammeter. The tests shown in Fig. 20, can usually be made on the car without removing any of the parts. Internal tests of the different parts, or "bench tests," will be treated farther on.

The idea of this combination electric system is to show where and how a voltmeter and ampere-meter can be used on the average electric system for testing circuits on the car. It is understood that the battery is a 6-volt, 3-cell battery, and also that the only instrument which is a regular equipment of the electric system in this example is the "dash ammeter." The other instruments (V1), (V2), (V3), (A1), (A2), are testing instruments, the use of which will be explained.

Voltmeter Tests

The voltmeter is always placed across the line, and shows the voltage or pressure of a circuit. The instrument used is the Weston, described on page 464 (Fig. 12), which read carefully.

Test V1: To test voltage of generator: Use the "0 to 30 connections" and "0 to 30 scale" of instrument. Place the test points (TP) on the connections leading from the two main brushes. The brush to the left leading to the shunt fields is the third brush and is a part of the shunt-field circuit, or the source of the shunt-field current supply. This test does not include the field circuit, but is for the voltage of the "charging circuit." The maximum voltage of the generator from its "main brushes" will be indicated when the generator is operating at from 7 to 10

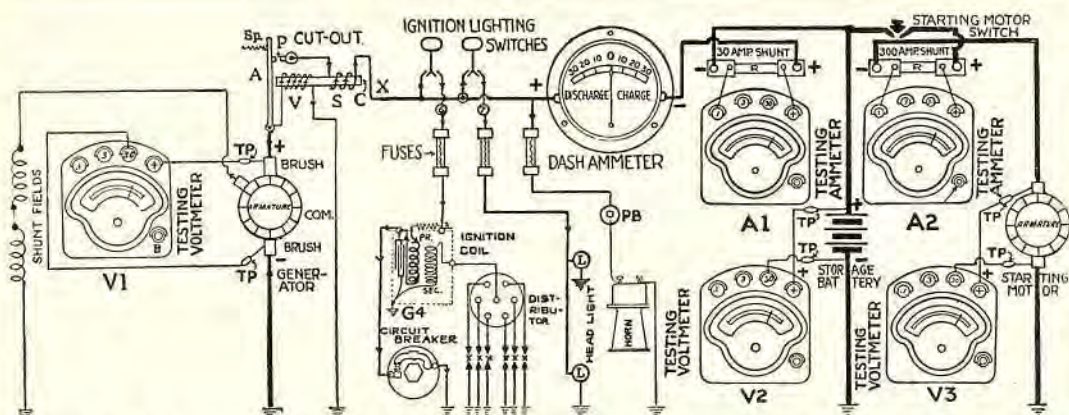


Fig. 20. The dash ammeter is so connected that it shows all current which would "discharge" from the battery, except starting-motor current. All current passing from the battery to the ignition or lighting circuit must first pass through the ammeter, which will show "discharge" on the left of zero in this example. Current passing from the generator to the battery will be indicated on the "charge" or right side of zero. The ignition circuit and light circuit will reduce the amount of charge going to the battery.

The testing meters (V1), (V2), (A1), (A2), and (A3), are not connected permanently in the circuits, but are intended to show how various tests can be made as explained in the text, and only one test is made at a time.

m.p.h. car speed, and the cut-out points (P) should be closed. The voltage of the generator should be slightly more than that of the battery, otherwise the generator will not have pressure enough to overcome the battery voltage. The battery voltage can be tested as shown at (V2).

If the generator voltage is found to be less than the battery voltage, then the cut-out points (P) will probably not close, because the purpose of the fine wire voltage winding (V) of the cut-out is to magnetize the core (C), thus drawing (A) to it and causing the points (P) to close. This winding is so wound that it does not exert sufficient magnetizing effect to draw the points (P) so that they are closed, until the generator voltage is slightly more than the battery voltage.

If the generator voltage is lower than the battery voltage, then the first place to examine is the "third brush" to see if it is seating properly. If it is seating only enough to make slight contact, or if a new third brush has been fitted without properly seating it to the curvature of the armature, the field strength cannot build up sufficiently to assist the armature in building up its full voltage.

The proper seating of the "main brushes" is also important. The commutator may have the mica protruding, or dirty, or the commutator may be rough, or the armature or field windings may be grounded.

If there is no indication of voltage at all, at the generator, then loose connections or open circuits exist, either at the brush-holders, the brushes, or the field-windings.

It is seldom that there will be no indication of current at all, if one armature coil is open, because, they are connected in parallel, and while one armature coil may be open, some indication would come from the other coils. Tests for internal troubles of the generator will be shown farther on.

If the generator voltage is above that of the 6-volt battery, and cut-out points (P) fail to close, then the cut-out spring tension may be too strong, or the cut-out voltage winding may be open-circuited or grounded, or there may be loose connections.

If the cut-out armature (A) makes a feeble effort to close, but does not close tight, when the generator

voltage is 6+, then it indicates that the spring tension is too strong, or that there is a ground, or a partial short circuit in the windings.

If the generator voltage is over 6 volts and the cut-out armature (A) makes no attempt to close at all, then the cut-out windings should be tested, providing the spring tension is not too great.

Sometimes the cut-out points (P) fail to open when the engine slows down or stops. This is caused by the points burning together, and thus the battery will discharge back through the generator, but the "discharge" would show on the "discharge" side of the dash ammeter when all switches are "off."

Tests of the cut-out windings are explained farther on.

Test V2: To test voltage of battery when discharging with lights on only, use the 0 to 30-volt connections and scale. The voltage, if charged for a 3-cell battery, will be 6 to 6.3 volts, or 2 to 2.1 per cell. If discharged, it will be 5.4 volts, or 1.7 volts per cell.

If tested when the starter is on, a charged battery will drop to 5.4, or 1.7 volts per cell, but will regain its normal voltage after a short while. If it drops to 5 volts or less, or 1.6 volts per cell, it is discharged; or, if fully charged, and it drops as low as this, then the plates are sulphated or an internal short circuit exists. See also the instruction on storage battery.

On testing the voltage of the generator (V1), and the voltage of the battery (V2), when the generator is charging the battery, if any difference is found, or a drop in voltage occurs, it will be the difference between the two readings.

Test V3: To test the voltage which reaches the starting motor from the battery, to see how much drop there is in voltage at the starting motor when operating, close the starter switch for an instant. There will be some drop. If the engine is cold and stiff, it will cause the motor to draw more current. The more current that is drawn, the greater the drop.

If the starting motor should fail to start when the starting switch is depressed, then test to see if there is an open circuit in the armature of the motor,

or in the brushes or the brush-holders. This test will determine if the current is reaching the motor.

If there is an open circuit in the armature, then the meter would indicate the voltage of the battery, because the top test-point would connect with the (+) of the battery, and the lower (TP) would connect with (-) of the battery. The armature being open, there would be a break at this point.

If the field-circuit is open, there would be no indication at all, because the field is in series with the brushes of the armature.

When a battery is supplying current to a motor and the amperage draw is heavy, there is a drop in voltage at the motor and also at the battery itself, which delivers the current.

Ammeter Tests

Ampere tests are to ascertain the quantity of current flowing. A "shunt" must be used (see page 465). Connect the shunt in the circuit as shown at tests (A1) and (A2), being sure that the positive (+) wire of the circuit is connected to the (+) connection of the meter, and the negative (-) wire of the circuit to .1 binding post of the meter.

Should the charging rate appear to be abnormally low with no apparent reason, it is a good plan to check the ammeter by connecting the test meter (A1) in series with it.

Reliable meters may become defective, as automobile service is extremely hard on a sensitive ammeter.

Test A1: To test the accuracy of the dash ammeter, use the 30-ampere shunt and connect as shown. Speed the engine up and note if the reading is the same on the dash ammeter as on the testing instrument.

A rough check on the accuracy of the ammeter may be obtained by noting the ampere readings of the various lights on the car, and then switching them on one at a time. The reading of the ammeter should correspond to the total amperage required for the lights.

With the engine running and the lamps on, the ammeter may register either "discharge" or "charge," depending on the speed of the engine, the

capacity of the generator with respect to the lamps, and the condition of the battery, that is, whether it is charged or not.

Unsteady reading of the ammeter may be due to a defect in the instrument, or to loose contact, or to intermittent ground.

Tapping the ammeter should jar the hand loose if it is only stuck. If it still refuses to register, examine the connections, and if these are all right, look at the cut-out points and see if they are closed. Finally, disconnect one of the main wires from the generator terminal to see whether any current is flowing from the generator, and follow the wires thence to the ammeter, examining them at each terminal to see whether current is flowing, by touching the disconnected wire to its terminal.

Test A1: To test cut-out: Use 0 to 30 shunt and scale. At a car speed of 7 to 10 miles per hour, cut-out points (P) should close, and at 15 or 20 miles car speed, the generator should be charging the battery at 10 to 20 amperes, if lights are off (this varies on different systems). If it shows less than 9 or 10 amperes, the "regulator" or "third brush" should be regulated to bring the current up to at least 10 amperes, 15 amperes being the average.

Throttle the engine slowly, and note that the needle will drop back towards zero. When it reaches zero, note whether cut-out points (P) open, and at what car speed.

Test A2: To test the amperage required by the starting motor: Use the 300-ampere shunt and connect as shown. Test with engine idle. It is assumed that the battery shows 1,275 to 1,300 hydrometer test, and is supposed to be charged.

The average starting motor requires 150 to 200 amperes, if the engine is warm and flexible, or 250 to 300 amperes, or even more, if cold and stiff. If the engine is flexible and an excessive current discharge is shown, then there may be a short circuit in the motor or brush-holders, or possibly the starter mechanism is out of order.

Note. The actual amount of current required by a starting motor varies according to the temperature, condition and size and compression of the engine. If it is extremely cold, the oil is congealed and all parts are stiff; thus a great deal more current is required than when the engine is warm and flexible.

If an engine has been standing for a long time, or out of use, it is likely that the motor will require more current than if in daily use.

HOW THE DASH AMMETER INDICATES TROUBLES

In this instance we refer to the ammeter as usually attached to the dash (cowl) of a car.

The dash ammeter indicates when the generator "charges" the battery, and at what rate. It indicates the rate of "discharge" from the battery to the lamps. It also indicates whether or not the system is working properly. When the battery is neither "charging" nor "discharging," the pointer should indicate "0."

Ammeter troubles may be divided into two classes: those that manifest themselves when the engine is idle and those that show only when it is running. Both classes have two subdivisions, with lamps on and with lamps off.

Remember that the ammeter should show "charge" at speeds above 8 or 10 miles per hour; and that when the engine is at rest with lights turned off, the needle should stand at "zero," and should not show "discharge."

It shows "discharge" when lights are on and the engine is idle, or at a speed of less than 8 miles per hour. In other words, the battery is then discharging, and is not being charged.

With these points always in mind, it is possible to diagnose many troubles by noting the action of the ammeter, for if it varies from its intended purpose, or its usual action, something is wrong.

When the generator is not charging the battery, and if the battery is being used for lights, ignition, or horn, the needle will be on the "discharge" side of (0) and the amount of current being consumed will be shown in figures on the dial.

When the car is running 10 or 12 miles or more per hour, the ammeter should indicate "charge."

If on connecting an ammeter to the circuit, the needle should go to the "discharge" side, when the engine is running at sufficient speed for the generator to charge the battery, then it indicates that the

terminals have been wrongly connected. Reverse the connections.

If the battery is wrongly connected, when the generator is running the ammeter will read in the opposite direction, or the cut-out points will vibrate back and forth, opening and closing the points and causing the needle to swing back and forth as it opens and closes.

On most of the third-brush regulated generators now in use, the cut-out would soon close, however, as the polarity of the generator would adapt itself to the battery polarity. In such case the needle of the ammeter would be steady, but it would read in an opposite direction to its former reading.

If the ammeter indicates zero when the generator should be charging the battery, it shows that the circuit is open, that cut-out points are stuck open, or that the generator is at fault.

If the ammeter does not indicate "charge" when the engine speeds up, but indicates "discharge" when the lights are turned on, then the generator is not delivering its proper output. Look to the "third-brush" or other regulation system, and see if it is properly adjusted; also see if the brushes seat properly; or there may be a short circuit in the lighting wiring.

If the needle is forced to the scale limit on the "discharge" side, it indicates an overload or a short circuit.

When the engine is running and lamps are burning and the ammeter hand stands at zero, it indicates that the generator is producing exactly the same amount of current that the lamps are consuming. Thus the battery is "floating on the line" and is not receiving a charge, nor is it discharging.

If the ammeter shows excessive "discharge" at low speeds, or when the engine is idle, this is caused by the cut-out contacts being held closed or "stuck." Thus current is flowing from the battery through the generator. This must be corrected at once by disconnecting the points. If the light switch is "on," then a ground or short may be in this circuit.

The ammeter will always indicate if a short circuit exists in any part of the wiring, except from the battery to the switch bus bar, and in the starting-motor circuit.

If the ammeter does not indicate "charge" with the engine speeded up, and does not indicate "discharge" with the lights on, and the engine at rest, there is an open or loose connection in the battery circuit; or the battery terminals may be loose; or

the generator terminals are loose; or the ammeter may be at fault.

If the ammeter indicates "discharge" with the lights turned off, and the engine at rest, the ammeter pointer may be bent; insulation on the wires may be injured, permitting contact with frame, causing ground or short circuit, or the cut-out points may be stuck.

If the trouble seems to be in the ammeter, it is well to place a test ammeter in circuit, to check the first instrument. If the instrument registers incorrectly it should be returned to its makers for repair.

If the ammeter indicates "charge," with the engine at rest, the ammeter pointer may be bent.

When the ammeter "charge" indications are below normal, the generator output varies with the condition of the battery on some generators. This may also be due to the regulation of the generator not being properly adjusted. For instance, the third brush may need resetting, or the brushes may not be making good contact, or the commutator may be dirty or rough, or may have high mica.

When the ammeter "discharge" indications are above normal, the lamp load may be excessive or the lamps may be old; wires may be grounded or shorted.

Ammeter needle unsteady and low charging rate with generator running. Look for carbon between commutator segments, and clean with a pointed instrument. This is usually due to too much oil, causing carbon. Also look for weak brush springs loose brush leads and short brushes or high mica.

If the ammeter pointer jerks intermittently to "discharge," limit of scale while engine is speeding up, there is a short circuit or a ground in the system or in the field-windings.

If fuses blow out repeatedly, look for a heavy ground, or the fuse may be too small for the current required, or a short circuit may exist in the system.

If larger bulbs than standard or extra lamps are used, "discharge" indications will be higher. The generator may not be capable of charging the battery sufficiently to overcome the excess load, especially if there is insufficient day driving or excessive use of lamps at night, thereby permitting the battery to discharge more rapidly. Therefore, before adding more lights or appliances to the electric system, the amount of charge that the battery receives should be considered, especially during cold weather, when the starting motor is used more and the drain on the battery is greater. If the battery receives less than 10 to 15 amperes on an average, it will be necessary to have it charged at an outside source occasionally. See also pages 563 and 506.

A VOLTMETER AND AMMETER FOR AVERAGE ELECTRICAL TESTING

To those who do not have sufficient electrical work to justify the purchase of the model 280 instrument mentioned on pages 465 and 701, or the model 45, page 545, the following instruments are recommended.



Model 301 Weston voltmeter,¹ with a scale reading of 0 to 15 volts with divisions on scale of $\frac{1}{2}$ volt (.5) each division. Price \$8.00.

Model 301 Weston ammeter,¹ with a scale reading 0 to 30 amperes with divisions on scale $\frac{1}{2}$ ampere (.5) each division. Price \$8.00.

With these two instruments mounted on a base a very serviceable portable electrical testing outfit can be made.

The voltmeter can be used for testing the voltage of all cells of a 6- or 12-volt storage battery, or each cell, also for testing the voltage of generator at speeds at which the generator cuts in and cuts out, grounds, short circuits, and many other tests as shown on page 470 and elsewhere.

The ammeter can be used for testing the ampere rate of current output from generator to battery, or the current consumed by all the lights or individual circuits, horn, ignition, coils, etc. The current consumed by the starting motor of course cannot be tested with this instrument. The manufacturers are Weston Electrical Instrument Corp., Newark, N.J.

Other concerns supplying electrical testing instruments are listed on page 545. See also pgs. 481 and 687.

¹ Can be obtained of A. L. Dyke Elect. Dept., Granite Bldg., St. Louis, Mo. We repair Magnets, Coils, Generators, and Starting Motors—send your repairs to us, if you are not equipped.

INSTRUCTION No. 43

TOOLS AND EQUIPMENT FOR THE AUTOMOTIVE ELECTRICAL REPAIR SHOP:¹ When to Test on the Car and on the Bench

TOOLS FOR ELECTRICAL WORK²

This subject is a broad one. The amount of repair work to be done would determine the equipment in each case. Therefore only a few of the really necessary tools are mentioned here.

Pliers: An assortment of about 5" long-nose, short-nose, and cutting pliers.



Screwdrivers: An assortment of about five or six, from very small ones to larger ones.

Chisels: Two or three sizes, and also a center punch for locking and unlocking pole screws in generator frames.

Files: One very fine jeweler's file for contact points, and a mill file and round for cleaning wires and battery terminals.

Thickness gauge to adjust contact-breaker points, cut-out, regular points, and spark plugs.

Flat wrenches: Various sizes; these can usually be purchased in sets or with tool kits.

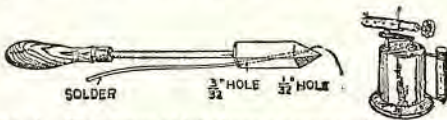


Fig. 2. Illustration at left shows a simple and handy method for soldering. The wire solder is inserted in a hole drilled in the soldering copper. A blowpipe torch is shown on the right.

Soldering irons: Three sizes, a pair each of $\frac{1}{2}$ lb., 1 lb., and 2 lbs., for soldering coil terminals, wire connections in field coils, commutator wires, armature wires, terminals, cut-out and regulator points, etc. The electric soldering iron is used extensively also.

Soldering flux for electrical work. Wire solder with flux inside is used extensively.

Blow-pipe torch: Very essential.

Tape: For taping inside of generators, etc. Where there is excessive heat, a tape called "English superfine twilled tape" is used. It is then coated with shellac and the alcohol is burned off by lighting with a match. Friction tape is the kind generally used for outside wire connections.

Shellac is used for armature work, connections, etc. See Index, "Shellac, how to mix and keep."

Note. When grounding a wire to the frame or to the engine, clean off all paint. Scrape thoroughly. After making the

connection, coat with vaseline to keep the connection from corroding or rusting.

When soldering a wire into a lead terminal, such as a heavy storage battery connection, clean well. Add flux, and then melt the solder in the terminal by means of a torch. When hot, insert the wire and let cool; this is termed "sweating."



Fig. 3. This hook, 4" long, is used for pulling brush springs.



Fig. 4. Socket wrench for brush mechanism and coil nuts.

A brush lifter for lifting brush springs on generators and motors is shown in Fig. 3.

A socket wrench suitable for the nuts on brush-holders, coils, etc., is shown in Fig. 4. Several sizes can be made.

A fine-pointed scratch awl to dig out copper dust and material that will short-circuit between commutator segments is another necessary tool. A tool made on the order of that in Fig. 3 would be suitable for this work.

Tools for undercutting mica are explained farther on.



Fig. 5



Fig. 7

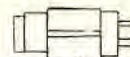


Fig. 6



Fig. 8

Pole-piece double gauge: It often happens that it is necessary to put new field-coils in the generator or motor, owing to the fact that they become shorted or grounded. In order to do this, it is necessary that the polar diameter be exactly right—that is, the distance between the faces of the pole-pieces. This distance is measured with a pole-piece double gauge (Fig. 5); one end of the gauge being a "Go" indicator, and the other end a "No Go" indicator.

Pole-piece spreader: If the gauge does not slip into the polar diameter on one end and fails to go on the other, the dimension is wrong. Generally it is too small, and the pole-piece must be spread farther apart and the tool (Fig. 6, pole-piece spreader) is used for this work. There is no possible way for spreading the pole-pieces so as to get the proper clearance between the armature and the poles without this tool. In other words, the object of these tools is, first, to spread the pole-pieces and frame to give the right air gap between the armature and pole-pieces with tool No. 6, and then to measure these dimensions with No. 5, after the work has been done, to see that it is right and, if not, to correct it.

¹ This subject does not include storage-battery equipment. This is fully treated under instruction on Storage Batteries.

² See pages 481 and 687 for firms who can supply tools for electrical work.

A pinion puller, used for pulling the generator-drive pinions off the armature shaft (Ford), is shown in Fig. 7¹.

A bearing puller, used for pulling ball bearings off the armature shaft, is shown in Fig. 8.

Lathe for Electrical Repair Work²

A lathe suitable for turning down armature commutators, and for making motor repairs and electrical work in general, suitable also for cutting screws and other small work, such as tools, gauges, taps, etc., and for making battery and ignition parts, is shown in the illustration below.



Fig. 9. This lathe can also be supplied with milling attachments, and keyway cutting attachments.

Bench Lathe for Commutator Work³

The illustration below is that of the Onan Lathe, which can be placed on a work bench and operated from a line shaft.

With this lathe it is possible to true up and turn the commutator of any starter or generator armature. Without removing the armature from the lathe, it is possible to undercut the mica between the bars.



Fig. 10. The turning tool is controlled by a hand-wheel screw feed—the carriage is operated lengthwise by a drop-forged handle with suitable adjustment for every commutator. The lathe is built with 7" swing; bed 22" long; furnished with two Armstrong high-speed tool bits, lathe dog, suitable wrenches, etc., and is complete, ready for operating. It is driven from any available power. Shipping weight complete, 35 lbs.

The subjects of commutator troubles, tests, and repairs, and also brush troubles (fitting and seating brushes, etc.) are treated on pages 491 to 496.

INSTRUCTIONS FOR CLEANING REPAIR PARTS OF ELECTRICAL APPARATUS

The cleaning outfit should consist of three sheet-steel tanks of suitable size (preferably about 35 gallons), which are mounted in such a manner that the contents may be kept heated to the desired temperature; three stone jars of approximately 15 gallons capacity; and a sawdust box.

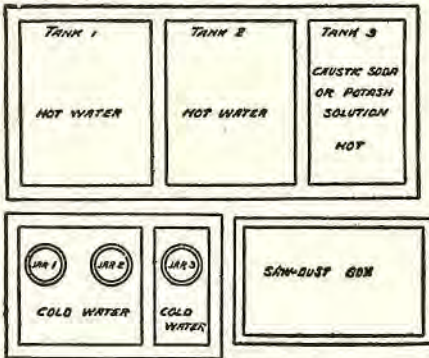


Fig. 11. Plan of arrangement of tanks and jars for cleaning.

Two of the steel tanks should be equipped with overflow pipes so that they can be kept about two-thirds full at all times. These will be spoken of as tank No. 1 and tank No. 2. They are used for clear, hot water for rinsing the apparatus after it has been cleaned. A supply of water should be available, so that this water can be kept clear.

The third tank does not need either a drain or overflow pipe, and should be used for the potash or caustic soda solution. This solution can be used for a long time without changing it by simply adding a

small amount of potash or soda as the solution is found to be weakened. All three tanks are maintained at a temperature of from 180° to 212° Fahrenheit, or approximately at boiling point.

The three jars mentioned above are to be used for the acid solutions, and will be spoken of as jar No. 1, jar No. 2, and jar No. 3, respectively.

A wooden tank should be provided which is large enough to permit the three jars to be set in it, and also to carry a supply of clear, cold water. This tank should also be divided so that jars No. 1 and No. 2 are in one division, and jar No. 3 in the other. This is very important, as the work cannot be rinsed in the same cold-water bath after being immersed in these various solutions. The sketch shown in the figure will give an idea of the outfit. See also pages 761 and 1039.

Note: A free pamphlet, "Modern Cleaning Methods," which gives instructions on cleaning metal surfaces of all kinds of small parts also engines, axles, etc., is issued by Oakley Chemical Co., 2 Thames St., New York (also deals with solutions to use and gas burners for heating the solution, etc.).

Cleaning Solutions

The solutions recommended are as follows:

In tanks Nos. 1 and 2, place clear, hot water.

In tank No. 3, place a solution of potash or caustic soda, made by mixing 1 lb. of potash or caustic soda with one gallon of water.

Jar No. 1 is filled with a solution made up carefully from the following formula: four gallons of nitric acid; one gallon water; six gallons sulphuric acid. The water is placed in the jar first, the nitric acid is added slowly, and the sulphuric acid is poured in last. This order should be very strictly observed, as it is dangerous to attempt to mix up a solution of these acids in any other manner.

¹ See page 481 for Automotive Electric Service Station Equipment concerns.

² Illustration is that of a screw cutting lathe, especially adapted for electrical repair shops, manufactured by The South Bend Lathe Works, South Bend, Ind.

³ Can be secured of Allen Electric Mfg. Co., Detroit, Mich., supplies a combination lathe and mica undercutter and other electrical equipment. Free printed matter to those mentioning this book.

The solution in jar No. 2 is made up from the following formula: one gallon hydrochloric acid to three gallons of water.

Jar No. 3 is filled with the following solution: $\frac{1}{2}$ lb. of cyanide to one gallon of water.

Tank No. 2 should be used for parts which have been in the potash solution, and for no other purpose; tank No. 1 is for general rinsing.

Cleaning Various Metals

Steel is boiled in the potash solution until the dirt is removed. This should take only a few minutes. It is then rinsed in tank No. 2, and dried in sawdust.

Cast iron is boiled in the potash solution until the dirt is removed, rinsed in tank No. 2, dipped in the acid solution in jar No. 2, rinsed in cold water, then rinsed in tank No. 1, and dried in sawdust.

Brass is boiled in the potash solution until the dirt is removed, rinsed in tank No. 2, dipped in the acid solution in jar No. 1, rinsed thoroughly in clear, cold water, dipped in the cyanide solution, rinsed in clear, cold water, rinsed in tank No. 1, dried in sawdust. Copper can be cleaned in the same manner.

Polished aluminum should first be thoroughly washed in benzine or gasoline, rinsed in tank No. 1, dipped in the acid solution in jar No. 1, rinsed thoroughly in clear, cold water, rinsed in tank No. 1, and dried in sawdust.

Plain aluminum (polished) should be dipped in the potash solution, rinsed in tank No. 2, dipped in jar No. 1, rinsed thoroughly in clear, cold water, rinsed in tank No. 1, and dried in sawdust.

Plain aluminum (not polished) should be dipped in the potash solution, rinsed in tank No. 2, dipped for a few seconds in the acid solution, rinsed in tank No. 2, dipped for a few seconds in the acid solution in jar No. 1, rinsed thoroughly in clear, cold water, rinsed in tank No. 1, and dried in sawdust.

It will be noticed that when the aluminum is put in the potash solution the metal is attacked or eaten away very rapidly. Care should therefore be taken not to leave the work in this solution any longer than is absolutely necessary. In cases where the work is covered with caked grease or has hard grease deposits on it, these pieces should first be washed in benzine or gasoline. Aluminum parts should never be washed in the potash or soda solution unless they can be put through the acid immediately after. The acid dip is used to neutralize the effects of the potash solution. Parts should be held in the acid solution for only a few seconds.

Paint on aluminum should be removed with a good varnish or paint remover, unless it is a very small quantity and the work is to go through the potash solution.

For enameled work, it is recommended that it be washed with soap and water, dried thoroughly, and then polished with a cloth dampened with Three-in-One or O'Cedar oil.

The methods described above are for solid metals only, and should not be used on any plated materials. Practically all Delco clips are tinned, and should be cleaned, therefore, in benzine or gasoline. All plated parts should be cleaned in benzine or gasoline.

A HOME-MADE ELECTRICAL TEST STAND

Tests for the internal parts of a generator, motor, cut-out, etc., will be explained in what follows. These tests might be termed "bench tests," and are usually for internal troubles. They are such tests as are necessary when the troubles are such that they cannot be remedied on the car, such as testing armatures, field windings, etc. Therefore some sort of testing apparatus is necessary in such cases.

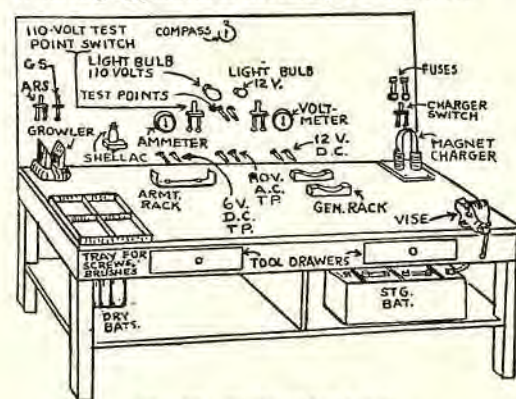


Fig. 12. Electrical test bench.

The bench (Fig. 12) can be made about 36" high and about 5' or 6' long, with a lower shelf about 6" or 7" from the floor.

A vise, with jaws opening to about 8", can be used to hold the generator when being driven by a motor. The vise is also handy for other work.

Note that the test leads, or cables, are of flexible wire and run through pulleys with weights (Fig. 12A),

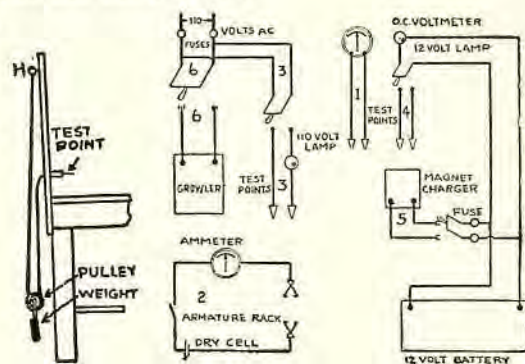


Fig. 12A

Fig. 12B

similar to pulleys and weights on a telephone switchboard, thus keeping the wires off the bench.

Necessary Parts and Wiring Circuits

Volt and ammeter: Model 280 Weston, combination volt and ammeter, as described on page 464, is recommended. This instrument is also fitted with a scale for cadmium tests of storage batteries (explained under the instruction on Storage Batteries).

If this represents too great an outlay of cash, then Model 301 Weston voltmeter and Model 301 Weston ammeter are recommended (see page 472). These instruments are suitable for readings up to 30 amperes or 30 volts.²

² These instruments can be furnished by A. L. Dyke, Electrical Dept., St. Louis, Mo.

The wiring of the different circuits is shown in Fig. 12B, as follows:

- (1) Voltmeter (Model 301 Weston) with test points.
- (2) Armature rack for testing for open and short circuits in armature. Dry cells can be used. Note that the ammeter (Model 301 Weston) is in series with the circuit.
- (3) Test-light and points (high voltage) for use with 110-volt circuit through a double pole switch. For testing for short and open circuits. The 110-volt lamp is in series. A tungsten carbon filament lamp of about 15 watts can be used.
- (4) Battery test-light and points (low voltage) are connected with a storage battery. Note that in (4) a low-candle-power lamp is in series, the voltage being same as battery (6 or 12 volts).
- (5) Remagnetizer for remagnetizing magnets. Connected with the battery by a double-pole switch and with fuses in the circuit.
- (6) Growler connected with a 110-volt alternating-current line for testing armatures for open and short circuits (explained farther on).

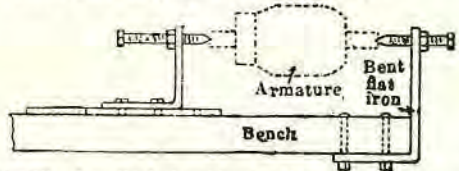
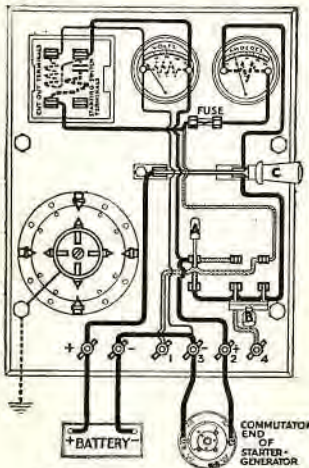


Fig. 13. A method of making an adjustable armature rack. This can be substituted for the one shown in Fig. 12, as it is more serviceable, being adjustable.

NORTH EAST TEST-BOARD

The test-board shown in Fig. 14 below, is

for testing the motor-generators and ignition units. It is shown in order to give the reader an idea of its construction.



TYPE 8901-B, 8901-C OR 8901-D TEST BOARD
Fig. 14. Test-board.

With this test-board it is possible to operate the motor-generator and all its parts as if connected on the car. It will, of course, be necessary to drive the motor-generator by some means, when used as a generator. The different circuits are as follows:

Starting-motor circuit: From (+) of the battery, to and through switch (C), through heavy black wires to switch (A), to terminal of board (+2), to and through the motor, to (-3), to (-) of battery.

HOME-MADE METHODS OF DRIVING A GENERATOR FOR TESTING

Various methods are used for driving a generator so cut-out and output of the generator can be tested.

We suggest three simplified methods, as follows:

1. By using a $\frac{1}{2}$ h.p. electric motor, (Fig. 15), with a constant speed of about 1,800 r.p.m. and cone pulleys used to vary the speed.

Cone pulleys can be placed on the motor (Fig. 15), to drive the generator, on which there are two sizes of cone pulleys. The cone pulley on the motor,

Note that the voltmeter is connected across this circuit at switch (A) (on the left), and by the small wire at (-3) terminal. The ammeter is not in the circuit, as it is open at the cut-out points of the cut-out (upper left corner).

Cut-out voltage circuit: Start from the motor-generator, which we will assume is being driven as a generator. Start at (+2) terminal of the board, which connects with the (+) main brush of the generator, to voltmeter (switch A is open), above the voltmeter to the cut-out, then through the fine wire voltage winding (small dotted lines), through the smaller or lighter wire to the voltmeter, to terminal (-3) of the board, to (-) main brush of the generator.

Note that the voltmeter is connected directly across this circuit and will indicate at what voltage and speed of the generator the cut-out points will close the charging circuit.

Generator charging circuit: We will assume the cut-out points close at a certain speed of the generator when a certain voltage was reached

The charging circuit would then be from (+2), to the voltmeter, above the voltmeter to the cut-out, through the closed points of the cut-out, through the cut-out series winding, to the fuse, through the ammeter, through switch (C) (switch A is open), to the (+) terminal of the board, to the (+) terminal of the battery, out the (-) terminal of the battery, to the (-) terminal of the board, to the (-) terminal of the generator.

Note that the voltmeter is across the circuit, and the ammeter is in series with the circuit. Thus the voltage and amperage generated at various speeds of the generator can be observed. For instance, at maximum speed, the generator should show a certain amperage and voltage and the third-brush regulation can be set accordingly.

At a certain low speed the cut-out points should open at a certain voltage when a certain amperage discharges back through the series winding of the cut-out (see page 370 for these data). All of this can be observed with the voltmeter and ammeter connected with the circuits.

The device on the left of Fig. 14 is for testing the ignition. See also, pages 228, 226, 371, 230.

of which there are five sizes, and also the one on the generator, of two sizes, can be made in one piece of hard maple or metal, by turning them up on a lathe. A $\frac{1}{2}$ " round belt is used to transmit power.

Sizes of motor pulleys: 2", 3", 4 $\frac{1}{2}$ ", 6" and 8".

Sizes of generator pulleys: 6" and 8".

The variations of speed of the generator which can be obtained with these pulleys are as follows:

8"	motor pulley to 6"	gen. = 2,400 r.p.m.
6"	motor pulley to 6"	gen. = 1,800 r.p.m.
4 $\frac{1}{2}$ "	motor pulley to 6"	gen. = 1,425 r.p.m.
3"	motor pulley to 8"	gen. = 675 r.p.m.
2"	motor pulley to 8"	gen. = 450 r.p.m.

To figure the speed and size of pulleys to use for other speeds than those given, see Index under "Speed of pulleys, how to figure."

On different generators there are different sizes of shafts. Some are tapered, but most shafts on later generators are straight keyed shafts, and average about $1\frac{1}{2}$ " to 2" in length. The average diameter is $1\frac{1}{16}$ ", $\frac{5}{8}$ " and $\frac{3}{4}$ ". Therefore bronze bushings should be provided for the generator pulley which can be removed, and in time a valuable collection will be at hand ready to use on subsequent tests.

Some sort of sliding base (V, Fig. 15), with a screw (S) to adjust the tension of the $\frac{1}{2}$ " round belt, should be provided. A clamp, similar to a woodworker's clamp, can be used to hold the generator to the base.

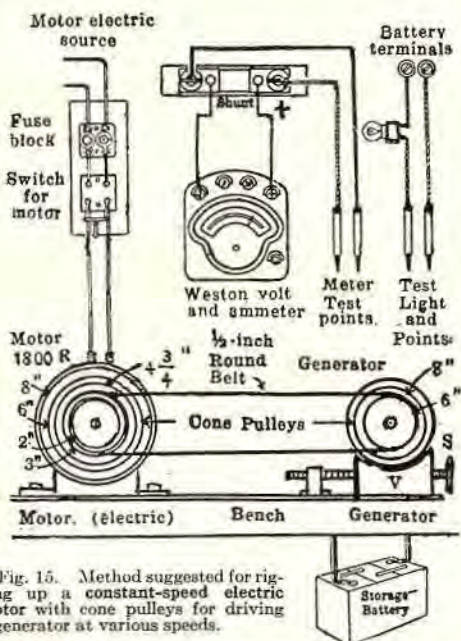


Fig. 15. Method suggested for rigging up a constant-speed electric motor with cone pulleys for driving a generator at various speeds.

2. Another method of driving the generator (Fig. 16) is by means of a constant-speed line shaft (300 r.p.m.). With cone pulleys to vary the speed.

Use a 4" face pulley, 18" diameter. This will give a speed to the countershaft of 1,800 r.p.m. if a 3" diameter 2" face pulley is used on the countershaft. Note that two pulleys are used on the countershaft, one with a 2" face by 3" diameter, which is tight to the shaft; the other is of the same size, but is loose, thus permitting the 2" flat belt to shift from one to the other, to start or stop the line countershaft.

As we have the same number of revolutions of the countershaft in Fig. 16, as we have of the motor in Fig. 15, we can therefore use the same diameter of cone pulleys.

HOW TO START TO MAKE ELECTRIC TESTS AND HOW TO LOCATE ELECTRICAL INFORMATION IN THIS BOOK

The greatest difficulty that the electrical repairman experiences in starting into this line of work is to know just how to start and where to obtain parts, etc. The object of these next few pages is to acquaint him with the details of making tests on the car and on the bench, and to furnish suggestions as to how and where he may obtain data and information. Refer to the Index often.

See Digest of Troubles, page 454, also pages 512 to 518, for locating other motor and generator troubles.

It will be noted that reference is frequently made to the fact that A. L. Dyke, Electrical Dept., St. Louis, Mo., is in a position to furnish testing instruments and books of data, etc., and also to do electrical repair work. This service is not so much conducted for profit as it is to assist the student in getting his initial start. The parts we purchase for filling orders are purchased of the local branches of the different manufacturers. Later on, after the student is established and actively in business, he can no doubt purchase direct.

The books and instruments that we recommend are those we know are needed. It is impossible to give all data in this one book; hence the necessity of purchasing a few others, such as a Wiring Manual and Service Manuals. See advertisements in the back of the book.

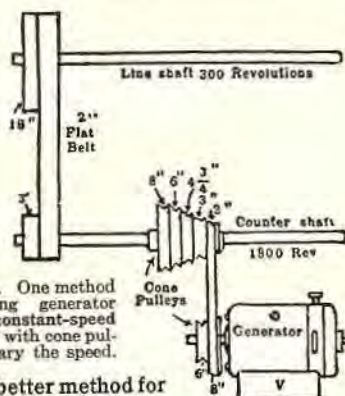


Fig. 16. One method of driving generator from a constant-speed line shaft with cone pulleys to vary the speed.

3. A better method for driving generator than either of the foregoing methods is by the use of a variable-speed alternating current motor (Fig. 16A).

Motor speed is from 0 to 3600 r.p.m. in either direction. Marketed by the Kimble Electric Co., Chicago.

A universal drive, universal vise, and tachometer are also supplied for assembling a testing outfit at a low cost. A blue print showing a plan for making a model Universal Test Bench is furnished with motor.

The Model 280 Weston combination volt and ammeter (Fig. 12, page 464) could be used with this outfit.

Other methods can be employed. These are suggestions only. See also page 507, for an electric test stand.

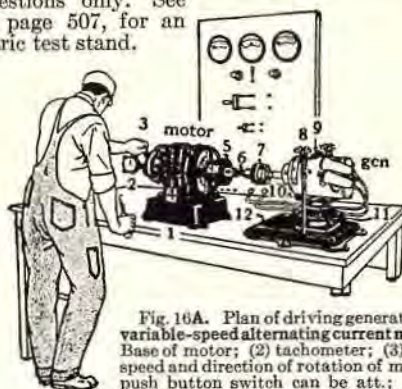


Fig. 16A. Plan of driving generator with a variable-speed alternating current motor: (1) Base of motor; (2) tachometer; (3) controls speed and direction of rotation of motor; (4) push button switch can be att.; (5) hand wheel for aligning gen.; (6) flexible coupling of universal drive; (7) chuck; (8) adjusting posts; (9) vise cross bar; (10) adjustable V-jack, supports generator; (11) hand wheel adjusts height of; (12) slots in base to give adjustment for shaft lengths.

When a car owner drives to your shop and tells you that his generator fails to generate current, or that the generator fails to charge properly, or that the lights burn dim, or that the battery constantly runs down, you must, like a good physician, make careful note of the troubles and then in your own mind analyze the symptoms and formulate a plan for your tests and diagnosis of the case.

The first procedure is to endeavor to make tests on the car without removing any of the parts. These tests are given under various headings in this book. Before any tests are made, however, turn to the "Digest of Troubles" and find the probable cause, and figure out in your mind which one of the causes would most likely apply to the case. Sometimes troubles are attributed to the electric system, when in reality they are engine troubles, or ignition troubles.

Then make the tests, first one, then another, thus eliminating one cause after another, until the real

cause is finally found. This is termed the "process of elimination," and is a mighty good term to memorize and keep in mind. See "Digest of Troubles." The good electrical repairman is classed as a very intelligent man, just as a good physician is, and he must study and be able to concentrate in order to do his work intelligently.

If, after making the tests, it is found that the internal parts are defective, such as a defective ignition coil, generator, cut-out, or battery, then it is time to remove the part to the bench and to make the tests.

Procedure of Tests, and Diagnosis

When starting to locate troubles in the electrical system of a car, first divide the electrical system into parts, as explained on pages 448, 455.

If the trouble is in the lighting circuit, see page 482.

The large Wiring Manual is very necessary in tracing circuits.

If the trouble is in the ignition system or circuit, determine the make of the system, see Index, and study up on that system. Refer to the Index for testing for ignition troubles.

If the trouble is in the storage battery, see the instructions on Storage Battery, and the "Digest of Troubles."

For battery work, we recommend the test outfit on pages 552 to 554, and the combination voltmeter, Fig. 12, page 464 (see also page 701), also a book entitled, "The Automobile Storage Battery," price \$5.00.

If the trouble is in the generator or cut-out, turn to the Index and the "Digest of Troubles."

Starting Motor

If the trouble is in the starting motor, refer to the "Digest of Troubles" page 454; and the Index on "Starting motors." The troubles with a starting motor are either electrical or mechanical. See also, pages 455, 517 and 486 to 490.

Mechanical troubles with the starting motor that are most common are as follows:

1. **Worn bearings:** Many starters have plain bronze bearings which become worn from lack of oil and long service. Thus when heavy charges of current of 200 to 300 amperes pass through the starter, the armature revolving is forcibly drawn to the pole pieces, as the air gap is very slight, thus damaging the armature. Worn bearings can be replaced if you are equipped with a lathe for turning up and boring out a new bushing.

The end plate can be returned to the manufacturer or to A. L. Dyke, Electrical Dept., St. Louis, Mo., and an end plate with bushing fitted will be supplied.

2. **The starter armature shaft is sometimes bent or twisted out of true,** as a result of back-firing of the engine and of hard strains. To test, place in lathe centers and straighten with a forked bar or otherwise. This trouble is more common with starters than with generators. See also, pages 455, 486, 489, 320.

Electrical troubles, most common with the starting motor are described below. But before making any tests of the starting motor electric system, the engine should be tested first to see if it is stiff or hard to crank. The next test is of the battery.

1. **Examine battery:** See if the electrolyte is above the top of the plates. If not, the battery is probably discharged, or nearly so. If the electrolyte covers the top of the plates, then test the electrolyte with a hydrometer to see if it is charged.

If the hydrometer shows 1.200 s.g., or less, it indicates that the battery is fairly well discharged. If it shows 1.225, it is fairly well charged, but not fully charged. The hydrometer should show 1.250 to 1.300. When testing the battery with a hydrometer, the temperature of the electrolyte should be about 70°, otherwise the readings will not be correct. See Index under "Testing battery, temperature."

2. **Loose or poor connections:** These are usually at the ground connection of the battery or on the starter switch. The starting switch blades may be bent or burned and corroded. These connections as well as all internal connections should be clean and tight.

3. **Poor brush contact.** Usually the result of lack of spring tension or worn brushes. Carbon brushes have a tendency to stick in the holders, especially if gummed with carbon dust and oil. Gauze brushes are sometimes used on starters, and should seat perfectly. See Index under "Brushes, seating of."

4. **Rough commutator:** This will necessitate removing the armature and turning the commutator down on a lathe (see Index under "Commutators"). Do not undercut mica on the starting-motor commutator.

5. **Soldered armature coil terminals loose from commutator.** Resolder. Loose terminals are often the result of heat produced by excessive current; also of poor soldering in the first instance. See Index under "Commutators."

The average speed of a starting motor, fitted with a Bendix drive, on a "free running test," or no load is: 3,725 r.p.m. minimum and 4,950 r.p.m. maximum. The amperage is about 70. Under load, the speed varies 1,000 to 2,300 with 8 lb. pull on a 6" pulley. The average amperage of starters when starting is given on page 471. This varies, however, as starters are designed in different sizes to start different sizes of engines. See page 489, giving an example of how starting motors are tested according to data given in the "Service Manuals."

Generator

The generator circuit is divided into parts as follows:

1. Generator.
2. Generator regulation system.
3. Cut-out.
4. Storage battery.
5. Wiring system connecting the above.

Generators are usually shunt-wound, and there are three different regulation methods in general use:

1. Third-brush (inherent constant current) regulated.
2. Voltage regulated; where resistance is inserted in the shunt-field winding by an electromagnetic regulation system (see Index under "Voltage regulation").
3. Current regulated; where resistance is cut into the shunt-field winding by an electromagnet (see Index under "Current regulation, electromagnetic").
4. Compound winding with a "differential" action (see Index).

The third-brush regulation is used most. The output of the generator can be increased by moving the third brush in the direction of the rotation of the armature, or decreased by moving it in the opposite direction. See Index under "Adjusting third brush."

The principle of the third-brush regulation is explained on pages 357, 361. After an approximate speed of about 1,800 r.p.m. is reached, the output begins to drop off, for the reason explained under "Armature reaction." See Index. It is important to see that the third brush always makes good contact with the commutator.

The output of the generator with the voltage or current-regulation method, using an electromagnetic principle, can be increased or decreased by decreasing or increasing the spring tension. See Index under "Adjusting regulators, electromagnetic."

A compound-wound generator, which is an inherent method of regulation, with constant current, has the two windings on fields opposing each other at high speeds of the generator, such as the "bucking-series" winding, and the "cumulative-compound" winding, explained under this subject; see Index.

With the compound-wound generator, not using a third-brush or electromagnetic principle of regulation, but depending upon the differential action of the two windings, there is no provision made for increasing or decreasing the output. Sometimes the series winding can be shortened, or lengthened, as explained on page 356.

The cut-out opens and closes the circuit between the generator and battery, the function of which is explained under this heading; see Index, generally, and also under "Testing and adjusting cut-out."

Generator Troubles

Conditions which necessitate tests of a generator are as follows:

1. When the generator fails to charge the battery.
2. When the generator output is low or excessive.
3. When the ammeter fails to indicate properly.
4. When the ammeter is not steady.

There are many other conditions but those just mentioned are the usual or most common causes for the necessity of testing. See also "Digest of Troubles."

First, test the generator on the car.

Before removing the generator, study out the internal circuits of the system by referring to your "Wiring Manual" and "Service Manual."

Then make the following tests while the generator is on the car:

1. There is a fuse which is sometimes placed in the shunt-field circuit of the generator. See if it is making good contact and is not blown.
2. Examine the brushes and see if they are making good contact.
3. Examine the cut-out points and see if they close at about 650 to 1,000 r.p.m. of the generator, and if they open at lower speeds. A "Service Manual," which gives all these data for all generators is advised. For cut-out troubles, see Index.
4. See that all connections are tight from the generator field connection of the brushes and from the generator to the cut-out, to the ground connection of the generator and the battery. The "Wiring Manual" will assist you in tracing.
5. Examine the commutator—see whether it has thrown solder, that is, whether the solder which binds the ends of armature windings to the commutator bars is loosened. If so, the generator must be removed and resoldered.

6. Examine the commutator and see whether it is rough or whether mica protrudes. If so, there will be sparking at the brushes. This will require removal of the generator, so that the commutator can be turned down and the mica undercut and the brushes made to fit properly. See Index under "Undercutting mica."
7. Place your testing ammeter in the generator circuit, as explained on page 470, at test A1, to see if the dash ammeter is reading properly. Then run the engine and check the readings.
8. If the generator output is lower or higher at maximum speed than the "Service Manuals" give for the type of generator being tested, then increase or decrease the output. See Index under "Regulation methods." See also "Digest of Troubles."

Generator Bench Test

Conditions which necessitate removal of the generator from the car are as follows:

1. If no current is indicated by the ammeter tests.
2. If the ammeter needle is not steady.
3. If the generator will not produce its proper output after adjusting the third brush or other regulation method. Failure of the third brush to seat properly is the cause of many generators not giving their proper output, or even giving none at all, or intermittently.
4. If there is excessive sparking at the brushes, and it cannot be remedied by proper brush adjustment.
5. If the commutator is rough and mica protrudes.
6. If there is noise.

After removal of the generator to the bench, there are four methods of testing:

1. By motoring the generator.
2. By examining the commutator.
3. By driving the generator.
4. By testing the armature and field windings.

Testing Generator by Motoring It

Connect the generator with a fully charged battery: It makes no difference which wire is connected, as most generators will automatically reverse their polarity. If, however, you know the (+) terminal of the generator, use it. The motoring test will determine if trouble is in the armature or the field.

Running the generator as a motor is a quick method of determining the general condition, and is easily and quickly tested out. See also page 491.

An ammeter with the 30-ampere shunt is connected in the line; the ammeter must be connected through the (+) pole of the meter to (+) of the circuit. See page 465 for description of the Weston meter, which we assume is being used for the tests.

The cut-out is not in the circuit in this test. If, however, the cut-out is in the generator, close the points, otherwise the generator will not motor. The generator should run in the driven direction, unless the field connections are wrong. In this case change the internal wires at the brushes.

If the generator fails to motor, the trouble is probably due to an open field circuit or to absence of brush contact.

If the generator motors, it should do so without undue sparking at the brushes or any unusual noise.

It should draw approximately from 3 to 5 amperes. On the Ford, the amperage is 4, and on a N.E. motor-generator (model G), it is about 5 amperes with the 12-volt battery. If it is over 8 amperes, then there is evidence of a short-circuited armature, providing the machine is free of mechanical defects.

The "Service Manuals" give these data for all generators.

The average speed of a generator when being motored is 400 r.p.m. with a voltage or relay type of regulation, and 350 r.p.m. with a third-brush type of regulation.

If the generator draws too much current when being motored, the trouble is very probably to be found in the armature.

If the needle of the ammeter vibrates, there is probably a short circuit.

The armature should then be removed, and placed in the stand (Fig. 13, page 476). Separate tests should then be made. See Index for "Armature tests."

Testing Generator by Examining Commutator

Eighty per cent of generator troubles are indicated by the condition of the commutator. Remove the cover (Fig. 17), and examine for the following:

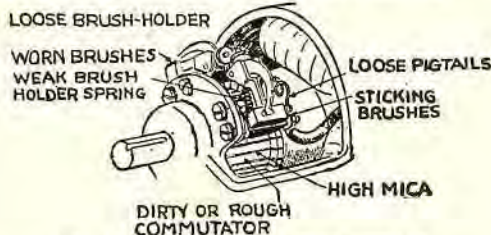


Fig. 17. Commutator and brush inspection.

1. If the commutator is burned black over its entire surface, it is usually due to grease, or carbon dust from the brushes. If caused by carbon dust, the commutator is probably rough, and should either be turned down on a lathe or sanded in (explained under "Commutator troubles"; see Index). It is best to turn the commutator down, but sanding will do in an emergency. Blow carbon dust out of the generator housing with air pressure.
2. Improper brush-spring pressure, which permits arcing, will also produce a rough commutator.
3. If there is an open circuit in the armature, there will in all probability be a flat place on the commutator segment or bar, the result of a heavy spark at the brush occurring on the open commutator bar when the brush makes contact with it. The cause of such an open circuit in the armature coil is usually a loose connection where it is soldered to commutator bar. Examine connections.

Troubles of this nature usually occur only when the armature is revolving at high speed, which causes the wire to fly loose, through centrifugal action of rotation. Commutator out of round will also cause weak generator current at high speeds.

4. If the mica protrudes above the commutator bars, or if the brushes or brush holders are loose, or if the brushes are worn, this indicates that there has been excessive sparking at the brushes. These parts should be examined carefully and remedied. See Index under "Commutator and brush troubles."

Testing Generator on the Bench by Driving It

Various methods are used for driving a generator so that the cut-out and output of the generator can be tested. A home-made outfit is shown on page 477. See also Index under "Electrical testing outfit."

Additional Pointers

If a generator fails to deliver its proper output, or if the cut-out fails to operate, the first step is to find out why. If the tests suggested above determine the fact that the generator armature coils, or the field coils, or the cut-out windings are defective, it does not pay to attempt to repair them, as armature winding is a trade learned only by careful study and long experience. It is best to return the part to the factory,¹ and order a new part. In many instances an allowance will be made on defective armatures toward a new one.

The electrical repairman can, however, do such work as testing, cleaning, and sanding the commutator, under-cut mica, fit or seat and adjust brushes, solder loose wires at commutator segments, etc., as explained under these different subjects.

He can also adjust and regulate the output of generators. Most generators now have the third-brush regulation. It is therefore a simple matter to increase or decrease the output by moving the third brush, after determining what make of electric system is used, and then referring to the Index of this book, or to the Service Manuals.

A Data Book or Service Manual giving the speed of different generators at which the cut-out should cut in and cut out, the amperage at various speeds, etc., is very necessary.

Bearings and Brushes

Bearings: Many generators had ball and roller bearings. Delco still uses ball and roller bearings. Most of the other generators and starters now use plain bronze bearings. You can fit new bearings if you are equipped with a lathe and can do the work accurately. It is advisable to send the end plate to the factory, and obtain a new bearing fitted into the end plate.

Many bearings become noisy or broken from incorrect line-up on engine with driving shaft and coupling. Excessive side or end pressure on bearings, especially a tight drive chain, produces noise and wear.

If the shaft is worn, then it is best to true it up on a lathe and to fit new bearing bushings and ream them out, so as to have the shaft correspond with the bore of the bearing bushing, or else to send the entire generator or motor to the factory.

Do not get oil or grease on Commutator, but oil generator and motor bearings often with 8 or 10 drops of engine oil.

Brushes: Generators usually use carbon brushes copper plated. Starting motors use a composition of graphite and carbon or some similar substance which is softer than generator brushes. Some starting motors use gauze brushes. See Index under "Brushes." It is best to obtain brushes as recommended by the manufacturer.

On page 494 we advise how to sand brushes. On some generators this is not possible, as the brush arm is too short. In this case, the brush should be placed on the generator, the generator should be "motored," and thus the high spots on the brushes will show. Scrape high spots of brushes down.

Good brush contact is very essential on both generator and starter.

¹ A. L. Dyke, Electrical Dept., St. Louis, Mo., is in a position to supply these parts and advise you where the nearest representative of the different electric companies is located. This service on our part is rendered not so much for the small profit, as for the benefit of our readers, in order to assist them in getting started.

Starting in the Electrical Repair Business

The most important essential of a successful automotive electrician is a thorough knowledge of the fundamental principles, troubles, tests, adjustments, and repairs of the various electrical units of an automobile. The automotive electrician depends less on skill, but more on knowledge, than other automotive repair specialists.

After obtaining knowledge by reading, and, if possible, attendance at school, it is advisable to work as a helper in an automotive electrical repair shop to gain practical experience. The helper should advance to the position of *automotive electrician* and serve in this capacity for a reasonable time and should obtain some knowledge of accounting before engaging in business for himself.

To start an electrical repair business, the automotive electrician should first endeavor to obtain contracts as an authorized service station or dealer for one or more of the manufacturers of automotive electrical parts as listed on this page. It then becomes necessary to obtain electrical data, stock of parts and supplies, testing instruments, and electrical service station equipment.

Electrical Data

The various electrical manufacturers publish manuals available to their authorized service stations and dealers.

A wiring manual showing the car wiring diagrams, factory electrical specifications, data for electrical tests and adjustments of the various electrical units should be in the possession of automotive electricians engaged in general automotive electrical work. See advertisement in this book on page preceding the index.

Electrical Parts to Carry in Stock

The amount or kind of parts to be carried in stock will depend on the conditions surrounding the business.

Advice may be obtained from one of the distributors or factory branches of the manufacturers who supply *popular parts assortments*.

Some of the most generally used parts and supplies are: lamp bulbs, spark plugs, fuses, ignition condensers, contact-breaker arms and points, coil resistance units, ignition coils, generator and starter brushes and springs, bushings and bearings, distributor rotor arms and caps, miscellaneous wire terminals, low-tension wire, high-tension wire, ignition cable sets, friction tape, miscellaneous fibre washers and small screws, solder, soldering paste, etc. As the business expands the following should be added: generator and starter armatures, relays (cut-outs), starter, ignition and lighting switches, headlamp lenses and reflectors, etc.

It is advisable to find out the make of cars in your vicinity and the electric systems used on the cars, in order to have appropriate parts on hand. By referring to "Specifications of Passenger Automobiles, Motorcoaches and Trucks" in this book, you will find the specific make of electric system listed with each make of car.

When replacing an electrical part, be sure to get the same make and type, or the one recommended by the manufacturer to take its place, because otherwise it may not be suitable for the engine or electrical system.

Where To Obtain Automotive Electrical Parts

Genuine original equipment parts for the electrical systems on passenger cars, motorcoaches, trucks, and tractors, such as generators, cut-outs, regulators, starting motors, switches, ignition distributors, coils, magnetos, etc., may be obtained from authorized service stations and dealers of the various electrical manufacturers. The address of the nearest dealer may be obtained from the manufacturers (or distributors), some of whom are listed below:

The Electric Auto-Lite Co., Toledo, Ohio, through their branches and authorized service stations, provide official repair

parts service for "Auto-Lite" and "Dyneto" generators, starting motors, ignition coils, and distributors.

United Motors Service, Inc., through their branches and authorized service stations, provide official repair parts service for "Delco-Remy," "North East" and "Klaxon" ("Overseas Motor Service Corp." in foreign countries).

Scintilla Magneto Company, Sidney, N.Y., through their branches and authorized service stations, provide official repair parts service for magnetos.

The Leeco-Neville Company, Cleveland, Ohio, through their branches and authorized service stations, provide official repair parts service for generators, voltage regulators, starting motors, and switches for gasoline and Diesel engines.

United American Bosch Corp., Springfield, Mass., through their authorized service stations, provide official repair parts service for "Bosch" magnetos, generators, starting motors, ignition coils, distributors, windshield wipers, horns; "American-Bosch" magnetos, Diesel fuel injection equipment; Pyro-Action spark plugs.

Mallory Electric Corp., Detroit, Mich., through their branches and authorized service stations, provide official repair parts service for ignition coils and distributors.

Where To Obtain Automotive Electrical Service Station Equipment

Electrical service station equipment, tools, electrical testing devices and stands, battery charging and testing equipment, engine tune-up equipment, and other types of testing devices may be obtained from authorized dealers of the various manufacturers.¹ The address of the nearest dealer may be obtained from the *manufacturer or distributor*, some of whom are listed below:

Allen Electric and Equipment Co., Kalamazoo, Mich.

Hinckley-Myers Co., Jackson, Mich.

Hobart Brothers, Troy, Ohio.

Stromberg Motoscope Corp., Chicago, Ill.

The Electric Heat Control Co., Cleveland, Ohio.

United Motors Service, Inc. (branches in 24 cities).

Joseph Weidenhoff, Inc., Chicago, Ill.

Automotive Supply Jobbers also handle service-station equipment.

Armature Replacements

When returning an armature to be replaced, always remove bearings and races and state clearly the make and model of car; also make and model and serial number of generator or starting motor from which armature was removed. When returning old armature to secure exchange allowance, consult your source of supply as to the proper routine to follow.

Genuine original equipment armatures are sold on an exchange basis at nominal prices and are available from the branches, authorized service stations, or dealers of United Motors Service; Auto-Lite distributors and authorized service stations; and other manufacturers' distributors and stations.

A few suggestions for proper installation of armatures follow:

1. Be sure that bearings are fitted properly.
2. See that there are no loose connections in the generator or starting motor circuit.
3. Be sure that brushes work freely in holders.
4. Be sure that armature core does not rub on pole pieces.
5. If armature rotates in reverse direction, be sure that field leads were not reversed.
6. Sand-in brushes so that they fit the circumference of the commutator.
7. Be sure to have enough spring tension so that brushes will be held to commutator face, otherwise there will be an arc which may burn up the armature.
8. Never turn down an armature core, as this will enlarge the air gap, and you will not get the proper amperage at low speeds.
9. Where there are plain bearings, be sure they are pinned so that they do not shift and allow winding to strike housing.
10. Never install an armature in a unit where bearings show signs of wear. Install new bearings.

¹ See also ADDENDA, pages 40-43, for engine testing and checking devices.

INSTRUCTION No. 44

DIFFERENT METHODS FOR TESTING THE ELECTRICAL PARTS OF A CAR: Lighting Tests; Armature Tests; Field Tests; Generator Tests; Starting Motor Tests; Cut-Out Tests

This instruction will deal with the subject of various methods of making tests. For instance, grounds are usually tested with the test light, although a meter can be used. (See also pages 448, 463, and 545-555.)

Armature and field ground tests are also usually tested with a test light, but a meter can also be used.

Armature tests for open circuits and short circuits are usually tested with a meter, using the millivolt drop test.

An ammeter of a 30-range capacity can be used for testing generator armatures for short circuits and

open circuits, as explained under the F. B. test-stand tests.

The "growler" is best for testing motor armatures, owing to the very low resistance of the motor coils. Torque tests and free-running tests can also be made of the motor, but the object of a "free-running test" of a motor, or a "torque test," is to find out if the trouble is in the field or in the armature.

Likewise, the "motoring test of a generator" is for the purpose of localizing the trouble: to discover whether it is in the armature or the fields, and whether it is an open circuit, a short circuit, or a ground.

LIGHTING TROUBLES

Lighting troubles are attributed to one or more of the following causes:

1. Poor connections.
2. Open circuits or broken connections.
3. Grounds.
4. Short circuits.
5. Weak battery.

Poor connections and open circuits may exist at any point on the lighting circuit, from the battery to the lamp bulb.

Grounds and short circuits may exist at any point on the lighting circuit.

Lighting Trouble Indications

If lamps do not light up:

1. Examine the fuse block for blown fuses. If the fuse is blown, do not replace it immediately, but look over the wiring for an accidental ground or short circuit. If the fuse in the headlight circuit blows, turn off the headlight switch until the trouble is located and removed. In looking for grounds, any abrasion of the insulation on the wire, or a metallic contact between the wires or between the current-carrying part of the wiring devices and the metal of the car should be watched for.

When the trouble has been located and corrected, then replace the blown fuse with another of the same capacity, making sure that it is of the proper size.

2. If the fuse is not blown, look for burned-out lamp bulbs, open circuits, loose contacts; or the lighting wire to the battery may be loose, or disconnected, or the battery may be run down, or discharged.
3. In case the battery is discharged, recharge it immediately, and if possible, give it a gassing charge. See Index under "Hydrometer test."

If lamps in one circuit do not burn:

1. The lamp may be burned out. Try another lamp in the same socket.

2. If the fuse is thought to be blown, try the same fuse in another circuit. If the fuse is blown do not replace it immediately, but look over the wiring for a ground or short circuit.

If the trouble cannot be located immediately, turn off the switch on the damaged circuit until the trouble has been located.

If the trouble is in a particular lamp socket, disconnect the attachment plug from this socket until the trouble can be removed, and see that the removed attachment plug does not dangle in such a way as to make a short circuit on the metal of the car.

3. There may be an open circuit or a broken connection in the wiring. Examine the places where the connections are made on that particular circuit.
4. In case the trouble is due to a short circuit on some particular lamp socket, disconnect the attachment plug leading to this socket until the difficulty can be remedied.

If none of the lamps will burn—and no spark is obtained for ignition:

1. Terminals of the battery may be disconnected or corroded, so that they do not make good contact.
2. Ground wire, from the battery to frame of car, may be disconnected or broken.

If the ignition is all right, the trouble may be due to:

- 1a. The lead wire from the switch to the lights may be disconnected or broken.
- 1b. The lead from the generator terminal to the fuse box may be disconnected or broken, or the fuses blown, owing to a short circuit.
- 1c. The lamps may be burned out.
- 1d. The battery may be run down.

If there are no lights or dim lights, with the engine running: There is a group of troubles which can be classified under the general head of open circuits. There are seven of these which are prominent:

1. The generator terminal or brush connections may be loose, or may make poor contact. If, how-

ever, the generator is charging the battery—which is indicated by the ammeter showing “charge”—then the trouble is not in the generator.

2. The wire connections to the switch may be defective.

3. The wire connections to the lamp connector terminals may be defective.

4. Lamp-socket terminal may be loose.

5. Bulbs may be burned out.

6. Bulb bases may be out of contact with lamp sockets.

7. There may be broken wires, especially where connections are made to the lamp sockets.

If lamps go out for an instant only: When the lamps in one circuit act this way, there is probably a loose connection on the circuit so affected. It may be in any part of the system, and the first place to look is at the fuse connection.

A slight short circuit which occurs at intermittent periods would also cause this trouble, but in this instance, a higher “discharge” rate will be shown on the “ammeter.”

If lamps flicker: This trouble is attributable to loose connections, usually at the lamp socket or fuse.

It can also be caused by bad contact or an intermittent ground. For instance, a contact might be just loose enough so that vibration would cause the circuit to be made and broken repeatedly.

A grounded wire would cause this trouble by alternately making and breaking the ground connection. Every time the ground is made, the light goes out because the current flows through the ground instead of through the lamp.

Obviously the trouble may be roughly located by noting whether all the lamps flicker, or only one. If all do, then the test should start at the ammeter; then at the switch; then at the circuit. If only one light flickers, then the trouble is in this individual circuit.

If lamps flicker and the ammeter is unsteady: This may be due to a loose connection in the light wires; a loose connection between battery and generator; a loose contact at lamp bulb; or, finally, to an exposed wire touching the frame intermittently, causing a short circuit.

If one lamp burns dim: Change the bulb; it may be old and blackened, or partially short-circuited in the filament. If the same lamp is still dim, test the wiring to the lamp. Examine the lamp socket. A great many of these troubles are found in poor connections in the lamp socket, or in a slight ground in this circuit.

If all lights burn dim: The usual trouble in this case is loose or slightly grounded connections, or poor or corroded connection at the battery. More likely the battery simply has not had sufficient charging. This can be determined by watching whether the lights brighten up when engine is

speeded up, at which time generator is supplying current.

If the wiring is all right, run as much as possible with lights off, so that the dynamo will charge the battery at a higher rate. Or it may be necessary to set the charging rate of the generator higher.

If the battery continues to run down, examine the cut-out. If the cut-out is in good order, then test battery with switch off, for a “ground” or slight “short circuit” in the sockets, or switch.

If there is no ground, then test the battery electrolyte, and also each cell separately, as directed in the instructions given under “Storage Battery.”

Lamps may also be old and blackened, in which case, try new bulbs.

If the lamps are bright with the engine speeded up, and dim when the engine slows down or is idle:

In this case the battery is discharged, because, when the engine is speeded up, the generator current is used, and if the lights brighten up, then it is clear that if the engine slows down and the battery supplies current and the lights are dim, the battery itself is weak. Loose or poor contact of the battery terminals might also cause this trouble, or probably the battery terminal is sulphated.

If possible, have the battery charged at once from an outside source. If this cannot be done, endeavor to run with fewer lamps than normal turned on for a few days, or until the battery voltage picks up again.

If the lights grow dim when the engine is speeded up, the wires are probably reversed at the generator.

If lamps burn very dimly when the starting pedal is used: The battery is weak, and probably almost discharged; or the battery is injured in one or more cells, probably due to lack of water; or battery terminals or ground wire is not tight.

If lamps will not light, but the starter cranks the engine: Lamps are burned out, or the filament is broken; or the system is short-circuited, or there is an open circuit at the fuse or the switch or the wiring.

If lamps seem to burn brightly, but fail to illuminate the road sufficiently: Lamps are out of focus. The rays of light are directed too far upward. (See “Focusing of lamps and reflectors.”)

If lamps are too bright: The regulation of the generator is evidently set for a higher voltage. Use lamps of higher voltage.

If lamps burn out often: This may be due either to a poor grade of lamps, or to improper voltage of lamps; also to sulphated or corroded battery terminals, or to loose battery connections. If generator should be generating a high amperage, and an open circuit should occur suddenly, this would cause a greatly increased voltage. For this reason fuses are usually placed in the generator field circuit (see page 430).

If fuses blow repeatedly: Lamp sockets or wiring are defective—probably with short circuits. First try new bulbs. The fuse may not be of large enough capacity.

TESTING THE LIGHTING CIRCUIT FOR OPEN CIRCUITS, GROUNDS, AND SHORT CIRCUITS WITH A TEST LIGHT

In this example we shall use a test lamp and test points from a 110-volt lighting circuit of either direct or alternating current. A voltmeter could be used.

A point to remember, when testing any circuit, is that a complete circuit is necessary in order to have the electric current do its work.

When using a test light, it is advisable occasionally to bring both test points together or to touch one with the other, to make sure that the test light is still in working order, as very often the filament of a lamp breaks, owing to the rough nature of test work. When this happens, one is led to erroneous conclusions.

It is a good plan to inclose the test lamp in a wire cage to prevent excess vibration to the lamp bulb and also to avoid injury to the small glass tip on the end of the lamp bulb.

Wiring-System Troubles

Wiring troubles are:

1. All lights out; none burn.
2. Only one branch of lights burns.

Cause of 1: Fuses blown; battery discharged or disconnected; poor connection at battery terminal or ground wire; open circuit; short circuit. Test the battery; examine connections.

Causes of 2: Open circuit; short circuit or ground in this branch. Test as suggested below. May be due to burned-out lamp bulbs or poor contact at lamp sockets.

A single-unit Delco electric system, using a single-wire grounded return wiring circuit is shown in Fig. 1 as an example. The tests however will apply to many of the other systems. The idea here is to point out how to make the tests for the different external circuits.

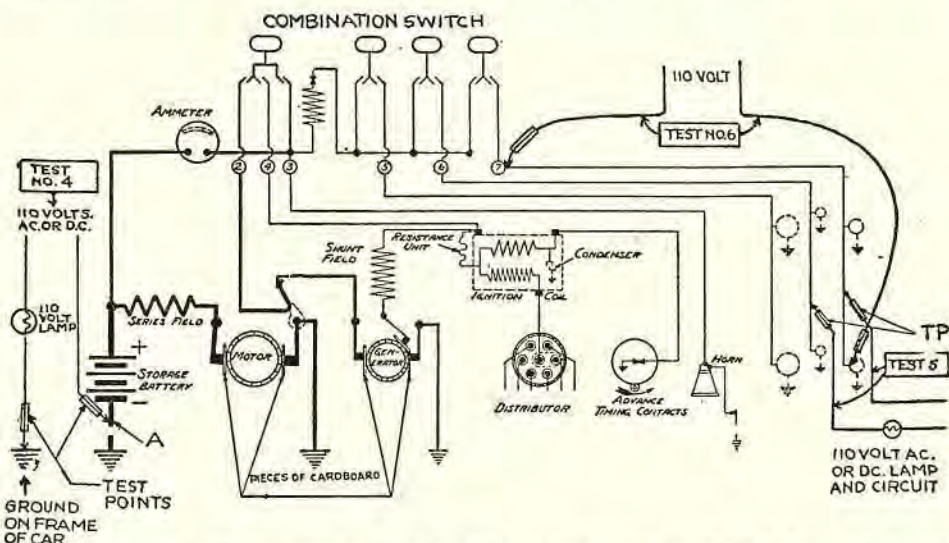


Fig. 1. Diagram explaining how to use a test light for testing for open circuits, grounds, and short circuits in the lighting circuit of a car or wiring system.

Most of the troubles in the wiring system are grounds, short circuits, and open circuits.

It will be observed that certain portions of this circuit are intentionally grounded to the frame of the car. The battery terminal, the lamp return wires, one motor and one generator brush, one of the timer contacts, one terminal of the horn push-button, and one terminal of the condenser in the coil are grounded.

When Testing for Grounds

1. Remove these grounded connections by disconnecting the battery terminal (negative [-] in this instance) from the battery which is grounded to the frame of the car, and remove all lamp bulbs.

2. Place a piece of cardboard between the commutator and the brushes of the motor and the generator (third brush also). See Fig. 1.

3. Disconnect the lead wire from the horn button and distributor and raise the base of the ignition coil so that it is insulated from the top cover of the motor-generator.

To Test for Grounds

See test No. 4; place one of the test points (T) on the frame of the car and the other test point (T1) on the negative (-) terminal of the battery (A).

If the test lamp lights, then a ground is indicated, and will likely be on the switch or in the motor windings (if all the switch buttons are pushed in).

Note. If the battery box becomes badly acid soaked, it may cause the lamp to light, owing to grounding through the box. Disconnect the (+) terminal of the battery from the wiring system, and test as before. If the lamp lights now, the battery box should be insulated from the frame of the car with a piece of dry wood and the battery should be cleaned and dried, and the battery box should be painted. See Index under "Battery box acid-soaked."

4. Now with one of the points still grounded to the frame of the car, touch with the other point different terminals of the combination switch.

If the lamp lights, then a ground is indicated. It should be found and removed.

To Test for Short Circuits

For testing for short circuits between two wires which are supposed to be insulated from each other—see test No. 5; place one test point (TP) on one wire and the other point on the other wire.

If the lamp lights, a short circuit is indicated between the two wires.

If the lamp does not light, then this portion of the circuit is in proper condition.

To Test for a Broken Wire

To test for a broken wire—see test No. 6; place the test point at each end of the wire as shown.

If the lamp lights, the circuit is complete.

If the lamp does not light, then there is a break somewhere between the two points. By gradually moving the test points toward one another, the break can be definitely located.

If Lights Burn Out Often

This is likely due to using a lower-voltage lamp than is used on the generator circuit. Test the voltage at the lamp socket with the voltmeter when the generator is running at normal speed, and use lamp bulbs accordingly.

TESTING THE LIGHTING, HORN, AND IGNITION CIRCUITS WITH A METER

Lights

Causes: If all the lights do not operate, the trouble may be due to the lighting system being short-circuited, open-circuited, or grounded.

If individual lights do not operate, the branch systems may have any of the defects mentioned, and, in addition, that of burned-out lights.

Testing Lighting System¹

Short circuit: To test for a short circuit in the general lighting system, insert the 300-ampere range shunt in the circuit. Connect the instrument to the shunt. An indication will be obtained if a short circuit exists. (An indication may also show a ground.)

If some of the lights only do not operate, connect the instrument as just described and close the switch for the branch containing those lights, for instance, between switch 7, Fig. 1, and the light circuit. An indication will be obtained if the branch contains a short circuit or ground. If a short circuit is indicated, the wiring and light sockets should be carefully examined.

Note. If the indication obtained is less than 30 amperes, the 30-ampere range shunt may replace the 300-ampere range shunt.

If any lights are burned out, measure the voltage at the socket, using the 30-volt range. This should be done for various engine speeds.

If a voltage is indicated which is higher than is proper for the particular system being considered, examine the generator regulator system to locate the trouble.

Open circuit: If all lights do not operate, and the instrument does not show a short circuit or ground, the general lighting system is open-circuited. This is probably due to a disconnected wire.

If some lights only do not operate and no short circuits or grounds are indicated, the branch systems which contain these lights are open-circuited. This may be in the wiring, or because the lights are burned out.

Grounds: Disconnect all wires from the battery and all intentional ground connections. Then proceed as described under "Short Circuits."

Testing the Electric Horn²

The causes for the horn failing to operate may be similar to those affecting the operation of the lights.

Open circuit: Connect the 30-ampere range shunt and instrument in the horn circuit, between the switch terminal 3 (Fig. 1) and the horn circuit. Close the horn switch. If no indication is obtained, the horn circuit is open-circuited. By inspection, the place at which trouble exists can readily be found.

Short circuit: If a test for an open circuit does give an indication, the horn circuit is short-circuited or grounded.

Note. If the indication is less than 3 amperes, the 3-ampere shunt may replace the 30-ampere shunt on the ammeter.

¹ The Weston "model 280" instrument is used as an example in these tests. See page 464.

² See also pages 445, 451, 453.

Ignition Troubles

Causes of trouble: Ignition troubles may be caused by loose connections, open circuits, grounded wires or spark plugs, short-circuited wires or spark plugs, improper adjustment of spark gap of plugs, incorrect order of cylinder firing, broken-down or short-circuited spark coil, and broken-down or grounded condenser.

If a magneto is supplied, trouble may be in the magneto.

Ignition troubles and tests are treated under the ignition instructions. See Index.

A visual inspection and the application of tests already described will undoubtedly enable one to locate the fault.

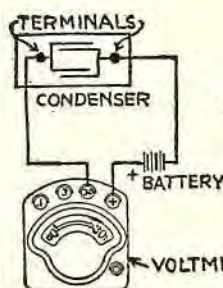


Fig. 2

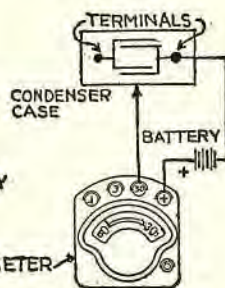


Fig. 3

Condenser broken down: Connect the negative (-) binding post of the battery to one terminal of the condenser (Fig. 2). Connect the positive (+) terminal of a battery to the (+) binding post of the instrument. Then, finally, complete the circuit from the 30-volt binding post to the other condenser terminal.

If the condenser is good, no indication will be obtained. If it is broken down, an indication will be obtained.

Condenser grounded: Remove one connection from a condenser terminal and touch it to the condenser case (Fig. 3). If an indication is obtained, that section of the condenser is grounded. Replace the connection to the condenser terminal and repeat, removing the connection from the other terminal and touching it to the case. See also Index, under "Condenser tests."

General Wiring Troubles

Causes of trouble: Troubles in the general wiring of an automobile may be due to short circuits, grounds, open circuits, and poor connections. These faults can result from oil and water-soaked insulation, from damaged insulation caused by rubbing of the wires against the metallic parts of the automobile, and from vibration of the automobile when in service.

These faults can be located by visual inspection and by the application of the various tests already described.

It is well to consult the manufacturer's wiring diagrams before attempting to make any changes in the wiring.

TESTS OF A STARTING MOTOR WITH A METER (ALSO APPLICABLE TO THE GENERATOR EXCEPT THE OPEN-CIRCUIT FIELD TEST)¹

The subject of starting-motor troubles is also treated on pages 455, 517, 518. The purpose here is to explain first the common troubles of a starting motor and then how to make the tests.

Starting-Motor Troubles

Starting-motor troubles can be divided under two headings:

1. Failure to operate.
2. Operates slowly and without sufficient power to crank the engine.

Causes of 1: Battery weak; open or short circuits, or grounds may exist in wiring from battery to starter switch; sticking of starting switch (common); mechanical troubles, such as a stuck Bendix drive gear, worn bearings, waste or foreign substance between armature and pole pieces; trouble with starter mechanism.

Test by examining each carefully. If none of these causes exist, then the trouble is an internal one of the motor, and may be due to an open circuit in the motor armature or field. Tests are shown elsewhere.

The trouble may also be due to a dirty commutator, to grounded brushes, or to the fact that the brushes are not making good contact. Tests are shown elsewhere.

Causes of 2: Battery discharged—test battery; poor contact at battery terminal or ground wire from battery to frame; poor brush contact; dirty commutator. Test. See also "Digest of Troubles."

The first test, however, which should be made, before making other tests, is to test the engine, to see if it cranks easily when cranked by hand. If the engine is stiff, it is probably using more than the normal amount of current, thus rapidly discharging the battery; or the engine may not start easily owing to carburetion or ignition trouble.

The second test should be that of the battery (see Index under "Testing the storage battery").

Failure of the engine to start when the starting motor is working satisfactorily: This may be due to failure of gasoline or spark. Test out as follows:

- (1) Ignition switch: Examine to see if "on."
- (2) See that there is gasoline in the carburetor, and that it reaches the engine, by priming. If there is no gasoline in the carburetor, which can be determined by depressing or raising the float to see if gasoline drips, then it is useless to waste current trying to start the engine with the starting motor. The gasoline may be used up, it may not be turned on, or the gasoline feed pipe or valve may be stopped up. If the system involves gravity feed, the gasoline may not flow into the carburetor on steep hills.

(3) If there is gasoline in the carburetor, take out one of the spark plugs and lay it on the engine with the sparking point in the air while the engine is turned over by hand or by the starting motor. Also examine the spark plug points—they may be too far apart. $\frac{1}{4}$ " to $\frac{1}{2}$ " apart is about right. If a spark passes, the trouble is not in the electric system, but is probably caused by cold gasoline or the need of priming.

(4) If there is no spark, then see "Digest of Troubles" and Index, and follow the diagnosis.

Before an engine will start, there must be gasoline and a spark.

If sometimes the gears mesh and the motor runs satisfactorily, and at other times it is impossible to mesh the gears, the motor refusing to turn when the contacts are closed, it indicates the possibility of an open circuit in the switch or starting motor.

If the engine does not pick up immediately after two or three trials, even though the motor turns the engine over, the trouble is in either the gasoline supply; the spark plugs; the carburetor; or the ignition system.

If the starting motor continues to run after the switch lever is released, see that the return spring on the switch, or switch lever, is strong enough to return the parts positively and fully to the "off" position.

If the starting motor cranks the engine very slowly: Battery is almost discharged; battery may be sulphated; engine may be stiff; brushes may be loose or may make poor contact.

If the starting motor does not rotate at all: Battery may be discharged; starting switch may not be making good contact; the motor brush may not make contact with the commutator; the battery terminals may not make good contact; switch contact may be poor.

Owing to the high volume of current carried through starting motor brushes, if they are worn or not properly adjusted, the commutator may become pitted and cause excessive wear—result: failure of starting motor to operate properly or excessive sparking and weak motor. Remedy: Take the armature out and true up the commutator on a lathe.

If the starting motor rotates but does not crank the engine: Roller clutch does not work properly (Delco system), or the Bendix drive is out of order; gears may be improperly meshed; if a Bendix automatic, spring may be broken. See pages 320, 456.

If the starting motor cranks the engine a few revolutions and then stops: Battery may be weak—almost discharged; a loose switch contact may exist.

If the starting motor cranks the engine and the engine does not start: These symptoms indicate that trouble is not in the starting system.

If the battery is all right proceed to examine the connections, beginning with the battery. The current may be shorted, because of electrolyte spilled over the top of it; or the terminals may be sulphated, in which case enough resistance will be offered to the current to prevent proper operation.

Scrape off the sulphate, wash surrounding metal parts in carbonate of soda or some other alkali.

Clean the battery terminals inside with a round file; clean the wire terminal with a flat file; replace the wire, and draw connections tight.

Next examine the ground connection of the battery to the frame. This should be cleaned and tightened, if not soldered. Looseness here is a frequent cause of open circuit. Then examine the connections from battery to starting motor switch; thence the brushes to the commutator. Good battery and ground connections are very important.

See "Digest of Troubles" for other starting-motor troubles, both "electrical" and "mechanical."

¹ Taken by permission from the Weston Instruction Book. Copyrighted, 1920.

Starting-Motor Troubles in Relation to Testing with a Meter

The following tests are made with a Weston "model 280" instrument.

Causes: If the starting motor does not operate, the fault may arise from several causes, acting separately or collectively. The more important causes are fully discussed in the following text:

The battery: The battery is generally the most abused part of the starting and lighting system, and consequently may easily become discharged. In this condition it is not capable of supplying sufficient current to operate the starting motor. The hydrometer test should be applied, and if this condition exists, the battery should be investigated. See Index for "Storage battery tests."

Wiring and starting switch: Open circuits, short circuits, or grounds may exist in the wiring from the battery to the motor, including the starting switch. A common cause is sticking of the starting switch.

Defective motor: The motor may not operate because of internal troubles. These may be an open-circuited or short-circuited armature or field, dirty commutator, brushes not bearing on the commutator, or grounded brush holders, armature, and field.

Mechanical troubles are not included in these tests. See "Digest of Troubles."

Testing for Trouble: Motor Will not Operate

To locate trouble: If the battery is in good condition and the starting motor does not operate, connect the 30-volt range of the instrument to the terminals of the motor as directed in test V3, page 470. Press down the starting switch. Quickly observe the indication of the instrument.

Caution: Do not hold the starting switch down any longer than absolutely necessary to obtain a reading, as the battery is under a heavy strain which may damage it.

Open circuit in wiring or starting switch: If no indication is obtained, an open circuit exists either in the wiring from the battery to the motor or in the starting switch. A visual inspection will locate the cause.

Short circuits and grounds in wiring or starting switch: If an indication is obtained when the voltmeter is connected to the motor terminals, but the indication is much less than the normal voltage of the battery (test battery as directed in test V2, page 470), the trouble may be due to loose connections at the battery, starting switch, or motor; or to grounded or partially short-circuited wiring. A visual inspection will locate these causes.

Short circuits and grounds in motor: If no troubles are found to exist in the wiring, the cause must be in the motor. The faults as indicated by the instrument would be short-circuited or grounded armature and field, or grounded brush-holders. See under "Short Circuits" and "Grounds" for details of tests.

Open circuits in motor: If an indication approximately equal to the battery voltage is obtained with the voltmeter connected to the motor terminals, the motor is open-circuited. An open circuit may exist in the armature or field, or it may be due to the commutator being dirty or the brushes not bearing on the commutator. A visual inspection will eliminate the last two faults. See under "Open Circuits" for details of tests on other faults.

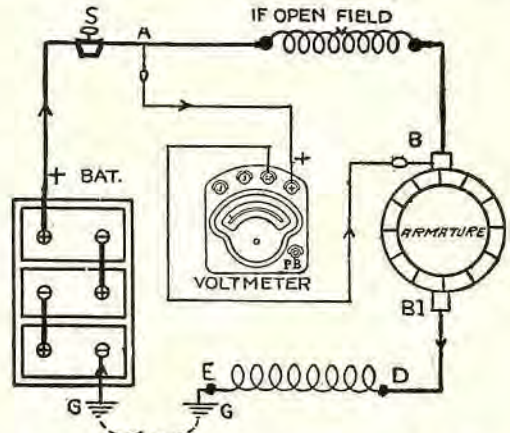


Fig. 4. Test for an open circuit in the motor field which would cause the motor not to operate. Use 30-volt terminal and scale.

To test for an open circuit in the motor field: See Fig. 4. Connect meter with the 30-volt terminal. Place voltmeter connections on one end of the field at (A) and the other at brush (B). Press starting switch (S).

If an indication shows on the meter that is approximately equal to the battery voltage, then there is probably an open circuit in the field, because the circuit would then be from (A), through the meter to (B), through the armature, to (B1), through the other field, to ground (G), to (-) of the battery.

If no indication is obtained, then the field is good and the motor should operate if the battery is strong. If it does not operate, then the armature may be open, and this is discovered by another test. If the field is good, there would be (approximately) no reading, because the meter would be connected on one side of the line. Therefore this test would not tell definitely if the armature is open, but it would be sufficient reason to test for an open armature.

This motor-field test is not applicable to the generator-field test.

Testing for Trouble: Motor Operates, but Slowly

If the motor will turn over, but too slowly to start the engine, any one or more of the troubles already mentioned may exist, except the open circuit in fields. In other words, an open circuit could be in one or two armature coils, or a short in one or two armature coils, and the motor would operate to a certain extent. Therefore tests of armature and field troubles will be given, which are also applicable to the generator, except the meter test of the open-circuit field of a generator, which is given on page 502.

Testing for open circuits in the armature: Connect the 30-volt range of the meter to the brushes, as shown in Fig. 5. Be sure that the brushes are bearing on the commutator. Press the starting switch.

If an indication shows on the meter and it is (approximately) equal to the battery voltage, then the armature is probably open. The current would then flow through the meter from the battery around the armature. All of the armature coils may not be open; turn the armature slowly and observe.

To test each individual armature coil to localize or find the open-circuited coil, is then the next procedure, if the armature is suspected of being open.

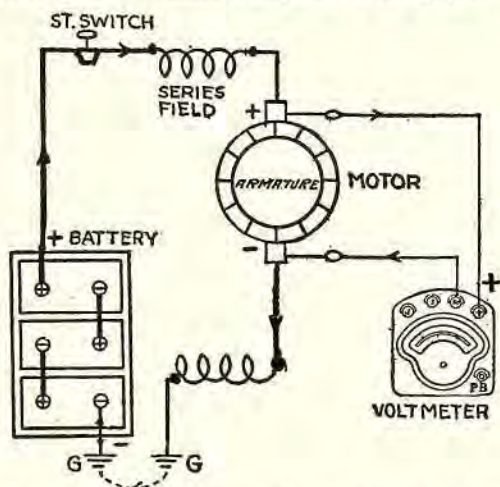


Fig. 5. Testing for open circuit in armature. Use the 30-volt terminal and scale.

Proceed as follows: Disconnect the fields from the armature, as in Fig. 6. Connect the brushes to a source of current, such as a single cell, and have a controlling resistor¹ in series to increase or decrease the current flow (see R, Fig. 6). Using the 3-volt range of voltmeter, measure between adjacent segments of the commutator.

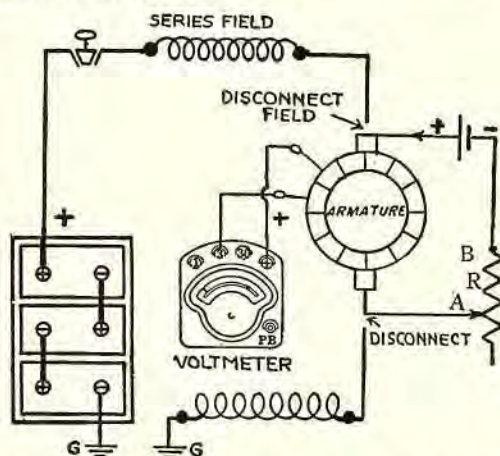


Fig. 6. Testing for open-circuited armature coils. Use the 3-volt terminal and scale. When testing for short circuits in armature coils, use the .1-volt terminals and scale. This test is what is termed a "comparative test," that is, the test points of the meter are placed on two adjacent bars all the way around the commutator, and the readings on each pair should be the same. Note resistor.

If an open-circuited coil is across the ends of the meter test-points, then an indication will be obtained which is relatively large as compared to that obtained from a good coil (see page 498 for the reason of this).

It is absolutely necessary that good contact should be had at the commutator segments in order to obtain reliable results.

Note. This method can also be used when testing the generator armature for open circuits.

Testing the armature for short circuits: Disconnect the field from the armature. Connect for test to determine open circuits in the armature (Fig. 6), and try the armature for open circuits as already described. Now change the connection from the 3-volt range to the .1-volt range and measure between commutator segments.

If a short circuit exists in any of the armature coils, the indication obtained, when the voltmeter test-points are connected to the ends of that coil, will be very much less than the indication obtained from a good coil (see page 498 for the reason).

Note. This is one of the special cases when the .1-volt range should be used.

If the indication is too large, decrease the current supplied through the brushes by increasing the controlling resistance.¹

This method is applicable to the generator.

Caution: Good contact must be had at the commutator segments in order to get reliable results.

Testing fields for short circuits: Connect one cell with a regulating resistor (R) in series to the ends of the entire field, as in Fig. 7. (The field is usually made in two or more sections.)

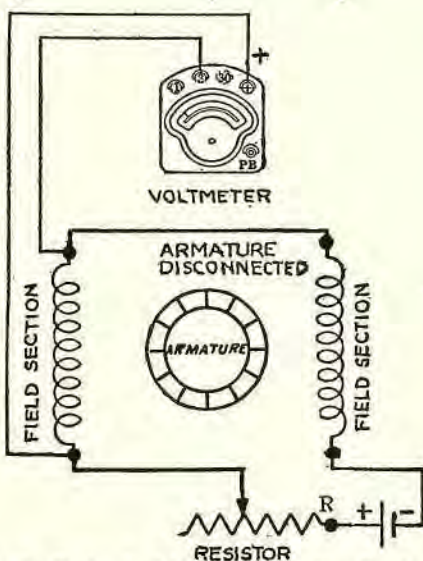


Fig. 7. Testing the fields for short-circuits. Use the 3-volt range to start with.

Using the 3-volt range, measure the voltage across one field section. Transfer the voltmeter leads to the other section in turn.

If on one of the sections no indication is obtained, that section is short-circuited, because there is no resistance offered by the field which is short-circuited. If it were not short-circuited, then the reading would be that of the voltage drop, due to the resistance offered to the flow of current passing through the coil winding. The greater the number of turns and the smaller the size of wire, the greater is the resistance. Therefore if a short circuit exists, there would be less resistance, depending upon the number of turns short-circuited.

¹ The purpose of the resistor is to furnish enough resistance in the circuit to cause sufficient voltage drop to obtain a satisfactory reading. The amount of resistance cut into the circuit can be varied with the resistor shown in Fig. 6; for instance, (R) is the resistance. By moving (A) down, more resistance is cut into the circuit; by moving (A) up, resistance (R) is cut out of the circuit. See page 467 for explanation, and for information as to where resistor can be obtained.

If on one section the indication is very much less than on the other section, a short circuit very likely exists in that section, because these tests are intended to compare one coil with another, and, if good, they should have approximately the same readings.

Note. If the indications obtained are less than .1 volt, the connection may be changed from the 3-volt range to the .1-volt range. This is the second special case where the .1-volt range can be used.

This method is applicable to the generator.

Testing the armature for grounds: Disconnect all intentional ground connections to the motor. Also disconnect the field from the armature. Lift the brushes off the commutator.

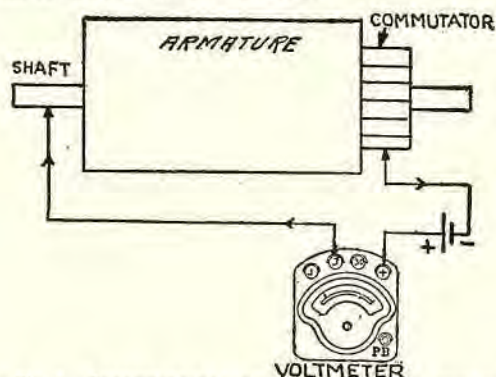


Fig. 8. Connections for testing for a ground in an armature. Use the 3-volt terminals and scale.

Connect the negative (–) terminal of a cell (Fig. 8) to a commutator segment, and the positive (+) terminal to the (+) binding post of the instrument. Complete the circuit from the 3-volt binding post to the armature shaft or motor frame.

If an indication is obtained, the armature is grounded. The cause of the ground is very likely due to damaged insulation on the armature conductors. The armature should be carefully examined for this.

On one-wire systems of the two-unit type, a grounded coil will result in slow cranking and a materially reduced charging rate.

In some starting and lighting outfits using motor-generators, two windings are placed on a single armature, each being brought out to a separate

commutator. One winding is for the motor and the other for the generator. A ground may develop between these windings.

To test for such a ground the terminal of the instrument which was attached to the shaft or frame of the car should be transferred to the second commutator and the general directions followed. See also test-light test, page 497, Fig. 28.

Testing the fields for grounds: Transfer the connection from the commutator segment to one end of the field. If an indication is obtained, the field is grounded.

When the system is of the single-unit type, such as a motor-generator, both motor and generator fields are wound on the same field frame. It is possible for these windings to develop a ground to one another.

The method of testing for such a ground is to interpose the instrument and a cell between one end of each winding. If a ground exists an indication will be obtained.

Caution: Be certain that the ends of the field coil are not touching the motor frame.

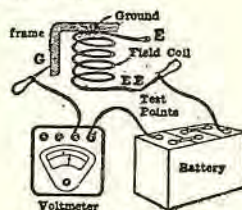


Fig. 9

When testing the field for a ground, be sure both field coil ends (E) and (EE) are disconnected from all terminals. Use the 30-volt connection as shown in Fig. 9. Place one test-point on (EE) and the other on the frame at (G). If deflection is shown, the coil is grounded and a new one must be supplied.

Testing grounded brush-holders: This test is made in the same manner as the test for a grounded armature, except that the connections should be made between the shaft of the armature or frame of the car and each brush-holder. Insert a piece of cardboard between the brushes and the commutator before making this test. If an indication is obtained, the brush-holder is grounded.

These tests are applicable to the generator.

EXAMPLE OF HOW A STARTING MOTOR IS TESTED ACCORDING TO DATA GIVEN IN THE SERVICE MANUALS¹

In order to make certain facts clear to the reader, which are usually found in Service Manuals, we shall use some data

on the test of a starting motor, model 118-A:

Speed, Torque, Current Data Table

Starting Motor.	Model 118-A, with Bendix drive.		
Torque			
(Pull with 6" Pulley)	R.P.M.	Ampere	Volts
0 lbs.	3750-4250	32-40	6.0
6 lbs.	1500-1540	88-98	5.7-5.8
9 lbs.	1200-1400	110-120	5.5-5.7
12 lbs.	1020-1150	130-145	5.4-5.5
16 lbs.	800-1000	158-175	5.3-5.4

Torque of an armature is the momentum tending to turn it. In a generator, it is the momentum

which must be applied to the armature to turn it in order to produce current. In a motor it is the turning momentum which the armature gives to the pulley or gear. The torque is greatest when starting, and is in proportion to the load.

Observe that the data given above are for a torque test of a starting motor. Therefore we shall use a simplified torque test apparatus, consisting of parts shown in Fig. 10.

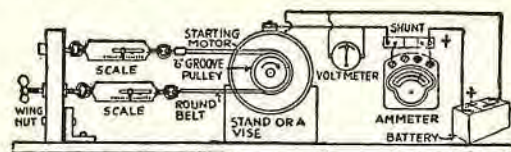


Fig. 10. Simplified illustration showing how a torque test of a starting motor is made.

¹ See advertisement on wiring manual in the back of this book, and notice a sample page of data (reduced size). This will give an idea as to the testing data given for generators, starting motors, battery, cut-out, ignition, lighting, ignition timing, firing orders, generator charging rates, etc.

The starting motor is placed in the stand (Fig. 10) with a 6" pulley on it, and is first given a "free running test" and then connected with an adjustable belt and two spring scales for making the "torque test."

The starting motor is then connected with a fully charged battery known to be in good condition (a 6-volt battery in this instance), and an ammeter with a 300-ampere shunt is connected in the circuit as shown. A voltmeter is placed across line.



19A. Speed Indicator.

A speed indicator is used to indicate the speed. On modern test stands, as shown on page 507, a tachometer indicates the speed, but in this instance a hand-type speed indicator (Fig. 10A) is used. The point of the speed indicator is placed in the end of the motor armature shaft, and the number of revolutions per minute is counted.

Motor Free Running Test

Note on the first line of the table, on page 489, that the torque is given as 0 lbs. at 3,750 to 4,250 r.p.m., and 32 to 40 amperes at 6 volts.

Procedure of test: The motor is placed on the stand with belt detached, that is, the motor is permitted to run "free." According to the second column of the table, the motor should develop 3,750 to 4,250 r.p.m.; according to the third column of the table, the ammeter should indicate 32 to 40 amperes under these conditions; according to the fourth column of the table, the voltmeter should indicate 6 volts.

Motor Torque Test

Note on the second line of the table (page 489), that the torque is given as 6 lbs. at 1,500 to 1,540 r.p.m., and at 88 to 98 amperes at 5.7 to 5.8 volts.

EXAMPLE OF HOW A GENERATOR IS TESTED ACCORDING TO DATA GIVEN IN THE SERVICE MANUALS

The Remy generator (relay regulated type) model "16-A" is used as an example.

Speed, Current Data Table

Generator without ignition. Model 16-A, using relay regulator regulation.

Amperes	R.P.M.	Volt
0.	370	6.0
7.	490	6.5
14.2	2200	6.9

On "battery test," field draws 3 to 3.5 amperes at 5.9 volts. "Generator motoring," draws 4 to 4.5 amperes, 5.8 volts and runs at 430 R.P.M.

Note that in the table there are given three methods of testing:

1. By driving the generator on the test stand and connecting it to the battery through the cut-out, as if on the car (Fig. 11).
2. By making a "battery test" of the amount of current drawn by the shunt-field windings, by connecting a battery across the shunt-field circuit with armature disconnected (Fig. 12).
3. By "motoring the generator," that is, by running the generator by the battery free, without a load, i.e., with no tight bearings or binding at any point (Fig. 13).

Procedure of test: The belt is now attached, the motor started, and the wing nut tightened until the difference between the readings of the two scales is 6 lbs. (that is, a pull of 6 lbs. is exerted by the motor). The speed should then be 1,500 to 1,540 r.p.m.; the ammeter should indicate 88 to 98 amperes, and the voltmeter should indicate 5.7 to 5.8 volts. The test should be continued, using the various values of torque as given in the table. Note that the "value of the torque" refers to the difference between the readings of the two scales.

An Explanation of Difference in Scale Readings

Suppose that the upper scale in Fig. 10 reads 26 lbs., and that the lower one reads 20 lbs. It seems at first that the motor is exerting a pull of 26 lbs. on the top scale; note, however, that the bottom scale is helping the motor by pulling with a force of 20 lbs., and that therefore the motor itself is only pulling 6 lbs., or the difference between 26 lbs. and 20 lbs.

Stalling or Locked Torque Test

Procedure of test: Tighten the wing nut until the motor comes to a dead stop: this is termed "stalling" or "locked." The difference in scale readings at this time gives the pull exerted by the motor. This pull should be very high, as it is the force which, when the motor first starts a cold engine, breaks the oil film. The amperage will also be very high.

Therefore, note that with a series-wound motor, the greater the load, the greater the amperage consumption and the less the speed. Also note that the greater the load, the greater the voltage drop.

Such data as these are given in the Service Manuals referred to in the advertisement in the back of this book.

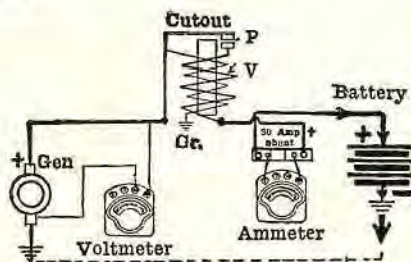


Fig. 11. Testing a generator by driving the generator.

Method 1: By driving the generator at a speed of 370 r.p.m., "0," or zero amperage, would be indicated (see table); but 6 volts is the voltage that should be indicated. The cut-out points (P) (Fig. 11) would be open, as the speed is not great enough to produce pressure sufficient to close contact-points (P). At 490 r.p.m., 7 amperes and 6.5 (6½) volts should be indicated. The cut-out points (P) should close, and the generator would charge the battery. At 2,200 r.p.m., 14.2 amperes (maximum) and 6.9 volts would be indicated. The ampere-meter is placed in series with the circuit indicated above, as in Fig. 11. A voltmeter is placed across the circuit, to indicate the voltage.

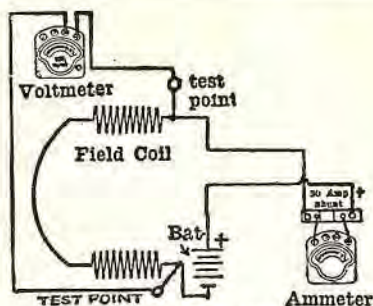


Fig. 12. Testing a generator by observing the amount of current taken by the shunt-field winding.

Method 2: By connecting a battery to the shunt-field winding terminals (Fig. 12) with an ammeter in series with the circuit, the ammeter should show 3 to 3.5 amperes. With a voltmeter across the circuit, as shown in Fig. 12, it should indicate 5.9 volts.

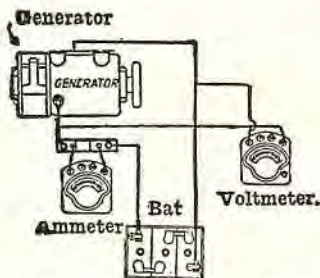


Fig. 13. Testing a generator by "motoring" it.

Method 3: By connecting this shunt-wound generator to a fully charged battery (Fig. 13) with the armature and all brush connections complete, and with an ammeter in series with the circuit and a voltmeter across the circuit, the generator running as a motor (termed "motoring-generator") should draw 4.0 to 4.5 amperes, and the voltmeter should indicate 5.8 volts; the generator operating as a motor should run at a speed of 430 r.p.m.

COMMUTATOR TROUBLES AND TESTS

Commutator troubles can be classed under three headings: (1) those due to defective manufacture; (2) those due to surface wear or deterioration in service; (3) those due to a dirty or burned commutator.

Defective commutators may be grounded, may have a short circuit between the segments, or may have loose segments or high mica, or loose brush-holder springs.

Sparking at the brushes will be caused by any of the causes mentioned above, or by loose pigtales, or by loose connections of wires to the brushes, by sticking brushes, by overloading of the generator, and by short circuits in the armature windings.

If the commutator is dirty, and if grease and carbon dust have accumulated between the commutator segments, to such an extent that the bars are shorted, excessive sparking will be the result, and no current, or very weak current, will be allowed to pass.

Examine the Commutator

First, examine the commutator to see if it is dirty, and if it consequently prevents proper contact be-

Generator Trouble Indications when "Motoring" a Generator on the Test Stand (Ford Generator as an Example)

The following tests and determinations may be made with an ammeter in the circuit and a generator connected with the 6-volt battery. Preferably one which has been in use is used, and the connections are made as shown in Fig. 14.

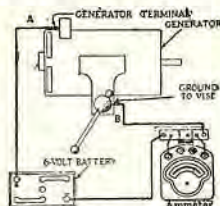


Fig. 14. Connections for motoring generator.

1. The correct reading is from 2 to 4 amperes, the generator running at a slow, steady speed, with no arcing at the brushes (see also page 510).

2. A heavy discharge, with the hands going beyond the limit of the instrument, indicates trouble in the head, such as the third brush not seated, fields open probably at the third brush or ground connection, the third or positive brush-holder or pigtail shorted. To prove an open field, raise the third brush and connect (A) to it. If open, no reading will be shown on the ammeter.

3. No reading on the ammeter indicates a dirty commutator or the brushes not seated upon it, because of the brushes sticking in the holders, or being worn too short to make proper contact, or sprung out of shape so one or both press against holder.

4. The ammeter fluctuating between 18 and 20 amperes, indicates short circuits in the armature.

5. The ammeter reading 6, with a higher r.p.m., indicates a shorted field.

6. If the ammeter is normal, but there is a decided flash at one point on the commutator, an open armature is indicated. Turn the armature over by hand, one segment at a time; if there is a point where the armature will not start to rotate, that coil is open.

tween the brushes and the commutator bars. If it is all blackened and covered with grease, no current, or a very small current only, will be allowed to pass. Or if copper dust has coated the insulation between bars, this will short circuit the commutator (see also pages 500, 508). This can be removed usually by cleaning or scraping. See also pages 515, 519, for testing commutator for grounds.

Cleaning Commutator

If the trouble is due to grease and dirt only, it can easily be cleaned. Start the generator, and while it is running, hold a piece of cloth dampened with gasoline against the commutator bars to remove the grease.

Next, use a finely pointed tool and clean out any dirt or grease that may have accumulated between the commutator bars.

Sanding the Commutator

If the commutator is dirty, caused by excessive sparking, it will be necessary to sand it by the use of a very fine piece of sandpaper, not coarser than No. 00, held against the commutator (rough side down) while the generator is running. Never use emery cloth.

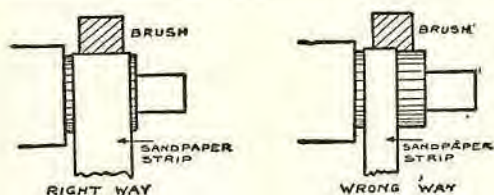


Fig. 15. Right and wrong way to sand a commutator.

The strips of sandpaper should be a little wider than the brush (Fig. 15) and wrapped around the commutator so as to make contact with at least half of its circumference. Fig. 15 shows the correct method on the left and the incorrect on the right.

Worn Commutator Bars

The next source of trouble may be a very badly worn commutator, which would allow the mica between the bars to become flush with the surface of the bars. The mica should be kept slightly below the surface of the bar (which is done by undercutting the mica as explained farther on).

Mica Protruding

If the mica insulation between the commutator bars becomes flush with the bars, the brushes cannot make good contact, and this causes arcing or sparking, which burns away the bars until they are below the level of the mica which then protrudes. This not only prevents the brushes from making good contact, but the bars are pitted and become very rough. Fig. 16A shows the appearance of a commutator with protruding mica.

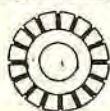


Fig. 16

Fig. 16A. Mica correctly undercut.



Fig. 16A

Fig. 16A. High mica before cutting.

This trouble is more common on generators. On starting motors, where brushes do not make contact, the commutator becomes rough and causes arcing. The mica is not undercut on a motor commutator, but if rough, it is put in the lathe and turned down with a very sharp lathe tool to take a very fine cut off the surface of the commutator.

Dressing Commutator Down and Undercutting the Mica

To remedy protruding mica: Remove the armature and very carefully true or dress it up on a lathe, as in Fig. 17. Then cut out the mica between the bars with a hack-saw blade, the sides of its teeth having been ground off so that it will cut a groove slightly wider than the mica insulation, as in Figs. 18A and 19. This will leave a rectangular groove free from mica; the depth should be about $1/32''$. It is important that these spaces be free and clear of all foreign matter.

The edges of the slots should then be slightly beveled, using a three-cornered file (Fig. 18) in order to prevent any burrs remaining, which would cause excessive brush wear.

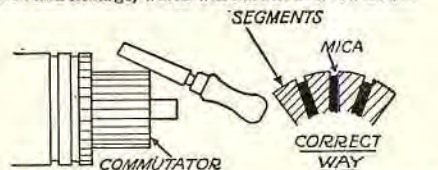
When properly finished, the commutator will have the appearance shown in Figs. 16 and 19.

Note. The mica can also be cut by placing a special tool in the lathe and moving it laterally as a planer (Fig. 17).

¹ Small lathes and mica undercutters and other electrical service-station equipment supplied by Allen Electric Mfg. Co., Detroit, Mich.; Jos. Weidenhoff, Chicago, Ill.; The Electric Machine Corp., Indianapolis, Ind. Free descriptive circulars on request.



Fig. 17. Dressing down a commutator on a lathe when it is very rough or pitted, or when mica protrudes above the commutator bars. Use a sharp tool and fine feed and take light cuts. Remove all copper or solder which may bridge segments and polish with sandpaper (not emery cloth). Holes in commutator segments can be filled with a paste made of glycerin and litharge, which will harden in a few hours.

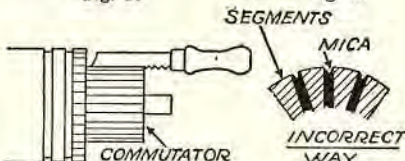


STARTING GROOVE IN MICA WITH 3-CORNERED FILE.

Fig. 18

MICA MUST BE CUT AWAY CLEAN BETWEEN SEGMENTS

Fig. 19



SLOTting MICA WITH PIECE OF HACKSAW BLADE.

Fig. 18A

MICA MUST NOT BE LEFT WITH A THIN EDGE NEXT TO SEGMENTS

Fig. 19A

The blackened and burned appearance of the commutator is not always caused by high mica. The same effect may be caused by having brushes of improper size or material, by an insufficient spring tension on the brushes, by an overload on generator, and by an open or short circuit in generator windings; or, where there are two windings on one armature with two commutators, by a short circuit between motor and generator windings.

Commutator and Other Noises

Protruding mica and improperly seated brushes produce a noise which can easily be detected.

Noises are sometimes due to bent armature shafts, broken balls, or worn bearings. If an improperly seated brush causes the noise, it can sometimes be eliminated by setting the brush to one side with a small stick. Do not use a screwdriver.

Do Not Use Grease on the Commutator

It is unnecessary to lubricate either a generator or a motor commutator, as the grease or oil mixes with the carbon dust from the brushes. This will soon soak into the mica insulation and form a path be-

tween the commutator bars or segments, thus short-circuiting the commutator bars, and, consequently, the armature coils connected with them. This will likely result in the generator charging rate being reduced, and the ammeter will be unsteady. Clean between the segments with a fine tool, and examine brush-spring tension and sand commutator. This is common on old generators where the bearings wear and permit oil to pass into and on the commutator.

Loose Commutator Connections

One can tell if the generator is generating its proper output by observing the dash ammeter. One should learn just what the maximum output should be. If it generates a very low amperage, say about 2 amperes, and then at times none at all, the trouble may be due to a loose connection and sometimes that loose connection is at the point where the end of the armature coil is soldered to the segment of the commutator, which, although apparently securely soldered, may be loose. Furthermore, it may not be loose when stationary, but when it is revolving, the connection is thrown loose by centrifugal force.

One method of testing is to use a test light and test points. Place one test point on the commutator segment connected with the suspected loose armature coil and the other on the segment 180° apart, or on the extreme opposite side of the commutator, which is the other end. On passing the current through the armature coil in this manner, there will probably be a slight spark or arc at the point where loose. Test all segments in like manner, and resolder any that are loose.

Another Commutator Trouble

High segments in a commutator, the result of the commutator having been turned or dressed down eccentrically with the armature shaft (out of round), will cause the generator to produce weak current or none at all, especially at high speeds, owing to the brushes not making good contact.

The test for these two conditions is to press on each of the commutator segments at both ends with some blunt instrument. If there is the slightest movement at either end of a segment it is loose, and a new commutator will have to be installed.

To determine whether or not the commutator is running true with the armature shaft center, whittle a piece of crayon to a point and, with the generator running, bring it slowly up against the surface of the commutator. If it is out of round with the armature center the chalk will mark the high spot and leave the low side unmarked, provided the test is carefully made.

If commutator is out of true, re-turning, using correct size of ball bearings as supports, will be necessary.

Besides the foregoing a few other causes will give rise to the same effect. Among these are weak brush springs, sticking brush-holders or brushes, connections which are not tight enough and which, vibrating at certain critical engine speeds, introduce a resistance into the exterior line.

BRUSH TROUBLES AND TESTS

Brush troubles are very common. Some of the troubles are: brushes sticking on their holders, brush springs not pressing on brushes with proper tension, loose brush-holders, loose connections to brushes, improperly seated brushes.

Brush and Brush Rigging

The open circuit is often caused by one of the brushes sticking in the brush-holder, from dirt. The remedy is obvious, that is, to clean the brush

It may also be possible that the armature windings are not secure in the slots, and that, at high speeds, one of the coils moves a trifle and, coming in contact with the iron of the armature coil, forms a ground. As the armature slows down, the natural spring of the coil brings it back to a normal position in slot and causes the armature to show "clear" when tested.

Testing for a Dirty or Rough Commutator with a Voltmeter

Connect the voltmeter terminals so that the voltmeter will read 0 to 30 volts as shown in Fig. 20. (This voltmeter is shown on pages 464 and 468.)

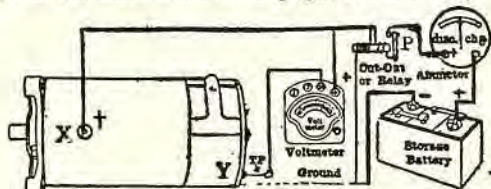


Fig. 20. Testing for a dirty or rough commutator with a voltmeter.

The positive (+) terminal of the voltmeter is connected to the positive (+) wire of the generator. The other terminal from the voltmeter which has a test point (TP) at its end, makes contact with the frame of the generator at (Y) (this being a grounded or return-wire system).

Then speed the engine up to a speed corresponding to a car speed of 10 to 15 miles per hour. The voltmeter should show slightly over 6 volts and the cut-out (V) should be closed, showing "charge" on the dash ammeter or indicator.

If the voltmeter does not show slightly more than 6 volts, this indicates a dirty or rough commutator, or else an open circuit in the shunt field. Press down lightly on the brushes while the generator is running, and if this causes voltmeter to indicate and cut-out to close, the trouble is due to bad brush contact, which can be remedied as just mentioned.

If the voltmeter cannot be made to indicate and the cut-out point (P) fails to close by cleaning the commutator and pressing on the brushes, the trouble is probably an open circuit in the shunt-field winding, which will have to be repaired locally or sent to the factory.

If the voltmeter does show 6 volts or more, by pressing down on the brushes, or by cleaning the commutator and brushes, but the cut-out will not close, it means that the cut-out is not in proper adjustment, and a new one should be provided if it is defective internally. The trouble may be due to loose connections on the cut-out, or to disarrangement of the contact-points, which can be examined and tested. See Index under "Testing cut-outs."

If the commutator is dirty then clean it. The probabilities are that the mica is protruding. This can be remedied as explained in preceding paragraphs.

thoroughly and see that it moves easily in the brush-holder and that the springs press firmly and squarely on the top of the brush. An open circuit will also be caused by a poor or broken brush lead, or pigtail connection.

No Spring Pressure

The brush spring may not have sufficient tension to hold the brush in contact with the commutator with sufficient force to give a good contact. This

not only will show a partial or full open circuit, due to insufficient contact pressure, but it will be the cause of serious sparking between the commutator and the brush, and will soon burn and blacken the commutator so badly that a full open circuit will result, and no current will be generated at all.

A new spring with sufficient tension is the best way of repairing this trouble. The brush spring tension should be strong enough so that when the brush is pulled off the commutator by means of the pigtail and then released, the spring pressure snaps it back freely on the commutator and should be of sufficient tension to press brush to commutator, yet move freely. Too much spring pressure has the effect of rapidly wearing out both commutator and brush, but is better than too little pressure.

The approximate average brush-spring tension on starting motors is 1 to 1 1/4 lbs., and from 12 to 18 oz. on generators.

Brushes Too Short

If the brushes are allowed to go too long without replacement, and are worn so short that the spring pressure is reduced very considerably, the same troubles will result. Be sure in replacing brushes to use only those of such a make as are recommended by the manufacturer; otherwise you are likely to have repeated troubles with both brush and commutator.

Squeaking and Noisy Brushes

Squeaking brushes may be overcome in most cases "by sanding-in" the brushes with sand-cloth or sandpaper. The squeaking may be due either to a poorly seated brush, improper brush spring tension, or to a hard spot in the surface of the brush. If commutator surface is rough or irregular, it should be made smooth before seating the brushes. This may require a turning in a lathe (see pages 491, 492). Noisy and singing brushes may sometimes be caused by brush not being in line with commutator, or brush surface not bearing evenly on commutator.

Importance of Correct Brush Seat

In order to obtain a correct generator charging rate at any given position of the third-brush, all brushes must be well seated on the commutator. Poorly seated brushes not only reduce the output and produce sparking and other troubles, but they are also noisy. See "sanding-in" brushes below, and on page 408, how to tell when brushes are not properly seated.

Fitting New Brushes

When fitting new generator brushes, it often happens that they do not always fit the commutator perfectly, that is, they are not rounded to the curvature of the commutator surface and should be "sanded-in" in order to form a perfect seat to the commutator. At least 50 per cent of the brush end surface should bear on the commutator curvature.

Sanding-In or Seating Brushes

Place a strip of No. 00 sandpaper or sand-cloth around commutator (slightly wider than brush) and with rough side next to the brush, when it is in the brush holder (each brush separately), and work this strip back and forth, holding the ends close together as in Fig. 21, so that it will conform with the curvature of the commutator. The entire surface of the brush must be treated, otherwise it will be uneven. The "pigtails," or brush connections, must also be kept tightened.

Another method is to wrap a strip of sandpaper or sand-cloth snugly around the commutator, gluing the overlapping edges of the sandpaper to secure it.

Time can be saved by placing a heated soldering iron over the paper to dry the glue. The end housing may then be replaced and all three brushes sanded at the same time.

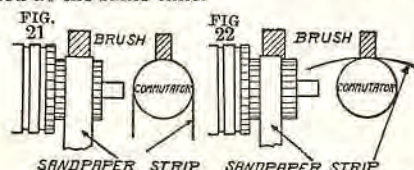


Fig. 21. Correct method of sanding brushes so that they will seat to curvature of commutator. Place rough side of sandpaper up, and use a strip slightly wider than brush.

Fig. 22. Incorrect method. Only part of brush is being seated (illustration to left); brush not being seated to curvature of commutator (illustration to right), it may be pulled off commutator while sanding.

When fitting "motor" brushes, the same method is applicable, but something harder than sandpaper must be used. A strip of carborundum cloth can be used on the "motor brushes," but sand-cloth should be used on the "motor commutator." It is seldom necessary to cut mica down on the motor commutator.

The motor brushes should be "sanded in," to avoid brush squeak which occurs sometimes as a result of a rough or irregular commutator surface, or grooves in the brushes. If the motor commutator is rough, smooth it up, and then "sand in" the brushes. If it is excessively rough, turn the commutator down in a lathe, being careful not to remove any more copper than is absolutely necessary.

On most of the Delco machines (motor generators) it will be found possible to "sand in" the upper and lower brushes separately; but in a number of cases, on account of the construction of the machine, it is advisable to "sand in" both motor brushes, as well as both generator brushes, at the same time.

Spotting in Brushes

On some generators it is not possible to "sand in" the brushes in the manner explained above, because the brush arm is too short. In this case, the brush should be placed in a brush-holder and let down firmly on the commutator. Then "motor" the generator by running it from the battery as a motor. Then disconnect battery and remove brushes, leaving the "high spots." These can be scraped down.

Seating the Delco Flexible Brush

The design of the flexible generator brush arms and the third brush carrying a thermostat, used on many Delco four-pole round types of motor-generators and generators is shown in Fig. 23 (a later design is shown in Figs. 23B and 23C). Instead of the brush arm being rigid, it is made quite flexible by the use of a thin piece of phosphor bronze between the body of the brush arm and the carbon brush. Damage to the commutator is prevented, in case of brush breakage, by the insulating safety plate on

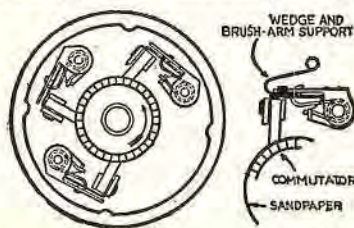


Fig. 23

Fig. 23A

Fig. 23. Front, or commutator end view of Delco generator showing the flexible brush arms.

Fig. 23A. A side view showing brush seated on commutator. This model is now replaced by those shown on the next page,

the end of the brush arm, this plate being loosely mounted by the special heads of the screws securing the brush to the brush arm.

It is very important to have this type of brush fully seated on the commutator. The brush cannot be properly sanded in by the usual methods of sanding brushes. It is necessary to place wedges between the brush arm body and the phosphor bronze, as shown in Fig. 23A, to prevent the flexible action of the brush arm during sanding. These wedges should be just thick enough to fit in place without falling out, approximately .075". A strip of fine sandpaper or sand-cloth may then be used to seat properly one brush at a time.

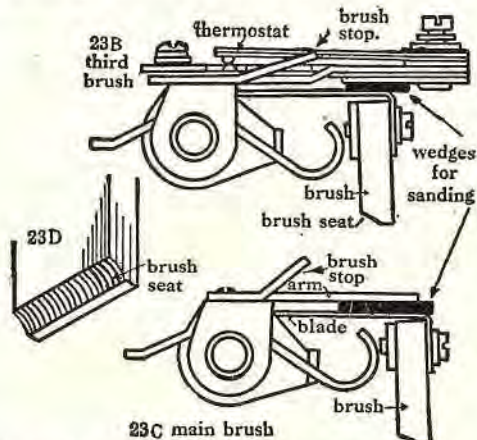
Another very successful method is to remove the end housing carrying the brush arms, so that a strip of fine sandpaper may be wrapped snugly once or twice around the commutator, gluing the overlapping edges of the sandpaper to secure it. The end housing may then be replaced and all three brushes properly sanded at the same time. This operation should cause the brushes to have a full seat on the commutator.

Remove the wedges in the brush arms and the sandpaper after the operation is completed.

The Delco Later Design of Flexible Brush Arms with Stops

A later design of Delco flexible brush arm with stops is shown in Figs. 23B and 23C. The brush should always be assembled on the inside of the arm as shown.

When installing new flexible brush arms, the stops should be inspected to see that they come into action so that the brush arm is not permitted to come closer than $\frac{1}{8}$ " from the commutator. Remove brushes to check this. It is advisable to adjust stops so that the stop of grounded brush comes into action after that of one of the other brushes, thus preventing overheating of armature and field coils.



Figs. 23B, 23C. Later design of Delco flexible brush arms with stops.

Fig. 23D. Showing how the brush should be seated.

Always replace all three brushes whenever inspection shows that the grounded brush has worn so short that its brush stop, coming into action, may soon keep the brush from contact with the commutator. This is the brush (on the Cadillac using No. 162 Delco motor-generator) which is on the right side of the commutator viewed from the front of the car.

It is very important to have this type of brush seated on the commutator, at least to the extent shown in Fig. 23D. The brush cannot be properly "sanded in" by the usual method of sanding brushes.

It is necessary to place wedges between the brush arm body and the bronze blade to which is attached the brush. Two sizes of wedges are necessary, one size for the main-brush arms, and the other for the third-brush arm, owing to the difference in space between the body of the arm and the bronze blade.

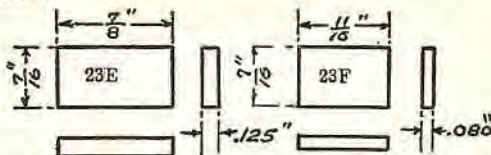


Fig. 23E. Dimensions of wedge for the third-brush arm.

Fig. 23F. Dimensions of wedge for the main-brush arms.

These wedges are shown in Figs. 23E and 23F. Figs. 23B and 23C show their application to the brush arms. These wedges prevent the flexible action of the brush arms during the sanding operation, keeping them rigid, and giving a seat more nearly over the entire brush.

These wedges should be just thick enough to fit in place without falling out, approximately .080" for the main-brush arms (23F), and .125" for the third-brush arm (23E). It will be found that the distance between the body of the arm and the bronze blade varies in some assemblies. It will be necessary in these cases to make the thickness of the wedges a little less by filing, or a little more than specified above by wrapping a couple of turns of paper around the wedges.

To sand the brushes after the wedges are properly fitted to the brush arms, wrap a 1" strip of sandpaper, or sand cloth, snugly once or twice around the commutator, gluing the overlapping end to secure it. A drop or two of glue should be put on the commutator previous to putting on the sandpaper to hold the paper in place and prevent it from slipping during the sanding operation. The sandpaper should be wrapped around the commutator in a counter-clockwise direction, looking at the armature from the generator-commutator end.

After the glue has dried a few minutes, place the end housing carrying the generator brushes on the armature shaft and lower the brushes down on the sandpaper which is around the commutator. To prevent chipping of the edges, do not snap the brushes down on the commutator. Hold the armature in a vertical position with the housing at the top and revolve the housing in a counter-clockwise direction. This will sand all three brushes at the same time. When proper seating is accomplished, raise the brushes, remove the housing from the armature shaft and the sandpaper from the commutator. Avoid waste of brush material by being careful with this operation. Remove all glue from the commutator by sanding and remove the wedges from each of the brush arms.

To determine the seating of the brushes, mount the housing on the armature again as was done in sanding; revolve the housing several times with the brushes on the commutator. Then remove the housing as after the sanding operation, and inspect each brush seat, which is shown by a polished surface.

If at least a 75 per cent brush seat is not obtained, the wedges should be inserted again and the brushes reseated until a good seat is obtained. It may be necessary to make the wedges slightly thinner, or thicker, according to whether the seat is on the heel or toe of the brush.

It is very important that good brush seats be obtained before installing the generator on the car. If good seats are not obtained, a change in the charging rate will result as soon as the brushes become thoroughly seated.

Setting Motor Brushes

Motor brushes should be set at the position of least sparking when the machine is carrying full load. This position will be located a short distance back (in the direction opposite to rotation, instead of with direction, as on a generator) from the neutral plane.

To set motor brushes in the correct position, place the machine on a block test and apply a load approximately equal to that which it is normally required to carry. (This load will be about 40 lbs., on a pulley of 6" diameter, or 10 ft. lbs. for starting motors.)

The speed of a motor is greatest when the brushes are at the neutral plane, and decreases as they are moved away from that position. The voltage of a generator and speed of a motor can be changed considerably by moving the brushes, providing the machine is not too heavily loaded so that it will not spark badly.

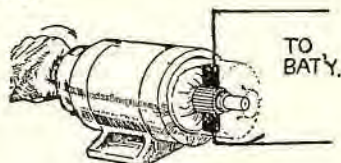


Fig. 24

In the absence of a torque-testing device, a good method for setting brushes on a starting motor is to place the motor on a "free running" test, no load (connected with battery), and to hold the shaft by hand, with a rag (Fig. 24), so as to offer more or less resistance; then shift the brushes to a point where they do not spark.

Setting Generator Brushes

If the generator will not come up to voltage, and the trouble is not due to improperly seated brushes, and the third brush is properly adjusted, set the brushes on "neutral" and then shift to the best position. See page 360, relative to neutral position.

Note. Use only brushes recommended by the manufacturer.

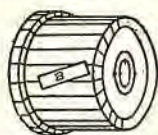


Fig. 25. Showing incorrect setting of brush on commutator.

Brushes should be set parallel to the commutator segments. Improperly seated brushes will act like a cut-out which is not working properly.

ARMATURE TROUBLES AND TESTS

In the preceding pages, the subject of "commutators and brushes" was treated. This is usually the first place to look for generator troubles.

Other troubles are:

Evidence of trouble: In all probability, trouble in the generator will be clearly shown by failure to generate a terminal voltage. The first warning of such a trouble would be the absence of an indication on the ammeter or indicator on the dash of the automobile, provided one is furnished with the automobile.

Causes: The causes of failure to generate a voltage may be due to (1) open circuits, short circuits

Brush Care

Once or twice a season the springs holding the brushes against the commutator should be raised and the brushes examined, to see that they operate freely in their holders. Oil or dirt should be removed with a stiff bristle brush and gasoline.

To Clean the Brushes

It is not necessary to remove them from the holders. Lift the brushes and wipe off the surface with a piece of cloth dampened with gasoline.

If the brush surface is apparently rough, then use sandpaper to fit them to the commutator, as shown in Fig. 21.

No lubricant is to be used on commutators, as the brushes are usually self-lubricating. Application of vaseline or grease is harmful, as all forms of grease possess insulating qualities to a greater or less extent.

Miscellaneous Brush Troubles

When spring tension fails, the brushes are worn too short, the tension is not adjusted or has been thrown out, through heat, or the springs themselves may be broken.

When the brushes stick, it may be due to binding or to dirt and grease. A little gasoline may tend to loosen them. When the brushes do not fit the brush-holders it is a matter of manufacture.

Overheating of brush-holders is caused by the sparking due to ill-fitting brushes or to the absence of brush lead connection and to lack of sufficient pressure on the brush.

Sparking at the brushes: If there is any sparking, or if the commutator becomes dull, it may be that the brush-holder springs are too loose, or there is excessive vibration, which may be due to a bent shaft, an unbalanced gear pinion, or to defective mounting. Brushes should be kept in perfect contact with the commutator, and it is advisable to use only the kind recommended by the manufacturer.

It may be found that where the generator is also used as a starting motor (on motor-generators), sparking will in time develop at the commutator. This is due to the arcing of the heavy starting current at the trailing edges of the brushes, and the trouble may be eliminated by filing down their contact surfaces.

Carbon dust (providing carbon brushes are used) may be worn from brushes by the commutator and deposited in the lower part of the generator. This ought to be blown out with air, otherwise it might cause a ground.

and grounds in the field or armature of the generator; (2) the commutator may be dirty, or the brushes may not bear on the commutator, or the commutator may be worn; (3) the brushes may be grounded.

Locating Armature Troubles

Armature windings may be burned out or grounded. When burned out, the trouble may be due to a current overload, caused by improper regulation, a soaked winding, or a steady and prolonged return flow from the battery, due to failure of the cut-out contact points to open. A grounded armature winding is due to defective insulation.

Armature troubles are sometimes found in the attaching leads at the commutator segments. The

INSTRUCTION No. 62

THE REPAIR SHOP OR SERVICE STATION, and Its Equipment

AUTOMOTIVE SERVICE STATION AND REPAIR SHOP

A garage is a place where cars are stored. A general service station supplies gasoline, lubricates cars, cleans and washes, and performs other types of simpler services that are required almost daily. A repair shop and mechanical service department can be incorporated as a part of the garage business or as a separate enterprise.

Service Department or Service Station

A mechanical service department or station is more particularly concerned with mechanical service and minor repairs, for example: (1) engine testing and "tune-up" service, which includes compression and vacuum tests, tests and adjustments of carburetion, fuel-pump, ignition, timing, spark plugs, and valve mechanism, etc.; (2) valve refacing, re-seating, or grinding, carbon removal, testing, cleaning and adjusting lamps, testing the electrical parts of the car, brake service, front-axle and steering-gear adjustments, wheel alignment, wheel and tire balancing, etc.; (3) "winter conditioning," which includes cooling-system service (flushing, installing new hose and making leakproof, adding antifreeze, checking fan belt, water thermostat, water pump, etc.), changing lubricants in engine, transmission, and rear axle to lighter viscosity, checking battery and ground, ignition cables, automatic choke, generator charging-rate, brushes and commutator, windshield-wiper blades, lights, heater, defroster, tire chains, etc., and "tuning-up" engine.

A service station is an indefinite term that may include any number of departments, such as: garage, general service, mechanical service, major repair shop, tire shop, paint shop, body shop, etc. A super-service station is a term that could be applied to a service station in which all kinds of service can be obtained.

Repair Shop

The repair shop usually undertakes major repairs, overhauling, or reconditioning of units, such as engines, rear axles, transmissions, clutches, etc. (see

also p. 665). The repair shop, if completely equipped, may have a machine shop, where suitable lathes are provided to true up brake drums, and cylinder grinders for enlarging cylinders, etc. More likely, portable cylinder-boring and honing machines will be found in the average shop. Machine shop work, however, is usually handled by specialists, who obtain such work from the mechanical service stations.

A body and fender repair department, including painting (lacquer or synthetic enamel spraying), is often added to the repair shop.

Equipment for Service Station and Repair Shop

Service stations and repair shops that are prepared to do efficient service should have modern equipment. To obtain information on modern equipment, get in touch with the nearest auto equipment jobbing house. See also pages 690, 691, 694.

The following is needed in almost every service station or repair shop, large or small, namely: a cash register, adding machine, and a good bookkeeping system (see p. 1040 on the latter). Three other items of equipment which every service station should have are: modern air compressor, a good hydraulic lift, and car-lifting jacks.

The air compressor is used not only for inflating tires but also for operating other equipment, such as hydraulic lifts, lubricating guns, spark-plug cleaners and testers, tire changers and spreaders, paint spray guns, solder guns, pneumatic hammers and drills, spring spray guns, garage and service station door-openers, and for blowing out fuel lines, valve seat chambers, carburetor parts, testing radiators, etc. See page 691 for listing of manufacturers.

The hydraulic lift is ideal for service work, such as lubrication, brake and wheel service, spring replace-

Note: The subject: "To Find Diameter of Pulleys," formerly on this page, is now on page 1040.

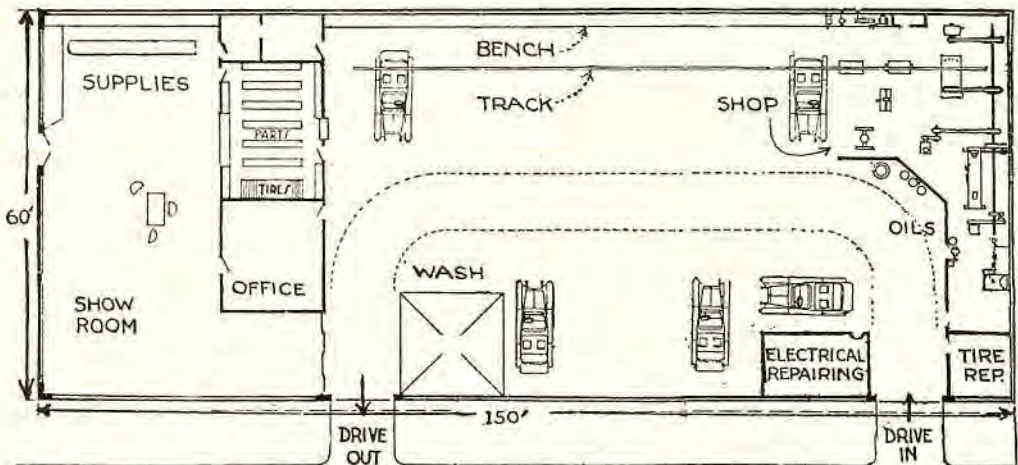


Fig. 1. This design illustrates the layout for a one-floor service station with an accessory and parts department, show room, office, repair shop, tire-repair and electrical-repair department, also a car wash. The gasoline pumps and lubrication department (not shown) could be added in front of the building. For greasing and general lubrication the hydraulic lift would be ideal, although a grease rack could be used. The layout shown in the illustration is not a recommended plan, but it will give a general idea which can be improved upon.

There are a great many different designs for service stations. Before deciding, one should obtain plans from those who specialize in this work. The location, size of lot, line of service, and other factors will have a great deal to do with the design.

TESTERS, VARIOUS KINDS. See the last four lines under "Testing Instruments" below.

TESTING ENGINE. Booklet: "Instructions on the Use of McQuay-Norris Compression-Vacuum Tester." Write McQuay-Norris Mfg. Co., St. Louis, Mo. See also "Testing Instruments."

TESTING INSTRUMENTS—FOR ENGINE TUNE-UP WORK (compression, ignition, carburetion) such as compression testers, vacuum testers, ignition distributor, condenser and coil testers, spark-plug testers, ignition timing light (stroboscopic type), cam angle meters, battery testers, mileage testers, exhaust gas analyzers, electro-tachometer (r.p.m. indicator), fuel-pump testers, generator testers, armature testers (growlers), complete electrical test benches or stands, etc. Write for literature to the following concerns. Mention specifically the devices on which you desire literature: Allen Electric and Equipment Co., Kalamazoo, Mich.; Burton-Rogers Co., Sales Div. of Hoyt Electrical Instrument Works, 857 Boylston St., Boston, Mass. (voltmeters, ammeters, battery cell and cable testers); E. Edelmenn & Co., 2332 Logan Blvd., Chicago, Ill. (ignition timing light, hydrometers, fuel-pump testers); Joseph Weidenhoff, Inc., 4340 Roosevelt Road, Chicago, Ill.; Kent-Moore Organization, Detroit, Mich.; McQuay-Norris Mfg. Co., St. Louis, Mo. (compression-vacuum tester); Rinck-Mellwene, Inc., 16 Hudson St., New York, N.Y. (compression tester, valve spring tester); The Electric Heat Control Co., 9123 Inman Ave., Cleveland, Ohio; The Lantz-Phelps Corp., Dayton, Ohio (operating instructions for ignition electrical circuit tester); Warner-Patterson Co., Chicago, Ill. (portable motor analyzer). See also, on these pages: "Battery Chargers and Testers," "Engine Tune-Up," "Exhaust Gas Analyzers," "Fuel-Pump Testers," "Ignition Timing Light," "Testing Engine," "Vacuum Tester (Mercury Column)." See also pages 40-44 Addenda.

TIRES. Display posters: "Tread Wear" and "Truck Tire Service," gives practical suggestions for improving tire wear and effect of load and speed on tire service. "Fabric Breaks" another display poster which describes and illustrates how tire carcasses are injured primarily due to underinflation and lack of reasonable care in driving (price 40 cents for the three above-mentioned posters). Write The Rubber Manufacturers Association, Inc., 444 Madison Ave., New York, N.Y.

TIRES. Service Bulletins: Deals with tire care and common abuse of tire equipment, giving the trouble or failure, and its cause and prevention as enumerated: Bulletin No. 1: "Rim Bruise"; No. 2: "Fast Tread Wear"; No. 3: "Run Flat or Almost Flat"; No. 4: "Misalignment"; No. 5: "Mismatched Duals"; No. 6: "Correct Method of Mounting Tires on Drop Center Rims"; No. 7: "Bead Failure from Damaged Rims"; No. 8: "Heat and Impact Breaks (Truck Tires)"; No. 9: "Overload Failures (Truck Tires)"; No. 10: "Cuts"; No. 11: "Regular and Cupped Tread Wear (Truck Tires)"; No. 12: "Wheel Balance"; No. 13: "Overinflation in Truck Tires" (price 15 cents for complete set of bulletins mentioned above). Manuals: "Manual of Tire Repairing" (price 10 cents). "Manual of Tire Retreading and Recapping" contains 20 pages and 14 illustrations (price 10 cents). Write The Rubber Manufacturers Association, Inc., 444 Madison Ave., New York, N.Y. Booklet: "Operators Handbook." Deals with truck, bus, farm, and industrial tractor tires. Write B. F. Goodrich Co., Public Relations Department, Akron, Ohio.

TIRES AND RIM. Book: "Tire and Rim Association Year Book" (price \$2.00). Write The Tire and Rim Association, Inc., Akron, Ohio.

TIRES, REPAIR AND RETREAD. Manual: "Goodyear Tire Repair and Retread Manual"—48 pages, over 100 illustrations. Write Goodyear Tire & Rubber Co., Inc., Accessories & Repair Materials Division, Akron, Ohio. See also, footnote 2, page 618.

TOOLS. Catalogue: Auto mechanics' hand tools, flat and socket wrenches; special service tools for carburetor, ignition, valve, cam removal, brake work, etc.; wrenches for Allen low set screws, screwdrivers for Phillips screws, and specialized service tools for popular cars. See footnote, page 698. See also pages 663, 694. Another manufacturer not mentioned on pages 668, 663 is the Duro Metal Products Co., 2649 N. Kildare Ave., Chicago, Ill.

TOOLS. Literature: Tube benders, flaring and cutting tools. Write E. Edelmenn & Co., 2332 Logan Blvd., Chicago, Ill.; Kent-Moore Organization, Inc., Detroit, Mich.; The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago, Ill. Literature: Diesel engine service tools. See "Diesel Engine."

TOOLS. Manuals: "Manuals of Approved Service Tools" for Chevrolet, Nash. Write Kent-Moore Organization, Inc., Detroit, Mich. For Cadillac-LaSalle, Buick, Oldsmobile, Pontiac, and Hudson, write Hinchley-Myers Division, Kent-Moore Organization, Jackson, Mich. Complete manuals cover everything from specially designed Flat-Rate Service Tools, Engine Tune-Up, Brakes, Wheel Alignment, Body Conditioning, etc. Available to all garages, service stations, and mechanics. Others send 25 cents in stamps.

TOOLS, BODY AND FENDER REPAIRING. See "Body and Fender Repairing Tools"

TORQUE-INDICATING WRENCHES. Literature: Deals with purpose, pressures, how to tighten aluminum and cast-iron cylinder heads, etc. Write Automotive Maintenance Machinery Co., 2100 Commonwealth Ave., North Chicago, Ill.; Black-

hawk Mfg. Co., Milwaukee, Wis.; Bonney Forge & Tool Works, Allentown, Pa.; Cedar Rapids Engineering Co., Cedar Rapids, Iowa; Duro Metal Products Co., 2649 N. Kildare Ave., Chicago, Ill.; Herbrand Corp., Fremont, Ohio; Snap-On Tools Corporation, Kenosha, Wis. See also page 733.

VACUUM TESTER (MERCURY COLUMN). Literature: "Operating Instructions." Write The Lantz-Phelps Corp., Dayton, Ohio; Weaver Mfg. Co., Springfield, Ill. See also "Testing Instruments."

VALVES. Booklet: "The Automotive Engine Valve and Its Servicing," 92 pages, 60 illustrations, by Walter Trefz (price 25 cents). Write Aluminum Industries, Inc., Cincinnati, Ohio, makers of Permite Products. Booklet: "Valve Functions." Write Cedar Rapids Engineering Co. of Delaware, Cedar Rapids, Iowa. Booklet: "Synchronized Valve Servicing" by E. A. Hall. Write The Hall Mfg. Co., Toledo, Ohio. Literature: footnote, page 772. Booklet: "Service Bulletin" Form No. 739. Write K-D Mfg. Co., Lancaster, Pa. See also, p. 694.

VOLTAGE REGULATORS. See "Generator."

WELDING ALUMINUM. Booklet: "The Welding of Aluminum." Write Aluminum Company of America, 801 Gulf Bldg., Pittsburgh, Pa.

WELDING AND CUTTING BY OXY-ACETYLENE. Book: "The Oxywelders Handbook," 330 pages fully illustrated (price \$1.00). Write The Linde Air Products Company, 30 East 42d St., New York, N.Y. Literature on oxy-acetylene welding and cutting is also available from the same address or from any of their district offices located in major cities of United States. Booklet: "Torchweld Instruction Book on the Use and Assembly of Oxy-Acetylene Welding and Cutting Apparatus," 80 pages fully illustrated (price 50 cents). Literature: Write Torchweld Equipment Co., 1035 W. Lake St., Chicago, Ill. Book: "Instruction Book Oxy-Acetylene Welding and Cutting," 250 pages (price \$1.00). Manual: 31 pages (15 cents). Literature: Write The Superior Oxy-Acetylene Machine Co., Hamilton, Ohio. Literature: Welding, cutting brazing and lead-burning equipment (oxy-acetylene and oxy-hydrogen process). Write The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago, Ill. Literature: Write Alexander Milburn Co., 1416 W. Baltimore St., Baltimore, Md. Catalog: Write Smith Welding Equipment Corp., Minneapolis, Minn. Catalog: R-120. Write The Bastian-Blessing Co., Chicago.

WELDING—ELECTRIC ARC WELDERS. Book: "Arc Welding and How To Use It," 340 pages, 320 illustrations (price \$1.50); Booklet: "Practical Lessons in Arc Welding," 100 pages, 78 illustrations (price 50 cents). Literature: "How To Build Your Own Arc Welder," "Carbon Arc Welding and Cutting." For any of the above write Hobart Brothers Co., Troy, Ohio. Booklet: "How To Weld 29 Metals," by Chas. H. Jennings, 108 pages, 12 illustrations and numerous tabulations and diagrams illustrating types of welded joints (price 50 cents). Literature on equipment: Write Westinghouse Electric and Mfg. Co., Advertising Dept., East Pittsburgh, Pa. or their nearest district office. Literature: "AC Arc Welders." Write The Electric Heat Control Co., 9123 Inman Ave., Cleveland, Ohio. Literature: Write Smith Welding Corp., Minneapolis, Minn. Literature: "Electric Arc, and Spot Welders." Write Allen Electric and Equipment Co., Kalamazoo, Mich. Literature: Write The Superior Oxy-Acetylene Machine Co., Hamilton, Ohio. Books and Booklets: "Procedure Handbook of Arc Welding Design and Practice," 8 chapters, 1012 pages, 1243 illustrations (price \$1.50; foreign \$2.00); "Lessons in Welding," 44 lessons mimeographed (price 50 cents; foreign 75 cents); "Simple Blueprint Reading" with particular reference to welding and welding symbols, 140 pages (mimeographed) with over 85 drawings (price 50 cents; foreign 75 cents); "Arc Welding in Design, Manufacture and Construction," 1048 pages, fully illustrated (price \$1.50; foreign \$2.00). Write The Lincoln Electric Co., Cleveland, O. Literature free.

WELDING ENCYCLOPEDIA. A book bearing this title containing 638 pages, 645 illustrations. Tells how to weld every weldable metal by each of the welding processes. Tells how to prepare parts for welding; how to install and care for welding equipment; meaning of all words and terms found in welding literature; where to buy all standard makes of welding apparatus and supplies (price \$5.00). Write The Goodheart-Willeco Co., Inc., 2009 South Michigan Ave., Chicago, Ill.

WELDING—SPOT WELDERS. Literature: Write Allen Electric & Equipment Co., Kalamazoo, Mich.

WIND-DRIVEN ELECTRIC-LIGHTING PLANTS. Literature: See page 1002.

WIRE (CABLE). Literature: Battery cable, spark-plug cable, primary cable, automotive wire, ignition cable sets, trailer lighting cables and connectors, wiring assemblies, re-wiring kits, etc. Write Belden Mfg. Co., 4607 West Van Buren St., Chicago, Ill.; Crescent Cable Co., Pawtucket, R.I.; Packard Electric Division, General Motors Corp., Dept. D, Warren, Ohio; Sterling Cable Division of the Electric Auto-Lite Company, Port Huron, Mich.; Triple-A-Specialty Co., 2101 Walnut St., Chicago, Ill.

WIRING. See "Re-Wiring a Car," and "Wire (Cable)."

WIRING DIAGRAMS. See "Electrical."

LUBRICATION SERVICE EQUIPMENT. Literature: Write Cincinnati Ball Crank Co., Cincinnati, Ohio; Stewart-Warner Corp., Alemti Div., 1826 Diversey Parkway, Chicago, Ill.; The United States Air Compressor Co., Cleveland, Ohio.

LUBRICATION—PANORAMA OF LUBRICATION. Books: A nonadvertising educational series of five issues as itemized. No. 1: "The Fundamentals of Lubrication"; No. 2: "Lubricating Friction Type Bearings"; No. 3: "Golden Shell: The Modern Motor Oil"; No. 4: "Diesel Engines and Their Lubrication"; No. 5: "The Fundamentals of Automotive Engine Lubrication." These books are expensively prepared; and the Shell Companies have advised that, while they will fill modest requests for copies, it will be necessary to state occupation or business connections and mention Dyke's *Automobile Encyclopedia*. Write nearest headquarters. Shell Petroleum Corp., St. Louis, Mo.; Shell Union Oil Corp., New York City, N.Y.; Shell Oil Co., San Francisco, Calif.

MACHINISTS AND REPAIRMEN. Books: See p. 718.

MAGNETOS. Literature: General information and maintenance data. State model of which literature is desired. Write American Bosch Corp., Service Dept., Springfield, Mass. "User Operating Instructions" on type C, CR, PC, and Vertex magnetos. State the one desired. Write Scintilla Magneto Div., Bendix Aviation Corp., Service Dept., Sidney, N.Y. "Service Parts List, Description and Brief Instructions for All Wico Magnetos" (price 25 cents). Write Wico Electric Co., Springfield, Mass. "Fairbanks, Morse Magneto Service Manual—No. 2807" (price 50 cents). Write Fairbanks, Morse & Co., Mfg. Division, Magneto Sales, Beloit, Wis. Manual: "Eisemann Service Manual" covering all Eisemann models (price \$2.50). Write Eisemann Magneto Corp., 60 East 42nd St., New York, N.Y.

MUFFLERS. Literature: Write Walker Mfg. Co., Racine, Wis. See also "Gaskets."

PAINT-SPRAYING EQUIPMENT. Literature: Write Binks Mfg. Co., Chicago, Ill.; The DeVilbiss Co., Toledo, Ohio; The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago, Ill.; The Wold Air Brush Mfg. Co., Chicago, Ill.

PAINTING. Manual: "Ditzler Repaint Manual" containing 64 pages with over 200 illustrations. Write Ditzler Color Co., Detroit, Mich. Booklet: "Modern Automobile Finishing Methods." Write The Sherwin-Williams Co., Cleveland, Ohio. Booklet: "Instructions for Using Du Pont Refinishing Materials." Write E. I. duPont de Nemours & Co., Finishes Division, Wilmington, Del. See also page 648.

PISTON SKIRT AND PISTON-RING EXPANDERS. Literature: Write list of manufacturers under "Piston Rings."

PISTON RINGS. Booklet: "Hastings Piston Ring Engineering Course." Write Hastings Mfg. Co., Hastings, Mich. Literature: Write Koppers Co., American Hammered Piston Ring Division, Box 626, Baltimore, Md.; The Perfect Circle Co., Hagerstown, Ind. Service Manual: "Pedrick Technical Service Manual." Write Wilkening Mfg. Co., Philadelphia, Pa. Service Manuals: See McQuay-Norris Mfg. Co.; Ramsey Accessories Mfg. Corp.; Sealed Power Corp. under "Engine Reconditioning."

PISTONS. Booklet: "The Piston and Its Finishing—Cam Grinding." 49 pages, 31 illustrations by Walter Trefz (price 25 cents). Write Aluminum Industries, Inc., Cincinnati, Ohio, makers of Permite Products. Service Manuals: See Sealed Power Corp.; McQuay-Norris Mfg. Co. under "Engine Reconditioning."

RADIATOR CORES. See "Gaskets."

RADIATOR SOLDER. Literature: Write Kester Solder Co., 4201 Wrightwood Ave., Chicago, Ill.

RADIO (AUTO). Book: "Radio Physics Course," 972 pages, 508 diagrams and illustrations. Just the book for the auto mechanic who knows nothing about radio fundamentals. Starts with elementary electricity and radio fundamentals, then gives a complete course on all types of radio construction and operation. Contains large chapter on auto radio. Price \$4.00 prepaid in U.S.A. (\$4.50 foreign). Write The Goodheart-Willeco Co., Inc., 2009 S. Michigan Ave., Chicago, Ill., for descriptive circular. Book: "Modern Radio Servicing," 1300 pages, 706 illustrations. A complete course in radio servicing, test instruments and servicing procedure. 115 pages devoted to installing and servicing auto radio receivers. Particularly adaptable for one who desires to make a specialized study of radio servicing, equipment, and methods. Price \$4.00 prepaid in U.S.A. (\$4.50 foreign). Write The Goodheart-Willeco Co., Inc., for descriptive circular.

RADIO (AUTO). Service literature: Write Galvin Mfg. Corp., Service Dept., 4545 Augusta Blvd., Chicago, Ill. "Motorola Radio" (specify model number of receiver on which service information is desired); Noblitt-Sparks Industries, Inc., Columbus, Ind. "Arvin Car Radios" (sales literature; specify model of radio for installation and servicing literature); The Crosley Corp., Cincinnati, Ohio. "Crosley Radios" (specify model number on which service information is desired). Literature:

Earl Webber Co., 1313 W. Randolph St., Chicago, Ill. (testing equipment); Joseph Weidenhoff, Inc., 4340 Roosevelt Road, Chicago, Ill. (testing equipment); The Clough-Bright Co., 5501 Broadway, Chicago, Ill. (testing equipment).

RECONDITIONING A USED CAR. See "Body and Fender Repairing" book.

RE-WIRING A CAR. Manual: "Copper Nerves: The Certified Re-Wiring Manual" by the makers of Packard cable. Free to readers of Dyke's *Automobile Encyclopedia*. Contains 24 pages and more than 70 illustrations including a chart "Packard Wiring Guide." Shows how to check and test the storage battery, battery cables and ground strap with a low-reading voltmeter; how to check and test the starting, ignition, and lighting circuits; how to install high-tension ignition cable; candlepower and life of lamp bulbs; testing lighting circuits for "voltage drop"; purpose of headlight relay and how installed; how to determine gauge of cable and how to select the proper size cable for re-wiring service; wiring guide; etc. Write Packard Electric Division, General Motors Corp., Department D, Warren, Ohio. See also "Wire (Cable)."

S.A.E. "Handbook," "Journal": See footnote Insert No. 1.

SERVICE BULLETINS. Write South Bend Lathe Works, South Bend, Ind. Mention Dyke's Automobile Encyclopedia. Bulletin No. 1: "How To Grind Valves"; No. 2: "How To Service Armatures"; No. 4: "How To True Brake Drums"; No. 5: "How To Service Differentials"; No. 6: "How To Bore Connecting Rods"; No. 7: "How To Make Bushings"; No. 9: "How To Finish Pistons"; No. 64: "Motor Mechanics Handbook"—how to service flywheels, pistons, brake drums, connecting rods, valves, crankshafts, clutches, differentials, etc.; No. 36-A: "How To Cut Screw Threads"; No. 33-JE: "South Bend 9-inch Auto Workshop Lathe Bulletin."

SERVICE INFORMATION (Ford V-8, Chevrolet, Plymouth, 1937-38). Manual: "NAPA Mechanics' Repair Manual." Over 130 illustrations (price, \$1.25). Literature gratis on this and other publications. Write National Automotive Parts Association, 705 Fox Bldg., Detroit, Mich. Tune-Up Service Manual: See "A.E.A."

SERVICE STATION EQUIPMENT. See "Equipment."

SHOCK-ABSORBER SERVICE TOOLS. Literature: Write Kent-Moore Organization, Inc., Detroit, Mich.

SILVER SOLDERING. Literature: Write Handy and Harman, 82 Fulton St., New York, N.Y.

SOLDER AND FLUX. For soldering aluminum, stainless steel, cast iron, zinc base die cast metal, monel metal, and chromium plated metals, radiators, etc. Literature: Write Kester Solder Co., 4201 Wrightwood Ave., Chicago, Ill.; L. B. Allen Co., Inc., 6719 Bryn Mawr Ave., Chicago, Ill.; Lloyd S. Johnson Co., 2241 Indiana Ave., Chicago, Ill. (formerly Alumaweld Co. of America).

SOLDERING. Booklet: "How To Solder Perfectly." Write Vulcan Electric Co., Lynn, Mass. Booklet: "Facts on Soldering." Write Kester Solder Co., 4201 Wrightwood Ave., Chicago, Ill. Literature: "Expert Soldering." Write Stanley Tools, New Britain, Conn. Literature: Ask for chart giving English wire gauges in decimals and fractions and melting points of metals and solder. Write Gardiner Metal Co., 4820 S. Campbell Ave., Chicago, Ill.

SOLDERING ALUMINUM. Literature: Write Kester Solder Co., 4201 Wrightwood Ave., Chicago, Ill.; L. B. Allen Co., Inc., 6719 Bryn Mawr Ave., Chicago, Ill.; Lloyd S. Johnson Co., 2241 Indiana Ave., Chicago, Ill. (formerly Alumaweld Co. of America).

SOLDERING BODIES AND FENDERS. Literature: Write Albertson & Co., Sioux City, Iowa (solder spray gun); Ernest Holmes Co., Chattanooga, Tenn. (spray method); Gardiner Metal Co., 4820 S. Campbell Ave., Chicago, Ill. (solder and flux); John Bean Mfg. Co., Lansing, Mich. (solder spray gun); Kester Solder Co., 4201 Wrightwood Ave., Chicago, Ill. (solder and flux); Lloyd S. Johnson Co., 2241 Indiana Ave., Chicago, Ill. (solder and flux "Tin-Ezy").

SOLDERING, BRAZING, LEAD BURNING. Literature: "Prest-O-Lite Torches" (used with Prest-O-Lite acetylene gas). Write The Linde Air Products Co., 30 East 42d St., New York, N.Y. Literature: Write The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago, Ill. Literature: "The Handy Torit Outfit" (used with Prest-O-Lite acetylene gas). Write Torit Mfg. Co., St. Paul, Minn.

SPARK PLUGS. Booklets giving instructive and valuable information. Write: AC Spark Plug Division, General Motors Corp., Flint, Mich., for "Today's Engines Demand More from Spark Plugs"; Champion Spark Plug Co., Toledo, Ohio, for "Facts about Spark Plugs and Engines"; Electric Auto-Lite Co., Merchandising Division, Toledo, Ohio, for "Auto-Lite Spark Plug Data Book." Literature: "Spark Plug Cleaners." Write above concerns. Literature: "Torqflash Tension French" for tightening spark plugs as well as U.S.S. and S.A.E. bolts." Write Blackhawk Mfg. Co., Milwaukee, Wis.

STORAGE BATTERY. See "Battery."

ELECTRICAL TESTING DATA AND WIRING DIAGRAMS. Book: See page 1152. **ELECTRICAL TESTING INSTRUMENTS.** See "Testing Instruments."

ENGINE BEARINGS. Manual: "Federal-Mogul Engine Bearing Service Manual," see footnote 6, page 789. Literature: "Federal-Mogul Bearing Oil Leak Detector." Write Federal-Mogul Service, Division of Federal-Mogul Corp., 4809 John R. St., Detroit, Mich.

ENGINE COOLING SYSTEM. See "Anti-Freeze."

ENGINE RECONDITIONING. Manual: "Engineered Motor Repairing." Some of the subjects are: Reringing; Reconditioning; Rebuilding; Piston; Piston ring; Bearing and valve steam clearances. Write McQuay-Norris Mfg. Co., St. Louis, Mo. Manual: "Ranco Motor Overhaul Service Manual." Some of the subjects are: Motor overhaul check-up chart; Characteristics of engine knocks and noises; Methods of engine overhaul; Cylinder wear and distortion; Correct installation of cylinder head gaskets; Pistons; Piston rings; Piston skirt expanders; etc. (price \$1.00). Write Ramsey Accessories Mfg. Corp., 3693 Forest Park Blvd., St. Louis, Mo. Manual: "Oil and Gasoline Economy with Better Performance." Write Sealed Power Corp., Muskegon, Mich. See "Tools," also p. 694.

ENGINE TUNE-UP. Course: "Allen Course of Modern Engine Tune-Up" sponsored by Allen distributors. Devoted to both theory and actual shop practice. Deals with ignition, generators, carburetors, gasoline, etc. (price \$15). For details, write Allen Electric and Equipment Co., Kalamazoo, Mich.

ENGINE TUNE-UP TESTING EQUIPMENT. See "Testing Instruments" and "Testing Engine."

ENGINE, TWO-CYCLE as applied to outboard motorboat engines. Literature: Write Bendix Aviation Corp., Marine Division, 754 Lexington Ave., Brooklyn, N.Y.; Evinrude Motors, Div. of Outboard, Marine & Mfg. Co., Milwaukee, Wis.; Johnson Motors, Div. of Outboard, Marine & Mfg. Co., Waukegan, Ill.; Muncie Gear Works, Inc., Muncie, Ind. See also, page 690.

EQUIPMENT FOR AUTOMOTIVE SERVICE STATION AND REPAIR SHOP. See pages 692-694, 585.

EXHAUST GAS ANALYZERS (also sometimes termed "Combustion Analyzer" and "Carburetion Analyzer"). Literature: Write Allen Electric and Equipment Co., Kalamazoo, Mich.; Charles Engelhard, Inc., Newark, N.J.; Joseph Weidenhoff, Inc., 4340 Roosevelt Road, Chicago, Ill.; The Electric Auto-Lite Co., Toledo, Ohio; The Electric Heat Control Co., 9123 Inman Ave., Cleveland, Ohio; The Lantz-Phelps Corp., Dayton, Ohio (also ask for operating instructions) (also mercury column vacuum tester); Weaver Mfg. Co., Springfield, Ill. (also mercury column vacuum tester). See also page 43 of Addenda, "Carburetor Testers."

FITTINGS. Brass replacement, for fuel and oil lines, etc. Literature: Write E. Edelmenn & Co., 2332 Logan Blvd., Chicago, Ill. Literature: "Useful Information on Brass Fittings." Write The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago, Ill. See also "Tools."

FUEL AND OIL LINES, FLEXIBLE. Literature (for most of the cars, trucks, and tractors). Write E. Edelmenn & Co., 2332 Logan Blvd., Chicago, Ill.

FUEL PUMPS AND PARTS. Literature: Write AC Spark Plug Division, General Motors Corp., Flint, Mich.; Chefford Master Mfg. Co. Inc., Fairfield, Ill. Catalogues: "P-39" deals with fuel-pump parts, testers, etc.; "M-38" with gas- and oil-line fittings, cables, wire, and speedometer parts; "I-39-S" with starting, lighting, and ignition parts. Write Kem Mfg. Co., Inc., 601 W. 26th St., New York, N.Y. (mention *Dyke's Automobile Encyclopedia*).

FUEL-PUMP TESTERS. Literature: Write AC Spark Plug Division, General Motors Corp., Flint, Mich.; E. Edelmenn & Co., 2332 Logan Blvd., Chicago, Ill.; Joseph Weidenhoff, Inc., 4340 Roosevelt Road, Chicago, Ill.; Kent-Moore Organization, Inc., Detroit, Mich.; Kem Mfg. Co., 601 W. 26th St., New York, N.Y.

GASKETS, OIL SEALS, ETC. Catalogue: "McCord Gasket Guide" including service information, also "McCord Radiator Guide and Muffler Catalog." Literature: "Grease Retainers and Oil Seals" and "Car Heaters." Write McCord Radiator & Mfg. Co., Detroit, Mich. Literature: "Correct Installation of Gaskets." Write The Fitzgerald Mfg. Co., Torrington, Conn., for forms 3228, 3295, 3226, 3278, 3279, 3283.

GASOLINE. Booklet: "Sparks, Octanes, and Performance." Instructive as well as interesting. Write Ethyl Gasoline Corp., Chrysler Bldg., New York, N.Y.

GASOLINE MILEAGE TESTERS. Literature: Write Houser Engineering & Mfg. Co., Bluffton, Ind.; Kent-Moore Organization, Inc., Detroit, Mich.; The Lantz-Phelps Corp., Dayton, Ohio.

GENERATOR VOLTAGE REGULATOR (checking of). See "Ignition, High Speed" (No. 6).

GENERATORS, WIND DRIVEN. See page 1002.

GRINDER AND BUFFER. Literature: Write Baldor Electric Co., St. Louis, Mo.; Hobart Brothers Co., Troy, Ohio.

HEADLIGHT RELAYS. Literature: Write Packard Electric Division, General Motors Corp., Department D, Warren, Ohio; Kem Mfg. Co., Inc., 601 W. 26th St., New York, N.Y.

HEADLIGHT TESTERS. Literature: Write Bear Mfg. Co., Rock Island, Ill.; Kent-Moore Organization, Inc., Detroit, Mich.; The Electric Heat Control Co., Cleveland, Ohio (headlight meter); Weaver Mfg. Co., Springfield, Ill.

HYDRAULIC LIFTS. See "Lifts."

HYDROMETERS AND ANTI-FREEZE TESTERS. Literature: Write E. Edelmenn & Co., 2332 Logan Blvd., Chicago, Ill.; The Imperial Brass Mfg. Co., Chicago, Ill.

IGNITION. Booklet: "Questions and Answers on Ignition." Write The Electric Heat Control Co., 9123 Inman Ave., Cleveland, Ohio. Course: "Mallory Ignition Course." A simple and fundamental study of the difficult subject of ignition. Recommended for all those interested and who wish to become ignition experts. Twenty-seven complete lessons assembled in a binder. Free, except for small enrolment fee of \$2.00. Write Mallory Electric Corp., Detroit, Mich.

IGNITION, ETC. Manual: "What Every Automobile Mechanic Should Know about Ignition Coils and Ignition." 101 pages of simplified, up-to-date information on such subjects as Ignition Coils, Interrupter Contact-Points, Condensers, Synchronizing, Cam Angle, Octane Selectors, Vacuum Control, Spark Plugs, Timing Ford V-8 Ignition, Voltage Regulation, Cutouts, etc., with Questions and Answers (price \$1.00). Write Machined Parts Corp., Detroit, Mich.

IGNITION, HIGH SPEED. Booklets (lectures) by W. A. Roberts, dealing with "Trouble-shooting on High Speed Motors." Write Kem Manufacturing Co., Inc., 601 West 26th St., New York City, N.Y., and inclose 10 cents for each. No. 1: "Use of the Volt Meter and Ammeter"; No. 2: "High-Speed Ignition Distributors. Coils and Condensers"; No. 3: "Testing Ignition Circuits: Primary and Secondary Tests"; No. 4: "Use and Abuse of the Vacuum Gauge in Motor Analysis. Checking Valve Action, Compression Checks" (also Testing Fuel Pumps, Gasoline Lines, Vacuum Pump, Etc.); No. 5: "Why Do We Time a Motor. Detonation Knocks, Pings"; No. 6: "Checking Voltage Regulators."

IGNITION TIMING LIGHT (Stroboscopic type). Literature: Write Allen Electric and Equipment Co., Kalamazoo, Mich.; "Instructions for Using Edelmenn Timing Light." Write E. Edelmenn & Co., 2332 Logan Blvd., Chicago, Ill.; Joseph Weidenhoff, Inc., 4340 Roosevelt Road, Chicago, Ill.

JACKS, CAR LIFTING. Literature: See page 694.

LATHES. Catalogue: "Modern Service Shop Equipment Catalog." Write South Bend Lathe Works, South Bend, Ind. Catalogue: Write Atlas Press Co., Kalamazoo, Mich., Book: "How To Run a Lathe," 128 pages, 350 illustrations (price 25 cents). Write South Bend Lathe Works, South Bend, Ind. Book: "Manual of Lathe Operation," 234 pages, 304 illustrations (price \$1.00). Write Atlas Press Co., Kalamazoo, Mich. Mention *Dyke's Automobile Encyclopedia*. See also page 694, and "Service Bulletins," next page.

LEAD BURNING. See "Soldering," and pages 585, 582.

LIFTS, ELECTRIC (AUTO). Literature: Write Curtis Pneumatic Machinery Co., 1987 Kienlen Ave., St. Louis, Mo.; The United States Air Compressor Co., Cleveland, Ohio; The Wayne Pump Co., Fort Wayne, Ind.; Walker Mfg. Co., Racine, Wis.

LIFTS, HYDRAULIC (AUTO). Literature: Write Curtis Pneumatic Machinery Co., 1987 Kienlen Ave., St. Louis, Mo.; John Bean Mfg. Co., Lansing, Mich.; The United States Air Compressor Co., Cleveland, Ohio; Weaver Mfg. Co., Springfield, Ill.

LIGHTING. Booklet: "Safety Lighting Service Manual." Write General Electric Co., Nela Park, Cleveland, Ohio.

LUBRICANT. Literature: "Orel for Rubber and Chassis Bearings." Write E. I. duPont de Nemours & Co., Inc., "Zerone" Division, Wilmington, Delaware.

LUBRICATION; COMBUSTION CHAMBER or UPPER CYLINDER. Literature: Write Acheson Colloids Corp., Port Huron, Mich.

AUTOMOTIVE SERVICE AND OTHER LITERATURE (Alphabetically Arranged)

A continuation of self-education is always advisable. The editor and publishers of this book are always anxious to commend, encourage, and assist those seeking proper automotive knowledge.

Below are listed firms from whom up-to-date and valuable literature can be obtained on the subjects mentioned. In writing to the various concerns, mention *Dyke's Automobile and Gasoline Engine Encyclopedia*, as they have agreed to serve our readers. Literature is gratis unless a price is given.

The list was prepared in 1939 and literature bearing other titles may now be available instead. In calling for a specific title, we suggest adding to your letter the words, "or similar literature."

If in writing for literature, no reply is received, we will thank our readers to notify A. L. Dyke, 406 Market St., St. Louis, Mo.

To obtain literature on subjects not mentioned below, address A. L. Dyke, 406 Market Street, St. Louis, Mo. Mention the subject in which you are interested, and directions for obtaining the literature will be furnished you if the information is available.

ACETYLENE. Literature: "Prest-O-Lite Dissolved Acetylene" giving information such as rated capacities of Prest-O-Lite cylinders, where obtainable, etc. Write The Linde Air Products Co., 30 East 42d St., New York, N.Y.

A.E.A. TUNE-UP SERVICE MANUAL (price \$2.00). Write Automotive Electric Association, 800 Michigan Bldg., Detroit, Mich., for descriptive literature, which includes information on the *A.E.A. Tune-Up System*.

AIR BRAKES. Manual: "Maintenance Manual" dealing with description, operation, maintenance, and fitting of Bendix-Westinghouse automotive air-brake equipment. Write Bendix-Westinghouse Automotive Air Brake Co., 5001 Centre Ave., Pittsburgh, Pa., and inclose 25 cents in stamps and ask for "B.W. 1027." Be sure and mention *Dyke's Automobile Encyclopedia*. Booklet: "Service and Maintenance Information on Wagner Air Brakes" (SD-377E). Write Wagner Electric Corp., Automotive Parts Division, 6400 Plymouth Ave., St. Louis, Mo. Descriptive Bulletin: "Wagner Air Brakes" (KU-12) describes rotary compressor. Write Wagner.

AIR COMPRESSORS. Literature: Write Brunner Mfg. Co., Utica, N.Y.; Curtis Pneumatic Machinery Co., 1987 Kielen Ave., St. Louis, Mo.; Hobart Brothers Co., Troy, Ohio; The Imperial Brass Mfg. Co., Chicago, Ill. (compressor for paint spray work only); The United States Air Compressor Co., Cleveland, Ohio; The Wayne Pump Co., Fort Wayne, Ind.

ALIGNMENT OF WHEELS AND AXLES. (Also brake service equipment and wheel balancers.) Literature: See page 1110. See also page 694.

ALUMINUM. Booklet: "Machining Aluminum," 32 pages. Write Aluminum Company of America, 801 Gulf Bldg., Pittsburgh, Pa.

ANTI-FREEZE AND COOLING SYSTEM. Manual: "The Eveready Manual of Cooling System Service." Write National Carbon Co., Inc., 30 E. 42d St., New York, N.Y. Manual: "Cooling System Service Manual." Write Willard Storage Battery Co., Cleveland, Ohio. Booklet: "A New Way To Get More Power from Your Car." Write E. I. duPont de Nemours & Co., Inc., "Zerone" Division, Wilmington, Del.

ANTI-FREEZE TESTERS. See "Hydrometers."

ARMATURE WINDING BOOKS. Write The Goodheart-Willeco Co., Inc., 2009 South Michigan Ave., Chicago, Ill.

ARMATURES, GENERATORS, AND FIELD COILS. Catalog: "Automotive Replacement Armatures." Also contains questions and answers prepared by an ignition expert. Write E. Edelmann & Co., 2332 Logan Blvd., Chicago, Ill.

AUTOMOTIVE HOME STUDY COURSE. Questions and Answers on elementary and advanced fundamental principles. See advertisement in back of this book on *Dyke's Self-Starter*.

BALL BEARINGS. Booklets: "How To Service," Very instructive. Write M-R-C Bearings Service Co., Jamestown, N.Y.

BATTERY. Book: See advertisement in back of this book.

BATTERY. Magazine: "The Battery Man." In addition to containing general information, each monthly issue contains an up-to-date directory of where to buy battery parts, equipment, supplies, etc. Sample copy will be sent free to readers of *Dyke's Automobile Encyclopedia*. Write The Battery Man Publishing Co., Terre Haute, Ind.

BATTERY. Manual: "Globe Battery Service Manual." Write Globe-Union Inc., Milwaukee, Wis. Manual: "U.S. Battery Service Manual." Write U.S. Battery Corp., Advertising Dept., Niagara Falls, N.Y. Manual: "A Complete Manual of Technical Information." Write Thomas A. Edison, Inc., Emark Battery Division, Kearny, N.J. Manual: "The Starting and Lighting Battery." Write Willard Storage Battery Co., Cleveland, Ohio. Literature: Write The Electric Storage Battery Co., 19th St. and Allegheny Ave., Philadelphia, Pa.

BATTERY CHARGERS, TESTERS, AND SERVICE EQUIPMENT. See pages 585, 555.

BODY AND FENDER REPAIRING. Book: "Automotive Body and Fender Repairs" by C. E. Packer. 325 pages, 232 illustrations. Everything from laying out a shop and selection of tools to refinishing car (price \$3.00). Descriptive circular free. Write The Goodheart-Willeco Co., Inc., 2009 S. Michigan Ave., Chicago, Ill.

BODY AND FENDER REPAIRING TOOLS. Catalogue or Literature: Write Albertson & Co., Inc., Sioux City, Iowa (solder spray gun and sander); Blackhawk Mfg. Co., Milwaukee, Wis. ("Porto-Power" hydraulic unit for all kinds of straightening work); Bonney Forge & Tool Works, Allentown, Pa. (tools); Duro Metal Products Co., 2649 N. Kildare Ave., Chicago, Ill. (tools); Ernest Holmes Co., Chattanooga, Tenn. (solder spray gun); Herbrand Corp., Fremont, Ohio (tools); Kent-Moore Organization, Inc., Detroit, Mich. (tools and equipment); Snap-On Tools Corporation, Kenosha, Wis. (tools); Stanley Tools, New Britain, Conn. (tools); United States Electrical Tool Co., Cincinnati, Ohio (sander); Vilech Tool Co., Cleveland, Ohio (tools); Weaver Mfg. Co., Springfield, Ill. (pneumatic hammer).

BRAKES. Literature: See footnotes, page 1083 (Lockheed) and page 1088 (Bendix) BRAKES, AIR. See "Air Brakes."

BRAKES, HYDRAULIC. Booklet: "How To Bleed and Refill Hydraulic Brake Systems" (HU-17). Write Wagner Electric Corp., Automotive Parts Division, 6400 Plymouth Ave., St. Louis, Mo. See also footnotes, pages 1083, 1088. Literature: (NU-19) explaining the principle of operation of the NoRoL as applied to hydraulic brakes to prevent car rolling backward during a momentary stop. Write Wagner Electric Corp. Service Tool Catalog (HU-9), describes all tools needed in servicing hydraulic brakes. Write Wagner Electric Corp.

BRAZING. See "Soldering."

CARWASHER EQUIPMENT. Literature: Write Curtis Pneumatic Machinery Co., 1987 Kielen Ave., St. Louis, Mo.; Hobart Brothers Co., Troy, Ohio; The Imperial Brass Mfg. Co., Chicago, Ill.; The Rotawasher Corp., Cleveland, Ohio; The Wayne Pump Co., Fort Wayne, Ind.; Weaver Mfg. Co., Springfield, Ill.

CARBURETION AND CARBURETORS. See advertisement of *Dyke's Carburetor Book* in the back of this book.

CARBURETOR TESTERS. See "Vacuum Tester (Mercury Column)," "Testing Instruments" and "Exhaust Gas Analyzers."

CARBURETORS. Manual: "Motor Tune-up and Carburetor Instructions" (price \$1.00). Write Carter Carburetor Corp., Sales Department, 2834 N. Spring Ave., St. Louis, Mo.

CARE OF CAR: POLISHING, UPHOLSTERY, ETC. Literature: Write E. I. duPont de Nemours & Co., Inc., Finishes Division, Wilmington, Del.

CLEANING. Booklet: "The Automotive Cleaning Handbook." Write Magnus Chemical Co., Inc., Garwood, N.J. Booklet: "Modern Oakite Cleaning Methods." Information on tank, automatic washing machine or steam cleaning for every part of a car; includes data on reverse flushing of radiators and removal of scale, rust from water jackets of engines (including Diesel engine water jackets), clogged radiators, etc. Write Oakite Products, Inc., 22 Thames St., New York, N.Y. Booklet: "Ki-Sol No. 3" (a solvent) for cleaning carburetors and fuel pumps. Write Ki-Sol Corp., St. Louis, Mo.

CONNECTING RODS. Literature: Exchange and babbiting service. Write Clawson & Bals, Inc., 4701 W. Lake St., Chicago, Ill.; Federal-Mogul Service, Division of Federal-Mogul Corp., 4809 John R. St., Detroit, Mich. (See also "Engine Bearings" footnote 6, page 786.)

COURSE. See "Automotive Home Study Course," "Engine Tune-Up Course," "Ignition Course."

DIESEL ENGINE. Booklet: "Diesel—the Modern Power." Developments from Dr. Diesel's mysterious disappearance to the modern streamline trains. Operation of the Diesel engine and wherein it differs from the gasoline engine. Write Department of Public Relations, General Motors Corp., Detroit, Mich. See also "Lubrication—Panorama of Lubrication." Literature: "Special Diesel Service Tools." Write Kent-Moore Organization, Inc., Detroit, Mich. Book: Write The Goodheart-Willeco Co., Inc., 2009 S. Michigan Ave., Chicago, Ill.

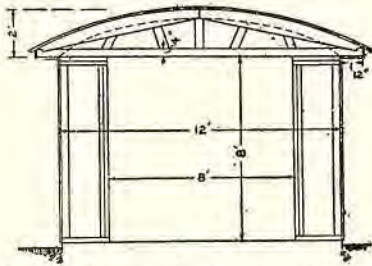


Fig. 30. End elevation, showing the rafter construction and the finishing fascia boards on the eaves.

The rafters are built up in a manner similar to that used on large garages now so popular. Each one, or each pair, consists of a cross-piece that rests on top of the plates at the sides and is notched at the ends, to receive the ends of the convex rafter pieces. The pattern for one of these pieces, with dimensions, is shown in the drawing (Fig. 31). After the three main parts are fitted to form one rafter across the building, they are fastened together with short pieces of boards, which can be cut from scrap. The rafters are set on the plates 16 inches apart from center to center.

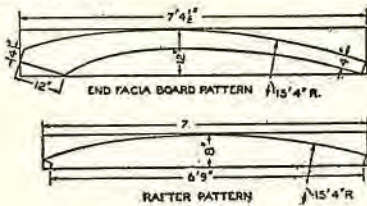


Fig. 31. Pattern layout for the rafter pieces and the finishing fascia boards for the eaves at the ends.

The sheathing boards are nailed to the curved edges of the rafters lengthwise, and as the material list calls for boards 12 feet long, one and one-half lengths will cover the rafters and allow 1 foot projection at each end for the eave. The fascia boards are cut on a curve in the same manner as the rafter pieces, and the under side is cut as shown in the detail, so as to make a neat-appearing connection to the end of the frieze boards. Straight fascia boards are fastened on the eaves, at the sides, in the same manner, and a frieze board is nailed to

the under side, the ends being finished, as shown in the detail drawing (Fig. 31).

Prepared roofing is fastened to the sheathing in the usual manner, beginning the layers at the eave and finishing in the center, allowing the center piece to overlap on both sides.

The windows consist of four single casements, two being placed on each side. These can be of any size to suit the builder, and can be bought from a mill ready to be set into the openings cut for them.

The doors can be made up of the same material as that used for the siding and battened together, or, if a more elaborate door is desired, they can be purchased at a reasonable price, paneled and with a glass in the upper part. If paneled doors are used, 18 boards can be deducted from the siding-material list. The double doors will require fastenings at the center, and, in placing the concrete floor, a keeper should be set in the surface cement for the foot latch. The upper keeper can be attached to the end rafter cross-piece. The usual hardware is necessary for the small door at the opposite end.

Material List

Concrete floors: 2 bbls. cement; 4.5 cu. yd. cinders; 2.2 cu. yd. sand; 4.3 cu. yd. gravel.

Sills, plates, and studs: 6 pieces, 16 ft. long, 2×4 in.; 4 pieces, 12 ft. long 2×4 in.; 20 pieces, 8 ft. long, 2×4 in.

Siding: 90 boards, 8 ft. long, 7/8×8 in.; 90 battens, 8 ft. long.

Rafters: 10 boards, 14 ft. long, 7/8×8 in.; 10 boards, 14 ft. long, 7/8×4 in.

Roofing: Enough sheathing boards, 12 ft. long to cover 260 sq. ft.; enough prepared roofing to cover 260 sq. ft.

Windows: 4 single casements.

Finishing pieces: 2 frieze boards, 18 ft. long, 7/8"×1 ft.; 2 fascia boards, 18 ft. long, 7/8"×4 in.; 4 fascia boards, 8 ft. long, 7/8"×1 ft.; 8 corner boards, 8 ft. long, 7/8"×4 in.; 6 door-facing boards, 8 ft. long, 7/8"×4".

Hardware: 1 pair of door hinges; 1 door lock; 3 pairs of heavy door hinges; 1 foot latch; 1 upper latch; 1 large door lock; 10 lb. 20-penny nails; 20 lb. 8-penny nails; 10 bolts, with double washers, 1/2"×5 in.

A garage built up in this manner and well painted will last for years, and if it becomes necessary to move it, nothing will be lost except the concrete floor, as the building can be lifted from the bolts and taken away bodily. (*Popular Mechanics*.)

Galvanized iron garages for home use can be purchased ready to assemble; likewise sectional garages made of wood.

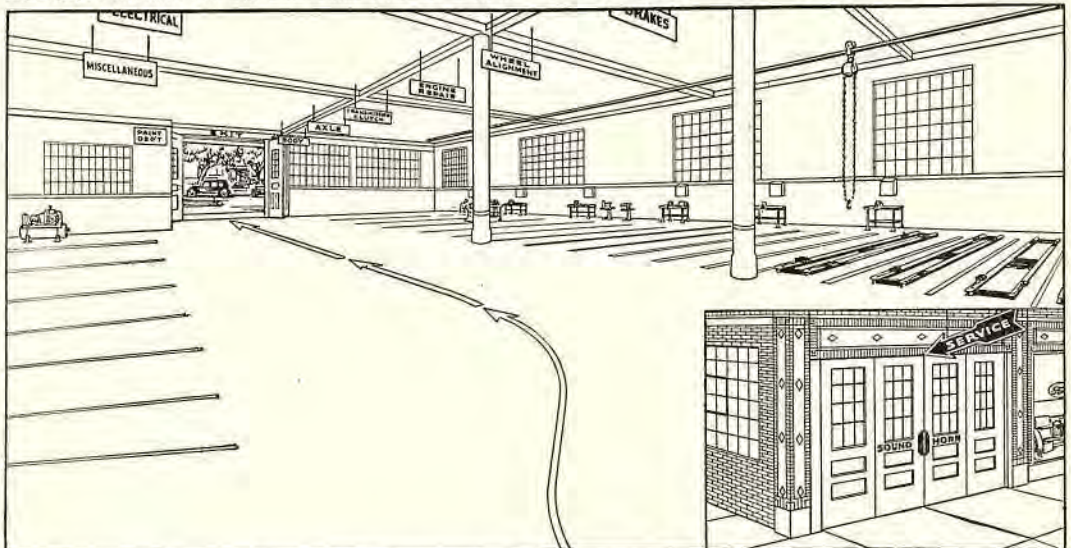


Fig. 1. Service department paint and color combinations.¹ Three color combinations suggested for dealers' service departments.

(1) Upper side walls and ceilings, aluminum; side wall stripe, red; lower side wall, tan; floor, light gray; lubrication lift, orange; lubrication lift trim, black; equipment, gray; entrance doors, cream; entrance door panels, white; entrance door push plate, black.

(2) Upper side walls and ceilings, glossy ivory; floor, dust gray; equipment, red; entrance doors, gray; otherwise same as (1).

(3) Upper side walls and ceilings, gloss white; lower side walls, gray; floor, dust gray; equipment, red; entrance doors, yellow; otherwise same as (1).

¹ Excerpts and illustration from *Ford Service Bulletin*, March, 1935, in which the three combination colors were shown.

West Virginia
 A. E. Supply Co. Parkersburg
 T. T. Hutchisson & Co. Wheeling
 Motor Car Supply Co. Charleston
 Williams Hardware Co. Clarksburg
 Van Zandt Leftwich Auto Supply Co. Huntington
 Baldwin Supply Co. Parkersburg

Wisconsin
 Andrae & Sons Co., Julius. Milwaukee
 Clemons Auto Supply Co. Eau Claire
 Phillip Gross Hardware Co. Milwaukee
 Shadbolt & Boyd Iron Co. Milwaukee
 Wisconsin Auto Sup. Co. Wausau

Wyoming
 Casper Supply Co. Casper
 Wyoming Automotive Co. Casper

Canada
 Bennet & Elliott, Ltd. Toronto, Ont.
 Bowman Bros., Ltd. Saskatoon, Sask.
 Canadian Fairbanks-Morse Co., Ltd. Montreal, Que.
 Jas. Cowan & Co., Ltd. London, Ont.
 Canadian General Electric Co. Toronto, Ont.
 Cutten & Foster, Ltd. Toronto, Ont.
 R. G. Edgcombe Co., Ltd. London, Ont.
 Garage Supply Co. Toronto, Ont.
 Ludger Gravel & Fils Montreal, Que.
 Hyslop Bros., Ltd. Toronto, Ont.
 Keyes Supply Co., Ltd. Ottawa, Ont.
 MacKenzie, White & Dunsmuir, Ltd. Vancouver, B.C.
 John Millen & Son, Ltd. Montreal, Que.
 Motor Car Supply Co. of Canada, Ltd. Calgary, Alb.
 Toronto Auto Accessories Co., Ltd. Toronto, Ont.
 Bowman-Anthony Co. Windsor, Ont.
 Maritime Accessories, Ltd. Halifax, N.S.

MANUFACTURERS OF (GASOLINE) PASSENGER AUTOMOBILES

Ajax Motors Co., Racine, Wis.
 American Motors Corp. of N.J., Plainfield, N.J.
 Apperson Automobile Co., Kokomo, Ind.
 Auburn Automobile Co., Auburn, Ind.
 Bay State Motor Co., Framingham, Mass.
 Beggs Motor Car Co., Kansas City, Mo.
 Buick Motor Co., Flint, Mich.
 Cadillac Motor Car Co., Detroit, Mich.
 Case T. M. Co., J. L., Racine, Wis.
 Chandler Motor Car Co., Cleveland, Ohio.
 Chevrolet Motor Co., Detroit, Mich.
 Chrysler Sales Corp., Detroit, Mich.
 Cleveland Automobile Co., Cleveland, Ohio.
 Cole Motor Car Co., Indianapolis, Ind.
 Courier Motors Co., Sandusky, Ohio.
 Cunningham, Son & Co., James, Rochester, N.Y.
 Davis Motor Car Co., Geo. W., Richmond, Ind.
 Diana Motors Co., St. Louis, Mo.
 Dodge Brothers, Inc., Detroit, Mich.
 Dorris Motors, Inc., St. Louis, Mo.
 Dusenbergs Motors Co., Indianapolis, Ind.
 Durant Motors, Inc., Lansing, Mich. (Star).
 Durant Motors, Inc., New York, N.Y. (Star, Flint, Locomobile)
 Elcar Motor Co., Elkhart, Ind.
 Essex—See Hudson Motor Car Co.
 Flint Motor Co., Flint, Mich.
 Ford Motor Co. (Highland Park), Detroit, Mich.
 Franklin Mfg. Co., H. H., Syracuse, N.Y.
 Gardner Motor Co., St. Louis, Mo.
 Gray Mfg. Co., Detroit, Mich.
 H. C. S. Cab Mfg. Co., Indianapolis, Ind.
 Hertz (See Yellow Truck & Coach Mfg. Co.)
 Hudson Motor Car Co., Detroit, Mich. (Essex, Hudson).
 Hupp Motor Car Corp., Detroit, Mich. (Hupmobile).
 Jewett (see Paige-Detroit Motor Car Co.)

Jordan Motor Car Co., Cleveland, Ohio.
 Kissel Motor Car Co., Hartford, Wis.
 Lincoln Motor Co. (Div. of Ford Motor Co.), Detroit, Mich.
 Locomobile Co. of America, Inc., Bridgeport, Conn.
 McFarlan Motor Corp., Connerville, Ind.
 Mercer Motor Car Co., Trenton, N.J.
 Möller Motor Car Co., M. P., Hagerstown, Md. (Dagmar).
 Moon Motor Car Co., St. Louis, Mo.
 Nash Motors Co., Kenosha, Wis.
 Nordyke & Marmon Co., Indianapolis, Ind. (Marmon).
 Oakland Motor Car Co., Pontiac, Mich. (Oakland, Pontiac).
 Olds Motor Works, Lansing, Mich. (Oldsmobile).
 Overland (See Willys-Overland, Inc.)
 Packard Motor Car Co., Detroit, Mich.
 Paige-Detroit Motor Car Co., Detroit, Mich. (Jewett, Paige).
 Peerless Motor Car Co., Cleveland, Ohio.
 Pierce-Arrow Motor Car Co., Buffalo, N.Y.
 Pontiac (see Oakland Motor Car Co.)
 Reo Motor Car Co., Lansing, Mich.
 Rickenbacker Motor Co., Detroit, Mich.
 Roamer Motor Car Co., (Canada) Ltd., Kalamazoo, Mich. (Barley).
 Rollin Motors Co., Cleveland, Ohio.
 Rolls-Royce of America, Inc., Springfield, Mass.
 Star (see Durant Motors, Inc.)
 Stearns Co., F. B., Cleveland, Ohio (Stearns-Knight).
 Sterling Knight Co., Warren, Ohio.
 Stevens-Duryea Motors, Inc., Chicopee Falls, Mass.
 Studebaker Corp. of America, South Bend, Ind.
 Stutz Motor Car Co. of America, Inc., Indianapolis, Ind.
 Velie Motors Corp., Moline, Ill.
 Wills Sainte Claire, Inc., Marysville, Mich.
 Willys-Overland, Inc., Toledo, Ohio (Overland, Willys-Knight).
 Yellow Truck & Coach Mfg. Co., Chicago, Ill. (Hertz).

A HOME GARAGE FOR ONE MACHINE

The home garage shown in Fig. 27 is designed for housing one machine, and to give a little space about it so that a person can clean the exterior of the automobile and do small repairs.

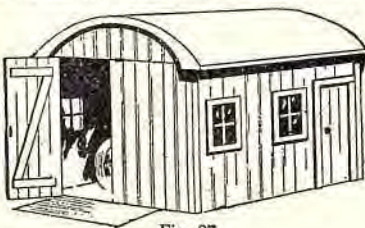


Fig. 27

The first thing to be considered is the foundation, or base, which is made of concrete (Fig. 28). The earth should be excavated for a depth of 6 inches, and to the exact dimensions given for the floor plan. The hole is then filled with cinders, well tamped in and leveled on top. A frame, about 4 inches high, is built up of cheap lumber, so that the space within measures 12 ft. wide and 16 ft. long, except at the double-door opening where a sloping runway is formed for the easy entrance of the automobile.

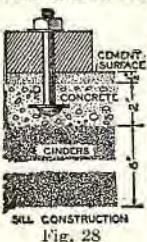


Fig. 28

A 2-inch layer of concrete—a mixture of 1 part cement, 2 parts sand, and 4 parts gravel, or crushed stone—is placed on top of the cinders, and a neat mixture of cement and sand, $\frac{1}{2}$ inch thick, is placed on the concrete and made perfectly level. When putting in the concrete, $\frac{1}{2}$ -inch bolts, about 5 inches long, are set in the edge with the threaded end extended about 3 inches above the upper surface of the cement, and in line with the center of the 2 by 4 inch timber used as a sill. The detail of this construction is shown in the sketch. About four

of these bolts should be set on each side, three on the end, and one on each side of the double doors.

The corner posts and studs are cut so that their length, together with the thickness of the sill and the two pieces for the plate, will measure 8 feet. This is the proper length to cut the boards without waste from standard lengths of lumber. After raising the corner posts and studs, and nailing the plate pieces on top, the siding boards are nailed on vertically to the plate and sill, and the battens are nailed over the joints.

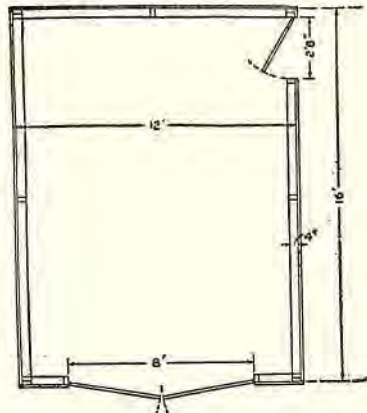


Fig. 29. Floor plan, showing the location of the sills, studs, and corner posts on the concrete floor.

Missouri

Ayers Auto Supply Co.	St. Joseph
Beck & Corbitt Co.	St. Louis
Campbell Iron Co.	St. Louis
Fred Campbell Auto Supply Co.	St. Louis
Equipment Co., The	Kansas City
Richards & Conover Hdw. Co.	Kansas City
The Faeth Co.	Kansas City
Joplin Supply Co.	Joplin
Myers Tri-State Supply Co.	Joplin
Kansas City Automobile Supply Co.	Kansas City
Ozark Motor Supply Co.	Springfield
Peake Auto Supply Co.	Kansas City
Herman Brownlow Co.	Springfield
The Straus Company	St. Louis

Montana

Northwestern Auto Supply Co.	Billings
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Nebraska

W. M. Dutton & Sons Co.	Hastings
Nebraska-Buick Auto Co.	Lincoln
Storz-Western Auto Sup. Co.	Omaha

Nevada

Nevada Auto Supply Co.	Reno
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New Jersey

Economy Auto Supply Co.	Newark
Elin Auto Supply Co.	Newark

New York

Albana Hdw. & Iron Co.	Albany
Auto Hardware & Equipment Co.	New York
Bushwick Auto Supply Co.	Brooklyn
Chapin-Owen Company	Rochester
Farrell Auto Supply Co.	Brooklyn
E. Krieger & Son	Brooklyn
Lowe Motor Supplies Co.	New York
Martin-Evans Company	Brooklyn
Miller Auto Supply Co.	New York
James Martin	New York
H. A. McRae & Co., Inc.	Troy
Thos. J. Northway, Inc.	Rochester
Olmsted Company, The	Syracuse
Onondaga Auto Sup. Co.	Syracuse
Perry & Sherman	Utica
W. E. Pruden Hdw. Co.	New York
Rappole & Robbins, Inc.	Jamesstown
The Ready Auto Sup. Co., Inc.	Brooklyn
S. B. Roby Co.	Rochester
W. H. Rowerdink & Son	Rochester
Strauss Co., Jos., Inc.	Buffalo
Superior Lamp & Automotive Equipment Co.	New York
H. D. Taylor Co.	Buffalo
Utica Cycle & Supply Co.	Utica
Weaver-Ebling Automobile Company	New York
Whipple's	Binghamton
Whittemore-Sim Co., Inc.	New York
Barker, Rose & Clinton Co.	Elmira
Automobile Necessities Co.	New York
Walters Rubber Co.	Mineola, L.I.
Lehr Auto Supply Co.	New York
Pyramid Motor Equip. Co.	New York

North Carolina

Boylan's, Inc.	Raleigh
Carolinas Auto Supply House	Charlotte
Glasgow-Stewart & Co.	Charlotte
Odell Hardware Co.	Greensboro
Brown-Rogers-Dixon Co.	Winston Salem

North Dakota

Quannrud, Brink & Reibold, Inc.	Bismarck
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Ohio

Julius J. Bantlin Co.	Cincinnati
C. & D. Auto Supply Co.	Cincinnati
Canton Hdw. Co.	Canton
Dine-DeWees Company	Canton
Griswold-Sohl Co.	Columbus
Hardware & Supply Co.	Akron
Lewis Motor Mart Co.	Dayton
Justus & Parker Co.	Columbus
M. & M. Company	Cleveland
Pennsylvania Rubber & Supply Co.	Cleveland
Roberts-Toledo Co.	Toledo
Sells Company, J. H. and F. A.	Columbus
Toledo Rubber Company	Toledo
Union Supply Company	Toledo
York Supply Co.	Greenville
I. J. Cooper Rubber Co.	Cincinnati
The M. D. Larkin Co.	Dayton

Oklahoma

J. B. Burwell Supply Co.	Oklahoma City
Severin Tire & Supply Co.	Oklahoma City
R. V. Smith Supply Co.	Oklahoma City

Southern Motor Sup. Co.	Oklahoma City
Wolf-Eagen Motor Supply Co.	Oklahoma City
Sharp Auto Supply Co.	Oklahoma City
Shawnee Motor Sup. Co.	Shawnee

Oregon

Ballou & Wright	Portland
P. J. Cronin Co.	Portland
Wiggins Co., Inc.	Portland

Pennsylvania

Berrodin Auto Supply Co.	Philadelphia
Cahall Motor Supply Co.	Philadelphia
Casanave Supply Co.	Philadelphia
Gaul, Derr & Shearer Co.	Philadelphia
General Automotive Sup. Co.	Harrisburg
Jackson Motor Supply Co.	Pittsburgh
Johnstown Automobile Co.	Johnstown
D. T. Lansing Co., Inc.	Scranton
J. H. McCullough & Son	Philadelphia
C. H. Miller Hardware Co.	Huntingdon
Motor Accessories Co.	Allentown
Geo. W. Nock, Inc.	Philadelphia
Philadelphia Motor Accessories Co.	Philadelphia
Pittsburgh Auto Equipment Company	Pittsburgh
H. C. Roberts Electrical Supply Company	Philadelphia
Supplee-Biddle Hardware Co.	Philadelphia
E. Mather Co.	Harrisburg

Rhode Island

Belcher & Loomis Hdw. Co.	Providence
Goodby-Rankin Company	Providence
Providence Auto Equipment Company	Providence
Waite Auto Supply Co.	Providence

South Carolina

D. W. Alderman, Jr., Inc.	Florence
Cameron & Barkley Co.	Charleston

South Dakota

Graff Motor Supply Co.	Sioux Falls
Watertown Motor Accessories Co.	Watertown

Tennessee

McClung & Co., C. M.	Knoxville
Mills-Morris Company	Memphis
Orgill Bros.	Memphis
Ozburn-Abston & Co.	Memphis
Southern Auto Supply Co.	Chattanooga
Keith Simmons Co., Inc.	Nashville
Buford Bros.	Nashville

Texas

Archenhold Automobile Supply Company	Waco
Borderland Auto Supply Company	El Paso
Corpus Christi Hdw. Co.	Corpus Christi
Automotive Appliance Co.	Dallas
Equipment Co. of Texas	Ft. Worth
Ferris Simpson Auto Supply Co.	Dallas
General Auto Supply Co.	Amarillo
Herrick Hdw. Co.	Waco
Hans Johnsen	Dallas
McCauley-Ward Motor Supply Company	Waco
McLendon Hardware Co.	Waco
Miller Company, The	Waco
Morrow, Wm. L.	San Antonio
Roper, Harris & Dunn Co.	Greenville
Southern Equipment Co.	San Antonio
Straus-Frank Company	San Antonio
Tips Company, The Walter	Austin
Tri-State Motor Company	El Paso
Wilson Hdw. Co., E. L.	Beaumont
J. P. Wooten Co.	Abilene
Schoellkopf Co.	Dallas
Auto Equipment Co.	Wichita Falls
Peden Iron & Steel Co.	Houston

Utah

Inter-Mountain Electric Co.	Salt Lake City
George A. Lowe Co.	Ogden
Motor Mercantile Co.	Salt Lake City
Salt Lake Hardware Co.	Salt Lake City

Vermont

Vermont Hardware Co.	Burlington
Hagar Hdw. & Paint Co.	Burlington

Virginia

Benj. T. Crump Co., Inc.	Richmond
Norfolk Motor Equipment Co.	Norfolk
Owens-Merritt Co., Inc.	Danville
Piedmont Hardware Co.	Danville
E. L. Taylor & Co., Inc.	Richmond
Benton Bailey Co.	Richmond
Richmond Hardware Co.	Richmond

Washington

Child, Day & Churchill, Inc.	Spokane
Reynolds & King, Inc.	Tacoma

AUTOMOTIVE SUPPLY JOBBERS¹

If you are a dealer doing repair work, send for catalogue of firm nearest to you.

		E. B. Collins Company.....	Danville
		Cummings & Emerson.....	Peoria
		Electric Appliance Co.....	Chicago
		Graham-Seltzer Company.....	Peoria
		E. D. Kimball & Co.....	Chicago
		Motor Car Supply Co.....	Chicago
		National Electric & Auto Supply Co.....	Peoria
		Sheridan Auto Supply, Inc.....	Chicago
		Tenk Hardware Co.....	Quincy
		Universal Automotive Supply Company.....	Chicago
		Washington Auto Supply Co.....	Washington
		Idaho	
		Bertram Motor Supply Co.....	Boise
		Indiana	
		Fort Wayne Iron Stores Company.....	Fort Wayne
		Mossman-Yarnelle Co.....	Fort Wayne
		Orr Iron Company.....	Evansville
		Wayne Auto Equipment Co.....	Fort Wayne
		The Gibson Co.....	Indianapolis
		Central Rubber & Sup. Co.....	Indianapolis
		Iowa	
		Robt. Donahue Company.....	Burlington
		R. F. & W. B. Fitch Co.....	Oskaloosa
		Heeb Company.....	Dubuque
		Herring Motor Company.....	Des Moines
		Mid-West Auto Supply Co.....	Dubuque
		Repass Auto Company.....	Waterloo
		Sieg Company.....	Davenport
		Wm. Warnock Co., Inc.....	Sioux City
		Kansas	
		Johnson Bros. Auto Sup. Co.....	Wichita
		Massey Hardware Co.....	Wichita
		Motor Equipment Co.....	Wichita
		Southwick Auto Supply Co.....	Topeka
		Kentucky	
		Louisville Auto Supply Company.....	Louisville
		Peaslee-Gaubert Co.....	Louisville
		Louisiana	
		Borden-Aicklen Auto Supply Co., Inc.....	New Orleans
		Electric Appliance Co.....	New Orleans
		Interstate Electric Co.....	New Orleans
		Jos. Schwartz Co.....	New Orleans
		Southern Hardware & Woodstock Co.....	New Orleans
		Monroe Auto & Supply Co., Inc.....	Monroe
		Maine	
		The James Bailey Co.....	Portland
		Darling Automobile Co.....	Auburn
		Maryland	
		Auto Supply Company.....	Baltimore
		R. W. Norris & Sons.....	Baltimore
		Holland, Baden & Ramsey.....	Baltimore
		Massachusetts	
		Alsten-Goulding Co.....	Worcester
		American Motor Equipment Co.....	Boston
		Bigelow & Dowse Co.....	Boston
		Butts-Ordway Company.....	Boston
		George Collins Co.....	Boston
		Duncan-Goodell.....	Worcester
		Hub Cycle & Auto Supply Co.....	Boston
		Lewis Automotive Equipment Co.....	Worcester
		Linscott Supply Co.....	Boston
		Tarbell-Waters Company.....	Springfield
		Wetmore Savage Automotive Equipment Co.....	Boston
		J. V. Wilson Co.....	Boston
		Michigan	
		Automobile Equipment Co.....	Detroit
		Automobile Supply Co.....	Detroit
		Cumings Brothers.....	Flint
		General Sales Company.....	Flint
		L. M. Hengesbaugh & Co.....	Flint
		Tisch Auto Supply Co.....	Grand Rapids
		Watkins & Radcliffe Co.....	Detroit
		Tyler-Lowery Co.....	Bay City
		Sherwood Hall Co.....	Grand Rapids
		Fornbrook Auto Supply.....	Flint
		Grier Sutherland Co.....	Detroit
		Minnesota	
		Duluth Auto Supply Co.....	Duluth
		Minneapolis Iron Store Co.....	Minneapolis
		Nicols Dean & Gregg.....	St. Paul
		Reinhard Bros. Company.....	Minneapolis
		C. J. Smith & Company.....	St. Paul
		Western Motor Supply Co.....	Minneapolis
		Williams Hardware Co.....	Minneapolis
		Alabama	
		Johnson Tire & Auto Co.....	Montgomery
		Long Lewis Hdwe. Co.....	Bessemer
		Arizona	
		Motor Supply Co.....	Phoenix
		Arkansas	
		Atkinson-Williams Hdwe. Co.....	Fort Smith
		Crow-Burlingame Co.....	Little Rock
		Ft. Smith Auto Sup. Co.....	Fort Smith
		Turner Auto Supply Co.....	Texarkana
		Voss-Hutton Mfg. Co.....	Little Rock
		California	
		The Banta Company.....	Los Angeles
		California Auto Supply Co.....	Stockton
		Chanslor & Lyon Co.....	San Francisco
		E. A. Featherstone, Inc.....	Los Angeles
		P. W. Gavin Company.....	San Diego
		Kay Motor Supply Co.....	Los Angeles
		Kimball Upson Co.....	Sacramento
		McCoy Motor Supply Co.....	San Francisco
		Motor Hardware & Equipment Co.....	San Diego
		James S. Remick Co., Inc.....	Sacramento
		Waterhouse & Lester Co.....	San Francisco
		Weinstock-Nichols Co.....	San Francisco
		Colorado	
		Auto Equipment Company.....	Denver
		Foster Auto Supply Co.....	Denver
		Hendrie & Bolthoff Mfg. & Supply Co.....	Denver
		Moore Hdwe. & Iron Co.....	Denver
		Motor Accessory & Tire Co.....	Pueblo
		Quinn & McGill Motor Supply Co.....	Denver
		B. K. Sweeney Electrical Co.....	Denver
		Connecticut	
		Horton-Gallo-Creamer Co.....	New Haven
		Magic Auto Supply Co.....	Hartford
		The C. S. Mersick & Co.....	New Haven
		Post & Lester Company.....	Hartford
		Hessell & Hoppen.....	New Haven
		District of Columbia	
		Chas. Rubel & Company.....	Washington
		Rudolph & West Company.....	Washington
		Southern Automobile Supply Co.....	Washington
		Florida	
		Berner Pease Co.....	Miami
		Bunny Supply Co., Inc.....	Miami
		G. Norman Baughman Co.....	Tampa
		Consolidated Automotive Co.....	Jacksonville
		C. W. Greene Co.....	Tampa
		Knight & Wall Co.....	Tampa
		Tampa Hdwe. Co.....	Tampa
		Wholesale Auto Supply House.....	Tampa
		Owen-Nicholas Co., Inc.....	Tampa
		Patrick's Inc.....	Jacksonville
		Georgia	
		Alexander-Seewald Co.....	Atlanta
		The Motor Supply Co., Inc.....	Savannah
		A. S. Hatcher Co.....	Macon
		Butler Bros. Co., Inc.....	Columbus
		Illinois	
		Automobile Supply Co.....	Chicago
		Barrett Hdwe. Co.....	Joliet
		Central Auto Equipment Co.....	Springfield
		Chicago Auto Equipment Co.....	Chicago
		Chicago Automobile Supply House.....	Chicago
		Clark-Smith Hardware Co.....	Peoria

¹ Note: We are not responsible for wrong addresses or responsibility of concerns listed. These and some other lists in this book have not been revised for some time. See footnote p. 685.

- Marion: American Motors Parts Co., Indianapolis, Ind.; Puritan Autoparts Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Marion-Handley: Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Mason: Puritan Autoparts Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Matheson: Matheson Co., Frank P., Wilkes Barre, Pa.; Puritan Autoparts Co., Detroit, Mich.
- Maytag: Puritan Autoparts Co., Detroit, Mich.; Wichita Auto Wrecking Co., Wichita, Kans.
- Maxwell-Briscoe: Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Mercedes: Connecticut Auto Parts Co., Hartford, Conn.
- Meteor: Auto Gear Co., 844 Eighth Ave., New York, N.Y.; Auto Gear & Parts Co., Atlanta, Ga.; Meteor Car Co., Piqua, Ohio.
- Michigan: Puritan Autoparts Co., Detroit, Mich.; Standard Motor Parts Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Midland: Auto Gear Co., 844 Eighth Ave., New York, N.Y.; Auto Gear and Parts Co., Atlanta, Ga.; Auto Parts Co., Houston, Tex.; Midland Motor Co., Philadelphia, Pa.; Puritan Autoparts Co., Detroit, Mich.
- Miller: Puritan Autoparts Co., Detroit, Mich.
- Milwaukee: Erbes, L. C., St. Paul, Minn.; Smith A. O. Corp., Milwaukee, Wis.
- Mitchell: Mitchell Motor Car Co., Racine, Wis.; Puritan Auto Parts Co., Detroit, Mich.
- Mogul: Auto Salvage Co., Kansas City, Mo.
- Moline: Standard Motor Parts Co., Freeport, Ill.
- Monarch: Puritan Autoparts Co., Detroit, Mich.
- Mora: Philadelphia Machine Works, Philadelphia, Pa.; Puritan Autoparts Co., Detroit, Mich.
- Morgan: Steele, W. M., Worcester, Mass.
- Moyer: Auto Salvage and Exchange Co., Des Moines, Iowa; Puritan Autoparts Co., Detroit, Mich.
- Nance: Gorey & Co., Jos. C., 354 W. Fiftieth St., New York, N.Y.
- Niagara: Auto Gear & Parts Co., Atlanta, Ga.
- Northern: Puritan Autoparts Co., Detroit, Mich.
- Northwestern: Puritan Autoparts Co., Detroit, Mich.
- Nyberg: Puritan Autoparts Co., Detroit, Mich.
- Ohio: Puritan Autoparts Co., Detroit, Mich.
- Omaha: Puritan Autoparts Co., Detroit, Mich.
- Owen: Puritan Autoparts Co., Detroit, Mich.
- Owen Magnetic: Magnetic Auto Parts Co., 5th Ave. and 142d St., New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.; United Parts Co., Muncie, Ind.
- Palmer-Moore: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.
- Palmer-Singer: Auto Gear Co., 844 Eighth Ave., New York, N.Y.; Auto Parts Co., St. Louis, Mo.; Puritan Autoparts Co., Detroit, Mich.; Singer Motor Co., 102 West End Ave., New York, N.Y.
- Parry: Puritan Autoparts Co., Detroit, Mich.
- Partin-Palmer: Puritan Autoparts Co., Detroit, Mich.
- Pathfinder: American Motor Parts Co., Indianapolis, Ind.
- Patterson: Patterson Motor Car Co., Flint, Mich.; Puritan Autoparts Co., Detroit, Mich.
- Penn: Buda Co., Harvey, Ill.; Puritan Autoparts Co., Detroit, Mich.
- Penn-Thirty: Puritan Autoparts Co., Detroit, Mich.
- Pennsylvania: Central Auto Supply Co., Philadelphia, Pa.; Dougherty, Philadelphia, Pa.; Gorey & Co., Jos. C., 354 W. Fiftieth St., New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.; Stehle, Remy W., Philadelphia, Pa.
- Peru: Puritan Autoparts Co., Detroit, Mich.
- Petrel: Flier & Stowell, Milwaukee, Wis.
- Pierce-Racine: J. I. Case T. M. Co., Racine, Wis.; Puritan Autoparts Co., Detroit, Mich.
- Pope-Hartford: Boulevard Motor Co., Cambridge, Mass.; Hartford Motor Car Co., Hartford, Conn.; Puritan Autoparts Co., Detroit, Mich.; Rosenfield, J., Boston, Mass.; Walker & Barkman Mfg. Co., Hartford, Conn.
- Pope-Toledo: Auto Salvage Parts Co., Chicago, Ill.; Connecticut Auto Parts Co., Hartford, Conn.; Puritan Autoparts Co., Detroit, Mich.
- Pope-Tribune: Puritan Autoparts Co., Detroit, Mich.; Walker & Barkman Mfg. Co., Hartford, Conn.
- Poss: Puritan Autoparts Co., Detroit, Mich.
- Pratt: Elkhart Carriage & Motor Co., Elkhart, Ind.
- Princess: Auto Gear and Parts Co., Atlanta, Ga.
- Pullman: Pullman Motor Car Co., York, Pa.; Auto Parts Co., St. Louis, Mo.; Puritan Autoparts Co., Detroit, Mich.
- Queen: Puritan Autoparts Co., Detroit, Mich.
- Rainier: Puritan Autoparts Co., Detroit, Mich.
- Rambler: Nash Motors Co., Kenosha, Wis.; Wycoff Auto Salvage Co., Sioux City, Iowa; Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Randolph: DeKalb Wagon Co., DeKalb, Ill.; Puritan Autoparts Co., Detroit, Mich.
- Rapid: Auto Parts Co., Houston, Tex.; Puritan Autoparts Co., Detroit, Mich.
- R. C. H.: Puritan Autoparts Co., Detroit, Mich.; R. C. H. Corp., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Read: American Motors Parts Co., Indianapolis, Ind.
- Regal: Puritan Autoparts Co., Detroit, Mich.
- Reliable-Dayton: Puritan Autoparts Co., Detroit, Mich.
- Republic: Republic Motor Car Co., Youngstown, Ohio; Puritan Autoparts Co., Detroit, Mich.
- Revere: Polaris Electric Refrigerator Co., Logansport, Ind.
- Rider-Lewis: American Motors Parts Co., Indianapolis, Ind.; Autoparts Mfg. Co., Detroit, Mich.; Longaker Co., V. A., Indianapolis, Ind.; Puritan Autoparts Co., Detroit, Mich.; Wichita Auto Wrecking Co., Wichita, Kan.
- Richmond: Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Ross: General Parts Co., Detroit, Mich.; Puritan Autoparts Co., Detroit, Mich.
- Royal Tourist: Auto Parts Co., St. Louis, Mo.; Puritan Autoparts Co., Detroit, Mich.
- Rush: Diehl Motor Truck Works, Philadelphia, Pa.; Levene Motor Co., Philadelphia, Pa.
- Sampson: Puritan Autoparts Co., Detroit, Mich.
- Saxon: Puritan Autoparts Co., Detroit, Mich.; Auto Parts Co., St. Louis, Mo.
- Schacht: Puritan Autoparts Co., Detroit, Mich.; Schacht Motor Truck Co., G. A., Cincinnati, Ohio.
- Selden: Auto Parts Co., Houston, Tex.; Puritan Autoparts Co., Detroit, Mich.; Sattler's Machine Shops and Works, Philadelphia, Pa.; Shepard Auto Co., Brooklyn, N.Y.
- Scripps Booth: Puritan Autoparts Co., Detroit, Mich.; Auto Parts Co., St. Louis, Mo.
- S. G. V.: Service Gear and Machine Co., Reading, Pa.; Puritan Autoparts Co., Detroit, Mich.
- Speedwell: Puritan Autoparts Co., Detroit, Mich.
- Sphinx: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.; Sattler's Machine Shops and Works, Philadelphia, Pa.; Service Gear and Machine Co., Reading, Pa.
- Standard-8: Standard-8 Motor Car Co., Flint, Mich.
- States: Auto Auction Co., Chicago, Ill.
- Staver: Puritan Autoparts Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Sterling: Puritan Autoparts Co., Detroit, Mich.
- Stevens-Duryea: Stevens-Duryea Co., Chicopee Falls, Mass.; Boulevard Motor Co., Cambridge, Mass.; Colwell, F. C., Philadelphia, Pa.; Walk Hill Garage, Mattapan, Mass.; Puritan Autoparts Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Stephens: Standard Motor Parts Co., Freeport, Ill.; Auto Parts Co., St. Louis, Mo.
- Stoddard-Dayton: Mid-West Auto Parts Co., Council Bluffs, Iowa.
- Suburban: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.
- Sultan: Puritan Autoparts Co., Detroit, Mich.
- Thomas: Thomas Motor Car Co., Buffalo, N.Y.; Puritan Autoparts Co., Detroit, Mich.
- Thomas-Detroit: Puritan Autoparts Co., Detroit, Mich.
- Toledo: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.
- Touraine: Gorey & Co., Jos. C., 354 W. Fiftieth St., New York, N.Y.
- Traveler: Single Center Buggy Co., Evansville, Ind.
- Trumbull: Puritan Autoparts Co., Detroit, Mich.
- Victor: Auto Gear & Parts Co., Atlanta, Ga.; Adams Gear Co., New York, N.Y.
- Virginian: Auto Salvage & Exchange Co., Des Moines, Ia.
- Vulcan: Savage Arms Corp., Sharon, Pa.
- Wagenhall: Puritan Autoparts Co., Detroit, Mich.
- Wahl: Puritan Autoparts Co., Detroit, Mich.
- Warren: Puritan Autoparts Co., Detroit, Mich.
- Washington: Davis, Carey A., Washington, D.C.
- Waverly Electric: Longaker Co., V. A., Indianapolis, Ind.
- Wayne: Puritan Autoparts Co., Detroit, Mich.
- Welch-Detroit: Puritan Autoparts Co., Detroit, Mich.
- Welch-Pontiac: Puritan Autoparts Co., Detroit, Mich.
- Westcott: Westcott Motor Car Co., Cleveland, Ohio.
- Whiting: Puritan Autoparts Co., Detroit, Mich.
- Winton: Winton Service, Inc., Cleveland, Ohio.
- Woods-Mobilette: Fohrman-Lesterstone Co., Chicago, Ill.
- Yale: Puritan Autoparts Co., Detroit, Mich.
- Zimmerman: Auto Gear & Parts Co., Atlanta, Ga.; Auto Salvage and Exchange Co., Des Moines, Ia.

¹ Note: This list and some of the other lists of concerns in this book have not been revised for some time. To keep directory lists of this kind up to date is beyond the scope of this book. The idea in showing these lists is to inform the reader that there are such firms in existence. If the reader desires such information and will be specific in writing, the publisher of this book will supply more recent addresses. We are not responsible for wrong addresses or responsibility of concerns listed.

CARS NOT NOW MANUFACTURED; WHERE TO OBTAIN PARTS

- Blomstrom: Puritan Autoparts Co., Detroit, Mich.
 Borland: Puritan Autoparts Co., Detroit, Mich.
 Bour-Davis: Puritan Auto Parts Co., Detroit, Mich.
 Briggs-Detroit: Levene Motor Co., Philadelphia, Pa.
 Briscoe: Earl Motors Mfg. Service Co., Jackson, Mich.; Puritan Autoparts Co., Detroit, Mich.; Auto Parts Co., St. Louis, Mo.
 Broc Electric: Puritan Autoparts Co., Detroit, Mich.
 Brown: Great Western Automobile Co., Kalamazoo, Mich.
 Brush: Auto Parts Co., St. Louis, Mo.; Davidson Repair Shop, 227 W. Sixty-fourth St., New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.; Standard Motor Parts Co., Detroit, Mich.
 Burg: Wichita Auto Wrecking Co., Wichita, Kan.
 Bush: Victor Motor Co., York, Pa.; American Gear Co., Jackson, Mich.
 California: Puritan Autoparts Co., Detroit, Mich.
 Cartercar: Puritan Autoparts Co., Detroit, Mich.
 Carthage: Puritan Autoparts Co., Detroit, Mich.
 Cavac: Puritan Autoparts Co., Detroit, Mich.
 Century: Puritan Autoparts Co., Detroit, Mich.
 Chadwick: Auto Salvage Co., Kansas City, Mo.
 Chase: Auto Parts Co., St. Louis, Mo.
 Cinco: Puritan Autoparts Co., Detroit, Mich.; Queen City Auto Parts Co., Cincinnati, Ohio; Cincinnati Auto Parts and Wrecking Co., Cincinnati, Ohio.
 Cino: Northway Auto Parts & Sales Co., Cincinnati, Ohio; Puritan Auto Parts Co., Detroit, Mich.
 Clark: Puritan Autoparts Co., Detroit, Mich.; Wichita Auto Wrecking Co., Wichita, Kan.
 Coates-Goshen: Coates, J. S., Goshen, N.Y.
 Colburn: Colburn Automobile Co., Denver, Colo.; Puritan Autoparts Co., Detroit, Mich.
 Colby: Auto Gear Co., Minneapolis, Minn.; Puritan Autoparts Co., Detroit, Mich.
 Columbia: Columbia Motors Co., Detroit, Mich.
 Columbus Electric: Butler Mfg. Co. Knightstown, Ind.
 Continental: Puritan Autoparts Co., Detroit, Mich.
 Corbin: Barney's Auto Parts Co., 236 W. Fifth St., New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.
 Courier: Puritan Autoparts Co., Detroit, Mich.; Standard Motor Parts Co., Detroit, Mich.
 Courier-Clermont: Puritan Autoparts Co., Detroit, Mich.; Standard Motor Parts Co., Detroit, Mich.
 Crescent: Puritan Autoparts Co., Detroit, Mich.; St. Bernard Garage, St. Bernard, Ohio.
 Croxton: Puritan Autoparts Co., Detroit, Mich.; United Parts Co., Muncie, Ind.
 Croxton-Keeton: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.; Cincinnati Autoparts and Wrecking Co., Cincinnati, Ohio.
 Crow-Elkhart: Crow-Elkhart Motors Co., Flint, Mich.
 Cutting: Puritan Autoparts Co., Detroit, Mich.
 Dart: Auto Salvage Co., Kansas City, Mo.; Puritan Autoparts Co., Detroit, Mich.
 Davis: Dayton Auto Parts Co., 351-55 W. Fifty-second St., New York, N.Y.
 Dearborn-Detroit: Puritan Autoparts Co., Detroit, Mich.
 Decauville: Gorey & Co., Jos. C., 354 W. Fifth St., New York, N.Y.
 DeKalb: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.
 Demot: Puritan Autoparts Co., Detroit, Mich.
 De Tumble: American Motors Parts Co., Indianapolis, Ind.; Puritan Autoparts Co., Detroit, Mich.
 Detroit: Mid-West Auto Parts Co., Council Bluffs, Iowa.
 Diamond: Auto Gear Co., 844 Eighth Ave., New York, N.Y.
 Dolson: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.
 Dort: Puritan Autoparts Co., Detroit, Mich.; General Parts Corp., Flint, Mich.; Auto Parts Co., St. Louis, Mo.; Dort Motors, Inc., Flint, Mich.
 Dragon: Philadelphia Machine Works, Philadelphia, Pa.; Puritan Autoparts Co., Detroit, Mich.
 Drexel: Auto Gear and Parts Co., Atlanta, Ga.
 Drummond: Auto Gear and Parts Co., Atlanta, Ga.
 Dupont: Auto Gear and Parts Co., Atlanta, Ga.; Victor Motor Co., York, Pa.
 Durocar: Auto Gear Co., Minneapolis, Minn.; Auto Parts Co., St. Louis, Mo.
 Earl: Earl Motors Mfg. Service Co., Jackson, Mich.; Jackson Motor Parts Co., Boston, Mass.
 E.M.F.: Puritan Autoparts Co., Detroit, Mich.; Studebaker Corp., of America, Detroit, Mich.
 Edwards-Knight: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.; Willys-Overland, Inc., Toledo, Ohio.
 Elgin: Elgin Motor Service Co., Flint, Mich.; Auto Parts Co., St. Louis, Mo.; Puritan Autoparts Co., Detroit, Mich.; Jackson Motor Parts Co., Boston, Mass.; United Parts Co., Muncie, Ind.
 Elmore: Puritan Autoparts Co., Detroit, Mich.
 Empire: Gibson Co., Indianapolis, Ind.
 Enger: Enger Motor Car Co., Indianapolis, Ind.
 Everrett: Puritan Autoparts Co., Detroit, Mich.
 Ewing: Gorey & Co., Jos. C., 354 W. Fifth St., New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.
 F.A.L.: Puritan Autoparts Co., Detroit, Mich.
 Fisher: Auto Gear & Parts Co., Atlanta, Ga.
 Flanders: Auto Parts Co., St. Louis, Mo.; Auto Salvage Co., Tulsa, Okla.; Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.; Sattler's Machine Shops and Works, Philadelphia, Pa.; Service Gear and Machine Co., Reading, Pa.
 Flanders Electric: Levene Motor Co., Philadelphia, Pa.
 Fuller: Jackson Auto Co., Jackson, Mich.; Puritan Autoparts Co., Detroit, Mich.
 Gaeth: Gaeth Motor Car Co., Cleveland, Ohio.
 Garford: Puritan Autoparts Co., Detroit, Mich.
 G-J-G.: Grossman Auto Parts Co., White Plains, N.Y.
 Gleason: Auto Salvage Co., Kansas City, Mo.; Bauer Machine Works Co., Kansas City, Mo.
 Glide: Auto Gear Co., 844 Eighth Ave., New York, N.Y.; Auto Parts Co., Houston, Tex.
 Grabowsky: Puritan Autoparts Co., Detroit, Mich.
 Gramm: Puritan Autoparts Co., Detroit, Mich.
 Gramm-Logan: Garford Motor Truck Co., Lima, Ohio.
 Grant: Grant Motor Service Co., Detroit, Mich.
 Great Eagle: Auto Salvage Co., Kansas City, Mo.
 Great Smith: Auto Salvage Co., Kansas City, Mo.
 Great Western: Puritan Autoparts Co., Detroit, Mich.
 Grout: Red Arrow Auto Co., Orange, Mass.
 H.A.L.: United Parts Co., Muncie, Ind.
 Halladay: Barley Motor Car Co., Kalamazoo, Mich.
 Haynes: Haynes Automobile Co., Kokomo, Ind.; Puritan Autoparts Co., Detroit, Mich.
 Hatfield: Auto Gear & Parts Co., Atlanta, Ga.
 Havers: Gorey & Co., Jos. C., 354 W. Fifth St., New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.
 Hazard: Puritan Autoparts Co., Detroit, Mich.
 Henderson: Puritan Autoparts Co., Detroit, Mich.
 Henry: Gorey & Co., Jos. C., 354 W. Fifth St., New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.
 Hercules: Auto Gear & Parts Co., Atlanta, Ga.
 Herff-Brooks: Auto Salvage Co., Kansas City, Mo.; Wayne Works, Richmond, Ind.; Puritan Autoparts Co., Detroit, Mich.
 Herreshoff: American Motors Parts Co., Indianapolis, Ind.; Puritan Autoparts Co., Detroit, Mich.
 Hewitt: International Motor Co., Sixty-fourth St. and West End Ave., New York, N.Y.
 Houpt Rockwell: New Departure Mfg. Co., Bristol, Conn.
 Hudson Franklin: Boston Auto Parts Co., Boston, Mass.
 Imperial: Puritan Autoparts Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
 Indiana: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.
 Inter-State: Inter-State Motor Service Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
 Jackson: Jackson Motor Service Co., Detroit, Mich.; Auto Salvage Co., Kansas City, Mo.; Puritan Auto Parts Co., Detroit, Mich.
 Jeffery: Nash Motors Co., Kenosha, Wis.; Brown Auto Wrecking Co., Kansas City, Mo.; United Parts Co., Muncie, Ind.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
 Jenkins: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.; Puritan Autoparts Co., Detroit, Mich.
 Keeton: Puritan Autoparts Co., Detroit, Mich.
 Kernath: Puritan Autoparts Co., Detroit, Mich.
 Kermeth: Knox Motor Co., Springfield, Mass.; Puritan Autoparts Co., Detroit, Mich.
 Knox: Knox Motors Association, Springfield, Mass.; Wycoff Auto Salvage Co., Sioux City, Iowa.
 Krebs: Dayton Auto Parts Co., 1777 Broadway, New York, N.Y.
 Krit: Puritan Autoparts Co., Detroit, Mich.; Wycoff Auto Salvage Co., Sioux City, Iowa; Mid-West Auto Parts Co., Council Bluffs, Iowa.
 Lambert: Great Western Auto Co., Kalamazoo, Mich.; Lambert Auto Service Co., Indianapolis, Ind.; Wichita Auto Wrecking Co., Wichita, Kan.
 Lansden-Electric: Kelland Motor Car Co., Newark, N.J.
 Laurel: Auto Gear & Parts Co., Atlanta, Ga.
 Lenox: Puritan Autoparts Co., Detroit, Mich.
 Lewis: Puritan Autoparts Co., Detroit, Mich.; Mid-West Auto Parts Co., Council Bluffs, Iowa.
 Lexington: Lexington Motor Co., Connerville, Ind.
 Lion: Puritan Autoparts Co., Detroit, Mich.
 Liberty: Liberty Motor Car Co., Detroit, Mich.; Puritan Autoparts Co., Detroit, Mich.; Mitchell Service and Parts Co., 419 W. 55th St., New York, N.Y.; Columbia Motors Co., Detroit, Mich.
 Lippard: General Parts Co., Detroit, Mich.; American Gear Co., Jackson, Mich.
 Little: Puritan Autoparts Co., Detroit, Mich.
 Logan: Gramm Motor Truck Co., Lima, Ohio.
 Lozier: Puritan Autoparts Co., Detroit, Mich.
 Lyons-Knight: Service Gear and Machine Co., Reading, Pa.; Wolf Auto Parts & Tire Co., Indianapolis, Ind.
 McIntyre: Puritan Autoparts Co., Detroit, Mich.
 Marathon: Puritan Autoparts Co., Detroit, Mich.; Wolf Auto Parts and Tire Co., Indianapolis, Ind.

Differential ring gears and pinions can be obtained from the manufacturers of the cars or their dealers.

When ordering gears, in addition to the part number, furnish the name, year, and model of car and, if possible, the serial number and the number of teeth in the ring gear and pinion.

Fender Replacement

There are several concerns who manufacture fenders. A concern with fender replacements for several makes of popular cars and who has distributors in different parts of the United States is the Fostoria Pressed Steel Corp., Fostoria, Ohio.

Rims and Wheels

For concerns who carry a complete line of rims, wheels, rim bolts, lugs, nuts, etc., see page 603.

Radiator Replacements

For replacement of radiator cores, see page 740.

Electrical Service and Parts

There are a number of concerns specializing in electrical service. By referring to page 481, a listing of the different manufacturers of electrical apparatus will be found. The name and address of their nearest distributor or authorized service station will be furnished on request.

See also page 481 relative to armature exchange service.

United Motors Service, Inc. (Overseas Motor Service Corp. in foreign countries), through their several branches and authorized dealers, provide official repair and parts service on: *AC* air cleaners, silencers, fuel pumps, gauges, speedometers; *Bendix* drives; *Delco* auto radios, batteries, car heaters; *Delco-Lovejoy* shock absorbers; *Delco-Remy* electrical apparatus, carburetor controls; *Guidelamps*, lenses; *Harrison* radiators, cores, car heaters; *Hyatt* roller bearings; *Klaxon* horns; *New Departure* ball bearings; *North East* electrical apparatus, speedometers, horns.

Electrical service and parts can be obtained from the authorized service stations of manufacturers listed on page 481.

Specialized Automotive Services for Reconditioning a Car

There are concerns who specialize in reconditioning different parts of a car and some who are equipped to recondition all parts of a car. Many of the repair shops and garages send work that requires special equipment to these specialists.

An itemized list of some of the kinds of work requiring special equipment follows.

Engine

Bearings fitted, main and connecting rod
Bearings align reamed or bored to fit reground crankshafts
Camshafts straightened
Connecting rods aligned and straightened
Crankcases welded and repaired
Crankshafts reground
Crankshafts straightened
Cylinder-block tops resurfaced
Cylinder-block water jackets repaired
Cylinder, cracked, fitted with sleeves
Cylinder heads resurfaced
Cylinders reground
Cylinders rebored and honed

Cylinder scores repaired
Engines chemically cleaned
Pistons reamed for oversize piston pins
Pistons regrooved
Pistons turned and ground to fit oversize cylinders
Tappet screws refaced
Tappets or valve lifters refaced
Valve stem-guides reamed oversize
Valve seats reseated
Valves refaced and reseated
Valve-tappet guides reamed oversize

Engine Rebuilding

Some car manufacturers exchange rebuilt engines for worn engines on a fixed price basis. Some provide engine rebuilding service. Several independent concerns in different sections of the United States specialize on regrounding crankshafts, camshafts, cylinder blocks, and rebuilding engines.

Rebabbiting Service

A connecting-rod rebabbiting exchange service is explained in the section on engine bearings. Old connecting rods are exchanged for rebabbitted rods.

Axle

Alignment of wheels and axles
Axle housings and torque tubes straightened
Brake drums refaced
Disc wheels straightened
Drive and axle shafts straightened
Drive shafts and drive pinions fitted
Front axles straightened
Special chassis parts made and machined

Miscellaneous

Brake lining installed (sometimes handled by exchanging shoes)
Air brake equipment repaired
Hydraulic brake equipment repaired
Vacuum brake equipment repaired
Carburetors repaired
Fuel pumps repaired
Windshield wipers repaired
Radiators repaired
Universal joint yokes welded to propeller shafts
Oxy-acetylene and arc welding
Frames straightened
Body and fender dents removed
Body and fenders repaired
Tops repaired
Upholstering
Glass fitted
Painting

NOTE: For a book and literature on body and fender repairing see page 690 under "Body and Fender Repairing." See also, pp. 690-691B for automotive service literature on many other subjects.

a parts book by the car manufacturer and the price of each part is given.

The car manufacturer does not always make all parts of the car, but is supplied with many of them by other manufacturers, and in many instances some of the same parts the manufacturer used in his car can be obtained of replacement-parts houses.

When the manufacture of cars is discontinued and the manufacturer goes out of business, some concerns usually purchase the parts of the manufacturer and they are usually new parts.

Some of the automobile parts concerns also salvage cars of different makes and sell the parts, and very often a part can be secured at a very reasonable figure. Concerns in this line issue circulars giving the description of such parts and their condition.

It is a good plan, however, always to ask your customer if he wants genuine parts, standard brands, or used parts, and never to substitute.

Remember that it is false economy to try to save a few cents on the cost of the particular part that is to be replaced. The repairman should guarantee his work by using only quality guaranteed standard brands and the parts should conform to the car manufacturer's specifications, and should be secured from a reputable concern or manufacturer.

Parts

can be classified in general as

Axle shafts
Bearings; engine
Bearings; chassis
Bearing shims
Brake lining
Chassis bearings; plain, roller and ball, for wheels, rear axles, transmission, generator and starter bearings, etc.
Connecting-rod bearings
Connecting-rod bolts and nuts
Clutch facings
Drive shafts
Differential gears and parts
Fan belts
Flywheel starter ring gears (see "Gears" below)
Gaskets
Ignition coils
Ignition cable
Main bearings
Pistons
Piston rings
Piston pins
Pump packing
Pinion drive gears and shafts
Radiator hose
Silent chains
Steering knuckle king bolts and king pins
Spring bolts
Springs
Starter ring gears (steel for replacement)
Tie-rod bolts
Timing chains
Timing gears
Universal joints
Valves
Water pumps, etc.

A great many parts that are carried by the automotive replacement parts concerns can also be obtained of the automotive equipment or supply jobber, as listed on page 687.

These concerns distribute replacement parts:

Atlanta, Ga., Automobile Piston Co.
Atlanta, Ga., Southern Bearing and Parts Co.
Birmingham, Ala., Southern Bearing and Parts Co.
Boston, Mass., Standard Auto Gear Co., Inc.
Buffalo, N.Y., Great Lakes Motor Parts Co.
Chicago, Ill., Motive Parts Co. of America, Inc.
Chicago, Ill., Smith Bgs. Co., Inc. L.C.
Cincinnati, Ohio, Dorman Automotive Parts and Gear Co.

Note: We are not responsible for wrong addresses or responsibility of concerns listed.

For Orphan cars formerly on this page, see page 684.

These and some other lists in this book have not been revised for some time. See footnote p. 685.

Cincinnati, Ohio, Motive Parts Co. of America, Inc.
Denver, Colo., Denver Gear and Parts Co.
Des Moines, Iowa, Wm. H. Metz Co.
Detroit, Mich., Michigan Replacement Parts Corp.
Detroit, Mich., Puritan Auto Parts Co.
Duluth, Minn., S. & S. Auto Parts Co.
Indianapolis, Ind., Motive Parts Co. of America, Inc.
Kansas City, Mo., Auto Parts Distributing Co.
Kansas City, Mo., The Dayton Auto Parts Co.
Los Angeles, Cal., John H. Dielmann Co.
Memphis, Tenn., J. B. Cook Auto and Mach. Co., Inc.
Minneapolis, Minn., Automotive Service Co.
New Orleans, La., New Orleans Auto Supply Co., Inc.
New Orleans, La., M. H. Rykoski
New York, N.Y., Barneys Auto Parts Co., Inc.
New York, N.Y., G & B Motor Parts, Inc.
Philadelphia, Pa., P. D. Q. Company.
Portland, Oregon, West Bearing Co.
Sacramento, Cal., Henderson Bros.
Sacramento, Cal., Triangle Parts Co.
San Francisco, Cal., Triangle Parts Co.
San Francisco, Cal., Patterson Parts, Inc.
Seattle, Wash., Piston Service, Inc.
Seattle, Wash., The Northwest Bearing Co.
Springfield, Mass., L. L. Bousquet.
St. Louis, Mo., Auto Parts Co.
St. Louis, Mo., Standard Auto Parts Co.
St. Paul, Minn., Automotive Service Co.
Stockton, Cal., Triangle Parts Co.

These concerns are distributors of parts:

Allentown, Pa., Quaker City Motor Parts Co.
Atlanta, Ga., Motor Parts Corp.
Baltimore, Md., Quaker City Motor Parts Co.
Boston, Mass., Campbell Motor Parts Corp.
Buffalo, N.Y., Unit Parts Corp.
Calgary, Ont., Canada, Vancouver Parts Co., Ltd.
Chicago, Ill., Standard Unit Parts Corp.
Cleveland, Ohio, The Automotive Parts Co. of Ohio.
Columbia, S.C., Whitton Automotive Parts Co.
Columbus, Ohio, The Automotive Parts Co. of Ohio.
Dallas, Tex., Motor Parts Depot., Inc.
Denver, Colo., The Gall Auto Specialty Co.
Des Moines, Ia., Standard Motor Parts Co.
Detroit, Mich., Automotive Parts Corp. of Mich.
Fresno, Cal., Colyear Motor Sales Co.
Grand Rapids, Mich., Automotive Parts Corp. of Mich.
Harrisburg, Pa., Quaker City Motor Parts Co.
Indianapolis, Ind., Central Motor Parts Co.
Kansas City, Mo., General Auto Parts Co.
Los Angeles, Cal., Colyear Motor Sales Co.
Louisville, Ky., Edinger Motor Parts Co.
Memphis, Tenn., Standardized Parts Corp.
Milwaukee, Wis., Standard Unit Parts Corp.
Minneapolis, Minn., Standard Unit Parts Corp.
New Orleans, La., Standard Motor Parts Co.
New York, N.Y., Chadick, De Lamater Corp.
Oakland, Cal., Colyear Motor Sales Co.
Omaha, Nebr., Omaha Motor Parts Co., Inc.
Philadelphia, Pa., Quaker City Motor Parts Co.
Pittsburgh, Pa., Superior Motor Parts Co.
Portland, Ore., Colyear Motor Sales Co.
Richmond, Va., Standard Motor Parts Corp.
Salt Lake City, Utah, Mendenhall Auto Parts Co.
San Francisco, Cal., Colyear Motor Sales Co.
Seattle, Wash., Colyear Motor Sales Co.
Spokane, Wash., Colyear Motor Sales Co.
Springfield, Ohio, The Automotive Parts Co. of O.
St. Louis, Mo., Authorized Motor Parts Co.
St. Paul, Minn., Standard Unit Parts Corp.
Toledo, Ohio, Automotive Parts Corp. of Mich.
Toronto, Ont., Canada, National Automotive Parts, Ltd.
Vancouver, B.C., Vancouver Parts Co., Ltd.
Washington, D.C., Quaker City Motor Parts Co.
Winnipeg, Man., Canada, Moncrieff & Endress, Ltd.

Gears

Some of the manufacturers of starter flywheel ring gears and other gears are as follows:

Accurate Gear Co., Springfield, Ohio.
American Gear Co., Jackson, Mich.
Automotive Gear Works, Richmond, Ind.
Hueter Machine & Tool Co., Indianapolis, Ind.
Kaufman Metal Products Co., Toledo, Ohio.
Springfield Mfg. Co., Springfield, Ohio.
Western Gear Co., Detroit, Mich.
Warren Gear Products Co., Warren, Pa.

Note: See page 837 relative to fitting starter ring gears for Bendix drive.



Fig. 22. Armored cable: This type of cable is used in all high-grade wiring installations. Conductor is standard copper

MONEY-MAKING ADDITIONS TO THE GARAGE

There are several departments which can be added to the garage, all necessary and well worth the investment.

A supply and parts department is very remunerative, providing the proper supplies are carried.

It is necessary, however, to display the goods so that customers can see them and ask for them. Sales follow as a natural sequence. A very serviceable and attractive display bin is shown in Fig. 25. Fireproof metal bins are of course preferable to wood construction.



Fig. 25. Steel display counter and shelving for accessory stores, service stations, dealers, etc.

Fig. 25A. Tool unit made of steel, for keeping tools handy in the shop or displaying them in the parts department.

Fig. 25B. Accessory display unit made of steel for convenient storage and display of accessories, etc. (Illustration from David Lupton's Sons Co.)

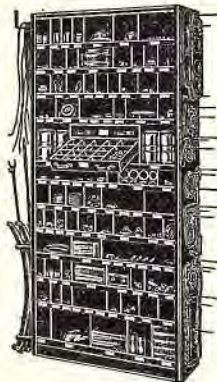


Fig. 25C. Accessory display unit, size 84" high, 12" deep, 48" wide. The case of three drawers contains 51 small compartments. Other units can be added (The Berger Mfg. Co., Canton, Ohio).¹

A sales and service chart is shown in Fig. 26. When the motorist drives up to your garage for gas or oil, or for air for his tires, give his car the quick once-over and see if you can't sell him some accessories.

When a motorist asks for an accessory, this should suggest something else that you can sell him. But it is not enough to ask him if he wants it. You have got to tell him why he ought to have it. That's what these selling arguments are for. Use them!

Tire department: A small or large vulcanizer for repairing tires. See discussion of the subject "Tires."

EQUIPMENT, PARTS AND SUPPLIES

Equipment and Maintenance Tools

The repairman or garage owner obtains his equipment from automotive equipment concerns, such as those listed on pages 687, 672, 803. Maintenance tools, material and supplies are also obtained from these sources.

¹ Some of the concerns who supply metal bins and racks for displaying and storing all kinds of automotive parts, accessories material, etc., for garages, service stations and repair shops, not only for small parts but bulky parts such as fenders, radiators, etc. They also supply racks for automobile glass and display shelving and counters for dealers, garages and accessory stores. Some of these are as follows: Lyon Metallic Mfg. Co., Aurora, Ill.; The Berger Mfg. Co., Canton, Ohio.; David Lupton's Sons Co., Philadelphia, Pa., and Detroit, Mich.

No. 16 gauge insulated with rubber and varnished fabric. Sherardized protecting cover on outside. Diameter, 3/16".

Figs. 23, 24. Spark and throttle ball-joints, used for connecting magneto timer levers and carburetor throttle lever, with levers on steering wheel. They eliminate all lost motion and give more perfect control. The screw end fits the timer and carburetor lever; the tapped hole fits the connecting rod. They come 25 in a box, assorted.

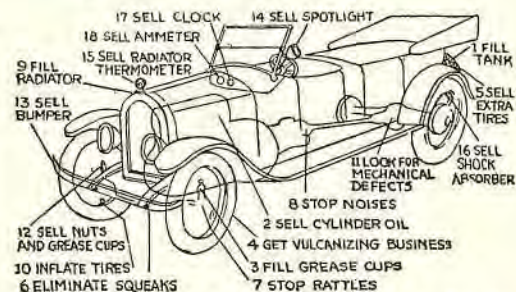


Fig. 26 shows a brief list of merchandise or auto supplies, etc., which the garage dealer ought to sell to his customers.

A battery charging and repair department: For recharging, starting, lighting, and ignition batteries. See "Storage Battery" Instruction.

During the winter months, there is much more of such battery recharging work brought to the garages because the cold weather reduces the charge-holding capacity of the storage batteries, while at the same time the cold engines require more current from the batteries to start them.

Electric testing and repair department. See Index under "Electric testing and repairs."

Engine reconditioning, such as crankshaft and cylinder grinding, bearings aligned, pistons and rings fitted, etc.

Oxy-acetylene outfit: For welding and carbon cleaning, see Index.

Carbon removing outfits for removing carbon from engine. See Index.

Radiator Repairs. See Index.

A lubricating service station. See page 673.

The car rental and towing service is something worth considering, and can be added in time. See page 676.

Lacquering cars does not take a very large investment, and one or two men could be kept busy; see pages 648, 756.

Of course, with all this, more room will be necessary, but it is surprising in how small a space all these departments can be carried on, if properly planned.

Automotive equipment or automotive supply jobbers carry all kinds of equipment for garage and shop use and also supplies and some lines of replacement parts. On page 687 is a list

It is a good idea for a repairman to get in touch with a good supply house nearest to him. **Note:** Don't feel offended when a business house requests references and asks that you give them a report as to your assets and liabilities. They are establishing your credit rating.

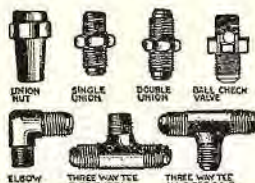
When it is necessary for a repairman to replace the parts of a car, he can obtain them through the agent of the car in the locality, who is supplied with

S. A. E. Fuel and Lubrication Tube Fittings: Flared Type¹

These are made of cast brass for use on carburetors, oil and gasoline pipe lines, etc., and are to fit tubing with outside diameter as listed.

UNION NUT					
Size tube (o. dia.) ²	1/4"	5/16"	3/8"	7/16"	1/2"
S. A. E. thread...	7/16x20	1/2x20	3/8x18	11/16x16	3/4x16
Length.....	15/16"	1 1/8"	1 5/16"	1 1/2"	1 3/8"

SINGLE UNION					
Size tube (o. dia.) ²	1/4"	5/16"	3/8"	7/16"	1/2"
I. P. thread.....	1/8"	1/8"	1/4"	1/4"	3/8"
S. A. E. thread...	7/16x20	1/2x20	3/8x18	11/16x16	3/4x16



DOUBLE UNION					
Size tube (o. dia.) ²	1/4"	5/16"	3/8"	7/16"	1/2"
S. A. E. thread...	7/16x20	1/2x20	3/8x18	11/16x16	3/4x16

BALL CHECK VALVE					
Size tube (o. dia.) ²	1/4"	5/16"	3/8"	7/16"	1/2"
I. P. thread.....	1/8"	1/8"	1/4"	1/4"	3/8"
S. A. E. thread...	7/16x20	1/2x20	3/8x18	11/16x16	3/4x16

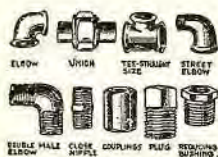
ELBOW					
Size tube (o. dia.) ²	1/4"	5/16"	3/8"	7/16"	1/2"
I. P. thread.....	1/8"	1/8"	1/4"	1/4"	3/8"
S. A. E. thread...	7/16x20	1/2x20	3/8x18	11/16x16	3/4x16

THREE-WAY TEE PIPE THREAD					
Size tube (o. dia.) ²	1/4"	5/16"	3/8"	7/16"	1/2"
I. P. thread.....	1/8"	1/8"	1/4"	1/4"	3/8"
S. A. E. thread...	7/16x20	1/2x20	3/8x18	11/16x16	3/4x16

THREE-WAY TEE; ALL SIDES S. A. E. THREAD					
Size tube (o. dia.) ²	1/4"	5/16"	3/8"	7/16"	1/2"
S. A. E. thread...	7/16x20	1/2x20	3/8x18	11/16x16	3/4x16

Brass Pipe Fittings³

See Index for "Pipe specifications," and for "pipe threads."²



ELBOW				
Size.....	1/8"	1/4"	3/8"	1/2"

UNION				
Size.....	1/8"	1/4"	3/8"	1/2"

TEE-STRAIGHT SIZE				
Size.....	1/8"	1/4"	3/8"	1/2"

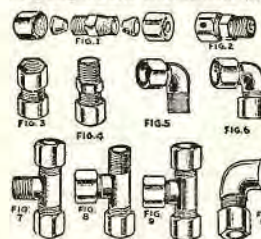
STREET ELBOW				
Size.....	1/8"	1/4"	3/8"	1/2"
DOUBLE MALE ELBOW				
Size.....	1/8"			
CLOSE NIPPLE				
Size.....	1/8"	1/4"	3/8"	1/2"
COUPLINGS				
Size.....	1/8"	1/4"	3/8"	1/2"
PLUG				
Size.....	1/8"	1/4"	3/8"	1/2"
REDUCING BUSHING				
Size.....		1/4"	3/8"	1/2"

Solderless Compression Couplings¹

Solderless fittings for gasoline and oil lines,¹ used for connecting tubing on gasoline and oiling systems without swaging or soldering.

They are made for 3/16", 1/4", 5/16", 3/8" and 1/2" outside diameter tubing; 1/4" size is generally used.

(1) Showing how ends are drawn together. (2) Check valve, straight. (3) Tapered female 1/8" or 1/4" pipe, one end. (4) Nipple union male 1/8" or 1/4" pipe, one end. (5) Elbow male. (6) Elbow coupling. (7) Tee coupling on opposite ends, 1/8" or 1/4" pipe thread (male) on other. (8) Tee angle coupling, male thread one end. (9) Tee angle on three ends. (10) Elbow coupling on one end, female pipe thread on other.



The size threads on the solderless compression couplings are as follows: 1/4"—7/16x24 thread; 5/16"—3/8x24 thread; 3/8"—17/32x24 thread.

All 1/4" and 5/16" tubing manufactured with iron pipe thread nipples have a 1/4" iron pipe thread. The 3/8" couplings with iron pipe thread nipples have a 1/4" iron pipe thread.



Fig. 11. Shut-off cocks; Fig. 12. Priming cups; Fig. 13. Priming cups for V-type engine.

Fig. 15. Rubber hose for radiators should be carried in all stock rooms. (See page 1055 for size for different cars.)

Fig. 16. Hose clamps are necessary. This type is the Sherman wrought brass clamp to fit radiator hose.

4-ply hose	4-ply hose	4-ply hose
3/4" inside diam.	1 1/2" inside diam.	2 1/2" inside diam.
1" inside diam.	1 3/4" inside diam.	2 3/4" inside diam.
1 1/8" inside diam.	2" inside diam.	3" inside diam.
1 1/4" inside diam.	2 1/4" inside diam.	

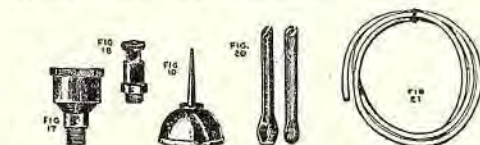


Fig. 17. Grease cups ought to be carried in every stock room. The sizes of grease cups run as follows: 000—1/8" pipe thread; 00—1/8" pipe thread; 0—1/8" or 1/4" pipe thread. The diameter of 000 is 3/4"; 00 is 1"; and 0 is 1 1/4".

Fig. 18. Oil cups run as follows: No. 1—1/4 x 32 thread, 3/8" diameter. No. 2—5/16 x 32 thread, 7/16" diameter. No. 3—3/8 x 24 thread, 1/2" diameter. No. 4—7/16 x 24 thread, 9/16" diameter.

Fig. 19. Oil cans which are in demand.

Fig. 20. Cotter pins: An assortment of cotter pins. 3/4", 1", 1 1/4", 1 3/4", and 2" lengths.

Fig. 21. Brass tubing: Annealed seamless brass, size 1/4", 5/16", and 3/8".

¹ Can be secured of automobile supply houses. Some of the manufacturers are Commonwealth Brass Corp., Detroit, Mich.; E. Edelmann & Co., Chicago, Ill.; The Imperial Brass Mfg. Co., Chicago, Ill.

² I. P. means iron pipe size.

³ Outside diameter.

Some of the Small Supplies and Fittings for Stock Room

The assortment listed below, as well as all other supplies, can be secured of automobile supply houses, such as listed on page 687. See also page 682.

Asbestos—sheet and wicking.
Babbit metal—for bearings.
Blue, Prussian, for "spotting in" bearings.
Body polish—brass and nickel.
Bolts—stove and carriage, assorted sizes.
Brake band rivets, Nos. 7, 8, 9, and 10 (copper).
Brake lining—see Index.
Brushes—for generator and motor.
Brushes—paint, scratch, file.
Bushings—for crank shafts.
Candle wicking—for pump packing.
Carbide—in cans.

U. S. E. AND S. A. E. THREADS



An assortment of 12 in a box. Two each, $\frac{1}{2}$ -inch bolt, 1 and $\frac{1}{4}$ -inch long. Two each, $\frac{3}{8}$ -inch bolt, 1 and $\frac{1}{4}$ -inch long. Two each, $\frac{1}{2}$ -inch bolt, $\frac{1}{4}$ and $\frac{1}{2}$ -inch long.

S. A. E. CASTELLATED HEXAGON NUTS



An assortment of 16 in a box. Four each, $\frac{1}{2}$, $\frac{3}{8}$ -inch; three $\frac{1}{4}$ -inch; two each, $\frac{3}{16}$, $\frac{1}{8}$ -inch. All perfect, well finished nuts.

STANDARD HEXAGON NUTS



An assortment of 24 in a box. Standard threads. Eight each, $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$ -inch. All perfect, well finished nuts.

LOCK WASHERS



An assortment of 10 each in the following sizes: $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$ -inch; three each, $\frac{3}{16}$, $\frac{1}{8}$ -inch.

CAMPBELL SPRING COTTERS



100 spring cotter pins assorted sizes; all sizes for automobile work put up in boxes.

TAPER PINS



An assortment of 40 in a box. Six sizes, from No. 1 to No. 6. High grade, turned pins.

Celluloid sheets—for top curtains.
Chalk line—for aligning wheels.
Chamois—for washing car.
Clamps—hose and screw.
Cloth—crocus and emery.
Cocks—compression and pet.
Cotter-pins—assorted sizes.
Cup and transmission grease.
Cylinder oil—light, medium, heavy.
Drill rods and drills.
Dry cells—testing not less than 25 amperes.
Electric lamp bulbs—see Index.
Ells—brass; for gasoline and oil lines.
Emery Cloth—No. 00 to No. 1.
Felt—sheet and washers.
Fibre—sheet and block.
Flux—for soldering aluminum and brass, etc.
Gaskets assorted—copper, asbestos lined for valve caps, carburetor, exhaust and inlet manifold, spark plugs, etc.
Gas tank keys—for Prest-O-Lite gas tanks.
Gas tips— $\frac{1}{2}$ ft. and 1 ft. sizes.
Graphite—powdered and flake.
Grease cups— $\frac{1}{8}$ ", $\frac{3}{8}$ ".
Hand washing compound.
Hemp wicking—for packing.
Hose—for radiator and gas.
Hose clamps—for radiator hose.
Inner shoes—for blow outs.
Inner valve parts—for tire valves.

Iron—bars and rods.
Iron—sheet.
Kerosene—for general cleaning.
Key stock—in bars.
Keys—Woodruff, Whitney and straight.
Lard oil—for thread cuttings, tapping and drilling.
Leather—(heavy) for under radiator and bodies and refacing cone clutches.
Lock washers— $\frac{1}{4}$ " to $\frac{3}{8}$ ".
Moboline, Raybestos, multibestos, etc.—for packing.
Nails—assorted.
Neatsfoot oil—for clutch.
Outer shoes—for cuts in casing.
Paper—heavy brown, sand, emery.
Pipe plugs—iron and brass $\frac{1}{8}$ " to $\frac{3}{4}$ ".
Platinum points—for interrupters, and magneto.
Priming cups.
Rivets—iron and copper, assorted.
Rubber—matting.
Rubber—sheet packing $1/32$ " to $3/16$ ".
Rubber—tubing for gas, air, tire hose, etc.
Screws—machine, cap, lag, wood and set.
Sheet—iron, brass, copper, tin and lead.
Shellac—for gaskets, etc.
Shims—laminated.
Soldier—half and half, string and aluminum.
Soldering compound and acid.
Spark plugs— $\frac{1}{2}$ ", S. A. E., metric.
Spring—steel and assorted springs.
Steel bars: a few feet of $\frac{1}{4}$ ", $\frac{3}{8}$ ", $\frac{1}{2}$ ", $\frac{3}{4}$ ", $\frac{1}{2}$ ", and 1" iron bars; also steel, brass, and wire rods.



Gasket, Assorted



License Bracket Bolt and Nut



Copper Wire Terminals



Spring Assortment



Machine Screws and Nuts, Assorted

Steel rods—bar, tool.
Switches—push, snap.
Tacks—assorted sizes.
Tape—adhesive; for electric wiring.
Taper pins— $\frac{1}{4}$ " to $\frac{3}{8}$ ".
Tees— $\frac{1}{8}$ ", $\frac{1}{4}$ " brass for gas lines.
Tubing—copper, brass, for gas and oil lines $\frac{1}{8}$ ", $\frac{1}{4}$ ". This tubing generally comes hard, but can be annealed (softened) by heating it.
Unions—brass, $\frac{1}{8}$ ", and soldering connections for gasoline lines.
Valve caps—for leading engines, valve caps for tire valves.
Valve grinding compound.
Valves—for gasoline and oil lines, tire valves and oversize valves for engine.
Washers—punched, split, and brass.
Wire—copper, brass, spring, piano, and insulated.
Wire—for wiring cars, such as: primary flexible cable and secondary cable.

Copper Gaskets for Spark Plugs

S. A. E: $\frac{3}{8}$ " (inside diameter $\frac{1}{8}$ "; outside diameter, $1\frac{1}{8}$ ").
Half inch: (inside diameter, $27/32$ "; outside diameter, $1\frac{1}{32}$ ").
Metric: (inside diameter, $23/32$ "; outside diameter, $63/64$ ").

Assorted Piston Rings

Select sizes of piston rings for those cars most popular in your locality. See also, page 1055.

Note: Subjects, such as "Automobile Parts Supply Houses," "Gear Manufacturers," etc., formerly on this page have been transferred to pages 682, 687.

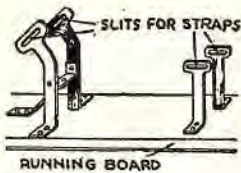


Fig. 64

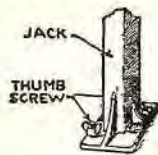


Fig. 65

Fig. 64. This is a detail drawing of the jack mounting shown on the service car illustrated in Fig. 60. In this case 5-ton jacks are carried, though any size can be substituted. Get them big enough to care for the heaviest work to be done, and they will also serve for light work.

Fig. 65. The service jacks can be carried bolted to the running board, like this, thumb-screws being used for quick action.

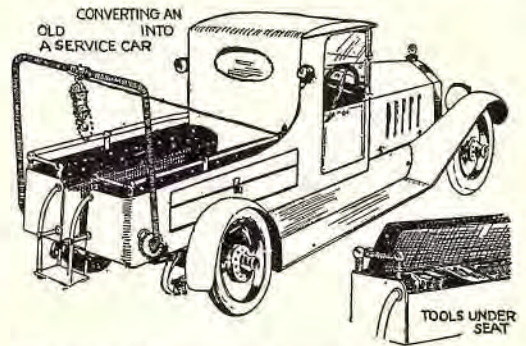


Fig. 66. Another example of a service car

THE STOCK ROOM

More money is lost in the repair shop and garage than in any other part of the business by having supplies scattered over the shop promiscuously.

Every repair shop, no matter how small, should provide a stock room with a good lock and key, and

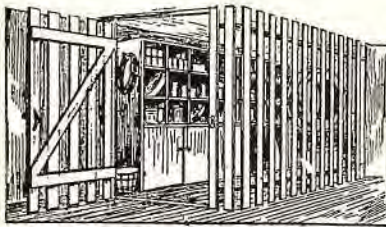


Fig. 67

everything in the way of supplies should be kept therein. (See Fig. 67.)

Systematic arrangement and a place for everything and everything in its place will save time and money.

The stock room is generally placed in some convenient place in the garage or repair shop. It is usually constructed of lattice work with a good Yale lock on the door. In large shops the stock room is in charge of a responsible person, whose business it is to keep the stock replenished and deliver material to the workmen and customers.

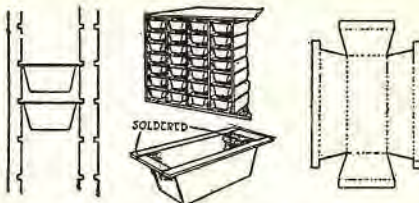


Fig. 68. Small parts, such as screws, bolts, washers, nuts, gaskets, and the like, are conveniently kept in tin drawers, as illustrated. The drawers are cut from a single piece of tin and are soldered, as shown by the heavy lines. The drawers slide in grooves cut in planks placed vertically. The grooves are made with a saw and chisel. The advantage of this method of storing parts is that the construction of the receptacles is very inexpensive, and maximum convenience is afforded. It is possible to see what is in the various drawers without pulling them out, which is a feature peculiar to this design, and saves considerable time when the exact drawer a certain part is in is not known.

Supplies in the rubber line: Repair shops can make extra money by carrying rubber supplies which are generally made by tire concerns. Some of these are as follows: Automobile rubber mats which come in rolls 3/32" to 1/8" thick and 35" to 48" wide; matting also comes corrugated and perforated; radiator hose; tire tape; rubber tubing; tire inflating tubing (comes in black, white, or red; sizes 1/8", 5/32", 3/16", and 1/4" inside diameter).

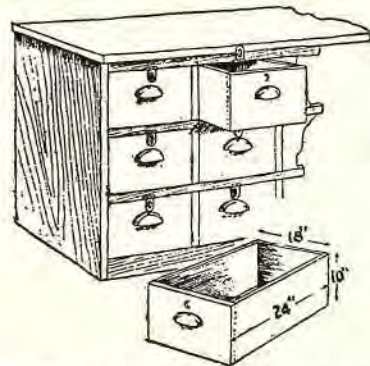


Fig. 69. Substantial drawers of large size provide convenient means for storing parts removed from cars that are being repaired. The usual method is to place the parts on the bench but this is objectionable because there is always danger of their being mislaid or used on other cars. A drawer 10" x 18" x 24" is large enough to take all the ordinary parts, such as bolts, nuts, washers, carburetor, magneto, pistons, connecting-rods, bearings, etc. The drawer may be placed at the side of the car, and as soon as all the parts have been removed it may be put back in the cabinet. A padlock safeguards the parts until they are needed again. These drawers also aid in keeping the shop neat and protect the parts from dirt. The top of the cabinet may be used as a bench or table.

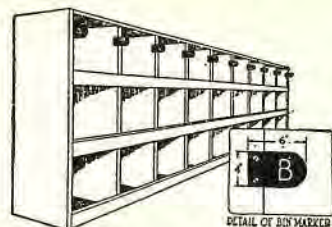


Fig. 70. This stock-bin marker permits ready location of any bin in the stock room. It is a sheet metal tag, bearing the number of the bin to which it is attached. As it projects out into the aisle, and is large enough to be easily read, the location of any desired bin may be seen at a glance.

Fig. 58C. Portable floor crane. The combination wrecking crane which is shown in the rear of service car (Fig. 58A) can be quickly converted into a portable floor crane by mounting it on its steel base as shown above. Capacity as a floor crane is 1½ tons and lifts 7 ft.



How to Make a Service Car

A service car is necessary in all up-to-date garages. It bears the same relation to a service station as does an ambulance to a hospital. It is a traveling representative of the service station, and should impress the public that quick, clean, and efficient service is given.

Any old chassis can be utilized for the purpose, and by following the dimensions in the table below (Fig. 59), a very attractive and serviceable car can be constructed.

Table of Service Car Body Dimensions

As Taken From Representative Detroit Service Cars

Car Model	A	D	E	F	G	H	I	J	L	M
Hudson 4-37	70	39½	20	14	12	15	12	70	43½	18
Cadillac 53	84	28	23	12	12	19	14	53	55	15
Studebaker 4-38	58	25½	25	8	10	18	12½	55	45	11
Ford T 48-up	O-up	15½	---	---	---	---	---	48	34	15½
Chevrolet 4-90	55	29	16	8	9	---	13*	43	32	13½
Dodge ---	60	35	19	11	8	16	12	43	47	17
Chalmers 5-15	68	31	24½	10	11	12	10	48	45	20
Hupmobile 32	47	23	15	9	5	---	---	50'	41	13
Page 6-46	68	30	22	10	10	---	12	52	54	12

(*—seat on one side only.)

All dimensions in inches.

Fig. 59. Dimensions referring to Fig. 61

The figures given are intended to be for the average requirements of the average service car built on the various chassis which are listed in the table.

One very important point to bear in mind is that the service wagon must be attractive in appearance—clean, well-painted, and it must run smoothly and quietly. It will be one of the best investments you can make.

Painting: Cars giving service are painted English vermillion, with black hood and

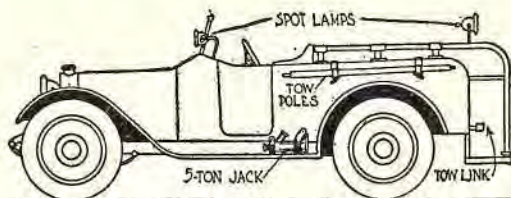
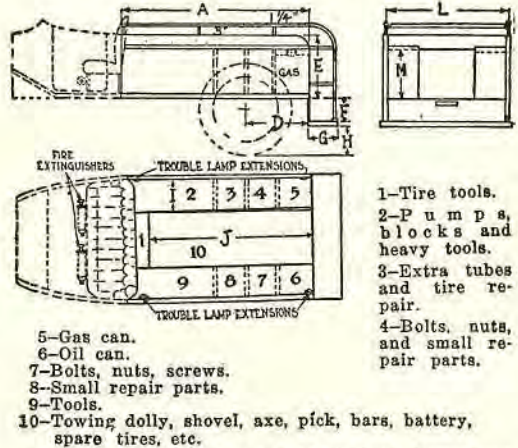


Fig. 60.

Note particularly the method of carrying the towing pole, the jack mounting on the running board, and the location of the several spot lamps.

running gear.

If the dealer is giving service on a particular make of car, he should find if a standard service car color is used; if not, the car may be painted any bright color that will give distinction.



- 1-Tire tools.
- 2-Pumps, blocks and heavy tools.
- 3-Extra tubes and tire repair.
- 4-Bolts, nuts, and small repair parts.
- 5-Gas can.
- 6-Oil can.
- 7-Bolts, nuts, screws.
- 8-Small repair parts.
- 9-Tools.
- 10-Towing dolly, shovel, axe, pick, bars, battery, spare tires, etc.

Fig. 61. Here is a detail drawing of the body shown above. The lettered dimensions on the drawing are given in the table (Fig. 59). The figures refer to the location of the various tools and accessories.

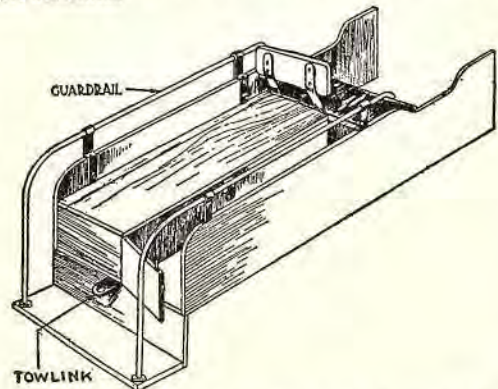


Fig. 62. An alternative type of body, built especially for very light chassis, is often desirable, in which case the arrangement can be made something like this. This is a body that is used quite successfully. There is an almost endless variety of arrangements, and in laying out a car a shop foreman should be guided by the particular class of work he expects to be called upon to do.

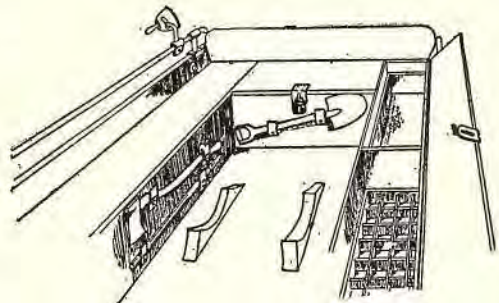


Fig. 63. This is a view of the interior of the service car shown in Fig. 60. Note the chocks and the neat arrangement of the tools, the seat at the right not being shown, so that the compartments are visible.

Note: A wrecking crane can be installed by modifying the interior of car and allowing room for same.

TOWING TRUCKS, WRECKING CRANES, SERVICE CAR, ETC.

A towing truck with devices for towing in disabled cars is a necessity and a profitable investment.

This device is also sometimes called a "dolly" and the Weaver Mfg. Co. calls its make "an auto ambulance."

Towing trucks are suitable for towing in cars where either the front or rear axle is disabled. For instance, if the rear axle is out of commission and the car cannot be towed from the front end, then it is necessary to place a dolly under the rear axle and to tow the car backwards, or from the rear end.

In this instance the steering wheel can be tied by passing a light rope around the windshield brace, and then tying it to the steering wheel and then to the other side of the windshield brace, which will keep the front wheels in line.

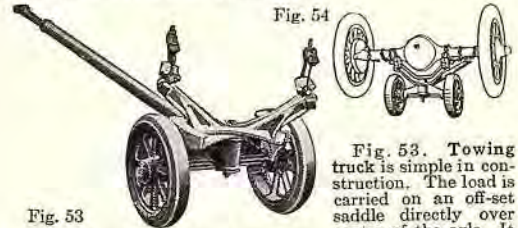


Fig. 53. Towing truck is simple in construction. The load is carried on an off-set saddle directly over center of the axle. It is equipped with roller bearings, located in the hubs, which are lubricated through large grease cavities; 14" wheels, 11 ft. massive two-inch telescoping towing pole, made from malleable iron and steel. It can be attached to the front or rear axle of any car.

Fig. 54. Shows the towing truck in place under a rear axle

A Home-Made Towing Truck

It will probably be cheaper to purchase a towing truck, but for those who have the time and inclination to make it themselves a brief description is given. (See Fig. 55.)

The heavy metal wheels are 11" di., 6" hub, 1 1/2" spindle. A tongue, preferably an I-beam steel member about 8' or 10' long with a coupling pin to couple to the tow link of the service car is mounted on the heavy metal axle of the dolly (towing truck). A hook-shaped flat piece with a hook at each end is provided to set the axle or differential housing on and to hold the axle in place.

Then chains are passed around the axle housing and fastened to the axle of the dolly, in order to keep the axle from moving sidewise. The rear end of the service car is then coupled to the end of the dolly and the car is towed backwards. The axle of the "dolly," in fact all parts, must be very substantial, as the vibration is very great. Chains with catch hooks should be provided to pass over the axle to prevent side play.

Towing Pole

A towing pole is shown in Fig. 56 and a towing bar in Fig. 57. Methods of using a rope Fig. 58.



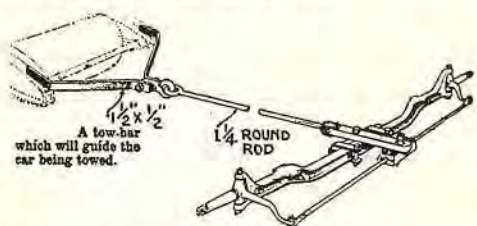
Fig. 56. Towing pole. With this device a car can be pushed or pulled. This towing pole supplies a rigid connection between towing car and disabled car, which prevents jamming on sudden stops or down grades.

The two clamps enable the pole to be rigidly clamped to front or rear of any car.

The two hooks form simple and effective universal joints which allow ample play in any direction when turning corners, towing over rough roads, etc.

Pole is of double-strength steel tubing in two sections, one telescoping within the other. Length adjustable from 5 ft. 6 in. to 8 ft. (Weaver Mfg. Co., Springfield, Ill.).

Fig. 57. A tow-bar whereby two cars may be brought in by one driver. A towing bar, attached to the rear of the driven car, pulls the towed car by a clamp in the front axle.



The bar extends behind the axle, and a stud on a clamp on the tie rod goes in a hole in the bar. In this way, when the bar turns, it moves the tie rod, and the towed car follows its leader.

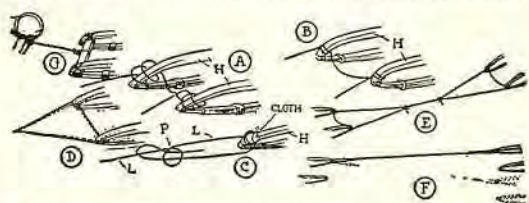


Fig. 58. Right and wrong methods of securing the tow rope to the vehicle to be towed. The best way is shown at (G), a piece of wood being tied under and across the frame horns as illustrated, and a single rope connecting it to the rear axle of the towing vehicle. The rope should be as long as convenient, and should be attached as near the outer end of the axle of the towing car as possible.

To loop the rope under the frame as at (D) is very bad, as a severe strain would bend the horns inward, as indicated by the dotted lines.

The bowline knot is the best to use at all times, as it is easy to make and just as easy to untie; it is illustrated at (C). Attention is called to the cloth wrapped (H).

When a bar of wood is not readily obtainable, and a heavy car is to be towed, the rope may be secured as illustrated at (E), two half-hitches being used, as shown at (A), to secure the rope to the horns of the frame, the rope between the two horns being left slack. When using this method, the bights also should be as long as possible. Two long bights are shown at (E); an undesirably short bight is depicted at (D). (A) shows how the two half-hitches are made, and (B) shows how they look when drawn taut, the slack being shown in the rope between the horns (H) to prevent their being drawn together at (D).

The knots at (A) and (C) are the most useful. Their advantage over other knots is that they will neither slip nor jam. (Motor Age.)

Wrecking Crane

A wrecking crane is a very profitable investment. There are a number of good wrecking cranes or derricks on the market. The one shown in the illustration is 2 1/2-ton crane and is adjustable at almost every angle. This crane is provided with two adjustable handles, making it possible for two men to operate it for heavy loads. A 5-ton crane is also made.



Fig. 58A. Shows how the wrecking crane is intended to be attached to the rear of a service car.



Fig. 58B. Shows how the crane can be used to lift the load and carry it. The crane can also be used as a portable floor crane, as shown in Fig. 58C

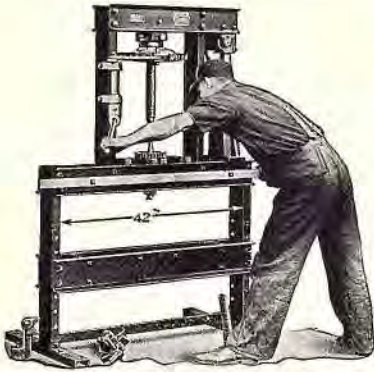


Fig. 45. A 22-ton press. Combination press, consisting of a powerful screw press, a high-speed rack and pinion sensitive press, and a straightening attachment all in one unit. Its 42' clearance is necessary for wide work and straightening jobs; its 30-ton capacity is required to handle all auto work; the rack and pinion press is essential for light work, and the straightening attachment is used continuously in every garage.

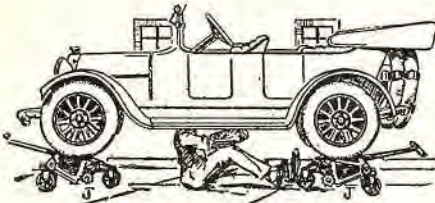


Fig. 46. Car raised by twin jacks.

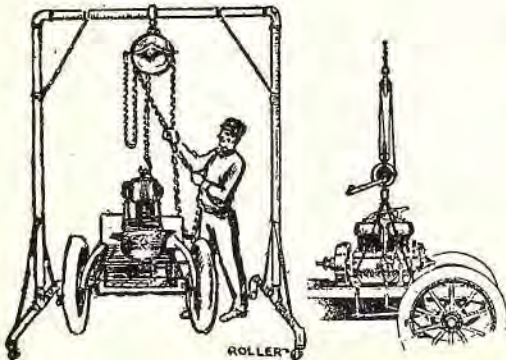


Fig. 47. A home-made chain hoist and frame for lifting engines from the chassis. The frame is made of heavy iron pipe with rollers.

Fig. 48. The Pull-U-Out is a combination device. It can be used as a hoist and also for pulling cars out of mud holes, etc. Can be carried in a car.

This device has advantages over the old-fashioned block and tackle, being lighter and more powerful. A pressure of 30 lbs. exerted on the handle will lift one ton, whereas a triplex chain block would require 82 lbs., and an ordinary block and tackle 176 lbs.

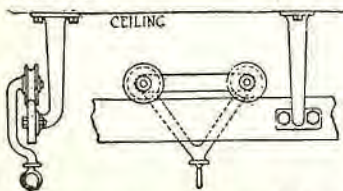


Fig. 49. An overhead railway for repairshop use may be patterned after those in use in large butcher shops. It consists of a track made out of stock about $\frac{1}{2}' \times 2'$, and suspended from the ceiling by arms at frequent intervals. On this track is placed a cap, to which the block and tackle is attached.

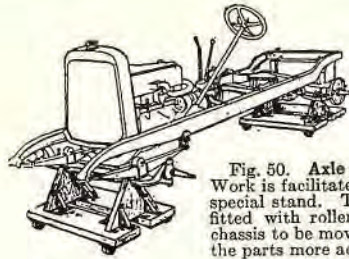


Fig. 50. Axle stand (home-made). Work is facilitated by the use of this special stand. The one illustrated is fitted with rollers and permits the chassis to be moved about, rendering the parts more accessible.

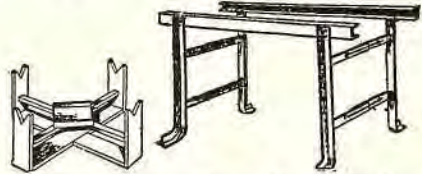


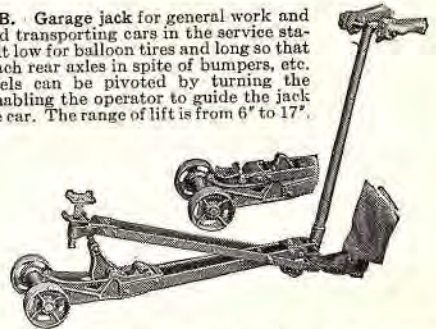
Fig. 51. Though designed for work on the Ford rear axle, this stand could readily be adapted to the requirements of many makes of axles. The ends of the axle are supported on notched uprights, about 30 in. from the floor, and the torque tube is placed on either of two uprights similarly notched.

Fig. 52. A home-made engine stand that is adjustable as to width, and that is very light yet strong, can be made out of structural steel. The top members are made of flat stock $2'' \times 3''$ T-iron, and the cross-members are made of flat stock $1\frac{1}{4}' \times 1''$.



Fig. 52A. The Hovey garage jack for general garage use.

Fig. 52B. Garage jack for general work and lifting and transporting cars in the service station. Built low for balloon tires and long so that it will reach rear axles in spite of bumpers, etc. The wheels can be pivoted by turning the handle enabling the operator to guide the jack under the car. The range of lift is from 6' to 17'.



Will lift 5,000 lbs. with ease. Can be had with steel wheels or rubber tires.

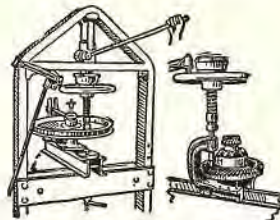


Fig. 52C. Wheel truing attachment for press.

Fig. 52D. Differential ring gear riveting tool attachment for press.

Fig. 52E. Portable garage light, adjustable to every required position.



Fig. 52E

See pages 692-694 dealing with service station and repair shop equipment. See also, pages 690, 691.

Engine Stands, Axle Stands, and Hoists

Engine stands for working on the engine at various angles, and hoists for lifting the engine or transmission from the frame are very necessary.

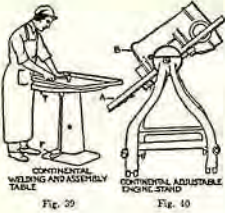


Fig. 39. Assembly and welding table greatly helps to speed up all kinds and types of assembly work. It is not necessary continually to change the position of the article being worked on, in respect to the table, as the table may be revolved and the work comes to the right position. The table is instantly locked.

Fig. 40. Adjustable engine stand.



Fig. 41. A portable hoist. This hoist is composed of steel angles thoroughly braced. The top frame is in the form of a standard bridge truss.

The hoist is wide enough to clear the fenders and allow the workman ample space to work efficiently between it and the car.

The chains may be used single or double, giving in the first case twice the speed with one-half the leverage, and in the second case the reverse, thus proportioning the leverage to the power required to lift any load quickly.

The 4,000 lbs. capacity hoist is ample for all passenger cars and light trucks. The 8,000 lbs. capacity truck is intended for the heaviest truck service.

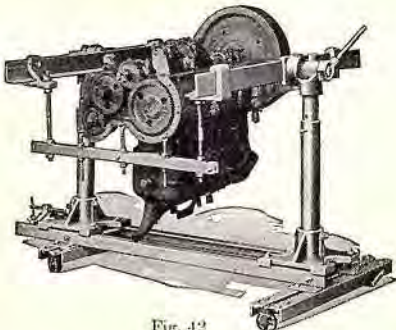


Fig. 42

Fig. 42. Universal engine stand. A cone locking clutch enables the operator to place and lock the engine in any position without the use of pins or other make-shift methods.

The unit construction enables this to be converted into an axle stand, thereby tripling the value to the garage. By removing the engine-stand parts, and putting on the axle-stand attachments, the machine is converted from one to the other in three to five minutes.

It will mount 85 to 90 per cent of all motors without special attachments, by means of the Universal suspension bar. Made in two types, geared and plain

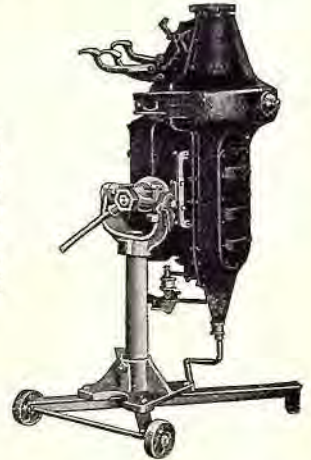


Fig. 43. Ford-Chevrolet universal engine stand. The cone-clutch-locking method allows the mechanic to lock the motor in any position in a complete circle. The whole power plant, including the oil pans, can be assembled or disassembled while on the stand.



Fig. 44. Ford-Chevrolet axle stand. The engine stand (Fig. 42) is converted into an axle stand by removing two cap screws, releasing the clutch and fitting assembly, and applying to the yoke the two clamps. A collar is placed over the upright to support the grease pan and outboard support. Separate support is included for torque tubes. It is adapted to all types of split rear axles and to any front axle.



Fig. 44A. Tire spreader, designed to spread casings for inspection and to hold casing spread while being repaired. When foot lever is released casing assumes its original shape. When break is located, casing is inserted under the four hooks of the detachable buffing plate and casing thus permanently spread, can be removed for buffing and stripping.

The gasoline pump units are usually of the "curb type," and in some instances they are inside of the station, termed the "drive-in" or "inside" type.

The gasoline is drawn from an underground tank to the pump by means of a rotary (or a piston-type) hand pump, electric motor or by air pressure. The hand pump is used most, the electric motor second, and air, third.

The hand rotary pump and also air pressure are sometimes combined. If the air pressure fails the hand pump can be used. Filters are provided on most all of the better grade pumps.

The gasoline pumps most used are of the "visible type" (Fig. 36A), and the "non-visible" or "blind" type (Fig. 36) is next most popular.

The capacity of the storage tank, which is usually placed underground as close to pump as possible, for the average station is from 5 to 20 barrels, 7 being the average. Larger tanks for larger installations. The storage tanks are placed 24" to 36" underground and are usually of about No. 12 gauge material and welded.

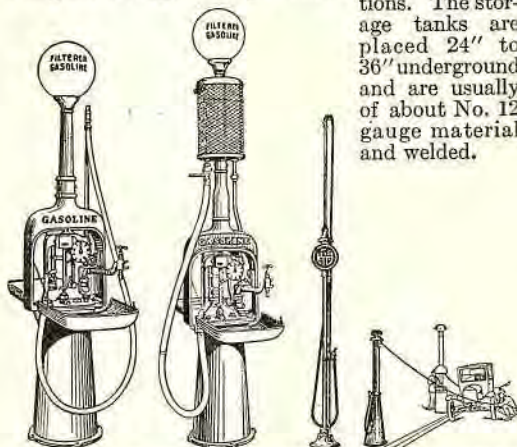
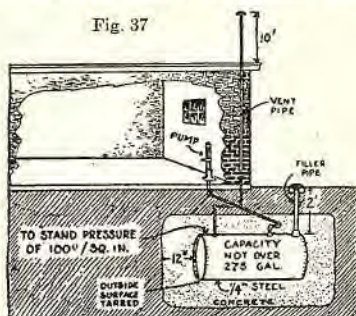


Fig. 36. Curb or roadway gasoline pump of the "non-visible" type. Hand rotary type pump.

Fig. 36A. Curb or roadway gasoline pump of the "visible" type. Hand rotary type pump.

Fig. 36B. Air and water stations.²

The gasoline storage tank to supply gasoline inside of the garage to a pump placed away from the tank requires special installation on account of insurance. The tank is placed underground, below the surface.



The insurance companies are very strict. The plan shown in Fig. 37 is one plan. Obtain information from your local insurance company. Give the tank 3 coats of asphaltum when placing it underground.

A Gasoline Filling Station Layout and Greasing Rack¹

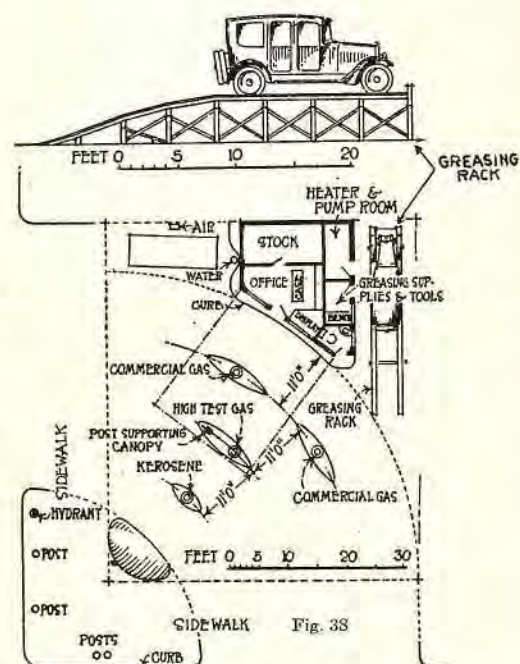
A suggestion for the layout of a filling station is shown in Fig. 38.

A good method of determining the probable trade in a certain location is to count the number of cars

passing per day at the location selected. If there are about 3,000 cars or more per day, on an average, passing the filling station, this will no doubt insure a profitable investment. There is no surer method of getting gasoline business than going where the traffic is heavy. A corner where traffic passes both ways, especially around the corner, is the most valuable kind of a plot.

The biggest problem in making a layout is the finding of space where cars may take on air and water and where a greasing rack may be placed without interfering with or obstructing the passages to and from the gasoline pumps.

The driveways in the plan shown in the illustration are very liberal, but they should be so, as it is of the utmost importance to make it easy for customers to get in and out without interference. This building does not seem large, but will be found of ample size. The necessary tanks and pumps are provided, i.e., about four tanks, two 1,500-gallon tanks for commercial gasoline, one 550-gallon tank for high-test gasoline, and one 550-gallon tank for kerosene oil. Free air and water should be provided



A mistake is often made in planning filling stations. Many times they place their free air hose so that a car taking on air will obstruct one of the passages. At ordinary times this does not matter, but during rush hours it matters considerably, since if there are several cars waiting, other prospective customers will go on to another station, rather than stand in line.

The greasing and oil-changing branch is quite an important factor in motor-car service, and, if handled intelligently, should be a good source of profit.

¹ A booklet showing plans for complete auto lubrication service stations, gasoline and accessory sales can be obtained by writing Alomite, Chicago, Ill.

² Air and water-tower stations can be obtained of Hobart Bros., Troy, Ohio; Romort Mfg. Co., Oakfield, Wis.; S. F. Bowser Co., Ft. Wayne, Ind., and air compressor manufacturers mentioned on page 623. See also pages 671, 761, 644.

Sponges, Chamois

In selecting sponges, chamois, use only the best.

it is advisable to

Chamois skins are used for washing and cleaning the body and fine surfaces. It is a difficult matter to obtain a good, genuine chamois skin, but it is worth the difference in price to get the best. The French chamois skin seems to be very durable and pliable. Chamois skins come in sizes 28" x 32" and 19" x 21". A package of chamois generally contains a dozen.



BALE OF SPONGES

Sponges often contain sand and grit, especially the cheaper grade. Many cars have received scratches which cannot be removed, by using the cheap gritty sponge. The best sponges are the Rock Island sheepswool sponges. They come in bales of 15, 25, 30, and 50 pounds. This class of material can be obtained of automobile supply houses.



BALE OF CHAMOIS

Methods for Working Under a Car

An inspection pit, placed at a convenient place, or, still better, a floor level underworker, as shown in Fig. 30, is far better than working on your back under a car in a limited space. Several different methods are shown below.

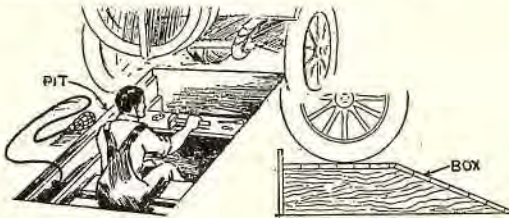


Fig. 30

Fig. 31

Fig. 30. A concrete repair pit, the depth of which may be varied, is illustrated here. Ledges are provided at different heights, and boards may be placed across, giving the mechanic free access to the work. Much of the dampness of this type of pit is removed by the wooden floor and the space beneath. Several of the boards on one of the upper ledges may be left in place and used as shelves for the tools and for steps for getting into and out of the pit. Size of pit is usually 6' long, 2'9" wide, and 2'9" deep.

Fig. 31. While not new, the substitute for a pit illustrated here is worth describing because of its merit. Two heavy wooden boxes, one for each wheel, with a slope of about 30°, and a flat space on top are used. The boxes are constructed of 1½" or 2" planks; the height is about 10", and the length about 4 feet. Such boxes will support even a heavy car.

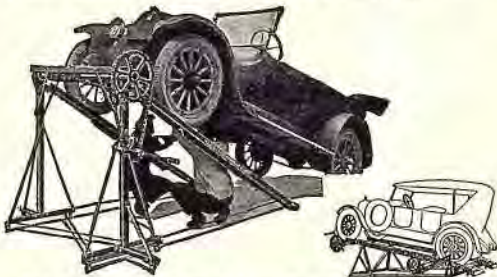


Fig. 32. A floor level underworker elevates the car to any desired height, so that the mechanic can work to advantage while sitting in a perfectly natural position.

Fig. 32A. Auto pit occupies space of 15' x 7'.

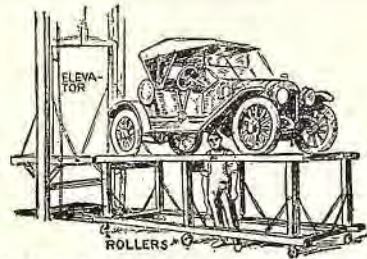


Fig. 33. Where there is an elevator and no pit. This structure serves the same purpose as a pit, with the additional advantages of being portable, more cleanly, and more accessible. It permits the workmen to perform most of their operations by daylight instead of subjecting them to the inefficient glare of an electric-light bulb. No skids are required with this structure in any garage where an elevator is provided; the elevator with the vehicle upon it is simply brought to a stop at the height of the truck, and the truck then adjusted so that the car can be rolled upon it. Being mounted on casters, the truck can be moved easily to the lightest portion of the shop.

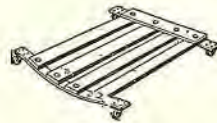


Fig. 34

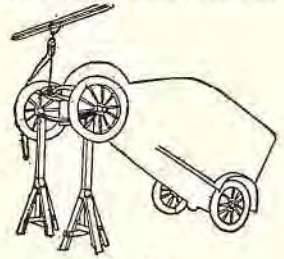


Fig. 35

Fig. 34. A creeper is easily made, and is strong enough to permit a car to run over it without injury. Cross strips are 2" x ½" steel and bent slightly to give clearance for the swivel casters and yet keep the body of the creeper low. Slats are 4" x ¾" hardwood.

The Koch Creeper has an adjustable head rest, made by Fort Recovery Stirrup Co., Fort Recovery, Ohio.

Fig. 35. Another method for working under a car. The front end of the car is hoisted by chain and specially made wood jacks are placed under the axle. The stands or jacks must be designed for the least space possible, in order to give working room between them. It is also advisable to have the car supported by the chain hoist securely, and then, in case the jacks give way, no injury will result; also block the rear wheels securely.



Fig. 35A. Service racks, also called service runways, for elevating cars to convenient positions for crank-case service, lubrication, washing and cleaning, for examination and adjustment and other work under a car.

Gasoline Storage Systems¹

This subject is dealt with briefly here. To those interested we suggest writing to concerns mentioned in footnote and asking for their catalogue. Most all of the manufacturers of gasoline pumps also manufacture lubricating pumps and tanks.

A gasoline filling station usually has two or more gasoline pumps and tanks, an air compressor outfit, and lubricating oil outfits, and often grease racks and air and water stations.

¹ Addresses of some of the gasoline storage-tank and pump manufacturers: American Oil Pump and Tank Co., Cincinnati, Ohio; S. F. Bowser Co., Ft. Wayne, Ind.; Tokheim Oil Tank and Pump Co., Fort Wayne, Ind.; Wayne Oil Tank Co., Ft. Wayne, Ind.;

NOTE: A modern hydraulic or electric lift is recommended for working under cars. Fire hazards are greater with pits, due to the collection of gasoline and oil vapors, oily rags, etc. See p. 690 under "Lifts." See also pp. 692-694 and "Note" p. 670.

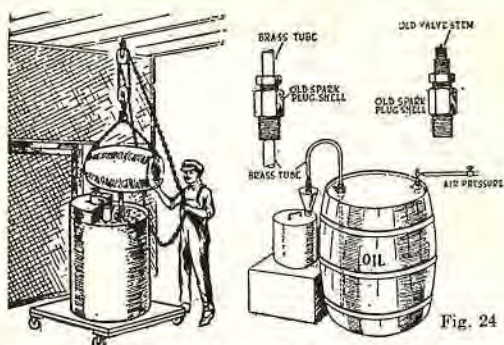


Fig. 24

Fig. 23. Oil may be transferred from the barrel to the storage can by the aid of a differential pulley and suitable grab-hooks. The storage cans are mounted on casters in the manner shown, and may be rolled under the suspended barrel, a hole drilled in the bung, and the oil transferred.

Fig. 24. To transfer oil from barrel to a smaller container: The oil is forced by air pressure from the barrel. Air pressure is applied through a valve that is an ordinary tire valve soldered into an old spark-plug shell, which in turn is screwed into a hole in the barrel. The oil is delivered through a bent brass pipe, passing through a second spark-plug bushing, also screwed into a hole in the barrel. This pipe must be long enough to extend nearly to the bottom of the barrel, as shown by dotted lines. Packing is placed between the bushing of the plug and the shell, so that the tube may be adjusted to any barrel, and the amount of oil is readily regulated by the pressure applied.

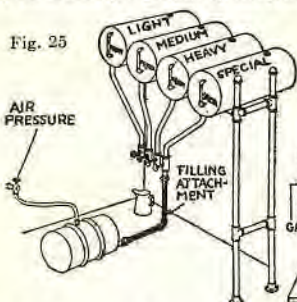


Fig. 26

Fig. 25. An oil storage system (home made), whereby oil is discharged by gravity. Several tanks with gauge glasses are supported on pipe standards. Oil is transferred from original barrel by air pressure. This gets tanks up out of the way and conserves space.

Fig. 26. Small storage tanks provided with gauge glasses. Tanks conical shaped at bottom. A shelf with drip pan is provided.



Fig. 27. Oil pump which can be obtained at supply houses for removing oil from barrel.

of farm implements, etc., but not to be used in car.

Fig. 27A. Settling tank. Oil drained from crank case is poured into this tank. The clean oil rises to the top. Sediment drops to bottom. The oil can be used for lubrication

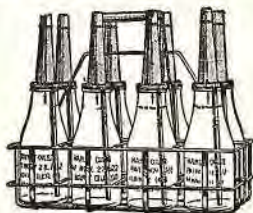


Fig. 27B. Oil dispensers. The one shown is the "Handy Oiler" outfit of 8 oilers.

Dispensers can be obtained of auto supply houses.

Fig. 27C. Portable oil tanks. The one shown is a double tank for two grades of oil, each compartment having a capacity of 30 gallons.

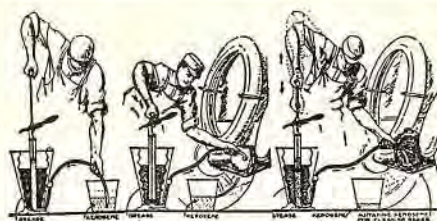


Fig. 27D. Valveless bucket pump, used to discharge lubricant into transmission, differential housing, etc. Can also be used to draw old grease out and discharge it into another receptacle without disturbing the supply of fresh lubricant contained within bucket. Differentials can be emptied, cleaned with kerosene, and filled with new grease in a few minutes time.

Grease Compressors

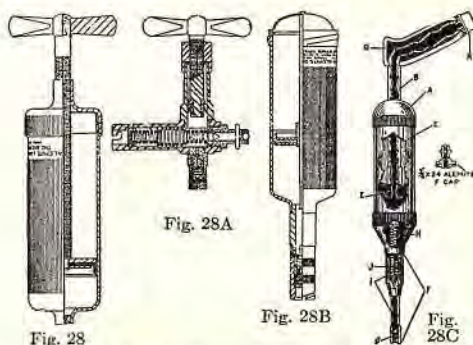


Fig. 28A

Fig. 28B

Fig. 28C

Fig. 28. Alemite standard high-pressure grease compressor for greasing cars by means of a metal hose and special fitting attached to the grease cup. Capacity is 1 lb. of grease and exerts a pressure of 500 lbs. per square inch.

Fig. 28A. A booster, which can be attached to all models of Alemite service hand compressors. Where the pressure of the Alemite compressor will not force out clogged dirt or old caked grease, the pressure can be increased by the booster to 5,000 lbs. per sq. in. This will clean out any bearing.

Fig. 28B. Alemite twist type compressor. Connected direct to Alemite nipple. This device has no handle. It is operated by rotating compressor back and forth on nipple. Develops pressure up to 4,000 lbs. per square inch.

Fig. 28C. Alemite-Zerk model 3-G service-type compressor. This is designed for light service work around a garage. Capacity is 9 oz., length 16", and exerts a pressure of 4,000 lbs. per square inch. It loads through the hollow handle. The lubricator is operated by pushing (not twisting) the pistol grip.



Fig. 28D. Dot high-pressure lubricating system

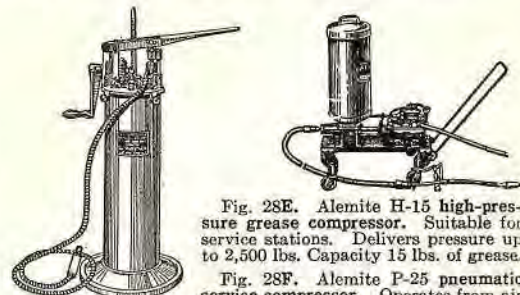


Fig. 28E. Alemite H-15 high-pressure grease compressor. Suitable for service stations. Delivers pressure up to 2,500 lbs. Capacity 15 lbs. of grease.

Fig. 28F. Alemite P-25 pneumatic service compressor. Operates from air compressor line. Pressure is 16 times that of air line. Capacity 25 lbs. of grease. More than one lead can be used.

printed matter on this subject can be obtained by writing manufacturers of Alemite products, Chicago, Ill.

FIXTURES AND SUPPLIES FOR A GARAGE

Fixtures for the repair shop should consist of such things as: shelves and racks for tools, such as stocks, hacksaws, etc.; these should be on the walls at the back of the vise. A set of stout drawers for keeping bolts and screws and brass rods should be provided. Some of the drawers should be fitted with locks and keys, for sometimes tools will disappear. Several shelves should be put up for storing various spare parts, mandrels, etc., but it must be remembered that the shelves when full may have to carry a very considerable weight; they should be stout and well secured.

Fixtures for the garage would also consist of such parts as lubricating oil tanks, gasoline tank, wash hose and washing rack, heating plant, turntable, stock room, etc.

A heating plant, either hot water or steam, with coil pipes or radiators must be provided. This plant should be in a cellar or on the outside of the building in a small brick enclosure.

A turntable is very handy for garages, but not altogether necessary. It should be placed in the center of the garage.

A wash rack is very essential. See page 645 for car washing methods.

A water connection in the repair shop will be handy, and should be installed.

Electric lamps with wire guards and a long cord for working around the car are very necessary.

An inspection pit is placed at any convenient place where the auto can be run over it. The pit permits the repairman to get under the car and work.

The pit can be made about 6 feet long, 2 feet 9 inches wide, and 2 feet 9 inches deep. A mirror is very handy for throwing the light in dark corners when at work in the pit under the car.

A chain hoist or crane, for lifting the engine and other heavy parts, will pay for itself many times over in time and labor.

Fire extinguishers should be kept handy. The only part of the building (if made of concrete or brick) that is subject to fire is the roof. In case of fire, keep two or three buckets of sand handy (or fire extinguishers) to put out a gasoline fire, as water is useless.

Gasoline often drips from a carburetor, and back-firing or a spark from a muffler will ignite the gasoline. Once a gasoline fire is started, it is difficult to extinguish. Never use water; it will serve only to float the gasoline and spread the flame. If a fire extinguisher is not at hand, keep a box of fine earth or sand and dash it over the flame. Flour will also do, if nothing else is handy.

For oil fires, a motor trade magazine advises to keep on hand a mixture of sawdust and soda (about 1 qt. of bicarbonate of soda to a bushel of sawdust).

A chemical fire extinguisher can be made by taking $7\frac{1}{2}$ gallons of water and mixing about 10 or 11 lbs. of ammonia salts and 21 or 22 lbs. of common salts. Put into bottles and keep on hand.

The gasoline supply should be stored in an underground tank, placed some distance from the building, from which it is piped to a pump located inside of the building usually, near the wash rack.

A garage or shop where gasoline is not sold regularly should have at least a 120 to 280 gallon capacity tank.

For gasoline service or filling stations, a tank capacity of not less than 1000 gallons should be provided.

NOTE: Adequate fire-extinguishing equipment forms an essential part of the garage or shop. Consult fire insurance company for such equipment. See some representative gasoline and oil firm for recommended tanks and up to date methods of installation. See pp. 690, 692-694, and "Note," p. 672.

A curb gasoline outfit is shown on page 673 and is generally used for regular gasoline filling stations.

Lubricating oils should be carried in about three grades: light, medium, and heavy gas-engine cylinder oil, as well as a supply of gear-case oil and greases. Sixty-gallon tanks are usually provided for lubricating oils.

Lubricating oil tanks and pumps capable of delivering anything up to the consistency of transmission grease are made by concerns specializing in this work (see page 671). Smaller and cheaper lubricating tanks can be had.

For the lubricating oils, a small enclosure can be provided made of wire fencing with a lock and key.

There is no end to the number of useful devices which can be installed in a repair shop and garage.

Many useful time-saving additions and devices are shown under "Useful hints, and suggestions" (pages 1035-1041).

The following few pages will be devoted to equipment and supplies usually required in a garage. By writing to some of the manufacturers, where names are given farther on, and who specialize in garage equipment, and to automobile supply houses useful catalogs and information on the latest improvements can be obtained if this book is mentioned in the request.

Fixtures for Handling Lubricating Oils, etc.

Below are shown methods of handling lubricating oils. Very elaborate equipments can be obtained for those who desire large outfits. Write for printed matter to the concerns mentioned farther on.

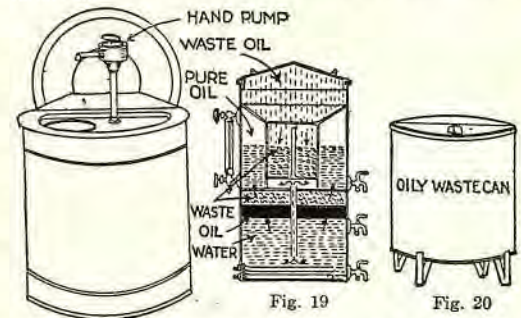


Fig. 18

Fig. 20

Fig. 18. Lubricating oil tank. This tank can be used for engine oil and general lubricating oil for a small garage. It is made of galvanized steel and holds 60 gallons, and is fitted with a positive-action force pump. The advantage is that it keeps the oil covered and free from grit and dirt. The Bowser Co., of Ft. Wayne, Ind., makes a more elaborate affair.

Fig. 19. The cross oil filter will save oil which is wasted by filtering the used oil through this filter. It will also rid the oil of grit and mineral substances.

Fig. 20. A waste can is required by the insurance companies, and instead of throwing greasy, oily, inflammable rags on the floor, it is placed in this can. Every garage should have this waste can.

Fig. 21. The Dover gasoline and radiator filler will prevent spilling, and is very easy to handle. It holds 5 gallons. It is not advisable to put gasoline in the same vessel used for water, but if it is necessary, then place a chamois skin in the funnel, and pour the gasoline through it. No water will then pass into the gasoline tank.

Fig. 22. Illustrates a smaller size of Dover radiator and gasoline tank filler. It is advisable to have one each for gasoline and water. This filler is also suitable for lubricating oil. Dover Stamping and Mfg. Co., Cambridge, Mass.

Sometimes it is convenient to give the whole floor a slight pitch in one direction—towards the side, front, or back. The best method, however, appears

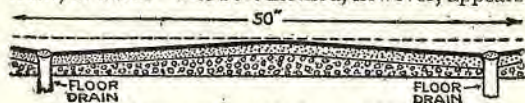


Fig. 11. Cross-section of the floor of a 50-ft. garage.

to involve making the center the highest point. In a long garage, 50 ft. by 100 ft., this high point would be a line 75 ft. long through the center; from this line the floor should fall off towards the walls at the rate of about one inch to 10 ft. The lowest point may be close to the wall, or it may be four or five feet from the wall, so as to come under the row of cars. Along this low line a tile must be laid below the floor with drains, protected by cast-iron grills entering it every 10 to 14 ft.

If the foundation soil is such that it becomes soft with moisture, it should be sloped slightly toward the drain tile, in the same way as the floor, so that no water can collect under the floor. When this is done, the bed material of cinders, coarse sand, or gravel is spread and tamped thoroughly to within three or four inches of the finished floor.

Strips of 2 by 4 are usually used as grounds; they are spaced 6 to 8 ft. apart, and are held in place by stakes and cross-divisions placed the same distance apart as the grounds, forming square blocks. When the filling is started every alternate space is filled; then the cross-pieces are taken out and the remaining spaces filled.

THE GARAGE OFFICE

The illustration shown in Fig. 1, page 665, will be used as an example of a garage office, which is also equipped as a reception room, which contains a desk, table, chairs, safe, and couch. The office is lighted by two 40-watt Mazda lamps with 12-inch diffusers. The price of the office furniture and safe is about \$100.

Pointers on Office Work

The system designed to take care of all the business of this garage is exceedingly simple. To carry it out, only three forms are required: a monthly checking sheet, a monthly supply sales sheet, and a repair card. In addition to these forms an ordinary ledger is used, in which each customer is given a page on which all his charges and credits are entered.

While it is very important to operate the office in a systematic manner, about seven out of ten neglect this part of the business.

Checking Sheet, Sales Sheet, and Repair Sheet¹

There are very many different methods for keeping records, books, etc., for automobile garage and repairwork.

A simplified system of checking sheets, etc., is explained below.

The checking sheet (Fig. 12) is 3 feet high by 11 inches wide, with nine 1-inch-wide columns, allowing sufficient space for checking one car in and out every day of the month. Thirty-

The proportions of cement and gravel for the base of a concrete floor are as follows:

Good quality bank gravel: 1 part cement; 5 parts bank gravel.

Washed gravel or crushed stone: 1 part cement; 2½ parts torpedo sand; 5 parts 1" gravel.

The proportions for the top dressing are as follows:

1 part cement; 1½ to 2½ parts torpedo sand.

Fill the forms with the base mixture to within ½" to ¾" of the top. Tamp well and finish with the top dressing, smoothing and striking off with a perfect straightedge. Never let the base dry out before the top dressing is added, or they are liable to separate and the top to scale off.

After striking off, the dressing should stand an hour or so for the excess water to settle before troweling is started. A wooden trowel is best for use in evening up; then after an hour or more the steel trowel may be used, if a smoother job is desired. Some desire the rougher surface given by the wood float, but there is little chance of cars skidding inside the garage, and the smoother surface is more easily kept clean.

Sometimes, instead of the fine cement top dressing, asphaltic compositions are applied. They make a less harsh and less crumbly surface, but eventually get soft from the constant applications of oil.

one horizontal lines are ruled one inch apart and the dates are printed under the heading "Date." Thus one square inch of space is provided for car "out" and "in." The checking times are entered by the day workman, who spends his time keeping garage and cars in shape. After the end of the month the sheet is filed for future reference.

Checking Sheet										Supply Sales Sheet			
April 1912										April 1912			
Car No.	1	2	3	4	5	6	7	8	9	Date	Car	Material	Qty
1										4-1	7	Gasoline	5 gals
2													
3										4-9	80c pt.	Gasoline	4 gals
4													
5													
6										4-30	8	Havoline	1 gal.
7													
8													
9													
10													
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Fig. 12

Fig. 13

Fig. 12. Monthly checking sheet for cars housed in garage.

Fig. 13. Monthly supply sales sheet kept with checking sheet.

¹The "Motor World" simplified system of accounting: A simple method of keeping accurate records of what you pay out and take in, telling how much you made or lost on each department, and showing you how much you received, how much the stock and labor cost, how much your customers owe you, the amount of your overhead expenses, etc.

Gasoline, oil, and other supplies bought by garage patrons are noted on the supply sales sheet (Fig. 13). If this sheet is made as large as the checking sheet, it will last a full month. On the last day of the month the sheet is taken off its board, the sales are entered on the car owner's pages in the ledger, and the stock records corrected in accordance with the sales record. Then the monthly bills are sent to the patrons. Where materials of any kind are sold to any but regular patrons, the price and the notation "Paid" is entered on the sales sheet instead of the number of the car.

to use all of it for display purposes. The question to decide is whether the advantage of having the whole front for display more than offsets the disadvantage of having the entrance to the garage on the side street. Even if the garage trade is the most important part of your business, and evidently it is not, the side entrance is not very objectionable, provided there is a large sign at the front stating that the garage entrance is on the side street.

Fig. 5 has capacity for only five cars in the repair shop. Entrance to the garage is from both streets, but when the demand for space is strong, the last cars in at night may be placed in the side entrance-way.

Fig. 6, which has no front entrance for cars, not only is a more attractive building to look at, but also the layout of garage and repair shop is more convenient.

As far as storage capacity is concerned, there is little to choose, Fig. 5 having room for twenty-eight cars, including five in the shop, and Fig. 6 having space for one less, including nine in the shop. The shop in Fig. 5 may readily be enlarged if desired, by lengthening it. (*Motor World*.)

Steam Heating a Garage

The usual plan is to heat by steam, or hot water. The method of assembling the pipes or coils is illustrated in Fig. 8. For garages of larger capacity there would be more coils and a larger boiler.

As an example we will give the dimensions for a garage 48 x 62: It is assumed that it is heated by a steam-heating system working at a pressure of 5 lb. gauge, and for this an ordinary low-pressure steam boiler, such as is used in heating houses is appropriate. (See Fig. 7 for a suggested plan.)

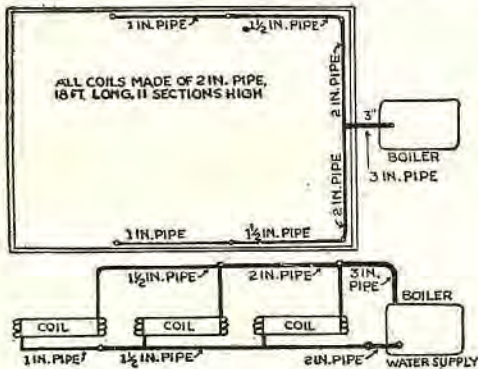


Fig. 7. Steam-heating system for garage 48 x 62. The heating coils are made of steel pipe 2 in. in diameter.

If you intend to place the boiler outside of the garage, you do not want to overlook the fact that it should be suitably housed, so that no heat will be wasted in warming the open atmosphere.

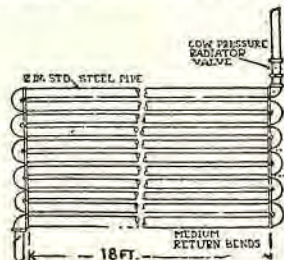


Fig. 8. The boiler must be set so that the water line will be below the level of the lowest radiator or coil, and so that the condensation will drain from the coils back to the boiler by gravity. If this is not done, the heating system will be very inefficient, as you will have to heat cold water up to the steaming point, instead of being able to reclaim some of the heated water. It is best to submit plans to a steam-heating specialist when installing a heating plant.

Lighting the Garage

Lighting the garage: This is a matter of providing the proper electric lights located to the best advantage. The local electrician is posted on this subject.

Artificial illumination of the garage proper is supplied by five 100-watt Mazda lamps, equipped with 12" steel diffusers with white enamel finish (Fig. 9).

Special lighting provision is made for washing the cars; there are four 25-watt Mazda lamps located at the corners of the wash rack (N) (Fig. 1, page 665), and these lamps are held in Holophane D'Olier steel reflectors, directing the light to the lower part of the automobile being washed.

The repair shop requires even more elaborate lighting facilities than the garage space. It is therefore equipped with five 60-watt lamps and two 25-watt lamps, all of which are of the Mazda (tungsten) type. Three 60-watt bulbs (W), fitted with Holophane D'Olier steel reflectors (Fig. 9), and dropped from the ceiling to illuminate any part of the car being worked on, while two 25-watt lamps (W1) shown in the shaded circles (Fig. 1, page 665), are fitted with the same sort of reflector and are so located as to be useful in seeking parts stored on the stock shelves (S1).

Two 60-watt lamps (U) with Holophane intensive glass reflectors are dropped above the lathe, planer, and drill press. To shed a concentrated light on the work.

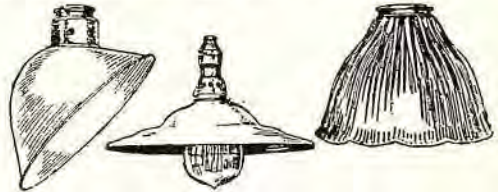


Fig. 9. Three types of reflectors for lighting a garage. Holophane type of D'Olier steel type; 12" diffuser; Intense type, D'Olier.

Building a Garage Floor

Cement concrete is the acknowledged material par excellence for the garage floor.

Wood is condemned as being short-lived and usually out of repair. Boards placed as close to the ground as is usual with garage floors rot in a short time. They also tend to warp both transversely and longitudinally by reason of the under sides being damp and the top dry; thus they pull loose from the under-pinning on account of the timber rattling and failing to hold the nails.

Wood blocks make a good pavement, but, unless creosoted, are also short-lived, and the creosote is said to be injurious to rubber.

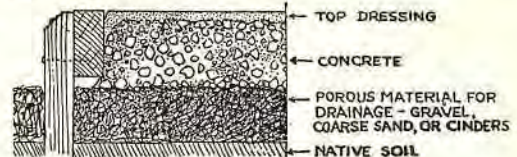


Fig. 10. Detail of construction

Before starting a concrete floor it is well to study the situation as regards water pipes and drains. If there is any filling to be done, the nature of the soil must be considered.

It is not safe to lay concrete over clay that has been filled, as the floor will surely settle. Gravel will immediately settle to a solid bed, as will sand if wet down sufficiently to wash it into any crevices that may exist under it. Clay is quite different from sand and gravel, though sandy clay is not quite as bad as gumbo or any of the more sticky clays.

If clay must be used, it should be placed when as dry as possible. After it is laid, it should be soaked with water until virtually soft and incapable of supporting a person's weight. When it has dried, it will be as dense as it can be made without process of time, and will have settled from 10 to 24 per cent of its original height.

The drainage of the floor should also be considered before the work actually begins; a puddle of water on the floor after a heavy rain is never desirable

The repair shop in this small 9-car capacity garage is but 24 feet long and 15 feet deep, and, besides the door connecting it with the office, has a sliding door between it and the garage proper. This door is sufficiently wide to permit of an automobile being passed through it into the shop, which also contains a small stock of raw material and repair parts stored in shelves (S1) and (S2), and a tool shelf (T). (Motor Age.)

A Fifteen-Car Garage

An arrangement and equipment of a garage and repair shop suitable for a town of 3,000 population with good transient and country trade is shown in Fig. 2. The size of the building is 50 by 120 feet, one-story brick or cement block, with the repair shop 40 by 50 feet at the rear.

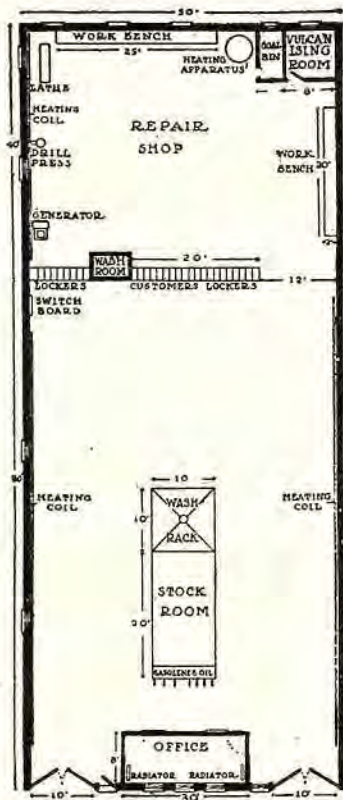


Fig. 2 shows a garage which would suit the requirements stated, beside being convenient and cheaply maintained. It allows of cars entering at one side and leaving at the other, thus avoiding any congestion in getting in and out. Gasoline and oil are handy to the street, beside being under the direct scrutiny of the office.

Posts should be barred and the roof supported by trusses, making the working space much more valuable and saving many square feet of lumber. Heat is supplied by a hot-water apparatus located in the repair shop. It is of the overhead supply type—that is, the supply veins extend from the boiler at the ceiling height, and branches drop down to the coils and radiators and return just above or under the floor. Steam could be used, but the boiler would have to be sunk considerably in a pit before this could be used at all successfully.

A small gasoline-electric generator-set with a suitable switch-board is suggested for electric charging and running the lathe and drill-press, in case the local service is not direct current. Sky or other kinds of roof lights are a necessity if the garage is on an inside lot, and are desirable in any case to make things cheerful and airy and attractive to transients who use it.

Average space to allow for storage of cars: 7 feet is the usual width. The length varies from 13 to 18 feet, according to length of cars stored. (*Motor Age*.)

Another Fifteen-Car Garage

A one-story building for a garage, salesroom, accessory store and shop: The plan is shown in Figs. 3 and 4. The size of the lot is 60 x 100 feet. The building is erected so that another story can be added.

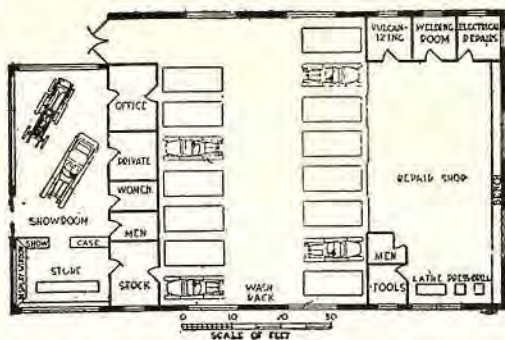


Fig. 3. Plan view. The cars in front, near the shop doors, should be the ones which are away from the garage the most.

The entrance to the garage is exposed so that light can be obtained from two sides into the showroom. Thus the building has practically all the advantages of being on a corner.

There is a small accessory store divided off from the showroom by showcases and an arch, a stockroom, private and general offices, rooms for men and women, garage space for fifteen cars, wash rack, and a shop big enough for five or more cars, and equipped with vulcanizing, welding, and electrical rooms. (*Motor World*.)

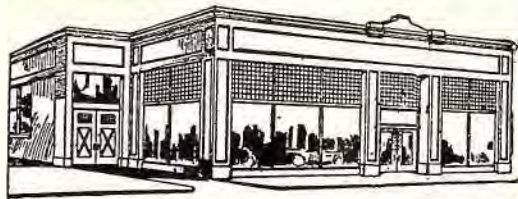


Fig. 4. Front view. Note that the driveway to the garage gives the showroom a corner appearance, and light.

A Twenty-Eight-Car Garage

A one-story corner building with alternative plans for garage, salesroom, accessory store, offices, toilets, garage and shop is shown in Figs. 5 and 6. Size of the plot is 66 x 112 feet.

There are two designs: Fig. 6 is probably the preferable one, considering all the conditions, but Fig. 5 is the one to use in case a front entrance to the garage is considered essential.

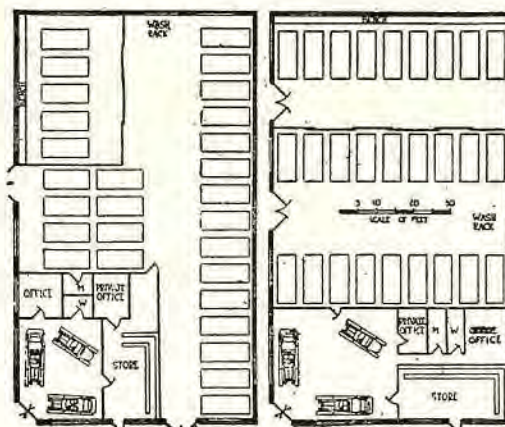


Fig. 5

Fig. 6

Fig. 5. Complete establishment located on a corner and with a front entrance.

Fig. 6. Complete establishment, with no front entrance.

The objection to the front entrance is that it restricts the frontage so that the display space for the showroom and accessory store is rather small; but with the entrance on the side, full advantage of the front may be taken. And inasmuch as it may be considered as valuable advertising space, it is essential

INSTRUCTION No. 61

THE GARAGE: Building and Equipping

Many, after starting in a small way, soon earn enough to start up a shop of their own. We will now lay out a procedure for starting a shop or garage.

A garage is a place where cars are stored and cared for. Most garages also have shops in connection.

If only a shop for repairing automobiles is planned, then figure on enough room to take care of at least four or five cars while working on them.

A repair shop without the garage is profitable, and can be started for much less capital. If the repairman is just starting out and his capital is limited, the best plan is, of course, to start in a small way.

The question to decide is whether you intend to do strictly repair work, or to store cars and repair, and also whether you will conduct an agency for some car, and carry supplies.

Garage

A garage is termed a place for storing cars, but is subdivided into departments: storing, salesroom, auto-supply department, and repair shop.

The garage equipment consists of suitable space for the number of cars you intend to store, bearing in mind that the space devoted thereto should be utilized to the best advantage. For instance, cars which are used frequently and regularly should

occupy that space where exit is easy, usually nearest the exit. The wash rack should be in a convenient location, and the garage supplies, such as oil and gasoline, should be where convenient, yet not interfere with the space occupied by the cars.

The salesroom, office, and stockroom should all be carefully planned. The stockroom quite often is utilized for small tools and accessories, but it is better to display the accessories in some sort of showcase or shelves in a space in the salesroom.

Repair Shop

The repair shop can be subdivided into departments as follows: machine shop, tire repair, welding room, electrical apparatus and testing department. The testing department should be a space allotted for the purpose of diagnosing the troubles, before actual work is begun. See also page 691.

The electrical repairs constitute recharging batteries, work on the electrical apparatus, etc.

By maintaining a system of departments in this manner, the parts belonging thereto are easily located, work is turned out quicker, and a higher degree of efficiency is maintained.

An extensive line of repair work can be carried on in even a small garage, and the sale of extras and sundries will add materially to the income.

LAYOUT FOR A GARAGE AND FOR SHOP BUILDINGS

Successful garage operation is largely a question of systematic economy. This holds true for smaller garages even more than large ones, and therefore such an establishment requires great care in its layout, construction, and subsequent operation. The more thought that is concentrated upon the system to be followed, once the building and equipment are ready for starting business, the fewer mistakes will be made and the greater will be the profit derived from the undertaking.

A Nine-Car Garage and Shop

The type of a small country garage, as described in Fig. 1, is designed for the storage and general care of nine automobiles. Besides the space necessary for garage work, the building contains a well-equipped repair shop and an office, which also serves as a reception room.

In the repair shop a limited supply of parts and supplies is kept, the latter being provided for the accommodation of the garage patrons. The supply stock consists of the most important accessories, tires, tubes, and ignition sundries, etc.

This garage is designed with a view to economy. It is a one-story brick building, 60 by 40 feet, with the longer side toward the street; the interior height is 14 feet from floor to roof, and the latter is carried on trusses 40 ft. long and spaced 8 ft. apart.

A skylight (L) 10 feet wide and 50 feet long with windows illuminates the garage during daytime.

Near the middle of the street side (1), 15 feet from one end, is located the main door, which is 10 feet wide. Entering through this door a row of four automobiles is arranged at the right, while at the left is the entrance to the garage office. Adjacent to the office door a board 3 by 3 feet is hung on the wall, on which checking forms, which constitute a part of the garage system, are kept.

Fig. 1. Floor plan of the garage, showing location of departments, skylight, and arrangement of tools and lamps.

The office is 10 feet wide and 15 feet deep, and besides the entrance mentioned, has one door leading into the repair shop and another into the garage proper, which has a floor space of 1,275 square feet.

The space filled by automobiles is shown by shading, and there is enough room to accommodate nine cars of 124 inches wheelbase and standard tread. The space between the dotted portions illustrates the passageway for automobiles driving to or from their assigned positions in the garage. From the garage proper a 10-foot door leads into the back yard, and adjacent to this door the wash rack and charging outfit are located.

The wash rack is formed by a rectangle deepening toward its center (K), whence a pipe from the flush valve leads to the sewer or the drainage system. The water supplied either through the medium of the ready-made car washer, or through one which can be readily made from $\frac{3}{4}$ " standard pipe, a stuffing box, four elbows, and about 12 feet of $\frac{3}{4}$ " water hose, at a cost of less than \$8.00. The method of assembling the parts is shown elsewhere (see Index under "Wash racks").

supplies current; see if ammeter indicates on "charge" side.

Inspect generator: (a) see if drive adjustment is necessary; (b) tighten all nuts or screws supporting generator; (c) see if generator delivers output according to test under "Inspection of electric system"; (d) oil generator; (e) generator charging rate may need setting up if battery does not stay charged (see pages 506, 563; also page 462N).

Inspection of Car on the Road

Make notes of different defects so that they can be corrected later.

Inspect engine: (a) see if engine starts easily; (b) see if engine runs without missing or loping; (c) see if engine idles properly; (d) see if engine picks up speed; (e) see if there is a clicking noise (after engine is warmed up); if so, it may be due to too great a valve clearance, or to worn tappet guides; (f) see if there is a carbon knock (see pages 778, 763, 167-170); (g) see if engine knocks (see page 777); (h) see if there is considerable smoke (see pages 103, 461, 168, 118).

Inspect brakes: (a) see if foot and hand brakes operate properly; (b) permit car to coast and see if brakes bind (see pages 886-888).

Inspect clutch: (a) see if it slips; (b) listen for noises; a ringing noise usually indicates loose or worn disc fabric; grinding noise, leak of lubricant or broken thrust bearing ball (see also pages 838, 839).

Inspect transmission: (a) see if gears shift hard (see page 855). If there is stiffness in gear-shifting lever during cold weather, this indicates oil is too heavy in transmission and rear axle. Drain off small amount and thin down with cylinder oil.

Inspect rear axle: (a) listen for humming or singing noises when driving straight ahead and turning corners (see pages 873, 870).

Inspect wheels: (a) while someone else drives the car, stand at rear and see if rear wheels wobble; this may be due to bent axle shafts or loose wheel nuts (see page 905); (b) also observe front wheels for toe-in, wobbling, etc. (see pages 906, 910).

Steering device: (a) see if it operates properly. There should be some backlash, but not excessive; (b) if steering is difficult the steering rods may be bent or loose, or there may be lack of lubrication.

Inspection of Car After Trial on the Road

Inspect engine: (a) with engine idle and warmed up, test the compression of each cylinder (see page 767); (b) inspect valve clearance when engine is warm; use thickness gauge (see pages 59, 775); (c) clean carbon deposit; to determine remove spark plug, insert carbon scraper and see if carbon is present (see pages 763, 168, 169); (d) grind valves if compression leaks from valves (see pages 770, 57).

Inspect brakes: (a) clean, adjust, and oil brake connections; (b) inspect brake lining to see if badly worn, if so relined; (c) if grease and oil are on brakes, find the cause (see page 887).

Inspect clutch: (a) adjust, if it slipped when testing on the road; (b) lubricate if necessary.

Inspect transmission: (a) drain lubrication and relubricate (see pages 172, 856); (b) tighten all nuts and bolts.

Inspect universal joints: (a) examine drive shaft for looseness by working back and forth by hand. If there is excessive looseness, determine if it is due to universal joints or to backlash in drive pinion; (b) if universal joint is a fabric type, examine nuts or fabric for torn or worn holes; (c) lubricate.

Inspect torque member: (a) examine for looseness, if cracked, etc.

Inspect rear axle: (a) see pages 865 to 875 for adjusting drive pinion and differential gear; (b) see if oil leaks (see page 882); drain lubricant and put in fresh lubricant (see pages 172, 882).

Inspect wheels: (a) clean, grease, adjust rear wheel bearings (see page 864); (b) if wheels are wobbly, see if due to loose rim bolts, or unevenness in tightening, or if bent axle shaft end, due to skidding or striking curb (a common cause), or if loose nut on end of axle shaft; (c) see if hub flanges are drawn tight; (d) see if paper gasket between hub flanges is loose or torn and if oil leaks out; if so tighten or replace; (e) tighten rim bolts, hub caps; (f) clean, grease, and adjust front wheel bearings (see page 908); (g) tighten nuts of front wheel spindle, hub flanges, and hub caps; (h) inspect balls in front wheels when greasing to see if broken (a clicking sound usually indicates broken balls).

Inspect steering device: (a) tighten all nuts from steering device to front axle steering arm; (b) adjust steering device; (c) grease.

Inspect chassis: (a) tighten all spring clips, shackle bolts; (b) clean and lubricate springs; (c) tighten all bolts and nuts starting at radiator and working back to rear axle, including differential cover cap screws; (d) be sure all cotter pins and lock washers are in place; (e) tighten all bolts holding body to frame.

Lubrication of Car

Follow instruction book for kind of lubricant, then start at front of car and work to rear, being sure each and every grease cup is screwed down to eject all grease; then refill and screw down again until you are certain grease is reaching the part to be lubricated. See pages 172-174, 761.

Don't overlook oiling the generator, starting motor, fan, ignition device, and control members and connections thereto. Also lubricate brake rod clevises.

Clean Engine and Car

Engine: (a) clean, grease, and oil from outside of engine (see page 760).

Car: (a) wipe off all surplus grease and oil; (b) wash car (see page 644); (c) clean top and upholstery (see page 647); (d) clean all glass, including lamp lenses (see page 646); (e) polish body (see page 645); (f) polish all nickel (see page 646).

Final Inspection

Before turning car over to owner: (a) see if there is plenty of gasoline in main gasoline tank; (b) see if gasoline gauge works properly; (c) see if starting crank is in tool box; (d) see if all tools are in tool box, including a jack and tire tools; (e) examine tires for glass, tacks or nails in them; (f) see if tires are properly inflated; (g) see if all rim nuts are tight; (h) see if all lights operate properly. The bright lights in some states should not be over 32" c.p. if deflecting lenses are used, and the lamp should be tilted down until the brightest rays of light strike the road about 200' in front of the car; (i) test battery for water above plates and with hydrometer, and see that all battery connections are tight; (j) see if oil indicator on engine shows "full" and if indicator works properly; (k) see if oil gauge indicates properly and oil pressure is properly adjusted; (l) see if starter operates properly; (m) see if ammeter indicates properly; (n) see if horn operates properly; (o) wipe off steering wheel; (p) see that seats and door handles are clean.

*Most states now allow a maximum of 32 c.p. in headlights. Adjustment of the upper beams of the headlamps is now usually adjusted by means of adjusting machines, or placed on a level surface 25' from a properly constructed headlight adjusting screen. Instructions will be found in most of the car instruction books, or in a manual such as mentioned under "Lighting," on page 690.



Fig. 6. A metal toolkit. (Snap-On Mechanikit K-21).

Fig. 6A. A bench for complete hand tool equipment that can be rolled to the job. (Snap-On roller tool bench No. K-7).

Fig. 7. A metal tool case with an assortment of 87 tools, suitable for general automotive repair work. (Blackhawk S7WD Set.)¹



INSPECTION BEFORE AND AFTER OVERHAULING A CAR

A procedure of inspection, adjustment, lubrication, cleaning and final inspection follows. See also, page 660, "Preparing a car for a tour and engine tune-up."²

Inspect tools: Make a list of the tools with which car is equipped, so that same tools will be returned to customer.

Inspection; Engine Not Running (But Warm)

Inspect cooling system: (a) water hose; (b) fan (oil); (c) fan belt; (d) radiator for leaks; (e) water pump for leaks.

Inspect engine lubrication: (a) clean or change oil filter; (b) drain old oil, flush and refill; (c) inspect oil-level indicator; (d) tighten oil connections; (f) change to lighter oil in winter (see also page 172).

Inspect carburetion and fuel line: (a) start at gasoline tank; see that all connections are tight; (b) inspect strainers in fuel pump or vacuum tank; (c) carburetor strainer; choker valve; throttle valve (see if they open and close properly); (d) carburetor dripping (see page 122); (e) see if gasoline reaches carburetor, by flooding it.

Inspect ignition system: (a) remove, clean, and adjust spark plugs; (b) examine cables; (c) clean distributor; (d) inspect interrupter for gap, smoothness of points; (e) see if interrupter shaft wobbles; (f) inspect primary wires; see if connections from battery to coil and interrupter are tight; (g) inspect secondary cables; (h) ignition switch for loose terminals; (i) ammeter terminals; (j) battery terminals; (k) battery ground; (l) oil or grease ignition device (see p. 462B for Major Tests).

Inspect engine bolts and nuts: (a) tighten cylinder head nuts; (b) inspect all cap screws on manifolds, carburetor, water head, oil pan, gear case, etc.

Inspect electric lights: (a) turn on different lighting circuits; (b) if any of the lights do not burn, look for blown fuses, defective bulbs, grounds in lamp sockets or wiring, loose connections; (c) trace lighting wire from switch to battery and see if good connections; (d) test signal lamp (stop light) switch and circuit; (e) examine battery connections and ground connections. See also "Final inspection," page 664, for tilting bright lights.

Inspect starting motor: (a) try starting motor; (b) tighten nuts supporting starting motor; (c) oil.

Inspect battery: (a) see if water is above plates; (b) test battery with hydrometer; (c) inspect battery

connections for looseness, corrosion, and for ground connection; (d) clean battery box; (e) tighten hold-down clips.

Inspection: Engine Running (Warmed Up)

Inspect cooling and lubrication system: (a) observe if water is circulating; (b) see if engine overheats (observe temperature indicator); (c) see if water pump leaks; (d) see if oil pressure gauge indicates properly (see pages 164, 162, 165).

Inspect carburetion: (a) see if engine idles properly; if not, see if throttle-lever idling-adjusting screw is properly adjusted; (b) see if engine idles without missing or loping; if not, see Index; (c) see if there are air leaks at carburetor, inlet manifold, or spark plug gaskets; (d) see if engine picks up speed quickly; (e) test action of throttle and accelerator (see also pages 462A and 462B).

Inspect ignition system: (a) See if engine idles properly; if not, examine interrupter points and spark plugs for proper gap and condition, test battery, test condenser (see pages 227, 230, 485), examine ground and other connections; (b) also applies to high speed (see also page 462A).

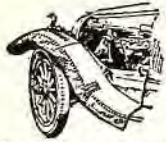
Inspect electric system in general: use ammeter to check action of generator and battery as follows: (a) speed engine up; note if "charge" is indicated at about 800 r.p.m. of engine. Note if ammeter shows at least 12-15 amperes with light switch "off." If "charge" is not indicated at high speeds, examine cut-out points, generator third-brush, and main brushes and commutator, also the field fuse on the generator and battery connections, as well as all other connections; (b) slow engine down; see if cut-out disconnects battery from generator (see pages 333, 504-506); (c) see if there is **sparking or arcing from spark-plug cables** (called static discharge). If so, and the rubber on cables is hard and porous, new cables should be installed (see page 241); (d) with engine running slowly, **turn on light switches.** See if battery supplies current for lights. As each light circuit is turned on the ammeter should indicate higher on "discharge" side; (e) with light switches on, engine speed up and see if generator

¹ Address of some of the manufacturers of wrenches and other tools suitable for automotive repair work: Blackhawk Manufacturing Co., Milwaukee, Wis.; Bonney Forge and Tool Works, Allentown, Pa.; Owatonna Tool Company, Owatonna, Minn.; Snap-On Tools, Inc., Kenosha, Wis. See also pages 698, 699, and 693-700, 763, 767.

² See also ADDENDA, pages 40-43, for engine testing and checking devices.

4. Don't pound the end of a shaft with a bare hammer. Use a babbit hammer, or deaden the blow with a piece of brass or wood.
5. Don't push a car around the shop with greasy hands on the varnished surfaces. Either wipe your hands or place a clean cloth between your hands and the car.
6. Don't leave a car standing in a pool of grease.
7. Don't use an 18" Stilson on a 3/8" nut.
8. Don't sit on the cushions with your greasy overalls. Spread a clean cloth or paper over them first, and don't put your greasy hands on doors, body, hood, etc.
9. Don't use the customer's gasoline just because its handier than to get some from the stockroom.

Overalls



Car overalls is the name given to washable duck protectors for upholstery, fenders, and cowl. They protect the seats, fenders, etc., from grease and repair-shop soiling when car is being worked on, and should be on hand in every shop. They should be laundered often and kept clean (also made in leatherette from which the grease can be removed with gasoline). Your own overalls should also be kept clean.

Starting in the Auto Repair Business

Automobile repair work may be classified into eight positions: (1) the helper, (2) the mechanic, (3) the specialist, (4) the assistant foreman or shop inspector, (5) the foreman, (6) the assistant service manager or service salesman, (7) the service manager, (8) the shop owner.

The above classifications are not followed by all organizations. Some have more, some have less, and some apply different names to the positions.

The helper. The best advice for one starting to learn the trade is to first obtain a fairly complete knowledge of the automobile by reading and, if possible, by attending a good school. Then get a position under a good foreman or shop inspector who can teach you the practical methods used in the trade. If you are to succeed, you must continue studying books and also good trade magazines and perfecting your knowledge.

One very important point is to refrain from doing work that you don't understand. It is better to ask the foreman's advice than to turn out a job about which you are uncertain.

By following the advice above and using good judgment, you should, after obtaining experience and knowledge, advance to a position as a mechanic.

The mechanic. The mechanic is capable of performing the routine jobs assigned to him without detailed instructions from the foreman. He is, however, still under the jurisdiction of the foreman and should still consult him on any conditions arising that are slightly unusual. One duty of the mechanic is to report to the foreman or shop inspector when the car requires certain repair work that has not been ordered. This is of particular importance to the mechanic himself when the repair needed but not ordered will affect the successful operation of the part on which he is working.

The specialist. After a certain amount of experience as a mechanic, one usually decides on becoming a specialist along certain branches of the trade. The number of such specialists are innumerable, but some of the most important divisions are: (1) general mechanic, (2) engine mechanic, (3) steering, axle, transmission, and clutch mechanic, (4) brake mechanic, (5) carburetor mechanic, (6) automotive electrician, (7) inspector, (8) trouble shooter, (9) welder, (10) body mechanic and trimmer.

The assistant foreman or shop inspector assists the foreman, in some large shops. He is a mechanic above the average in ability, and possesses about the

same ability as the foreman but possibly not as much experience.

The foreman. The foreman occupies a very responsible position in that he has complete charge of the shop and the mechanics. He must, first of all, be an expert along all lines of automobile repair-work. While he need not necessarily know all the details of each specialty listed above, he should have a general knowledge of each of them. Some of the main attributes of the successful foreman are: (a) ability to select and recognize good mechanics and helpers, (b) ability to teach mechanics and helpers, (c) constant watchfulness and observation of work performed by his mechanics, (d) ability to observe minor details that may be overlooked by his mechanics, (e) ability to know the quickest and most economical method of performing a job, (f) ability to maintain enthusiasm and loyalty among his mechanics.

The assistant service manager or service salesman assists the service manager, in some large shops. He deals directly with the customer and makes out orders and delivers the car to the shop foreman with instructions. He makes a final inspection of car when work is completed, and includes a road test if necessary. He returns the car to customer.

The service manager. The unusually good foreman advances to the position of service manager, who is in complete charge of all of the elements relating to mechanical service. This position requires the maximum in ability and character. The attributes of a successful service manager, in addition to those listed for foreman, are: (a) a pleasing personality in order to successfully deal with the customers; (b) good business ability, as he is obliged to supervise charges made to the customer, the quality and amount of stock and supplies to be purchased, the price to be paid for stock and supplies, the wages and working conditions of shop employees, systematic handling of the work, the general appearance of the shop, the necessary clerical work, and to increase the volume of profitable business.

The shop owner to be successful should possess all of the attributes of a service manager. In addition, it is also advisable to have some knowledge of accounting.

Equipment for Automobile Mechanics

As a general rule, helpers, mechanics, and specialists are required to supply their own hand tools. There is no definite rule regarding the exact number or kinds of tools that should be obtained. The selection is ordinarily dependent on the mechanic's personal preference and the nature of the work or specialty in which he is engaged.

The best advice for the helper or beginner to follow in the selection of tools for his first job is to ask the foreman's advice and, if possible, obtain his recommendation regarding the kinds and quality of tools to obtain.

Parts, special tools, and supplies are handled by the stock room department, which is operated by men familiar with the purpose, names, and price of all the parts of a car.

The shop stock room usually supplies special tools and testing devices, such as: reamers, drill bits, machine tools, electric drills, extension lamps, blow torches, soldering irons, taps and dies, jacks, wheel pullers, gear pullers, bearing pullers, special wrenches, valve grinding and valve reseating tools, cylinder hones, piston, connecting rod, tire and wheel alignment tools, precision instruments, such as micrometer calipers, electrical testing instruments, such as volt and ampere meters, condenser testers, battery hydrometers, neon ignition timing light, spark plug tester and cleaner, and other testing devices such as compression gauges, vacuum gauges, brake testers, etc.

For further information on tools see footnote next page and Instructions Nos. 63, 62, 64, and 65.

INSTRUCTION No. 60

THE AUTOMOBILE REPAIRMAN: Pointers for the Beginners; Starting in the Repair Business; Light Tool Equipment for the Auto Mechanic

POINTERS FOR THE BEGINNER

The auto repairman must know how to adjust any part of the car. To know how to adjust, he must first know the principles underlying the construction of the parts, as explained in previous Instructions, and must know when and where to look for trouble. (See Index under "Digest of Troubles.")

About one-half of the work of the automobile repairman is in making adjustments and fitting parts, such as carburetor adjustments, removing carbon, grinding valves, fitting horns, shock absorbers, diagnosing troubles, and numerous other little details, which do not require a machine shop, but do require a good assortment of tools, and a knowledge of the principles involved in the construction of a car.

A machine shop is not necessary, unless there is sufficient work to keep more than one machinist busy. A great number of small repair shops put in only the tools needed for the average repair work, and when they have a job of machine work to do, they take it to a machine shop. In other words, a machinist and an auto repairman follow two different trades. The auto repairman need not be a machinist; by machinist I mean one who can turn all kinds of metal parts on a lathe and do actual machine work.

System and Order

When beginning work on a car or engine, remember that system and order are two things every repairman ought to learn early. They mean success. Have a place for everything and keep everything in its place, and then you will not have to ramble around the shop trying to find tools and parts.



Fig. 1. Don't throw nuts or bolts on the floor. Place them in a box or pan.

There is nothing more disgusting to a man who owns a car, than to walk into a repair shop and find a careless workman dumping nuts, bolts, etc., here and there on the floor. That customer will say to himself: "If that workman is as careless as that, he is careless enough to leave a nut in my crank case and ruin my engine when it is started up, or he will leave off lock nuts or lock washers and cause me expense and damage."

A little piece of metal, such as a piece of a cotter pin or the like, accidentally dropped into a can of grease or oil and subsequently put into the gear case of a motor car has been known to cause much damage, and to cause the driver or owner of the car considerable trouble and expense.

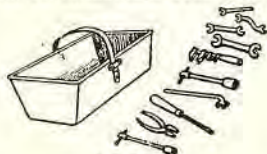


Fig. 2

Fig. 2. Keep your tools in a box or kit, not on the floor.



Fig. 3

Fig. 3. Before turning a car over to the customer, be sure that all nuts are tight and that lock washers are under those nuts that are supposed to have them.

What Is a Good Auto Mechanic

A good auto mechanic is one who strives to do careful, accurate work, endeavors to improve his knowledge by studying, and is truthful, courteous, clean, and uses system and order in his work.

One who possesses these traits is bound to make good. If you do not possess such traits, try cultivating them. Also cultivate the habit of thinking before you act. Such traits as these develop service managers and foremen.

A Careful Mechanic the One in Demand

If you do your work thoroughly and carefully and always do a little more than you agree to do, and be truthful, you will be sure to make a success.

It's the careful man the car owner wants to handle his car, not the fellow he can't depend upon.

Here is an example of a young man who had just started into the business as an auto mechanic. Judge for yourself which of the traits named above he lacked, and what kind of a business he could build up.

A car owner left his car with instructions to lubricate it thoroughly and not omit any of the places that should be lubricated; he also told him to be sure and see if the connections in the fuel line running to the gasoline tank were tight; he had an idea that there was a slight leak. He went away, and when he came back that afternoon he asked the mechanic if he had attended to the different things he told him to do. He said yes. Next day the owner ran out of gasoline. He found that the mechanic had not examined the connection carefully, if at all, and the leak had exhausted the tank—the connection was in a difficult place to get at under the car, so the mechanic simply took it for granted that it was all right and let it go at that. So you see a careless man is of very little value—it's the dependable fellow who will win.

Don't Overcharge

We want to warn you that in the matter of charges, it pays to be liberal. Make it a rule to do a little more than you agree to. It is well to comment on your work, in talking to the auto owner, like this: "I noticed that some of the nuts were loose on the carburetor base, so I went over all the nuts on the engine and found that many needed attention. You want to watch those little things, and then you won't need me so often." The owner may not say anything out loud, but he will certainly comment to himself, "There's a good repairman," and that is the most profitable reputation you can establish.

You are building a business for the future when you do your work right, and treat your customers fairly.

Dont's for the Repairman

1. Don't lay wrenches, hammers, chisels, etc., on the fenders or on the seat cushions. Cover the fenders, and remove the cushions during the work.
2. Don't spill oil, or smear grease over the finish or upholstery. Cover the seats and fenders with cloth protectors when working on a car.
3. Don't try to squeeze one car past another in the shop.

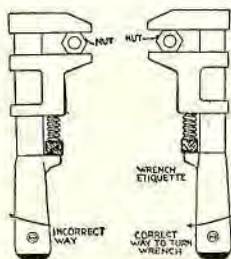


Fig. 4. Monkey-wrench etiquette. When using a monkey wrench or a Stillson wrench, use it as shown above. Most all nuts and bolts turn to the right to tighten and to the left to loosen. The proper method of using a wrench for the desired turn is shown above, and don't use a large wrench on a little nut.

The United States marker is used on designated cross country or interstate roads, in an effort to simplify highway markers, and form a national standardized system. Contrary to some opinions, the United States marker is not erected by the federal government, and neither is it limited strictly to Federal-aid roads. The system and the design of signs was decided at a meeting called by the Bureau of Public Roads and attended by state highway engineers. The road marker is a white shield, bearing in black letters and figures the name of the state in which the marker is erected, and the letters U.S., together with the highway number. In addition to the number sign the system embraces standardized warning and caution signs with a yellow and black color scheme.

The state marker differs with each state and is confined in location within the state border. The design is generally either an outline of the state, or a geometric figure, with the road number in the center. Color combinations are decided by the state, but white or yellow with black figures predominates. In most states, routes posted with U.S. markers do not bear additional state markers, although some exceptions of double marking prevail. As in the federal marking system, the state markers include necessary caution and warning signs.

State Motor Laws Affecting Tourists

Motor vehicle registrations are not standard throughout the country, although an effort is being made to this end by the adoption of the Hoover Code by many states and cities. The automobile tourist when traveling today must be prepared with a knowledge of the more important regulations of the states he visits, especially with reference to speed, licenses, lights, and arm signals. This data can be obtained from the Travel Bureau of any A.A.A. Motor Club. The Hoover Code mentioned above is explained on pages 655-657.

License Reciprocity Granted to Tourists

Every state recognizes licenses of other states, on tourists' automobiles, for periods of time varying from twenty days to the entire remainder of the license year. This reciprocal privilege is granted only to tourists and does not apply to persons who take up a residence within the state. In addition to granting the privilege, some states require that tourists register their car when entering the state, and furnish a dated visitor's permit. Information on license regulations can be obtained from any A.A.A. Motor Club, and are embodied in the maps and touring publications prepared by that organization.

Preparing Car for a Tour

Before starting on a tour, where car is to be run continuously for long periods of time, the car should be thoroughly checked as follows:

Engine tune-up: Adjust timing chain; adjust fan belt; examine electrical system as explained farther on; clean and adjust carburetor; clean gasoline filter; check gasoline fuel vacuum line, or fuel pump line for tight connections; test engine lubricating oil filter cartridge and renew if necessary; check valve tappet clearance.

Valve tappet clearance should be set at maximum clearance. If set at minimum clearance, they may become so hot that they will expand and keep valve open and thus not only burn the valve but will also burn valve-seat, necessitating new valves and reseating of valve and seat. This condition reduces power, prevents proper idling and pick-up and may cause missing. (See also pages 57, 58 and 776B.)

If the engine lacks power and does not pick-up as it should, it is advisable to test the compression, as explained on page 766. If it does not come up to standard, it may be necessary to re-grind the valves. If this does not increase compression, then look to the pistons and cylinders as explained on pages 768, 812, 814 and 825. If the piston rings, cylinder walls and pistons are badly worn, a greater consumption of oil will be the result as well as reduced power.

If engine overheats, examine fan belt; if slipping, this is one cause. See other causes, pages 152, 460. This is a good time to clean out the cooling system and put on new radiator hose, and also put radiator oil into the cooling system. (See page 730.)

Lubrication of chassis: If the rear axle and transmission was not drained and refilled at the beginning of the season, it is advisable to drain and flush same out and refill with reasonable lubricant. Also give a complete chassis lubrication. (See also pages 172 to 174A.)

Lubrication of engine: Change engine oil when starting on a tour, and often while touring, as the oil gets thin on long-continued runs. Don't forget to lubricate distributor mechanism and generator.

Steering device: Check steering device for adjustment, loose connections, and thoroughly lubricate.

Brakes: See if properly operating; lining, if worn, renew; adjust.

Clutch-pedal: Check for clearance. (See page 840.)

Rear axle: Check differential pinion for end play by rocking drive shaft when gears are in high; if pinion jumps in and out, bearing needs adjusting or renewing. Don't mistake the normal back lash in all drive shafts as an indication.

Electrical system: Examine battery; see if level of water is above plates; clean and tighten all connections, including the ground connection, and also see if tight in battery box.

Examine generator brushes and connections; renew brushes if necessary. The generator charging rate should be reduced so that generator and battery will not overheat and burn out. A good plan is to set generator so that when lights are on, the ammeter will stand at zero when running at high speed. If lights are put on to reduce the charge going to battery, this may cause generator to overheat. If generator gets extremely hot, the solder may melt and loosen the wires at the commutator segments. The best plan is to reduce the generator charge. Overheating of the battery will ruin the separators and probably buckle the plates. (See page 543.) The battery, of course, should be kept charged, but not overcharged. See that electrolyte covers the plates and separators.

If the connections become loose at the battery, battery ground, or generator, it may burn out all lamps; if loose at any lamp it will burn out that particular lamp, therefore see that all connections are tight.

Examine timer-distributor contact-breaker points. See that points are clean and square and set gap as recommended by manufacturer. See that the cam and breaker-arm are not worn and wobbly. It is a good plan to renew these parts if worn. (See also footnotes on page 1051.)

Examine spark plugs: Clean; adjust to gap recommended by the manufacturer. Examine porcelain to see if cracked. This is a good time to renew the spark plugs. (See page 236, footnotes 1 and 2, explaining about hot and cold running spark plugs.) A spark plug for touring may require a different heat range.

Tires: Check tire and tool equipment. Good tire tools and a hydraulic type of jack are very necessary.

Tool box. A metal tool box with a good lock which can be placed in a convenient location rather than have the tools under the seat is recommended. A good assortment of 12 point double broached socket wrenches is also recommended. (See page 699.)

Extras should be carried of those parts of your car most likely to require attention. Ask the service manager of the car agency. It is well to carry an extra fan belt, contact-breaker points, spark plugs, a small roll of tape, lamp bulbs, a piece of insulated wire and a tow rope.

Miscellaneous

To use your watch as a compass: Point the hour hand of your watch to the sun at any time of the day; then lay the watch flat in your hand. A point midway between the hour hand and 12 on the dial will be due south.

When stuck in the mud: If the rear wheels are stuck in the mud, dig holes in front of the front wheels for them to fall into, to give the initial start, and if the car does not continue, then block the rear wheels instantly and repeat the operation. Place brush in front of the rear wheels and turn them as slowly as possible to keep from churning. If one rear wheel is on a good road, try putting on the handbrake fairly tight to destroy the action of the differential, or fasten the mired wheel so that it cannot turn, and the other wheel will do the work and slide the mired wheel along the ground.

The instant you realize you are getting stuck in sand or mud, stop right there and look over the situation, instead of fighting the car and burying it deeper and deeper.

Note: The subject of touring has been revised in this edition. Some of the minor subjects formerly discussed on these pages and indexed were omitted.

If you are standing still on the side of a street and intend to start and turn into the street, signal in the manner shown in Fig. 27 and look before you turn into the street. Many accidents have occurred from a failure to do this.

Courtesy Rules

1. When a man approaching you from behind sounds his horn as a signal that he wishes to pass, don't "step on it." Draw over to the right and let him go by.
2. Do not use more than your half of the road, thus crowding others into the ditch.
3. Keep well to the right of the road, especially on curves and over the crest of hills and where driving slowly.
4. It is not courteous to "steal" a parking space from a man who is just getting ready to back into it.
5. Do not imagine that every motorist on the road who tries to pass you is starting a race. He may be on important business.
6. When you pass a man from behind going in the same direction, do not cut in directly in front of him. This is discourteous.
7. Do not shove another man's car along the curb to make room for yours, jamming his car against a fireplug, or car ahead.
8. It is discourteous to halt behind a traffic jam and honk your horn.
9. The giving of hand signals is courteous as well as safe.

Headlight Courtesy on the Road

You know how very difficult it is to see when you are approaching another machine with glaring headlights. You are simply blinded, and cannot tell whether you are running off the road, are too close to the oncoming machine, or are striking

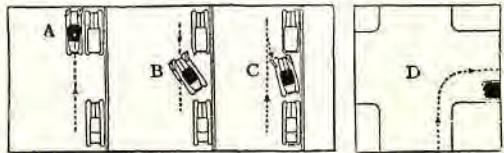
obstructions. It is a peculiarly helpless feeling to be directing a car when confronted by the other fellow's glaring lights.

If your headlights are on and are not equipped with non-glare devices, he is in just the same predicament, however, and the least either of you can do is to dim the headlights while passing. This is a safety factor as well, for it protects each from running into the other, or off the road. In most states a law prohibits the use of glaring headlights.

How to Park a Car

Parking a car in a limited space can easily be accomplished if a little judgment is used.

First: Drive up alongside of and parallel with the car ahead. Then turn the wheels sharply to the right as shown at A.



Second: Back up until the right front fender of your car just clears the left rear fender of the car ahead as in B.

Third: Then turn the wheels sharply to the left and continue backing slowly until into position alongside of the curb as in C.

Do not park so close to a corner that it will interfere with drivers wishing to make a right-hand turn. Park close to the curb and keep the prescribed distance away from intersection or any fire hydrants, mail boxes or traffic signals. (See D.)

INSTRUCTION No. 59

TOURING: General Information; Transcontinental Routes; Highway Markers; State Motor Laws Affecting Tourists; License Reciprocity Granted to Tourists; Preparing a Car for a Tour

GENERAL INFORMATION

Touring from any point in the United States, north, east, south or west, for short or long trips, can be made with comfort and ease and without a doubt is the most enjoyable and healthful mode of traveling, particularly so if one will take the precaution to prepare for the trip in advance, that is, to obtain all information necessary regarding the best route, condition of the roads, accommodations along the route and also to prepare the car for uninterrupted service.

Authentic information as to the routes, if construction work is under way, necessitating detours; accommodations, such as affiliated hotels and garages with which clubs have contracts to render adequate service to members, etc., can best be had through an automobile club affiliated with the A.A.A., which stands for the American Automobile Association, a national organization of motor-car users. It was organized in 1902 and now has a membership of over 900,000. By joining any A.A.A. club, the dues of which run approximately \$5.00 to \$15.00 a year, according to the local benefits offered, you automatically become a member of all A.A.A. clubs and have available for yourself and family the resources and facilities of the world's largest travel organization. Consult any local A.A.A. club for further details.

Transcontinental Routes

Transcontinental automobile travel is increasing year by year, but figures reveal that tourists concentrate on only a few highways in their journeys from one border of the country to another. There are ten principal east and west routes and sixteen north and south routes.

The east and west routes are as follows: U.S. 2 Houlton, Me., to Rouses Point, N.Y.—500 mi., then via Canadian roads, continuing to Sault Ste. Marie, Mich., to Bonners Ferry, Idaho—1,910 mi.; U.S. 10 Detroit, Mich., to Seattle, Wash.—2,495 mi.; U.S. 20 Boston, Mass., to Yellowstone Park—2,540 mi.; U.S. 30 Atlantic City, N.J., to Astoria, Ore.—3,350 mi.; U.S. 40 Atlantic City, N.J., to San Francisco, Calif.—3,215 mi.; U.S. 50 Annapolis, Md., to Sacramento, Calif.—2,970 mi.; U.S. 66 Chicago to Los Angeles—2,485 mi.; U.S. 70 Beaufort, N.C., to Holbrook, Ariz.—2,330 mi.; U.S. 80 Tybee, Ga., to San Diego, Calif.—2,750 mi.; U.S. 90 Jacksonville, Fla., to Van Horn, Tex.—1,580 mi.

The north and south routes are as follows: U.S. 1 Fort Kent, Me., to Key West, Fla.—2,330 mi.; U.S. 11 Rouses Point, N.Y., to New Orleans, La.—1,730 mi.; U.S. 25 Port Huron, Mich., to Statesboro, Ga.—1,005 mi.; U.S. 31 Mackinaw City, Mich., to Mobile, Ala.—1,385 mi.; U.S. 41 Copper Harbor, Mich., to Naples, Fla.—1,925 mi.; U.S. 45 Chicago, Ill., to Mobile, Ala.—920 mi.; U.S. 51 Hurley, Wis., to New Orleans, La.—1,360 mi.; U.S. 61 Grand Marais, Mich., to New Orleans, La.—1,850 mi.; U.S. 65 St. Paul, Minn., to Natchez, Miss.—1,140 mi.; U.S. 67 Milwaukee, Wis., to Dallas, Texas—1,055 mi.; U.S. 71 Bemidji, Minn., to Baton Rouge, La.—1,685 mi.; U.S. 75 Emerson Jct., Canada, to Galveston, Tex.—1,615 mi.; U.S. 81 Emerson Jct., Canada, to Laredo, Tex.—1,770 mi.; U.S. 91 Great Falls, Mont., to Daggett, Calif.—1,390 mi.; U.S. 99 Blaine, Wash., to El Centro, Calif.—1,670 mi.

These routes carry the bulk of cross country travel and are intersected by hundreds of U.S. and state routes which act as alternates and feeders. It will be understood that these roads are not entirely hard-surfaced or in all-weather condition, and are subject to their share of road construction and detours.

Highway Markers

The roads of the United States were trail marked as little as fifteen years ago, but today the colored bands and geometric figures have almost disappeared, their place being taken by numbered signs. These are of two classes, the United States marker, and the state marker.

Note: The subject of touring has been revised in this edition. Some of the minor subjects formerly discussed on these pages and indexed were omitted.



Fig. 4 (left). Keep to the extreme right when going over a hill and do not pass a car going in the same direction when near the top, as this would put you directly in the path of a car coming over the hill from the opposite direction.

Fig. 5 (center). Many accidents happen because automobiles become stalled on railroad tracks. It is wise to shift into second before crossing railroad tracks, particularly if there is a slight grade at the crossing, or if the tracks are obscured by hills, trees or buildings.

Fig. 6 (right). Automobile must stop at rear door of street car which has stopped to take on or discharge passengers. In some cities where there are safety zones (see Fig. 23), automobiles are permitted to pass street cars stopped to take on or discharge passengers. People who have just alighted from a trolley car are sometimes bewildered and do not know which way to go. Give them plenty of time to get their bearings before attempting to pass them.



Fig. 7 (left). Be especially careful at crossings where there is more than one track. Do not cross directly behind a train that has just passed. Another train may be coming from the opposite direction on the next track.

Fig. 8 (center). Automobile drivers must be especially careful to avoid injuring people who cross the middle of the block. Many accidents also occur at regular street crossings. If the pedestrians do not, or will not, pay attention to your horn, remember that hundreds of people are using the streets whose old age, youth, infirmities or physical defects would throw all the responsibility of an accident upon you.

Fig. 9 (right). Passing a street car on the left is a violation of the law. The right way to pass a street car is on the right, and if passengers are getting on or off, stop, unless there is a safety zone.



Fig. 10 (left). Slow-moving vehicles should keep close to curb.

Fig. 11 (center). Keep over as near as practicable to the right-hand curb when driving slowly, so as to leave the center of the street free and open for faster traffic—the slower the speed, the nearer the curb.

Fig. 12 (right). One car passing another going in the same direction should pass on the left of the car ahead. Do not cut directly in front of the car which you pass.



Fig. 13 (left). In turning corners, with a car coming, give a signal with your hand to indicate the direction in which you intend to go and as a hint for him to slow up. Always observe a central point in the intersection of streets, and clear it when turning.

Fig. 14 (center). Approaching a circle: arrows point the way in which to enter and leave.

Fig. 15 (right). Don't park closer than 15 feet to a fire hydrant. The distance varies; in some cities 10 feet is the limit.

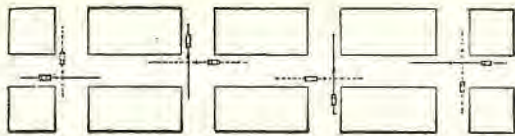


Fig. 16. It is the rule in many cities that when two vehicles approach a street intersection simultaneously in the manner illustrated, the vehicle at the right, as indicated by heavy lines, shall have the right-of-way, regardless of direction traveled.

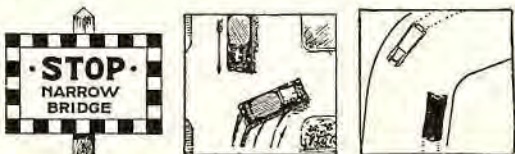


Fig. 17 (left). Do not fail to observe danger signs; they are for your protection.

Fig. 18 (center). Do not take sharp turns, or make quick movements of the steering wheel when driving fast on wet pavements. Cautiously approach all turns, street intersections and street cars. Do all braking gradually. Four-wheel brakes are very efficient.

Fig. 19 (right). When approaching a curve in the road, keep to the extreme right.

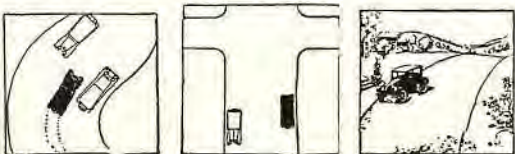


Fig. 20 (left). Do not attempt to pass another automobile on a curve in the road. There may be a car coming which you cannot see. When passing hospitals, blow the horn as infrequently as possible. When passing a schoolhouse during the school season, drive with extreme care. Duly respect any officer of the law. Obey all local traffic regulations.

Fig. 21 (center). When stopping or parking your car, pull up close to the right curb or edge of the road so that it will not interfere with traffic, keep away the prescribed distance from fire hydrants, and far enough away from a corner not to hinder other cars from making a good right-hand turn.

Fig. 22 (right). When stopping on an incline, make sure that the hand brake is fully on and, if conditions warrant, stop the engine and leave the transmission gears in mesh and turn the wheels sharply toward the curb.

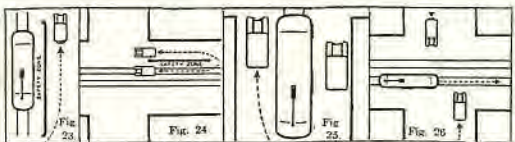


Fig. 23. If there is a safety zone you can drive past street car stopped to take on or discharge passengers. If there is not a safety zone, automobile must stop at rear door. (See Fig. 6.)

Fig. 24. Automobiles may pass on either side of a safety zone unless sign or traffic officer directs otherwise.

Fig. 25. On one-way street when passing to the left of street car, automobile must be stopped abreast of front end of street car before proceeding over intersection.

Fig. 26. When a street car has started across an intersection no automobile shall be driven into the intersection in front of the street car.

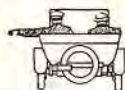


Fig. 27. When you intend to slow down, stop, or turn, signal as above. In many states the law requires closed cars to be equipped with a signal lamp in the rear of the car, such as a red or amber light, which is automatically thrown on when the car slows down, backs up, or turns. Ample warning should be given before backing up.

Standing or Parking Close to Curb: Article VI, Section 34:

(a) Except when necessary, in obedience to traffic regulations or traffic signs or signals, the driver of a vehicle shall not stop, stand or park such vehicle in a roadway other than parallel with the edge of the roadway, headed in the direction of traffic, and with the curb-side wheels of the vehicle within six inches of the edge of the roadway.

Parking Vehicle for Sale Prohibited: Article VI, Section 35:

It shall be unlawful for any person to park upon a street any vehicle displayed for sale.

Using Vehicle for Primary Purpose of Displaying Advertising Prohibited: Article VI, Section 36:

It shall be unlawful for any person to operate or to park on any street any vehicle for the primary purpose of displaying advertising.

Stop Before Entering a Through Street: Article VII, Section 37:

One-Way Streets: Article VII, Section 38.

Operation of Vehicles on Approach of Authorized Emergency Vehicles: Article VII, Section 39:

Upon the approach of any authorized emergency vehicle, or vehicles, giving audible signal by bell, siren or exhaust whistle, the driver of every other vehicle shall immediately drive the same to a position as near as possible and parallel to the right-hand edge or curb of the street, clear of any intersection, and shall stop and remain in such position until the authorized emergency vehicle or vehicles shall have passed, unless otherwise directed by a police officer; and the motorman of every street car shall immediately stop such car clear of any intersection and keep it in such position until the authorized emergency vehicle or vehicles shall have passed, unless otherwise directed by a police officer.

Following Fire Apparatus Prohibited: Article VII, Section 40:

It shall be unlawful for the driver of any vehicle, other than one on official business, to follow closer than five hundred feet any fire apparatus traveling in response to a fire alarm, or to drive into or stop any vehicle within the block where fire apparatus has stopped in answer to a fire alarm.

Crossing Fire Hose: Article VII, Section 41:

No street car or vehicle shall be driven over any unprotected hose of the Fire Department when laid down on any street, private driveway or street car track to be used at any fire or alarm of fire, without the consent of the Fire Marshal or Fire Department official in command.

Unlawful to Drive Through Procession Unless Directed by Traffic Control Signals or by a Police Officer: Article VII, Section 42:

It shall be unlawful for the driver of any vehicle or motorman of any street car to drive between the vehicles comprising a funeral or other authorized procession while they are in motion, provided that said vehicles are conspicuously so designated. This provision shall not apply at intersections where traffic is controlled by traffic control signals or police officers.

Limitations on Turning Around: Article VII, Section 43:

It shall be unlawful for the driver of any vehicle to turn such vehicle so as to proceed in the opposite direction unless such movement can be made in safety and without backing or otherwise interfering with other traffic.

Limitations on Backing: Article VII, Section 44:

The driver of a vehicle shall not back the same unless such movement can be made in safety.

Emerging from Alley or Private Driveway: Article VII, Section 45:

The driver of a vehicle emerging from an alley, driveway or building shall stop such vehicle immediately prior to driving onto a sidewalk or onto the sidewalk area extending across any alleyway.

Vehicles Shall Not Be Driven on Sidewalk: Article VII, Section 46:

The driver of a vehicle shall not drive within any sidewalk area except at a permanent or temporary driveway.

Obstruction to Driver's View or Driving Mechanism: Article VII, Section 47:

(a) It shall be unlawful for the driver of any vehicle to drive the same when such vehicle is so loaded, or when there are in front seat of such vehicle such a number of persons as to obstruct the view of the driver to the front or sides, or to interfere with the operator's control over the driving mechanism of the vehicle.

(b) It shall be unlawful for any passenger in a vehicle or street car to ride in such position as to interfere with the driver's view ahead or to the sides, or to interfere with the driver's control over the driving mechanism of the vehicle.

Clinging to Moving Vehicles: Article VII, Section 48:

It shall be unlawful for any person traveling upon any bicycle, motorcycle, coaster, sled, roller skates or any toy vehicle to cling to or attach himself or his vehicle to any other moving vehicle or street car upon any roadway.

Note to Section 48. Improper riding in or upon any street car or vehicle is prohibited in Sections 23, 47 and 49.

Riding on Handle Bars Prohibited: Article VII, Section 49:

It shall be unlawful for the operator of any bicycle or motorcycle, when upon the street, to carry any other person upon the handle bar, frame or tank of any such vehicle, or for any person to so ride upon any such vehicle.

Use of Coasters, Roller Skates, and Similar Devices Restricted: Article VII, Section 50:

It shall be unlawful for any person upon roller skates, or riding in or by means of any coaster, toy vehicle, or similar device, to go upon any roadway except while crossing a street or crosswalk.

Motor Vehicles Left Unattended, Brakes to Be Set and Engine Stopped: Article VII, Section 51:

No person having control or charge of a motor vehicle shall allow such vehicle to stand on any street unattended without first setting the brakes thereon and stopping the motor of said vehicle, and, when standing upon a perceptible grade, without turning the wheels of such vehicle to the curb or the side of the street or highway.

Lights on Parked Vehicles: Article VII, Section 52:

Whenever a vehicle is parked or stopped on a street during the times between one-half hour after sunset and one-half hour before sunrise, or at any other time when there is not sufficient light to render clearly discernible any vehicle on the street from a distance of 200 feet, there shall be displayed upon such vehicle one or more lamps, one of which shall be on the roadway side and project a white light visible under normal atmospheric conditions from a distance of 500 feet to the front of such vehicle and one of which lamps shall project a red light visible under like conditions from a distance of 500 feet to the rear, except that such parking light or lights need not be displayed upon any vehicle stopped or parked in accordance with other provisions of this Ordinance upon any street designated by the (traffic authority) where there is sufficient light to reveal any person within a distance of 200 feet upon such street.

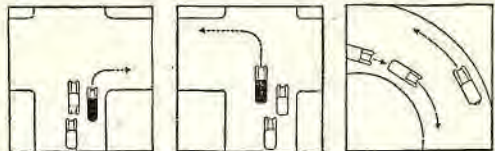
POINTERS ON SAFE DRIVING GRAPHICALLY ILLUSTRATED¹

The following illustrations show some of the safety precautions on how to make turns, pass other vehicles and street cars, etc., and are suggestions only, and may not correspond with the exact wording of the uniform code on preceding pages.

Fig. 1 (left). When about to make a right-hand turn, approach the corner on the extreme right. Do not drive up the middle of the street before making a right turn. This would necessitate cutting across in front of the car behind and would place the responsibility of an accident upon you.

Fig. 2 (center). When about to make a left-hand turn, approach the corner near the center of the street, but not on the left-hand side. Do not drive up on the extreme right and do not cut diagonally across the corner. Approach the intersection as illustrated and make a sharp turn to the left.

Fig. 3 (right). Keep to the extreme right when going around a turn in the road. This will avoid all interference with any



car coming from the opposite direction. Never attempt to pass a car going in the same direction on a curve, as this would necessitate driving out near the left-hand side.

¹ Credit is extended to instruction books of Frank in Automobile Co., The Studebaker Corporation of America, and *Missouri Motor News*, issued by The Automobile Club of Missouri, for some of the illustrations and text.

Note: For subject of touring and other subjects formerly on this page see pages 659-660.

Yellow or "Caution," when shown alone following the green or "Go"—Traffic facing the signal shall stop before entering the nearest crosswalk at the intersection unless so close to the intersection that a stop cannot be made in safety.

Red or "Stop"—Traffic facing the signal shall stop before entering the nearest crosswalk at the intersection or at such other point as may be designated by the (traffic authority), and remain standing until green or "Go" is shown alone.

(b) The driver of a vehicle or the motorman of a street car intending to turn to the right or left at an intersection where traffic is controlled by traffic control signals or by a police officer shall proceed to make either such turn with proper care to avoid accident and only upon the "Go" signal, unless otherwise directed by a police officer or by official traffic signs or special signals.

Display of Unauthorized Signs and Signals Prohibited: Article III, Section 11:

It shall be unlawful for any person to place or maintain, or to display upon or in view of any street, any unofficial sign, signal or device which purports to be or is an imitation of or resembles an official traffic sign or signal, or which attempts to direct the movement of traffic or which hides from view or interferes with the effectiveness of any official sign or signal. Every such prohibited sign, signal or device is hereby declared to be a public nuisance, and the (Chief of Police) is hereby empowered to remove the same, or cause it to be removed, without notice.

Interference with Signs and Signals Prohibited: Article III, Section 12:

It shall be unlawful for any person to wilfully deface, injure, move, obstruct or interfere with any official traffic sign or signal.

(Traffic Authority) Authorized to Designate Crosswalks: Article III, Section 13:

The (traffic authority) is hereby authorized to establish and to designate and shall thereafter maintain, or cause to be maintained, by appropriate devices, marks or lines upon the surface of the roadway, crosswalks at intersections where, in (his) opinion, there is particular danger to pedestrians crossing the roadway, and at such other places as (he) may deem necessary.

(Traffic Authority) Authorized to Designate Safety Zones and Lanes for Traffic: Article III, Section 14:

(a) The (traffic authority) is hereby empowered to establish safety zones of such kind and character and at such places as (he) may deem necessary for the protection of pedestrians.

(b) The (traffic authority) is also authorized to mark lanes for traffic on street pavements at such places as (he) may deem advisable, consistent with the provisions of this Ordinance.

Pedestrians' Right of Way: Article IV, Section 15:

(a) The driver of any vehicle shall yield the right of way to a pedestrian crossing the roadway within any marked crosswalk or within any unmarked crosswalk at the end of a block, except at intersections where the movement of traffic is being regulated by police officers or traffic control signals, or at any point where a pedestrian tunnel or overhead crossing has been provided.

(b) Whenever any vehicle has stopped at a marked crosswalk or at any intersection to permit a pedestrian to cross the roadway, it shall be unlawful for the driver of any other vehicle approaching from the rear to overtake and pass such stopped vehicle.

(c) Every pedestrian crossing a roadway at any point other than within a marked or unmarked crosswalk shall yield the right of way to vehicles upon the roadway, provided that this provision shall not relieve the driver of a vehicle from the duty to exercise due care for the safety of pedestrians.

Pedestrians' Rights and Duties at Controlled Intersections: Article IV, Section 16:

At intersections where traffic is controlled by traffic control signals or by police officers, drivers of vehicles shall yield the right of way to pedestrians crossing or those who have started to cross the roadway on a green or "Go" signal, and in all other cases pedestrians shall yield the right of way to vehicles lawfully proceeding directly ahead on a green or "Go" signal.

Pedestrians to Use Right Half of Crosswalks: Article IV, Section 17:

Pedestrians shall move, whenever practicable, upon the right half of crosswalks.

Pedestrians Soliciting Rides: Article IV, Section 18:

It shall be unlawful for any person to stand in a roadway for the purpose of soliciting a ride from the operator of any private vehicle.

Passing Street Cars: Article V, Section 19:

(a) The driver of a vehicle shall not overtake and pass upon the left any street car proceeding in the same direction, whether

actually in motion or temporarily at rest. This provision shall not apply on one-way streets, or on streets where the tracks are so located as to prevent compliance with the rule.

(b) The driver of a vehicle overtaking any street car stopped, or about to stop, for the purpose of receiving or discharging any passenger, shall stop such vehicle to the rear of the nearest running board or door of such street car and keep it stationary until any such passenger has boarded such car or reached a place of safety, except that where a safety zone has been established, a vehicle need not be stopped before passing any such street car, but may proceed past such car at a speed not greater than is reasonable or proper, and with due caution for the safety of pedestrians. This provision shall not apply to passing upon the left of any street car on a one-way street.

Driving on Street Car Tracks: Article V, Section 20:

(a) It shall be unlawful for the driver of any vehicle proceeding upon any street car tracks in front of a street car upon a public street to fail to remove such vehicle from the tracks as soon as practicable after signal from the motorman of said street car.

(b) When a street car has started to cross an intersection, no driver shall drive upon or cross the car tracks within the intersection in front of the street car.

Driving Through Safety Zone Prohibited: Article V, Section 21:

It shall be unlawful for the driver of a vehicle at any time to drive the same over or through a safety zone as defined in this ordinance.

Boarding or Alighting from Street Cars or Vehicles: Article V, Section 22:

It shall be unlawful for any person to board or alight from any street car or vehicle while such street car or vehicle is in motion.

Unlawful Riding: Article V, Section 23:

It shall be unlawful for any person to ride on any street car or vehicle upon any portion thereof not designed or intended for the use of passengers when the vehicle is in motion. This provision shall not apply to an employee engaged in the necessary discharge of a duty, or to persons riding within truck bodies in space intended for merchandise.

Stopping Prohibited in Specified Places: Article VI, Section 25:

It shall be unlawful for the driver of a vehicle to stop, stand or park such vehicle in any of the following places, except when necessary to avoid conflict with other traffic or in compliance with the directions of a police officer or traffic control sign or signal:

- (1) Within an intersection.
- (2) On a crosswalk.
- (3) Between a safety zone and the adjacent curb or within thirty (30) feet of points on the curb immediately opposite the ends of a safety zone, unless the (traffic authority) shall indicate a different length by signs or markings.
- (4) Within twenty-five (25) feet from the intersection of curb lines, or, if none, then within fifteen (15) feet of the intersection of property lines at an intersection, except at alleys.
- (5) Within thirty (30) feet upon the approach to any flashing beacon, stop sign or traffic control signal located at the side of the roadway.
- (6) Within fifteen (15) feet of the driveway entrance to any fire station.
- (7) Within fifteen (15) feet of a fire hydrant.
- (8) In front of a private driveway.
- (9) On a sidewalk.
- (10) Alongside or opposite any street excavation or obstruction when such stopping, standing or parking would obstruct traffic.
- (11) On the roadway side of any vehicle stopped or parked at the edge or curb of a street.
- (12) At any place where official traffic signs have been erected prohibiting standing and parking.
- (13) Within fifty feet of the nearest rail of a steam or inter-urban railway crossing.

All Night Parking Prohibited: Article VI, Section 33:

It shall be unlawful for the driver of any vehicle to park said vehicle on any street for a period of time longer than thirty (30) minutes between the hours of (2) A.M. and (6) A.M. of any day, except physicians on emergency calls.

Note: For subject of touring and other subjects formerly on this page see pages 659-660.

INSTRUCTION No. 58

TRAFFIC REGULATIONS: Uniform Code; Pointers on Safe Driving

Since 1928 representatives from 42 states have been interested in promoting a uniform vehicle code as first suggested by Hon. Herbert Hoover, when Secretary of Commerce. A final draft of such a code was adopted at the third National Conference on Street and Highway Safety in May, 1930. This is known as the Hoover Code.

The excerpts which are given in this discussion are taken from one of the several publications issued by the National Conference on Street and Highway Safety, entitled Model Municipal Traffic Ordinance, as of May, 1930.

Those interested in additional information and also state laws on such fundamental matters as state highway patrols, drivers' license, safety responsibility laws and proper regulations of commercial vehicles, also other state laws set forth in the uniform traffic regulations, in addition to the model municipal traffic ordinances, such as driving while intoxicated, reckless driving, speed restrictions, the right-of-way rule and other rules of the road, etc., can obtain additional information regarding this code from the American Automobile Association, Washington, D.C.

A Summary of the Recommendations of the National Conference on Street and Highway Safety:¹

- Traffic Accident Statistics
- Protection of Railway Grade Crossings and Highway Intersections
- Maintenance of the Motor Vehicle
- Measures for the Relief of Traffic Congestion
- Uniform Traffic Regulation, accompanied by Uniform Vehicle Code, consisting of:
 - Uniform Motor Vehicle Registration Act
 - Uniform Motor Vehicle Anti-Theft Act
 - Uniform Motor Vehicle Operators' and Chauffeurs' License Act
 - Uniform Act Regulating Traffic on Highways
- Model Municipal Traffic Ordinance
- Manual of Street Traffic Signs, Signals, and Markings

Excerpts from Model Municipal Traffic Ordinance²

Definitions: Article I, Section 1: Wherever in this Ordinance the following terms are used, they shall have the meanings respectively ascribed to them in this section:

Street or Highway. Every way or place of whatever nature open to the use of the public, as a matter of right, for purposes of vehicular travel.

Private Road or Driveway. Every road or driveway not open to the use of the public for purposes of vehicular travel.

Roadway. That portion of a street or highway between the regularly established curb lines or that part improved and intended to be used for vehicular travel.

Sidewalk. That portion of a street between the curb lines and the adjacent property lines.

Intersection. The area embraced within the prolongation or connection of the lateral curb lines or, if none, then of the lateral boundary lines of two or more streets or highways which join one another at an angle, whether or not one such street or highway crosses the other.

Crosswalk. That portion of a roadway ordinarily included within the prolongation or connection of curb and property lines at intersections, or any other portion of a roadway clearly indicated for pedestrian crossing by lines or other markings on the surface.

Safety Zone. The area or space officially set apart within a roadway for the exclusive use of pedestrians and which is protected or is so marked or indicated by adequate signs as to be plainly visible at all times while set apart as a safety zone.

¹ Revisions have been made. This code is now known as "Uniform Vehicle Code." Publications listed below are superseded by the following: Act I—Uniform Motor Vehicle Administration Registration, Certificate of Title and Antitheft Act; Act II—Uniform Motor Vehicle Operators' and Chauffeurs' License Act; Act III—Uniform Motor Vehicle Civil Liability Act; Act IV—Uniform Motor Vehicle Safety Responsibility Act; Act V—Uniform Act Regulating Traffic on Highways; Model Traffic Ordinances. These publications, the "Uniform Vehicle Code" and the "Model Traffic Ordinances," can be obtained from the Federal Works Agency, Public Roads Administration, Washington, D.C.

² The new name is "Model Traffic Ordinances," in which there have been a number of revisions.

NOTE.—The American Automobile Association have available many publications on safe driving suitable for use in high schools, colleges, and among adults, C.C.C. camp enrollees, etc., including their own textbook, "Sportsmanlike Driving," and the Sportsmanlike Driving text pamphlets with the following titles: "The Driver," "Driver and Pedestrian Responsibilities," "Sound Driving Practices," "Society's Responsibilities," and "How To Drive." For further information see the local AAA Motor Club, or address Safety and Traffic Engineering Dept., American Automobile Association, Washington, D.C.

Vehicle. Every device in, upon, or by which any person or property is or may be transported or drawn upon a public highway, except devices moved by human power or used exclusively upon stationary rails or tracks.

Motor Vehicle. Every vehicle, as herein defined, which is self-propelled.

Street Car. Every device traveling exclusively upon rails when upon or crossing a street, other than cars or trains propelled or moved by steam.

Authorized Emergency Vehicle. Vehicles of the Fire Department (Fire Patrol), police vehicles and such ambulances and emergency vehicles of municipal departments or public service corporations as are designated or authorized by the Chief of Police.

Pedestrian. Any person afoot.

Traffic. Pedestrians, ridden or herded animals, vehicles, street cars and other conveyances, either singly or together, while using any street for purposes of travel.

Right of Way. The privilege of the immediate use of the street or highways.

Parking. The standing of a vehicle, whether occupied or not, upon a roadway, otherwise than temporarily for the purpose of and while actually engaged in loading or unloading, or in obedience to traffic regulations or traffic signs or signals.

Official Traffic Signs. All signs, markings and devices, other than signals, not inconsistent with this Ordinance, placed or erected by authority of a public body or official having jurisdiction, for the purpose of guiding, directing, warning or regulating traffic.

Official Traffic Signals. All signals, not inconsistent with this Ordinance, placed or erected by authority of a public body or official having jurisdiction, for the purpose of directing, warning or regulating traffic.

Traffic Control Signal. Any device, whether manually, electrically or mechanically operated, by which traffic is alternately directed to stop and proceed.

Police Officer. Every officer of the Municipal Police Department or any officer authorized to direct or regulate traffic or to make arrests for violations of traffic regulations.

Traffic Signs and Signals: Article III, Section 8:

(a) The (municipal legislative body) shall, by resolution, determine and designate the character or type of all official traffic signs and signals.

Subject to this selection, the (traffic authority) is hereby authorized, and as to those signs and signals required hereunder, it shall be (his) duty to place and maintain, or cause to be placed and maintained, all official traffic signs and signals. All signs and signals required hereunder for a particular purpose shall so far as practicable be uniform as to type and location throughout the (City).

(b) No provision of this Ordinance for which signs are required shall be enforced against an alleged violator if, at the time and place of the alleged violation, the sign herein required is not in proper position and sufficiently legible to be seen by an ordinarily observant person. Whenever a particular section does not state that signs are required, such section shall be effective without signs being erected to give notice thereof.

Obedience to Traffic Signs and Signals: Article III, Section 9:

It shall be unlawful for the driver of any vehicle or for the motorman of any street car to disobey the instructions of any official traffic sign or signal placed in accordance with the provisions of this Ordinance, unless otherwise directed by a police officer.

Traffic Control Signal Legend: Article III, Section 10:

(a) Whenever traffic at an intersection is controlled by traffic control signals exhibiting colored lights or the words "Go," "Caution" and "Stop," said lights and terms shall indicate as follows, except as provided in Section 16:

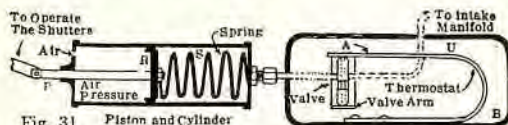
Green or "Go"—Traffic facing the signal may proceed, except that vehicular traffic shall yield the right of way to pedestrians and vehicles lawfully within a crosswalk or the intersection at the time such signal was exhibited.

Note: For subjects: parking, see pages 659, 656, 657; A.A.A., meaning of, see page 659; road signs, see page 659, formerly on this page.

Thermostat may be adjusted to open shutters at 10° to 15° higher temperature by increasing the tension of a "closing spring," by lifting a knob on the side. If it fails to do so, this spring may have become detached (on earlier models this adjustment was by means of a hexagon nut on the side, and turning clockwise increased the tension).

If shutters should fail to open fully when engine is heated up, the thermostat disks (B) may have become porous, or they may leak where soldered. The disks are replaceable.

Another example of a single-unit detachable type automatic radiator shutter controlled by a thermostat formerly manufactured and shown here as an example was the Irving, the principle of operation being shown below, Fig. 31.



Operation: A thermostat (A) (Fig. 31) is made of U-shaped Wilco metal, being encased in (B) and mounted on back of shutter so that it will rest against the radiator and is connected with a cylinder and piston as shown.

When thermostat (A) is heated to about 140° it rises and opens a pin valve, allowing the suction of intake manifold of engine to create a vacuum or suction effect in cylinder to the right of piston (R), and air entering on the left of piston (R) causes (R) to move against tension of spring (S), which opens shutters by means of a bell crank connected with piston arm (P).

As long as heat is above 140° , (A) will remain up, keeping valve and shutters open; but when engine cools to a temperature below 140° , (A) lowers, closing valve; consequently (R) moves to the left by tension of spring (S), closing shutters; stopping the engine stops the suction from intake manifold, and if shutters are in the open position, (S) will force (R) to the left, closing shutters.

Adjustment can be made for opening of valve at a higher temperature by bending the thermostat slightly up with a pair of pliers at (U); for lower temperature, bend slightly down. Replace valve with a new one if inoperative.

Note: The Irving automatic shutter is now out of production. The Irving hand-controlled shutter is manufactured by Irving Engineering Co., Inc., Sioux City, Iowa.

As an example of the two-unit type of automatic radiator shutter controlled by a thermostat and built into the radiator assembly, which automatically controls the water temperature, is the type used on the Buick, models 8-50, 8-60, 8-80 and 8-90. See Fig. 32.

Purpose: This device prevents circulation of air through the radiator core when the engine is cold, thereby permitting the engine to quickly reach an efficient and economical operating temperature, at which time the shutters automatically open and permit just enough cooling air to pass through to maintain this efficient temperature. Shutters are bolted to the inside of the shell.

The thermostat unit is placed in the upper tank of radiator and is in direct contact with the water in the upper radiator tank. It is attached to the tank by six screws and the joint between the two is provided with a gasket which must be kept in good condition to prevent water leaks at this point.

Operation: When the water in the engine reaches a predetermined temperature, the thermostat begins to expand, and by means of a lever, connecting link and bell crank causes the shutters to open from their normal closed position. As the engine temperature rises, the shutters continue their opening until a water temperature of 135° to 145° degrees F. is reached and maintained. Should the cooling effect of the air coming through the radiator tend to lower this temperature, the thermostat will at once contract, partially closing the shutters and again raising the engine temperature. This contraction of the thermostat is hastened by the action of a closing spring which pulls against the expansion of the thermostat. The change in the thermostat is so calibrated that a minimum engine temperature of 135° to 145° F. is maintained at all times.

Adjustment: To check adjustment of the linkage, remove fulcrum pin of lever and pin of adjusting nut. Adjusting nut should be screwed on one-half turn beyond the point of alignment of the following three points: connecting link, fulcrum point on the cover and pin hole in adjusting nut. This will provide the proper amount of tension in the linkage.

Removal: The thermostat unit may be removed from the radiator by removing the fulcrum pin and the pin at the adjust-

ing nut. If the core is to be removed from the shell, the pin in the connecting link and lever must be removed, lock bar of link withdrawn and the link lifted from the shutter bell crank. Core should be taken in replacing these parts to place the link pin on the shutter bell crank pin before the lock bar is moved into position.

Inspection: Thermostats should be tested for correct operation as follows: At 135° F., water temperature, thermostat should not expand under a load of 14 lbs. At 145° F., water temperature thermostat must lift a load of 14 lbs.

It is not the custom, nor is it necessary, to remove the shutters during summer weather, as it does not interfere with the circulation of water which might cause an increase of temperature during the hot months.

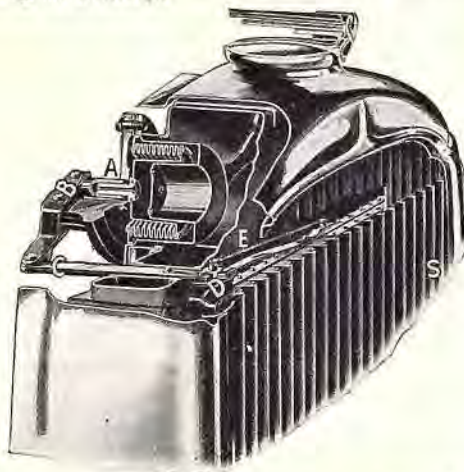


Fig. 32. Two-unit built-in type of automatic radiator shutter with vertical shutters. Name of parts: A, thermostat adjusting end; B, shutter operating lever; C, shutter operating link; D, shutter bell crank; E, shutter return spring.

Electric Signal Lamp

In a number of states there are laws providing that all closed cars shall be equipped with a rear signal device which will indicate to the driver of the car in the rear that the car is going to slow down or stop. This is a very necessary device.

There are a number of devices on the market for this purpose, one which is called the Neo-Lite (now out of production). See also pages 431, 430A.

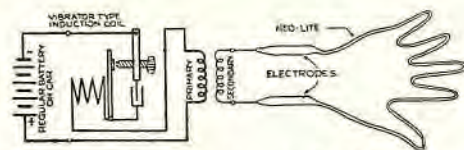


Fig. 33. The Neo-Lite stop signal. Principle of operation is as follows: A small induction or secondary vibrator-type coil is used which intensifies the low voltage to a high voltage. The connection for closing the circuit is attached to the brake pedal, so that when the car is slowed down, the current from the battery is connected. The device is enclosed in a metal case mounted in the rear of the car. Owing to the low resistance offered by Neon, the current consumed is approximately one-eighth less than that of an electric bulb generally used. Experiments have proved that Neon offers so little resistance to the passage of electricity that, where a 15,000-volt current is required in air, a 200-volt current will suffice in pure Neon. In other words, a spark that will jump 1 inch in air will jump 75 inches in pure Neon.

Neon is an element of the air. When air is split up into its component parts: oxygen, nitrogen, argon, etc., Neon is one of the elements segregated, and it is this Neon that is used in a glass tube shaped like a hand, which is used as a stop signal. Neon is one of the air's rarest gases. There is only 1 cubic inch of Neon in approximately 100,000 cubic inches of air.

The glass tube (shaped like a hand) is filled with Neon, which has 75 times less resistance than air. For this reason, when connected with the secondary terminals of the coil and contact is closed, the Neon glows, giving an orange-red glow.

Note: See pages 655-659 for traffic regulations and rules of the road, etc., formerly on this page.

riates tube with the inside of the oil pan above the oil level. This is essential because varying pressures are apt to exist in the crankcase and these pressures would register on the gauge if it were not for this counterbalancing or equalizing connection. The servicing of the two gauges, however, is quite different, therefore service operations follow.

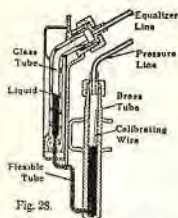
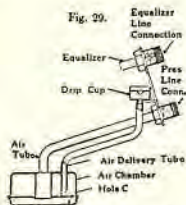


Fig. 28 (left). Dash unit or head. Fig. 29 (right). Oil pan unit.



Service Operations

Warning: Do not remove dash unit from instrument board or start putting on new units until the following adjustments have been made. Make these checks first:

1. Disconnect both pressure and equalizer lines at pan unit. Then at dash unit. Examine cones and cone seats on all connections for dirt and flaws.
2. Set liquid in dash unit even with bottom line of dial by adding or removing liquid at brass tube where pressure line was disconnected. Use only K-S Telegage liquid of the same color as originally in dash unit.
3. Clean out both lines by forcing a cupful of gasoline through each line.
4. Dry both lines (follow exactly): (a) use a hand tire pump (nothing else will do); (b) cut metal tip from tire pump hose and push hose over end of line; (c) give at least 25 continuous strokes.
5. Test both lines for air leaks. Hold a finger over one end and suck with mouth on the other. If the suction will hold the tongue for one minute, the line is O.K.
6. If either line leaks, change it.
7. Reconnect lines at both ends, making tight joints.

To test Telegage: Drive car until liquid registers the amount of oil in the pan. Stopping, starting and turning corners will speed up this action.

Now: If the gauge reads correctly while car is being driven and also holds its reading for thirty minutes with the engine dead, then the repair is completed.

But: If after the test has been made the gauge does not register or the reading does not hold with engine dead—

Then: The pan unit must be examined. Note: Defective pan units are very rare, therefore inspect carefully the dash unit, lines and all connections before removing pan unit. Caution: Disconnect both lines at pan unit before draining oil. The procedure of examining the pan unit follows:

1. Drain oil; 2. remove oil-pan; 3. remove pan unit and examine for broken joints or signs of damage; 4. if pan unit appears O.K., rinse thoroughly in gasoline and dry with air (make sure that small hole in bottom of pan unit is open); 5. clean oil-pan; 6. replace pan unit, making sure that lip of drip cup is tight against side of oil pan; 7. replace oil-pan and reconnect both lines; 8. pour oil back in pan and check gauge for registration as above.

Radiator Shutters

The radiator shutter is classified as a necessary device for regulating the temperature of the cooling system. This device prevents circulation of air through the radiator core when the engine is cold, thereby permitting the engine to quickly reach an efficient and economical operating temperature.

Types: There are two types in general use: the hand operated type (see page 149) and the automatic type.

Automatic Radiator Shutters

The automatic type of radiator shutter is of two types: the single-unit type and the two-unit type. The single-unit type is where the thermostat and shutter assembly are in one unit and can quickly be attached and detached to and from the front of the

radiator core. The two-unit type is where the thermostat is installed in the upper tank of radiator and the shutter is held in place by bolts and radiator shell or, in other words, built into the radiator assembly. (See Fig. 32.)

As an example of the single-unit type of automatic radiator shutter controlled by a thermostat, the "Winterfront," Fig. 30, is shown. This device can be secured for most makes of cars and fits over the outside flat surface of the radiator core. The shutters can be obtained in a horizontal or vertical position.

Operation: The shutters (R) are ribbed and turn in brass trunnions (G). All shutters operate in unison and are connected with a thermostat.

The thermostat consists of a pair of thermo-wafer cells (B) with a spacer (C) and an aluminum heat-conducting flange or plate (A). The thermo-wafer cells are filled with a liquid mixture which forms gas proportioned to make the cells expand or contract at the desired temperatures. For ordinary requirements they are filled to begin expansion at 130° F., and fully expand at 160° to 170°. The heat is derived from the radiator core, through the aluminum heat-conducting flange (A) which rests against the core of the radiator, and as it warms up the heat is carried to the thermo-wafer cells (B), causing them to expand. As the cells (B) expand, they turn the double bell crank (D) which is connected with the shutters (R), opening them gradually as the heat of the radiator rises above 130°, and fully at 160° to 170°. When the temperature drops below 130° the thermo-wafer cells (B) contract and automatically close the shutters (R).

To close shutters when stopping the car (to retain heat under hood), the button (N) can be pressed which, instantly locks them shut. The automatic release (L) restores the shutters to operating position when the car is started (by vibration of car).

Adjustment of the releasing attachment (L) can be changed with a small wrench which fits a brass bolt. This bolt can be reached through the space above the top shutter, when the shutters are open. Turning to the right will make the adjustment more sensitive, and to the left less sensitive. This adjustment of (L) should be so sensitive that it will barely hold when (N) is pushed in so that the least vibration will release (L), thus restoring the shutters to operating position. This does not regulate temperature opening of shutters.

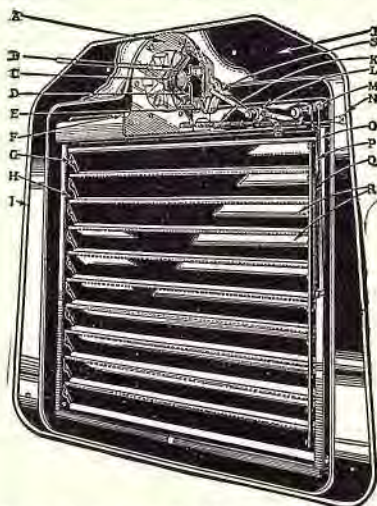


Fig. 30. Single-unit detachable type of automatic radiator shutter with horizontal shutters (the Winterfront). Rear view is shown. Names of parts: A, aluminum heat-conducting flange; B, thermo-wafer cells; C, cell spacer; D, double bell crank; E, thermostat insulator; F, frame insulator; G, brass trunnions; H, composition bearings; I, cushion cord; J, shell; K, safety spring; L, automatic release; M, shutter lever; N, closing button; O, shutter rod; P, shutter operating bar; Q, closing spring; R, shutters; S, closing release. (Manufactured by Pines Winterfront Co., 1135 N. Cicero Ave., Chicago, Ill.)

¹ The Winterfront is now made with vertical shutters and is a later design, but the principle of automatic operation is practically the same.

Note: See pages 655-659 for traffic regulations formerly on this page.

ohms F2 between No. 2 and ground J1, the voltage at No. 2 on the dash unit will be halfway between the voltage at 1 and the ground. It is thus seen that the voltage at No. 2 on the dash unit is the same as the voltage at H2, and consequently no current will flow from one point to the other.

The quarter-full position is when rotor assumes position H4 and the three-quarter-full position is when it assumes position H5.

Service Instructions

The troubles and remedies following are practically universal and applicable in general, way for all installations of the Moto-Meter RKD electric gasoline gauge, with the exception of the specific reference to models, and to the pressure system of gasoline feed. The same basic principle of operation applies to all Moto-Meter RKD electric gasoline gauges as installed on various cars, the only difference being in the car wiring diagram, as some cars have the positive terminal of battery grounded and some have the negative terminal grounded and a slight change in constructional detail.

It is of vital importance that the electrical connections in the gauge circuit be correctly made. If connections are reversed, the gauge will not only fail to register correctly, but is likely to be injured.

In cases where connections are apparently correctly made and still the gauge operation is faulty, it is a valuable expedient to connect the dash and tank units with additional wires outside the harness (regular wiring system) for testing purposes only, thereby indicating possibly that the fault may lie in the harness itself, and showing the exact location of the difficulty.

Caution: Do not attempt to lubricate either dash or tank unit. Do not use gasoline or oil in cleaning tank unit parts. Use alcohol only.

Explanation of trouble chart below: The blackface wording at the beginning of the sentence refers to the gauge action; the wording to which (a) and (b) are prefixed refers to the cause; the wording to which numerals are prefixed refers to the probable location of the fault.

No definite reading:¹ (a) ground in No. 1 line: 1, ground in instrument board unit at No. 1; 2, ground in line; 3 ground in tank unit at No. 1. (b) open battery circuit: 1, loose terminal; 2, broken wire from ammeter; 3, open resistance unit between ammeter and gauge.

Reads empty until tank is about full, then no definite reading:
(a) ground in No. 2 line: 1, ground in instrument board unit at No. 2; 2, ground in No. 2 line; 3, ground in tank unit at No. 2.
(b) No ground in dash unit: 1, defective ground between dash unit and dash; 2, defective instrument.

Tank empty, reads empty. Tank full, reads $\frac{1}{4}$: (a) break between dash and tank in No. 1 line: 1, loose terminal; 2, broken wire; 3, open resistance at No. 1.

Reads "full" until nearly empty, then no definite reading: (a) reversed connections: 1, all connections O.K. except battery is on No. 2 of dash unit; (b) open circuit in dash unit: 1, No. 1 double terminal not connected to No. 1 of dash unit; 2, defective dash unit.

No definite reading at empty; at $\frac{1}{4}$ filling gauge goes to $\frac{3}{4}$ and then gradually moves to full with tank filling: (a) reversed connections: 1, instrument leads from tank unit reversed, battery on No. 1; 2, tank leads reversed.

Tank empty, reads about $\frac{1}{2}$. At about $\frac{1}{4}$ filling goes to full and remains until tank is full: (a) reversed connections: 1. instrument leads from tank unit reversed, battery on No. 2 of dash unit.

Reads $\frac{1}{2}$ at all points: (a) break in No. 2 line: 1, loose terminal; 2, broken wire; 3, defective tank unit; 4, poor contact at center brush of tank unit caused by dirt; 5, sticking plunger in tank unit; 6, weak spring behind contact plunger.

Tank empty, reads $\frac{3}{4}$. Tank full, reads "full": (a) no ground in tank unit: 1, poor ground between tank unit and tank; 2, open resistance at ground end.

Gauge action erratic, unstable or inaccurate: (a) intermittent contact in tank unit: 1, loose terminal; 2, broken wire in No. 2 line; 3, high wires in potentiometer winding; 4, poor contact in center brush of tank unit; 5, sticking plunger in tank unit; 6, weak spring behind contact plunger. (b) water on car terminal block: 1, car terminal block should be kept dry as possible to prevent electrolytic action.

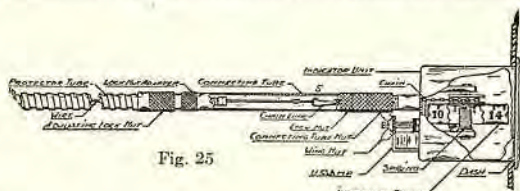
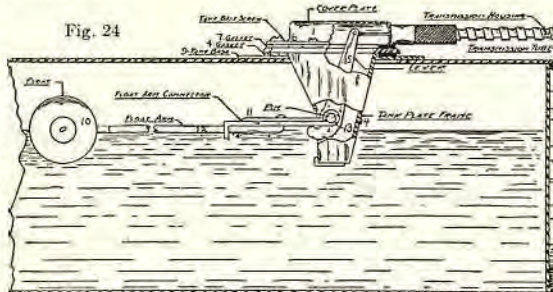
Gauge reads high: when tank is empty, does not read zero:
(a) faulty mechanical adjustment: 1, bent float rod (all rods should be straight; 2, loose screws holding contactor in place. (When float is at empty, contactor should be at extreme end of potentiometer. This adjustment secured by two screws.)

Gauge reads low: when tank overflows, gauge has not yet reached full: (a) faulty mechanical adjustment: 1, bent float rod (all rods should be straight); 2, loose screws holding contactor

in place. (When float is at empty, contactor should be at extreme empty end of potentiometer. This adjustment secured by two screws.)

Grolan Mechanical Type of Gasoline Gauge

The Grolan model F gasoline gauge shown in Figs. 24 and 25 is a **mechanical** type. The indicator unit located on the instrument board shows the amount of gasoline in the main gasoline tank at rear of car. The **tank unit** is placed in the tank and these two units are connected by a transmission wire housing, inside of which is a transmission tube, and inside of the transmission tube is the operating or transmission wire.



For further information, showing how to test and remove tank unit, etc., write The Grolan Mfg. Co., Dayton, Ohio.

K-S Oil Level Telegage™

Consists of four units: dash unit or head, pan unit, pressure line and equalizer line. In operation, the pan unit, pressure line and equalizer line are filled with air, Fig. 26. This oil level gauge operates on the hydrostatic principle.



Fig. 26 (left). Oil level Telegage in operation. Oil pan empty. Fig. 27 (right). Oil level Telegage in operation. Oil pan full.

The principle of operation of the K-S oil level Telegage is identical with the operation of the K-S gasoline Telegage, with the exception that the oil level Telegage employs the use of an equalizer and equalizer line which connect the top of the

¹ When the gauge is in the ignition circuit and that circuit is broken by opening switch, there is no current energizing the gauge and hence the gauge will neither retain a correct reading, nor is it required to return to zero.

In cases where fault is found conclusively to lie in the dash unit, the complete dash unit should be sent to the manufacturers, Moto-Meter Gauge & Equipment Corp., Toledo, Ohio, who advise to not attempt to repair and do not furnish parts. The operations involved are of so delicate and specialized a nature as to require special tools and fixtures.

² Made by King-Seeley Corpn., Ann Arbor, Mich.

Note: See pages 655-659 for traffic regulations formerly on this page.

Note: Do not attempt to repair either gauge head or fitting. Present inoperative unit to nearest Moto-Meter gauge authorized service station or forward to manufacturer.

The screw holes in the tank fitting and the tank are so spaced that the fitting can be installed in only one position, this being necessary to insure the proper movement of the float arm.

Be sure that rubber housing, which protects the connection between the tank fitting and the frame wire is in place, as a connection between the terminal and the tank would cause a ground which would make the gauge read full regardless of the position of the float.

Caution: If necessary to remove gauge head, disconnect battery terminal to prevent possible short circuits, which would be liable to damage other electrical equipment. Do not remove or install tank fitting without first being sure that ignition switch is off so as to prevent danger of sparks near gasoline supply. (Manufactured and guaranteed by Moto-Meter Gauge & Equipment Corp., LaCrosse, Wis.)

Moto-Meter RKD Electric Gasoline Gauge

Description: The following refers to the Moto-Meter RKD electric gasoline gauge. The three major parts consist of a float-unit in the gasoline tank, a tank-resistance-unit on the tank and an indicating-unit (gauge) on the instrument board.

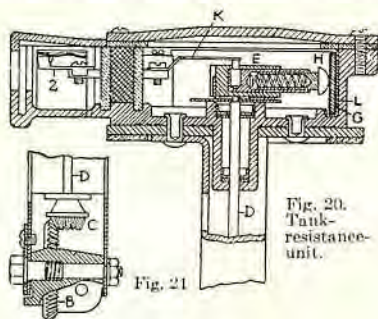


Fig. 20.
Tank-resistance-unit.

Fig. 21

The float-unit consists of a float which, as it rises and falls, actuates a bevel gear B, Fig. 21, which in turn actuates a pinion gear C, which is connected to shaft D, Fig. 20. Shaft D is connected to rotor E of the tank-resistance-unit. When the gasoline level rises, the float rises, causing shaft D and rotor E to revolve clockwise. When the gasoline level lowers, the float lowers, causing shaft D and rotor E to revolve counter-clockwise. The tank-resistance-unit is attached to an opening in the main fuel tank. It is protected by means of a cover and gasket. The attachment with proper gaskets is important.



The indicating-unit or dash gauge, Fig. 22, indicates the quantity of fuel in the tank. There are two coils, F1 and F2, in the gauge, each connected with one part of the tank-unit-resistance. The gauge is connected in the ignition circuit and is in operation only when the ignition is switched on. The purpose of this arrangement is that the gauge will not draw current while the car is not in use. The current consumption is low, between 55 and 65 milliamperes.

The float-unit consists of a float which, as it rises and falls, actuates a bevel gear B, Fig. 21, which in turn actuates a pinion gear C, which is connected to shaft D, Fig. 20. Shaft D is connected to rotor E of the tank-resistance-unit. When the gasoline level rises, the float rises, causing shaft D and rotor E to revolve clockwise. When the gasoline level lowers, the float lowers, causing shaft D and rotor E to revolve counter-clockwise. The tank-resistance-unit is attached to an opening in the main fuel tank. It is protected by means of a cover and gasket. The attachment with proper gaskets is important.

Electrical operation: The gauge is essentially a current balancing instrument, the two coils housing the same number of turns of wire. The operation of the unit depends on the relative magnetic strengths of the two coils caused by supplying more current to one coil than to the other through changes in resistance. As both coils are actuated by the same voltage from either battery or generator, it makes no difference what the actual voltage may be, since any change in voltage will affect both coils in the same ratio. Therefore differences in battery or generator voltage do not affect the accuracy of the gauge.

In the tank unit there is a resistance G, Fig. 23, or more properly, a potentiometer, around the inside of which travels a contactor, which through the gears is actuated by the float. This contactor, in assuming its various positions, H1, H2, etc., divides the potentiometer G into varying parts, and these parts directly control the relative current values of the coils F1 and F2 in the dash unit.

The dash unit consists primarily of two magnetically opposed coils F1 and F2 of identical current and magnetic characteristics but opposite direction of winding. Through these two coils travels a magnetizable vane V, Fig. 22, to which is affixed the

pointer of the instrument. As the current values of the two coils differ, their turns remaining constant, the relative values of magnetism, expressed in ampere-turns of those coils, will of course differ correspondingly, causing the gauge to assume a position in direct relation to the float position.

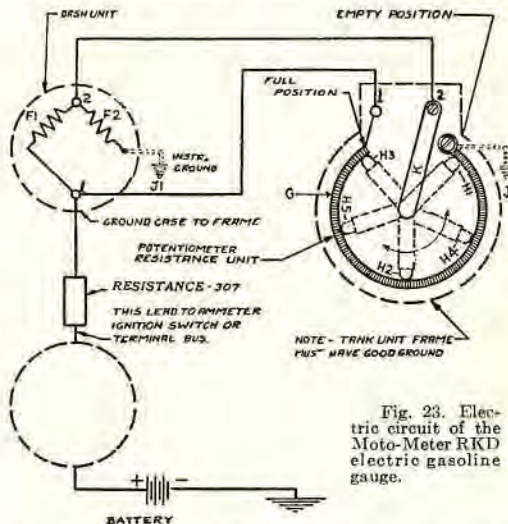


Fig. 23. Electric circuit of the Moto-Meter RKD electric gasoline gauge.

To take specific examples, let us consider the empty position of the gauge when the rotor and contactor will assume the position H1 as shown in Fig. 23. In this position the current will flow from positive (+) of battery or generator, through the ignition switch or terminal bus, to No. 1 terminal of the dash unit. It will there divide itself in parallelled circuits. A portion will flow to No. 1 of the tank unit through the 120 ohm tank unit resistance G to the ground J, and will have no effect on the indicator. Another portion will take a path through the left-hand coil F1 of the dash unit of 120 ohm resistance, to the No. 2 terminal of the tank unit, through K and the contactor H1 at the empty position, and directly to the ground J at that point. In this condition, the left-hand coil F1 of the dash unit is fully energized and the current traveling through the right-hand coil F2 is reduced to a minimum, as it is practically short-circuited by the wire 2 being grounded through H1 at J. The magnetic field produced by coil F1 is therefore very strong but practically no magnetism is produced by F2. Coil F1 will therefore draw vane V to the left and throw the pointer to empty. See Fig. 22, showing vane V.

Let us consider the full position of the gauge when the rotor and contactor will assume the position H3 as shown in Fig. 23. The current will flow from positive (+) of battery or generator through the ignition switch or terminal bus to the same terminal of No. 1 of the dash unit. It will again divide in parallel circuits. As in the "empty" position, a portion of the current will flow to No. 1 of the tank unit through the resistance G to ground J but will have no effect on the indicating unit. Another portion will flow to No. 1 of the tank unit through H3 and K to terminal No. 2 on the tank unit, thence over the wire to No. 2 on the dash unit and through the right-hand coil F2 to ground J1. There will be another small portion that will flow through coil F1 and coil F2 to ground J1, but the current in F1 is negligible, as this coil is practically short-circuited by wire 1, H3, and wire 2. In this condition, the right-hand coil F2 of the dash unit is strongly magnetized but there is practically no magnetism in F1, therefore F2 will draw vane V to the right and throw the pointer to full.

Let us consider the half-full position when the rotor and contactor will assume the position H2 as shown in Fig. 23. The current will flow from positive (+) of battery or generator to No. 1 of the dash unit. It will then divide in parallel circuits. A portion of the current will flow to No. 1 of the tank unit, through resistance G to ground J but will have no effect on the dash unit. Another portion will go through coil F1 to No. 2 on the dash unit, then through F2 to ground J1. The same current which goes through F1 also goes through F2, therefore both coils receive equal current and produce the same amount of magnetism and vane V will be the same distance between them and throw the pointer to "½."

Note: There will be no current in wire No. 2 for the following reasons: Since there are 60 ohms of resistance G between H2 and terminal No. 1, and also 60 ohms of resistance G between H2 and ground J, the voltage at H2 will be halfway between the voltage at 1 and the ground. Since there are 120 ohms F1 between No. 1 and No. 2 on the dash unit and also 120

Note: See page 654 for Irving radiator shutter, and pages 655-659 for traffic regulations formerly on this page.

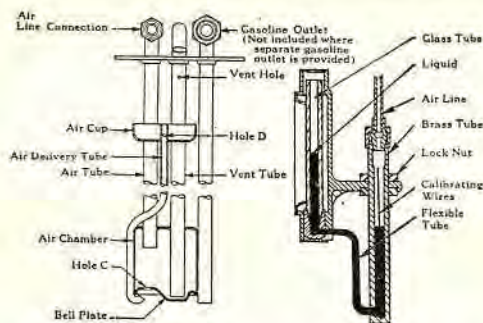


Fig. 16 (left). The tank unit.

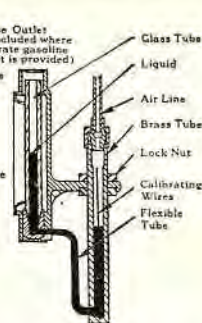


Fig. 17 (right). The head.

The remainder of the tank unit, that is, the air cup and a delivery tube, acts only as a means of supplying air to the air chamber. This is to overcome the loss of air due to absorption in the gasoline and contraction due to a sudden drop of temperature.

The air supply mentioned above is obtained by using the movement of gasoline in the tank. When the air cup is above the level of the gasoline it is constantly being filled by the surge and splash when the car is in motion. This gasoline runs through the drain hole D and down the air delivery tube, drawing with it a few bubbles of air. At the bottom of the tube the air bubbles out and rises under the air chamber. It enters the air chamber through hole C and displaces any gasoline which may be there. When the air chamber is full of air these bubbles simply pass off and are not used.

The head, shown in Fig. 17, is mounted on the instrument board. It is simply a U-tube containing a special heavy red liquid. (K-S liquid is selected because of its specific gravity and other characteristics. No other will do. Every dealer should have a bottle of K-S liquid to cover emergencies.) The front half of the U-tube is a glass tube open at the top. The back half is a brass tube. A U-tube containing liquid is the most accurate instrument known for measuring pressure. The calibrating wires are essential for accurate operation. They compensate differences in glass tube diameters and the correct amount is inserted in each head at the time of manufacture.

The air line is simply a hollow tube which connects the tank unit with the head. Any pressure which comes through the air line will press the liquid downward in the brass tube and upward in the glass tube. In fact the difference in levels of the liquid in the two tubes is an exact measurement of the pressure coming through the air line and hence records the depth of gasoline in the tank. By marking the dial in gallons, an exact reading in gallons is shown on the instrument board.

Service Instructions

Warning: Servicing by the use of any other method will bring no results. Do not remove gauge head from instrument board, or change any unit until you have followed instructions.

Make the checks following first:

1. Remove tank filler cap. On cars where a hole in filler cap is necessary, see that it is free from dirt and open. Do not replace filler cap, or drain gas tank.
2. Try tank unit connection to be sure it is tight. Use a second wrench to prevent tube from twisting.
3. Disconnect gauge line (air line) at front end only. Red liquid must now read even with bottom line of dial. Add or remove liquid as required at top of brass tube where air line was disconnected. Use a medicine dropper to add liquid; use a toothpick or match to absorb some. Be careful that toothpick or match does not pull out any shims (small wires). Never loosen lock nuts to move brass tube up or down. If dial or paper reflector back of glass tube is stained at the bottom, install a new complete gauge head. Use only K-S Teleage liquid—no other will do.
4. Dry air line. Follow exactly or get no results: a, use a good hand tire pump (never use compressed air); b, cut metal tip from tire pump hose; c, push hose securely over front end of line; d, give 50 good full strokes continuously (at least).
5. Reconnect air line, making tight joint.
6. Replace tank filler cap.

You are now ready to make a test to see if the trouble has been corrected; by determining whether you can bring gauge up to proper reading by supplying air to the tank unit. There are two methods:

1. If gasoline outlet is in tank unit, disconnect the fuel-feed line from the top of the vacuum tank or fuel pump and blow with the mouth through this line into the main tank.

2. If gasoline outlet is not in tank unit, drive the car until the red liquid no longer comes up. A correction cannot be made if the tank is more than three-fourths full.

Now—if the reading stays set with the car standing; then—the Teleage is O.K. and the job is completed.

But—if you cannot get a reading by driving or blowing back through the feed line; or you can get a reading, but it will not hold for an hour with the engine dead; then—there is a defective unit to be located by following the repair instructions.

Repair Instructions

Follow instructions given above, first.

To determine whether the failure is in the air line or tank unit: 1, disconnect the air line front and rear; 2, inspect cones and seats for dirt or flaws; 3, blow out air line (see check 4), and test for a leak. Hold finger over one end and suck on the other end. If the suction created will hold the tongue for one minute the line is O.K.; 4, if the air line shows a leak, or is plugged, change it; 5, if the air line and connections check O.K., the defect is in the tank unit, which should be changed.

Caution: Defective tank units are very rare; therefore, inspect carefully the gauge head, air line and connections, as the trouble is more likely to be in one of these places than in the tank unit. (Manufactured by King-Seeley Corp., Ann Arbor, Mich.)

National Electric Gasoline Gauge

Description: This electric gasoline gauge, type C, consists of two principal parts, the indicating instrument or gauge head, on the dash, and the actuating apparatus or tank fitting which is installed on the gasoline tank. These two parts are connected by a wire running along the frame of the car.

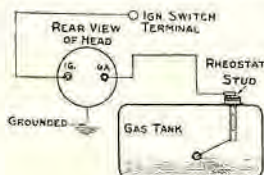


Fig. 18. Wiring layout of the National type C electric gasoline gauge.

The gauge head is of the balanced coil type and has inherent characteristics which render it unaffected by variations in voltage, consequently the indications are not materially different when the battery is low or when it is being charged by the generator. The gauge is wired from one stud, or terminal (marked "Ign. Sw.") to the ignition switch. The gauge indicates only when the switch is turned on, and at other times the pointer will register empty.

At the filling station, the height of the gasoline can be checked by turning on the ignition switch without starting the engine.

The second stud on the gauge head (marked "Ga.") is connected by the wire which runs along the frame to the stud or terminal on the tank fitting. The gauge head is grounded through its case to the metal instrument board. When the instrument board is made of wood, it is necessary to run a special ground wire from the gauge case to the car frame.

The tank fitting consists of a rheostat or variable resistance, and through the agency of a float and a series of gears, a sweep-arm is moved across the face of the rheostat, thereby increasing or decreasing its resistance as the depth of the liquid in the tank is raised or lowered. As the resistance of the rheostat is varied, there results a proportionate variation of current in the indicating instrument or gauge head, which is calibrated to accurately indicate the gasoline level in the tank. The tank fitting is grounded by means of the screws which attach it to the tank, thus completing the electrical circuit.

Service Pointers

If gauge does not register properly, first check all wire connections to be sure that they are tight. Then make sure that gauge case is grounded to metal dash and that tank fitting is grounded by the attaching screws.

If, after checking all grounds and wire connections, gauge does not indicate properly, remove wire from tank fitting stud and ground it to frame while ignition switch is on. Gauge should then read full. Remove wire from frame (with ignition switch on) and gauge should read empty. If this is not the case, gauge head should be replaced with a new one. If the gauge indicates as described, the trouble is probably in the tank fitting, which should be replaced.

Note: See pages 652, 653 for Grolan gasoline gauge and Winterfront radiator shutter formerly on this page

NECESSARY AND USEFUL ACCESSORIES

Necessary accessories are those which protect the occupants from accident or injury and the car from damage. **Useful accessories** are those which add comfort and convenience to the occupants of the car. Material of this kind can be secured of auto supply houses.



Fig. 7. A rear-view mirror is a necessary accessory and is usually placed inside of car.

Fig. 8. Type of mirror for placing on fender. Often used on commercial cars, where rear of car does not permit clear vision.

Fig. 9. Windshield cleaners and wipers are necessary accessories and operate by hand, or are automatic. Automatic wipers are of two types, operating by suction of the engine and by electricity. The suction (vacuum) type consists of a small metal cylinder mounted on top of frame of windshield. It contains a small piston attached to a scraper arm fitted with a rubber strip. A piece of tubing is connected to the cylinder from inlet manifold of engine. When turned on, the cleaner swings constantly, and removes rain or snow until stopped. The electric type is similarly mounted, but is operated from the battery or generator. Another type of windshield cleaner is an electric heater which warms the windshield glass, enabling the windshield wiper to remove the melted ice and snow.

Fig. 10. A visor, attached as shown; sleet, rain, snow or sun cannot obscure driver's vision. This is a necessary accessory.

Fig. 11. Spotlights are necessary when touring but must be used with caution. Can also be used as a spot or trouble light. There are a number of different makes of spotlights. Can be secured of auto supply houses.



Fig. 13. Tonneau or rear-seat windshield. Gives the open car the comforts of a closed car. A useful accessory. Manufactured by the Tonneau Shield Co., Inc., New York, N.Y.

Fig. 13A. Bumpers for both front and rear are necessary accessories. Insurance rates are reduced in most policies where cars are equipped with front and rear bumpers. There is a great variety of bumpers.

Fig. 13B. Compression whistle, which is screwed into cylinder; serves instead of electric horn and saves current.

A good clock for automobile use is a useful accessory and should be of the best in order to withstand vibration and temperature change. It should have a compensating balance. An electric type of clock is also manufactured.

A speedometer and warning signal (horns) are necessary accessories and usually come on most cars as a standard equipment. See page 443 for horns; a popular type not mentioned is the Moto Vox.

Gasoline Gauges

Types: Gasoline gauges, more correctly termed fuel gauges, are classified as a very useful accessory. There are two general types, the tank gauge and the dash gauge.

Tank gauges are placed directly on the main gasoline tank and are usually mechanically operated as shown in Fig. 5, page 111.

Dash gauges are placed on the instrument board with the operating mechanism (tank unit) in the main gasoline tank connected with tubing, or wire on the electrical type. There are three types in general use, the hydrostatic type, electrical type and mechanical type.

The hydrostatic principle is explained farther on. With this principle there are two methods for replenishing air, necessary due to absorption of the air by the gasoline during atmospheric changes, etc.

One is by interconnecting with the vacuum system, and the other, by using the movement of gasoline in the tank, the latter being the principle used in the K-S gasoline Telegauge. There are also two types of gauge heads, the diaphragm type which actuates a hand the same as an oil gauge, and a U-tube gauge containing red liquid, the latter being the type used on the K-S.

K-S Hydrostatic Gasoline Telegauge

This gauge is of the hydrostatic principle, meaning pressure proportional to depth, that is, the air trapped in the air chamber (Fig. 15), when gasoline is added, or drawn from gasoline tank, will be under a pressure proportional to the depth of the gasoline.

There are three units: the head, tank unit and air line. In operation the air tube and air chamber of the tank unit and the air line connecting the tank unit to the head are filled with air. (See Fig. 14.)

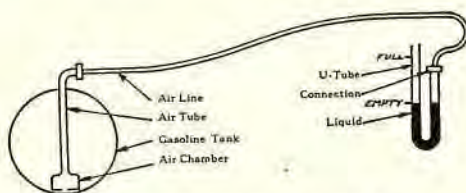


Fig. 14. Simple Telegauge in operation; tank empty.

Operation: When the tank is filled, the gasoline tries to rise to the same level in the tank unit as it is in the tank, but cannot because of the air trapped between the bottom of tank unit and the liquid in the head. The gasoline trying to get into the air chamber presses on the trapped air; this pressure is transmitted through the air tube and air line to the head on the instrument board, where it is recorded by the rise of the red liquid in the glass tube (Fig. 15).

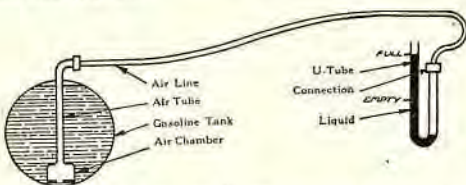


Fig. 15. Tank full. Note: The air cup and air delivery tube shown in Fig. 16 have been omitted from the illustrations, Figs. 14 and 15, purposely in order to simplify the explanation, as they take no part in the reading of the gauge.

It can be seen from Fig. 15 that the operation of the Telegauge depends upon air being trapped securely in the tank unit and air line. A loose connection would permit the trapped air to escape and the gasoline would rise in the tank unit to the same level as in the tank. There would also be no pressure on the liquid in the head unit and the liquid would fall to the bottom mark on dial regardless of how much gasoline there was in the tank. The connection can be tightened but the head unit will not register correctly until the tank unit has been cleared of gasoline and again filled with air. This is done by the splash of gasoline as explained below in the description of the tank unit.

The tank unit, Fig. 16, shows the air tube and air chamber which must always be filled with air. The gasoline tries to enter through hole C, Fig. 16, and thus presses on the trapped air. This is the only part of the tank unit that has anything to do with the reading of the gauge. (The Telegauge provides a reserve of approximately $\frac{3}{4}$ " of gasoline, that is, the bottom $\frac{3}{4}$ " in the tank never shows on the gauge, as the reading starts at hole C. Above this point the gauge reads exactly, gallon for gallon, all gasoline in the tank.)

The vent tube, open at the top, is a safety device which protects the gauge against high pressure. It does not enter into the operation of the gauge in any way.

After body, fenders, etc., have been sanded and touched up attention should be given underneath the fenders and chassis. On account of its being practically impossible to remove all grease from the wheels, axles, springs, joints, etc., these surfaces should be prepared for repainting (after sanding to remove loose paint and rust) by brushing on a mixture of three parts denatured alcohol and one part shellac. This will dry in about five minutes and prevent the grease from becoming mixed with the paint, which would cause non-drying and peeling.

Apply one coat of auto enamel black to the springs, axles, and under-sides of the fenders, top-bows, joints, windshield frames, etc., (or color desired). Refinish top with a top dressing, unless a closed-type car with metal top, in which case it is finished like the body.

Clean wheels and give a coat of auto enamel.

After all touched-up spots have dried give body a coat of auto enamel of color desired. Use two varnish brushes ($2\frac{1}{2}$ " and 1").

Start applying auto enamel to the doors and, with the small varnish brush, do the top and around the hinges. With the large brush give door a good solid coat, applying paint up and down. Then cross and go over the entire surface from left to right. Next brush across the top with the small brush and "pick up" any enamel under the hinges. Finally take the large brush, brushing from bottom to top. Press brush firmly against bottom of door, gradually relieving the pressure as brush nears the top. (This is called "laying off.")

Proceed with body as on the doors, working in strips not over eighteen inches wide. Have a piece of cheesecloth saturated with gasoline handy to wipe off any enamel which may drop on fenders.

If wheels need a second coat, it may be applied.

Hood should be washed inside and out with gasoline, using an old paint brush, cloth, or sponge to remove all grease. Then sand thoroughly with No. $\frac{1}{2}$ sandpaper which has been dipped into a preparation of half linseed oil and half gasoline. Then wash off with gasoline all remaining particles, and when dry, shellac around the hinges, handles, and other places where grease is liable to lodge. The shellac preparation is the same mixture as was used on under parts of chassis. Next stand hood on end (end that rests on radiator, down) and apply a liberal coat of auto enamel of the color desired with a large brush. Watch for sags and runs.

Note: Usually the hood, frame and fenders are finished with a baked enamel finish. If this finish is still in good condition, do not refinish all of the hood with color enamel, but merely touch up the rust spots with it and allow it to dry and apply a coat of clear finish varnish.

Fenders. Finish with auto enamel of the color desired. Often times cleaning with gasoline will bring back the gloss on baked enamel fenders. If not, a coat of good finishing varnish may be applied, providing the enamel is not flaked off in places. If so, the enamel should be removed with a good varnish remover such as "Taxite." Then finish the same as with the automobile, or take to a concern that does baked enamel work.

Final varnish coat: (after previous coats have dried for 36 to 48 hours), take No. 0000 sandpaper dipped in a preparation of half linseed oil and half gasoline and sand body and cowl

carefully enough to cut the gloss so that the succeeding coat will have a smooth surface to which to adhere.

Take a pound of FF powdered pumice stone and a sponge and give entire surface a light rubbing, dipping sponge into water and then into pumice stone, using lots of water, which will remove the oil used in sanding. Then wash with clean water and chamois skin. This is an important operation to insure a good clean-up for a good finish. After sanding wipe off with cheesecloth saturated with clean varnish and wrung dry and shake out.

Take a quart of auto enamel clear (clear finish varnish) and apply to doors, then body, as well as wheels and fenders.

Repainting a Car Where Finish Is Checked

If surface is worn and paint beaten off and the base metal or wood is disclosed, or if checked and cracked, it is best to remove all old paint with a paint and varnish remover and do a complete job of repainting.

Probably the best plan would be to have it sprayed with lacquer enamel, which requires special equipment.

The car owner may feel disposed to do some of the work himself; for instance, he could clean the car and remove the old paint, and then pass it on to the shop equipped with the lacquer enamel process, or if it is to be painted and varnished, he could pass it on to the professional painter.

If a paint and varnish job is to be done without removing all of the old paint, then the process is practically the same as previously explained, except the old finish is thoroughly sanded down with No. 1 sandpaper and then a coat of auto enamel primer (plain oil paint) is applied to body (fenders and top of hood only if they are cracked, not otherwise), using a 2" camel's hair brush.

When dry, sand lightly with No. $\frac{1}{2}$ sandpaper, dust off, and then proceed with the application of the first coat as heretofore described.

Enamel is a combination of finish varnish to which has been added color pigment (oil paint). Usually paint for automobiles comes ready mixed in an enamel form, known as auto enamel. It may be obtained in various colors.

Enamel clear is a clear-finish varnish, known as auto enamel clear to work over auto enamel. Enamel primer is especially made for use under auto enamel, known as auto enamel primer. It is an oil paint, not varnish, used for undercoating.

To clean out a new brush, take a small quantity of raw linseed oil, working out the brush thoroughly with the fingers in the oil and rinsing it frequently with turpentine. Repeat this until you can take a brushful of oil and wipe it on a piece of glass and let it flow down without showing any specks. This may take fifteen minutes or more, but the time is well spent, as the cleaner the brush, the cleaner the job.

After using brush, thoroughly clean it out in turpentine and suspend by wire hook in a can, so that the bristles will not touch the bottom. Sufficient raw linseed oil should be kept in the can to cover the bristles of the brush. In this way brushes may always be kept in good condition.

LACQUER FINISHING-NITRO CELLULOSE¹²³

Automobile finishing with Duco, Opex, Nitro-Valspar, Lacqueroid, Murcote, etc., differs from paint and varnish, or oil finishes in many ways. Drying comes through evaporation of the solvents rather than from oxidation of the oil. Technically, lacquer is a solution of solids in solvents which evaporate with great rapidity, which makes it necessary to apply it with a spray gun instead of a brush.

For this reason the refinishing shop must be equipped with a compressor, spray booth, ventilating equipment and the necessary spray gun. (See page 756.)

The major advantage of the lacquer³ method of finishing comes in saving of time and the durability of the finish. This finish does not have as high a gloss or luster as a varnish finish, but the lacquer finish is more durable and will improve with age, whereas a varnish finish will become duller with age. The lacquer finish, it is claimed, is not affected by rain, snow, heat or cold, by grease, alkalis, salt water or mud; not easily marred or scratched, and frequent polishing only improves the luster. An injured spot can be finished to match the original finish. In addition to the saving of time, there is also an appreciable saving in labor, material, and floor space in the application, and instead of frequent washing of the car, all that is required is an occasional rubbing with a dry cloth. While it is not necessary to exercise as much care as with varnish finishes, ordinary care should be exercised—a lacquer finish can be damaged by scratching.

Nitro-cellulose lacquer can be applied to almost any surface, wood or metal, that is, if it is absolutely free from dirt, rust, wax, or grease, otherwise the lacquer will peel and chip off. It works best over clean metal surfaces.

If the body and metal parts of the car have been painted before, a better finish is possible, if all of the old paint is removed. However, very satisfactory work can be obtained by applying the lacquer over old painted surfaces, as explained on page 756.

¹Part of the information pertaining to this subject was obtained from a booklet, *Modern Automobile Finishing Methods*, published by The Sherwin-Williams Co., Cleveland, Ohio, manufacturers of "Opex" lacquer enamel.

²Nitro-cellulose lacquers are obtained by treating cotton plant fiber in a mixture of nitric and sulphuric acid in order to combine it with nitrogen. This nitro-cellulose is dissolved in powerful solvents to permit easy application on a smooth surface. Gums are then added to give thickness and long-life adherence. Addition of colored pigment (paint coloring) produces a liquid lacquer enamel.

³There are a number of lacquers on the market, all of which have trade names. Some of these are "Duco" (E. I. DuPont de Nemours & Co., Parlin, N.J., or Chicago, Ill., or San Francisco, Cal.); "Kodalak" (Eastman Kodak Co., Rochester, N.Y.); "Lacqueroid" (Glidden Co., Cleveland, Ohio); "Mimax" (Pittsburgh Plate Glass Co., Milwaukee, Wis.); "Murcote" (Murphy Varnish Co., Newark, N.J.); "Opex" (The Sherwin-Williams Co., Cleveland, Ohio), and many others.

Mohair tops should be frequently dusted and brushed off. To wash, use a pail of tepid water and a bar of castile soap. Place the soap in the pail and work with the hands until a good lather is obtained. A large clean sponge is dipped into the water and top is then thoroughly washed.

Pantasote tops and curtains are best cleaned with a soft brush dipped in water in which a little ammonia has been added. Rub dry. Never clean top and curtains with gasoline or kerosene.

Do not fold the top until it has become thoroughly dry, because any moisture remaining in the folds is prone to cause mildew, besides making the top leaky and unsightly with spots. When the car is not used for some time, it is best to open the top, which keeps it well stretched and smooth.

If the top is dirty, use a broom first. After it has been cleaned with soap, go over it with clear water so that no alkali spots will appear.

Cleaning Upholstery

Do not use gasoline for cleaning leather upholstery. Plain water with a little ammonia will remove the dirt, and a brisk rubbing with a clean woolen or flannel cloth will do the rest. For still more careful treatment, use a regular leather dressing on all leather.

Recipe for a dressing for leather upholstery: Raw linseed oil and turpentine, mixed in proportions of two of the former to one of the latter, is a time-honored formula.

For cleaning cloth upholstery, such as plush, velour, and mohair, which has become dirty from use, wash with soap and warm water.

Rub with the "pile" or "nap," not against it. Have the "suds" thick, not watery. Rinse suds with a cloth dipped in

clean water and wring out fairly dry. Wipe with a dry cloth. When dry give a light brushing.

Another method is to use clear water and a mixture of $\frac{3}{4}$ oz. common salt and 2 oz. of either grain or wood alcohol, simply rubbing the cloth with a sponge dampened in the mixture.

To remove dust from cloth upholstery, beat the cushions and backs lightly with a switch or a carpet beater.

First remove cushions or seats. The dust removed from sides and rear will settle and can be wiped up. Cushions should be held upside down so that the dust will fall away from cushion, because dust cannot enter the base of plush, velour or mohair and should fall off readily. (The vacuum cleaning method is best.)

Grease or oil may be removed by the application of a solution of lukewarm water and ivory soap, applied with a woolen cloth. Any of the approved methods for cleaning woolen cloth may be used with success on this upholstery.

Gasoline, naphtha, or carbona is also excellent, but has a tendency to spread. Cleaning should start well outside the area of the grease spot, and then work with a circular motion toward the center of the spot. Do this several times and use a clean spot on the cleansing cloth each time and plenty of cleansing fluid.

Plush upholstery which is flattened down can be freshened up by using dry steam, or a cloth wrung out of very hot water and placed immediately over the flat spot, where it should be smoothed out in close contact with the upholstery. Leave cloth on for several minutes, then remove. When dry, give it a light, deft brushing with a stiff brush and the fabric will look fresh and new.

Mechanics should wear clean dusters when working on the interior of a car, thus protecting the upholstery from grease. Another plan is to cover interior of car with cloth covering, tied in place. See also page 662.

PAINTING RADIATOR, ENGINE, CYLINDERS, MANIFOLD, ETC.

To paint the radiator, mix 3 oz. boiled linseed oil, 4 oz. lamp black, 1 oz. turpentine, and thin down with turpentine to the proper consistency. In applying, the radiator must either be dipped into the solution (in this case a great deal more must be mixed), or sprayed (see also, Index under "Painting radiator"), or the radiator can be placed on boxes, face up, and the thin mixture can be applied plentifully so that it will run through the cellular parts of radiator. A camel's hair brush can be used to reach places not covered.

To paint cylinders: Mix 8 oz. white lead in oil, 6 oz. boiled linseed oil, 2 oz. turpentine, and $\frac{1}{2}$ oz. lamp black. If too heavy, thin down with turpentine. This will make a gray paint sufficient for six cylinders. Aluminum mixed with bronzing liquid can also be used.

To paint the intake manifold: Use regular aluminum, which can be secured at any drug store.

To paint the exhaust manifold: Use aluminum. No paint has as yet been found which will remain on hot exhaust pipes; here is a recipe suggested:

Heat-proof paint: Use 2 parts of black oxide of manganese, 3 parts of graphite, and 9 parts of Fuller's earth, thoroughly

mixed, to which add a compound of 10 parts of sodium silicate, 1 part glucose, and 4 parts of water, until it is of such consistency that it may be applied with a brush.

Tire paint: Liquid rubber is a preservative and beautifier of tires. It gives the tire a white coating. It is made of pure unvulcanized rubber in solution. It can be applied with a brush, and if used at regular intervals, it will, it is claimed, prolong the life of the tire because it penetrates and runs into any small cuts or holes and seals them over, thus in a measure preventing moisture from reaching the fabric. It is also suitable for golf balls, rubber mats, and is a highly satisfactory rust preventive for rims. Secured at supply houses.

A tire paint for finishing the inside of a tire after repairing may be made by mixing thoroughly 1 gal. gasoline, $\frac{1}{2}$ pint Firestone rubber C-35 cement, $1\frac{1}{2}$ lbs. soapstone and $\frac{1}{2}$ lb. whiting. See also page 612.

Rust preventive: Melt one pound of fresh lard and add one half ounce of camphor. Remove the scum that forms and add graphite to give the desired color and consistency. Allow to cool and apply to tools or parts, permitting it to set for twenty-four hours. Finally polish with a soft woolen cloth. (*Am. Auto Digest*.)

SUGGESTIONS FOR REPAINTING A CAR AT HOME

On a car that has a paint and varnish finish, the gloss or luster finally gets dull, due to the varnish finish deteriorating. Varnish is much more sensitive to wear and temperature changes, etc., than a car with a lacquer finish. The varnish finish has a much higher luster.

A car with a dull varnish finish which is not badly checked or cracked, can be rubbed down with very fine sandpaper, applying a coat of auto enamel, and then a finish coat of varnish over this.

When the varnish is deteriorated and color coats are checked and cracked (fine lines running in all directions) and in bad condition generally, it is best to remove completely all of the old varnish and paint and then prime and build up on a perfectly clean surface free from grease and dirt.

The modern method of finishing a car is to spray on nitro-cellulose lacquer enamel, instead of applying paint and varnish with a brush. This would no doubt be the cheapest and best in the long run, but this would have to be done by a shop equipped for such work, as this method requires special equipment (see page 756).

Refinishing a Car Where the Varnish Is Dull but Finish Is Not Checked or Cracked

A thorough cleaning is very necessary, the idea being to remove all grease and obtain a perfectly clean surface, so that the paint will adhere properly.

Clean chassis and underneath parts, and remove all grease from hubs, springs, axles and joints with gasoline or kerosene.

Remove wheels, hood, cushions, mats, door handles, etc. and scrape out corners where dirt and grease may have lodged, and scrape any loose paint from body and fenders.

Sandpaper the surfaces to be finished with No. $\frac{1}{2}$ sandpaper to level off any broken, rusted, or raised spots. Then dust off carefully.

Touch up all bare spots with auto enamel of the color to be used. This can best be done with a camel's hair pencil brush.

Cleaning and Polishing Dull Varnish

In many cases, dull varnish is not "dead," but is simply coated with a deposit of dirt. When this deposit is removed, the original luster of the varnish may be restored to a certain extent (this does not apply to lacquered cars).

Cleaning: Wash the car thoroughly with a non-alkali, pure linseed oil soap (such as "Flaxoap").

If the finish is very dull after washing, saturate a small pad of selected soft waste (there must be no grit or thread cords in this pad) with water, and dip lightly into fine rotten stone. Do not make a mistake and use pumice stone, for it will completely destroy the finish. Rub with the pad and rotten stone until the surface shows a bright luster. Continue over a complete panel. Be sure to keep the pad saturated with water while rubbing.

Rotten stone has relatively no abrasive effect on gum varnish, but does rapidly abrade the imbedded deposit if the varnish is free from oil and grease. As fast as this deposit is cut away the varnish acts as a lubricant, as the easy sliding of the rotten stone pad will indicate. Remove all rotten stone with damp cheesecloth.

If the finish is only slightly dull or gray, rub with a mixture of 1 oz. rotten stone and 3 oz. linseed oil instead of rotten stone and water. Shake the mixture while using.

Polish: After cleaning as above, polish with Percival automobile polish. The formula follows:

24 oz. wood alcohol.....	(By weight)
48 oz. raw linseed oil.....	(By weight)
40 oz. white vinegar.....	(By weight)
3 oz. aqua ammonia.....	(By weight)
3 oz. spirits camphor.....	(By weight)
6 oz. butter antimony.....	(By weight)

It is imperatively important that these ingredients be mixed together in the order given, and that they be shaken thoroughly.

To the formula given above add a mixture of 2 oz. grated beeswax and 3 oz. turpentine, which have been mixed and allowed to dissolve thoroughly for 48 hours. When added, the whole mixture must be shaken. Always shake before drawing from the main supply and while using.

To use the polish: Saturate a pad of fine cheesecloth with the polish and rub the varnish briskly until a full luster appears. The luster can be determined by wiping the parts occasionally with a clean cloth or with the palm of the hand, and looking at the surface as into a mirror. A perfect reflection should be obtained. If dullness appears after the car is used, it will indicate that the deposit was not entirely removed with the rotten stone, or that the polishing was not thoroughly done. Hard, consistent rubbing will invariably bring the desired results.

After thoroughly polishing, wipe off all polish carefully with cheesecloth that has been washed and dried. Then dampen a piece of cheesecloth with alcohol (wood alcohol will be satisfactory), and shake the cloth until no free alcohol is left on its surface. The cloth will then feel cool to the face, but not damp. Wipe over the complete job, occasionally dampening the cloth as described above. This operation removes all traces of oil and polish and leaves the original varnish clean and brilliant. Be careful not to spill alcohol on the finish, and do not use a moist cloth, as the alcohol will dissolve and soften the varnish.

CLEANING ENGINE, TOPS, UPHOLSTERY, ETC.

A car-cleaning and lubrication business² is a very remunerative business if conducted properly.

Cleaning Engine

This subject is treated on page 760.

Cleaning Tops

Prepared dressing³ for tops, also cleansing fluids for upholstery and polishes, etc., can be obtained of auto supply houses. The following are only suggestions.

To clean top—outside: A top that has been in use for some time can be cleaned by using the following mixture: $\frac{1}{2}$ pint raw linseed oil; 4 cups water; $\frac{1}{2}$ cup turpentine. Apply with clean rag and rub dry.

NOTE: Polish mentioned above was for cars which were formerly painted and varnished. See p. 690 under "Care of a Car," also "Car Washer Equipment," and write for literature. See also "Painting."

After polishing, the car should be treated as if it were newly painted, with the added advantage that there will be no danger of spots appearing as with a newly painted job.

As it is absolutely necessary that the polish be neutral in its action upon the varnish, use the Percival formula.

This process will not be satisfactory on varnish which has been oiled or waxed repeatedly, or on which ordinary furniture polishes have been used.

Cracks which appear on doors of cars are usually caused by slamming the doors, or from other excessive vibration.

To Remove Road Tar Spots

Carefully rub with the fingers, using a small amount of kerosene. To remove oil, dampen a piece of soft cloth with alcohol, shake out to evaporate practically all moisture, and very lightly rub the oil off the surface.

Cleaning Celluloid

If dirty or greasy, it can be cleaned with soap and water or lye. If clouded, put in new celluloid.

Cleaning Brass

Any good brass polish will work satisfactorily. All these preparations contain some fine abrasive, for which reason care must be taken not to let the polish come in contact with the varnish body surfaces.

Cleaning Nickel-Plated Parts³

Nickel polish can be secured at supply houses. Regular silver cleaner paste, or Putz pomade, is often used. Use only the softest flannel rag or chamois to rub with. Do not use brass polish on nickel.

To Prevent Nickel and Brass from Tarnishing

After nickel is polished, an oily rag frequently rubbed over the nickel surfaces will tend to keep it from tarnishing. Use "3 in 1" oil or white vaseline.

Before going out for a run in damp or rainy weather, the nickel or brass can be given a coat of polish without wiping it off; or use the oily rag mentioned above. This will tend to prevent tarnishing and save labor in repolishing. When there is little time to give a cleaning brass or nickel parts, paint it with black or colored enamel or have it enameled, which looks better than when tarnished. Two coats of good lacquer, each to dry twelve hours (after cleaning surface with alcohol) will protect nickel polish for a limited time.

Cleaning Lamp Reflectors

Do not clean lamp reflectors except when absolutely necessary, as they are often silver plated and easily spoiled. See page 439.

To Clean Glass

For cleaning glass—windows, windshields, lamp lenses, mirror lenses, etc.—there is nothing better than a mixture of half alcohol and half water, which will readily clean off dirt and leave a bright polish.

To prevent rain or snow from sticking to glass: A trade magazine gives the following mixture to use: 2 oz. glycerine and 1 oz. water with 1 dram salt. Apply to the windshield with cheesecloth—wiping up and down.

A dressing for leather tops: A very good recipe for the purpose is: One part liquid asphaltum to two parts castor oil, to which add $\frac{1}{2}$ oz. ivory black to each pint of the mixture. Apply with a soft brush. Also suitable for a rubber top.

² Complete automobile lubrication as a business is explained in a booklet issued by The Bassick Mfg. Co. (manufacturers of Alemite), Chicago, Ill.

³ Polishes, top dressing, fender enamel, engine paint, tire paint, aluminum paint, gasket shellac, paint for painting a car at home, radiator cement, etc., can be obtained of auto supply houses.

When grease or oil is found on the varnished surfaces, it should be removed with a good furniture polish applied with a clean cloth. The polish should be applied only to the grease spots and then removed with another clean cloth.

Wash under parts of vehicle with running cold or lukewarm water, soaking mud off as much as possible.

Grease and oil on the under parts of chassis, can be removed by washing with gasoline or kerosene and drying with a clean cloth. See page 760 for cleaning engine.

A high-pressure stream can be used on the running gear and underneath the car and fenders, but care must be taken to prevent water from being forced into the wheel bearings.

Running boards can best be cleaned with soap and water. Thoroughly rinse with running water after cleaning.

Supplies and Equipment For Washing Car

Auto supply houses (page 687) supply complete equipment and supplies for washing cars. Some of the supplies necessary are as follows.



Fig. 2. Two good, clean, soft "wool" sponges, two ten-quart soft pails, several clean soft chamois, a quantity of canton flannel, a quantity of ivory or pure castile soap, or pure linseed oil soap, clear running water, a soft wool duster, gasoline

or kerosene for use under the car in extreme cases to remove oil and grease. Two whisk brooms are necessary, one for the interior and one for the floor mats. Rubber boots are necessary for the washer.

Two sets of pails, sponges, and chamois are recommended, so that the pail and sponge used for the first washing may be kept separate from those used in the final washing. See page 672 for kind of sponges and chamois to use.

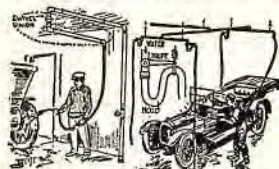


Fig. 3. (left) A washrack or washstand is usually made about 12 or 14 ft. wide and about 15 or 18 ft. long. It is made of granitoid, so arranged that the water flows to a trap in the center for draining. In some instances a service runway (Fig. 5) is used for washing as well as oiling and greasing.

The water for washing cars in winter is usually heated so that it is lukewarm but not hot, as it may soften the varnish.

Overhead washers² are usually constructed with a swivel joint, so that it is possible to swing around the car as in Fig. 3. This washer is made of standard $\frac{3}{4}$ " galvanized iron seamless pipe and fittings. Washrack hose is usually a 4-ply hose of $\frac{3}{4}$ " inside diameter. A flexible wash-hose nozzle is best to use instead of a metal nozzle.

BODY, METAL, AND GLASS POLISHES

There are two general kinds of finishes for bodies: The varnish finish and nitro-cellulose pyroxylin lacquer finish.

The lacquer finish has a satin finish in appearance and is very durable, does not scratch as readily as varnish, and improves in luster with age, it is claimed. One thing to avoid on a lacquer finish is alcohol; this is a solvent of lacquer. A good polish for a lacquered car is "Duco polish No. 7."

¹ It is claimed by The Simoniz Co., Chicago, that with a coating of "Simoniz" on a car it can be kept clean without washing (unless muddy). When dusty, it can be wiped off without scratching, termed a "dry wash." Mud is removed with water, and rain is wiped off with a chamois. This concern also specializes on cleaners and polish. Write for free circulars.

² An overhead washer, is of a construction which allows the swivel arm and hose together with an electric light to swing around the car. This concern also supplies six styles of special nozzles and a special water control, which is easily operated with one hand.

Fig. 4 (center) shows a washer with several hose outlets. Each hose is connected to a plug valve which is spring-closed and opened by a slight pull on the hose. The advantage is that it allows more than one man to work on a car.

Car Washing Methods

The methods used to wash a car may be generally classified as hand method (hose, bucket, sponge, chamois), as explained on left column of this page, and power methods.



There are two types of power methods: water atomized with compressed air, and water at an adjustable pressure, from

a very low pressure up to a very high pressure; the low pressure being applicable to the body and finished surfaces and the higher pressure for cleaning crusted mud or caked grease from chassis, under fenders, etc.

Washing by power saves labor, thereby increasing profits.

The Curtis air-mist car-washing system (Fig. 6) uses water atomized with air, the air coming in contact with the water at the nozzle employing both an air hose and water hose. This system is so designed that the proper amounts of air and water are used to produce correct atomization, thus preventing injury to finishes.

Most power car-washing outfits can also be used to supply compressed air for other purposes, such as cleaning engines and chassis with kerosene, spraying lubricating oil on the springs, blowing out rugs and cushions, spraying lacquer enamel, tire inflation, operating pneumatic door openers, pressure grease and oil guns, pneumatic valve grinders, etc.

Instructive free printed matter on power car-washing methods may be obtained from the following manufacturers: Brunner Mfg. Co., Utica, N.Y.; Curtis Pneumatic Mch. Co., St. Louis, Mo.; Hardie Mfg. Co., Hudson, Mich.; Kellogg Mfg. Co., Rochester, N.Y.;

The United States Air Compressor Co., Cleveland, Ohio.

Washing the Radiator

The clean the radiator spaces of accumulated mud, flush from the rear, not from the front, and thus avoid getting water into ignition system.

Sponge off Hood

After car has been run for a long run it becomes fairly hot, and if rained upon, and the rain-drops are left to dry, rain spots will remain. The car should be washed down at once, or if it is not possible, the hood should be sponged off and wiped dry immediately with a chamois.

A good furniture body polish will usually remove grease and rain spots from a hood or body.

The varnish finish is a higher luster finish than the lacquer finish. Varnish finish can be over paint undercoatings or over lacquer undercoatings.

The baked enameled finish is generally used on the fenders and is very durable. Lacquer is also used on fenders.

Varnish coatings do not become thoroughly seasoned until six or eight weeks, and extreme care should be taken with a new car where the varnish is fresh.

Never rub dirt or rust off a varnish finish, as the grains of dirt will cut or scratch the varnish. Dust it off first with a soft wool duster. If car is new, it is best not to dust but to flush with cool water, without pressure. A dry wash with a dust rag is practically harmless to lacquer.¹

It is not advisable to use polishes on the body of a new car, except to remove grease or oil spots, as explained above. Use cool water to harden the finish (see page 736 for a polish for lacquer finish).

It is dangerous to run over a dog. It is far safer to slow down when one is barking in front of the car than to try to push it out of the way.

Blow the horn when approaching a turn in the road, for another car may be coming. Do not run on the low speeds if it is possible to run on the high.

Don'ts for Drivers

Don't drive a car until you are old enough to have good ordinary "horse" sense. Don't look around when your hat blows off. Don't try to kiss the lady in the seat beside you. Don't go to sleep while driving. Don't trust one hand to do the guiding. Don't try to make up lost time by speeding down hill. Don't run at night without lamps. Don't delay putting on the chains when the roads get greasy. Don't forget to "STOP, LOOK and LISTEN" before crossing a railway track—Safety First, Last, and All the Time.

Subjects Formerly on This Page

Some of the subjects formerly on this page were transferred to other pages as follows:

Fire with gasoline (see page 103).

Meaning of 25-35; engine rating (see page 1037).

Pointers on care of tires (see pages 628, 611).

Rattling noise see page 462.

Right side of automobile (see page 80).

Why engine runs more smoothly at night (see page 1037).

Cold-Weather Precautions

The following changes should be made in the late fall as winter approaches in order to obtain satisfactory service from a car during the winter.

1. Drain out all engine oil, clean strainer and renew with a lighter body but high-grade engine oil of proper cold test.
2. Cold weather has the effect of thickening the lubricant in the rear axle, and it should be diluted with enough cylinder oil to bring it back to its summer consistency.

An undiluted oil in cold weather may become entirely non-fluid, so that it lines the walls of the case without lubricating the gears and bearings. The best plan would be to drain the oil from the rear axle case and to flush out the case with kerosene (be sure to remove all kerosene afterwards), and refill with fresh lubricant of the proper consistency and of a very low cold test (see page 761).

3. Cold weather has the effect of thickening the lubricant in the transmission also, and it should be diluted with enough cylinder oil to bring it to its summer consistency.

If the oil is too thick, increased difficulty will be found in shifting gears. The best plan is to drain the oil from

the transmission and to flush out the case with kerosene (be sure to remove all kerosene afterward), and refill with fresh lubricant of the proper consistency and of a very low cold test (see page 761).

- 5A. Cold weather also thickens the lubricant in the steering device and causes difficult steering. It should be treated the same as in 2 and 3.

4. Grease car and lubricate all parts.

5. Drain and clean radiator. To clean the radiator, remove the hose connections and flush by forcing water under city pressure through it from the bottom to the top.

Avoid excessive pressure. The cylinder water jackets should be thoroughly cleaned and flushed at times of overhaul.

6. Put on new water hose, tighten all gaskets, including cylinder-head gasket and fill the cooling system with non-freeze solution (see page 154).

7. Put on lower covers (see page 150).

8. Put on radiator front (see page 1041).

9. Recharge battery and keep it within 50 points of full charge (specific gravity test), and use starter sparingly and economize on current, because the battery is less efficient in winter.

On cold days crank engine by hand, that is, give it two or three turns before using starter, especially after car has been standing a long time in the cold.

- 9A. Ignition operates under three voltage conditions: 4 volts, when starting (battery voltage being reduced by starting motor current draw); 6 volts for a normally charged battery when engine is running at a speed below that which generator starts to charge; 8 volts, when generator is charging a fully charged battery.

10. Set generator charging rate up (not necessary on some generators equipped with a thermostat). This is a good time to have generator commutator cleaned.

11. Readjust the carburetor, also the choke connections, and look over the fuel-feed line.

12. Install a windshield wiper.

13. Grind the valves and see that valve clearance is properly set (see pages 57, 58, relative to importance of this).

14. Clean and adjust interrupter points and install new points if necessary.

15. When storing a car, jack up the wheels, drain all water, see that battery is fully charged, and cover car with a paper bag (can be obtained of supply houses or Kennedy Car Liner & Bag Co., Shelbyville, Ind.).

16. Examine battery and ground connection to see if clean and tight (see page 428).

WASHING THE CAR

As stated on page 645, there are two general kinds of finish for bodies, the varnish finish, and nitro-cellulose pyroxylin lacquer finish, which is entirely different from paint and varnish. The varnish finish is more brilliant but more sensitive as to care.

Care when washing: The car should not be washed in the hot sun, which will dry the panels before the chamois has been applied, neither should it be washed immediately upon being brought in from the cold—let it warm up to a reasonable room temperature. Dust, mud or rain spots should not remain on the car, especially when new and varnish is not fully seasoned. Cold water serves to harden the varnish and increase its brilliancy.

Dust or mud should be removed from the car first. If new, it is best to remove dust by washing it off with cool water without pressure. Do not wipe it off; this simply rubs the grit into the varnish and makes scratches.



A soft wool duster can be used if the dust is to be removed without washing. A dry wash with a soft dust rag is less harmful on a lacquer finish.

Washing Car—Hand Method

Soak mud off with plenty of running cold or lukewarm water. Do not rub it off, for the varnish would be scratched. Let the water run gently out of the hose (no nozzle) and flow over the mud.

Varnished and enameled parts of car should be washed only with cold or lukewarm water, and no soap, polish or other cleansing material should be used unless there are grease spots, which should be removed after washing as explained below.

After flushing with cold or lukewarm water, then softly wipe with a clean, soft sponge held in a slow stream of water. The sponge used for this operation must be kept clean and free from grit, and should not be used on the under parts of the car.

The surfaces should then be dried by vertical wiping with a chamois skin softened in water and wrung dry. Only so much surface should be washed at one time that it will not dry before being chamoised. The chamois skin should be kept clean and free from grit. (Sponge and chamois can be washed in clean soft water and castile soap.)

The wheels of the car (if varnished) are to be treated in the same manner.

¹ See pages 628 and 611 for "Pointers on Care of Tires," formerly on this page.

INSTRUCTION No. 57

CARE OF CAR: Pointers on Driving; Washing, Polishing, and Cleaning Car; Polishes; Painting a Car at Home; Nitro-Cellulose Lacquer Finish; Cold-Weather Precautions; Accessories

GENERAL POINTERS ON DRIVING THE CAR

The driver must keep his eyes and ears open, watching the other occupants of the road as well as the running of the car. See Index relative to "Traffic ordinances," "Rules of the road," etc.

The ear is the best judge of the running of the engine, as it shows any defect by a change in its steady throb. With practice, it becomes easy to recognize a new noise, and the cause should be located and remedied at once. A squeak or rattle that comes at regular intervals may be located in one of the revolving parts; if not regular, it comes from something that is not revolving—the springs, brakes, or a similar part.

Irregular running of the engine may not be serious, but rather the result of a rough road or loose ignition connections. Knocks or pounds should be located at once, for they may lead to a serious breakdown.

Know Your Car

Remember that in the care and operation of a motor car, much must be left to the judgment of the operator, who should study the construction of his car, the functions of its various parts, and the "why" of everything connected with it.

Learn the speed at which the car will take a turn on mud or wet asphalt, without skidding or side-slipping, and never exceed it. Learn the grade of a hill that the car will climb easily; on steeper grades do not wait for the engine to labor before changing the speed.

Learn the turn that the car will make for every position of the steering wheel, and always make the broadest turns that the width of the road will permit. A sharp turn is more likely to strain and injure the tires, running gear, and steering mechanism, than a broad turn, and, if the car is speeding, is more likely to cause an upset.

Learn the distance that the car will travel before it becomes necessary to refill the tanks—not from the catalogue, but from your own experience.

Learn the rapidity with which the car will pick up speed after a slow-down, as it will help when running through traffic, or in dodging another vehicle.

It is important to learn the shortest distance in which the car can be stopped for its different speeds, and the exact extent to which it slows down for each application of the brakes. Learn to use the brakes so that the motion becomes automatic, and can be done without wasting time thinking about it. Learn to judge distance, and the speeds at which the car travels; ability to estimate speeds may prevent arrest.

Learn to recognize the noises of the engine when it is running smoothly: the click of the valves, the hum of the timing, pump, and magneto gears, the puff of the exhaust, so that unusual noises may be easily recognized.

Learn the feel of the compression, by cranking the engine, so that leaks may be detected. Learn

the effort required to push the car on a smooth floor by hand, or how freely it will coast down a hill, so that a binding brake or a tight bearing may be felt. In short, get in tune with your car—be part of it—make it part of you; that is, if you want to get good service from it, and save on the repair bills.

Other Points to Remember

The flashy driver, who makes quick turns and sudden stops, attracts attention, but ruins the car. The more smoothly a car is operated, the longer it will last, and the less often it will get out of order.

Easy turns, gentle stops, the running of the engine as slowly as possible for the speed desired, proper adjustments, and constant care, mean long life to the car and freedom from trouble.

When the engine is not acting right, do not rush in and readjust the ignition or the carburetor without first being sure that the trouble has been correctly located. Throwing the carburetor out of adjustment on a guess makes it all the harder to get going again, for its readjustment must be added to the trouble already present. An automobile is not difficult to handle, but neither is it so simple that brain work is not necessary. Get all of the facts possible before doing anything to the mechanism—the noise that the engine made in stopping, the way it stopped, the reasons for the unnatural noises, and the bolts from which nuts may have dropped off. An automobile is constantly in a state of severe vibration, and almost any part is liable to work loose when least expected.

Some accessories are convenient, and others are nuisances. Do not load the dash up with devices that are not of practical use, for they only add to the parts that must be watched and taken care of. Provide the car with a good horn, and use it well when necessary, but never needlessly.

The lubrication is important and must be watched carefully; it takes only a little running without oil to cut the cylinder walls and piston rings. Excessive oil in the crank case means fouled spark points, and should never be permitted; however, it is better to have too much than not enough. (See page 171 about ill effects of racing an engine.)

When running, keep to the right, and in meeting another vehicle turn farther to the right, so that it will have room to pass. In passing a vehicle going in the same direction, pass so that it is on your right, and do not swing back to the right side of the road too close in front of it. The other vehicle may speed up as you pass, and be closer than you realize.

Get thoroughly familiar with the different speeds so that there will always be time to stop when necessary. Keep your eye on the people alongside of the road, for they may start to cross without warning. Children are liable to run out of a gate or to cross the road when they are least expected. Cross-roads and cross-streets must be watched, for vehicles or people may come along them.



FIG. 40



Fig. 40. Driving compartment of the Cadillac V-8 series "355" car showing instrument board, control levers and pedals. The Cadillac V-12 series "370," and V-16 series "452" driving compartment, instrument board and controls are similar except the accelerator pedal and the location of the spark control and the cigar lighter.

The transmission is of the sliding gear type with three forward speeds and one reverse. The S.A.E. standard gear shift is used on all Cadillac cars. The synchro-mesh transmission, explained on page 862D, is used on all Cadillac and LaSalle cars.

The operation in general is the same as the operation of the conventional selective sliding-gear type of transmission. The positions of the gear-shift lever are the same and the directions in which the control lever is moved are the same. It is also necessary to disengage the clutch before moving the control lever, the same as with the conventional transmission.

The only difference is in the manner of moving the control lever. With the conventional transmission, it is customary when shifting to a higher gear to hesitate momentarily in neutral and the hesitation in neutral or for the rapid movement of the lever during the latter part of this shift. Instead, the movement of the control lever should be one smooth, continuous movement as explained on page 862D.

Names of parts, Fig. 40: 1, hand throttle; 2, horn switch button; 3, lighting switch; 4, transmission control lever; 5, ventilator; 6, clutch pedal; 7, foot brake pedal; 9, accelerator; 10, starter pedal; 11, hand brake lever; 12, light switch for instrument board; 13, control for windshield wiper; 14, rear view mirror; 15, windshield wipers; 16, windshield regulator; 17, sun shade.

Fig. 41. Instrument board of the Cadillac V-S, series "355." Names of parts: 1, instrument board light; 2, gasoline gauge (electric); 3, oil pressure gauge; 4, ignition control; 5, clock; 6, clock set; 7, cigar lighter; 8, ignition switch lock (automatically locks transmission in neutral or reverse; will not lock in any other speed); 9, speedometer; 10, choke control; 11, temperature indicator; 12, instrument board; 13, ammeter.

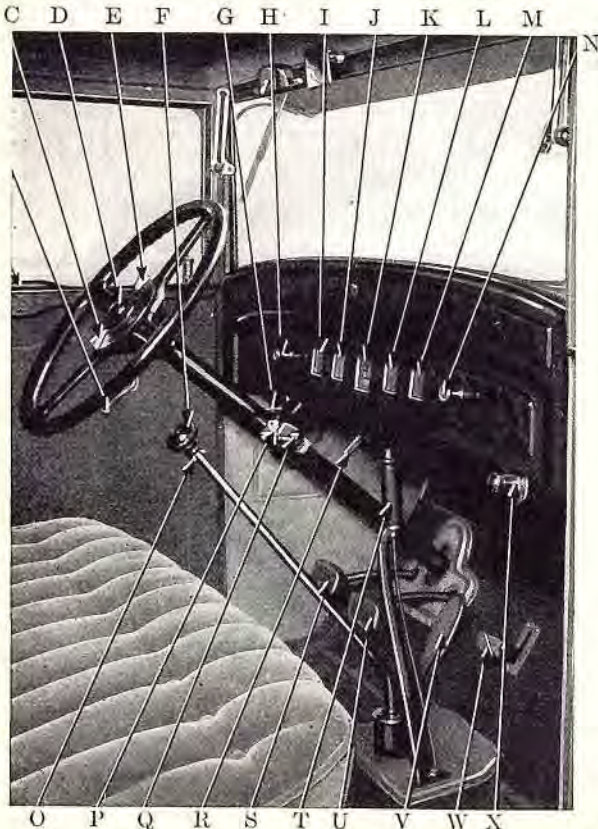


Fig. 42. Driving compartment of the Graham standard eight and special eight, model 42, car showing instrument board and controls. Names of parts are:

- C. Light switch lever.
- D. Horn button.
- E. Throttle lever.
- F. Gear-shift lever.
- G. Manifold heat control handle.
- H. Spark control button.
- I. Oil pressure gauge.
- J. Gasoline gauge.
- K. Speedometer.
- L. Ammeter.
- M. Water temperature indicator.
- N. Carburetor choke button.
- O. Transmission first speed shift latch.
- P. Ignition lock key.
- Q. Auxiliary ignition lever.
- R. Cowl ventilator handle.
- S. Clutch pedal.
- T. Emergency brake lever.
- U. Foot brake pedal.
- V. Accelerator pedal.
- W. Starter pedal.
- X. Cigar lighter.

Transmission and gear shift: The standard eight is equipped with a three-speed transmission and gear shift is the S.A.E. standard. The special eight is equipped with a four-speed transmission, briefly described as follows: 4 speeds; a latch O controls pawl which prevents moving the transmission lever into first-speed position without first lifting this latch. The latch is provided for convenience because it is not necessary to use first speed for starting if the car is on a level, paved street. The second, third, fourth and reverse gear positions are identical with the first, second, high and reverse gear positions of the conventional three-speed transmission.

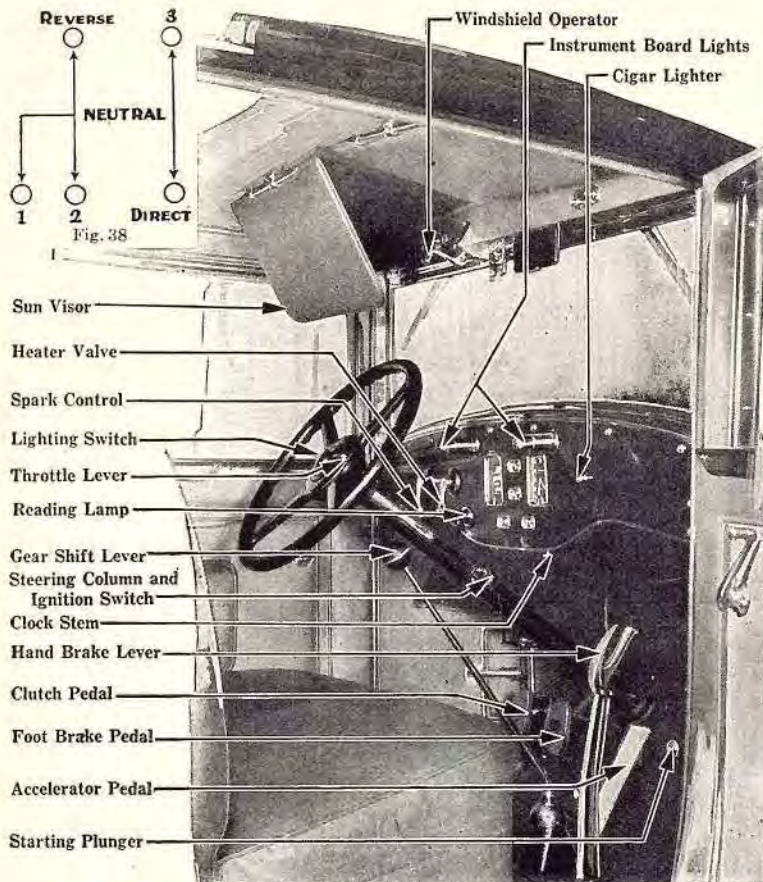


Fig. 37. Driving compartment of the Pierce-Arrow eight-in-line, models A, B, and C, cars showing the instrument board, control levers and pedals. The transmission has four-speeds forward and one reverse. The gear-shift lever position and direction of shift is shown in Fig. 38.

The transmission provides a special low first speed for starting the car under unusually

bad road conditions. Ordinarily it is not necessary to use the first speed and the car should be started with the gear-shift lever in the second-speed position. First speed is engaged by placing lever in neutral position as for engagement of second speed, then pulling lever over to the left against spring pressure and back into the position shown in Fig. 38. The gear-shift lever should not be moved without first releasing the clutch. It should always be in the neutral position before starting the engine. See pages 1055-1062 for specifications of the Pierce-Arrow and other cars.

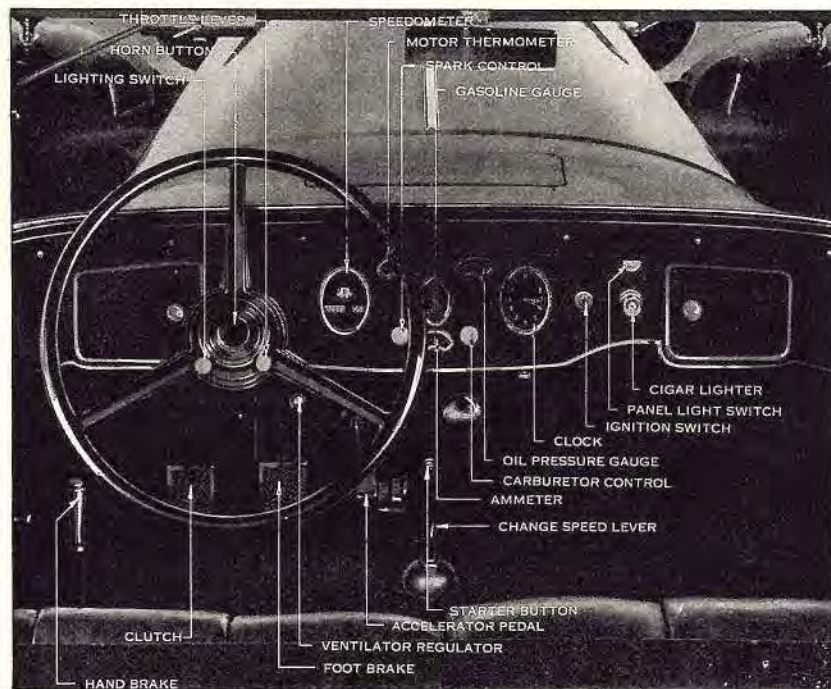


Fig. 39. Driving compartment of the Packard eight-in-line "eighth" series cars showing the instrument board, control levers and pedals.

The transmission has four speeds forward and one reverse. See page 862D for transmission and gear shift.

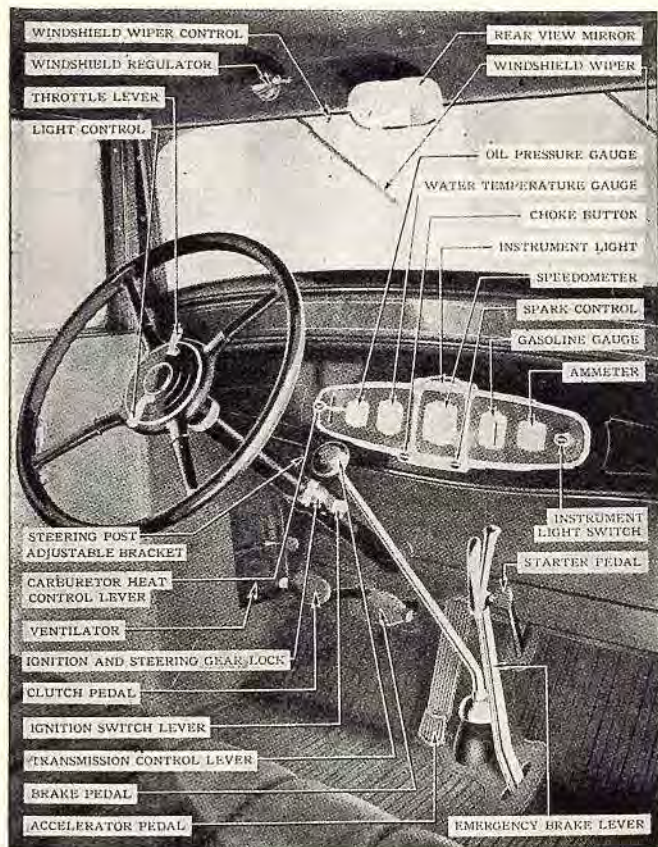


Fig. 35. Driving compartment of the Buick series 8-50, 8-60, 8-80 and 8-90 cars showing the instrument board, control levers and pedals. Gear shift is the S.A.E. standard three-speeds forward and one reverse.

The transmission used in the 8-60, 8-80 and 8-90 models is the "synchro-mesh" type.

For Buick electrical system see page 307A for ignition, and page 424A for starting motor, generator and wiring diagrams.

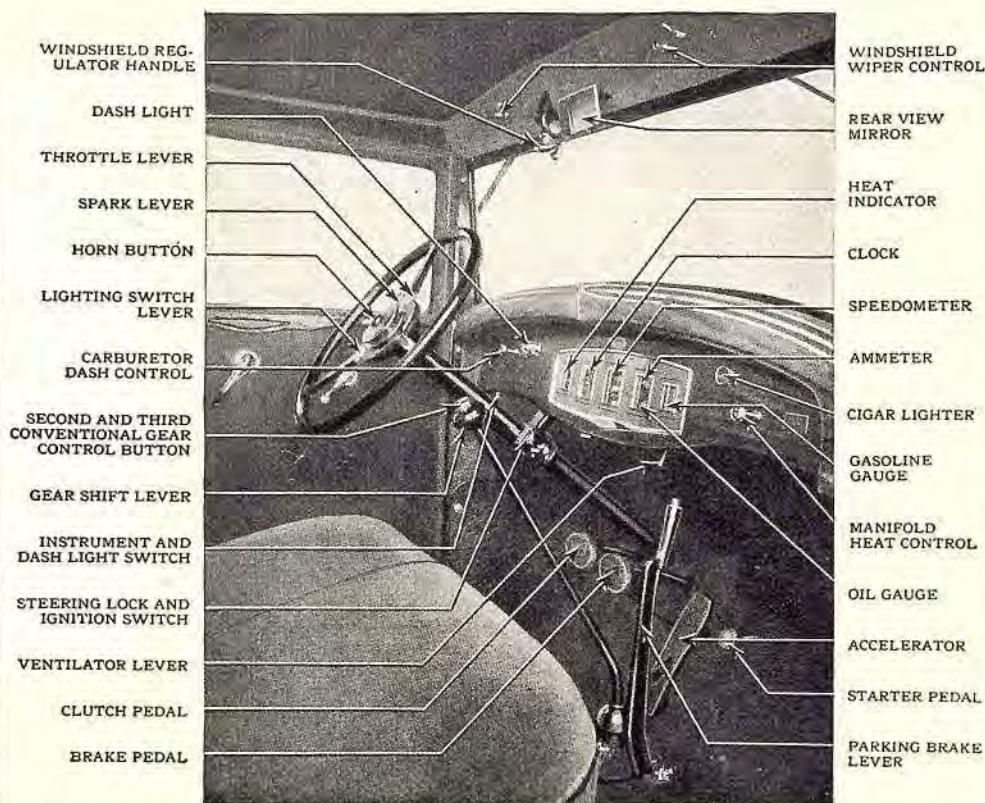


Fig. 36. Driving compartment of Studebaker President Eight (80 and 90 series) showing the instrument board control levers and pedals. The gear-shift lever positions are the same as in a conventional transmission and is the S.A.E. standard three-speeds forward and one reverse, with the additional shifting lever positions for the "free-wheeling" transmission used on this car.

The free-wheeling feature is included in both the high and intermediate gears (the low and reverse gears are of the conventional type) with the shifting lever in the normal positions for these gears. The shifting lever positions are the same as in a conventional transmission. If, however, the operator does not desire to make use of the free-wheeling feature, pressing a small button in the top of the shifting lever ball permits the shifting lever to be moved slightly farther back than normal for intermediate gear, or slightly farther ahead for high gear, as described on pg. 862C. These are conventional (positive) drive positions and the transmission operates to drive the engine as a brake, as in a conventional transmission, when descending a steep hill or mountain. See page 862C.

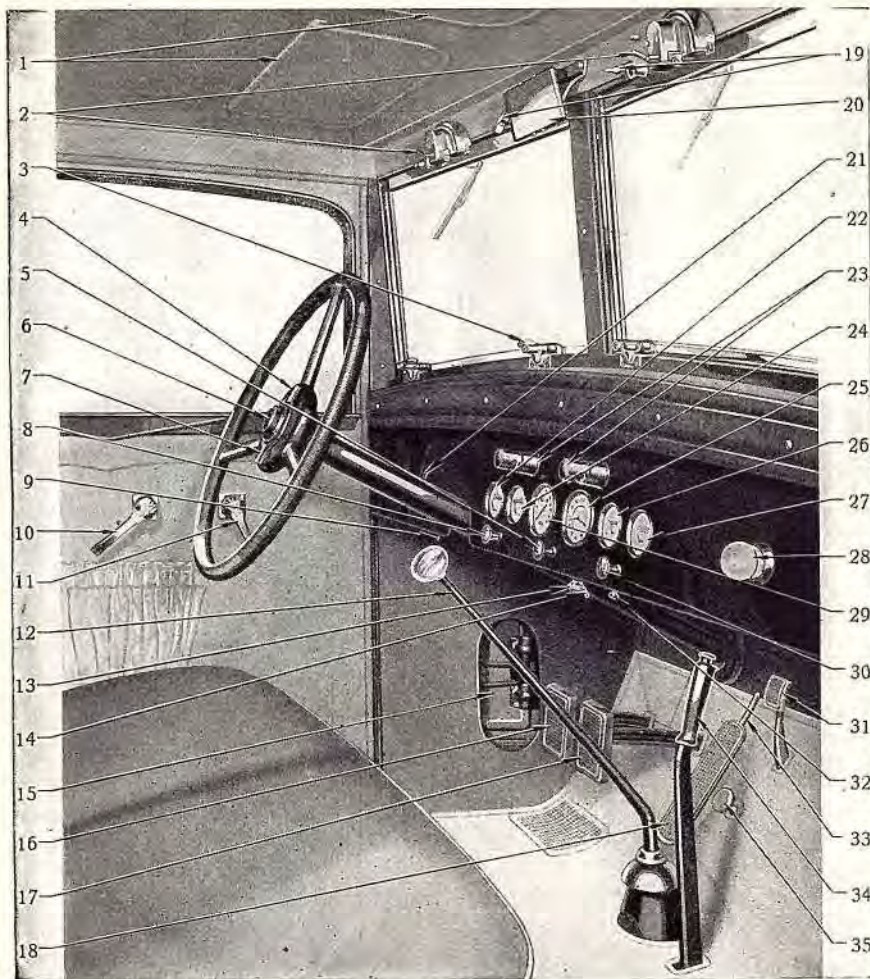


Fig. 33. Front compartment of the Chrysler Imperial Eight (1930), showing the instrument board, control levers, pedals and gear shift. The names of the parts are given at the right of illustration.

Note: Where parts A, B, C and D are added means that they are later additions.

- | | |
|----------------------------------|---|
| 1. Sun visors | 19. Windshield regulator wing nuts |
| 2. Windshield wiper controls | 20. Pear view mirror |
| 3. Windshield fasteners | 21. Ignition switch and lock |
| 4. Throttle control hand lever | 22. Thermometer |
| 5. Spark control button | 23. Instrument lamps |
| 6. Horn push button | 24. Oil pressure gauge |
| 7. Light control hand lever | 25. Clock |
| 8. Choke control button | 26. Ammeter |
| 9. Instrument lamp switch | 27. Fuel and oil level gauge (panel unit) |
| 10. Door remote control handle | 28. Cigar lighter |
| 11. Door window regulator handle | 29. Speedometer |
| 12. Gear-shift lever | 30. Manifold heat control button |
| 13. Clock wind and set stem | 31. Starter pedal |
| 14. Speedometer trip set | 32. Oil level gauge switch |
| 15. Ventilator | 33. Accelerator pedal arm |
| 16. Clutch pedal | 34. Transmission brake hand lever |
| 17. Brake pedal | 35. Accelerator pedal foot rest |
| 18. Accelerator pedal | |

The transmission used on the Chrysler Imperial Eight (1930) has four forward speeds and one reverse. Fourth speed drive is direct from engine to rear axle.

The gear shift is termed multi-range gear shift and has the following gear arrangement:

Reverse: Called "reverse range." Located where "reverse" is on the conventional three-speed transmission. See Fig. 34.

First: Called "heavy duty range." Located to the left (against spring pressure) of "starting range." This is a forward speed which provides power at the rear wheels for starting and driving the car under unusual operating conditions. Used when negotiating steep grades, deep mud, sand or snow.

Caution: If at any time it becomes necessary to shift from "heavy duty range" to "starting range," care should be exercised not to shift into "reverse" while the car is moving forward.

Second: Called "starting range." Located where "first" is on the conventional three-speed transmission. Capable of speeds up to 30-35 miles per hour. The shift into "acceleration range" can be made as quickly as desired. Always used for starting under all ordinary driving conditions. It is necessary to attain a speed of 18-20 miles per hour before shifting into the "acceleration range." For unusual starting conditions "heavy duty range" (first) should be used.

Third: Called "acceleration range." Located where "second" is on the conventional three-speed transmission. The "acceleration range" is quiet when in operation. Speeds up to 55-60 miles per hour can be attained in this range. This gear is an "intermediate high." Used at speeds below 20 miles per hour for heavy traffic. Also used for acceleration and speed in hill climbing. It is possible to shift back and forth between this range and "speed range" (fourth) quietly at any speed. Never use this gear for starting.

Fourth: Called "speed range." Located where "high" is on the conventional three-speed transmission. With the car in "speed range," engine revolutions per mile are reduced, resulting in greater smoothness, comfort, and quietness as well as a marked increase in oil economy plus longer life of engine parts. Used when driving at moderate and high speeds, under average road conditions. Especially valuable on long trips for cross country driving. To maintain high road speeds, when encountering hilly country, it is necessary to shift to "acceleration range." This can be accomplished quietly and quickly at any speed.

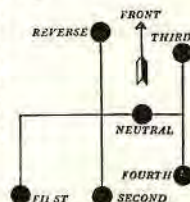


Fig. 34

If oil leaks out of the transmission bearings, see Index under "Transmission-oil leaks."

Drive Shaft and Universal Joint

1. Test for looseness (see Index under "End play in universal joint"): If this is excessive, the looseness is in either worn gears or bearings in the transmission, or there are loose universal joints or loose adjustment of the drive pinion to the differential driven gear (see Index under "Differential gear adjustments").

Rear Axle

1. Test adjustment of drive pinion (see Index under "Noisy rear axle"). On some cars, Ford for instance, there is no adjustment, therefore a new drive pinion must be fitted.
2. Examine the differential by removing the cover, if a "full-floating" type (see Index), or remove the axle housing, if a "semi" or "three-quarter floating" type (see Index), in order to ascertain if any of the nuts are loose or small differential pinions are worn.
3. Test wheels for alignment (see Index).
4. Test for wobbly wheels (see Index).
5. See if axle shaft is bent—usually at the hub, which would be indicated by the wheel wobbling.
6. See if oil is working out of the rear hub into the brake lining.
7. Test brakes (see Index).
8. Gear ratio of car should be determined if possible. See Index: "Gear ratio of passenger cars" and "Gear ratio, how to compute." This however is difficult to ascertain. Sometimes, in order to make it easy for a small engine, or one in the best of condition to pull hills on high gear, a larger ring gear and smaller drive pinion are put in the rear axle, but the speed of the car is reduced (see also page 1098, explaining how this change is effected). If the reduction is low, a very small engine will make a good performance on hills and will be economical on gas, but will wear out quickly and not develop proper car speed. If the engine is of large dimensions and is geared low, it will perform well on hills and will have long life, but will be a glutton for gas and will not give proper car speed.

Steering Device

1. Test for play, and for loose bolts and nuts (see Index under "Steering devices, testing of").

Miscellaneous Tests

1. See if engine will idle without missing. See also page 59, "Valve clearance pointers."
2. Test the battery: if a coil and battery ignition system (see Index).
3. Test the magneto: if a magneto system of ignition, by idling and speeding up the engine to see if there is a missing of explosion.
4. Examine the wiring and see if it is oil soaked and ragged.
5. Test the carburetor by idling and speeding up the engine to see if explosions are even and if the engine picks up readily under load. Also

note if the carburetor air intake and the carburetor mixture are heated.

6. Examine the spark plugs, to see that the gap distance is correct at the points (about .025"), and that the porcelains are not cracked.
7. Run the car and test the mileage gained per gallon of gasoline. This will require at least a 20 or 25-mile run. Many 6, 8, and 12-cylinder engines will not average over 9 to 14 miles per gallon—depending upon the condition of the rings, or whether there is leakage of gasoline into the crank case, as well as on the size of the cylinders and whether the roads are hilly or level.
8. Examine all bolts and nuts on the engine, springs, etc.
9. See that the engine is properly oiled and that all parts of the car are greased.
10. If parts have been replaced, such as the steering knuckles and spindles in the front wheels, etc., see that they are not made of castings instead of forgings.
11. The storage battery is another part which should be examined. Have it tested at a battery station. You can tell if the battery has been repaired by looking at the connectors. Figures are usually stamped at the factory at each end of the connector where they are burned to the post. If there is a bright spot with no figures, it indicates that the battery has been repaired since leaving the factory. The battery should be tested by testing each cell, as explained under "High-amperage tests" and "Cadmium tests of storage batteries."

Note: See also page 1066, giving pointers on the study of the mechanical part of a car.

Bill of Sale for a Second-Hand Car

When purchasing a second-hand car, demand a bill of sale. It should be drawn in accordance with the laws of the state where the purchase was made. The following form of bill of sale will answer in a majority of cases, in most states:

Know All Men by These Presents that I (here insert name and address of party selling the car) in the County of _____, State of _____, in consideration of (here insert amount of money to be paid party selling by party buying) Dollars this day to me in hand paid, do hereby grant, sell transfer and deliver unto the said (here insert name of party buying) the following goods and chattels to wit: (then insert name of automobile, its model, the engine number and the car number, also the type of car, its color, together with any other information which will help to identify it); to have and to hold said goods and chattels to the said (name of purchaser), his executors, administrators and assigns to their use forever.

I hereby covenant with the said grantee that I am the lawful owner of the said goods and chattels; that they are free and clear from all encumbrances; that I have good right to sell the same and that I will warrant and defend the same against the lawful claims and demands of all persons.

I witness whereof, I, the said (name the party selling) hereunto set my hand and seal the _____ day of _____ 192__.

Signature of party selling _____ (SEAL)

If there are any special warranties or promises on the part of the party selling, they should be set forth in detail and should be inserted in the bill of sale in a separate paragraph after that part of the bill of sale which describes the automobile, and should be worded as follows:

I hereby warrant the said automobile above described to be (here set out warranty made); and I do for myself, my heirs, executors, administrators, and assigns, covenant and agree to and with the said (put in name of party to the buying) to warrant and defend the said automobile hereby sold to the said (here insert name of party buying) his executors, administrators and assigns, against all and every person and persons whatsoever. (*American Automobile Digest.*)

best fitted to serve his purpose with the greatest efficiency. It is a very common sight to see a heavy type of delivery wagon make a trip of several blocks and sometimes miles to deliver one or two small packages or baskets of groceries, when one of the smaller types of commercial cars could have done it just as well and with greater efficiency, reducing materially the overhead cost. On the other hand, we have often seen a light delivery or a very heavy type of truck making a trip with an overload. This is just as impractical as an underload, for it will ruin the expensive motor equipment, making the car depreciation very considerable.

A very good rule to stick to closely is to have the car filled nearly to capacity on every trip that is made. A motor truck or delivery wagon should not be chosen with either a maximum or minimum load in mind, but an average load. To get the

greatest efficiency out of a commercial vehicle, keep it loaded and moving the largest possible number of hours during the working day.

The manufacturers of large trucks (1½ ton and above) usually sell the chassis only; the body is usually built by some local concern specializing in this work, and is designed to meet the individual requirements of the user. The design of a suitable body is a very important factor; a reliable truck dealer can materially aid the purchaser in making the correct selection.

If electricity is produced in your own plant at a very low cost, and it is possible to secure a man who understands and can care for storage batteries, then it may pay to investigate the electric vehicle.

JUDGING AND TESTING A SECOND-HAND CAR

In order that the purchase of a second-hand car may be attended with some degree of safety, as to its condition, the following tests should be given. It will no doubt be impossible for the purchaser to make all of these tests, but what follows will give a general idea of what should be done to testing or overhauling any car. See also pages 663, 664.

General Condition

Ascertain the age, make, and type, and also the horsepower of the engine (see Index under "Horsepower"). If the car is an obsolete model or of antiquated design, it will be a difficult matter to dispose of it later on at any price. Find out if the manufacturer is still in business, in order to know whether parts can be obtained if required. Do not judge a car by its outside appearance alone. Paint is ordinarily cheap.

Tires and Rims

Many sizes of tires on some of the older cars have been discontinued (see page 594 for sizes now being made). You may have difficulty in obtaining tires.

Also learn the make of rim. The old-style "one-piece clincher" rim is obsolete, except on Ford, Chevrolet, Maxwell, and Overland model "Four." The modern rim is "straight-side," demountable type.

The best tire is the "cord" tire (see page 609). The "fabric" tire is explained on page 608. Examine the condition of the tires after reading page 610, and test for "stone-bruises."

Engine

1. Test the compression of each cylinder (see Index under "Testing compression"). First learn what compression means (see Index). The compression test will indicate the condition of the rings and cylinder walls and valves. If the cylinder walls are scored or cut, then this is an expensive job to repair (see Index under "Cylinders scored"). If the valves leak, then this is not so expensive (see Index under "Grinding valves"). If the rings leak, this is an item worth noticing (see Index under "Piston rings"). If there is considerable smoke from the exhaust pipe when running the engine (see page 168), and the smoke is blue or light in color, there is too much oil in the crank case of the engine, or the pistons are pumping oil as explained on page 168, or the rings are loose, or the cylinder walls are scored. If smoke is heavy and black, the carburetor is feeding too much gasoline and should be adjusted. Many new engines have had the cylinders scored by running the engine

at too high a speed during the first 1,000 miles and from lack of oil.

2. Test the bearings. The best method for doing this is to make a long run, taking at least one or two fairly steep hills, and noting if the engine knocks. By studying the subject (knocks), you can learn to distinguish the cause of different kinds of knocks (see Index under "Knocks").

When testing for knocks, make allowances if the engine is a four-cylinder, especially of small size, and when taking hills slowly. Many four-cylinder engines must get the engine up to a fairly good speed to take a steep hill, as the power depends upon the momentum of the fly wheel, whereas the six, eight, or twelve-cylinder engine should take a hill with less speed, without pounding or knocking, if the spark is retarded properly.

3. Test the cooling system. After making the run suggested above, note if steam comes from the radiator at the vent or overflow tube or filler cap. If so, the engine runs hot, and the trouble is attributable to one of the causes explained on page 152 under "Engine overheats." Understand that an engine runs best at about 170° temperature, but should not steam. Also observe if there are leaks. Usually the leaks are at the hose connections and can be tightened, but if the hose is worn, replace it.

The Clutch

1. See if the clutch slips when taking a hill.
2. See if the clutch drags when released.
3. See if the clutch "grabs" or is "fierce" (see Index under "Clutch grabs").
4. Ascertain the type of clutch used in the car by referring to the Index for "Specifications of leading cars." Then turn to Index under the appropriate titles, and note the construction and troubles and remedies.

Transmission

1. Test the gear shift while the engine is running, by shifting from reverse, 1st, 2d, 3d speed, to see if the gears can be changed without a clashing noise. If not, then the trouble may be due to the clutch pedal not being thrown far enough "out," or the clutch "drags" or "spins," or the transmission or clutch shaft are out of alignment, owing to worn bearings, or the teeth of the gears are burred.
2. Test for worn or broken gear teeth: With the engine running slowly, place the gears in 1st speed; place the finger on the gear lever—if there is a worn place at one point or all round the gear, it can be felt by the vibration. Try this on all speeds and on reverse.
3. If the transmission is noisy, and there is plenty of oil in the transmission case, the trouble is probably due to a broken ball or roller bearing or a worn bearing.

¹ The Wasson Motor Check is a device or testing apparatus for determining the performance of a car under actual road conditions. It measures the brake horse-power delivered at rear wheels, slipage of working charge past the pistons, gasoline consumption under varying load conditions, oil dilution in relation to mileage, compression of each cylinder, etc.

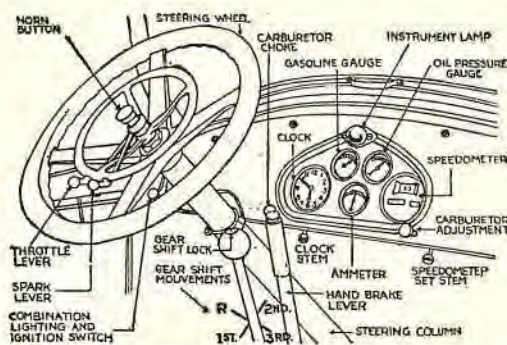


Fig. 32. Marmion 1922 instruments and controls. The controls and instruments will be found grouped conveniently about the driver's seat, as shown in the illustration. The clock, speedometer, ammeter, and gasoline and oil pressure gauges are centrally located in the instrument board, being attached to a die-cast frame which is covered with one piece of glass. The instruments have no individual glass over their respective dials.

POINTERS ON SELECTING A NEW CAR

Power: This is determined by the number of passengers to be carried and the condition of the roads. If the country is a flat district, a low-powered car will do efficiently and infinitely more economically what in a hilly country would necessitate perhaps nearly twice the power to do the work on high gear. For hilly country a car with a low reduction to the rear axle should be selected in order that the engine may take the hills on high gear.

Body: This is not much a matter of choice nowadays, as the cars are all built in large quantities and to a standard type. Putting aside for the moment the case of those who, from consideration of price alone, would confine themselves to a car of power and size suited for a two-seated body only, it is best to have a "touring car" body of 5-passenger type. Though the back seats may be used only once in a while, they are nevertheless too often wanted if not there, and the advantages of being able to give friends a lift and of having plenty of room for luggage and parcels are well worth the slight difference.

Enclosed bodies: The touring-car body is equipped with a very serviceable top, and, in combination with a glass front or wind shield and suitable side curtains, this type of body can be converted into a fairly weatherproof vehicle.

The coupe and cabriolet body (page 5) is a very popular type for business purposes, as it protects one from the dust and weather, and is a very comfortable type of body for winter use.

The sedan type of body is a very popular type for family use, and can be fully enclosed for winter and opened for summer use. This type of body is adapted for those who drive their own car. A suggestion to those who are considering a closed car, yet really prefer an open car, is to purchase an open car and fit the rear with a tonneau wind shield as described on page 649. The difference in cost of an open car and a closed car is quite a sum, and the low cost of the tonneau wind shield will save quite a sum of money, and yet will give the open car a nifty appearance as well as being comfortable. A closed car requires more power and gasoline, and there is usually a greater depreciation in its value. A closed car is generally geared lower than an open car, thus relieving the strain on the engine.

The limousine is a more elaborate type of body and is used where a chauffeur is employed, as the driver's seat is separate from the other seats.

The price with many fixes itself; that is to say, their means enable them to decide in a very short time how far they can go. In any event, to arrive at a maximum figure one must include in the calculation a sum not less than, say, \$75.00 to \$100.00 for a small car, and so on in proportion to the size, in addition to the purchase price, in acquiring those accessories, spare tires, and tubes, which are necessary.

Service: When purchasing a car don't forget that in time you will need parts and your car will require expert attention. Investigate this feature and find out if the agent carries parts in stock and if he gives his other customers satisfactory service and if he is reasonable in price.

Constant attention is necessary: Whether you intend to employ a chauffeur or to look after the car yourself is a point to consider. There is a limit to the size of car which the owner can (if the car is kept in pretty constant use) attend to himself, unless he be a man of great leisure, and moreover keen enough to put up with the drudgery involved. It is useless to conceal the fact that a car will require constant attention, and while a man may find the time to do justice to a moderate-sized car, a large car might be too much for him.

The speedometer trip mileage can readily be set at zero with the adjusting pin. The season mileage can be changed only by returning the instrument to the manufacturer.

The combination switch, on the instrument board just to the left of the steering column, controls the lighting and ignition circuits. The ignition lever has two positions, the "ON" and the "OFF." The lighting lever has three positions. Firing order, 1, 5, 3, 6, 2, 4.

The location of control members not shown in the illustration: The clutch pedal is the left foot pedal; the foot-brake pedal is the right foot pedal; the accelerator pedal is between the two pedals; the starter-switch pedal is just above the toe board.

The gear-shift movement is the standard S. A. E. three speed, as shown in the illustration.

The rear axle is shown on page 16. The steering device and its adjustments are explained under "Adjustment of steering devices" (see Index).

The engine is a six-cylinder engine with overhead valves, the principle of which is shown in Fig. 92, page 53. Note in this illustration that the valve push rods are shown on each side of the cylinder, in order to explain the action of both valves in the head, whereas, all of the push rods are on one side of the cylinders.

The pistons used in this engine are of a different design from other pistons; see Index under "Marmion pistons."

The bore and stroke of the engine are $6\frac{3}{4} \times 5\frac{1}{8}$ ", and the piston displacement is 339.7.

Cost of running—or up-keep: Here lies the crux of the whole matter. Closely allied with the important question of original outlay is that of the running cost, which must be taken into consideration to a certain extent, when buying. The size of the bill for up-keep bears, of course, a direct proportion to the mileage run. As regards the fuel consumption, this item will not be a large one in any car up to, say, 25 h.p., unless there is some radical defect in the system, or a temporary want of adjustment. In large and heavy cars the gasoline bill quickly mounts up.

Tires are the largest item in the cost of up-keep, and this charge becomes heavier as the speed increases and is again directly proportionate to the mileage run.

There are two kinds of pneumatic tires in general use: the "fabric" tire and the "cord" tire. The "cord" type is the best. The initial cost may be greater, but there is a saving in the long run.

The non-skid tire should be selected for rear wheels. This extra cost is well worth the difference, as the extra wear from the extra amount of rubber, to say nothing of the non-skid feature, is worth a great deal.

Small, light tires spell constant trouble, not to mention short life. Be sure the car is equipped with tires of ample size to sustain the weight and speed; also determine if the size of tire is a standard size, and if it can be obtained readily. Many of the former sizes have been discontinued (see page 594 for standard sizes).

Also determine if the rim is a popular type. The "straight-side," quick-detachable, demountable rim is the rim now used most. One should always carry a tire inflated on a spare rim to replace a damaged tire. It can be mounted on the rim of the wheel by loosening a few bolts and without having to use an air pump at all. There is also an advantage in having the tires the same size on all four wheels.

Which is the best car to buy? This is a question we hear daily. After determining the size of car you want, I will tell you how I would settle the choice, if I were unable to decide otherwise. Go to a used car concern and ascertain which car brings the best price or what make of car sells more readily than others. This may help to answer this question.

Selecting a Commercial Car

There is a distinction between a truck and a delivery wagon. Some of the important points to be decided are:

What type of car is required for your particular needs—gas or electric?

What horsepower?

How many pounds capacity shall it have?

Should several cars be used, or one big one?

Will the use of trailers result in economy?

Shall it be equipped with pneumatic or solid tires?

Can an inexperienced man be given charge of the running and repair work?

Is there any special equipment necessary for greater efficiency?

Should the car always be loaded to capacity?

Should the truck have a long or short wheel base?

Today there are motor trucks and delivery wagons of every conceivable size and design. Therefore, it is the problem of the prospective purchaser to choose carefully the kind of a car

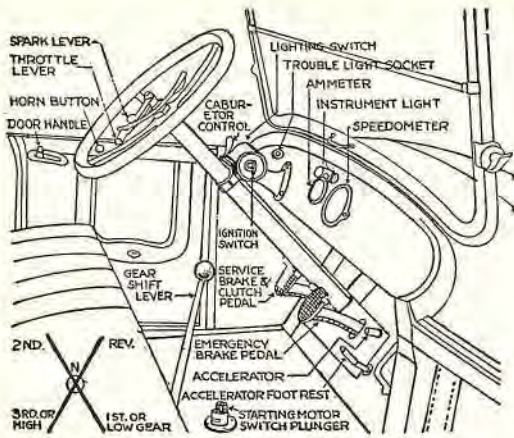


Fig. 28. Reo models "T6" and "U6." Note that the combination switch for the ignition, lighting, and carburetor control is mounted under the steering wheel. The carburetor control, when moved towards "Start," enriches the mixture by lifting the nozzle needle of the carburetor. The model "LL3P" Rayfield carburetor is used.

The North East model "L," third-brush regulated generator is used, as also the North East ignition unit. Spark-plug gaps are set at .030", and the firing order is 1, 4, 2, 6, 3, 5.

The clutch pedal operates the external brakes on the brake drum on the rear wheels, and the emergency (foot brake) pedal (right) operates the internal brakes in the brake drums on the rear wheels.

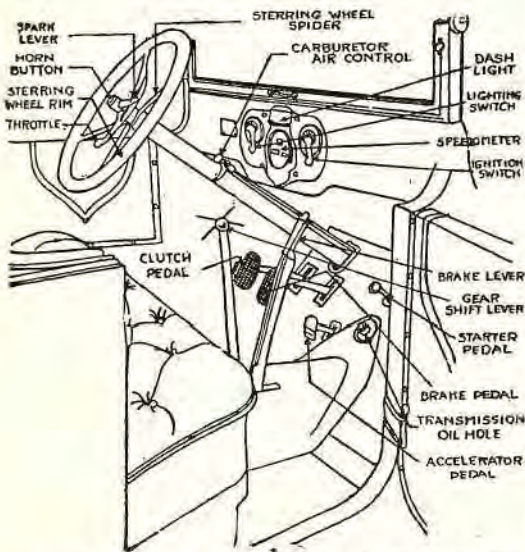


Fig. 29. Hupmobile instrument board and gear shift. Firing order, 1, 2, 4, 3. Gear shift is the S. A. E. standard three-speed gear shift.

As an example of the information concerning a car, which can be obtained from the "Specifications of Leading Cars" (see Index), the data (below) concerning the Hupmobile are taken from same as follows:

Model, R; wheelbase, 112"; engine make, own; cylinders, 4; bore, $3\frac{1}{2}$ "; stroke, $5\frac{1}{2}$ "; piston displacement, 182.5; cylinder shape, L; cylinder head, detachable; cylinder cast, in block; cam-shaft drive, chain; cooling, thermo-syphon; lubrication, force through hollow crank shaft; oil pump, gear; carburetor make, Stromberg; ignition, Atwater Kent; electrical system, Westinghouse; rear axle, own; rear axle type, three-quarter floating; steering-gear make, Jacox; hand brake, internal on rear wheel; foot brake, external on rear wheel; rear-axle bearings, roller; front-wheel bearings, roller.

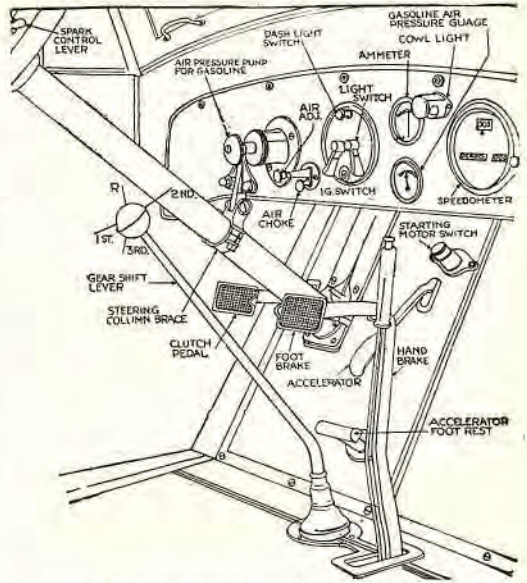


Fig. 30. H. C. S. series 2 and 3 instrument board and gear shift. The spark-control lever is the one on the outside of the sector of the steering wheel. Firing order is 1, 3, 4, 2.

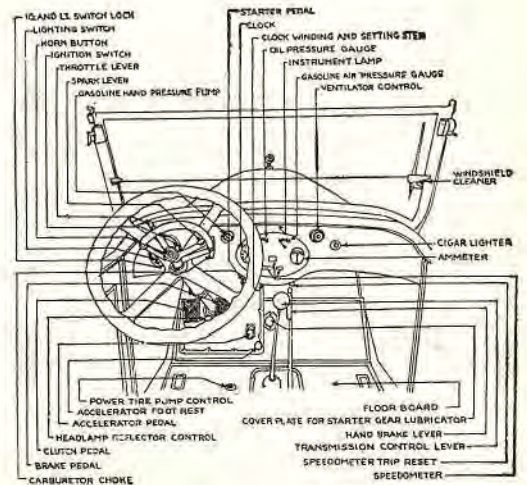


Fig. 31. LaFayette instrument board and control members. Gear shifts are as follows: for 1st gear, lever is moved to the left and to the rear; for 2d gear, right side forward; for 3d or high gear, right side, rear; for reverse gear, left side, forward.

The number of teeth in the differential ring gear and the drive pinion is represented by either of the following combinations which would give a rear-axle ratio as below:

54-11	4.9 to 1
55-12	4.58 to 1
54-13	4.15 to 1

Note that the 54 is the number of teeth in the master or differential ring gear, and that 11 is the number of teeth in the drive pinion. To find the rear-axle ratio, divide $54 \div 11 = 4.9$. Therefore the drive pinion or propeller shaft would revolve 4.9 times to 1 of the rear wheels or axle shafts.

Engine: Bore, $3\frac{1}{4}$ "; stroke, $5\frac{1}{2}$ "; S.A.E. h.p. rating, 33.8; actual h.p. developed, in excess of 100; valve lift, $\frac{3}{8}$ "; valve diameter, $1\frac{1}{4}$ "; valve-stem diameter, $5/16$ "; valve-seat angle, 45° ; carburetor, 2"; piston displacement, 348 cubic inches; angle between cylinders, 90° ; firing order, 1, 4, 2, 6, 8; 1, 7, 3, 5.

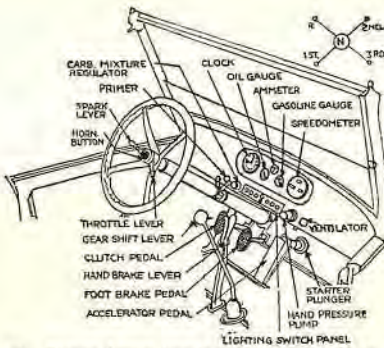


Fig. 22. Pierce-Arrow "series 32," 1921. Note the short spark and the throttle levers on the steering wheel. See Index for the rear-axle ratio of Pierce-Arrow "series 32" car. Three forward speeds and one reverse are used on this car. Radiator capacity is $7\frac{1}{2}$ gallons; gasoline tank, 26 gallons; engine oil in crank case, 18 pints. To start the Pierce-Arrow engine:

1. Be sure the gear-shift lever is in neutral.
2. Insert the switch key and turn one complete turn to the left. Pull out the ignition button stamped "Double."
3. Advance the throttle (right) lever $1\frac{1}{2}$ ".
4. Advance the spark lever about halfway on the quadrant for starting and about two-thirds when driving under normal conditions or up to 50 m.p.h.
5. Prime the engine by pulling out for an instant on the priming button.
6. Press firmly on the starting plunger and release as soon as the engine starts under its own power.
7. Close the throttle until the engine runs slowly.
8. If necessary, move the dash carburetor regulator until the engine runs evenly without missing, by turning to the left.
9. Allow the engine to run a few minutes until it warms up. It will run a great deal smoother and pull better when it starts to move the car.
10. When the engine is thoroughly warmed up, turn the dash carburetor regulator back to normal (center) position. Firing order, 1, 5, 3, 6, 2, 4.

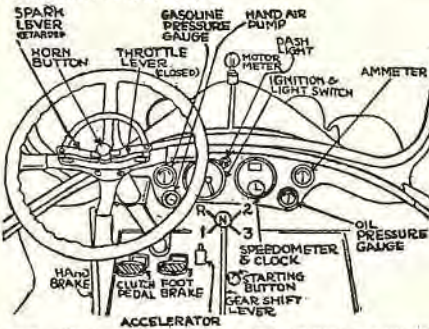


Fig. 23. Packard Twin-Six, models "3-25" and "3-35," instrument board and controls and gear changes.

Packard eight uses the same gear shift, which is the standard S. A. E. three-speed gear shift.

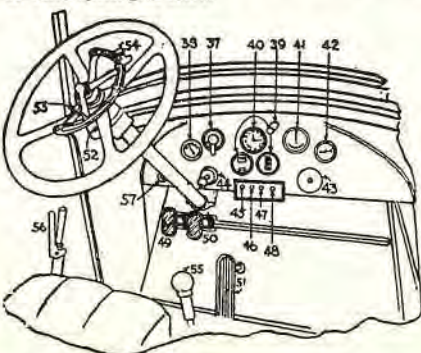


Fig. 24. The Locomobile instruments and control members: (37) ignition switch; (38) gasoline pressure gauge; (39) dash light; (40) speedometer and clock; (41) voltmeter; (42) oil

gauge; (43) locking switch; (44) hand-pressure pump; (45) starting button; (46) panel-light button; (47) side and tail-light button; (48) head, tail-light button; (49) clutch pedal; (50) brake pedal; (51) accelerator pedal; (52) carburetor adjustment; (53) throttle lever; (54) spark advance lever; (55) gear-shift lever; (56) hand-brake lever; (57) dimming button.

Locomobile 48, series seven, rear-axle ratio is 3.85 to 1. Transmission gear ratio is as follows:

1st speed	15.40 to 1
2d speed	7.39 to 1
3d speed	5.38 to 1
4th speed (direct)	3.85 to 1
Reverse	21.75 to 1

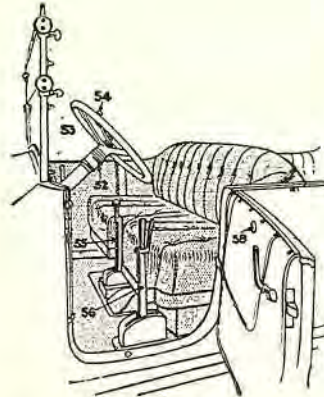


Fig. 25

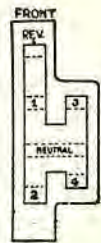


Fig. 26

Fig. 25. Locomobile operating levers.

Fig. 26 shows the four-speed "gate" type of selector, giving the movements of the lever for 1st, 2d, 3d, 4th, and reverse. See Fig. 17, page 100, for the Locomobile steering device. See page 70 for Locomobile valve timing. Firing order, 1, 5, 3, 6, 2, 4.

Flint model 6E is standard S. A. E. gear shift.

Durant 4 is standard S. A. E. gear shift.

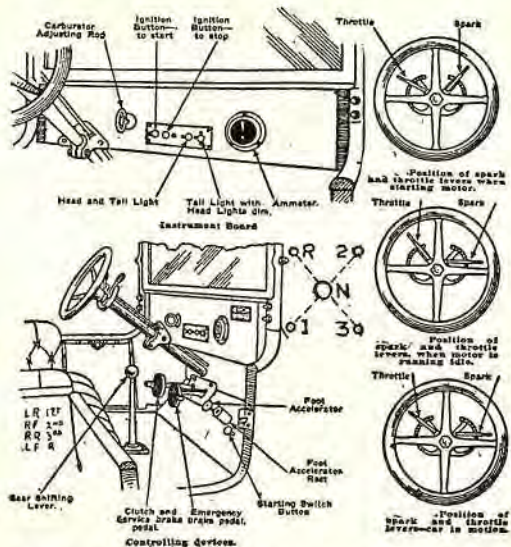


Fig. 27. Chevrolet "490." Firing order, 1, 2, 4, 3. The gear shift is shown.

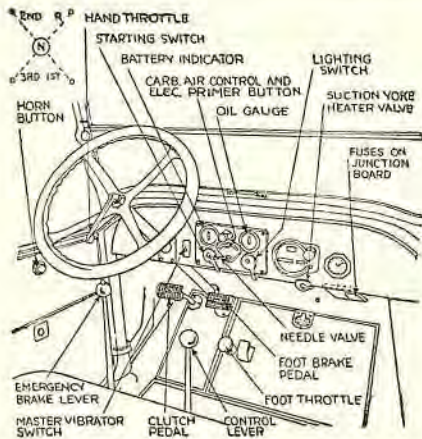


Fig. 17. Franklin series "9-B." Gear-shift movement is shown. Firing order is 1, 4, 2, 6, 3, 5. Franklin series "10" car employs the S. A. E. standard gear shift (pages 27, 29).

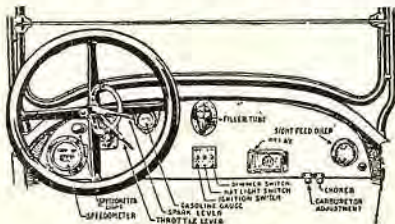


Fig. 18. Briscoe.

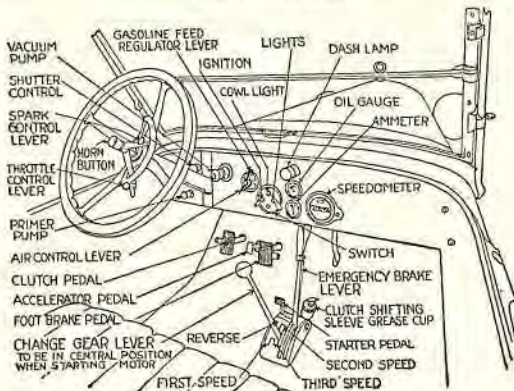


Fig. 19. Hudson model "O." To start the Hudson engine: Place the spark lever near the top; open the throttle slightly; place the gasoline feed-regulator lever a little to left of center position; when the engine is cold unlock the primer pump by turning knob until it releases. Give the plunger two slow strokes. Look again by turning the knob until the pin lines up with the slot. Then press in and give a quarter-turn. Notice that the primer must always be locked when driving; turn on the ignition switch; press the starting pedal and release it when the engine starts.

If the engine does not start immediately, turn the air control lever, or choke to the right for a few revolutions, and then let it go back again. Firing order, 1, 5, 3, 6, 2, 4.

Ammeter: Shows whether the storage battery is discharging or being charged by the generator. It should always show charge when the car is traveling over 10 m.p.h. with the lights out. See page 397 for wiring diagram.

Oil-pressure gauge: Simply an indication as to whether the oil pump is delivering oil or not. It should always show pressure when the engine is running. It does NOT register the quantity of oil being delivered to the motor. That is governed by an adjustment of the pump itself. See page 163.

Carburetor control: The upper lever adjusts the amount of fuel allowed to enter the motor. The lower one is a choke to facilitate starting in cold weather or when the motor has been idle for some time. See pages 136, 137 for Hudson carburetor.

Vacuum pump: Used for filling the vacuum tank (see (14), Fig. 1, page 113) when it has become emptied. Ordinarily the motor supplies the vacuum necessary to deliver the fuel.

Spark lever: Controls the distributor and spark timing. The distributor is controlled by an automatic adjusting mechanism, but to obtain all-around efficiency, the spark must also be controlled manually to a certain extent. If the engine shows a tendency to knock on a heavy pull, gradually retard the spark until the knock ceases. It is a good rule always to carry the spark advanced as far as possible without the engine exhibiting any tendency to knock. See page 397 for electrical wiring diagram.

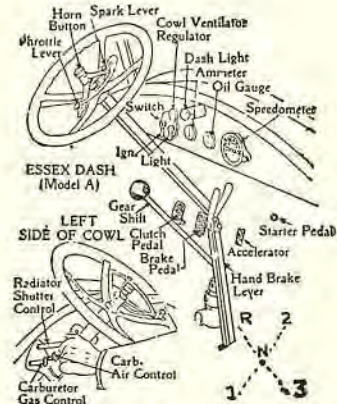


Fig. 20. Essex model "A." Firing order, 1, 3, 4, 2.

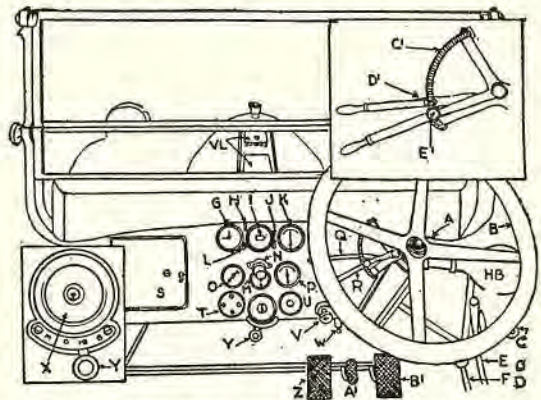


Fig. 21. Pierce-Arrow dash and control units (1918-19 model): (A) gasoline regulator on column; (A1) accelerator pedal; (B) steering wheel; (B1) brake pedal; (C) dimmer button; (D) Klaxon horn button; (E) hand-brake lever; (F) gear-shifting lever (see page 27); (G) clock; (H) handle to operate ventilator (VL) on hood; (I) autometer or odometer; (J) knob for setting tenths of a mile; (K) speedometer; (L) knob for setting odometer trip figure back to zero; (M) gasoline gauge; (N) dash lamp; (O) oil gauge; (P) ammeter; (Q) spark lever (see top illustration); (R) throttle lever; (S) left-hand dash cabinet door; (T) lighting switch; (U) starting button; (V) hand-pressure pump handle (arrow pointing to the right for "off" position; arrow pointing to the left for "vent" position); (W) plunger for priming; (X) starting switch (lock above); (Y) starting-switch handle; (Z) clutch pedal.

On some of the Pierce-Arrow models of cars as shown above, the switches (X) and (Y) are two lever switches: ignition and lights, with starting button (U) mounted above the two levers and a Klaxon horn button in the top of the steering column. Note that on this model and on prior models of the Pierce-Arrow car, the throttle and spark levers are placed under the steering wheel. See page 27 for the four-speed gear shift of this model.

Pierce-Arrow 38 and 48 h.p. cars each have four speeds forward, and one reverse; direct on fourth. The rear-axle gear ratio on the 38 h.p. is 3.78 to 1, and 3.53 to 1 on the 48 h.p.

	38 h.p.	48 h.p.
1st speed (trans ratio)	3.88 to 1	4.1 to 1
2d speed (trans ratio)	2.22 to 1	2.15 to 1
3d speed (trans ratio)	1.65 to 1	1.65 to 1
4th speed (trans ratio)	direct	direct
Reverse (trans ratio)	4.66 to 1	4.93 to 1

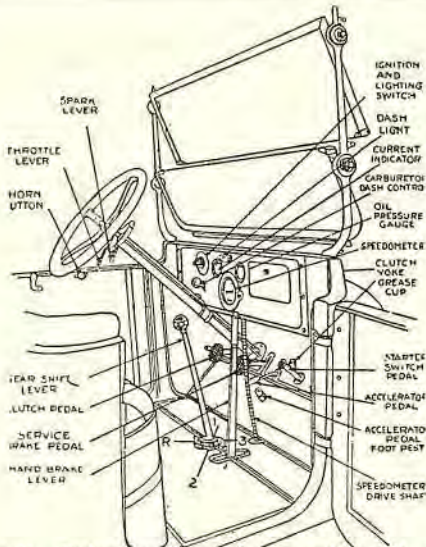


Fig. 11. Dodge Bros. (4-cylinder car, early model). Gear-shift movement is shown on floor board. Later models use the standard S.A.E. gear shift.

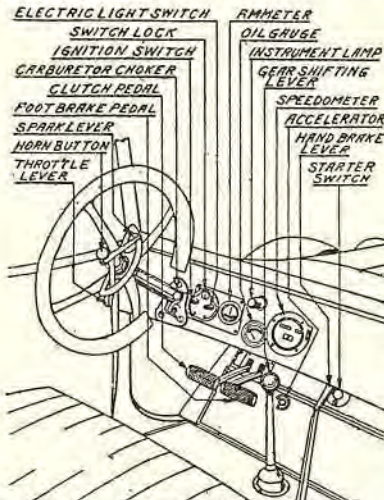


Fig. 12. Oakland model "34B." The gear-shift movement is standard S. A. E. three-speed, as shown in Figs. 14 and 15. Firing order, 1, 5, 3, 6, 2, 4.

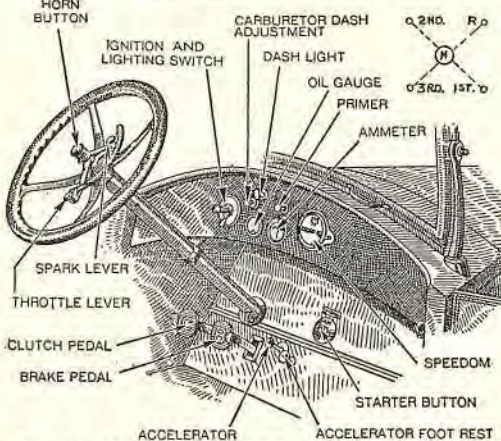


Fig. 13. Mitchell model "F." Gear-shift movement is shown at top. Firing order is 1, 5, 3, 6, 2, 4.

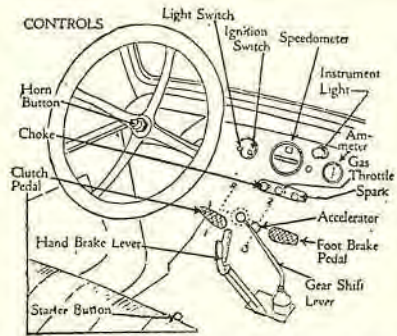


Fig. 14. Overland "4." Note that the spark and throttle control is on the cowl board. Firing order, 1, 3, 4, 2. Gear-shift movement is shown.

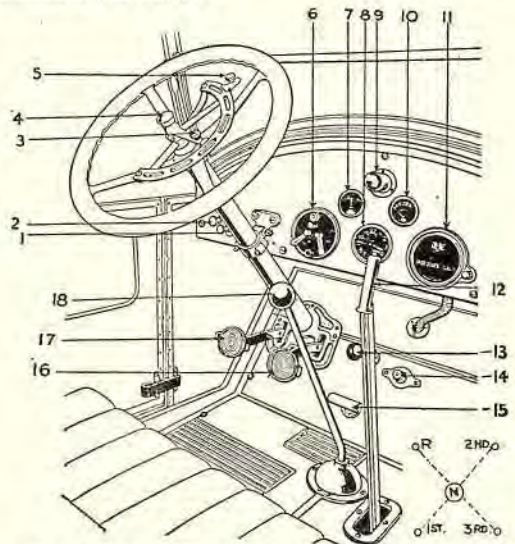


Fig. 15. Cole model "870." Gear-shift movement is shown. Firing order is 1-8, 3-6, 4-5, 2-7. Parts: 1, carburetor choke button; 2, carburetor adjusting button; 3, spark lever; 4, horn button; 5, throttle; 6, ignition switch; 7, ammeter; 8, clock; 9, cowl light; 10, oil gauge; 11, speedometer and odometer; 12, hand-brake lever; 13, accelerator; 14, starting-motor switch; 15, accelerator heel rest; 16, foot-brake pedal; 17, clutch pedal; 18, gear-shift lever.

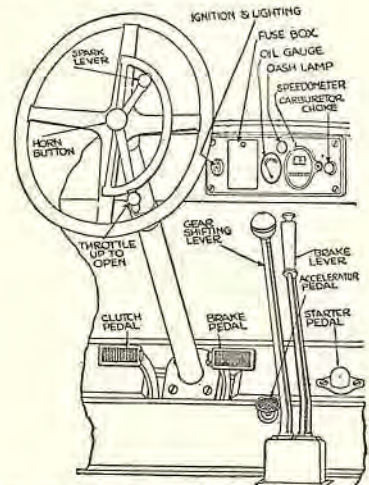


Fig. 16. The Chandler uses the S. A. E. standard three-speed gear shift (see pages 27, 29).

On steep hills, when descending, the engine can be used in assisting to hold back the car by leaving the clutch engaged and the transmission gears in first or second speed, as the resistance offered by the compression in the engine will make it unnecessary to apply the brakes so hard, thus assisting in preventing their becoming overheated.

When operating the car in the above manner, or when coasting, keep the throttle closed but do not turn off the ignition switch as a certain amount of unburned gas might accumulate in the exhaust pipe and muffler and there would be danger of this gas igniting and bursting the muffler when the ignition switch is again turned on.

When the Car Skids

Although the driver feels helpless at first, a little experience will soon give him confidence. Most skids can be corrected by the manipulation of the steering and brakes. An expert driver can keep his car straight under almost any conditions, but it is impossible to explain just how he does it. Usually the rear end skids first, and in the right-hand direction, this being caused by the crown of the road.

INSTRUMENTS, CONTROL LEVERS, PEDALS, AND GEAR SHIFTS OF SOME OF THE PASSENGER CARS

The following illustrations show the hand levers, foot pedals, dash or cowl with instruments, and also the gear-shift movements of some of the leading cars.

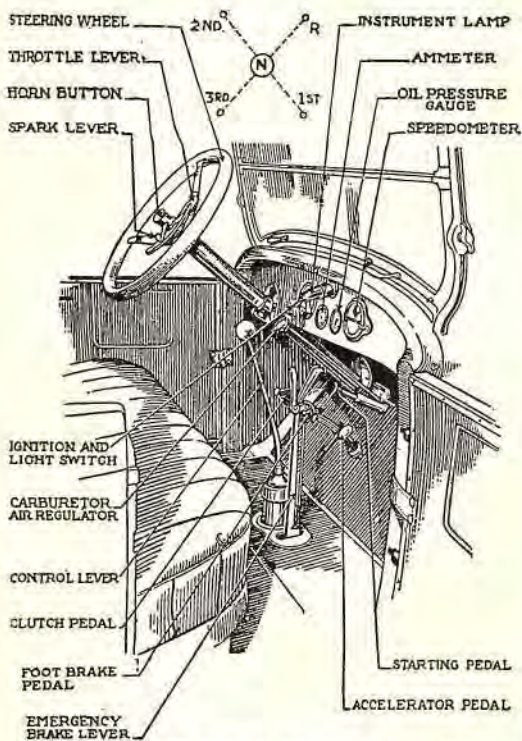


Fig. 9. Buick, 1921, 1922, six-cylinder car. Gear-shift movement is shown at top of illustration. Firing order of engine is 1, 4, 2, 6, 3, 5. (S.A.E. standard gear shift used beginning with 1928 cars.)

The purpose of these illustrations is to familiarize the reader with the gear-shift movements and the location and purpose of the control members.

Under such conditions, the skidding action will be aggravated if the brakes are applied, and the car may be ditched or continue to skid until it hits the curb.

In an emergency of this kind the correct action is to let up on the accelerator pedal to shut off the power, but not entirely so, or it will have the same effect as putting on the brake. If the car seems to right itself, the power may be applied gradually, and it will be advisable to steer for the center of the road again. However, if the car continues to skid sideways, steer for the center of the road, applying the power gently. This will aggravate the skid for the moment, but will leave you with the front wheels in the center of the road and the car pointing at an angle. By so doing, you can mount to the crown of the road again, and the momentum of the car will take the rear wheels out of the ditch on the right-hand side. It is customary to advise turning the front wheels in the direction in which the car is skidding, in order to correct the action, but this can hardly be said to be true in all cases. It holds good where there is unlimited side room, but usually the car hits the curb, or is in the ditch, before you can straighten it out with the steering wheel.

Most cars now use the "ball-and socket type of gear-shift" lever.

The "gear-shift movement," or the direction in which to move the gear-shift lever to obtain various speeds, is shown in each illustration.

Most of the gear shift movements are, what is termed the S. A. E. standard gear-shift movement as described on page 27 and illustrated in Figs. 19 and 22, page 29 and Fig. 10 below. Some are different, as, for example, the Buick (Fig. 9) and Dodge (Fig. 11). Very near all cars use the "ball and socket" type of gear shift lever (page 27).

The make of electric system used on these cars, as well as on other makes of cars, can be found by referring to the Index for "Specifications of cars."

The make of carburetor, steering device, rear axle, engine, etc., can also be found in these specifications.

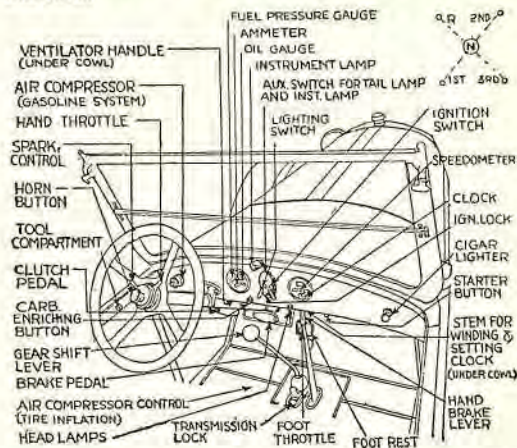


Fig. 10. Cadillac type "61." Note the short spark and throttle levers, and also that the fuel pressure gauge, the ammeter, and the oil gauge are in one unit on the cowl.

Gear-shift movements are shown at top to the right above. The firing order of types "51 to 61" engine is shown on page 84 and type "V-63" on page 1051.

When reversing, remember to bring the rear wheels to a dead stop before letting the clutch in. Complete familiarity with the motions of going from one speed to another and back again should also be acquired before attempting to run on the open road.

Learn to drive by throttling the engine, instead of constantly throwing the clutch out. The average driver uses the clutch about twice as much as he should.

Instructions on Steering a Car

Steering is largely a matter of practice.

The positions to assume in steering or driving a car are shown in Fig. 8 (2), (3), (4), and (10). A very slight movement of the steering wheel or lever is sufficient to turn the car, and too sudden a turn may cause an upset.



Fig. 8. Correct and incorrect positions in driving: (1) fierce grip, a bad method; (2) correct hold for forward movement; (3) finish of forward movement; (4) alternative grip suitable for many gears; (5) awkward hold of wheel; (6) proper and comfortable hold; (7) wrong foot position; (8) nervous, uncomfortable position; (9) careless, lounging position; (10) correct "seat." (*Popular Mechanics*.)

When learning to drive a car, it is a good plan to select a straight road, as wide as possible, and with the engine running slowly, throw in the low speed. The car will move forward slowly, and it will then be necessary to steer. The first inclination will be to grip the wheel as tightly as possible, but after a little running a light grip will be found sufficient. At this stage it is necessary to learn self-control first, and not to get "rattled."

If the car begins to run off the road, or into an obstruction, throw out the clutch and apply the foot brake, so that it comes to a standstill. When the excitement has died down, try again, and it will not be long before steering comes easily.

There is no time lost between the turning of the steering wheel and the turning of the car; when taking a corner do not move the wheel until the car is at the point where turning is necessary.

How to Use the Brakes

When the brakes are suddenly applied with full force to the wheels of a car speeding along at the rate of, say, thirty miles an hour, the braking action will be so powerful as immediately to stop the rotation of the driving wheels—but the car will not come to an immediate standstill; its momentum will send it forward, and the locked rear wheels will slide over the ground with most destructive effect on the tires.

When you consider that in railroad practice the so-called "flat wheel" is produced by too sudden braking, you will be able to appreciate the effect which a similar practice must have on the soft rubber tires of an automobile.

Bear in mind, therefore, that the best method of using the brakes is that which applies pressure on

them so gradually that the forward movement of the car and the rotation of the wheels come to a stop together.

Nothing is more severe on a car than the spectacular stopping often indulged in by ignorant drivers, in an effort to "show off."

The careful driver shuts his power off before he reaches the stopping point and permits the car to carry him along on its momentum, bringing it, with a gradual application of the brakes, to a halt at the exact spot.

In order to slow down gradually, as when approaching a crossing, close the throttle and apply the foot brake without disengaging the clutch. It is more economical to wear out the brakes than to wear out the clutch. It is of course necessary to disengage the clutch when making a complete stop.

Whenever it becomes necessary to slow down quickly, release the clutch first; that alone will have an immediate slowing-down effect on the movement of the car, because it disconnects the power. If additional checking is needed, apply the foot brake, or, for a quick stop, the foot and hand brakes together. To make it plain, the clutch pedal goes down first, the brake pedal next.

If a full stop is not desired, assuming that the emergency has passed, release the brake pedal first, then let the clutch pedal come up. If you did the reverse, the engine would be compelled to pull against the brake, with a consequent rapid wearing down of the brake lining. (See also "Brake adjustments," under the discussion of the repair subject.)

No motorist is qualified to give his car the best care until he has mastered the control of the gears and of the brakes.

Slipping brakes are usually caused by oil working out the rear axle on to the brake lining.

If a grade is long and steep, use the foot and hand brakes alternately. This equalizes the wear on them, and also gives them a chance to cool.

If the Brakes Fail

If the engine stops while descending a hill, the brakes should be thrown on at once to keep the car under control. If poor adjustment of the brakes renders them insufficient for this, then place the gears in low speed. This will tend to check the car. It is then a matter of steering the car to the best advantage.

If, when ascending a hill, the engine stops and the brakes fail, try putting the gears in reverse. This will then turn the engine in the right direction, and ought to start it. It may be possible to steer it—owing to its extremely slow speed—off the road into a bank or other obstruction that will stop the car without much damage to it or to its occupants.

Situations such as these require a cool head and a steady hand, and the more experience in operating that the driver has, the greater are the chances for handling it in the right way.

Stopping a car on an up-grade and starting again requires skill, for the brakes must be withdrawn and the clutch let in at the same instant with one movement.

On a long descent, when you find it necessary to use the brakes constantly, apply the hand and foot brakes alternately, to avoid burning out the brake linings.

there are usually gaskets. During the first few days of service a gasket may become slightly compressed, thus loosening the crank case to oil-pan bolts. Consequently it will pay to go over the nuts on the bottom of the oil pan with a wrench and tighten them up. Drive a few days, and try them again. Continue to do this until the gasket has become fully compressed and the parts have settled into permanent working position. If you will take this precaution, the joint will be absolutely tight and you will never have any trouble, such as loss of oil or water, and dirt being washed into the oil pan and then circulating with the oil through the bearings, causing excessive wear and cutting.

At first, it will be well occasionally to go over all of the bolts that hold the engine to the frame, and see that they are kept tight. If you find them perfectly tight after inspecting them two or three times, you need never fear that they will loosen up.

It is advisable to put a wrench to all nuts on different parts of the car and make sure that they are perfectly tight after it has been driven a hundred miles or so. When they have once been screwed up as tightly as possible and the car has been thoroughly "run in," there will not be so much danger of loosening up and causing damage.

Spring clips will loosen if the nuts on the clips are not tightened occasionally. It is very important to tighten these nuts often.

Fender bolts also demand attention.

The universal joints should be kept well supplied with grease.

Lubrication of a new car. It is needless to remark that lubrication is one of the most important things to look after on a new car. All parts should be thoroughly lubricated and greased as directions provide. Follow the lines there suggested. In the absence of directions from the maker, study the lubrication subject carefully.

Remember one thing: cheap oil will cost ten times more, maybe a hundred times more in the long run, in the way of repairs. The best oil is none too good.

Also remember that oil should be changed in the engine often, for reasons stated on page 167. Just how often to change will be determined by the amount of gasoline in the oil, which one should take particular note of, when changing.

"Running in" a New Engine

"Running in" a new engine is a very important factor in the life of a car. More harm can be done during the first few days than one can imagine—if care is not exercised. For an explanation of this, read pages 171, 167, relative to the importance of lubrication and slow running for the first 500 or 1,000 miles, in order to work the pistons properly to a smooth fit to the cylinders, and so as to avoid cutting or scoring the cylinders. See also Index under "Reaming cylinder."

Don't race an engine: Never open the throttle suddenly, or leave it open very far, when the car is standing and the engine is running idle. This is known as racing the engine, and there is nothing more injurious, especially when the engine is cold. More engines have been ruined by racing while idle than have been worn out in actual driving under load.

When the engine stands over night, don't immediately race the engine to warm it up, because the oil has drained from the bearings, the cylinder walls, etc. Consequently it is going to take a few minutes to lubricate these parts properly. Therefore first let it run slowly for a minute or so.

Hill Climbing

Until you have become thoroughly familiar with the operation of the car, and have mastered the things necessary to make a good driver, do not attempt to climb "on high" every hill you see, just because your neighbor possibly has said that his car would do it. There can be nothing more detrimental to the engine and driving parts than to try climbing everything on "high."

The first and second-speed gears are placed in the car for a purpose, and if the hill that you are approaching is at all steep, shift into "second" a little before you are really on the hill. Do not try to go into "second," however, at any time unless the speed of your car has been reduced to the pace at which the second speed would carry you if it had already been changed. Many accidents, and serious ones, have resulted from a driver attempting to rush a hill "on high," getting half-way up, and having the speed of the engine so reduced that when he came to shift into low it was too late; the engine would not then accelerate sufficiently to carry the car up on low, and possibly the brakes were not working just as they should, the result being that the car would back down the hill faster and faster, until it finally landed in the ditch. Backing down hill with brakes is a task for a skillful and experienced driver, and even he cannot guarantee a good job. It is a most confusing situation and requires the instant exercise of good judgment.

The secret of successful hill climbing is to keep your engine running a little faster at all times than its work requires it to run, i.e., to keep it "ahead" of its work, so that it is ready for extra duty without stalling at the critical moment. The foregoing does not mean that many hills cannot be climbed "on high," but it is best not to try until you are sure of yourself and of your ability to get into second, or even first if necessary, half-way up the hill, and also to determine from the sound of the engine whether it is "working hard." If you must go into a lower gear on a hill, shift with a quick, firm movement, and take care not to let the momentum of your car be reduced any more than is absolutely necessary. Every second that you have the clutch disengaged on a hill for gear shifting, counts, as the car slows down at a very surprising rate.

If, on climbing a hill on "third," the engine has been stalled before reaching the top, it may require considerable skill to start from your standing position on the incline. Immediately upon finding yourself in such a predicament, apply the hand brake with all your strength, and be sure that the brake ratchet catches; then throw the gear-shifting lever into neutral. After starting the engine again, push out the clutch (leave the hand brake still on), push the gear lever into first speed, and slightly race the engine (the only condition under which it is permissible, excepting when in a mud hole or the like); then take hold of the hand brake and keep the engine speeded until the brake has been entirely released, the clutch entirely engaged, and a safe start has once more been made up the hill. Experience is the best possible teacher where there is a considerable amount of hill work to do.

Importance of the Clutch

The clutch of an automobile is a device by means of which the power of the engine and the driving mechanism may be connected or disconnected at the will of the driver. This particular part is probably used more than any other part of the car, and a careful study of its purpose and principle is advised. Though the device is simple and its use plain at first glance, the clutch, nevertheless, lends itself to a number of skillful uses in the hands of the experienced driver. Remember always to "throw out" the clutch before changing gears.

When the clutch is "let in," or engaged, this should at all times be done smoothly and so gradually that the motion of the engine shaft is transmitted to the drive shaft without jarring.

A suddenly let-in clutch will do one of two things: it will either rack the mechanism of the entire car, or stall the engine. With a little practice the left foot may be schooled to let the clutch in quickly, yet gently and smoothly.

When you meet a stretch of road covered with sharp, broken stones, it is an excellent plan to speed your car a little before you reach the stones and then disengage your clutch, permitting your car to coast over the bad spot. By shutting off the driving power you protect your tires against a very destructive action, termed the "traction," which otherwise would be set up between the sharp stones and the tires.

To stop the engine, turn the ignition switch off. Before doing so, however, it is good practice to move the spark lever to the starting position and set the hand brake before leaving the car.

Lock the ignition switch when leaving the car standing alone. Never leave the car with the engine running, as this is a useless waste of gasoline, and there is always a chance that someone may throw the gears into mesh.

Reversing

To reverse the motion of the car, it is first necessary to stop the car. Never attempt to shift into "reverse" gear when the car is in motion. With clutch disengaged, move the shifting lever to left and forward, and then gradually engage the clutch and accelerate the engine as before. One rule that the driver must always remember is that the clutch must be disengaged whenever gears are shifted.

Starting Car on a Grade

To start a car when on a grade, start the engine as before; then release the hand brake and hold the car with the foot brake while shifting gears. Now accelerate the engine with the hand throttle while gradually releasing pressure on both pedals together. It takes practice in operating the clutch and brake pedals to make the one take hold while releasing the other without "stalling" the engine.

Shifting from a High to a Lower Gear after Car Is Under Way

Shifting down is the term used when a car is running on high gear and it is desirable or necessary to shift to a lower gear.

Shifting from third or high to second: To shift from "third" or "high," to "second" gear, disengage the clutch; accelerate the engine to approximately twice the revolutions at which the engine was turning over previous to shifting gears; then push the lever to "second" gear position and re-engage the clutch.

"Low" or "first" gear is ordinarily used only in starting, but in exceptional cases of very heavy pulls, it will be better to shift back to "first" gear, which is done in a similar manner as the shift from "third" to "second." In coming to a bad piece of road, full of ruts, bumps, or holes, it is best to shift immediately into "second," or "first" if necessary. Thus, you have much better control of the car and can pick up more readily. When using lower speeds you can control the car almost entirely with the accelerator, letting yourself down easily into holes and over bumps without having to slip the clutch.

When passing through traffic, it is sometimes desirable to change to a lower gear on level ground without slowing down the car. To attempt this by de-clutching and putting the lever directly into the lower speed notch—in the same way that this is done while ascending a hill—would be to invite a very noisy clash of the gears.

Instead of this, the change is made in three progressive steps, as shown in Fig. 7, and the speed of the car is not reduced to any appreciable degree.

The first movement shown at (A) in the illustration (Fig. 7) is to disengage the clutch and shift the gear-shift lever forward from high to neutral (center position as shown in the dotted lines). This leaves the car coasting with the engine running.

The clutch is now let in, and the levers are in the position shown at (B). Now this is the point at which skill is required, and where practice is necessary.

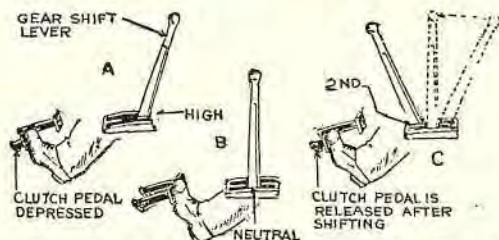


Fig. 7. Example of shifting from high to second gear while the car is in motion: (A) clutch out and gear-shift lever brought to neutral; (B), gear-shift lever in neutral position; (C), clutch out and gear-shift lever pushed forward to second; clutch is then released.

The engine is speeded up until it is turning over at the same rate of speed as it would be were the low speed engaged. It will take a little practice to accustom the ear to judge by the sound of the engine whether it is turning over at the correct speed or not.

After the engine is speeded up to the proper degree, the clutch pedal is depressed, and the change gear lever brought into second speed gear as at (C). The same method will apply in going from second to first.

Changing from higher to lower speed on a grade: When the car is facing upwards, it is a little more difficult to be able to judge when the speed is sufficiently great to justify a change from first to second speed. The hill may be of such slope that it is an easy matter for the car to take it on high in ordinary running, but may still be so steep that the pause in the gear-shifting act is sufficient to cause the speed to drop considerably. In a case of this kind the driver should be able to judge at just what speed he should throw out his clutch and make the change. The steeper the hill, the greater will be the speed required before the change can safely be made.

Trouble in dropping to lower speed on a hill can be averted if the critical moment at which to make the change is learned. If the driver waits too long, he may "kill the engine," and sometimes place himself in a very serious position.

If he tries to make the change too soon, he will clash gears.

By changing at the critical moment, however, an easy, quick change can be made.

"Running in" a New Car

When setting up and starting any new piece of complicated machinery, you would ordinarily expect to watch it pretty closely, and go a little easy with it until its various bearings, parts, etc., had become thoroughly "worked in." An automobile is no exception to the rule. While every bolt and nut in the automobile is drawn tight, and secured with either cotter pins or lock washers when the car leaves the factory, nevertheless it is advisable to go over a few of the more important points and make sure that everything is in perfect shape.

The following points should receive your special attention during the time that the car is being driven the first few hundred miles:

Between the upper crank case and the oil pan, or between the cylinder heads and the cylinder block,

is obliged to overcome the pressure of the expanded gases of the exploded charge before it can commence on its power-delivering stroke.

Furthermore, when the spark is advanced too far, a slight pounding noise in the engine is the result. This pounding is sometimes not noticed by the beginner, as it usually is but slight, owing to the substantial construction of the crank shaft, and by the uninitiated it is often accepted as permissible.

Advancing the spark too far is very injurious, because by it the bearings, crank shaft, and connecting rods are required to withstand strains which are greatly in excess of those produced when the ignition occurs at the proper moment.

The engine should never be allowed to run for any length of time with the spark retarded.

With a retarded spark and a late explosion, the combustion or burning of the charge of gas is not complete. This causes a great amount of carbon to be deposited on the walls of the cylinders, combustion chambers, piston heads, spark plugs, etc. It also causes the engine to heat to a much higher temperature, which causes a very severe action on the valves and valve seats. When the charge is ignited at just the right instant, the combustion is practically complete, so that when the valves open a thoroughly burned charge passes out. On the other hand, when the charge is ignited late, the charge is still burning when it passes through the valve opening and tends to heat, burn, and scale, and to cause pits on the valve and valve seats. In time, this creates a condition which prevents the valves from seating properly or fitting tightly, and therefore a loss of compression and a corresponding loss of power is the result.

Starting a Car—Shifting Gears

How to start a car: After the engine has started, be sure that the oil-pressure gauge and ammeter are indicating properly; then release the hand brake. Place the left foot on the clutch (left) pedal (see Fig. 3), and press it forward as far as it will go, thus disengaging the clutch. The engine is now running independently of the transmission, the gear-shift lever is supposed to be in "neutral" position, and the clutch is held "out" by the left foot. The next operation is to place the right hand on the gear-shift lever and to move it to the left, sidewise, and pull it back into "first" gear position.

Next, slowly release the pressure on the clutch pedal, at same time pressing easily on the accelerator pedal with the right foot, to increase the speed of the engine. As the clutch takes hold, the car will commence to move forward.

Shifting from first to second gear: When the car is moving about four to six miles an hour, the gear shift from "first" to "second" gear should be made. This is done by disengaging the clutch, as explained above, and moving the gear-shift lever forward to "neutral" position, then to right and forward again to "second speed" position. Re-engage the clutch and accelerate as before. The gears are now in "second gear" position. (See gear-shift movement of the Studebaker at the lower right-hand corner of Fig. 3. See also, page 29, Fig. 22.)

Shifting from second to third or high gear: The car should be accelerated to about eight to ten miles an hour, and the gear shift from "second" to "third" gear should be made by pulling the lever straight back, the clutch being disengaged as before. "Third" or "high" gear is used in all ordinary driving, but there are times when it is necessary to shift

to second gear: for instance, when climbing hills, or when on rough or heavy roads, or when slowing down for traffic.

To increase the speed of the car under these conditions, the butterfly throttle valve of the carburetor is opened gradually, by means of the accelerator, and the spark lever should also be advanced as the speed increases.

Pointers on Shifting Gears when Starting Car

When shifting from a lower to a higher gear, as when first starting, it is important that the speed of the car be accelerated just before making the change, so that the two gears that are to be meshed together will be running at approximately the same speed. The proper handling of the clutch pedal and accelerator so as to make the motor "pick up" its load quickly, and at the same time prevent it from "racing" when the clutch is released, requires considerable practice.

In changing gears, especially when starting the car from a standstill, always let the clutch pedal come back gently, otherwise, a quick release of the foot clutch pedal will let the clutch take hold with a violent jerk.

In shifting gears from one speed to another, the motion should be made firmly and without hesitation. If the gears fail to mesh correctly the first time, release the pressure on the control lever and clutch pedal for a moment and try again. With a little practice, the various changes can be made easily and without noise.

When there is a grinding noise on shifting gears, it is usually the result of the clutch not being "thrown out" sufficiently, and the engine is thus driving the main transmission shaft. By pressing firmly on the foot clutch and quickly shifting the gears, the shift should be made without a particle of noise—providing the clutch pedal is not released until the shift is made.

If there is noise, such as a clashing of gears, with the foot clutch pedal thrown out fully, then the clutch is dragging, or the transmission main shaft bearings are worn.

Most cars use a selective type of transmission, giving three forward speeds and one reverse speed. The Locomobile uses four speeds forward and one reverse speed (Fig. 25, page 638). The Pierce-Arrow (Fig. 21, page 637) also used four forward and one reverse. The "series 32" model (Fig. 22, page 638) uses three speeds forward and one reverse.

Stopping Car and Engine

To stop the car, slow down the engine by removing the foot pressure on the accelerator pedal by pressing down on the clutch pedal with the left foot. Then disengage clutch, gradually press down on the foot-brake pedal (right pedal), so as to bring the car to a gradual stop. At the same time move the gear-shift lever to "neutral" position at which time the foot can be removed from the clutch pedal. After the car has stopped, apply the hand brake by pulling the hand-brake lever to the rear. Never leave the car standing with the hand brake released.

If the road surface is wet and slippery, a greater breaking effect may be had by pushing in on the foot-brake pedal intermittently, i.e., hold the brake pedal down for an instant only, then release and apply again. Keep doing this until the car is brought to a stop. If the brake is constantly applied, the rear wheels will be locked and traction will be lost.

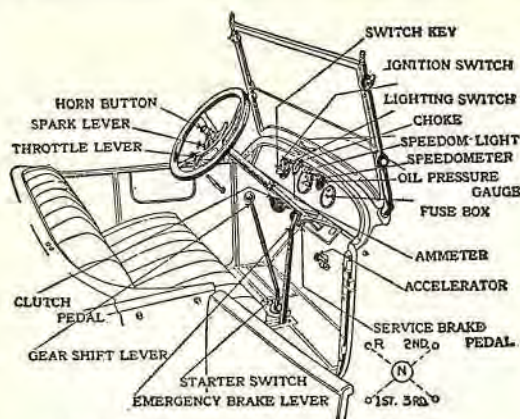


Fig. 3. Studebaker model "EJ" control levers, etc.

If an engine is equipped with a manual or hand control alone, and with no automatic advance of spark, it is best to retard the spark when starting, especially when starting the engine with the hand crank.

Position of throttle lever: Open the butterfly valve in the carburetor slightly by means of the hand-throttle lever on the steering gear sector; turn the ignition switch to the "On" position.

If the engine is cold, it will be necessary to pull out the carburetor "choke" button, located on the instrument board (Fig. 3). It may be found necessary to leave the "choke" button pulled part way out for a short time until the engine is warm. (See carburetor instructions.)

Make sure that the gear-shift lever is in "neutral" position; then press down on the starter switch. The instant the engine starts on its own power, release the starter switch. **This is important.**

After the engine starts, advance the spark lever half-way on the sector. If the engine does not start within a few seconds after you have pressed down on the starter switch, release the switch, as the continued use of the starter will discharge the battery. Investigate and find out where the fault lies, and correct it before attempting to start the engine again. (See "Digest of Troubles," page 454.)

In connection with the releasing of the starting-motor switch pedal, be sure to remove your foot from the starting switch, the moment the engine starts, and be sure that the lever springs back into its original position.

The time required for the operation varies from one half-second under good conditions when the engine is warm, to from five to ten seconds for cold weather starting. If the engine does not start within the period mentioned, release the starting switch, since you will know that something is out of adjustment and that you are throwing an undue strain on the battery. (For a full explanation of this operation and the proper care, see the starting-motor instructions, referring to the type of motor system with which cars are equipped.)

Cranking the engine by hand: If, for any reason, the driver wishes to crank the engine by hand, the adjustment for starting should be the same as for operation of an electric starter except that the spark should be retarded. When cranking by hand, be sure to make the crank engage at the point with the handle nearest the ground. Then it should be pulled up clockwise with a short, snappy pull.

While on this subject, an explanation should be given of the proper method of cranking an engine, as illustrated in Figs. 4, 5, and 6. The reason for the necessity of starting a gasoline engine, either by cranking by an electric motor, or by hand, is explained on page 31.



Fig. 4



Fig. 5



Fig. 6

Fig. 4 shows the proper method of grasping a starting crank.

Fig. 5 shows the direction as indicated by the arrow point, in which to pull up on the crank with a quick, snappy pull, in order to spin the engine crank shaft. With the crank grasped as shown in Fig. 4, and the "pull-up" made as in Fig. 5, there is no chance for a back-fire of the engine to cause a kick-back.

In Fig. 6, note that if the starting crank is pushed down, and if the engine should back-fire, which often occurs, when the engine is being slowly cranked, if—under these conditions—the spark lever is advanced, the full force of the kick-back is against the arm, and a sprained or broken wrist may result. Never push down on a starting crank to start an engine. Pull up.

Another point to remember is, do not tire yourself out by continually cranking, if an engine does not start after cranking five or six times. Find the cause of the failure to start.

After the engine is started, close the throttle and place the spark lever about half or two-thirds on sector until the engine runs slowly and evenly. On the Studebaker "EJ," the instructions are to place the spark lever at full manual advance; on the Buick, about half-way, and on the Westcott, at two-thirds advance.

As the engine warms up, the "choke," button should be pushed in; in fact, this should be done as soon as possible.

Never allow the engine to run any length of time with the air regulator turned to "choke," as this gives an excessively rich mixture and uses an abnormal amount of gasoline.

Handling the Spark

Ordinarily, on most engines using an automatic advance of spark, the spark lever should be about half to three-quarters of the way to the top of the quadrant for normal driving conditions. On the Studebaker "EJ," the automatic spark advance for starting and running speeds is full advance; on the Westcott, using an automatic advance, the spark lever is placed about three-quarters of the way to the top of the quadrant or sector; on the Buick about half way. The automatic spark advance, which is incorporated in the ignition system, will control the spark position without further attention on the part of the driver. It is arranged so as automatically to advance or retard the spark to the proper position, depending on the speed of the engine; but as the car slows down, as on ascending a steep hill, or when negotiating a heavy road, it is necessary to retard the spark lever by hand until the engine runs smoothly and without knocking.

With engines not equipped with an automatic advance of spark, it is best to start the engine with the spark lever near full retard, and then, after the engine is started, it should be advanced. The exact location of the lever will depend upon the speed of the engine.

Just how much the spark should be advanced, or, rather, how much spark advance the engine will stand, depends largely on how fast it is running. The faster the engine is running, the more the spark should be advanced. Bear in mind constantly, however, that there is such a thing as overdoing it and advancing the spark lever too far. When this is done, the ignition takes place before the charge has been fully compressed, and consequently the piston

INSTRUCTION No. 56

OPERATING A CAR: Gear Shifts, Control Levers and Pedals of Some of the Leading Cars; Pointers on Selecting a New Car; Judging and Testing a Second-Hand Car

HOW TO OPERATE A CAR

When learning to operate an automobile, the first step is to become familiar with how to start and stop the engine and how to control the speed. This can be learned best with the engine running.

The simplest way in which this can be done is to jack up the rear wheels so that they are clear of the ground, letting the weight of the car rest on a solid box. The point is to get the driving wheels clear of the ground, and free to revolve without moving car.

The different speeds may then be handled, and the movements of the levers and pedals may be gone through with, without being under the necessity of steering, the steering being the simplest and easiest part to learn. Care should be taken to block the front wheels so that the vibration of the engine cannot shake the car from its support.

Lever Systems

There are three types of side-lever systems: (1) the type which operates the planetary transmission gears; (2) the type which operates the old-style progressive gears, and (3) the type which operates the selective type of gear.

The planetary gear type is used on the Ford car, and is very simple. See the Ford instruction.

The progressive gear type is now seldom used. Its principle and operation is shown on page 25.

The selective type is the type most used, and it is with this type that we shall deal principally. This type is shown on pages 26, 28, 29.

The gear-shift lever used with a selective transmission is constructed in two types: the "gate" type, and the "ball and socket" type (page 27).

The emergency or hand-brake lever is usually placed alongside the gear-shift lever. On early model cars these levers were placed on the side of the car, but are more commonly found in the center (see Fig. 3 page 630). For a further description of the selective lever operation, see pages 26 to 29.

Pedal Systems

The foot brake is a pedal operated by the right foot. The clutch pedal is a pedal operated by the left foot.

The accelerator is usually placed to the right of the foot-brake pedal.

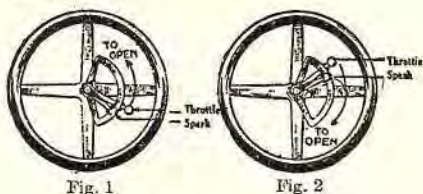


Fig. 1

Fig. 2

Fig. 1. On most cars the throttle and spark lever are moved up to open the throttle and advance the spark. Full open throttle and full advanced spark would then be all the way up. Full retard would be all the way down.

Fig. 2. On some few cars the throttle and spark lever are moved down to open and advance.

Note. On some makes of cars the long lever is the spark lever.

The spark and throttle levers are, in most instances, placed on the steering wheel. On a few cars they are placed under the wheel on the steering post. The throttle lever is usually the longest of the two. The movement of the throttle lever, whether up or down, to open the throttle is easily determined by noting the movement of the throttle on the carburetor. The spark lever for advancing can also be determined by noticing the direction in which it moves the timer or interrupter on the magneto. Usually the throttle and spark lever are pushed up to open and to advance.

Note that on the Pierce-Arrow "series 32" and the Cadillac "type 61" (pages 638, 635), the spark and throttle levers are now made very short.

Preparing a Car for Service

Before attempting to drive the car, make sure that it is ready for the road. See to the following:

1. That there is gasoline in the tank at the rear.
2. That the radiator is filled to the level of the overflow with clean water, or with an anti-freezing mixture in winter.
3. That the crank case is filled with oil to the level indicated by the oil gauge.
4. That the storage battery is properly connected.
5. That the gasoline shut-off cock between the vacuum tank and the carburetor is fully open.
6. That the car is provided with a driving license.
7. That the fan is working.
8. If the car has been standing idle for several days, it may also be necessary to prime the vacuum tank by removing the pipe plug in the cover and introducing a pint or so of gasoline (see page 115). Be sure to screw the plug in tight when replacing it.
9. See that the tires are properly inflated (see page 593).
10. See that a spare tire is supplied for emergency use.

How to Start the Engine

As an example, the Studebaker "Light Six," model "EJ" will be used.

Gear-shift lever: See that the gear-shift lever stands in neutral (upright) position, where it is free to move sideways. (See also Fig. 22, page 29.)

Position of spark lever when starting engine: The automatic advance as well as a hand or manual advance of the spark is used on this car. The spark lever (short lever) is placed in normal driving position, or about two-thirds of the way to the top of quadrant when starting the engine with the starting motor.

and more comfortable riding tire. The diameter is very large. Difficult steering may be experienced where balloon tires are applied to cars formerly equipped with high-pressure tires.

Some of the advantages claimed for balloon tires are: greater tire mileage, because of better rear wheel traction; less danger of skidding, due to greater road contact; improved engine performance and longer chassis life through elimination of road shocks, as they are absorbed before they reach the axles and springs of the car. Soft tires of large diameter ride easier and negotiate sand and soft mud on the same principle as the snowshoe.

The increased size of the cross-section of the tire has been obtained by reducing the size of the wheel, and thus leaving the outside circumference of the tire substantially the same as that of the regular cord tire.

The true balloon type tire is of small inside diameter, that is, it requires a smaller wheel and rim, or tire-seat which will take tires of the cross-section diameters

See also page 615, for the different sizes and number of plies.

Some of the tire companies suggest the following replacements if true balloon tires are to be applied to cars with high-pressure tires. A 4.40" tire with four plies on a 28 x 3½" straight-side rim for cars now using 3½" casings; the 5.25" tire with four plies on a 29 x 4" rim to replace the 4" tire now

being used; a 6.20" tire with four plies on a 29 x 4½" rim to replace the 4½" tire; the 7.30" tire with four plies on a 30 x 5" rim to replace a 5" high pressure tire. (The foregoing refers to true balloon tires and requires new wheels and rims of 20" or 21" dia.)

To determine the inside diameter of a tire: Twice the cross-section diameter deducted from the over-all diameter of the tire will give the inside diameter. For example: The inside diameter of a 30 x 3½" tire would be 2 x 3½" = 7" deducted from 30" = 23".

Therefore a 23" diameter rim would not take a true balloon-size tire as the tire-seat diameter must not be over 21" diameter.

Inner tubes for balloon tires are special as to thickness, size and construction.

The interchangeable, or semi-balloon type of balloon tire is also made by some of the tire firms in the sizes mentioned below for regular straight side rims:

30 x 3½"	31 x 4.40"
31 x 4"	32 x 4.95"
32 x 4"	33 x 4.95"
33 x 4"	34 x 4.95"
32 x 4½"	33 x 5.77"
33 x 4½"	34 x 5.77"
34 x 4½"	35 x 5.77"
33 x 5"	35 x 6.75"

The 31 x 4.40" size is also made by some of the tire manufacturers for clincher rims. See page 594 for oversize tires that can be used on the same rims.

If the rim is a 30 x 3½" clincher type, it will be necessary first to apply straight side rims.

Note. The sizes of tires, etc., as mentioned on this page are now different. Obtain literature giving the latest standards from your local tire dealer. See also specifications, pages 1055-1062.

POINTERS ON CARE OF PNEUMATIC TIRES¹

Tires should be kept inflated to the recommended figure, thereby reducing the wear and facilitating the ease of steering.

Test the tire pressure with a reliable gauge once a week. When touring, this should be done every morning. See pages 593, 607 for proper inflation pressure according to size and load.

When an under-inflated tire revolves, the excessive flexing of the carcass sets up heat which destroys adhesion of the cord layers. They separate, weaken, and finally show a break around the inside of the tire.

If the injury is discovered before more than the innermost plies are broken, a reliner may be cemented or vulcanized in, and the tire placed in service again. If the injury is more serious, it cannot be repaired and, therefore, it is better to prevent this trouble by close attention to air pressure.

In case of tire trouble on the road, do not run tire flat even for a hundred feet, for the carcass will be mashed between the steel rim and road and will be broken so that repairing is impossible.

An unusual jolt or strain from bumping a curb, hitting a rise or hole in the road, or from scraping along gutters, may cause misalignment or wobbling of wheels or both. Then rapid tread wear results, because the wheel no longer runs true with the one opposite but, instead, travels over the road with a diagonal grinding motion. To check proper alignment of front wheels, see pages 903, 904, and 612.

In crossing loose or broken stone, as on a new road, do not drive the car over, but get up speed, and as the car strikes the stones throw out the clutch so that it will coast.

If the car has not enough momentum to cross, let it go as far as possible before again throwing in the clutch. Driving across sharp stones forces the wheels to grind against them, while if the car moves without being driven, the tires roll over the stones, and are not so liable to injury. See also page 610 for cause of stone bruises.

To prevent wearing off tread rubber always apply brakes gradually. When breaks are thrown on suddenly, the tires are dragged over the pavement and depreciation is extremely rapid. Letting the clutch in too suddenly is another cause of worn treads by causing rear tires to slip and spin before getting a grip on the road surface.

If a tire blows out, do not jam on the brakes—cut off the power and let the car coast to a stop. Jamming on the brakes might cause a skid, and that would fatally ruin the tire.

When the rubber on the side walls of a tire is scraped off by ruts or curbs, the cord or fabric underneath is exposed to the rotting action of dirt and moisture. Repair small side-wall cuts while still new with cement and tire putty (see page 616), and have large ones vulcanized at once.

Always apply chains loosely, because if applied tightly the cross-chains strike the tire at the same spots continually and soon cut into the tread.

Never put chains on one rear wheel only, because the opposite wheel will spin and wear the tread of the tire, and the differential is also liable to damage.

Do not reverse chains by placing the worn side against the tire, as the edges of the links sharpened by use cut into the tread.

If chains are necessary in an emergency, remove them as soon as the emergency is passed.

Oil rots rubber. If oily, wipe with a cloth soaked with gasoline.

If the car is to be idle for a week or more, jack up the wheels to take the weight from the tires.

Rusty rims cause rim cuts. Scrape or rub with emery cloth and give a coat of shellac or lead paint to prevent rusting again.

In applying new tires, put them on rear wheels, moving the half-worn one to the front wheels. This will give them a longer life. In applying a single new tire, put it on the right-hand rear wheel, as this is the one that has the hardest work.

Skidding ordinarily occurs only on slippery surfaces and in rounding turns at high speed. The car will also occasionally slide on dry surfaces, like loose gravel, etc. See Index for "Skidding."

¹ See also page 611 for additional information on care of tires

Solid Tire Troubles

Solid tire troubles occur mostly as a result of cuts and bruises which soon cause the tire to wear rapidly. These are caused by driving in car tracks, by chains being too tight, wheels being out of alignment, by skidding, overloading, by speeding on bad roads, etc.

The solid tire cannot be successfully vulcanized. Therefore the only recourse is to run the tire for as long a time as possible.

Chains for Solid Tires

Chains for solid tires are a very important factor, as the solid tire has a tendency to skid—more so than pneumatic tires. They are also essential for gripping the road, snow, ice, etc.

Several methods of applying chains and grips are shown below. Figure numbers read from left to right.

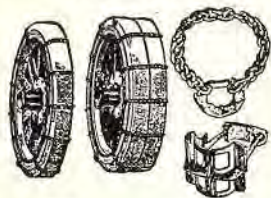


Fig. 91. Weed solid tire chains for single solid tires; Fig. 92. Weed solid tire chains for dual solid tires; Fig. 93. Woodworth solid tire chains; Fig. 94. Mud hooks.

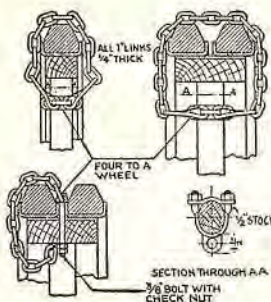


Fig. 95. Either twisted links or straight link chains may be used on solid tires as shown. Chains should be applied at 4 points on each rear wheel. They should be removed when not required. The illustration at the lower left shows where clearance will not allow a chain on the inside tire of dual construction (Gen'l Vehicle Co.).

Increasing the Tire Repair Business

There are many ways of building up a tire business. Many tire repairmen, instead of depending alone upon obtaining work from the owner, build up a respectable business through the garages and gasoline filling stations. Garage men will not go out of their way for this, and therefore the usual discount allowed is 25 per cent. Tires can be left at the garage man's place and can be called for by the tire repairman.

Another way to increase business is to suggest to owners of trucks to change the solid tire to pneumatics. Of course you would not suggest changing solids to pneumatics on a 5-ton truck hauling sand or coal for short distances, but where a 2, 2½, or 3-ton truck is making daily trips of 75 or 100 miles over fairly good roads, it would pay the owner at least to fit the front wheels of such a truck with pneumatics, and this is the business you should look for.

Before soliciting this work, first consider carefully if pneumatics will do the work. Having decided that the change would be an advantage to the owner, the next step is to decide the proper size of tire to use.

This may be done by running the front end of the truck, fully loaded, on a scale. Then when you know the weight which the front tires are carrying, it is a simple matter to refer to the table on page 593, and select a size of cord tire designed to carry that weight.

THE BALLOON LOW-PRESSURE PNEUMATIC TIRE

The low air-pressure pneumatic tire, properly termed "air cushion tire," also termed "balloon tire," "doughnut tire," etc., is a type of tire developed in 1923 for passenger car service. The pressure carried is from 18 to 35 pounds. The air capacity or volume has been approximately doubled, thus requiring only about one-half as much air pressure. The balloon tire is usually of a cord type construction and for straight side rims only.

Note. High pressure cord tires now have from 8 to 14 layers of cord fabric (used extensively on heavy duty trucks). Bus balloon tires have from 8 to 14 layers of cord fabric (also used on trucks). The balloon low pressure tire now has from 4 to 6 layers. Ask local tire dealers for literature on the latest construction. See "Note" page 608.

For a 1-ton capacity truck, a 34 x 5 cord pneumatic tire is the usual size. If only two wheels are to be fitted with pneumatic tires, then fit the front wheels with this size.

For 1½-ton capacity trucks, use 36 x 6 cord pneumatics; for 2-ton trucks, 38 x 7 or 40 x 8 Giant cord pneumatics, or 38 x 7 on the front and 40 x 8 on the rear.

The carrying capacities for solid tires and for pneumatic tires are given on pages 627 and 593.

Of course, if a 2-ton capacity truck usually carries light loads of a bulky nature, but not up to capacity, the proper course is to figure the load carried by each wheel and select tires accordingly.

Some of the points to bear in mind relative to fitting a truck with tires are as follows:

Pneumatic tires, of course, will give greater truck protection through the absence of vibration, and will also increase the radius of travel per day. The minimum speed is increased because it is not necessary to slow down for rough spots in the road. In such work as hauling in oil fields it is almost impossible to use solid tires, and only pneumatic tires can be used. In coal mines and on extremely rocky roads and with heavy hauling, the pneumatic tires would be more expensive, and solid tires are better adapted here.

The cushion tire is pressed on to the wheel, just like the regular solid tire. The cushion tire might be classed half-way between the solid tire and the pneumatic tire, in that it is softer than the solid tire and has greater resiliency, but is a solid tire in the true sense of the word. The fire department uses the cushion tire to a great extent, and it is also used on 1, 1½, and 2-ton trucks to a large extent.

For extremely heavy duty, such as 3½, 5, and 7½-ton trucks, where extremely heavy loads are carried and at a very slow speed, the Giant solid tire is the most economical.

Very few trucks have the same size tires all around, and we find that sometimes most of the load is carried on the rear. If the same size tires are carried on all four wheels, then the load should be equally distributed.

For example, suppose we had a truck weighing 4,000 lbs. and it carried a load of 2,000 lbs.; this would give us total load carried by the four wheels of 6,000 lbs., providing the load was equally distributed on all four wheels. By dividing the 6,000 lbs. by 4, we have 1,500 lbs. load per wheel. Therefore by referring to our capacity table on page 626, we should use a 4" tire which carries a wheel load of 1,700 lbs. Always figure over rather than under.

If, however, three-fourths of the load is carried on the rear wheels, or 4,500 lbs., then one-half of this 4,500 lbs. would be carried on each rear wheel, or 2,250 lbs. per wheel. By referring to our capacity table on page 626, we find that we should use a 5" tire on the rear, and a 3" tire would be sufficient for the front.

For the best plan for finding the wheel load for any particular size tire: See page 594, which explains how to weigh, and how to find out how much of a load each wheel carries. Then refer to the table giving the carrying capacity of the different sizes of tires.

When fitting truck wheels with pneumatic tires, which are already equipped with solid tires, it will be necessary to have new rims fitted to the wheels. This should be done by a wheelwright who specializes on this work.

The usual cost of such work runs about \$15 per wheel plus the cost of the rims, with a discount of 20 per cent to the dealer. Time required for changing two wheels would be about one day.

For example, the cost of changing two solid-tired wheels to pneumatics would be estimated, approximately, as follows:

Wheelwright's charge, 2 wheels at \$15.00 . . .	\$ 30.00
2 34 x 5 rims complete with felloe bands, bolts, etc.	40.70
2 34 x 5 cord pneumatic tires at \$53.50	107.00
2 34 x 5 high-test red inner tubes at \$5.85	11.70
	\$189.40

Usually, when the owner of a truck agrees to have the solid tires changed to pneumatic tires, he insists on having his solid tires traded in on the job. This can usually be adjusted with the tire branch.

The average high-pressure tire has a comparatively thick wall, usually with 4 to 8 layers or plies of fabric, in order to resist the internal pressure of the tire. This thick wall does not permit much deflection without breaking the fabric.

The balloon tire, using a low air-pressure, permits the use of thinner walls, of from 2 to 4 layers, which permits more bending and flexibility without rupturing the tire, thus providing a much easier

Compressed-Air Fittings

Supplies of this kind can be secured of auto supply houses as enumerated on page 687.



Fig. 74. Wire-wrapped air hose for garage work: inside diameter $\frac{1}{4}$ " and $\frac{3}{8}$ ".

Fig. 75. Copper-wrapped brass-wire-woven flexible hose: inside diameter $\frac{1}{4}$ " and $\frac{3}{8}$ ". For hand or portable pumps. The hose generally used is $\frac{3}{16}$ " or $\frac{1}{4}$ " diameter.



Fig. 76. Romort style "A" automatic air valve for use on air hose where it is in constant use. Bronze; instantaneous in opening and closing; air-tight; step-up stem fits any size tubing from $\frac{1}{4}$ " to $\frac{1}{2}$ ".

Fig. 77. Air hose couplings: Takes care of any hose, large or small, metal covered or rubber; the hose is expanded at the end and the threaded nipple is so designed that the harder the pull the tighter the grip; bushing is furnished to use on hose of small diameter. The type shown is the Romort "Universal," and is shown connected to metal covered hose. It can also be used on plain rubber air hose.

Fig. 78. Tire tester and air-valve attachment combined. The Schrader tire air-pressure gauge is shown attached to the Romort automatic air valve.

Fig. 79. Romort blow gun: bronze metal; can be used wherever there is a lathe or other machine where it is necessary to remove chips, dirt, or other waste matter; entirely automatic; the valve closes when pressure on the trigger is released;



connection to the hose is made by the Romort Universal hose connection, which fits all popular sizes of rubber hose and prevents the gun from blowing off the hose: can be used in the garage for cleaning the dirt from tires to be vulcanized, for cleaning cushions, cleaning engine and parts, dusting out cars, and for various other purposes.

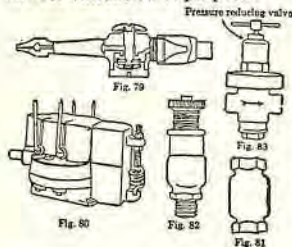


Fig. 80. Automatic electric air-pressure controller designed for use in motor-driven air compressors for garages, pneumatic water systems, etc.; automatically maintains air-tank pressure between predetermined limits; carries sufficient current to operate single, two, or three-phase A. C. motors up to 2 h.p. and 440 volts; also suitable to operate D. C. motors up to and including $\frac{1}{2}$ h.p.; regularly

adjusted to start motor at 115 lbs. tank pressure, and stop it at 140 lbs.; can be adjusted at factory for other limits, but there must be 25 lbs. difference between maximum and minimum limits.

Fig. 81. Vertical check valve for air lines for female connections $\frac{1}{4}$ " and $\frac{3}{8}$ ".

Fig. 82. A safety valve: Has a ball seat; can be adjusted to blow off at any desired pressure up to 175 lbs.; intended as a tank safeguard by preventing higher tank pressure than that for which the valve is set.

Fig. 83. A pressure-reducing valve: Metal construction, designed for work on air tanks carrying up to 150 lbs. initial pressure, and will reduce air-line pressure to a steady flow at any point between 10 and 60 lbs. to the square inch; by turning the adjusting screw in the top, the pressure can be instantly raised or lowered to any point between these limits; for service in reducing pressure on pneumatic tools or any other service where accuracy is desired (Brunner Mfg. Co., Utica, N.Y.).

SOLID TIRES

Solid tires can be divided into two classes: (1) the single, and (2) the dual type. The single solid tire is the type in general use. It has what is termed a hard base pressed on a single solid tire. The rim used is a channel-type non-detachable rim.



Fig. 84. The original automobile solid tire (now obsolete) was held in place by side wires.

Fig. 85. The hard-base pressed-on type of solid tire and channel rim.

Fig. 86. The cushion tire is used where more resiliency is required. The rubber is softer than that in the regular solid tire. Fig. 86 shows a cushion type of tire on a clincher rim. This rim is now obsolete, and a channel rim, the same as used with other solid tires is now used. This type of tire is used extensively on fire-department trucks.

Fig. 87. The solid tire mounted on a quick detachable, demountable rim is shown. This rim is now obsolete, the principle involved in the hard-base pressed-on tire being used instead.

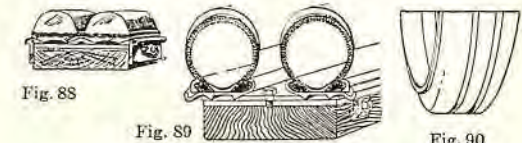


Fig. 88. The dual solid tire is now being replaced with single Giant solid tires. The dual construction consisted of sections or blocks, mounted on demountable rims.

Fig. 89. The dual pneumatic tires for truck use, mounted on quick-detachable side-ring type rims is now seldom used; instead, the Giant pneumatic cord tire, or the Giant solid tires are used.

Fig. 90. The Giant single solid tire is the type of solid tire in general use for heavy trucks. It has a hard base and is pressed on the rim.

Kinds of Solid Tires¹

The solid tire in general use is in three classes:

1. The "Regular" single solid tire.
2. The "Cushion" solid tire.
3. The "Giant" solid tire.

Carrying Capacities of "Regular" "Cushion" and "Giant" Tires

For tires of 36" or less:

3 inch, maximum load per wheel, 1,000 lbs.
3½ inch, maximum load per wheel, 1,300 lbs.
4 inch, maximum load per wheel, 1,700 lbs.
5 inch, maximum load per wheel, 2,500 lbs.
6 inch, maximum load per wheel, 3,500 lbs.
7 inch, maximum load per wheel, 4,500 lbs.
8 inch, maximum load per wheel, 5,500 lbs.
10 inch, maximum load per wheel, 7,500 lbs.
12 inch, maximum load per wheel, 9,500 lbs.

Dual solid rubber tire capacities are figured by multiplying the figures given above by 2.

For tires of 38" and 40":

5 inch, maximum load per wheel, 3,000 lbs.
6 inch, maximum load per wheel, 4,000 lbs.
7 inch, maximum load per wheel, 5,000 lbs.
8 inch, maximum load per wheel, 6,000 lbs.
10 inch, maximum load per wheel, 8,000 lbs.
12 inch, maximum load per wheel, 10,000 lbs.
14 inch, maximum load per wheel, 12,000 lbs.

Standard Sizes of Regular Solid Tires

32 x 3	36 x 3½	32 x 5	32 x 6
24 x 3½	32 x 4	34 x 5	34 x 6
32 x 3½	34 x 4	36 x 5	36 x 6
34 x 3½	36 x 4	40 x 5	40 x 6

Standard Sizes of Giant Solid Tires

34 x 7	36 x 10
36 x 7	40 x 10
40 x 7	36 x 12
34 x 8	40 x 12
36 x 8	36 x 14
	40 x 14

Cushion solid rubber tires are made in the foregoing sizes, except 32 x 3, 36 x 3, 40 x 5, 34 x 7, 34 x 8, 36 x 12.

¹ The classifications and sizes of tires, etc., as mentioned on this page are now different. Obtain literature giving the latest standards from your local tire dealer. See also pp. 965-977B for size and type of tires used on trucks and p. 998 for motorcoach.

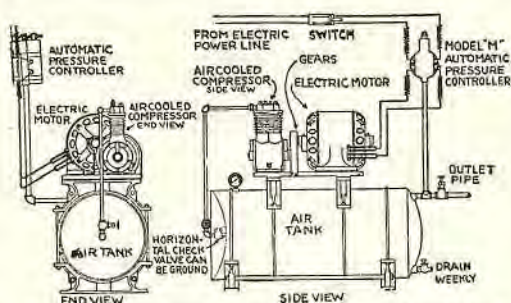


Fig. 68. A self-contained air compressor outfit¹ suitable for garages up to 60 to 70 car capacity. This air compressor is air cooled and is driven by an electric motor, $\frac{1}{2}$ h.p.

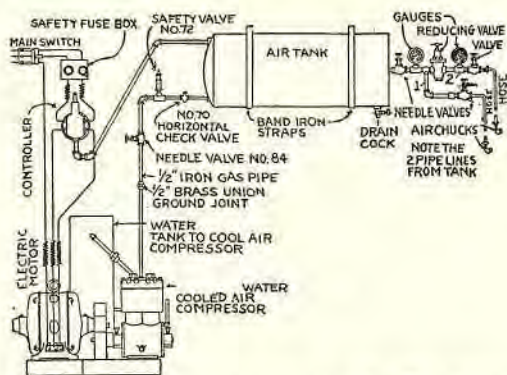


Fig. 69. A heavy-duty air compressor outfit. This air compressor is water cooled and driven by an electric motor, 2 h.p. Designed for very large garages, for tire air service, and also for operating paint sprayers, small pneumatic tools, general shop work, etc. Note that there are two pipe lines leading from air tanks 1 and 2. No. 1 is at normal pressure of the tank, and No. 2 is at a reduced pressure through the reducing valve.

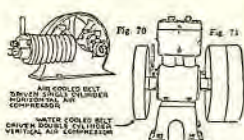


Fig. 70. Belt-driven single-cylinder horizontal air compressor, adapted to small vulcanizing shops: bore $1\frac{13}{16}$ " stroke, 2"; guaranteed pressure up to 175 lbs. at 350 r.p.m., the capacity is 1 cu. ft.; at 400 r.p.m., $1\frac{1}{6}$ cu. ft.; at 450 r.p.m., $1\frac{1}{3}$ cu. ft. free air per minute; uses $1\frac{1}{2}$ "

belt for an 8" loose and tight pulley; power required, $\frac{1}{2}$ h.p. at 100 lbs. pressure; outlet pipe is $\frac{1}{4}$ "; weighs 23 lbs.

A Belt-driven double-cylinder vertical air compressor gives about twice the capacity. With 9" pulley and friction clutch. Requires $\frac{1}{2}$ h.p.

Fig. 71. Belt-driven double-cylinder water-cooled vertical air compressor for continuous service under high pressure; bore 3"; stroke 3"; capacity at 250 r.p.m., 6 cu. ft.; at 500 r.p.m., $12\frac{1}{4}$ cu. ft. of air per minute. Pulleys 16×3 "; fly wheel. Requires $1\frac{1}{2}$ h.p. at 100 lbs. pressure, 300 r.p.m.

Care of Air Compressors

An air compressor might be compared with a gasoline engine. A piston draws air into the compressor cylinder through an inlet valve on the suction stroke. As the piston returns on its next stroke, the valve closes and the air is compressed and forced through the outlet valve to the air-storage tank.

The valves must seat properly, otherwise pressure will be reduced. The valves are of the poppet type.

Lubrication of compressors is a subject of importance; that is, it is highly necessary to use the proper grade of oil as recommended by the manufacturer. Too much oil will gum the rings and get into the air tank, and will also necessitate frequent and costs only slightly more than a single-stage compressor. The average compressor unit now installed in automotive service stations is usually a two-stage unit with $1\frac{1}{2}$ hp. or larger motor. See page 690 under "Air Compressors" and write for literature. See also, pages 692-694.

valve grinding. Lack of oil will result in burned-out bearings.

Cylinder-head bolts should be drawn tight, otherwise the compressor will fall below its capacity. Cylinder head gaskets should be used as recommended by the manufacturer. Paper or rubber will not do.

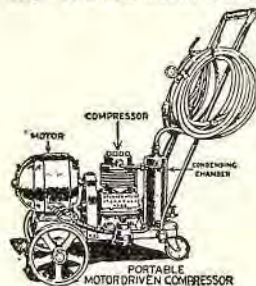
Knocks are often due to loose flywheels, carbon on the piston, or to worn bearings.

Compressed Air and Its Use in the Service Station and Garage

Compressed air can be used for various purposes, some of which are enumerated as follows: cleaning upholstery (with suction attachment), blowing out rugs and cushions, washing car, cleaning engines and chassis with kerosene, spraying lacquer enamel, for tire inflation, operating pneumatic door openers, pressure grease and oil guns, pneumatic valve grinders, etc. See also pages 623, 645 and 756.

Portable Air Compressor

Fig. 72. Portable motor-driven air compressor outfit (Brunner). It can be moved to different parts of the garage, and is suitable for inflating tires and other purposes direct without the aid of a tank and storage system.



The attachment plug is screwed into a lamp socket which operates the $\frac{1}{4}$ h.p. electric motor. This operates the air compressor which stores air in the tank. The advantages are apparent.

Vacuum Cleaners

Vacuum cleaners of the portable type for cleaning the interior of a car are of two types. One type operates from the vacuum created in the inlet manifold of the engine and the other by an electric motor.

An electric motor type vacuum cleaner of small size made especially for car use and to be operated from a lamp socket is described below.

Fig. 73. An electric vacuum cleaner and blower.



An example of the type of cleaner which garages, service and auto-washing stations, and repairshops can use to advantage and on which a good profit can be made during the year. This device is handy for cleaning automobile upholstery and for general use, and can be used from a lamp socket and on 32 to 250 volts A.C. or D.C. current.

In addition to cleaning by suction, it can also be used as a blower.

¹Two types of air compressors are now in general use in automotive service shops. The single-stage may have one, two or more cylinders; if more than one, the cylinders pump in parallel. Air is drawn into cylinder on the downward movement of piston and compressed to the final pressure on the upward movement. They are satisfactory for pressures up to 150 lbs. The two-stage always has two cylinders. Air is drawn into one cylinder and compressed to approximately 40 pounds. It then travels through an intercooler or copper tube (in order to dissipate part of the heat) to a smaller cylinder, where it is further compressed to the final pressure of approximately 175 to 200 lbs. The two-stage compressor is said to be more efficient.

POWER-DRIVEN AIR COMPRESSORS FOR SERVICE STATION AND GARAGE USE¹

Compressed air is used for inflation of tires, washing and cleaning cars, spraying kerosene for cleaning engine and chassis, spraying lacquer for finishing cars, for operating pneumatic garage door openers, grease and oil guns, valve grinders, hoists, and a variety of other purposes.

There are two types of power-driven air compressors for general service station and garage use: (1) the air-cooled compressor; (2) the water-cooled compressor.

Where compressors are used almost continuously, the water-cooled type is recommended, because, for heavy constant duty, the air-cooled compressor would heat. When heating occurs, the air drawn into the hot compressor expands; then when it cools in the tank, it contracts, with the consequence that the pressure drops. The usual pressure is maintained at about 150 lbs., which is sufficient for all ordinary requirements. The pressure in the tank must, of course, be somewhat higher than at the outlets, usually about 15 lbs. higher. This, naturally, is determined by the number of outlets. There is usually a safety valve on the air tank which can be adjusted accordingly.

When purchasing a compressor be sure that it is over-size rather than under-size, as the business may grow; furthermore it is hard on the compressor if operated continuously when under-size.

Size Tank to Use

Tank capacity: The following table is taken from the instructions furnished with the air compressors manufactured by the Brunner Mfg. Co., Utica, N.Y.

Tank	Size	200 lbs.	150 lbs.	100 lbs.	50 lbs.
85 x 48 x 24	14 cu. ft.	4 Tires	2 Tires	2 Tires	1 1/2 Tires
14 x 20 x 10	10 cu. ft.	3 Tires	2 Tires	2 Tires	1 1/2 Tires
18 x 20 x 10	12 cu. ft.	4 Tires	2 Tires	2 Tires	1 1/2 Tires
18 x 20 x 12	16 cu. ft.	5 Tires	3 Tires	2 Tires	1 1/2 Tires
24 x 20 x 12	20 cu. ft.	6 Tires	3 Tires	2 Tires	1 1/2 Tires

Tank sizes, at pressure given in table, will inflate the given number of 35 x 4 1/2 tires to 85 lbs. as shown in the table. For example, a 40-gallon tank at 180 lbs. pressure will inflate eight 35 x 4 1/2 tires to 85 lbs.

After inflating tires of this size, each will have from 89 to 90 lbs. left, with which to inflate several smaller tires.

Drive methods: The air compressor can be driven by a belt from a line shaft, or by an electric motor. When self-contained—all in one unit—it can be driven by a belt, by a silent chain, or by gears.

Pointers on belt-driven compressors: A belt should be used of the width of the compressor pulley. If a smaller belt is employed, it will slip and stretch. Leather belts are best, as it is easier to lace them than fabric belts.

The speed of the compressor should be exactly that which the manufacturers advise. If it is run too fast, the compressor will heat; if run too slow, the capacity will be reduced.

How to Determine Speed and Size of Pulley to Use for Driving Air Compressors

The speed at which air compressors should operate is of importance and is determined by the sizes of pulleys. It should be remembered that the larger the driving pulley, the faster the compressor, having a given size of pulley, will be driven, and vice versa. We give here the method of determining the pulley sizes and speeds under different conditions:

When the compressor is driven direct from an electric motor, a 3" pulley is generally used in order to keep the pulley on the compressor as small as possible. To determine the size of the compressor pulley, multiply the speed of the motor pulley by the diameter of the motor pulley, and divide the result by the number of revolutions of the compressor.

Example: What size of compressor pulley is required to drive an air compressor at 340 r.p.m. direct from an electric motor having a 3" pulley and running at 1,700 r.p.m.?

$$1,700 \times 3 = 5,100 \div 340 = 15" \text{ pulley on the compressor.}$$

When it is desired to drive a compressor from a motor by means of a countershaft, to ascertain the size of the countershaft pulleys, multiply the speed of the motor by the diameter of its pulley, and divide by the desired speed of the countershaft; this gives the size of the driven pulley on the countershaft. Then multiply the recommended speed of the compressor by the diameter of its pulley, and divide the result by the speed of the countershaft for the size of its driving pulley.

Example: It is desired to drive an air compressor, having a 9" pulley, at 350 r.p.m. by a motor having a 3" pulley and a speed of 1,700 r.p.m. The compressor cannot be driven direct from the motor, and a countershaft must be used. What size of pulley must the countershaft have?

$$1,700 \times 3 = 5,100 \div 425 \text{ (speed of countershaft)} = 12 \text{ in., the size of the driven pulley.}$$

$$350 \times 9 = 3,150 \div 425 \text{ (speed of countershaft)} = 7.4 \text{ in.}$$

The nearest commercial pulley is 8". Therefore an 8" driving pulley is used on the countershaft.

When the countershaft runs at the same speed as the compressor, then the pulley on the compressor and the drive pulley on the countershaft must be of the same diameter, irrespective of what that diameter is (anywhere from 3" to 3 ft.).

When an air compressor is driven from a line shaft without a countershaft, and the size of the driving pulley is required, multiply the speed of the compressor by the diameter of its pulley, and divide by the speed of the line shaft.

Example: An air compressor having a 9" pulley is to be driven at 350 r.p.m. from a line of shafting having a speed of 450 r.p.m. What size of pulley must be used on the line shaft?

$$350 \times 9 = 3,150 \div 450 = 7 \text{ in., the size of the driving pulley on the line shaft.}$$

See also Index under "Diameter of pulleys; how to find," for further suggestions on the subject of finding the diameter of pulleys.

Installing an Air Compressor

Place the compressor on a firm foundation in a location where the pipes will not have to extend too far. Locate it preferably where short pipes can be used, and where fresh air and not gasoline fumes will be drawn into the compressor. It is best to draw the air from outside the building with a screened air intake.

Locate the tank where it can be easily drained, as vapor in the air condenses and should be drained. It does not matter if the tank is placed in a horizontal or in a vertical position.

Locate the air pipes where they can be used most and will be accessible for the greatest number of purposes, such as for outside free air service, for the vulcanizing department, for the tire-testing tank, for the buffing machine, etc.

Use flexible, woven-fabric-covered hose of very small diameter, as it is better than rubber.

Pipe and pipe joints should be connected by using shellac, asphaltum, or a mixture of litharge and glycerine to insure airtight joints. The elimination of air leaks is a very important factor. Use the size of pipe recommended by the manufacturer of the compressor. The pipe leading to the inlet of compressor should never be smaller than the full diameter of the compressor inlet opening, and also of the outlet pipe. Iron or steel pipe is satisfactory.

Attach the outlet pipe from the air tank as high as possible from the tank, to avoid water condensation going to the tires.

A draincock in the pipe should be placed at the lowest point, especially when outside of the building, as the condensation is likely to freeze.

Air-Compressor Outfits¹

The illustration (Fig. 67) is the layout for a belt-driven air compressor outfit, and in Figs. 68 and 69, electric motor-driven compressors are shown.

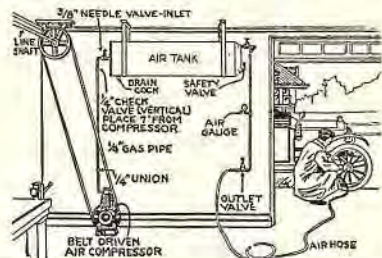


Fig. 67. Belt-driven garage outfit for garages housing from 15 to 20 cars, and for vulcanizing shops.

¹ See addresses of Air Compressor Manufacturers on page 623 (footnote) and write for catalogue if interested, which will give later prices and outfits.

AIR COMPRESSORS FOR USE ON THE CAR¹

Air compressors can be classified under two headings: (1) hand air pumps; (2) power air compressors.

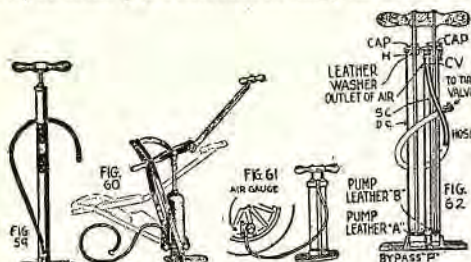
Hand Air Pumps

This type of air pump is made in the "single" and "compound" type.

The single-acting hand air pump (Fig. 59) is made with a single barrel. It is seldom used, because it requires a heavy exertion to pump a tire to the proper pressure, unless the fulcrum is great enough to reduce the effort required.

A type of hand air pump for garage use, employing the fulcrum and lever principle, is shown in Fig. 60.

A compound type of hand air pump is shown in Figs. 61 and 62. This type of pump employs two barrels; on some types there are as many as three barrels.



Principle of operation: The air is drawn in from the atmosphere into the large cylinder and is compressed by the down stroke of the handle; at the same time it is forced into the smaller cylinder through by-pass (P).

The up-stroke of the pump forces the air from the smaller cylinder into the tire through check valve and hose (CV), and the large cylinder sucks in another charge.

While the air admitted into the large cylinder is receiving its first compression, it is forced through passage (B) into the upper portion of the smaller cylinder. The cup leathers (A) and (B) are fitted to their pistons in opposite positions, that is, the leather (A) is put in with its open side downward, and leather (B) has its open side upward. If both leathers are put in the same way, the pump will not work.

A pump of this kind differs from a single-cylinder pump, in that each stroke is a power stroke, while in a single-cylinder pump only the down strokes are power strokes.

Keep the leather packing washer (around the piston rod of the small cylinder) tight, otherwise the air will blow through here instead of going into the tire.

Power Air Compressors for Use on the Car

Under this heading there are two types of pumps: (1) the impulse air pump; (2) the power-driven air compressor.

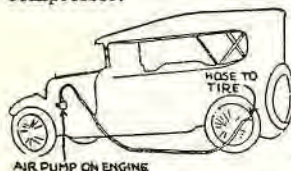


Fig. 63. Illustrating how the connection is made from the air pump (driven from the engine, or transmission shaft) to the tire. The air hose is detachable, and is usually carried under the seat.

The Brown impulse air pump: This pump (Fig. 64) has the appearance of a compound pump, because of the large and small cylinders, but they are built in this form to make it possible to pump the high pressures necessary for large tires, and at the same time not have any too good a compression in the engine cylinder. The lower piston, with its large area, receives its impulse from the compression in the engine cylinder, and transmits it to the upper piston through the medium of the hollow piston rod, to which both pump pistons are attached.

Action: As the engine piston makes its suction stroke, it draws fresh air through valve (1) which opens inwardly, and at the same time, both pump pistons make their downward stroke. You will note that piston rod (6) is hollow. This is the air passage to the upper cylinder through ball check (12).

As the engine piston makes its compression stroke, it forces its charge of compressed air into the upper cylinder and against the lower piston of the pump, and causes it to make an upward stroke. This piston being so much larger than the upper piston, the charge is further compressed and sent through outlet valve (21), at the top, thence through the hose to the tires or the tank.

These pumps are very often spoken of as compound pumps, because of the fact that the air pressure is raised in two stages; but don't forget that the first stage is performed in the engine cylinder and not in the pump cylinder. It is a single-stage pump, capable of raising the pressure from 50 or 60 lbs. in the engine cylinder to 100 lbs. or more in the tire or the tank. It is advisable to let the pump make a few strokes before attaching the hose to the tire valve.

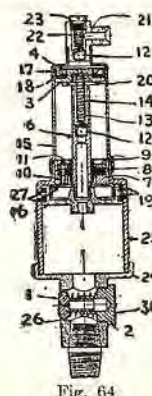


Fig. 64

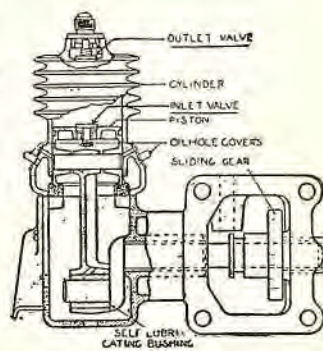


Fig. 65

Fig. 64. The impulse pump, sometimes termed the spark-plug pump, because it is screwed into the spark-plug hole and operates by means of the compression of the engine cylinder. (1) Inlet valve disk; (2) Inlet valve body; (3) Upper piston; (4) Upper piston nut; (6) Piston rod; (7) Stuffing box; (8) Rod packing; (9) Rod packing nut; (12) Ball check valves; (13) Upper piston pin; (14) Check valve spring; (15) Upper cylinder shell; (16) Lower piston; (18) Piston cup leather; (19) Piston rings; (21) Outlet valve; (22) Outlet valve spring; (23) Outlet valve cap; (24) Cylinder base; (25) Lower cylinder shell; (26) Inlet valve seat.

Fig. 65. A power-driven tire air compressor.

Power-Driven Tire Air Compressor

The illustration (Fig. 65) is the compressor used on type 57 car. It is bolted to left-side transmission case and is driven by a sliding gear which meshes with the reverse idler gear in transmission. The sliding gear is thrown in when needed, and out when not needed, by a lever.

To operate: Stop the engine, wait until the transmission gears are idle, then shift the gear of the compressor in mesh with the reverse idler gear. Then start the engine, being sure that the gear-shift lever is in neutral position.

Run the engine at speed of 900 to 1,100 r.p.m. with all lights turned off. This is indicated by the ammeter showing 16 or 18 amperes, if the third-brush is properly regulated on the generator. 1000 r.p.m. on the type "V-63" car will indicate about 13 amperes. If the portable lamp is in use, the ammeter will indicate about 10 amperes. Do not race the engine when inflating tires. Throw the gear out of mesh when through pumping tires. Lubricate the compressor often. By observing the illustration, it will be seen that the inlet of air is taken in through the "inlet valve" in the top of the piston, from the crank case of the pump, when the piston travels down. It is compressed and forced out of the "outlet valve" as the piston travels up.

¹ Some of the manufacturers of single and compound type of air pumps and air compressors, engine driven: Kellogg Mfg. Co., Rochester, N.Y.

² Some of the manufacturers of air compressors, power-driven, for general garage use, tire repairshops, etc.: Am. Oil Pump and Tank Co., Cincinnati, Ohio; Brunner Mfg. Co., Utica, N.Y.; Curtis Pneumatic Machinery Co., St. Louis, Mo.; Globe Mfg. Co., Battle Creek, Mich.; Hobart Bros. Co., Troy, Ohio; Kellogg Mfg. Co., Rochester, N.Y.; U.S. Air Compressor Co., Cleveland, Ohio. See trade magazines for others. Auto supply jobbers, page 687, supply air compressor outfits. See also page 645 relative to compressed air for washing cars, and page 756 for spraying lacquer.