The FORD STANDARD ELECTRICAL EQUIPMENT

STARTING - LIGHTING - IGNITION

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PREFACE

Many Starting and Lighting Systems for the Ford car have been made, all of them designed to be installed on the car after it left the Ford factory. This fact made the number of installations limited. Now, however, the Ford Company is beginning to install a starting and lighting system on its cars at the factory. Ford repairmen will need complete and detailed explanations and repair instructions.

This book has been written to fill this need. Every detail of the starting and lighting system has been explained, and the numerous illustrations will be of great assistance in simplifying the explanations and instructions.

While the greater portion of the book is devoted to the starting and lighting system, a full description of the ignition system is also given, with diagrams and instructions for making tests.

Troubles, other than electrical, which may arise in the operation of the car, are also explained in detail.

ILLUSTRATIONS

INDEX

AMBU KEY NUMBERS.

In making the regular Ambu tests on the F. A. Starting and Lighting System, the Key Numbers are as follows:

UPPER: Use 9 when engine is running at speed which would drive car at 20 miles per hour in high speed.

LOWER: (a) Use 4 when tail lamp and large bulbs in headlights are burning.

(b) Use 2 when tail lamp and small bulbs in headlamps are burning.

TESTS.

The regular tests with Ambu are made just as on any other car.

WHAT CHARTS TO USE.

Chart 1, Page 53.

ENGINE NOT RUNNING, LAMPS OFF.

Consult this chart if you find that battery is discharging when engine is not running, and all lamps, and the ignition is turned off.

Chart 2, Page 64.

ENGINE NOT RUNNING, LAMPS OFF.

Consult this chart if pointer goes backward when you connect meter in series with the battery for making tests.

Chart 3, Page 65.

ENGINE NOT RUNNING, LAMPS ON.

Consult this chart if no lamps burn when switch is turned on.

Chart 4, Page 69.

ENGINE NOT RUNNING, LAMPS ON.

Consult this chart if your ammeter connected in series with battery indicates more than 5.4 amperes when tail lamp and large bulbs in headlamps are burning, or more than 1.25 amperes when tail lamp and small bulbs in headlamps are burning.

Chart 5, Page 71.

ENGINE NOT RUNNING, LAMPS ON.

Consult this chart (a) when some of the lamps do not burn when switch is turned on, (b) when some or all of the lamps burn dimly when switch is turned on.

Chart 6, Page 76.

ENGINE NOT RUNNING, LAMPS ON.

Consult this chart if your ammeter, connected in series with the battery, reads backwards when the lamps are turned on.

Chart 7, Page 77.

ENGINE RUNNING, LAMPS OFF.

Consult this chart if your ammeter, connected in series with the battery, indicates that battery is not receiving any charging current. Run engine on magneto, and turn off all lamps when making this test.

Chart 8, Page 84.

ENGINE RUNNING, LAMPS OFF.

Consult this chart if your ammeter, connected in series with the battery, indicates that battery is discharging instead of being charged when lamps are off, and engine is run on the magneto.

Chart 9, Page 87.

ENGINE RUNNING, LAMPS OFF.

Consult this chart if your ammeter, connected in series with the battery, indicates that generator is receiving less than 10 amperes charging current when lamps are turned off, and engine is run on magneto.

Chart 10, Page 103.

ENGINE RUNNING, LAMPS OFF.

Consult this chart if your ammeter, connected in series with the battery, indicates that battery is receiving more than 10 amperes charging current when lamps are turned off, and engine is run on magneto.

Chart 11, Page 105.

Consult this chart is the pointer on your ammeter, connected in series with the battery, jumps about from place to place on the scale of the ammeter, and does not come to rest.

Chart 12, Page 107.

STARTING TROUBLE.

Consult this chart if the starting motor does not turn over the engine, or turns it over too slowly for engine to start.

Ford Starting and Lighting System

The Ford Starting and Lighting System with which Ford cars are equipped at the Factory is made up of the following parts:

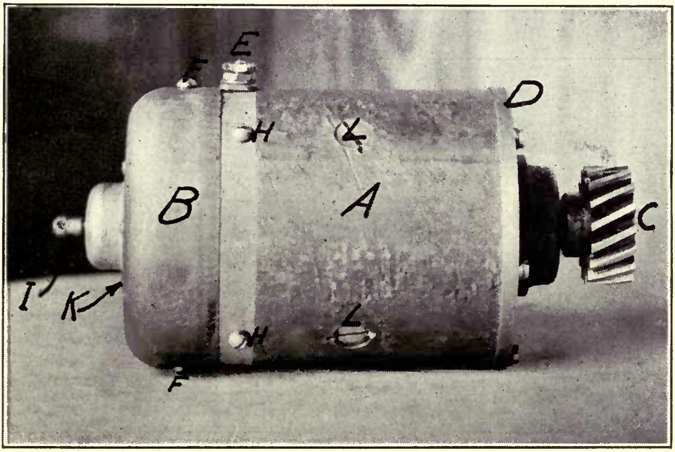


FIGURE 1.
SIDE VIEW OF FA GENERATOR.

A is Main Generator Frame. B is cover over rear end housing. C is driving pinion. D is front end cap. E is generator terminal. F are screws which hold B in place. H are screws which hold rear end housing in place. I is rear bearing oiler. K are screws which hold brush ring in place. L are screws which hold field poles in place.

1. **THE GENERATOR,** Figure 1, which (a) charges the battery when the engine is running. (b) Furnishes the current used by the lamps when the engine is running at a speed of over 12 miles per hour. (c) May be used to furnish the current used by the ignition coils when the engine is running, although the regular Ford

magneto should be used for this purpose.

2. **THE STARTING MOTOR**, Figure 2, which does the work ordinarily done by the hand crank—turns the engine over fast enough when starting to enable it to begin to run under its own power. The starting motor is used only to crank the engine, and is not in operation after the engine is running under its own power.

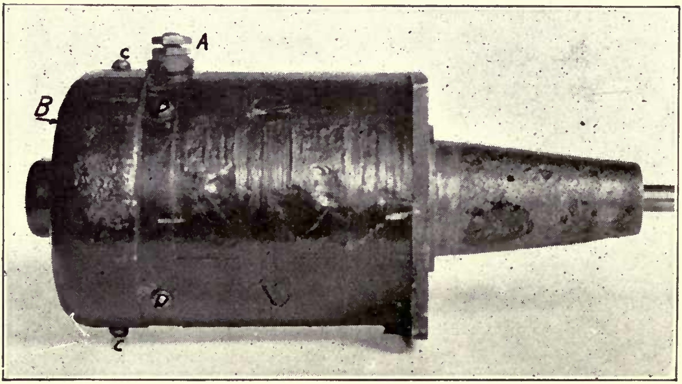


FIGURE 2.

SIDE VIEW OF FA STARTING MOTOR.

A is Motor Terminal. B is cover over rear end housing. C are screws which hold B in place. D are screws which hold rear end housing in place.

3. **THE STORAGE BATTERY**, which (a) furnishes the current that causes the starting motor to crank the engine. (b) Furnishes current for the lamps when the engine is not running. (c) Furnishes current for the ignition coils when the engine is started.

4. **THE AUTOMATIC ELECTRICALLY OPERATED SWITCH, OR "CUT-OUT"** as it is usually called, which automatically connects the generator to the battery as

soon as the voltage of the generator is slightly greater than that of the battery, and which automatically disconnects the generator from the battery, as the engine slows down, when the voltage of the generator becomes less than that of the battery. The cut-out does **NOT** disconnect the generator from the battery when the battery is fully charged.

5. **THE AMMETER**, mounted on the instrument board in front of the driver. This is an electrical instrument which indicates the strength of the current passing in or out of the battery. The ammeter has a pointer which moves over a scale marked directly in amperes. The zero line on the scale of the ammeter is on the center line of the scale. The maximum indication shown on this meter is 20 amperes. The readings to the left of this zero line are marked "Charge". This means that when the generator is delivering current to or is "charging" the battery, the pointer moves to the left of the zero line, coming to rest over a line on the scale which gives the number of amperes charging current which is passing into the battery. When the battery is not receiving any current from the generator, but is furnishing current to operate the lights or ignition coil,—and hence is "discharging",—the pointer of the ammeter will swing to the right of the "0" line to the part of the scale which is marked "discharge". The pointer will come to rest over a line which indicates how many amperes current is being furnished by the battery to the lights or ignition coils.

6. **THE COMBINATION LIGHTING AND IGNITION SWITCH**, which enables the driver to turn the lights on or off, and to connect the ignition coils to either the battery or magneto or to disconnect them from battery or magneto. This is located on the instrument panel in front of the driver.

7. **THE STARTING SWITCH,** which is operated by the driver's foot, and which enables the driver to connect the starting motor to the battery in order that it may crank the engine, and to disconnect the starting motor from the battery after the engine is running under its own power. The switch is located under the floorboards in front of the driver.

8. **THE LARGE AND SMALL LAMPS** in the headlights and the tail lamp.

9. **THE WIRES AND CABLES** which connect together the various parts and units together.

The parts will be described in the order named.

1. THE GENERATOR.

LOCATION AND MOUNTING. The generator is located on the right side of the engine at the front end. See N. Figure 20. It is bolted to the cylinder front end cover, with three standard three-eighth inch cap screws with seven-sixteenth standard heads. A paper gasket (See O. Figure 4) is placed between the generator and the cylinder cover to prevent oil leaks.

DRIVE. Mounted on the front end of the generator shaft is a pinion having 16 teeth cut spirally. See C. Figure 1. This pinion engages with the large timer gear. The generator runs at one and one-half times the engine speed.

LUBRICATION. Both front and rear generator bearings are equipped with ball-bearings. The front ball-bearing is lubricated by oil splashing from the timer gear. At the rear end housing of the generator is an oil cup (Shown at I in Figure 1) through which oil may be squirted to lubricate the rear ball bearing. A few drops of oil should be squirted in this oiler occasionally. To do this turn the knurled head on the oiler to the right as far as it will go. This will uncover an oil hole through which the oil may be applied. When the knurled head is released a spring rotates it back into place, covering the

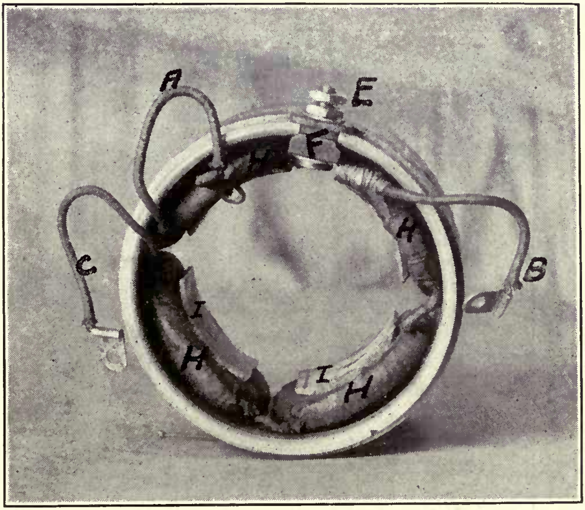


FIGURE 3.

LOOKING AT GENERATOR FRAME WITH END HOUSING REMOVED.

A is a field lead which is connected to the third brush. B is armature lead which is connected to main ungrounded brush. C is field lead which is connected to grounded main brush. E is generator terminal. F are insulating bushings around generator terminals. H are the shunt field coils. I are two of the field pole pieces.

oil hole. Always be sure that this oil hole is covered after applying the oil, so as to keep dirt out of the oil. Do not oil the rear bearing too often as the oil will be thrown on the commutator, get under the brushes and prevent the generator from charging the battery. A great deal of the trouble with the generator is due to excessive oiling. There is a round felt washer pressing against front and rear ball-bearings, the purpose of which is to keep oil off the commutator and other parts where it does not belong. If too much oil is used, however, it will work past these washers and collect on the commutator and other parts.

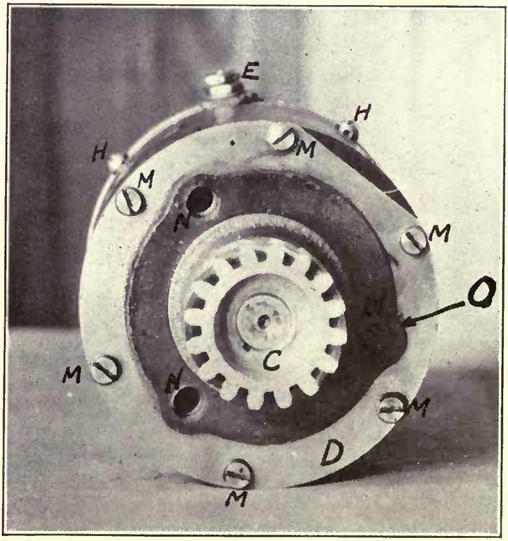


FIGURE 4.

FRONT END VIEW OF GENERATOR.

C is driving pinion. D is front end cap. E is generator terminal. H are screws which hold rear end housing in place. M are screws which hold front end cap in place. N are holes into which are turned the screws with which the generator is held in place on the car. O is paper gasket.

FRAME. The main portion of the frame (Shown at **A** in Figure 1) is made of a wrought iron pipe, having an outside diameter of 4½ inches, inside diameter of 3–31/32 inches, and length of 4–7/16 inches. Bolted to the inside of the frame are four steel pole-pieces over which the field coils are wound. These pole pieces are arranged as shown in Figure 3. Each pole piece is held in place by a flat head machine screw. These screws are prevented from turning by a center-punch mark on the edge of the heads.

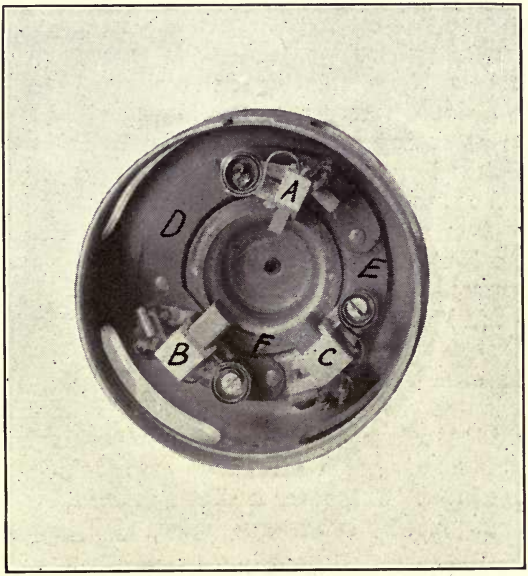


FIGURE 5.

LOOKING AT INSIDE OF GENERATOR REAR END HOUSING.

A is the "3d" brush holder. B is the ungrounded main brush holder. C is the grounded main brush holder. D is fiber insulating the third brush and ungrounded main brush from the brush ring, E. F is narrow ring which clamps brush ring in place by means of four screws, as shown, whose heads are shown at K in Figure 8.

If the pole pieces are removed to work on a field coil, be sure to make another center-punch mark when you reassemble the pole piece to prevent the screw from turning. Each pole face is $2\frac{1}{8}$ inches long, measured from front to rear. The "field bore", or the diameter measured between the opposite pole faces is about 2⅞ inches.

At the front end of the frame is a flat cast iron end cap (shown at D in Figures 1 and 4) which carries the front bearing, and which contains the holes shown at N in Figure 4, into which are turned the bolts which fasten the generator to the engine. This end cap is fastened to the generator frame by six screws (shown at M in Figure 4) which turn into the front end of the frame. These screws may be removed with a screw driver when it is desired to remove the end cap and armature. At the rear end of the generator is a removable U shaped housing, as shown in Figure 5. This carries the rear end bearing and the brush ring. It may be removed by taking out four screws, two of which are shown at H in Figure 1. As seen in Figure 5, there are four openings in this housing through which the commutator, brushes, and wiring may be examined. In removing this housing be careful not to crack the insulation (shown at F in Figure 3), which is placed around the generator terminal. Fitting over this housing is a sheet iron cover which closes up the four holes. This cover is shown at B in Figure 1. It is held in place by two screws, shown at F in Figure 1.

BRUSHES. There are three carbon brushes, as shown in Figures 5 and 6. The two lower ones carry the charging current out of and into the armature. The upper one is called the "third" brush, and connects to one end of the field as shown in Figure 6. The two lower brushes are ⅜ inch wide, ¾ inch long, and 13/16 inch high. The third brush is 3/16 inch wide, ¾ inch long, and 13/16 inch high. The most important work on the brushes is to keep the surface which bears on the commutator perfectly clean, and rounded off so that every point of the brush surface touches the commutator. This may be done by inserting a piece of fine sandpaper (never use emery cloth) between the brush and the commutator, with the sanded side toward the brush. Then move sandpaper back and forth as shown at B in Figure 7, until the brush surface is clean and rounded. After sandpapering, or "sanding" the brushes, it is best to run the engine for about twenty minutes before making any test readings on the generator.

It is also important that each bare copper pigtail be fastened securely to the brush, and connected firmly to the brush holder. See that the end of each brush spring bears firmly and squarely on the top end of the brush, and that the end is not bent so that it rests on the brush holder instead of on the brush, and so that it does not bear against

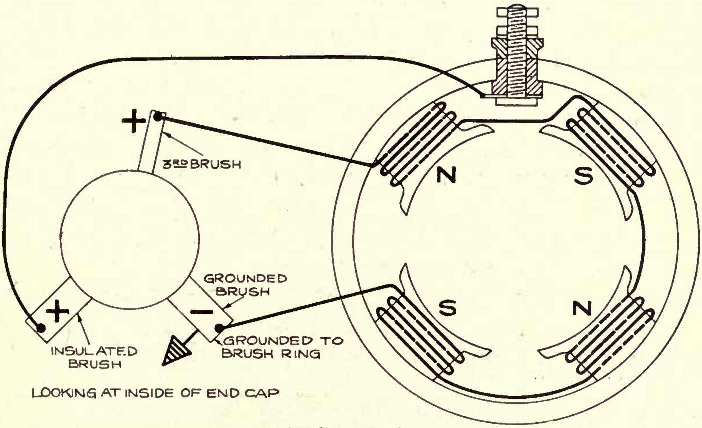
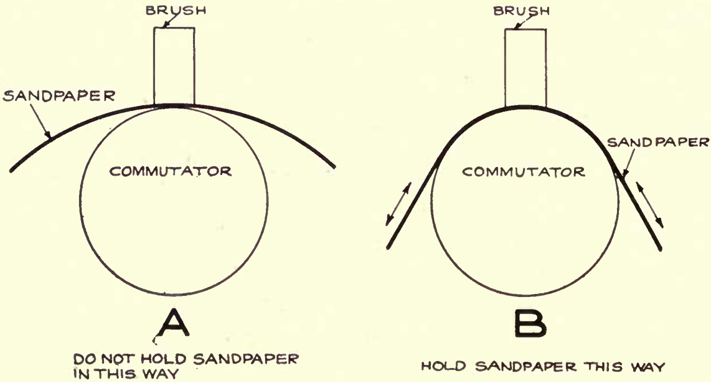


FIGURE 6.
GENERATOR BRUSHES AND FIELD COILS.

the side of the brush instead of the top, thus preventing the brush from touching the commutator. The spring adjustment and position may be tested by raising the brush a short distance by means of the pigtail and then suddenly releasing it. The brush should snap back on the commutator and strike the commutator with a click.

The pigtail is fastened to the brush holder in each case with a round head machine screw. The end fastened by this screw is soldered into a flat terminal which fits under the head of the screw. The brush holders, shown at A, B and C in Figure 5 are made of aluminum. The two lower, or main brush holders are riveted to a flat ring, and cannot be moved relative to each other. The third brush holder is bolted through a slot in this ring, as shown at A in Figure 11. The nut on this bolt may be loosened, thus allowing the bolt to be moved to any position in the slot. In this way the third brush holder is moved, and the brush may be made to bear on different points of the commutator. This feature will be discussed more fully later.



WRONG & RIGHT WAY TO HOLD SANDPAPER IN CLEANING BRUSHES

FIGURE 7.

The main brush holder shown at B in Figure 5, and the third brush holder, shown at A in Figure 5, are insulated from the ring by a strip of fiber but the main brush holder shown at C in Figure 5 is riveted directly to the metal of the brush ring, and is thus "grounded" to the ring.

On the inner circumference of the brush ring are four slots as shown at B in Figure 11. Bearing against the brush ring is a smaller ring which is seen when looking at the brushes and toward the inside of the end housing. This small ring has four screw holes into which four round head screws are turned. These screws are inserted through holes in the end cap of the generator, as shown at K in Figure 8. These screws pass through the slots cut in the inner circumference of the brush ring, and when they are turned in, clamp the small ring against the brush ring, which is in this manner held in place

FIGURE 8.

REAR END VIEW OF GENERATOR.

E is generator terminal. H are two of the screws that hold rear end housing in place. K are screws which hold brush ring in place.

rigidly. If the four screws shown at K in Figure 8 are loosened, the entire brush ring may be rotated as far as the length of the slots in the brush ring will permit.

The springs which press the brushes against the commutator are made of flat spring steel. One end of each spring is fastened in a slotted stud. The spring is coiled into several turns and the free end bears on the upper end of the brush. The stud which holds one end of the spring is fastened rigidly to the brush holder. The construction is shown in Figure 5.

FIELD WINDINGS. On each of the four field poles is wound a single field coil. The four coils are connected in series, as shown in Figures 3 and 6. The joints

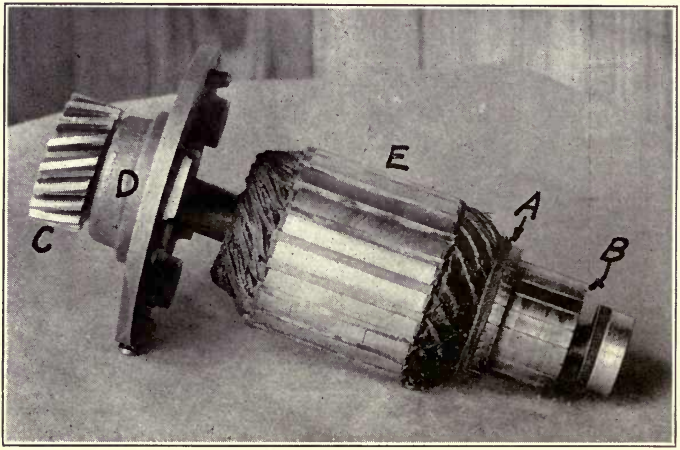


FIGURE 9.
GENERATOR ARMATURE.
A-B is commutator. C is driving pinion. D is front end cap. E is armature core.

between successive coils are made by soldering the wires together and covering the joint with tape. The resistance of the four coils when cold is about 2.45 Ohms. In order to disconnect the field coils from each other, the tape must be removed and the joint unsoldered.

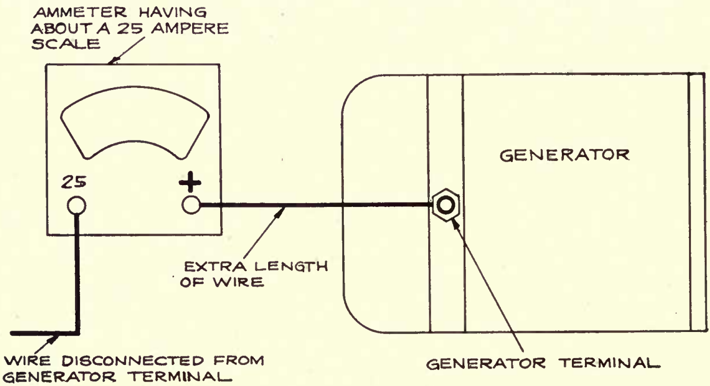
ARMATURE. The generator armature is shown in Figure 9. It has 21 slots, and 21 segments on the commutator. The wires are cotton covered enameled wire. The only part of the armature that requires attention is the commutator upon which the brushes bear. This should be kept clean, smooth, and free from oil. If the rear end bearing on the generator is not given too much oil, there will be no trouble caused by an oily commutator. Never put any grease, graphite, or other lubricant on the commutator. To clean a dirty commutator, first hold a dry rag against it while the engine is running. This will remove most of the dirt. To finish, hold a rag moistened with gasoline against the commutator. This will remove all remaining dirt. Do not use too much gasoline on the rag, and always run the engine afterwards for several minutes with the cover removed from the rear end housing. This is to drive off any gasoline vapor.

The space between segments should be kept free from oil, grease, and bits of carbon and copper. To clean these spaces, use a sharp pointed tool, and scrape out the dirt until the clean mica shows the entire length of the segment, between the points marked **A** and **B** in Figure 9. The mica should be cut down until it is about 1/32 inch below the surface of the commutator.

If the commutator is rough or scratched, it may be made smooth by holding a piece of fine sandpaper against it, while the engine is running, until it is perfectly smooth. After doing this, examine the spaces between segments to make sure that no particles of copper have lodged in them.

REGULATION OF CHARGING CURRENT. The strength of the current delivered by the generator is regulated by the "Third Brush" system. The field winding is connected between the grounded main brush and the small "third" brush (shown in Figure 6) which, as already described, bears on the upper part of the commutator. The position of this brush may be changed so that the brush may be brought nearer to or farther from the grounded main brush. The distance between these two brushes, or in other words the number of commutator segments that the "third" brush is away from the grounded main brush, determines the maximum strength of the current delivered by the generator. The strength of the current may be varied from 8 to 12 amperes.

When it is desired to change the maximum generator current, an ammeter should always be connected in the circuit between the battery and the generator. This is most easily done at the generator, as shown in Figure 10.



CONNECTING AN AMMETER IN SERIES WITH GENERATOR WHEN CHANGING POSITION OF THE THIRD BRUSH

FIGURE 10.

In this figure the connections are shown for cars in which the cutout is mounted on the dash. On cars having cutout on generator, disconnect the wire from the "B" terminal on the cutout. Fasten this wire to the "—" or "25" post of your ammeter. Then connect the "+" post on your meter to the "B" terminal on the cutout. The generator should be warm when the change is made. All lights should be turned off and the engine should be run on the magneto. Remove the cover which closes up the openings in the rear end housing of the generator.

This is done by taking out two round head screws, as shown at F in Figure 1. The nut which holds in place the bolt which clamps the third brush holder to the brush ring is reached through the opening in the rear end housing, which is to the right of the generator terminal when facing the rear end of the generator. This is a hexagonal nut, and a small thin open end wrench is the best tool to use in turning this nut. Loosen this nut and

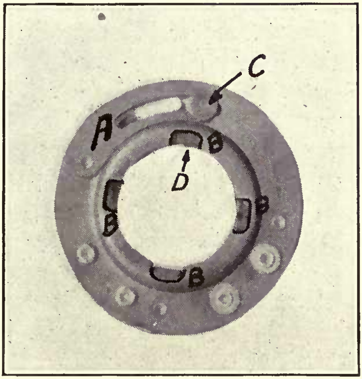


FIGURE 11.

LOOKING AT BACK OF GENERATOR BRUSH RING.

A is slot in which the bolt C that holds third brush holder in place may be moved, thus changing position, or "setting" of the third brush. B are notches cut in inner circumference of brush ring, through which the screws whose heads are shown at K in Figure 8 pass. D is the narrow ring which clamps brush ring in place. D is also shown at F in Figure 5.

then tap the third brush holder so as to move it in the slot shown at A in Figure 11. Moving the third brush in the same direction as the armature is rotating increases the generator current. Moving it in the opposite direction decreases the current. The engine should be running at about 800 revolutions. When the desired value of current is obtained, tighten the nut. Then run the engine at different speeds so as to be sure that the current does not reach a value greater than that indicated on the ammeter when the nut was tightened. It is a good practice to sandpaper the under surface of the third brush after the brush has been set in its new position. Directions for sanding brushes are given on page 8.

GENERATOR PERFORMANCE. The cutout should close when the generator is turning at a rate of 600 revolutions per minute, or at car speed of 10 miles per hour. At this speed the voltage of the generator should be a little higher than the voltage of the battery, in order that the generator may begin to deliver current to the battery as soon as the cutout closes. As the speed of the engine increases, the current will continue to increase until the generator is turning at 1200 revolutions per minute, or until the car is traveling at the rate of 20 miles per hour in high speed. At this speed the current reaches its maximum value. At higher speeds, the charging current gradually decreases. This decrease is caused by the armature current twisting the magnetic field so that the current through the field coils decreases as the generator speed increases.

A charging current of 10 amperes is the best for average driving conditions. As the speed of the engine is decreased below 20 miles per hour, the current will also decrease, because the voltage of the generator will decrease. The cutout will not open and disconnect the generator from the battery until the voltage of the generator has dropped slightly below that of the battery. The battery will then begin to discharge into the generator. This will be indicated by the pointer on the ammeter coming down to the "0" line on the scale and then moving on past the "0" line for one or two amperes. This discharge current should not exceed several amperes, and should flow for only an instant before the cutout opens.

HOW TO REMOVE THE GENERATOR FROM THE CAR. First remove the three cap screws which fasten the generator to the cylinder front end cover. Then place the point of a screw driver between the generator and the front end cover, and gradually force off the generator. Always start prying at the top of the generator and force the generator backward and downward at the same time. If it is desired to run the car while the generator is removed, the time gear should be covered with a plate until the generator is replaced. The plate may be obtained from a Ford dealer.

HOW TO TAKE GENERATOR APART. 1. Remove the cover which closes up the openings in the rear end housing. This is done by taking out the two screws which hold it in place as shown at F in Figure 1.

2. Grasp the pigtail on each brush with a pair of long nosed pliers and pull the brush up until the brush spring snaps from the top of the brush and bears against the side of the brush. This will hold the brush clear of the commutator.

3. Take out the six flat head screws, shown at M in Figure 4. Then insert point of screwdriver between the front end cap and the frame and pry the cap loose. Then grasp the pinion and pull out the armature.

4. Remove the rear end housing by taking out the four screws shown at H in Figure 1. Pry the housing loose with a screw driver. **IN REMOVING THIS HOUSING BE EXTREMELY CAREFUL NOT TO DAMAGE THE INSULATION AROUND THE GENERATOR TERMINAL.**

5. When the rear end housing is loose it may be pulled back as far as the wires which are fastened to the brushes will allow. To remove the housing entirely, disconnect the wires from the brushes, being careful to note the connections. Figure 6 shows the proper connections.

6. To remove the brush ring, take out the four screws shown at K in Figure 8. The main brush holders are riveted to the ring and cannot be removed from the ring.

2. STARTING MOTOR.

LOCATION AND MOUNTING. The starting motor is located on the left side of the engine at the rear end, as shown at A in Figure 21. It is fastened to the transmission cover by four 5/16 inch bolts.

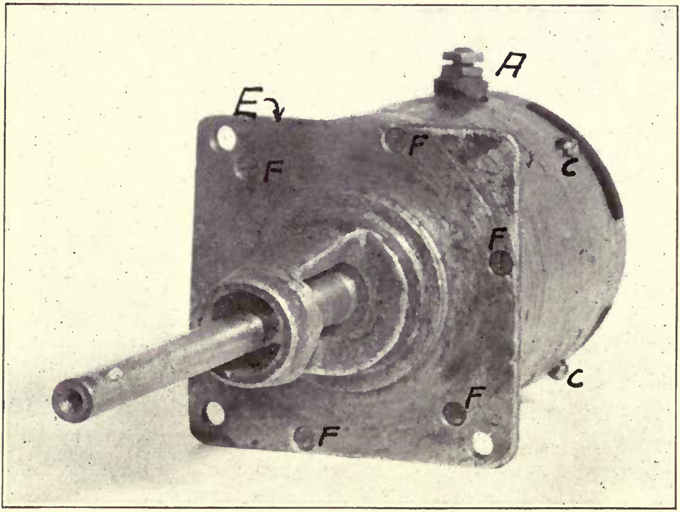


FIGURE 12.

LOOKING AT FRONT END OF STARTING MOTOR.

A is motor terminal. C are two of the screws which hold rear end housing in place. E is front end cap. F are screws which hold front end cap in place.

DRIVE. The well known Bendix drive system is used. This system is used so extensively on automobiles that no description is needed here. The motor pinion has 10 teeth, and engages with a gear of 120 teeth cut on the circumference of the flywheel. The motor therefore turns twelve times as fast as the engine.

LUBRICATION. The motor has plain bearings without balls. The motor is used very little and therefore does not require much lubrication. The bearing next to the flywheel is lubricated by splash from the flywheel. The other motor bearing is not lubricated.

The front bearing has a brass or bronze bushing, and the rear bearing has a bushing of soft bearing metal.

FIGURE 13.

LOOKING AT INSIDE OF MOTOR REAR END HOUSING.

A are the brushes. B are the grounded brush holders. BG are the insulated brush holders. C are the bare copper pig-tails which connect brushes to brush holders. D are the brush springs. E is the brush ring.

FRAME. The frame, pole pieces, rear end housing, and rear end housing cover are all of the same material and dimensions as those of the generator, as already described. The cap on the drive end of the motor is different. Its shape and construction are shown at E in Figure 12. It is fastened to the end of the frame by six screws shown at F in Figure 12.

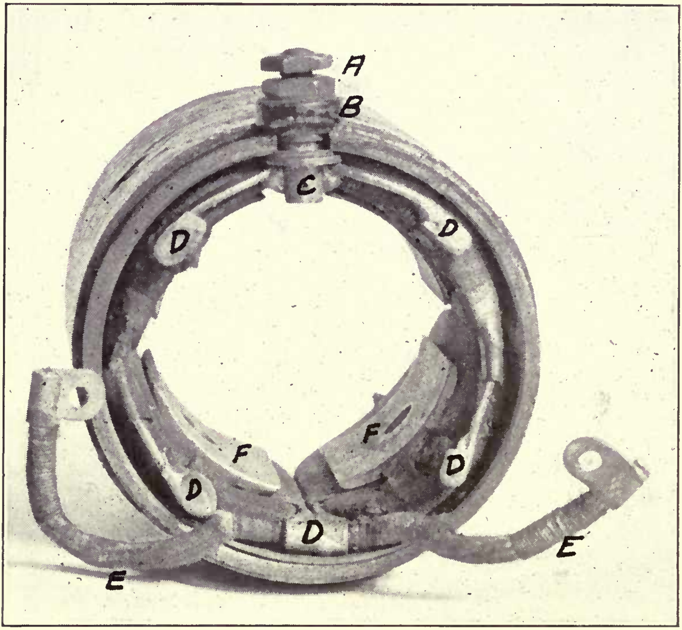


FIGURE 14.

LOOKING AT FRONT END OF MOTOR FRAME.

A is the motor terminal. B is the insulation around the motor terminal. C is lower end of motor terminal. D are the joints between the field coils. E are leads connecting field coils to brushes shown at BG in Figure 13. F are the field pole pieces.

BRUSHES. The motor has four copper composition brushes arranged as shown in Figure 13. Each brush has two heavy bare copper pigtails, the free ends of which are soldered into flat copper terminals that are fastened to the brush holder by a round head machine screw. The brushes are each 3/4 inch long, 3/8 inch wide, and 3/4 inch high.

The brush holders are made of aluminum, and are riveted to the brush ring. The two brushes shown at BG in Figure 13 are insulated from the brush ring by fiber strips. These brushes are connected to one end of the field coils. The brushes shown at B in Figure 13 are riveted directly to the metal of the brush ring, and are therefore the "grounded" brushes. They have no wires except the pigtails from the brushes attached to them.

The motor brush springs are similar to those in the

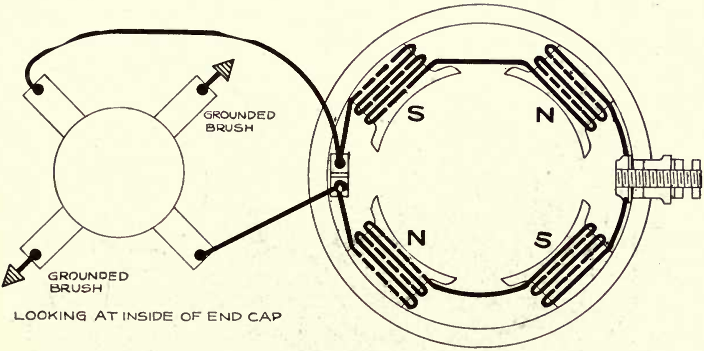


FIGURE 15.

MOTOR BRUSHES AND FIELD COILS.

generator. Each spring is made of coiled flat spring steel, one end bearing on the top of the brush, and the other end being fastened in a slotted stud which is mounted directly on the brush holder.

The brush ring is riveted to the housing with four rivets and therefore cannot be removed or shifted.

The remarks made about taking care of the generator brushes apply to the motor brushes also.

FIELD WINDINGS. Each of the four motor field poles carries one heavy coil, as shown in Figure 14. The connections of these coils are shown in Figure 15. The joints between field coils (shown at D. Figure 14) are not covered with any insulating material, and care should be taken that the bare copper does not touch the motor frame, as this would practically short circuit the battery when the starting switch is closed.

ARMATURE. The motor armature (shown in Figure 16) has 21 slots and 21 commutator segments. The winding is made up of heavy flat copper, the top layer being insulated merely with an insulating lacquer or varnish.

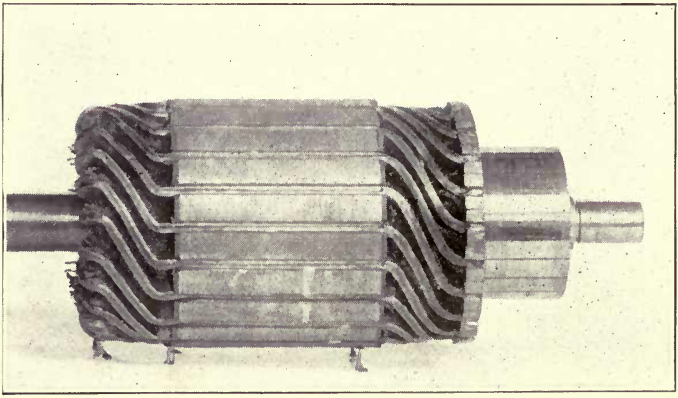


FIGURE 16.
MOTOR ARMATURE.

The conductors in the bottom layer are insulated with a cloth tape.

As to the care of the commutator, the remarks already made about the care of the generator commutator apply to the motor commutator also.

PERFORMANCE. The duty of the starting motor is simply to turn over, or crank the engine in order to start the engine. This it does by the Bendix pinion on the motor shaft meshing automatically with the gear teeth cut on the rim of the flywheel. When the engine starts and runs under its own power, the Bendix pinion is automatically driven out of mesh with the flywheel gear. As already stated, the motor turns at 12 times the speed of the engine, there being 10 teeth on the Bendix pinion and 120 on the flywheel gear.

The results of some tests are given below:

(a) Motor takes 70 to 80 amperes when running without load.

(b) Motor takes 140 to 200 amperes when cranking a loose engine.

(c) Motor takes 225 to 300 amperes when cranking a stiff engine.

(d) Motor takes 300 amperes when blocked and not permitted to turn.

(e) Running without load, motor consumes 373 watts, or 1/2 H. P. The current was 65 amperes at 5.75 volts.

(f) Tests on a typical new engine: Motor turning at 900 R. P. M. engine at 75 R. P. M. Motor taking 275-300 amperes at 4.5 volts, giving a maximum power consumption of 1350 watts, or 1.8 H. P.

(g) Tests on a typical run-in engine: Motor turning at 2200 R. P. M., engine turning at 183.3 R. P. M. Motor taking 140 amperes at 5 volts, giving 700 watts, or 0.93 H. P.

HOW TO REMOVE MOTOR FROM THE CAR: (a) Remove engine pan on left hand side of engine.

(b) With a screw driver remove the four small screws which hold the shaft cover to the transmission cover, in back of the flywheel.

(c) After this cover is removed, turn the Bendix drive shaft around so that the set screw on the end of this shaft is in a horizontal position with the head pointing toward the left, as you face the rear of the flywheel. Under this set screw is a split spring lock washer having sharp points or spurs at the joint between the two halves on opposite sides of the washer. One of these spurs is turned against the Bendix collar and the other is turned up against the screw head. Bend back the spur which has been forced against the screw, and remove the set screw. The lock washer may be broken in doing this, and a new one should be used when the motor is again made ready for cranking.

(d) Next pull out the Bendix pinion, spring and sleeve.

(e) Remove the four screws that hold the starter housing to the transmission cover, and pull out the motor, taking it down through the chassis; through the opening made when the engine pan was removed.

(f) When you replace the starting motor, be sure that the terminal mounted near the rear end of frame is on top.

(g) If the car is to be used while the starting motor is removed, put the transmission cover plates in place. If these are not at hand they may be obtained from a Ford dealer.

HOW TO TAKE MOTOR APART. Having taken off the Bendix drive mechanism, take the starting motor apart as follows:

(a) Remove the cover from the rear end housing by taking out the screws shown at C in Figure 2, and forcing the cover off with a screw driver.

(b) Grasp a pigtail of each brush with a pair of long nose pliers and pull up until the brush spring snaps off the top of the brush and bears against the side of the brush. This will hold the brushes clear of the commutator.

(c) Take out the six screws in the drive end cap, shown at F in Figure 12. Pry the end cap off with a screw driver.

(d) Pull out the armature.

(e) Remove the four screws shown at C in Figure

12, which hold the rear end housing in place. Pry off this housing with a screw driver.

(f) Disconnect the two leads from the ungrounded brush holder.

(g) Brushes may be removed by unscrewing the copper pigtails and then lifting brushes out. Brush holders cannot be removed.

3. THE BATTERY.

TYPE. The battery is an Exide, 6 volt, 13 plate battery, type 3-XC-13-1.

LOCATION. On earlier cars the battery was mounted on the left running board. In later cars the battery is under the left rear floor boards.

MOUNTING. The battery when placed under the floor boards is carried in a frame made of flat iron bars. It is held down by two flat pieces which press down on the top of the box at the ends. These pieces are held in place by two thumb screws. Battery may be removed by removing the thumb screws and lifting out the two flat pieces. The floor boards must be lifted up in order to expose the battery. In the Coupe, there is a removable section of floor boards just beside the gas tank in the rear compartment. In the Sedan the removable section of floor boards is in front of the rear seat.

MAINTENANCE, CARE AND REPAIR OF BATTERY. This is a subject which requires special and complete treatment. The book "The Automobile Storage Battery, Its Care and Repair," published by the American Bureau of Engineering, Inc., covers the subject of the storage battery completely from the repairman's point of view.

4. CUTOUT.

LOCATION. On many cars the cutout is mounted under the engine hood at the right side of the dash board.

The base of the cutout is then grounded to an iron arm projecting upward from the frame of the car. On other cars the cutout is mounted on top of the generator frame, and its frame is then grounded directly to the generator frame.

CUTOUT ON DASH. There are three terminals on the base of the cutout, as shown in Figure 24. The two outside terminals are marked "Gen." and "Bat.", respectively. The one marked "Gen." is connected to the generator terminal, and the one marked "Bat." is connected to the ammeter. The two outside terminals are insulated from the base of the cutout, while the middle one, which is not marked, is grounded to the base.

The movable arm carries one of the contact points. A flat spring at one end tends to hold the two contact points apart. Passing through an opening in this arm near the contact point is a bent over brass piece. By bending or straightening this piece, the distance between the two contact points may be varied. The correct distance is about 1/32 inch.

The stationary contact point is carried on an arm which is insulated from the upright piece on which it is mounted. The distance between the points may also be changed by moving this arm up or down.

CUTOUT ON GENERATOR. Figure 24B shows the internal connections of the cutout which is mounted directly on top of the generator frame. The piece marked "T" is bolted to the generator terminal. Piece T is connected to part H by a round head machine screw which may be seen by looking at the bottom of the cutout. T and H are both insulated from the base of the cutout which is fastened to the generator frame. The arm E is mounted on, and is in electrical connection with H. At one end of arm E is one of the contact points as shown. The other contact point is fastened to piece D, which is insulated from H and E. A brass hook, L, which is an extension of piece D, acts as a stop for the arm E. The end of this hook touches a small disc of insulation on the arm E, as shown in the diagram. By bending the hook, the air-gap between the cutout points (when engine is not running) may be changed so as to secure proper operation of the cutout in closing. A spring, S, tends to hold the contact points away from each other. By bending this spring its tension may be increased or decreased, to secure proper action of the cutout both in closing and opening the circuit between the generator and the battery. Directions for adjusting the cutout action are given on page 29.

PATH OF CURRENT THROUGH CUTOUT. Current from the generator enters the cutout at T, goes through T into parts H and E, thence through the two contact making points into part D, thence through the current coil (the outside one, which is made of the heavy wire) into piece C (which is insulated from all parts except the current coil), then through a screw A (which passes through the cutout cover, but is insulated from the cover) into the insulated plate, as shown in Figure 24A, and thence to the battery along the wire fastened to this plate under the screw which is marked "B" in the diagram and also on the cutout.

Screw A is sealed to the cover, and should always be turned down tight, since the charging circuit is broken if this screw is taken out. Screw A must, of course, be removed if it is desired to take off the cutout cover.

The base of the cutout, which is screwed down to the generator frame, is connected to one end of the voltage coil, but is insulated from all other parts except the cover which fits over it. The other end of the voltage coil is connected to piece H.

The circuit for the voltage coil is: From the ungrounded main generator brush to the generator terminal, through piece T to part H, through the voltage coil to the base I, through the generator frame, thence through the grounded main generator brush and back to the armature.

INSTRUCTIONS APPLYING TO BOTH CUTOUTS.

The contact points should at all times be clean and smooth, and when they are touching each other they should be making contact at all points of their surfaces. They may be cleaned by drawing between them a rag moistened with gasoline, while pressing down on the movable contact. To make them smooth, or to improve the contact, a piece of fine emery cloth, or a very fine file may be used, drawing the emery cloth or file between the contacts while pressing down on the movable contact.

The movable arm which carries one of the contact points is insulated from the base of the cutout, and care must be taken that it does not become grounded to the base.

In prying off the cover of the cutout, be careful to bring it up straight, so as not to touch either contact point with the cover, as this will ground the battery if the cover is touching the base also.

ACTION. The purpose of the cutout is: (1) To connect the generator to the battery automatically as soon as the voltage of the generator is slightly higher than that of the battery. (2) To disconnect the generator from the battery automatically, as soon as the voltage of the generator falls below that of the battery.

THE CUTOUT PERFORMS NO OTHER DUTIES THAN THESE. It does not protect the battery from being overcharged. To accomplish the automatic action of the cutout in connecting the generator to, and disconnecting it from the battery, two windings are placed upon the cutout. One is made of heavy wire and carries all the current delivered by the generator. The other is made of a small wire, and is connected so as to receive the full generator voltage across it. The small wire or voltage coil performs the duty of closing the contact points when the generator voltage is slightly greater than that of the battery. As soon as the contact points close, current flows through the heavy wire winding. As long as the generator is charging the battery, the magnetic effects of both coils act in the same direction, and have a tendency to hold the contact points closed tight. When the voltage of the generator falls below that of the battery, the battery begins to discharge into the generator, and therefore the current through the heavy wire coil of the cutout is reversed. The current in the shunt coil does not reverse its direction. The magnetic effect of the small wire coil and the heavy wire coil are then opposed to one another, and this causes the cutout core to lose its attraction for the movable arm, and hence the points separate and open the circuit between the generator and the battery.

ADJUSTMENT. To properly adjust the cutout, connect an ammeter in series with the generator as shown in Figure 10. Be sure that the generator is delivering current of about 10 amperes. The specific gravity of each cell of the battery should not be less than 1.250. Turn off all the lamps and run the engine on the magneto. With the engine running, gradually close the throttle until the engine runs so slowly that the cutout points open, or separate. The points may be watched to determine when they have separated, or else the pointer on your ammeter may be observed. The pointer will swing past the "0" line on the ammeter scale for an instant just before the cutout opens and will then come back to and remain stationary over the "0" line.

Now gradually increase the speed of the engine, while carefully watching your ammeter pointer. When the generator is running at 600 R. P. M., or the engine is running at a speed that would give a speed of 10 miles per hour on the road, the cutout points should close. There should be a slight movement of the ammeter pointer when the cutout closes, indicating a charge of 2 or 3 amperes. With a further increase of speed, the ammeter pointer should swing across the scale until it is indicating a charge of 10 amperes. This should be the maximum charge.

If, when the cutout closes, your ammeter pointer reads reversed, and thus indicates that the battery starts to discharge into the generator, the cutout is closing before the voltage of the generator is equal to that of the battery. This should be remedied by bending the spring on the movable arm of the cutout so as to make the spring hold this arm up with greater force, requiring a higher generator voltage to close the cutout. Another way is to increase the distance between the points by straightening the bent over piece or hook in the arm a little.

If, when the cutout closes, your ammeter pointer does not move, it indicates that the generator and battery voltages are equal at that instant. The spring on the movable arm should be made stiffer by bending, or the distance between the points should be increased as already described.

If, when the cutout closes, your ammeter pointer indicates the full charging current of 10 amperes, the cutout does not close soon enough. To remedy this, weaken the spring on the movable arm, or decrease the distance between the points.

The cutout is closing at the proper instant if the ammeter pointer indicates a charge of not more than two or three amperes at the instant the points close.

To check the action of the cutout in disconnecting the generator from the battery, decrease the speed of the engine gradually and watch the ammeter pointer. The pointer will move down toward the "0" line and will swing down past it a slight distance before the cutout opens. The distance which the ammeter pointer swings below the "0" line should be such as to indicate a discharge current of not more than two amperes or so before the points open, and the pointer should be below the "0" line for an instant only. Should the pointer indicate a discharge of more than three amperes, or should it remain below the "0" line for more than an instant, the points are not opening soon enough, and the spring on the movable arm should be strengthened.

After making any adjustment on the cutout, be sure to check its action to be sure that it is then working as it should.

5. FORD AMMETER.

LOCATION. The ammeter is mounted on the instrument panel in front of the driver, and to the right of the combined lighting and ignition switch.

PURPOSE. The ammeter is connected so that it will indicate the current flowing in or out of the battery, except that it does not indicate or measure the starting current.

WHEN THE ENGINE IS NOT RUNNING, AND THE LAMPS ARE ALL TURNED OFF, the ammeter pointer should be over the "0" line on the scale, indicating that the battery is neither charging nor discharging. Should the pointer under these conditions indicate that the battery is discharging, by moving to the part of the scale which is marked "Discharge," there is some trouble in the electrical system which should be located immediately, to prevent the battery from running down. Such troubles are described in Chart 1, beginning on page 53.

WHEN THE LAMPS ARE TURNED ON and the engine is not running, the ammeter pointer should move over to the part of the scale marked "Discharge," indicating that the battery is furnishing the current to operate the lights.

WHEN THE ENGINE IS RUNNING, AND THE

LAMPS ARE TURNED OFF, the ammeter pointer should move to the part of the scale which is marked "Charge," showing that the generator is charging the battery. The pointer should indicate a charge of about 10 amperes. If the pointer does not move from the "0" line when the engine is running, it indicates that the battery is not receiving a charging current. Troubles that cause this condition are taken care of in Chart 7, beginning on page 77, and Chart 9, beginning on page 87.

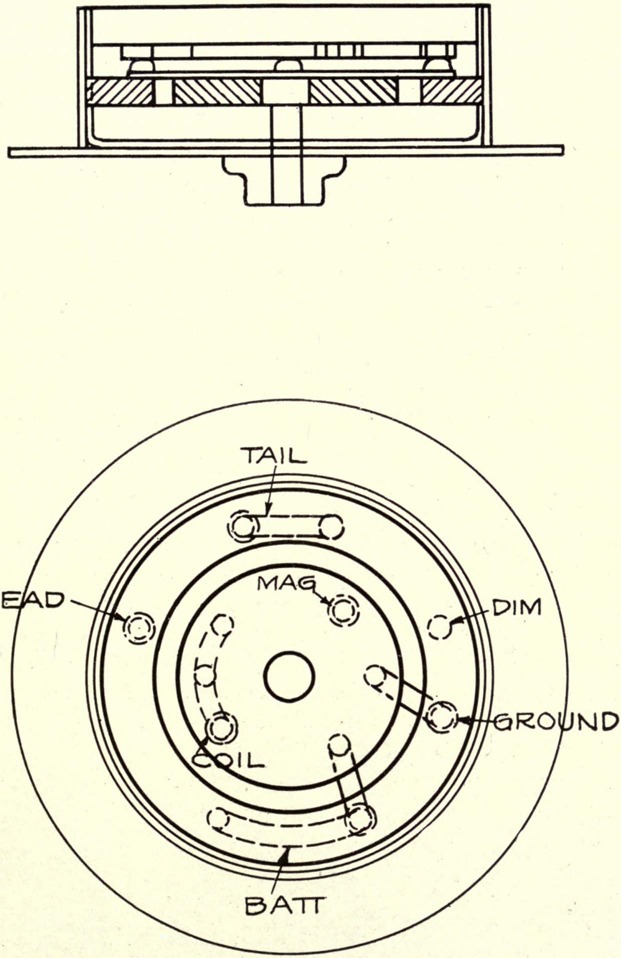
A good way to test the ammeter is to turn on the lights when the engine is not running. If the pointer does not move from the "0" line, the ammeter is defective. Should the pointer move to the part of the scale which is marked "charge," under these conditions, the connections on the studs in the back of the ammeter should be interchanged.

6. LIGHTING AND IGNITION SWITCH.

Several types of switches have been used. On some early models there were several separate push and pull buttons on the dash for controlling the lamps. On somewhat later models the round type switch shown in Figure 17 was used. On still later models the round type switch shown in Figure 18 was used. Each of these round type switches have a handle extending downward from the center of the switch for controlling the lamps. The ignition is switched on or off, and to the battery or the magneto by a key inserted in a key hole in the center of the switch.

In the early type of round switch, several troubles have been found, due to short circuiting between the various terminals. This was done by the wires which are connected to the terminals on the back of the switch (shown in Figure 24) or by trouble inside the switch. The troubles which have been found consist of the following:

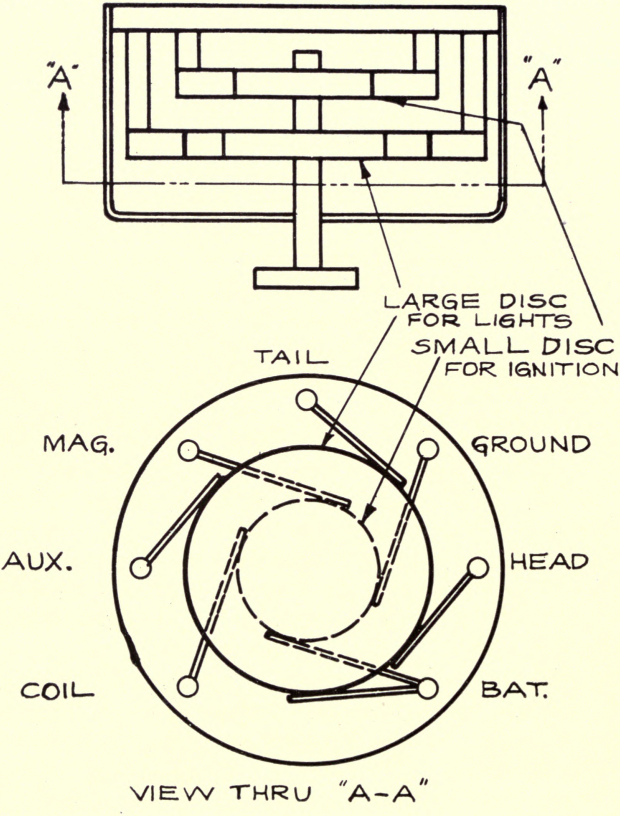
(a) **"COIL" TERMINAL SHORT-CIRCUITED WITH "BAT" TERMINAL.** This trouble makes it impossible to



LIGHTING & IGNITION SW. EARLY TYPE

FIGURE 17.

turn off the ignition, and the engine continues to run after the ignition key is turned to "Off." If the ignition key is turned to the "Mag" position while this short cir-



LIGHTING & IGNITION SWITCH
LATER TYPE

FIGURE 18.

cuit exists, the battery will discharge into the magneto at a rate of about 18-20 amps while engine is not running.

(b) **"HEAD" TERMINAL SHORT-CIRCUITED WITH THE "COIL" TERMINAL.** If the ignition key is turned to the "Mag" position, when engine is running, the lamps burn out. Using the battery for ignition with this short circuit present, makes head lamps burn even if the lighting switch is turned off.

(c) **IF "MAG" TERMINAL SHORT CIRCUITS WITH THE "DIM"** terminal, the small bulbs in the head lamps will burn out.

With the later type of round switch, these short circuits do not occur.

The later type of switch has two movable round discs, one for the ignition, and one for the lights.

When the ignition key is turned to the "Bat" position marked on the front of the switch, the battery will be furnishing the ignition current when starting. When running, the generator will be furnishing the ignition current. With the ignition key turned to the "Mag" position, the Ford magneto is furnishing the ignition current.

If the handle controlling the lights is turned to the "Dim" or "Aux." position, the tail lamp, and the small bulbs in the headlights will burn. With the handle turned to the "On" position, the tail lamp and large bulb in the headlights will burn.

If any of the short circuit troubles listed above occur, the entire panel on which the ammeter and switch are mounted may be removed by taking out the four screws in the corners of the panel. The wires attached to the back of the switch should be inspected carefully to make sure that they are not causing the trouble. The entire rear cover may be removed from the switch in order to look for internal short circuits.

7. STARTING SWITCH.

LOCATION. Under the floor boards in front of the driver.

PURPOSE. The only duty of the starting switch is to connect the starting motor to the battery when it is desired to have the motor crank the engine. The switch is closed by pushing down on it with the foot. The switch plunger is held in the open position by a spring, which opens the switch when the foot is removed from the top of the plunger. The plunger is insulated from the switch. Should this insulation become defective the battery will be short-circuited when the plunger is pushed down. This will run the battery down and burn the switch contacts.

CONSTRUCTION. The starting switch housing is in two parts held together by two flat head screws. The top part contains the plunger and the lower part contains two contact plates. Be sure to keep the space between the contact plates in the lower part of the switch free from dirt of any kind.

Any burning or pitting caused by arcing when the starting circuit is opened or closed should be removed with sandpaper or emery cloth.

The starting cables are fastened to terminals on the lower part of the switch. It is essential that all terminal connections in the starting circuit should be perfectly clean and tight, because a loose connection might cause such a drop of voltage when cranking the engine with the motor that the motor will not crank the engine fast enough.

8. LAMPS.

In the headlights are two National Mazda 6-8 volt, 17 candle power lamps, and two 6-8 volts, 2 candle power lamps. The tail lamp is a 6-8 volt, 2 candle power lamp also.

9. WIRING.

The wiring is shown clearly in Figures 19, 20 and 21. From the battery a heavy cable leads to the starting switch. A second heavy cable leads from the starting switch to the starting motor. At the right hand side of the dash under the engine hood, as you face the dash, is

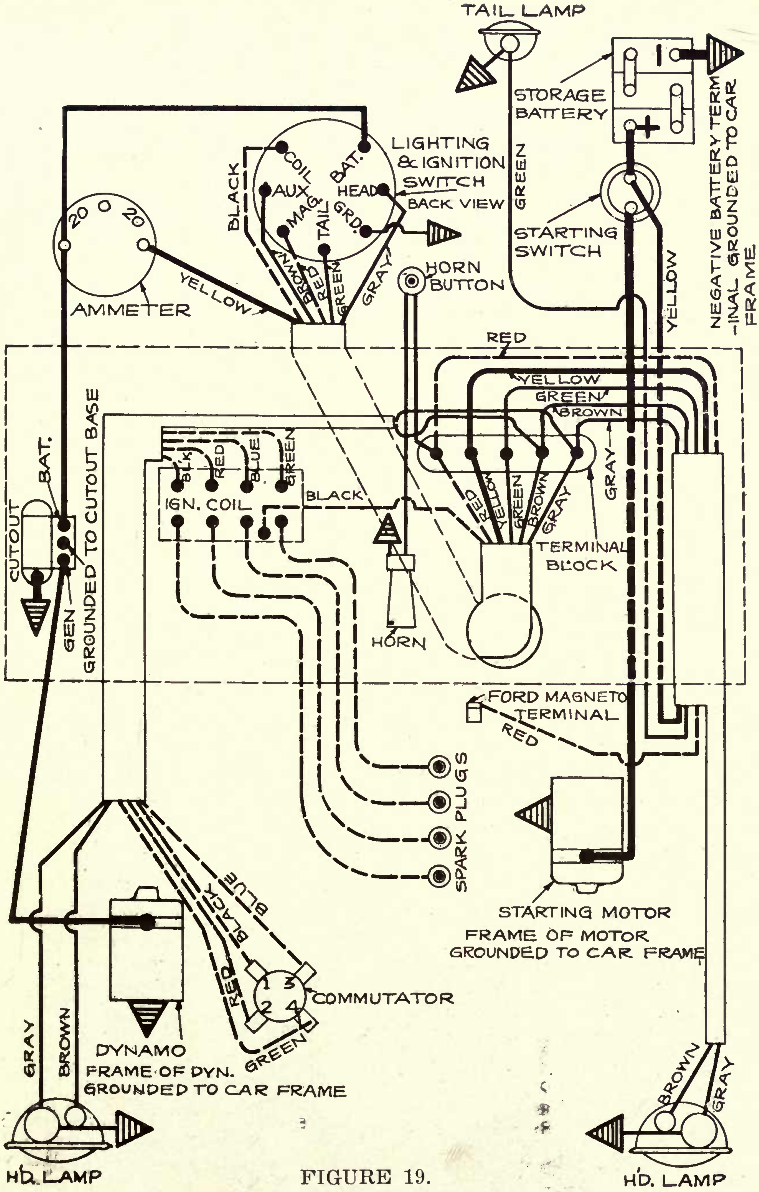
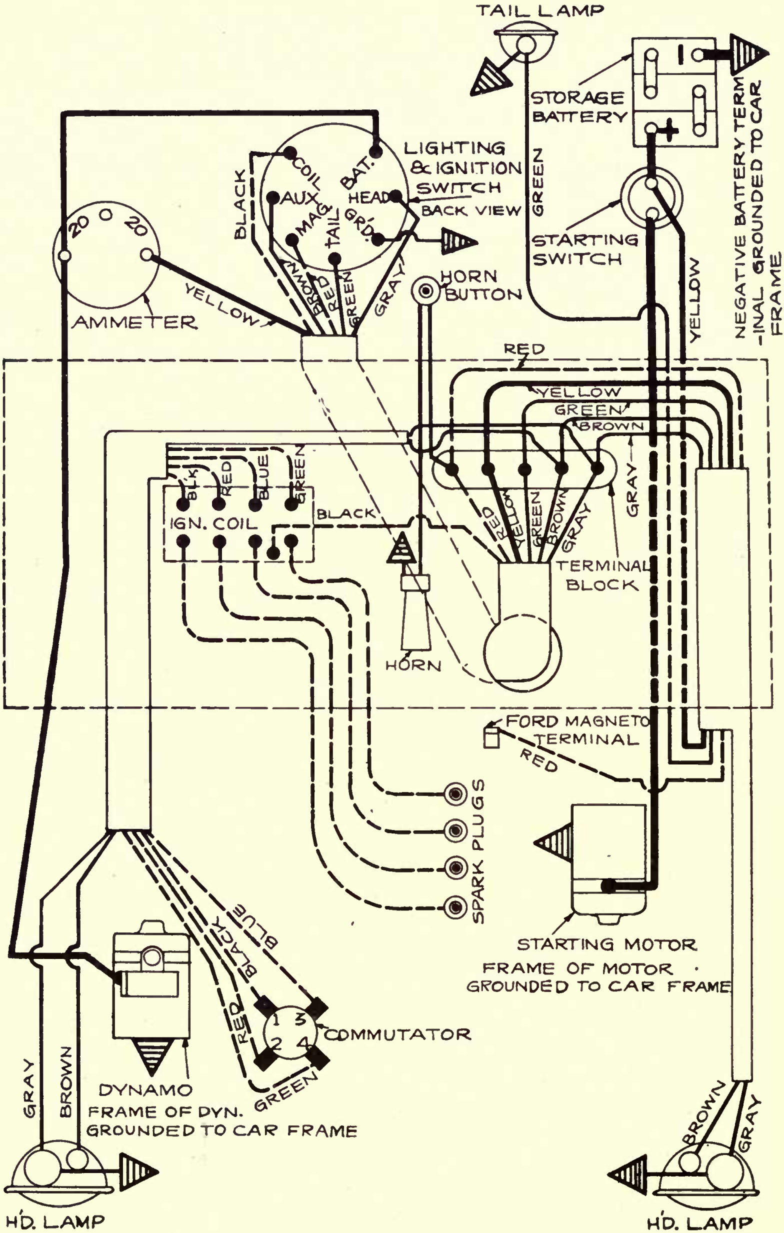

TAIL LAMP
STORAGE BATTERY
LIGHTING & IGNITION SWITCH BACK VIEW
COIL
BAT.
AUX.
HEAD
MAG.
TAIL
GRD.
BLACK
GREEN
AMMETER
20 0 20
YELLOW
BROWN
RED
GRAY
HORN BUTTON
STARTING SWITCH
NEGATIVE BATTERY TERM-INAL GROUNDED TO CAR FRAME
RED
YELLOW
GREEN
BROWN
GRAY
BAT.
CUTOUT
GEN
GROUNDED TO CUTOUT BASE
BLK
BLUE
IGN. COIL
BLACK
TERMINAL BLOCK
HORN
FORD MAGNETO TERMINAL
SPARK PLUGS
STARTING MOTOR
FRAME OF MOTOR GROUNDED TO CAR FRAME
COMMUTATOR
DYNAMO
FRAME OF DYN. GROUNDED TO CAR FRAME
HD. LAMP
HD. LAMP

FIGURE 19.


TAIL LAMP
STORAGE BATTERY
NEGATIVE BATTERY TERM-INAL GROUNDED TO CAR FRAME
LIGHTING & IGNITION SWITCH BACK VIEW
COIL
BAT.
AUX
HEAD
MAG
GRD.
TAIL
BLACK
BROWN
RED
GREEN
GRAY
YELLOW
20 0 20
AMMETER
HORN BUTTON
STARTING SWITCH
RED
YELLOW
GREEN
BROWN
GRAY
BLK
BLUE
IGN. COIL
BLACK
TERMINAL BLOCK
HORN
FORD MAGNETO TERMINAL
SPARK PLUGS
STARTING MOTOR
FRAME OF MOTOR GROUNDED TO CAR FRAME
COMMUTATOR
DYNAMO
FRAME OF DYN. GROUNDED TO CAR FRAME
H'D. LAMP
H'D. LAMP

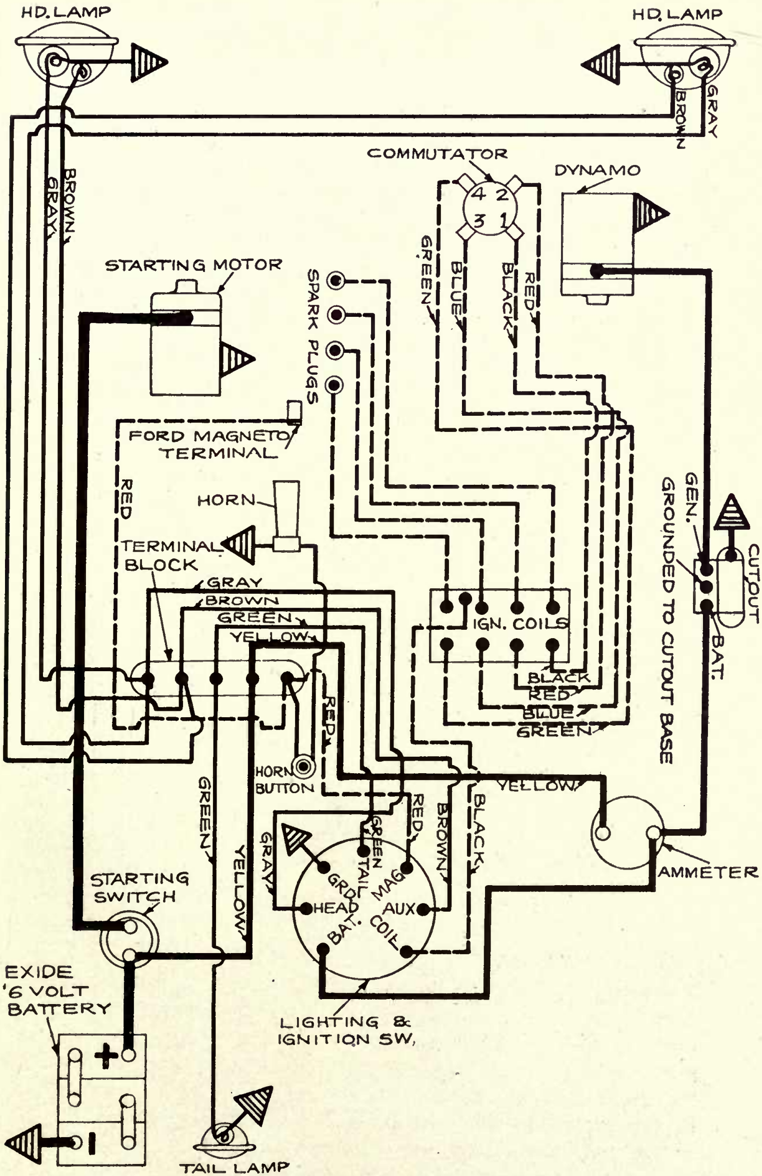

HD. LAMP
HD. LAMP
GRAY
BROWN
BROWN
GRAY
COMMUTATOR
4 2
3 1
DYNAMO
GREEN
BLUE
BLACK
RED
STARTING MOTOR
SPARK PLUGS
FORD MAGNETO TERMINAL
RED
HORN
TERMINAL BLOCK
GRAY
BROWN
GREEN
YELLOW
IGN. COILS
GEN.
GROUNDED TO CUTOUT BASE
CUTOUT
BAT.
BLACK
RED
BLUE
GREEN
RED
HORN BUTTON
YELLOW
GREEN
GRAY
YELLOW
GREEN
TAIL
RED
BROWN
BLACK
GRD.
MAG.
HEAD
AUX.
BAT.
COIL
AMMETER
STARTING SWITCH
EXIDE
6 VOLT
BATTERY
LIGHTING & IGNITION SW.
TAIL LAMP

FIGURE 19b.

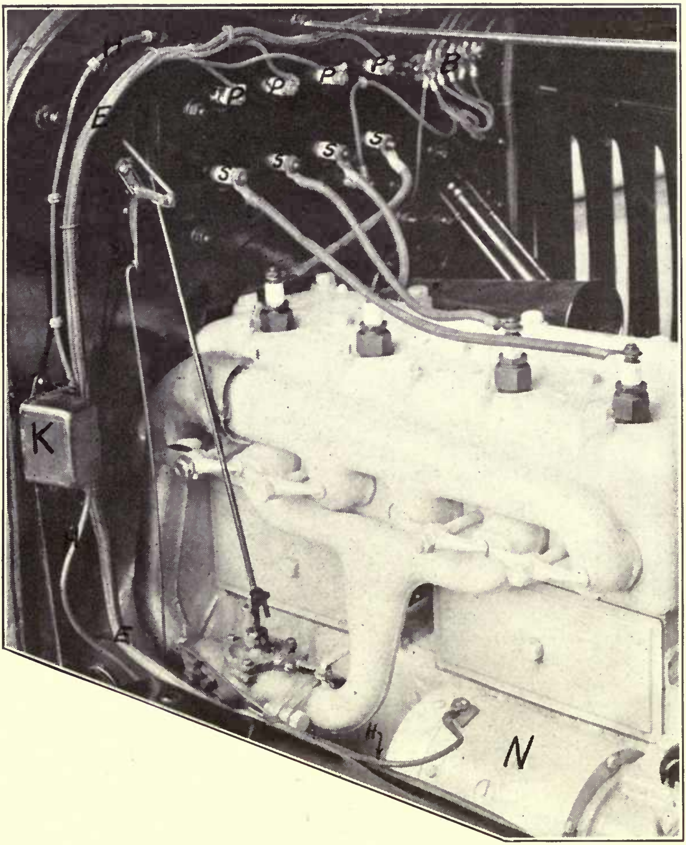


FIGURE 20.

FA INSTALLATION ON FORD CAR.

B is the terminal block. E is cable carrying ignition wires leading from the low tension, or primary terminals, P, on the ignition coils to the commutator. It also carries two wires for the right headlamps. H is wire leading from generator to cutout terminal marked "Gen", and from cutout terminal marked "Bat" to the Ford ammeter on the instrument panel in front of the driver. K is the cutout. This may also be mounted directly on top of the generator. N is the generator.

S are terminals connected to one end of the high tension winding of each Ford Ignition Coil.

a multiple conductor cable, shown at C in Figure 21, which consists simply of five insulated wires covered with one braid. These wires in this cable are connected to the starting switch, tail light, Ford magneto, left headlight and the terminal board at the right side of the dash under the engine hood as you look at the dash from the front of the car. The wires have different colored insulations as shown in Figure 19. The purpose of this is to enable one to trace the circuits by means of the colors.

The terminal board (shown at B in Figure 21) carries five terminals to which are connected the wires from the cable mentioned in the preceding paragraph, and the wires from a second cable (shown at D in Figure 21) which leads to the ammeter and combined lighting and ignition switch.

Near the center of the dash are the terminals of the four ignition coils, there being one coil for each engine cylinder. The lower set of terminals (shown at S in Figures 20 and 21) are connected to the high tension windings of the coils and have cables attached to them which lead to the spark plugs. The upper row of terminals (shown at P in Figures 20 and 21) are connected to the low tension windings of the ignition coils. Attached to the upper terminals are wires with colored insulations that go into a cable (shown at E in Figure 20) which leads down and forward to the ignition commutator and the right head lamp. The cables are all covered with a cloth braid insulation, no metallic conduits or coverings of any kind being used.

CIRCUITS.

1. **STARTING CIRCUIT.** From the positive (+) battery terminal to the starting switch, to the terminal on top of the starting motor, through the motor field coils,

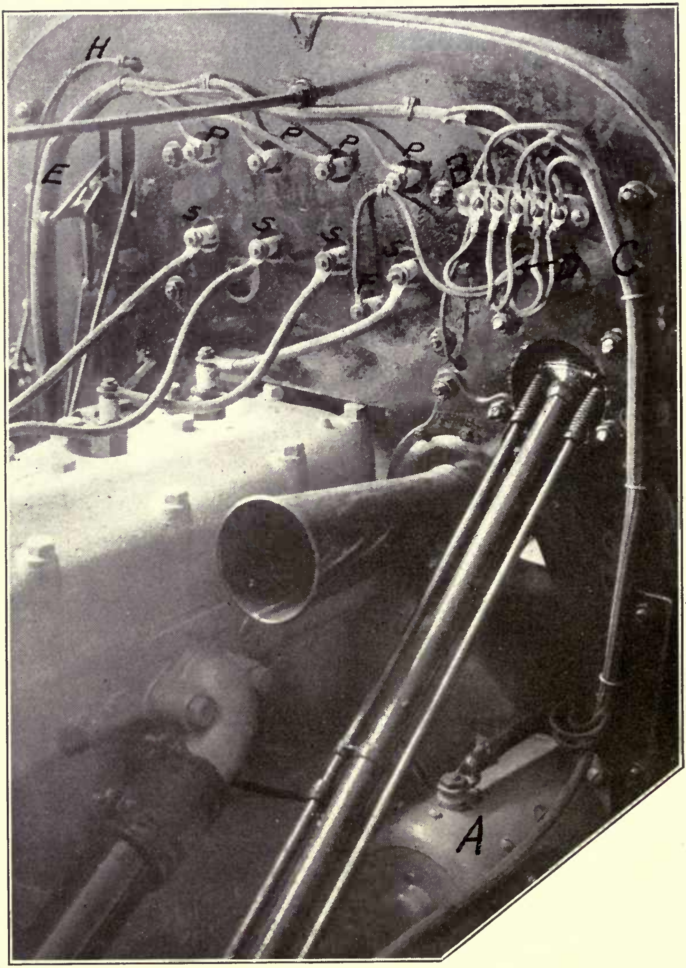


FIGURE 21.

FA INSTALLATION ON FORD CAR.

A is the Starting Motor. B is the terminal block. C is cable containing wires leading from terminal block to Ford magneto, tail lamp, left hand lamps, and starting switch. D is cable containing wires leading from the terminal block to *the Ford ammeter and the combination lighting and ignition switch on the instrument panel in front of the driver. E is cable containing wires leading from low tension, or primary ignition coil terminals, marked P, to the commutator. One end of each high tension winding is also connected to P. It also contains two wires leading from terminal block as shown, to the right headlamps. F is common terminal which is connected to one end of the low tension or primary winding of each Ford ignition coil. H is wire leading from cutuot to Ford ammeter on the instrument panel in front of the driver. S are terminals connected to one end of the high tension, or secondary winding of each Ford Ignition Coil.*

through the motor armature by means of the two ungrounded brushes, to the frame of the motor through the two grounded brushes, through the motor frame into the car frame, through the car frame back to the cable from the negative (—) battery terminal which is attached to the frame, through this cable to the negative (—) terminal on the battery.

2. **IGNITION CIRCUITS.** a. When Using the Battery. From the positive terminal on the battery to the starting switch, along the yellow wire attached to the starting switch to the second terminal from the left on the terminal board, along the second yellow wire attached to this terminal down into the cable that goes through the hole in the dash just below the terminal board, up to the ammeter, through the ammeter to the "Bat" terminal on the back of the lighting switch, through the switch to the "Coil" terminal on the back of the switch, through the black wire attached to this switch terminal to the terminal in the lower right hand corner of the set of ignition coil terminals on the dash, through the low tension windings and the vibrators on the ignition coils, out by the upper row of ignition coil terminals, through the wires that go into the cable that leads to the ignition commutator, and to ground. If the ignition key is turned to the "Bat" position when the engine is running at 15-

20 miles per hour, the generator will furnish the ignition current. In this case the circuit is the same as that of the charging current as far as the ammeter. From the ammeter the circuit is the same as for the battery ignition current.

This completes the low tension part of the ignition circuit. The high tension part starts in the high tension windings of the ignition coils, goes out at the lower row of coil terminals, along the cables to the spark plugs, across the gaps, to the engine, then back to the coil through the commutator and along wires that lead from one end of the low tension winding of the coil to the commutator. One end of the high tension winding is therefore connected to one end of the low tension winding. The internal coil connections are shown in Figure 42, page 115.

b. When using the Ford Magneto. From the terminal on top of the magneto, through the red wire attached to this terminal, into the cable at the right hand side of the dash, as you look at the dash from front end of car, to the left hand terminal on the terminal board, along the second red wire attached to this terminal, through the cable which passes through the dash just below the terminal board, to the terminal on the back of the lighting and ignition switch which is marked "Mag", through the switch to the terminal on the back of the switch which is marked "Coil," and then through the same wires and paths already described for the battery ignition current.

3. **CHARGING CIRCUIT.** (For cars with cutout on dash. For circuits of new cutout, see page 55.) From the armature of the generator through the cutout, through the insulated upper frame work of the cutout, through the cutout contact points, through the heavy wire winding on the cutout to the "Bat" terminal on the cutout, through the black wire attached to the cutout to the ammeter,

through the ammeter and the yellow wire which is attached to the ammeter, and which leads into the cable containing the wires attached to the back of the lighting and ignition switch, to the second terminal from the left on the terminal board into the cable at the right side of the dash, as you look at dash from front of car, along the yellow wire coming from the lower end of this cable to the starting switch, along the heavy starting cable to the positive (+) battery terminal, through the battery and out at the negative (—) terminal, through the cable fastened to the negative (—) battery terminal, into and through the car frame, through the frame of the generator, into the generator brush ring, through the grounded main generator brush, and back into the armature.

4. **LIGHTING CURRENT.** From the battery to the "Bat" terminal on the back of the lighting and ignition switch, through the same wires as for the battery ignition current. From the switch the circuits are as follows:

(a) Large Bulbs in Headlights. From the "Head" terminal on the back of the lighting switch along the gray wire attached to this terminal, down into the cable which connects the switch and ammeter to the terminal board, to the right hand terminal on the terminal board. From this terminal one gray wire goes into the cable at the right hand side of the dash (facing the dash), then to the large bulb in the left hand headlight, through the bulb into the frame of the car, through the frame of the car back to the negative battery terminal. A second gray wire leads from the right hand terminal on the terminal board into the cable at the opposite side of the dash and to the large bulb in the right hand headlight, through the bulb, through the frame of the car, and back to the negative battery terminal.

(b) Small Bulbs in the Headlights. From the "Aux" or "Dim" terminal on the back of the lighting switch, along the brown wire attached to this terminal into the cable that connects the terminal board to the lighting switch and ammeter, to the second terminal from the right on the terminal board (facing the terminal board). From here two brown wires lead. One goes into the cable at the right hand side of the dash (facing the dash), thence directly to the small bulb in the left headlight, through the small bulb, through the frame of the car and back to the negative battery terminal. The second brown wire leads from the terminal board into the cable at the left hand side of the dash (facing the dash), thence directly to the small bulb in the right hand head lamp, through the bulb, through the frame of the car back to the negative terminal of the battery.

(c) Tail Lamp. From the terminal on the back of the lighting switch which is marked "Tail," along the green wire which is attached to this terminal, into the cable which connects the terminal board to the ammeter and lighting switch, through this cable to the third terminal from the left on the terminal board, along the second green wire which is attached to this terminal down into the cable at the right hand side of the dash (facing the dash), out of this cable at the lower end and along the green wire directly to the tail lamp bulb, through the bulb to the frame of the car, through the frame of the car back to the negative battery terminal.

5. **GENERATOR FIELD CURRENT.** From the third brush to the upper left hand field coil (facing the terminal end of the generator) through this field coil to the upper right hand coil, through the upper right hand coil to the lower right hand coil, through the lower right hand coil to the lower left hand coil, through the lower left hand coil to the grounded main brush, through the armature windings back to the third brush.

TROUBLES IN THE STARTING AND LIGHTING SYSTEM.

Troubles that occur in the electric starting and lighting system may be classified as follows:

1. Troubles that occur when the engine is not running and all lamps are off.

2. Troubles that occur when the engine is not running and the lamps are turned on.

3. Troubles that occur when the engine is running and the lamps are turned off.

4. Trouble with the starting motor, or in the starting motor circuit.

These four classes will include any troubles that may arise in the starting and lighting system. These troubles may be best handled by a set of instructions which we may call Charts. In the Ambu Electric Trouble Shooter, there are twelve such charts and the same system will be followed here. Considering the four classifications just given, we have:

1. **ENGINE NOT RUNNING, LAMPS OFF.** Under these conditions, every electrical part and unit on the car should be at rest and there should be no flow of current anywhere. Since the generator is now at rest, it cannot deliver any current. The battery, however, is capable of delivering a current, and therefore the only trouble that can occur under these conditions consists of a flow of current from the battery, the causes of which are taken up in Chart No. 1, page 53.

2. **ENGINE NOT RUNNING, LAMPS ON.** Troubles that can occur under these conditions are all concerned with the lighting system. The lights may or may not be drawing the proper current from the battery. If all the lights burn satisfactorily, and draw the proper current from the battery, no trouble is present. If the lamps do not draw the right amount of current, they may be drawing none at all, too much current, or not enough current. These conditions are taken care of in charts 3, 4 and 5 on pages 65, 69 and 71, respectively.

3. **ENGINE RUNNING, LAMPS OFF.** Troubles that occur under these conditions affect the charging circuit, consisting of the generator, cutout, ammeter, battery, and the wires that carry the charging current from the generator to the battery.

We may have the correct charging current, which, of course, is not a condition of trouble. We may have no charging current, not enough charging current, too much charging current, or else the current in the charging circuit may be reversed. These troubles are taken care of in Charts 7, 8, 9 and 10, on pages 77, 84, 87 and 103, respectively.

4. **STARTING TROUBLE.** The duty of the starting motor is to crank the engine. If it fails to do this, there is trouble in the motor itself, in the circuit between the motor and the battery, or in the battery. These troubles are taken care of in Chart 12, page 107.

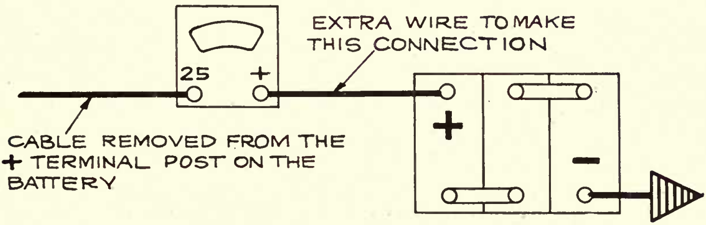
TESTING FOR TROUBLE. All troubles in the starting and lighting system affect the flow of current in or out of the battery, especially in the first three of the four classes just described. Therefore, the best way to make tests in locating troubles is to connect an ammeter in series with the battery. This is the method used in the Ambu Electric Trouble Shooter. The Ambu instrument is a combined ammeter and voltmeter. Directions for using it are given in a special Ambu Instruction Book. The instrument is connected in series with the battery, using the 25 ampere scale. This is done by removing the cable from the positive terminal post on the battery, and then connecting the cable to one terminal of the instrument, and connecting the positive post of the battery to the other terminal on the instrument, as shown in Figure 22. With the instrument connected in this manner, all current passing in or out of the battery must now pass through your ammeter. This ammeter will hereafter be referred to as "your ammeter," to distinguish it from the ammeter mounted on the dash of the car, which will be referred to as the "Ford ammeter."

With your ammeter connected in series with the battery, make three tests under the following conditions:

1. ENGINE NOT RUNNING, LAMPS OFF.
2. ENGINE NOT RUNNING, LAMPS ON.
3. ENGINE RUNNING, LAMPS OFF.

Let us now make these tests:

1. **ENGINE NOT RUNNING, LAMPS OFF.** Make sure that the ignition and all the lamps are switched off. Now look at the pointer on your ammeter. If the pointer



HOW TO CONNECT METER IN SERIES WITH BATTERY IN ORDER TO MAKE TESTS ON STARTING & LIGHTING SYSTEM

FIGURE 22.

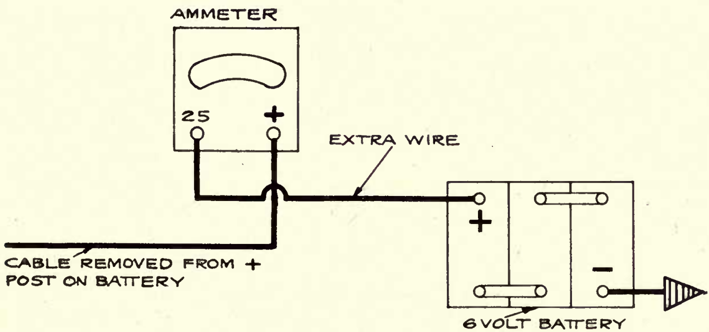
moves backward, see Chart 2, page 64. If it moves from the "0" line on the scale, indicating that current is flowing through your ammeter, turn to Chart 1, page 53. Here you will find a diagram of that part of the electrical system in which the trouble causing the flow of current may exist. Below the diagram begins a set of instructions for finding the trouble. If the pointer does NOT move, no trouble is present, and you should proceed to make the next test.

2. **ENGINE NOT RUNNING, LAMPS ON.** Turn the handle on the lighting switch to the "ON" position. Then look at the pointer on your meter. It should be over the "5.4" ampere line on the scale. Should the

pointer not move, the entire lighting system is dead, and no lights burn. If this is the case, see Chart 3, which begins on page 65. Should the pointer indicate much less than 5.4 amperes, see Chart 5, which begins on page 71. Should the pointer indicate more than 5.4 amperes, see Chart 4, beginning on page 69. Now turn the handle of the lighting switch to the "Dim" position. This will cause the tail light, and the small bulbs in the head lamps to burn. The ammeter pointer should move to the 1.25 ampere line on the scale. If it indicates less current than this, see Chart 5, beginning on page 71. If it indicates more current than this, see Chart 4, beginning on page 69. Having consulted one of these charts, according to the above instructions, in case the pointer did not indicate 1.25 or 5.4 amperes, and having followed the instructions in the Chart which you consulted, you will have found any trouble which may have existed in the lighting circuits and are now ready to make the third test.

3. **ENGINE RUNNING, LAMPS OFF.** Turn the handle of the lighting switch to the "Off" position. Short circuit your ammeter, or remove it temporarily, and replace the battery cable in the positive (+) battery terminal post. The purpose of this is to prevent the heavy current drawn from the battery by the starting motor from damaging your ammeter. Turn the ignition key to the "Bat" position, and start the engine with the starting motor. As soon as the engine is running under its own power, turn the ignition key to the "Mag" position. Then connect your ammeter in series with the battery as before, but reverse the connections to the meter, as current is now being delivered to the battery instead of being drawn from it. The cable removed from the battery should now be connected to the "+" terminal on your ammeter, and the positive battery post to the "—" or "25" terminal on your ammeter (see Figure 23). Be careful to connect in your ammeter as quickly as possible, as the generator must not be run except for a

very short time only with the charging circuit open. With the engine running at a speed which would drive the car on the road at 20 miles per hour in high gear, look at the pointer of your ammeter. It should be over the 10 ampere line on the scale, and should move in the same direction from the "0" line as it did when the test was made with the Engine Not Running, and the Lamps On. If the pointer moves in the opposite direction to this, the current in the charging circuit is flowing in the wrong direction and Chart 8, begin-



CONNECTIONS OF METER IN MAKING TEST "ENGINE RUNNING, LAMPS OFF"

FIGURE 23.

ning on page 84, should be consulted. If the pointer moves in the right direction, but does not move as far as the 10 ampere line, consult Chart 9, beginning on page 87. If the pointer moves in the right direction, but moves farther than the 10 ampere line, consult Chart 10, beginning on page 103. If the pointer does not move at all, consult Chart 7, beginning on page 77.

IF THE POINTER FLUCTUATES. If, in making any test, the pointer does not come to rest, but moves about in an irregular, jerky manner, consult Chart 11, beginning on page 105.

STARTING TROUBLE. If the starting motor fails to crank the engine satisfactorily, consult Chart 12, beginning on page 107. It is not necessary to measure the starting current, as the current may vary from 140 to 300 amperes and still there may be no trouble in the starting motor or its circuit.

SPECIAL NOTES ON TROUBLES.

SYMPTOMS. Generator stops charging suddenly as engine is speeded up. This has been found to be due in most instances to spring on third brush being weak, or high mica on commutator. The third brush breaks contact with commutator at the high speeds.

Consult page 32, for troubles caused by short circuits on the back of the old style lighting switch.

SPECIAL INSTRUCTIONS.

1. IF LAMPS BURN OUT WHEN THEY ARE TURNED ON WHILE ENGINE IS RUNNING AT SPEED CORRESPONDING TO 20 MILES PER HOUR IN HIGH SPEED, there is a loose connection between the battery and lighting switch, or else the generator is charging at too high a rate. Connect ammeter in series with battery, turn off the lamps, and read charging current. If this amounts to less than 10, or if there is no charging current, see Chart 7, page 77. If it is more than 10 amperes, see Chart 10, Page 103.

Also examine the battery by removing the vent cap from each cell. Look down into each cell, and if the level of the electrolyte has fallen below the tops of the plates, pour in distilled water until it covers plates about ⅜ of an inch.

2. IF LAMPS BURN DIMLY WHEN ENGINE IS NOT RUNNING, AND BURN OUT IF TURNED ON WHILE ENGINE IS RUNNING, follow the same instructions given above in Section 1.

ENGINE NOT RUNNING
LAMPS OFF

FORD—CHART 1
F. A. SYSTEM

TO BE CONSULTED IF THERE IS A DISCHARGE OF CURRENT FROM THE BATTERY, WHICH SHOULD NOT TAKE PLACE WITH THE ENGINE NOT RUNNING, AND THE LIGHTING AND IGNITION SWITCHES TURNED OFF.

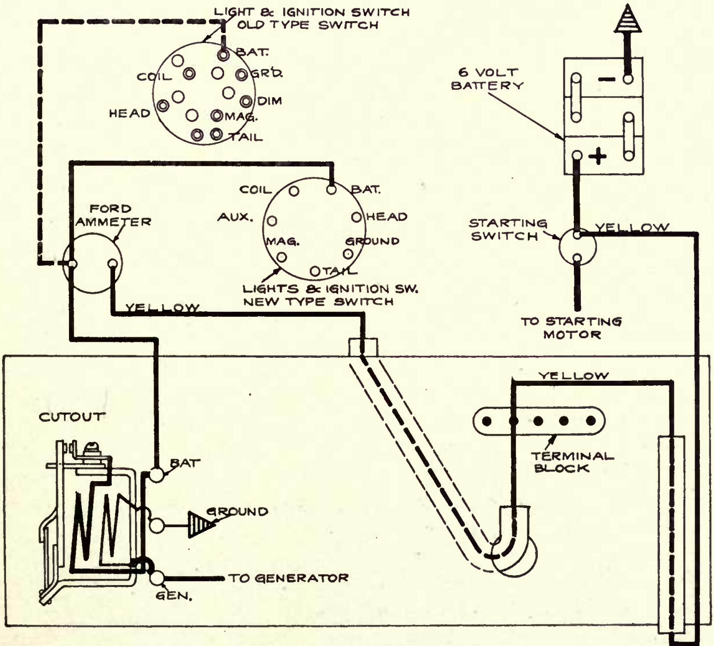


FIGURE 24.

FOR CARS HAVING CUTOUT ON DASH.

NOTE. First inspect all the wiring for damaged insulation which allows the wires to make contact with the metal of the car. If none is found, proceed with the following instructions.

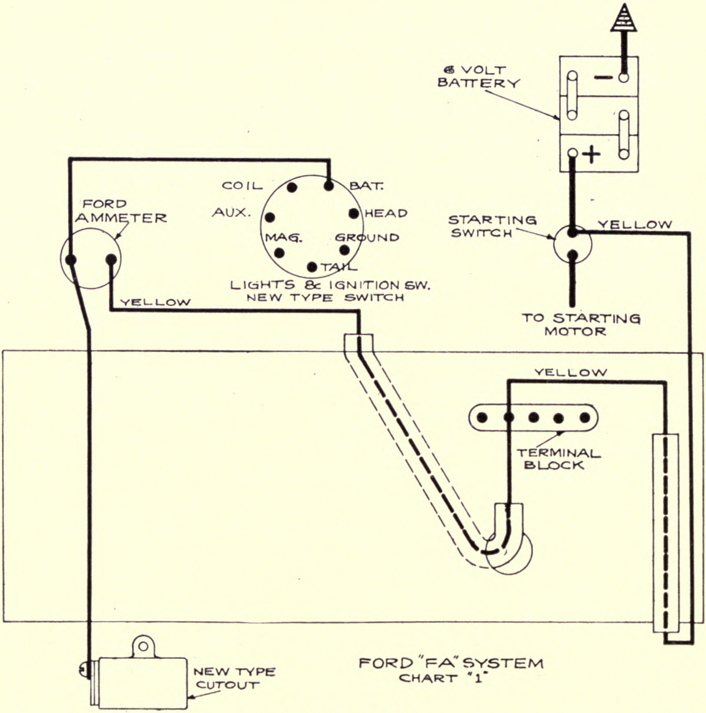


FIGURE 24a.
FOR CARS HAVING CUTOUT ON GENERATOR.

A. CLOSED CUTOUT OR OTHER CUTOUT TROUBLE. The cutout is either mounted on top of the generator, or else is mounted on the dashboard just inside the engine hood to the right of the engine.

TESTS FOR CUTOUT WHICH IS MOUNTED ON THE DASH.

TEST. Remove the wire from the "Bat" terminal of the cutout. Then look at your ammeter. If ammeter pointer now goes back to the "0" line, read the instructions given in the next "Remedy" paragraph. If the pointer does not return to the "0" line, consult Section B.

CHART 1

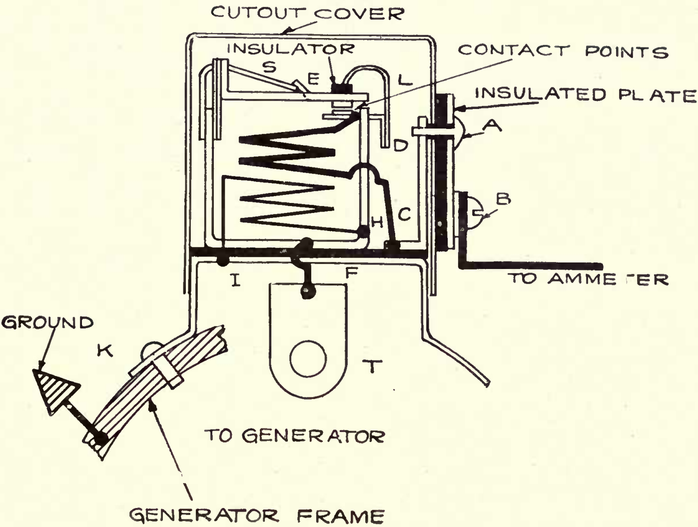


FIGURE 24b.

INTERNAL CONNECTIONS OF CUTOUT MOUNTED ON GENERATOR

REMEDY. There is trouble in the cutout. Replace the wire which you removed from the "Bat" terminal on the cutout. If the pointer does not now move away from the "0" line, the trouble was caused by the cutout contact points having been closed, but opening when the wire was removed from the "Bat" terminal. The contact points should be made smooth with fine emery cloth or a fine tooth file so that they will not stick together when the engine is stopped the next time.

If the pointer again moved away from the "0" line when you replaced the wire on the "Bat" terminal on the cutout, pry off the cover with the tip of a screwdriver. Examine the contact points which are under the movable arm at one end. You will probably find that they are stuck together. If this is the case separate them and make them perfectly smooth with fine emery cloth or a fine toothed file so they will not stick together the next time the engine is stopped. Make sure of this by starting the engine, running it fast enough to close the cutout and then stopping it and examining the points to see whether they still stick together.

If you found that the cutout contact points were not stuck together, there must be trouble in the cutout windings. These may be tested for as described below, using a circuit tester made of a lamp as shown on page 57, Figures 25 or 26.

(a) CURRENT COIL TROUBLE—TEST. Remove the wires which are connected to the "Gen" and "Bat" terminals. Now hold one test point on the "Bat" terminal, and hold the other test point on the middle terminal on the cutout. If the lamp lights consult the next paragraph starting "Remedy". If the lamp does not light consult Section B.

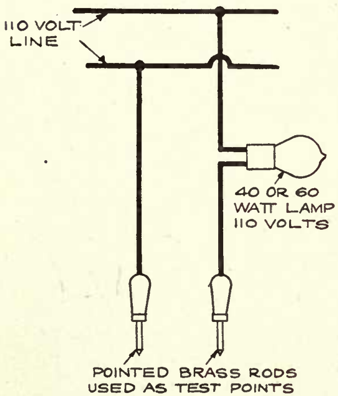
REMEDY. There is a ground in the current coil, or the current coil is short circuited with the voltage coil, or else the stationary cutout contact point is making a metallic connection with the part on which it is mounted.

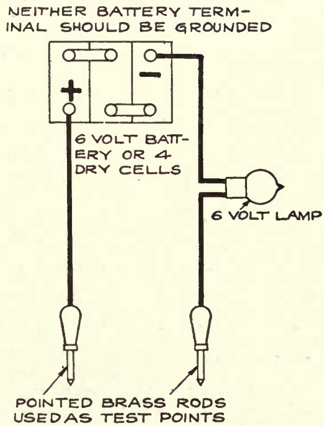
Remove the screw which holds the stationary contact point in place. Hold this contact point clear of any other metal part of the cutout, and repeat the test by holding one test point on the "Bat" terminal, and the other on the middle terminal on the cutout. If the lamp lights, the trouble is still present. If the lamp now does not light, the stationary contact point was grounded to the part on which it was mounted, and new insulation should be put under it.

If the lamp lighted, disconnect the heavy wire from the under side of the "Bat" terminal on the cutout. Now hold one test point on the wire which you removed from the "Bat" terminal, and hold the other test point on the middle terminal on the cutout. If the lamp lights the current coil is grounded, or else short circuited to the voltage coil. If the lamp lighted, it will be necessary to unwind the coils of the cutout until the short-circuit or ground is found, and the wires reinsulated at this point and rewound. If new cutouts are available, it will be best to put in a new one. If the lamp does not light, the "Bat" terminal is grounded to the base of the cutout, and new insulation should be put under it.

TESTS FOR CUTOUT MOUNTED ON GENERATOR—TEST. Remove the wire from the cutout terminal. Then look at your ammeter. If the pointer has now gone back to the "0" line on the scale, read the instructions starting with the following "Remedy" paragraph. If the pointer has not returned to the "0" line, consult Section B.

REMEDY. There is trouble in the cutout. Replace





TWO WAYS OF MAKING A CIRCUIT TESTER, USING A LAMP

FIGURE 25. FIGURE 26.

the wire on the cutout terminal. If pointer now does not move away from the "0" line on your ammeter, consult paragraph (a) below. If pointer again moves away from the "0" line when you replace the wire on the cutout, consult paragraph (b) below.

(a) **CUTOUT FAILED TO OPEN THE LAST TIME ENGINE WAS STOPPED.** If pointer does not move away from the "0" line as you replace this wire, the cutout contact points were closed but they separated when you removed the wire from the cutout. The cause of the points being closed may have been as follows:

If, when the engine is running, and the generator is charging the battery, the generator circuit between the generator and the cutout is suddenly opened by the breaking of a wire, by a brush being suddenly stuck in its holder so as to prevent it from touching the commutator, etc., the cutout will probably remain closed. The battery will send enough current through the voltage coil of the cutout when the generator circuit is suddenly opened to keep the cutout closed. The sudden opening of the generator circuit prevents the battery from beginning to discharge back into the generator, which would reverse the current through the current coil of the cutout. This reverse current is necessary to demagnetize the cutout, and cause the spring to pull the contacts apart. When you removed the wire from the cutout, the battery was disconnected from the voltage coil and the spring therefore opened the cutout. Replacing the battery wire on the cutout will not cause it to close again because the points must be closed before the battery can send current into the voltage coil.

(b) **CUTOUT CONTACT POINTS STUCK TOGETHER, OR OTHER CUTOUT TROUBLE.** If pointer on your ammeter again moved away from the "0" line when you replaced the wire on the cutout, take out the screw in the cover which is marked "A" in Figure 24B. Then pry off the cutout cover. If your ammeter pointer goes back to "0" when you remove the cover and hold the cover away from any metallic part of the car one of the following troubles may be present:

(c) **CONTACT POINTS STUCK TOGETHER.** If you find the contact points to be stuck together, force them apart and make them perfectly smooth by drawing a piece of fine emery cloth or a fine toothed file between them, so that they will not stick together again the next time the engine is stopped. Make sure of this by replacing the cutout cover, running the engine (see precautions, page 50, about short circuiting your ammeter) fast enough to close the contact points, and then stopping the engine. If your ammeter pointer now does not move away from the "0" line, the contact points did not stick together.

(d) **COVER SCREWS A OR B (SEE FIGURE 24B) GROUNDED TO CUTOUT COVER—TEST.** With the wire still attached to screw B on the cutout cover, touch the cutout cover to the oiler at the rear end of the generator so as to ground it. If the pointer on your ammeter now moves away from the "0" line again, screw B is grounded to the cutout cover. If the pointer does not move from the "0" line, push screw "A" through its hole in the cover and hold it in place firmly. Now touch the cutout cover to the oiler at the rear end of the generator again. If pointer on your ammeter now moves away from the "0" line, screw "A" is grounded to the cover. If pointer does not move in either test, see (e) below.

REMEDY. Renew the insulation under screws A and B, or see if holes in cover are so small that screws touch cover when they are screwed in.

(e) **PIECE C (SEE FIGURE 24B) OR CURRENT COIL ON CUTOUT GROUNDED—TEST.** Use a lamp circuit tester as shown in Figure 25 or 26, page 57. Hold one test point on piece C and hold other test point on the base of the cutout. If lamp lights, piece C or current coil are grounded to the base, or current coil is short circuited with voltage coil, and following "Remedy" should be consulted.

REMEDY. Carefully inspect the ends of the wire of the current coil. See that they do not touch anything but pieces C and D (see Figure 24B) to which they are soldered. If these wires are clear from all other parts, unsolder them from pieces C and D. Test pieces C and D for ground by holding one test point on base of cutout and holding other test point on each piece, C and D separately. If lamp lights as either C or D are tested, that piece is grounded to the base, and the insulation is defective and must be replaced.

If pieces C and D are not grounded, the current coil is grounded to part M or is short circuited with the voltage coil. In either case, it is best to install a new cutout. If you want to repair the cutout, take it apart by removing the screw which turns up into the cutout from beneath. Unwind the coils until the defective insulation is found. Reinsulate, and rewind coils.

OTHER CUTOUT TROUBLE.

(f) If the insulation on the current coil is all burned off and the coil is short circuited between turns, this may prevent cutout from opening when engine is stopped, although it would not prevent cutout from closing properly. If this is the case, put in a new cutout or else remove the current coil and reinsulate it.

(g) Make sure that the spring which is supposed to hold the contact points open is not weak, bent, or broken, or has not slipped out from under the hook at its free end, and that the spring with which the arm is mounted is not bent so as to force the contact points together.

B. STARTING SWITCH SHORT CIRCUITED OR GROUNDED. The starting switch is located under the floorboards in front of the driver. It may be inspected from underneath the car. The terminal on the switch which is toward the rear, and which is connected to the battery, also has a smaller yellow wire connected to it. Remove this yellow wire, and the large cable from this terminal, and hold their ends together. Now look at the pointer on your ammeter. If it has gone back to the "0" line, consult the next paragraph. If it still indicates that current is flowing from the battery, replace the cable and yellow wire on the starting switch and consult section C.

REMEDY. The starting switch is defective. Disconnect the cable leading to the motor. Remove switch by taking out the two screws or bolts by which it is fastened to the car frame. Remove the cover by taking out the two screws that hold it in place. Carefully inspect the inside of the switch and make sure that the parts attached to the plunger are not loose or bent so that the switch fails to open the starting circuit entirely. See that there are no pieces of brass or copper short circuiting the contacts.

C. TROUBLE IN WIRE BETWEEN STARTING SWITCH AND AMMETER. The yellow wire that is attached to the starting switch leads to the terminal board on the dash and then to the Ford ammeter, as shown on the diagram at the beginning of this Chart. Disconnect this yellow wire from the terminal on the back of the Ford ammeter and look at your ammeter. If the pointer of your ammeter has gone back to zero, consult Section D. If the pointer indicates that current is still flowing from the battery, consult the following Remedy:

REMEDY. The yellow wire leading from the starting switch to the Ford ammeter is grounded, or short-circuited with one of the other wires in one of the two cables (shown at C and D in Figure 21) whose wires are connected to the terminal block. To determine in which cable the trouble is, first examine the cables carefully, and inspect the yellow wire from the starting switch to the first cable (C in Figure 21), and from the terminal block to where it enters the second cable (D in Figure 21). If no damaged insulation can be found which will cause a short circuit or ground, open all the joints at the terminal block. If the pointer of your ammeter moves to the "0" line, when this has been done, the trouble is in the cable (D in Figure 21) leading from the terminal block to the Ford ammeter and lighting switch. If your ammeter indicates that current is still flowing from the battery, the trouble is in the cable (C in Figure 21) at the right side of the dash (facing the dash). In either case put in a new cable, or else cut the outside insulation of the cable carefully so as to separate the wires. Then look for the damaged insulation and repair it.

D. **LIGHTING SWITCH CLOSED, SHORT CIRCUITED OR GROUNDED—TEST.** All wires must be connected in place, but your ammeter must, of course, be left connected in series with the battery. Remove the wire from the "Bat" terminal on the lighting switch. Look at your ammeter. If the pointer has gone back to the "0" line, replace the wire on the switch and consult the following "Remedy" paragraph. If the pointer still indicates that current is flowing from the battery, see Section E.

REMEDY. Remove, one by one, the wires from the various terminals on the back of the lighting switch, but do not remove the wire from the "Bat" terminal. Watch your ammeter as you remove each wire. If the pointer does not go back to the "0" line when you remove a certain wire, replace it before removing the next wire. If the pointer goes back to the "0" line when you remove a certain wire, there is a short circuit between the terminal to which that wire is attached, and the "Bat" terminal on the switch.

Remove and open the switch and examine the parts for the short circuit. Troubles that have been found with the old style switch are described on page 32. If, when all wires have been removed except the one on the "Bat" terminal, your ammeter indicates that current is still flowing from the battery, the switch itself is grounded and a careful inspection should be made to find the trouble.

E. OTHER TROUBLE. The only other places where the trouble may be are the Ford ammeter, the wire connecting the Ford ammeter to the lighting switch, and the wire connecting the Ford ammeter to the cutout. Inspect these wires carefully for damaged insulation which allows the wire to touch some metallic part of the car. If the wires are not damaged, the Ford ammeter must be defective.

F. TROUBLE IN ACCESSORY OR EXTRA LAMP LINES. Be sure that no extra equipment, such as spotlights, cigar lighters, handwarmers on the steering wheel, fuel vaporizers, etc., have been added to the regular equipment of the car. If any such apparatus has been added, make sure that it is turned off, and that its wires do not have damaged insulation at any point.

CHART 2—FORD **ENGINE NOT RUNNING**
F. A. SYSTEM **LAMPS OFF**

REVERSED METER CONNECTIONS.

Should your ammeter pointer go backwards when you connect it in series with the battery, reverse the connections to the meter, and consult Chart 1.

ENGINE NOT RUNNING
LAMPS ON

FORD—CHART 3
F. A. SYSTEM

TO BE USED IF AMMETER POINTER DOES NOT MOVE FROM THE "0" LINE WHEN LIGHTS ARE TURNED ON.

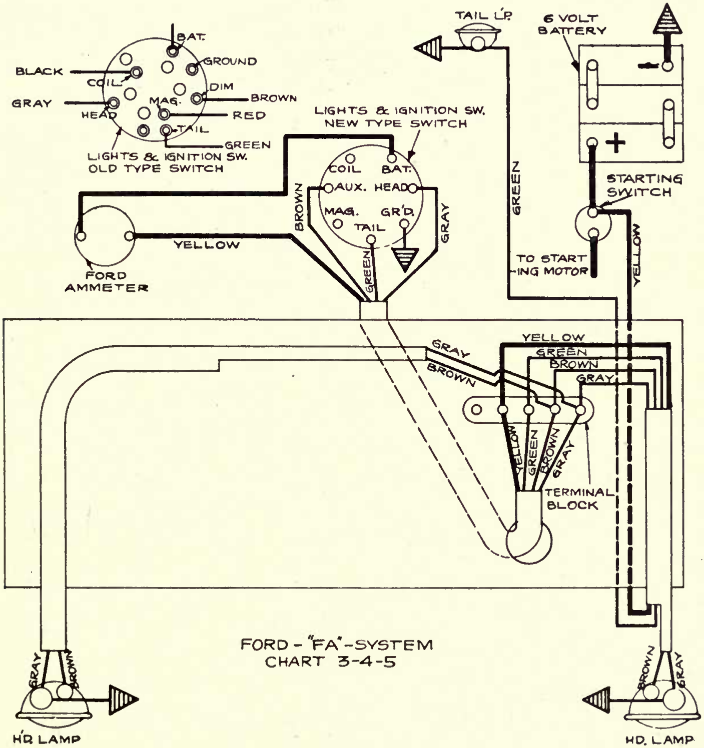


FIGURE 27.

A. OPEN CIRCUIT IN BATTERY, OR BATTERY "DEAD." Make sure that the battery terminals are free from dirt, and that the top connectors are not loose. If any corrosion is present, clean off the top of the battery with a rag wet with ammonia or a soda solution. If a terminal is badly corroded, open the joint if possible and scrape off the corrosion before replacing the cable. If it is impossible to loosen the cable, drill off the terminal and boil it in soda or ammonia solution. If this does not help burn on a new terminal and cable.

If the battery is clean and very little corrosion is present, measure the voltage of each battery cell. If one or more cells show little or no voltage, it is "dead," and the battery must be opened for repairs. Complete directions for doing this are given in the book "The Automobile Storage Battery, Its Care and Repair," published by the American Bureau of Engineering.

If the voltage of each cell measured 2 or more, see Section B.

B. LOOSE CONNECTIONS IN WIRING. Inspect all the wiring as shown in the diagram (Figure 27), at the beginning of this Chart. See that cell connections are clean and tight. Run your hand along each wire and feel for a break in the wire under the insulation. If no such break can be found, see Section C.

C. LAMPS BURNED OUT. Inspect the lamps. If they are all good, see Section D. If all the lamps are burned out, it is probable that the car has been run with the battery removed without taking care to ground the generator, or else there is an open circuit in the yellow wire which is connected to the starting switch at one end and to the Ford ammeter at the other.

Put in good lamps. If they all burn the trouble is not due to an open circuit in the yellow wire mentioned in the preceding paragraph, but was caused by running the car without the battery. If the lamps do not burn, take an extra length of wire, and with it connect together the terminal on the starting switch, to which the yellow wire is attached, and the terminal on the Ford ammeter to which a yellow wire is also attached (See Figure 27). If this causes the lamps to light, there is a break in the yellow wire.

To determine in which cable the break exists, hold the extra wire between the Ford ammeter terminal and the second terminal from the left on the terminal block. If the lamps now light the break is in the cable (shown at D in Figure 21) leading from the ammeter and lighting switch. To repair it, cut outside insulation on cable, separate the wires, find the break and repair it.

If the lamps did not light up, hold the extra wire on the second terminal from the left on the terminal board, and on the starting switch terminal to which the yellow were is attached. If the lamps now light up, the break is in the cable (shown at C in Figure 21) which runs down the right side of the terminal block.

D. DEFECTIVE LIGHTING SWITCH. With a short length of wire, connect the "Bat" terminal on the back of the lighting switch to the "Head" terminal, then to the "Tail" terminal, then to the "Aux" or "Dim" terminal. If the lamps connected to these terminals light up as the "Head", "Tail", and "Aux" or "Dim" terminals are connected to the "Bat" terminal, the switch is defective, and should be removed and opened for inspection. If the lamps do not light up when these terminals are connected to the "Bat" terminal, see Section E.

E. OPEN CIRCUIT IN LIGHTING LINES. Get an extra length of insulated wire about 6 feet long. Connect one end of this wire to the terminal on the starting switch to which the yellow wire is connected. With the other end of this wire touch the following points in the order in which they are named below:

(a) Second terminal from the left on the terminal block.

If lamps now light up, there is a break in the yellow wire between the starting switch and terminal block.

(b) Terminal on Ford ammeter to which yellow wire is connected.

If lamps now light up, there is a break in the yellow wire between the terminal board and the Ford ammeter.

(c) Other terminal on the Ford ammeter.

If lamps now light up, there is a break in the Ford ammeter.

(d) "Bat" terminal on back of lighting switch.

If lamps now light up, there is a break in the wire connecting the Ford ammeter to lighting switch.

ENGINE NOT RUNNING
LAMPS ON

FORD—CHART 4
F. A. SYSTEM

TO BE USED IF LAMPS DRAW TOO MUCH CURRENT FROM BATTERY.

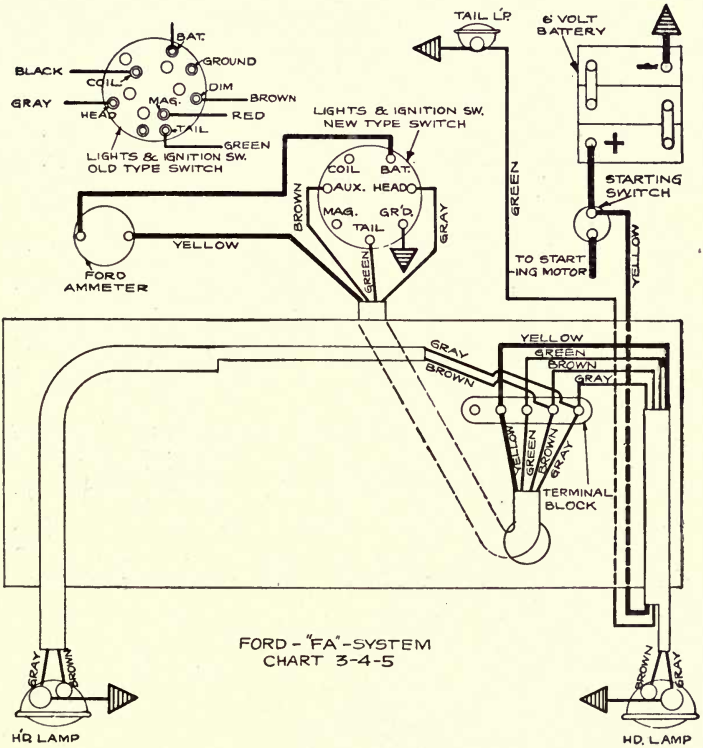


FIGURE 27.

NOTE. If you have not made the test for Engine Not Running, Lamps Off, do so now, as any condition which causes a discharge reading in that test might cause an excessive discharge from the battery in this test.

CHART 4

A. EXTRA EQUIPMENT HAS BEEN ADDED. If, upon examination, it is found that any spot light, extra body lamps, trouble lamps, fuel vaporizers, hand warmers on the steering wheel, cigar lighters, etc., have been attached to the car, they should be disconnected, or their switches turned off. Only the original factory equipment of lamps should be used for this test. If only the factory lamp equipment is being used when you make this test, consult section B. For a list of lamps which are standard, see below.

The factory equipment of lamps is as follows:

Two—6-8 volt, 17 candlepower lamps in headlights.
Two—6-8 volt, 2 candlepower lamps in headlights.
One—6-8 volt, 2 candlepower lamp in taillight.

B. SHORT CIRCUITS OR GROUNDS IN LIGHTING LINES—TEST. Remove all the lamps from their sockets. Now look at your ammeter. If the pointer indicates that current is still flowing from the battery, there is trouble in the wires leading from the lighting switch to the lamps.

To locate this trouble, remove, one at a time, the wires from the "Head", "Tail", and "Aux" or "Dim" terminals on the back of the lighting switch. As each wire is removed, look at your ammeter, and if the pointer goes back to the "0" line, there is a ground or short circuit in the wire which caused the pointer to go back to the "0" line when you removed it.

ENGINE NOT RUNNING
LAMPS ON

FORD—CHART 5
F. A. SYSTEM

TO BE USED IF SOME LAMPS DO NOT LIGHT, OR IF SOME, OR ALL LAMPS BURN DIMLY.

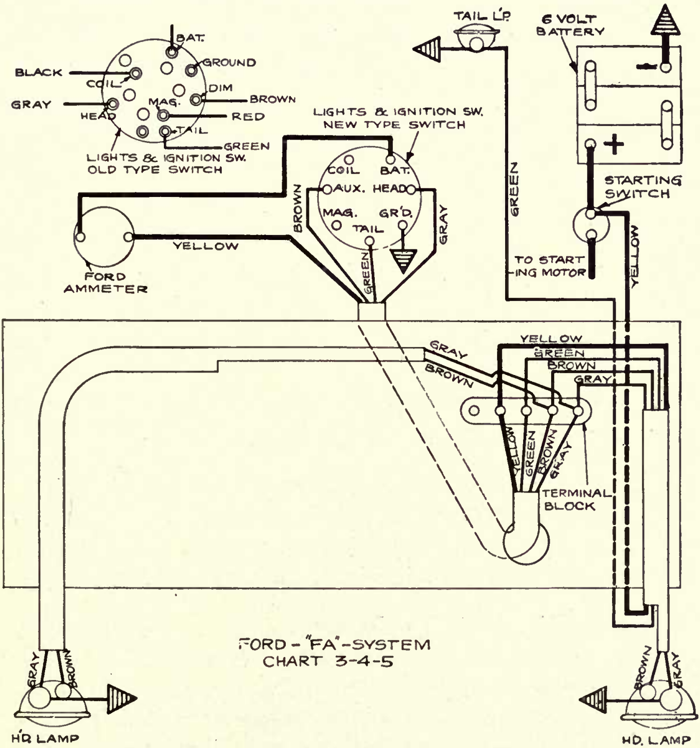


FIGURE 27.

NOTE. In the following the instructions given in this chart, read those paragraphs the heading at the beginning of which describes the conditions which you found.

A. IF ALL LAMPS BURN DIMLY—BATTERY TROUBLE. Make sure that the battery terminals are free from dirt, and that the top connectors are not loose. If any corrosion is present, clean off the top of the battery with a rag wet with ammonia or a soda solution. If a terminal is badly corroded, open the joint if possible and scrape off the corrosion before replacing the cable. If it is impossible to loosen the cable, drill off the terminal and boil it in soda or ammonia solution. If this does not help burn on a new terminal and cable.

If the battery is clean and very little corrosion is present, measure the voltage of each battery cell. If one or more cells show little or no voltage it is "dead", and the battery must be opened for repairs. Complete directions for doing this are given in the book "The Automobile Storage Battery, Its Care and Repair", published by the American Bureau of Engineering.

If the voltage of each cell measured 2 or more, see Section B.

B. IF SOME OR ALL LAMPS BURN DIMLY OR SOME DO NOT LIGHT UP—LAMP TROUBLE.

TEST: Turn the defective lamps around in their sockets to make sure that the trouble is not due to the bulb not making good contact in the socket. If this does not cause the lamp to burn brightly, consult the following remedy:

REMEDY. Look for the following trouble in the defective lamps:

(a) Broken or burned out bulb.

(b) Double contact bulb in single contact socket.

(c) Contact pieces in socket too short to make contact with the contacts on the lamp base.

(d) Bulb or socket contacts dirty.

(e) Connectors on end of wires supplying current to the lamp dirty, or not making contact with the socket. Push this connector piece inward and turn it about to make sure that it is closing the circuit to the socket.

(f) Bulbs of a higher voltage than 8.

(g) Bulb turned the wrong way in socket.

(h) Loose, dirty, or broken wires or connections in the lamp socket.

(i) Lamp old, and almost worn out.

C. ALL LAMPS DIM—HIGH RESISTANCE BETWEEN BATTERY AND LIGHTING SWITCH. See that the terminal connections are clean and tight. Remove any oil, dirt, or grease, and see that terminals on wires are clean, that there is no corrosion at the soldered joint between the wire and the terminal on the end of the wire, and that none of the wire strands are cut through at the terminal. If only a few strands are unbroken, cut the wire at the terminal and resolder the wire to the terminal.

In this way inspect the following terminals:

(a) At starting switch terminal to which yellow wire is connected.

(b) At terminal block, second terminal from the left as you face the terminal block, to which two yellow wires are attached.

(c) Terminal on Ford ammeter to which yellow wire is attached.

(d) Other terminal on Ford ammeter.

(e) "Bat" terminal on back of lighting switch.

If you do not find any trouble at these terminals, and cannot make the lamps light up properly by making terminals clean and tight, proceed as follows:

Get an extra length of wire, about 6 feet long. Attach one end of it to the starting switch terminal to which the heavy battery cable, and the yellow wire are connected. (Leave cable and yellow wire connected to this terminal also.) With the other end of the extra wire, touch the following terminals, in the order named:

(a) Terminal on terminal block to which two yellow wires are connected.

If lamps now light up, there is a partial break in the yellow wire which leads from the terminal block to the starting switch. If this cannot be found by inspection, cut the outside braid on the cable which is at the right side of the dash, looking at the dash from the front end of the car. Look for the partial break in that part of the yellow wire which runs in this cable.

(b) Terminal on Ford ammeter to which the yellow wire is connected.

If lamps now light up, there is a partial break in the yellow wire which connects the Ford ammeter to the terminal block. If this cannot be found by inspection, cut the outside braid on the cable which contains the wires leading from the terminal block to the Ford ammeter and lighting switch. Look for the partial break in that part of the yellow wire which was enclosed in this cable.

(c) Other terminal on Ford ammeter.

If lamps now light up, there is a loose connection in the ammeter.

(d) "Bat" terminal on lighting switch.

If lamps now light up, there is a partial break in the wire leading from the Ford ammeter to the lighting switch.

If the trouble has not been found up to this point, see Section D.

D. SOME OR ALL LAMPS DIM, OR SOME LAMPS UNLIGHTED. TROUBLE IN LIGHTING SWITCH, OR BETWEEN LIGHTING SWITCH AND LAMPS. With the end of the same wire used in Section C, touch the "Head", "Tail" and "Aux" or "Dim" terminals on the back of the lighting switch. If, when you touch one of these terminals, the lamp or lamps connected to this terminal light up, there is a loose contact connection inside the switch, and the switch should be taken apart and loose, dirty, or bent contact pieces looked for and adjusted.

If lamps do not light when you touch terminals of switch, the trouble must lie between the switch and the lamps. It may be in the wires leading to the lamps, or in the ground connection at the lamp.

Remove the connector which is attached to the lamp wires in back of the light containing the bulbs which burn dimly. With the wire which you have been using for testing, touch the terminals in that part of the connector which is in the reflector. If this causes the lamps which have been burning dimly or have not been burning at all, to light up, the ground connection at the bulb socket is defective and should be inspected and put in working order.

If lamps do not light up, the trouble is in the wires leading from the lighting switch to the lamps, and if it cannot be found by inspecting those portions of the wires which are outside the cables, cut the outside braid on these cables (see C, D, and E in Figures 20 and 21), and look for the trouble inside the cable.

CHART 6—FORD ENGINE NOT RUNNING
F. A. SYSTEM LAMPS ON

TO BE USED
IF AMMETER IS CONNECTED UP WRONG.

If ammeter reads backwards, when lamps are turned on, reverse the wires connected to the meter.

ENGINE RUNNING **FORD—CHART 7**
LAMPS OFF **F. A. SYSTEM**

TO BE USED IF BATTERY IS NOT RECEIVING A CHARGING CURRENT.

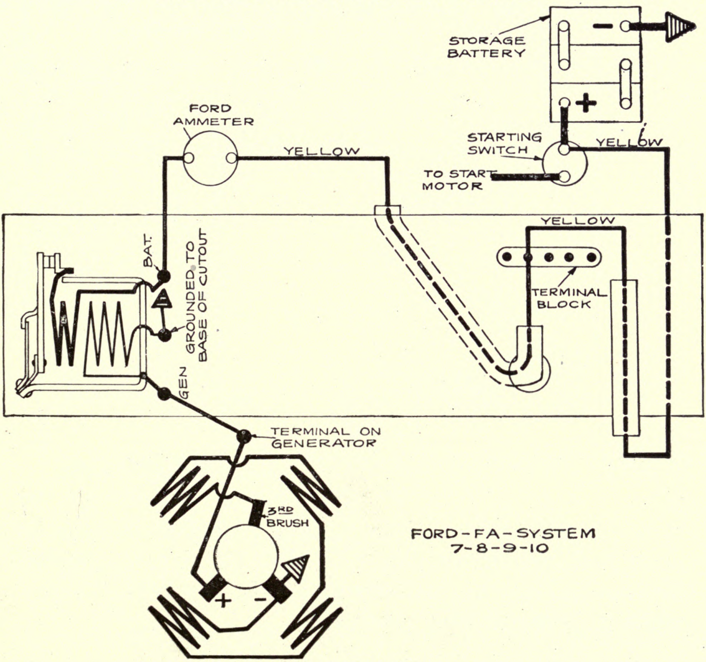


FIGURE 28.
FOR CARS HAVING CUTOUT ON DASH.

AMMETER CONNECTIONS. Be sure to reverse the ammeter connections before making a test with the engine running, and the lamps turned off.

NOTE. Sometimes the generator may be made to charge the battery by holding the cutout contact points together for an instant, and then forcing them open again, or by short circuiting the cutout. If the points

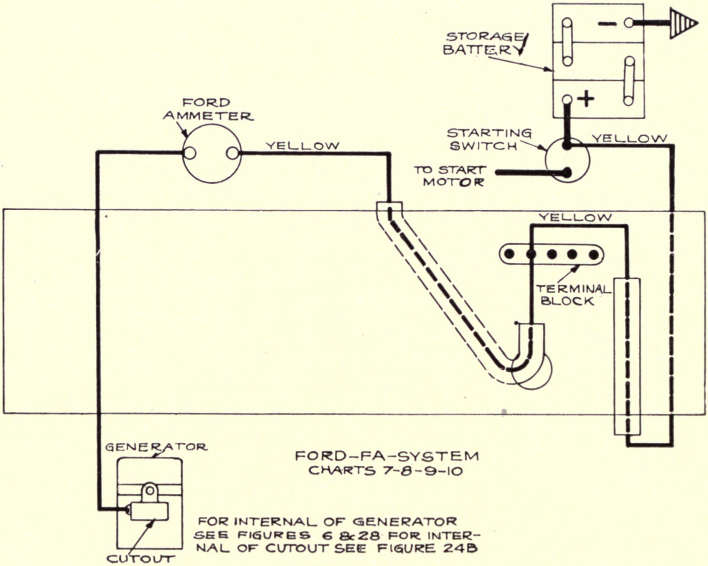


FIGURE 28a.

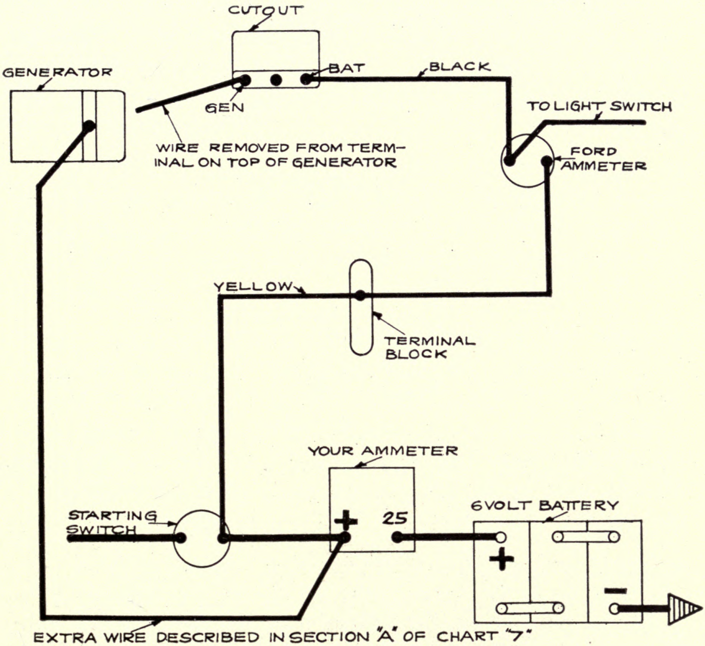
FOR CARS HAVING CUTOUT ON GENERATOR.

close automatically after you have forced them open by hand, look at your ammeter. If the pointer now indicates that the battery is receiving a charging current, the generator is now working properly.

A. LOCATING THE TROUBLE—TEST. Get an extra length of insulated wire with ends bared, not smaller than a No. 12 in size. Connect one end of this wire to the terminal on top of the generator.

If the cutout is mounted on the dash, remove the wire from the generator terminal before attaching the extra wire.

If cutout is mounted on top of the generator, remove wire from cutout before attaching the extra wire. Connect the other end of the extra wire to the terminal post

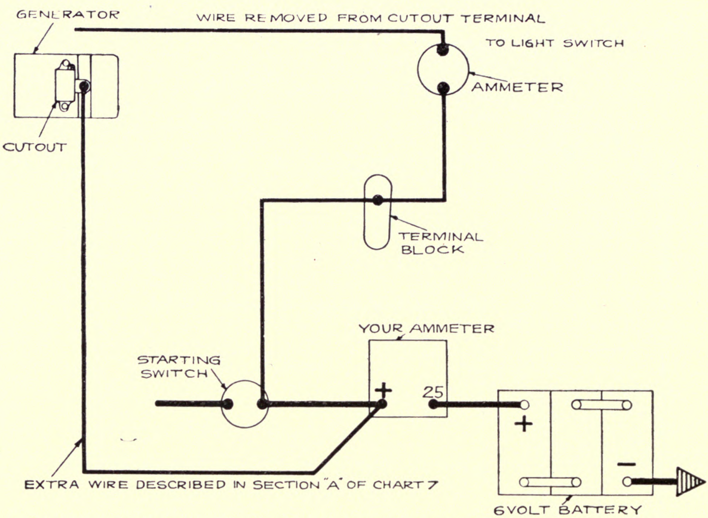


SHOWING TEST CONNECTIONS TO BE MADE AS DESCRIBED IN SECTION "A" OF CHART "7" WHEN CUTOUT IS MOUNTED ON THE DASH

FIGURE 29.

on your ammeter, to which you already have connected the wire which you removed from the positive (+) post on the battery when you first connected in your ammeter. These connections are shown in Figure 29 and 29a.

Now look at your ammeter. If the pointer is still over the "0" line, indicating that no charging current is flowing, or if the pointer goes backward, indicating that the battery is discharging into the generator, the generator is not working properly, and the instructions given in Chart 9, beginning on page 88, should be followed.



SHOWING TEST CONNECTIONS TO BE MADE AS DESCRIBED IN SECTION "A" OF CHART 7 WHEN CUTOUT IS MOUNTED ON TOP OF GENERATOR

FIGURE 29a.

If the pointer on the ammeter indicates that the generator is now charging the battery at 10 amperes, there is a break in the circuit between the generator and the battery, and the following instructions should be followed.

LOCATING TROUBLE OUTSIDE THE GENERATOR.

B. LOOSE CONNECTIONS, OR BROKEN WIRES. Disconnect the extra wire from the terminal on your ammeter. The other end of the extra wire should still be connected to the terminal on the generator. With the end of the extra wire, which you removed from the terminal on your ammeter, touch the following terminals, looking at your ammeter as each terminal is touched.

(a) **"GEN" TERMINAL ON CUTOUT.** (If cutout is mounted on the dash). If your ammeter now indicates generator is charging battery, examine wire leading from generator to cutout for a break. This break may be under the insulation. If your ammeter pointer stays over the "0" line, see (b).

(b) "BAT" TERMINAL ON CUTOUT, if cutout is mounted on the dash. "B" terminal on cutout, if cutout is mounted on the generator. If pointer on your ammeter now indicates that generator is charging battery, see Section C.

(c) TERMINAL ON FORD AMMETER TO WHICH TWO WIRES ARE CONNECTED. If pointer on your ammeter now indicates that generator is charging battery, there is a break in the wire connecting the cutout to the Ford ammeter. This break may be under the insulation, and the hand should be run along the wire to feel for such a break.

(d) TERMINAL ON FORD AMMETER TO WHICH A YELLOW WIRE IS CONNECTED. If your ammeter now indicates that generator is charging battery, there is an open circuit in the Ford ammeter.

(e) TERMINAL ON TERMINAL BLOCK TO WHICH TWO YELLOW WIRES ARE CONNECTED. If your ammeter now indicates that generator is charging the battery, there is a break in the yellow wire connecting Ford ammeter to terminal block. Inspect this wire. If no break can be found, cut outside braid on cable (shown at D in Figure 21) in which this wire runs and look for break in that portion of the yellow wire enclosed in the cable connecting terminal block to Ford ammeter.

(f) If your ammeter still does not indicate that generator is charging battery, the trouble must be in the yellow wire connecting starting switch to terminal block. If trouble in this wire cannot be found by inspection, cut braid on cable (shown at C in Figure 21) in which the wire runs and look there for the break.

C. CUTOUT TROUBLE. For cutout which is mounted on the dash. Use circuit tester shown in Figures 25 or 26, page 57. Remove the wires from the "Gen" and "Bat" terminals on cutout.

(a) CURRENT COIL OPEN CIRCUITED.

TEST: Hold one test point on "Bat" terminal on cutout, and hold other on stationary contact point on cutout shown in Figure 28 at beginning of this chart. If lamp does not light, current coil is open circuited. See following "Remedy" paragraph. If lamp lights, see (b).

REMEDY. Put in new cutout, or else unwind coils until break is found, repair break and rewind coils.

(b) VOLTAGE COIL OPEN CIRCUITED.

TEST: Hold one test point on "Gen" terminal on cutout. Hold other test point on the terminal in the center between the "Gen" and "Bat" terminals. If lamp does not light, there is a break in the voltage coil.

REMEDY. Install new cutout, or unwind coils until break is found, repair break, and rewind coils.

FOR CUTOUT MOUNTED ON TOP OF GENERATOR.

Use lamp circuit tester shown in Figures 25 or 26, page 57.

(a) CURRENT COIL OPEN CIRCUITED.

TEST: See that Screw A (see Figure 24B) is not missing, as this would open the charging circuit. If screw A is in place, take it out and remove the cover from the cutout. Hold one test point on piece C, and hold the other test point on piece D. If lamp lights see (b), but if lamp does not light, consult the following "Remedy" paragraph:

REMEDY. Carefully inspect the soldered connections between pieces C and D, and the two ends of the current coil. This is the only place where it is at all likely that an open circuit in the current coil may be found.

(b) **VOLTAGE COIL OPEN CIRCUITED.**

TEST: Hold one test point on the base of the cutout, and hold the other test point on piece H. If lamps light, see (c), but if lamp does not light, consult the following "Remedy" paragraph.

REMEDY. There is an open circuit in the voltage coil. Carefully inspect soldered connections between the base, piece H, and the ends of the voltage coil. If the connection is open, or wires are broken near the joint, resolder the wires. If these points are in good shape, the break is inside the voltage coil, and a new cutout should be installed, or else the coil unwound, repaired, and then unwound.

(c) **OTHER CUTOUT TROUBLE.** In either style of mounting, a short circuit in the voltage coil will prevent the cutout from closing. If no cutout trouble has been found, replace the wires on the cutout and short circuit the cutout with a short length of wire, or with a pair of pliers. If this gives a charging current, as indicated on your ammeter, the voltage coil on the cutout is probably short circuited. The cutout will also be very hot. A ground in the winding would have the same effect as a short circuit. The remedy is to install a new cutout, or unwind the coils, and wind a new voltage coil, using the same size and length of wire found in the defective voltage coil.

The cutout action should also be checked according to the instructions on page 29.

CHART 8—FORD F. A. SYSTEM

ENGINE RUNNING LAMPS OFF

TO BE USED IF BATTERY DISCHARGES INSTEAD OF BEING CHARGED.

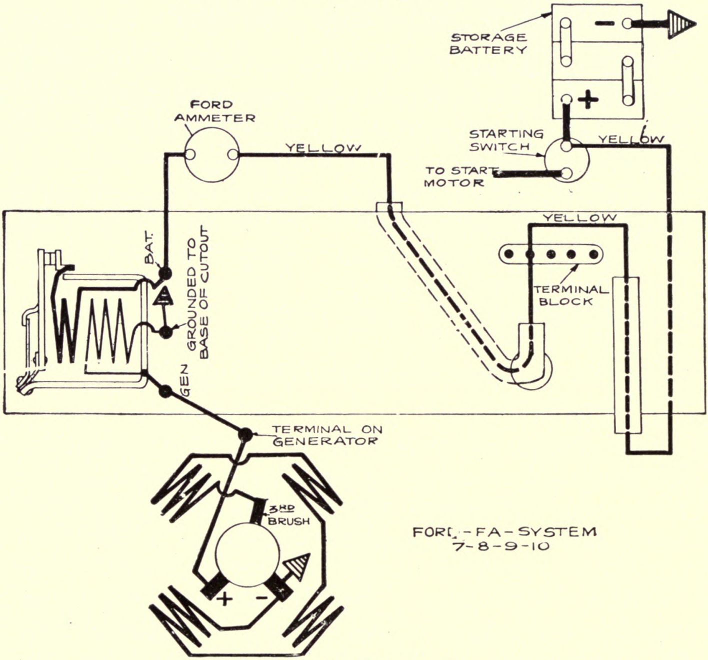


FIGURE 28.
FOR CARS HAVING CUTOUT ON DASH.

NOTE. Be very careful to have your ammeter connected up properly. For the test with the engine running, and the lamps turned off, the cable which you disconnected from the positive (+) terminal of the battery must be connected to the (+) post on your ammeter. The "25" or "—" post on your ammeter must be connected to the positive (+) terminal of the battery. See Figure 23.

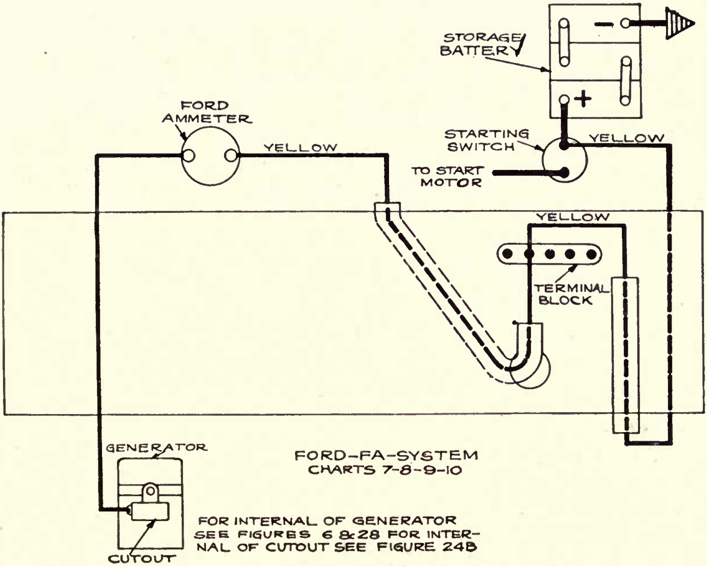


FIGURE 28a.

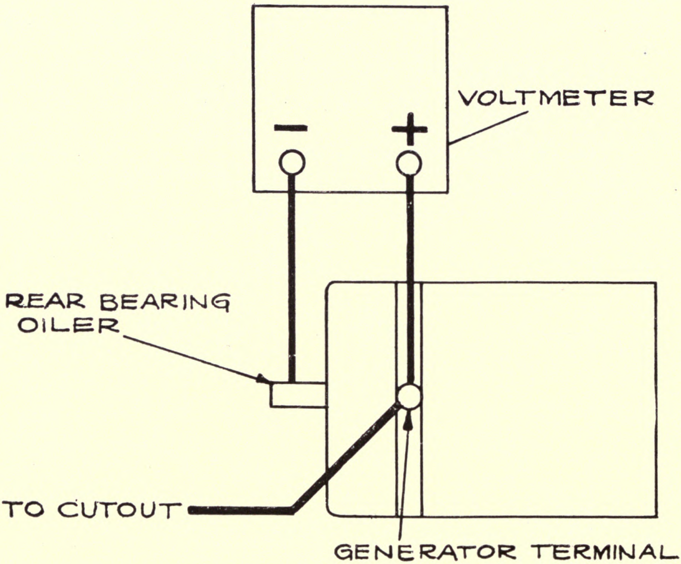
FOR CARS HAVING CUTOUT ON GENERATOR.

A. **TROUBLE IN WIRING.** Be sure that you have made the test with the Engine Not Running and the lamps turned off. Any ground between battery and cutout will have been located in that test.

Inspect the wire leading from the cutout to the generator to see that it does not make metallic contact with any part of the frame.

B. **BATTERY CONNECTIONS REVERSED.** The negative battery terminal should be connected by a short cable to the frame of the car. Be sure that the positive is not connected to the frame of the car instead of the negative.

C. **GENERATOR REVERSED—TEST.** Use a voltmeter as shown in Figure 30. Hold one test point on a



MEASURING VOLTAGE OF GENERATOR

FIGURE 30.

clean spot on the dynamo frame (the rear bearing oiler will do). Hold the other test point on the generator terminal. The voltmeter pointer should show a voltage of about 7 to 7½. If the pointer moves backward the polarity of the dynamo is reversed.

REMEDY. This can only happen when the battery is run down. Put in a fully charged battery and hold the cutout closed by hand for an instant. Then look at your ammeter to see if generator is charging battery. If battery is still discharging, reverse field connections in generator. To do this interchange the field wires which are connected to the third brush and the grounded main brush.

ENGINE RUNNING **FORD—CHART 9**
LAMPS OFF **F. A. SYSTEM**

TO BE USED IF BATTERY IS NOT RECEIVING ENOUGH CHARGING CURRENT.

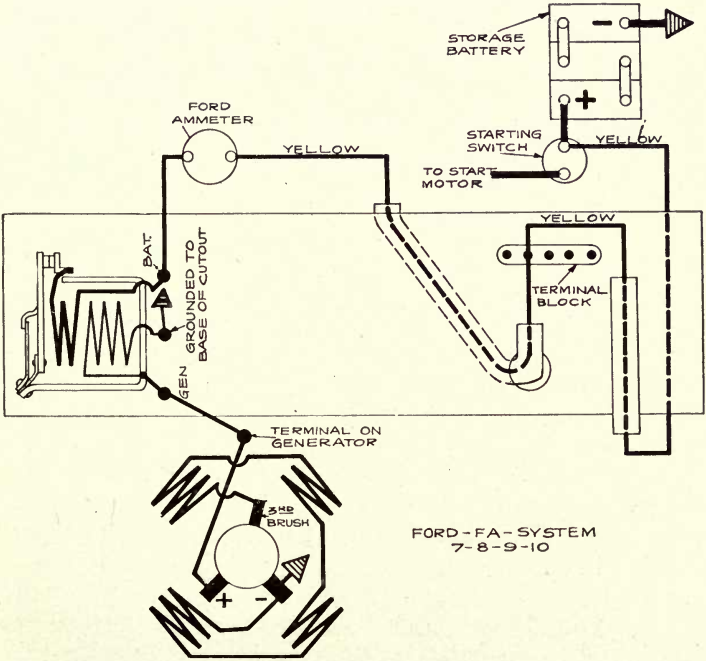


FIGURE 28.
FOR CARS HAVING CUTOUT ON DASH.

NOTE. Try closing cutout by hand for an instant and then opening it. The same result may be obtained by short-circuiting the cutout. If it then closes automatically and generator begins to charge battery at 10 amperes, the trouble has been removed. If generator is charging about 8 amperes, someone may have changed the setting of the third brush. For adjusting third brush, see page 14.

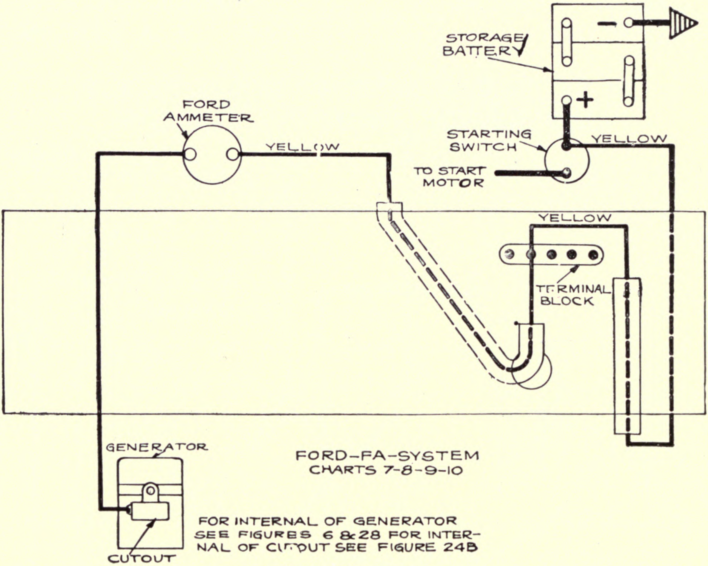


FIGURE 28a.

FOR CARS HAVING CUTOUT ON GENERATOR.

If charge is less than 8 amperes, carry out the following instructions.

A. LOCATING THE TROUBLE. To determine whether the trouble is in the generator, or between the generator and the battery, make the test described in Chart 7, on page 78.

LOCATING GENERATOR TROUBLES.

NOTE. Generator field takes about 2.5 amperes when connected to a 6 volt battery if field is O. K. Generator runs as motor takes 9 amperes from a 6 volt battery if there are no shorts or grounds in armature, and if field is O. K.

B. TROUBLE IN THE DRIVING MECHANISM. Watch the dynamo shaft while the engine is running to see that it turns smoothly and continuously and in the proper direction. Run the engine at various speeds. If the dynamo shaft follows the changes in the speed of the engine closely and runs in the proper direction, the driving mechanism is working properly and section C should be consulted.

If the armature alternately runs and stops, or runs irregularly, or in the wrong direction, the driving mechanism is not working properly and should be put in good shape before proceeding farther.

The driving mechanism is described on page 4.

C. LOOSE, GROUNDED, OR SHORT CIRCUITED WIRES AND CONNECTIONS. Remove the cover from the rear end housing. See page 17 and Figures 1 and 5. Look in through the openings in the housing and inspect the wire leading from the terminal on the generator to the ungrounded main brush and the wires leading from the field coils to the third brush and grounded main brush. See that the insulation on these wires is not torn or cut at any point. See that the pigtails connected to the brushes do not touch the end housing or brush ring. The pigtails may, of course, be allowed to touch the brush holders.

D. WATCH FOR EXCESSIVE SPARKING AT THE BRUSHES. This may be due to:

(a) Brushes of poor material, or replaced with wrong size or type.

(b) Armature loose, or carried eccentrically in its bearings.

(c) Brushes not bearing on the proper points of the commutator. The whole brush ring may be shifted as described on page 11.

(d) Short circuited, grounded, or open circuited coil in the armature. This sparking will occur only as the commutator segments to which the coils are connected pass under a brush. If two adjacent segments are blackened or burned, it almost invariably indicates a short circuit between the windings connected to these two segments.

For tests to locate short circuits and open circuits, see Section G.

Any of the above troubles will cause insufficient charging current.

The trouble given in next section may also cause sparking.

E. BRUSH TROUBLE. The brushes are reached by removing the cover from the end housing. To inspect the under side of the brushes, take a pair of long nosed pliers and pull upon the pigtail at the brush. The brush may be removed and inspected in this way.

Stop the engine and examine the brushes for the following trouble:

(a) Dirty, pitted or broken contact surface.

(b) Insufficient contact surface. The parts of the brush surface that makes contact with the commutator will look smooth and polished, while other parts will look dull and rough. In either (a) or (b), if the brush contact surface is not perfect, cut a piece of fine sandpaper a little wider than the brush and insert it between the brush and the commutator with the sanded side toward the brush. Draw the sandpaper back and forth under the brush so that the smooth side of the sandpaper follows the surface of the commutator closely. When all imperfections in the brush surface have been removed, remove the sandpaper and carefully wipe away all carbon dust which may have fallen on the commutator.

(c) Brushes too short to give satisfactory contact surface should be replaced with new ones obtained from the car makers.

(d) Improper spring tension. See that the springs are not broken or loose from the brush, or the brush stuck in the holder.

(e) Defective insulation. Broken, cut or cracked insulating washers or bushings should be replaced with new ones. Remove any dirt, grease or gummy substance from the brushes and brush holders with a stiff hair brush soaked in gasoline. After putting the brushes in good shape, make another test for Engine Running, Lamps Off, after running the engine for about twenty minutes to "seat" or "run in" the brushes. If the generator now gives a 10 ampere charge no further work need be done. If the charge rate is still too low, stop the engine and consult section F.

F. COMMUTATOR TROUBLE.

(a) **DIRTY.** A commutator that is in good condition has a polished brownish or purple appearance. If there is any dirt or grease on it, clean it by holding a rag moistened with gasoline against it while the engine is running. In a similar way, remove any dirt from the contact surfaces of the brushes.

(b) **HIGH MICA, OR HIGH, LOW, OR ROUGHENED SEGMENTS.** If any segments are higher or lower than adjacent ones, or have grooves caused by uneven wearing, or if any mica is flush with, or projects above the surface of the segments, and if cleaning the commutator did not cause a normal charging current, remove the dynamo from the car and place the armature in a lathe and take off a fine cut. Then undercut the mica. If a lathe is not available, smooth the commutator with fine sandpaper and then undercut the mica.

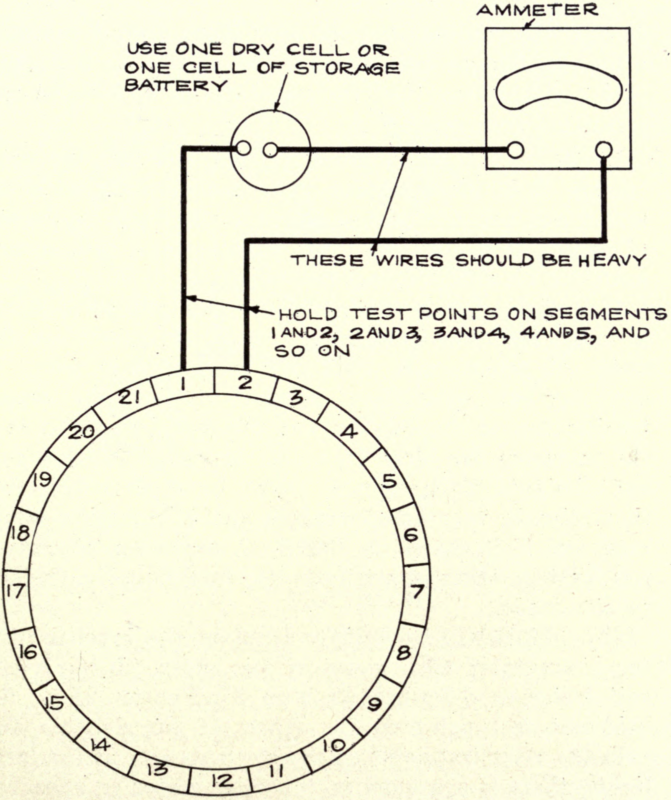
To undercut the mica, use a piece of hack saw blade, the sides of whose teeth have been ground off until they will cut a slot slightly wider than the mica. With this tool, cut away the mica until it is below the surface of the segments by about 1/32 of an inch. To start the cut, draw the end of the saw blade lightly along the mica so as to make a scratch on it. Gradually enlarge this scratch until the blade may be drawn along the mica vigorously without slipping upon the segments. After undercutting the mica, the edges of the segments should be beveled slightly with a three cornered file in order to remove any burrs caused by the saw blade.

Be sure to get all the mica cut to the desired depth, especially those pieces next to the segments. If possible, use a small magnifying glass to determine whether you have removed all the mica. Do not use a sharp pointed tool in this work, as this will simply make a V shaped groove and will not remove those pieces next to the segments.

G. COMMUTATOR AND ARMATURE WINDING TROUBLE. The best device for locating short circuits, grounds, open circuits, and crossed connections in any sized armature, no matter whether it is one inch or 20 feet in diameter, and of any voltage, using only one ampere of test current, is the Ambu Armature Tester. This Tester may be used on any test supply circuit, either D. C. or A. C., and having any voltage from 6 to 220. A less sensitive test is given below.

(a) OPEN CIRCUITS OR SHORT CIRCUITS—TEST. Take a single dry cell in good condition, and attach two wires to its terminals. Connect one post on the cell to one terminal of your ammeter and connect a wire to the other terminal on your ammeter. The free ends of the wire connected to the terminal on your ammeter and the second post on the cell are to be used as the test points. The ends of these lines may be fitted with testing points or may simply be twisted so that there are no loose strands. See Figure 31.

To make a test, the brushes should be raised from the commutator. Starting at any point on the commutator, rest the test points on adjacent segments and quickly note the approximate reading on the scale of your ammeter. In this way take a reading between each pair of adjacent segments all the way around the commutator, but do not allow the test points to rest on the segments



TESTING ARMATURE FOR SHORT CIRCUITS, OPEN CIRCUITS AND GROUNDS

FIGURE 31.

any longer than absolutely necessary to note the approximate reading. If the commutator and armature are free from short circuits and open circuits, the reading between each pair of segments will be about the same all the way around. In case the reading becomes much greater with the test points resting on any pair of segments, it indicates that the segments being touched, or the armature coil attached to these segments is short circuited.

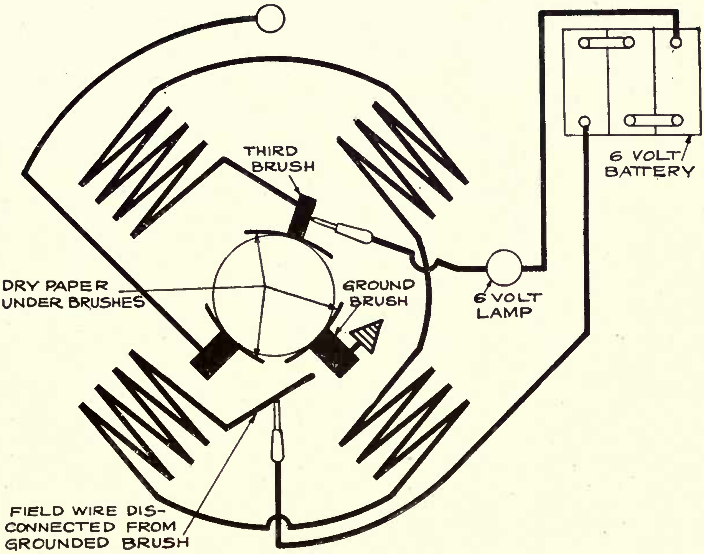
In case the reading becomes very much less, it indicates a broken, burned out, or otherwise open circuited armature coil between the two segments on which the test points are then resting.

REMEDY. If an open circuit exists, see that the wires leading from the segments make good contact with the latter, and are not broken as far as they can be traced. If no trouble can be found, the winding must be unwound until the trouble is found and repairs made.

If a short circuit exists, remove any bits of metal or carbon which may have lodged in the mica between the slots. To remove dirt use a stiff brush or a bellows. If any segments have been damaged so that the copper touches the next segments, cut the metal away so that the segments are clear from one another. If this does not eliminate the trouble, as shown by another test for a short circuit, the short circuit is in the armature windings, and if it cannot be found by inspection, the winding must be taken apart until the trouble is located and repairs made.

(b) **GROUNDED—TEST.** Insulate the brushes from the commutator with pieces of dry paper. Using a circuit tester as described on page 57, Figures 25 or 26, hold one test point on the frame of the dynamo and hold the other test point on the commutator. If the lamp lights, there is a ground in the commutator or armature windings.

REMEDY. Look for broken wires, or loose strands which may cause a ground. Remove any grease, dirt or moisture from the segments. If the ground cannot be be eliminated in this way, remove the wires from the segments, and repeat the test for a ground. If the trouble still remains, the commutator itself is grounded and should be reinsulated. If the ground has disappeared, the trouble is in the winding, and if it cannot be found by inspection, the winding must be removed until the trouble is found and repairs made.

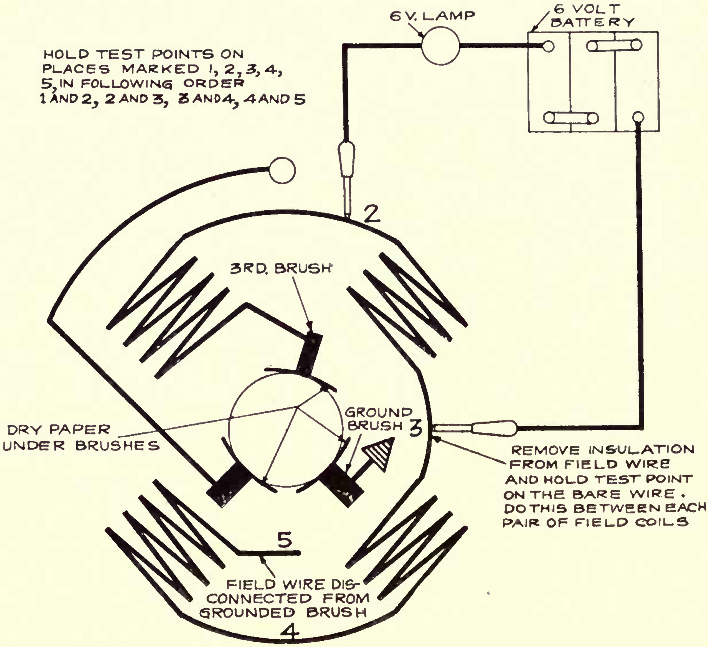


TESTING FIELD COILS FOR OPEN CIRCUITS
FIGURE 32.

H. SHUNT FIELD TROUBLE. In order to test the fields, remove the end housing. (See directions page 17, and Figures 3 and 4.) Do not disconnect the wire which is attached to the third brush holder. Disconnect the wire from the grounded main brush holder. Use a circuit-tester as shown on page 57, Figures 25 or 26.

(a) **OPEN CIRCUIT—TEST.** Put pieces of dry paper under the third and both main brushes. Hold one test point on third brush holder, and hold other test point on the wire removed from the grounded main brush holder. See Figure 32. If lamp lights, see paragraph (b). If lamp does not light, see following remedy.

REMEDY. There is an open circuit in the field coils. Inspect carefully the joints in the connections between field coils. These joints should be well soldered. If these joints are all in good shape, unwind the tape from

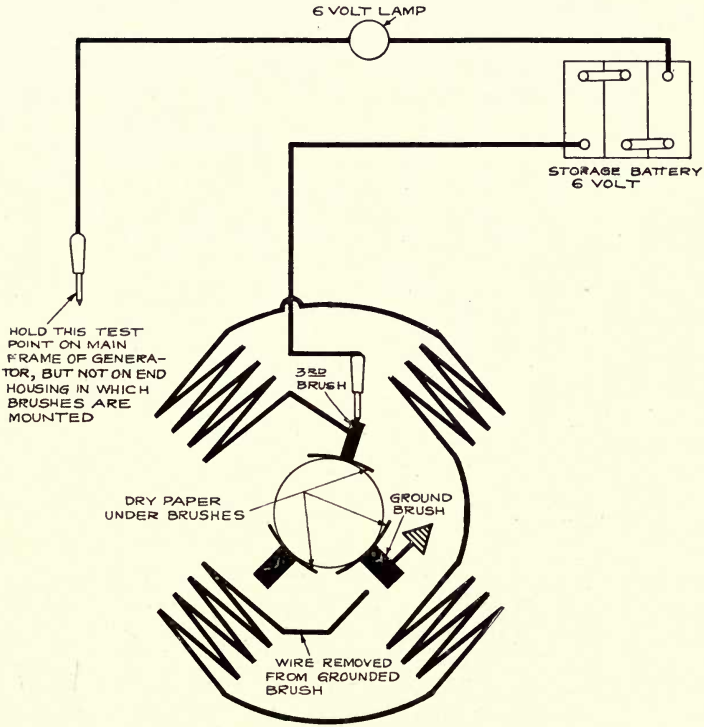


TESTING EACH FIELD COIL FOR OPEN CIRCUIT
FIGURE 33.

them. Then test each field coil for open circuit by holding the test points on the bare ends of the coil. See Figure 33. Each good coil will cause the lamp to burn when tested in this way. If lamp does not burn when any coil is tested in this way, that coil is open circuited.

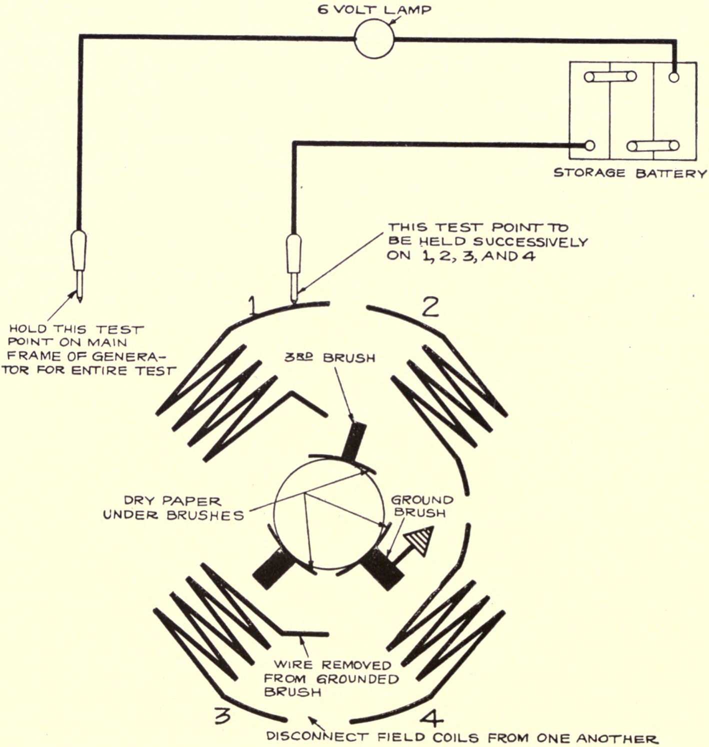
Remove the defective field coil. To do this, take out the screw which holds the pole piece in place. Remove pole piece. Disconnect field coil from the others and then remove it. If you cannot find any break in the coil by inspection, unwind the coil carefully until you find the break. Repair break and replace the coil.

(b) **GROUND—TEST.** Use same circuit tester. Hold



TESTING FIELD COILS FOR GROUND
FIGURE 34.

one test point on the third brush and hold the other test point on any part of the main frame. See Figure 34. (Not the end housing. This housing should not be touching generator frame, or any other metal part). If the lamp lights, there is a ground in the field coils, and you should consult the following "Remedy" paragraph. If the lamp does not light, hold the test point which you were holding on the generator frame on the end housing. If the lamp now lights the third brush holder is grounded to the end housing, and you should consult the following "Remedy". Now hold one

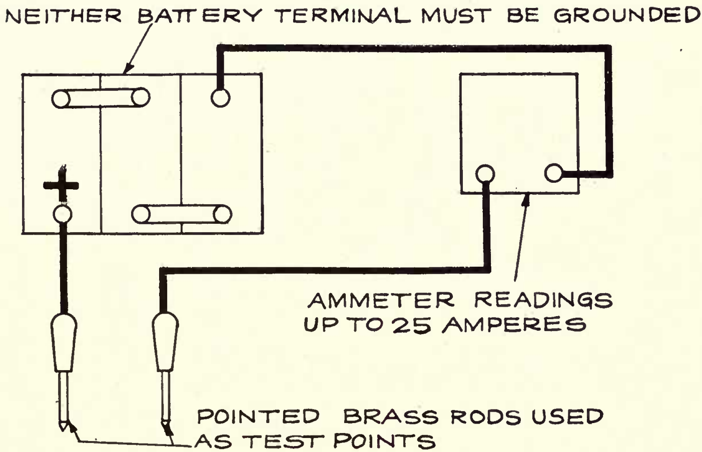


TESTING EACH FIELD COIL FOR GROUND

FIGURE 35.

test point on the insulated main brush holder and hold the other test point on the end housing. If lamp lights, consult following "Remedy." If lamp does not light, see paragraph (c).

REMEDY. IF THE LAMP LIGHTED WHEN YOU HELD ONE TEST POINT ON THE THIRD BRUSH, AND THE OTHER TEST POINT ON THE MAIN FRAME OF THE GENERATOR, there is a ground in the field coils. Carefully inspect the connections between the field coils for damaged insulation which allows the bare field wire



MAKING A CIRCUIT TESTER WITH AN AMMETER
FIGURE 36.

to touch the main generator frame. If no ground can be found in this way, it will be necessary to disconnect the field coils from each other by unsoldering the joints between them. Then test each coil separately by holding one test point on the main generator frame, and with the other test point touch one after another, the wires leading to the coils. See Figure 35. If lamp lights when any coil is tested in this way, that coil is grounded. Remove coil as directed in (a) above, and carefully inspect it for any damaged insulation. If you cannot find any, unwind the coil carefully until the damaged insulation is found. Repair insulation and rewind coil.

IF LAMP LIGHTED WHEN YOU HELD ONE TEST POINT ON THE END HOUSING OF GENERATOR AND WITH THE OTHER TEST POINT TOUCHED THE THIRD BRUSH HOLDER, OR THE INSULATED MAIN BRUSH HOLDER, the third brush holder, or the insulated main brush holder is grounded. Remove brush ring as directed on page 17, and inspect the insulation under

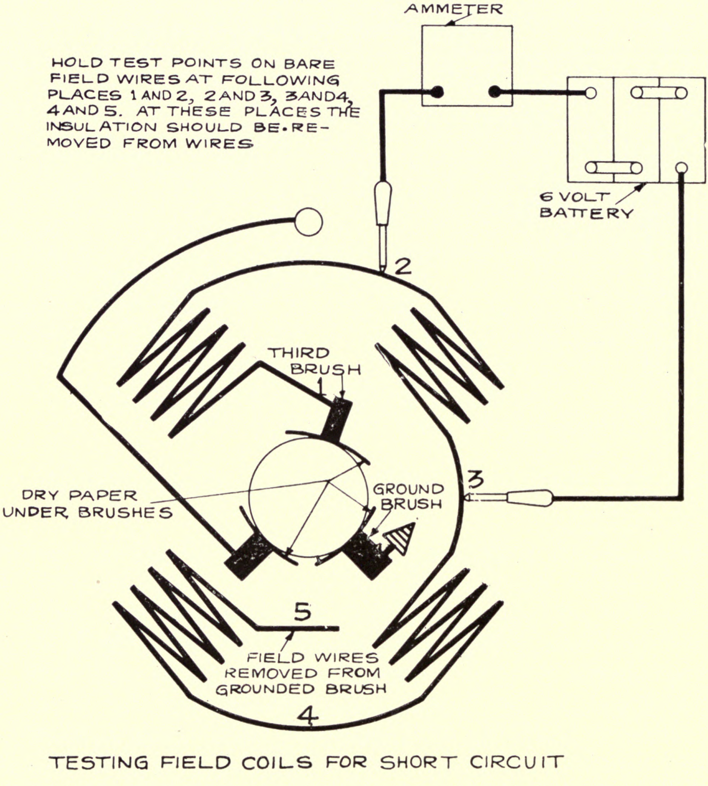


FIGURE 37.

the third brush holder and main brush holder to which the wire from the generator terminal is connected. Look for any damaged part which allows brush holder to make metallic contact with brush ring, or which allows brush ring to make metallic contact with end housing.

(c) **SHORT CIRCUIT—TEST.** Use a circuit tester as shown in Figure 36. Test each coil by holding test

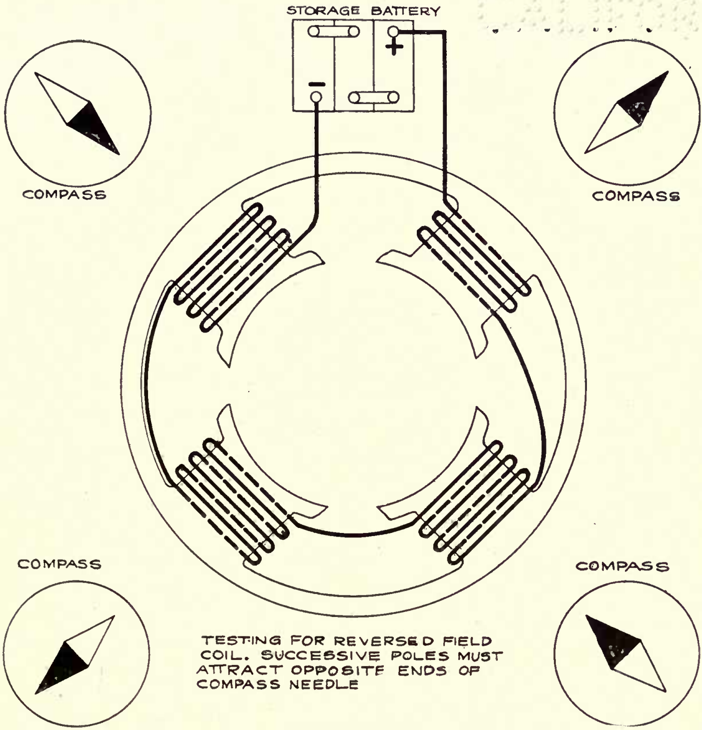


FIGURE 38.

points on the two bare ends of the wire of the coil. See Figure 37. Note what current is indicated by your ammeter as you test each coil. With a 6-volt battery, each coil should take about 10 amperes. If any coil takes more than 10 amperes when tested in this way, that coil is short circuited, and the following "Remedy" should be consulted. If each coil takes only 10 amperes, consult paragraph (d).

REMEDY. Remove, inspect, and repair defective coil as already explained.

(d) **ONE FIELD COIL REVERSED—TEST.** For this test you will need a compass. Any small pocket compass will do. Connect the two end field wires (that are ordinarily attached to the third brush holder, and grounded main brush holder) to a 6-volt battery. See Figure 38. Hold the compass right side up in your hand about one foot away from generator frame. Now gradually bring compass toward one of the screws which hold the field poles in place. As the compass is brought near this screw, one end of the compass needle will be attracted and will point directly at this screw. Now move compass straight out from generator until it is about one foot away. Then bring compass toward the next screw holding a field pole in place. As the compass is brought near this second screw, the other end of the compass needle should be attracted and should point at this second screw. Test the next two field poles in the same way. Each field pole screw should attract the opposite end of the compass needle that the previous pole did. See Figure 38. If three successive poles attract the same end of the compass needle, the middle one of these poles which you tested is connected wrong, and the connections to it should be reversed.

I. GENERATOR TERMINAL GROUNDED. The insulation around the generator terminal has given trouble by cracking and allowing generator terminal to become loose. If this terminal is loose it may become grounded to the generator frame. Inspect this insulation carefully. If it is broken or cracked, so as to allow the terminal to touch the frame, put in new insulation.

ENGINE RUNNING
LAMPS OFF

FORD—CHART 10
F. A. SYSTEM

TO BE USED IF GENERATOR CHARGES BATTERY AT MORE THAN 10 AMPERES.

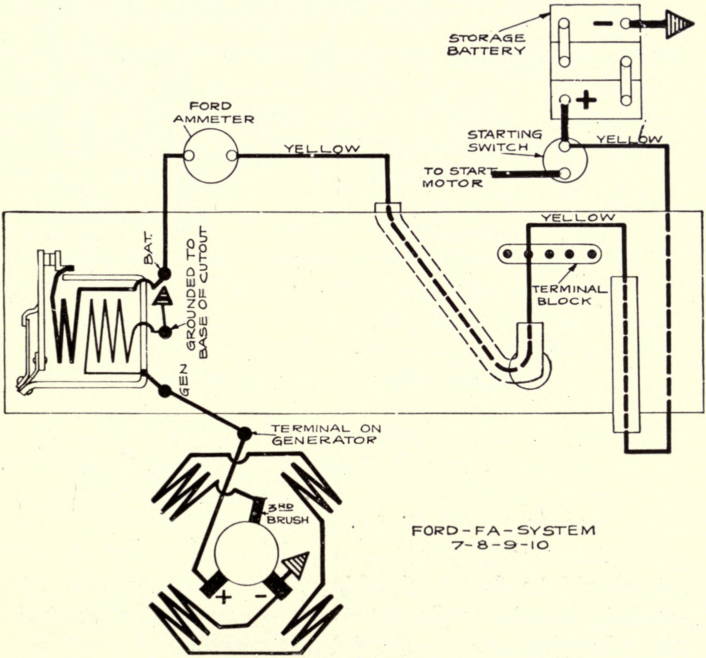


FIGURE 28.
FOR CARS HAVING CUTOUT ON DASH.

NOTE. The high charging current may be necessary on account of peculiar driving conditions. If the car is driven much at night, or if the starting motor is used often, 10 amperes may not keep the battery charged. Find out carefully whether the battery runs hot while engine is running, and if it is necessary to add water oftener than usual. If this is the case, the charging

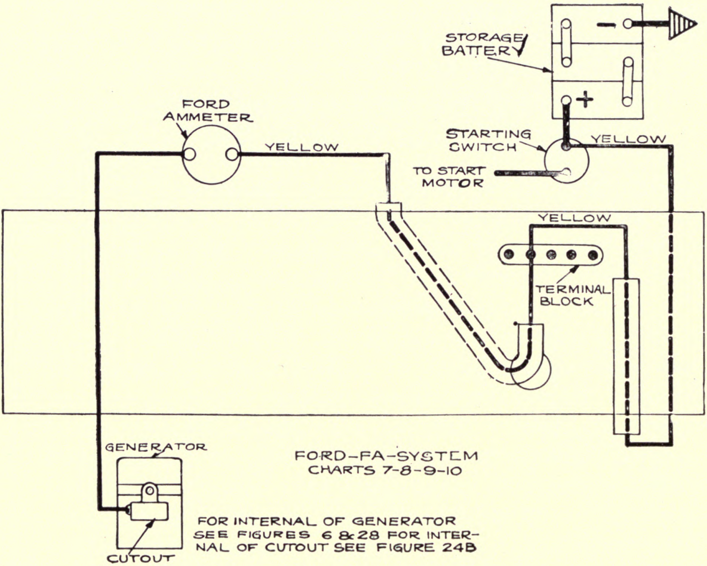


FIGURE 28a.

FOR CARS HAVING CUTOUT ON GENERATOR.

rate should be decreased. If, however, battery does not run hot, or water does not have to be added too often, the high charging rate need not be decreased.

For directions to increase or decrease the charging rate, see page 14.

FORD—CHART 11
F. A. SYSTEM

TO BE USED IF YOUR AMMETER POINTER JUMPS AROUND ALL OVER THE SCALE OR IS OTHERWISE UNSTEADY.

A. **LOOSE CONNECTIONS IN LIGHTING LINES.** If the pointer jumps while the engine is not running, look for loose or broken wires, loose or dirty connections, loose switch contacts, etc., in the line from the battery and generator to the lighting circuits.

B. **TROUBLE IN LAMPS.** If the pointer jumps only with certain lamps turned on, look for loose or broken wires, loose or dirty connections, short circuits, or grounds in the lines to these lamps, and in the connections at the lamp bases, or for loose lamp bulbs. The lamps in whose circuits the trouble exists will flicker.

C. **TROUBLE IN GENERATOR.** If the charging current is unsteady, look for the following troubles:

(a) **FAULTY DRIVING MECHANISM.** Watch the shaft at the dynamo while the engine is running. Run the engine at various speeds, and if the dynamo does not run smoothly, but alternately starts and stops, or if its speed does not change with that of the engine, the driving mechanism is at fault, and sheared keys and broken drive gear, should be looked for.

(b) **BRUSHES AND CONNECTIONS.** Examine the brushes and their holders and see that the contact surfaces on the brushes are clean and smooth, that the brushes are not loose in the holders, that the springs are not loose, broken or weak and that they make good contact with the brushes, and that the pigtails leading from the brushes make good contact.

(c) **COMMUTATOR.** Examine the surface of the commutator for dirt or grease, high, low or loose segments, insulation sticking up between the segments, for loose or broken wires leading from the segments, and for bits of metal or carbon on the insulation between segments.

(d) **LOOSE OR BROKEN WIRES.** Look for loose or broken, or crossed wires inside the generator. See that the generator terminal is clean and tight.

(e) **OTHER TROUBLE.** Consult Chart 9, beginning page 92, and make the tests for grounds, open circuits and short circuits in the field coils and armature. Examine the cutout to see that neither spring is loose or broken, that the contact points are clean and smooth, that the arm moves freely and does not bind at the pivot.

D. TROUBLE IN THE CHARGING LINE. If the charging current is unsteady after making the above tests, follow the charging lines and look for loose, dirty connections, broken wires, and defective insulation which may cause intermittent short circuits or grounds.

STARTING TROUBLE **FORD—CHART 12**
F. A. SYSTEM

TO BE USED IF STARTING MOTOR DOES NOT CRANK ENGINE SATISFACTORILY.

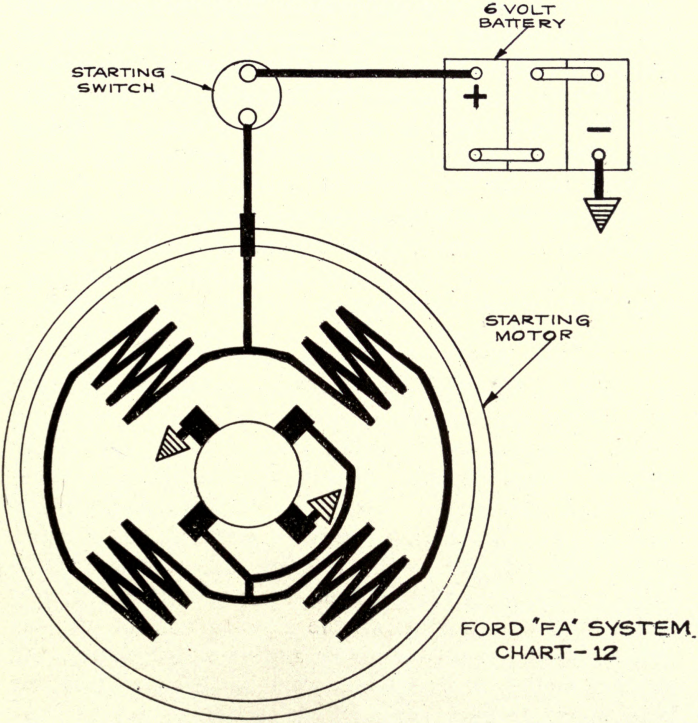


FIGURE 39.

A. MECHANICAL TROUBLE—TEST. Crank the engine by hand to make sure that it will start. If it starts, see paragraph B, but if it will not start, consult the following remedy:

REMEDY. There may be ignition or carburetor trouble, or some parts of the power plant may be binding from overheating, lack of lubrication, some accident may have caused damage, the transmission gears may be in mesh, or some other purely mechanical trouble may be present.

B. **NOTE.** Having determined that the engine will start when cranked by hand, if the motor will not crank the engine, or starts it too slowly to start the engine, make the tests for Engine Not Running, Lamps Off; Engine Not Running, Lamps On; and Engine Running, Lamps Off; before proceeding with the work of this chart. To make the test for Engine Running, Lamps Off, it will be necessary to crank the engine by hand. If the reading in each of the above tests is not correct, follow the instructions given in the proper charts. If this does not make the starter action satisfactory, consult Section C.

C. **HIGH RESISTANCE IN CIRCUIT BETWEEN BATTERY AND MOTOR.** Inspect carefully the battery for corroded connections or loose terminals or connecting straps. Inspect entire cable leading from battery to starting motor. Inspect terminal connections at starting switch and motor. Clean and tighten all terminals that need it. See that there is no looseness or corrosion at the lugs soldered to the starting motor cable. If no trouble is found in this way, hold a length of heavy wire across the two terminals on the starting switch. If this causes starting motor to crank engine satisfactorily, the starting switch is defective. Open switch and look for loose dirty, or bent parts which should be put in good shape.

D. **GROUND BETWEEN STARTING SWITCH AND MOTOR.** As a ground in the starting motor cable between the starting switch and the battery would have been discovered in the test for Engine Not Running, if there is any ground in the starting cable, it must be between the switch and the motor. Inspect this cable carefully to make sure its insulation is not damaged so as to allow cable to touch metal parts of car.

E. LOW VOLTAGE OR OPEN CIRCUIT IN BATTERY. Remove, one at a time, the battery cables attached to the battery. Scrape away any dirt or corrosion with a knife, and then clean the contact surfaces on the cables and battery posts with fine sandpaper. Replace the cables and screw them firmly into place. After making all battery connections clean and tight, see if the motor will now crank the engine. If not see next paragraph.

TEST NO. 1. With the starting switch open, measure voltage of battery. Should the indication be less than 6 volts, measure the voltage for each cell. If any cell should show less than two volts, or no voltage at all, look for loose, dirty, broken or corroded terminal connections on top of the battery.

TEST NO. 2. With the starting switch closed, again measure the voltage of the battery, as directed in Test No. 1. If the voltage now drops to a very low value, consult test No. 3. If the voltage in this test is about 5, proceed with section F.

TEST NO. 3. With a hydrometer, measure the gravity of each cell of the battery. The gravity should not be less than 1.250 for any cell. If any cell shows a gravity which is much less than the others, consult the chapter in the Ambu Battery Book headed "What is the Trouble". If all cells show low gravity, the car has not been run long enough in the day time to keep the battery charged, some trouble has been causing a leakage of current, the dynamo has not been delivering sufficient charging current, or else there is trouble in the battery as described in the Trouble Charts in the Ambu Battery Book. If the starter action is still unsatisfactory, consult Section F.

F. TROUBLE IN THE STARTING MOTOR. Make the tests on the brushes, commutator and armature, described in Chart 9, beginning page 90, paragraphs E, F and G. In addition, make the tests described below, on the motor fields.

Use a lamp circuit tester as shown on page 57, Figures 25 or 26. The starting motor field coils are made of heavy copper conductors. The ends of the coils are not taped up (See Figure 14), and the bare copper should be inspected carefully to see that none of it touches the main motor frame.

(a) **GROUND—TEST.** If no ground is found, put pieces of paper under the brushes so as to insulate them from the commutator. Now hold one test point on the terminal on the motor. Hold the other test point on the frame of the motor. If lamp does not light, see (b) below. If lamp lights, see the following "Remedy."

REMEDY. There is a ground in field circuit. Disconnect one at a time, the two large insulated field wires from the two insulated motor brush holders. Repeat above test as each of these wires is removed. If lamp goes out after one of these wires is removed, the brush-holder to which that wire is attached is grounded to the brush ring, and must be reinsulated.

If lamp still burns after both wires are removed from the brushes, the ground is in the field coils of the motor. This may be located by disconnecting each field coil and testing each one separately. When the lamp lights up when certain field coil is tested (by holding test points on motor frame, and end wire of coil), that field coil is grounded. Remove and repair coil as already directed for generator field coils.

(b) **OPEN CIRCUIT.** It is very unlikely that one of the motor field coils is open circuited. The soldered joint, between coils should, however, be inspected carefully to see that joint is well soldered.

To test for open circuit, open the joint between any two field coils. Use lamp circuit tester as shown on page 57, Figures 25 or 26. Test each coil by holding the test points on the bare ends of each coil. If lamp does not light as one of the coils is tested in this way, that coil is open circuited and should be removed and repaired as already directed for the generator field coils.

G. DRIVE TROUBLE, BENDIX TYPE. The driving parts between the armature shaft and flywheel gear should be examined as follows:

(a) The screw shaft must be clean and free from grease and dirt.

(b) The spring which fastens the screw shaft sleeve to the extension of the armature shaft should be unbroken and tightly bolted.

(c) The small pinion should be clean, the teeth should be smooth, and it should be possible to rotate the pinion freely on the screw shaft.

(d) The flywheel gear teeth should be clean and smooth. If they are burred, they should be filed until roughness is removed.

GENERAL.

Ford cars which are equipped with the F. A. Starting and Lighting System retain the standard Ford magneto and the vibrator coils on the dash. The storage battery may be used for ignition also, but should only be used when starting the engine, and in case of the magneto failing. A circuit diagram of the ignition circuits is shown in Figure 40. See page 43 for path taken by ignition current. The switching from battery to magneto, or magneto to battery is done with the ignition key in the lighting switch. When this key is turned toward "Bat", the Ford magneto is cut out and the battery (or generator if car is running) is then used for ignition. When the key is turned to the "Mag" position, the Ford magneto is used for ignition.

THE FORD MAGNETO. This magneto is of a unique construction, having been designed especially for the Ford car. It consists essentially of two parts, one of which remains stationary, and the other of which rotates. The stationary part consists of sixteen coils or spools of copper ribbon as shown in Figure 40 wound on short iron cores. The cores are mounted on an iron plate, through which the magnetic circuit between spools is completed. Adjacent coils have their copper ribbon wound around the cores in opposite directions. One end of the set of coils is connected to a terminal block at the top, the magneto terminal which projects through the top of the flywheel case making contact with this terminal block. The other end of the set of coils is connected to the iron base plate upon which the spools are mounted.

The rotating part of the Ford magneto consists simply of a set of 16 permanent magnets mounted on brass, which, in turn is fastened to the flywheel. Each magnet is a magnetized, U shaped, steel bar. These magnets are placed as shown in Figure 41. In mounting these magnets, like poles of adjacent magnets are placed together. That is, the north pole of any magnet is placed

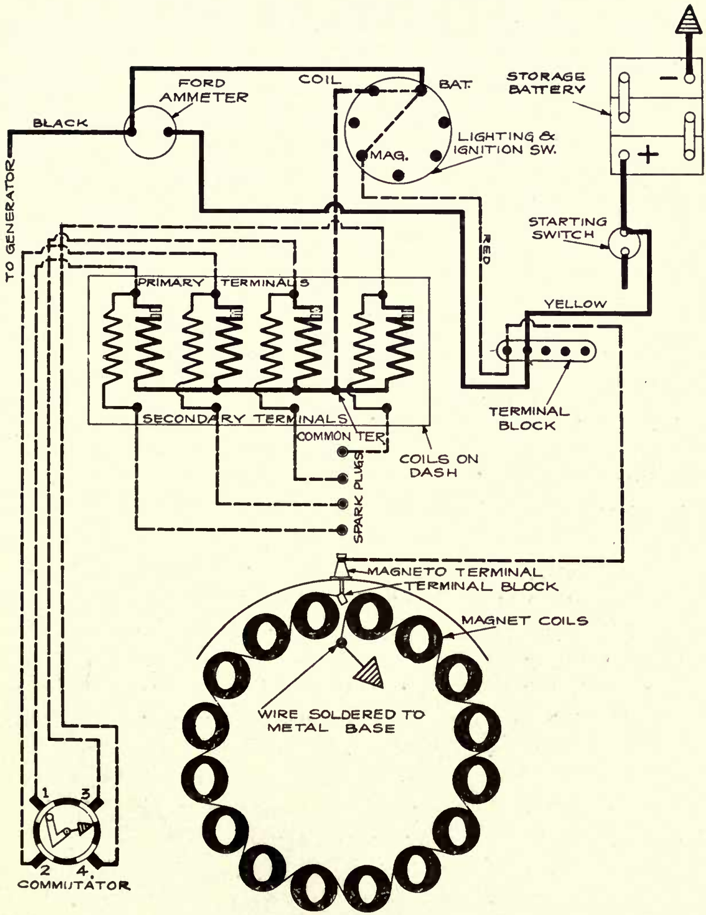
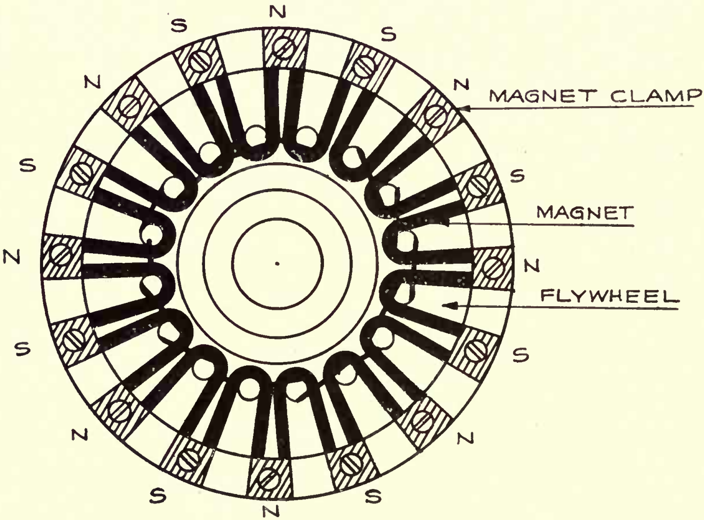


FIGURE 40.

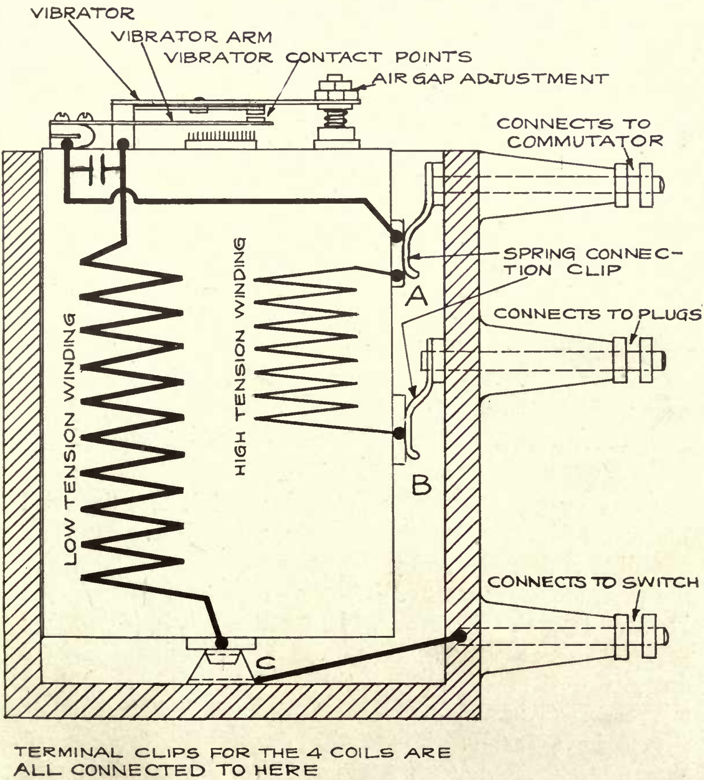
next to the north pole of the next magnet on one side, and the south pole of the magnet is placed next to the south pole of the adjacent magnet on the other side of it. In placing the magnets in this manner, the magnetic circuit of the magnets is left incomplete, since the like poles of the adjacent magnets repel each other, and lines of force cannot pass from one magnet to the next.

The magnets rotate with the flywheel, their ends passing very close to the iron cores of the spools of copper ribbon. The lines of force from the magnets pass through these cores and the iron plate from which the cores are mounted, thus completing the magnetic circuit. The lines of force passing through the spools generate the voltage



MAGNETS OF FORD MAGNETO
FIGURE 41.

of the magneto. The voltage in each spool alternates, or reverses in direction every time a different magnetic pole is opposite the spool. Suppose at a certain instant, the north poles of a pair of the magnets is opposite the core of any spool. The lines of force will then go from the magnets and into the spool. The next poles on the magnets are south poles, and when they are opposite the spool, the lines of force go from the spool and into the



FORD IGNITION COIL UNIT
FIGURE 42.

magnets, which is the reverse of the direction taken by the lines of force when the north poles of the magnets are opposite the spool. The Ford magneto therefore, generates an alternating voltage, and the current flowing in the magneto circuits is also alternating, or one whose direction is reversed regularly as the engine rotates.

HOW TO REMOVE FORD MAGNETO. In order to remove the Ford magneto, it is necessary to remove the engine. When this has been done remove crank case and transmission cover. Take out four cap screws which hold flywheel to crankshaft. Mark parts properly to facilitate reassembling.

When assembling magnets and lining up magneto, take care that faces of magnets are just 1/32 inch away from surface of core of spools.

FORD DASH COILS. The Ford Ignition coils contained in the coil box on the dash consist of four separate units which are enclosed in wooden boxes. Each unit is merely slipped into place, electrical contact being made between three round contact plates or buttons, and spring contact clips fastened to the terminals on the outside of the box. The construction and arrangement of one of the coil units are shown in Figure 42.

The only attention that the coils need is cleaning and keeping adjusted the vibrator contact points. If these are dirty, clean them by drawing between them a rag moistened with kerosene. If they are rough, they should be made smooth with a flat, fine toothed file, having filing surface on both sides. When the vibrating arm is held down, the distance between the contact points should be slightly less than 1/32 inch. If it differs from this, it should be adjusted. To do this, loosen the top one of the nuts on the top vibrator arm (see Figure 42), and then turn bottom nut to bring air gap to correct length. Then turn down top nut again and lock the bottom nut in place. All adjustment must be made with these two nuts and not by bending the arms which carry the contact points.

It is important that the vibrators be properly adjusted. This does not mean that the adjustment should be tinkered with continually. Once the proper adjustment is made, the vibrator should not be touched again unless absolutely necessary in order to put in new contact points, or reduce the air gap when it becomes too great on account of the points wearing down.

COMMUTATOR. The commutator completes the circuit of each ignition coil, when the piston in the cylinder whose spark plug is connected to that coil is in the firing position. It consists of a roller which runs on the inside of a ring which has four contacts embedded in insulating material. The roller is mounted on a shaft which is driven by a gear mounted on the main engine shaft. This gear also drives the F. A. generator. The roller rotates at half the speed of the engine. As the roller comes in contact with each metal segment, or contact piece mentioned above, the circuit of the ignition coil which is connected to that segment is completed. The vibrator of this coil then begins to act, and a high voltage is induced in the high tension secondary winding of that coil. This voltage is high enough to cause a spark to pass between the points of the spark plug which is connected to this winding.

HOW TO REMOVE COMMUTATOR. 1. Detach spark rod from commutator by taking out the cotter pin.

2. Release the spring which bears on the commutator case by loosening nut on breather pipe which holds the spring in place. Case may then be removed.

IGNITION AND ENGINE TROUBLES. When every part of the power plant is doing its work properly, there will be a steady purring sound from the exhaust. If there is any trouble which affects the action of the engine, this steady purring sound will not be heard. Most troubles are indicated and may be detected by sound. There are certain symptoms by which trouble is indicated, and this trouble may or may not lie in the ignition system. In order to determine whether the ignition system is at fault, certain tests must be made. These will be described later.

The symptoms which always are signs of trouble are:

1. ENGINE REFUSES TO START.

2. ENGINE STARTS, BUT ONE OR MORE CYLINDERS DO NOT FIRE. THIS FAILURE TO FIRE IS CALLED MISSING.

3. BACKFIRING, OR EXPLOSION OF CHARGE WHILE PISTON IS TRAVELING UPWARD ON THE COMPRESSION STROKE.

4. POUNDING, OR ABNORMAL NOISES IN THE ENGINE, USUALLY CALLED "KNOCKING".

5. ENGINE IS WEAK, AND DOES NOT DEVELOP FULL POWER.

6. ENGINE GRADUALLY LOSES POWER.

7. IRREGULAR ACTION OF ENGINE.

Each of the above troubles may be due to the fuel system, the ignition system, or may be in the cylinders.

1. ENGINE REFUSES TO START.

A. FUEL SYSTEM. Gasoline tank empty. Gasoline line shut off. Water in gasoline. Gasoline supply line choked up. Dirt in carburetor float base. Engine flooded with gas on account of continual turning over with carburetor air choke closed. Carburetor float stuck. Carburetor needle valve closed. Gasoline not vaporizing in cold weather.

B. ENGINE. Air leak in intake manifold. Poor compression. Water in cylinder because of leak in water jacket. Valves not timed properly.

C. IGNITION. If you tried to start on the magneto, turn the ignition key over to the "Bat" position. If engine now starts, trouble is in magneto.

MAGNETO CONTACT SPRING. If ignition is weak when running on magneto, but strong when running on battery, the trouble may be due to dirt under the magneto contact spring which is held in place by the binding post on top of crankcase. To examine this spring, remove the screws in base of binding post. You can then remove the binding post and spring and clean out any dirt.

TESTS ON FORD MAGNETO COILS. First take out the coils. To test them, proceed as follows:

(a) **OPEN CIRCUIT—TEST.** Use lamp circuit tester as shown on page 57, Figures 25 or 26. Hold one test point on terminal block and hold other test point on plate on which coils are mounted. If lamp does not light, there is an open circuit.

REMEDY. Carefully inspect connection from terminal block to coil, and from next coil (to the right) to the plate on which coils are mounted. Then inspect all connections between coils. If no trouble is found in this way, scrape some insulation from all the connections between coils. Test each coil by holding test points on successive bare spots, similar to the method shown in Figure 33. Defective coil will not cause lamp to light and should be unwound until break is found. Repair break and carefully rewind coil.

(b) **GROUND.** Remove ground connection of right hand top coil from plate on which coils are mounted. Hold one test point on terminal of left hand top coil and hold other test point on plate on which coils are mounted. If lamp lights, there is a ground in one of the coils.

REMEDY. Carefully inspect all coils for cut, torn, or oil or water soaked insulation. If none can be found, disconnect one coil at a time from the other coils and test it for ground until the grounded coil is found. Then unwind and reinsulate defective coil and rewind.

(c) **SHORT CIRCUIT.** Use an ammeter circuit tester as shown on page 99, Figure 36. Scrape insulation from connections between coils. Test each coil, in a manner similar to that shown on page 100, Figure 37. If any coil takes much more current than the others, it is short-circuited. Unwind, reinsulate, and rewind defective coil.

(d) **REVERSED COILS—TEST.** Connect a battery to the wires connected to the two top coils. Test each coil by bringing a compass towards it. Successive coils should attract opposite ends of the compass needle, similar to Figure 38. If two or three successive coils attract same end of compass needle, the second or middle coil is reversed. It may be necessary to reverse this and all the remaining coils. This should be tested with the compass.

(e) **TESTING MAGNETO TERMINAL FOR GROUND.** The wire should be disconnected from the terminal. The terminal must also be insulated from the coil connection inside the magneto. Use lamp circuit tester as shown on page 57, Figures 25 or 26. Hold one test point on terminal, and hold other test point on frame of engine. If lamp lights, the magneto terminal is grounded and should be taken off and reinsulated.

TESTING COMMUTATOR. If engine still refuses to start, trouble is in coils, commutator, or wiring. Look first inside the commutator. See that roller and segments on inside of ring are clean and free from grease. Remove dirt, oil, or grease with a rag wet with gasoline. Make all parts smooth with fine sandpaper. See that roller spring is not loose or broken, preventing roller from making contact. See that roller revolves and touches each contact segment as engine is turned over.

TESTING DASH COILS. If no trouble is found in commutator, turn to the coils. Remove the wires from the upper row of binding posts on the back of the coil units. Switch the ignition to the battery. With a screwdriver, pliers, or short length of wire, short circuit each of the binding posts in the top row to the rod which supports the radiator, or short circuit them to any part of the engine. As each binding post is short circuited to the engine or radiator rod, the coil conected to that post should buzz. If one or more do not buzz, or if all of them do not buzz, remove the coil units and examine the three contact buttons on each coil unit. See that these are clean and smooth. See that the spring contact clips which are attached to the back of the binding posts are not bent or missing. See that vibrator points are smooth, clean and adjusted as previously described.

The common terminal (see Figure 42) is connected to the brass strip which extends across the bottom of the coil box. This connection sometimes comes loose. Test this with the lamp circuit tester shown on page 57, Figures 25 or 26. Hold one test point on the common terminal, and hold the other on the brass strip in the bottom of the coil box. If the lamp does not light, the connection between the brass strip and the common terminal is broken. The break will probably be found in the soldered joints located at the back of the common terminal, or in the center (approximately) of the strip in the bottom of the coil box.

If trouble has not yet been found, test each coil unit with the lamp circuit tester. Remove each unit to test it.

(a) Test across (that is, hold the test points on the two places mentioned) contact buttons A and B. If lamp does not burn, test with voltmeter circuit tester as shown in Figure 43. If voltmeter pointer does not move, high tension winding is open circuited.

(b) Test across contact button C and arm on top of coil which carries stationary vibrator contact point. If lamp does not light, low tension winding is open circuited.

(c) Put card or paper between vibrator points. Then test across stationary and movable vibrator points. If

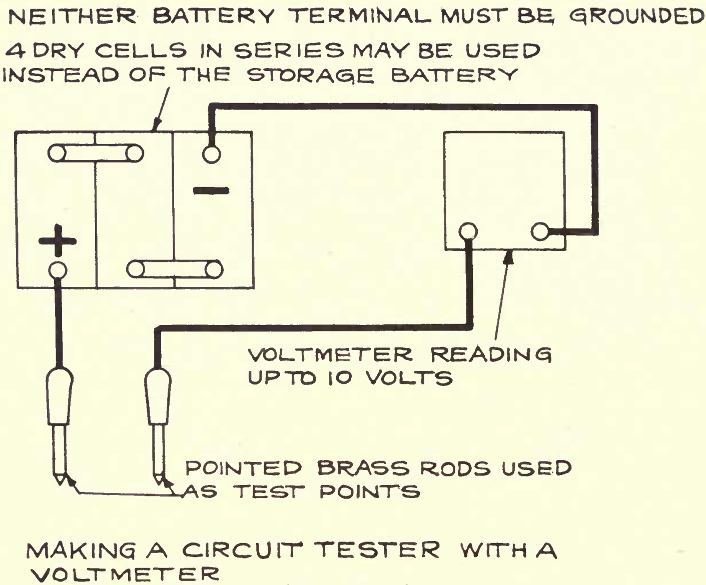


FIGURE 43.

lamp lights, these two vibrator points are short-circuited to each other. The short circuit may be in the wires which are connected to these vibrator points, or the primary and secondary windings may be short-circuited.

(d) Remove wires from commutator. Test between each wire removed and the other wires carried in the same cable. The other ends of these wires must, of course, be removed from the coil box. If lamp lights up as any pair of wires is tested in this way, these two wires are short circuited to each other. Cut outside braid on cable and examine wires. Find defective insulation and repair it. The insulation on this cable is sometimes destroyed by oil leaking on it, and gradually dissolving the rubber in the insulation.

2. ENGINE STARTS, BUT ONE OR MORE CYLINDERS MISFIRE.

To determine whether trouble is in fuel or ignition systems, or in engine, test as follows:

Stop engine and turn it over by hand. If compression is weak in any cylinder, that cylinder is causing the misfiring. If compression is good on all cylinders, the trouble must be in fuel system or ignition system. The color of the exhaust will help some in determining in which system trouble is located.

Colorless exhaust with no backfire, indicates ignition trouble.

Black smoke at exhaust indicates too rich a gasoline mixture.

Blue smoke indicates color in cylinder or oil supply system.

If trouble seems to be in ignition system, locate missing cylinder as follows:

Run the engine throttled down. Take a screwdriver which has a thoroughly insulated wooden handle. Hold tip of screwdriver on top of engine near the spark plug. Bring shank of screwdriver up against terminal on top of spark plug. This will short circuit the plug and cut out that cylinder. If this makes no difference in the sound of the engine, and engine does not slow down, you have found the cylinder which is at fault. If there is a marked difference in sound of engine, and engine slows down, you are testing a live cylinder and you have not found the faulty cylinder. You should then test each cylinder until you find the faulty one, as indicated by no difference in sound of engine when you short circuit the plug.

Another method of locating missing cylinder is as follows:

Open throttle slightly. Remove cover from coil box on dash. Hold down three of the vibrators. By holding down these vibrators you kill the ignition in the corresponding cylinders. If the engine now stops, the remaining cylinder is the faulty one If engine still runs the remaining cylinder is firing properly. Hold down three vibrators at a time in the following order, until engine stops when three are held down: (a) 2, 3, 4. (b) 1, 3, 4. (c) 1, 2, 4. (d) 1, 2, 3.

Some men prefer to hold down only one vibrator at a time and note the effect on the engine. If engine slows down, the cylinder corresponding to the vibrator which is being held down is a live one. If engine does not slow down, the cylinder is the dead one. Having located the faulty cylinder, take the screwdriver again. Hold the tip of the screwdriver on the top of the engine and bring the shank near the top of the plug. If a spark passes between the shank of the screwdriver and the plug when the screwdriver is more than 3/32 of an inch away from the plug, it shows that the points in the plug are too far apart. The correct distance between points is 1/32 inch, which is about the thickness of a smooth worn dime.

If the greatest distance between screwdriver and plug across which a spark will pass is much less than 3/32 inch, the voltage of the coil unit corresponding to that cylinder is weak, or else the plug is partly short-circuited by carbon so that the current goes around the bypass of carbon inside the plug rather than jump from plug to screwdriver. If this is the case, remove the spark plug wire and hold it about ¼ inch away from a cylinder. If spark passes from the wire to the cylinder, the voltage is as it should be, and the trouble is in the plug. Put in a new plug or else remove the old plug. To clean the plug thoroughly, it should be taken apart. To do this, clamp the large hexagon steel shell in a vise and loosen the pack nut that holds the porcelain in place. Scrape carbon from shell and porcelain, taking care not to scrape the enamel off the porcelain, as the porcelain will then carbonize more easily. Finally wash porcelain and shell in gasoline. In reassembling plug do not tighten pack nut so much that porcelain is cracked.

If no spark passed from plug wire when latter was held within $\frac{1}{4}$ inch of engine, ground the primary terminal on the coil box, which corresponds to the dead cylinder (the primary terminals are those in the top row). To do this, hold the tip of a screwdriver on the primary terminal, and bring the shank against the radiator stay rod. If, when you do this, a spark passes between the end of the plug wire and the cylinder when the wire is held $\frac{1}{4}$ inch away from cylinder, the coil unit is working properly, and the trouble lies in the wires leading from the primary coil box terminals to the commutator. Test these for short circuit as described on page 121. Also examine the terminals on the commutator and coil box. Pull on the wires to see if they are broken.

Another, and perhaps a quicker way to proceed after locating the dead cylinder, is to put in a coil unit which you know is good, and put in a new plug. If this stops the missing leave new coil unit and plug in place.

Still another method is to take the coil unit from one of the cylinders which is firing regularly and interchange it with the coil unit corresponding to the dead cylinder If the cylinder which now has coil taken from dead cylinder now misses, that coil unit is defective. If the original cylinder still misses, change the spark plug with a cylinder which is firing regularly. If cylinder with plug from dead cylinder now misfires, that plug is defective.

If trouble has not been found as yet, try the following tests:

(a) Disconnect horn wire from left hand terminal on terminal block. If this stops misfiring, the horn circuit is grounded.

(b) Inspect all terminals on coil box, back of lighting and ignition switch on dash, ammeter, terminal block, and commutator. Run your hand along each wire as far as possible and feel for break under insulation. See that all insulation on wires is not cut, torn, or oil or water soaked.

(c) See that contact pieces in commutator are all smooth, clean, and free from moisture or oil. See that insulation between contact pieces is smooth and dry. Stop engine and see that roller turns freely on its pivot; that the spring on roller arm is not loose, bent, broken, or too long; that roller has no flat spots, and that roller makes good contact with each contact piece as it passes over it.

3. BACKFIRING.

Backfiring occurs when the mixture is exploded before piston has come near enough to the top of its stroke for the momentum of the flywheel to carry it over. Backfiring is not the explosion of gas in the muffler. It is also caused by anything that will fire the mixture in the inlet manifold or carburetor.

A. A SLOW BURNING MIXTURE which burns so slowly that it is still burning when inlet valves open, thus igniting the incoming mixture in the intake manifold and carburetor.

A mixture which is too rich or too lean will burn slowly. Poor compression or incorrectly timed valves will also cause slow burning mixtures. If the mixture is too rich, carbon will accumulate in the cylinder and finally cause pre-ignition and backfiring by becoming heated to incandescence.

B. PRE-IGNITION DUE TO IGNITION TROUBLE. The most likely trouble is a short circuit or ground in the cables leading from the ignition coils to the commutator. Test these as described on page 121. It might also be due to a worn or dirty commutator. The spark may be advanced too far.

C. PRE-IGNITION DUE TO OVERHEATED CYLINDERS may be due to failure of cooling system, incandescent carbon in cylinders, or retarded spark.

In looking for the trouble, do the things that are easily done and require but little time. Advance spark lever. Examine the ignition wires for cut, torn or oil soaked insulation. Examine commutator for dirt, moisture, or worn parts. Try changing the gasoline mixture by adjusting the carburetor. Tap the carburetor to release a float which is stuck to the walls of the float chamber. Be sure that there is enough water in the radiator. If water boils, and steam comes out of radiator filler cap, the engine is overheated. To determine whether there is incandescent carbon in cylinders, switch off the ignition. If engine continues to run with ignition switched off, there is incandescent carbon in the cylinders, or sharp point of metal in the cylinder head or on top of piston, may have become incandescent.

To test cooling system if engine is hot, stop the engine and allow it to cool. Then start it again. If the backfiring occurs before the water boils, it is due to incandescent carbon, or a hot point of metal in the cylinder. If water boils before backfiring begins, the cooling system is at fault. If backfiring begins immediately upon starting engine after it has been allowed to cool, the cooling system is not at fault.

If backfiring occurs immediately after engine is started after having been allowed to cool and seems to be taking place in one cylinder only, locate the cylinder by grounding plug with screwdriver, or by holding down one vibrator at a time on the ignition coils. In this way you will cut out the defective cylinder, and, by causing it to stop firing, will eliminate the backfiring.

Having located the defective cylinder, stop the engine. Test the compression of this cylinder by turning engine over slowly, with spark plugs removed from the other cylinders. If compression is weak, the backfire was probably caused by gas leaking out of cylinder and causing a weak mixture.

To locate cause of weak compression, see that the cylinder head gasket does not leak. A leaky gasket will cause a peculiar squeak when engine is running under load. See that cylinder head bolts are drawn down tight. See that spark plug is screwed down tight. To test pour a little oil around plug and watch for gas bubbling through it. If the gas leak is very bad, the sound of the escaping gas may be heard.

Test the valve action by removing the valve door. See that inlet valve stem is not too loose in its guide. Too much clearance at this point allows too much air to be sucked into cylinders.

If the backfiring does not occur regularly, and cannot be found by cutting out several cylinders at the vibrators, it is probably in the fuel system. Having tried the carburetor adjustment without succeeding in eliminating the backfiring, drain the gasoline from the sediment bulb on the gasoline tank and carburetor bowl. Open valve at gas tank and drain cock at the carburetor to see if there is a steady flow of gasoline in the supply line. Also examine the inlet manifold and gasket for an air leak, by pouring oil at the suspected places and see if oil is drawn in.

D. IGNITION TROUBLES CAUSING BACKFIRING. If the backfiring occurs while cranking a cool engine, the trouble is probably in the ignition system.

If any coil buzzes continuously, the trouble must be in the wires running from the coil terminals to the commutator. See E, Figure 20. The cable containing these wires should be examined for cut, torn, or oil or water soaked insulation. To prove conclusively that trouble lies in this cable, disconnect the wires from the primary coil terminals and commutator. Run an extra set of four separate wires from the coils to the commutator. If this eliminates the backfiring, the regular cable is defective, and should be replaced.

Other ignition troubles that may cause backfiring are:

(a) **COMMUTATOR NOT BEING SET PROPERLY.**

When the spark lever on the steering column is fully retarded (up as far as it will go), the center of the commutator case pull rod should be $2\frac{1}{2}$ inches from the center of the cap screw on the commutator case spring. If this distance is not $2\frac{1}{2}$ inches, make adjustment by turning the rod in or out of the ball socket joint. If this does not give enough adjustment, bend the pull rod to get the proper distance.

(b) WET COIL BOX, ESPECIALLY IN DAMP WEATHER.

4. KNOCKING.

A. CARBON. Carbon causes a short metallic knock when the spark is advanced. An accumulation of carbon on the piston and upper part of cylinder walls will reduce the compression space sufficiently to cause the engine to pound from excessive pressure. After engine is warmed up, the carbon may become incandescent and cause pre-ignition and consequent knocking and backfiring. A good way to test for carbon is to shut off the ignition after engine has become thoroughly warmed up. If the engine continues to run for some time after the ignition has been shut off, the knock was caused by carbon.

The increase in compression caused by carbon decreasing the compression space gives a mixture which burns more quickly, and the spark should be retarded to eliminate the knock. If there is no knock when the engine is cool, as when it is first started, but a knock develops as the engine warms up, it is probably due to carbon.

The best way to remove the carbon is to remove the cylinder head and scrape off the carbon.

The Model T motor lends itself readily to the operation of removing carbon. It is such a simple matter to remove the head, scrape the carbon out and touch up the valves that it is unnecessary to risk burning or loading the seats of the valves by burning out the carbon or removing it with any of the many compounds which are on the market today. Excessive carbon is not only very annoying because of its resulting in knocking and lazy motor action, but it also subjects the engine to unnecessary abuse, resulting in egg-shaped bearings and burned valves.

Drain the water from the cooling system by opening the drain cock on the radiator outlet connection. If the water does not flow, run a piece of wire into the opening of the cock to loosen the sediment. While the water is running, disconnect the spark plug wires and loosen the plugs. When the water has stopped flowing, remove the capscrews which hold the cylinder head outlet connection to the cylinder head, run out the cylinder head capscrews and remove the head, leaving the screws assembled in it. If it sticks, drive a cold chisel between the head and the motor block. If the gasket remains on the block, remove it also. The combustion chambers have now been divided in two parts:

(a) The cylinder head.

(b) The cylinder block together with the pistons and valves.

Remove the spark plugs from the head and insert plugs of rags (or better still of wood with a head to keep them from dropping through) into holes leading into the water jacket.

The carbon is removed by scraping with an old file ground flat on the end or with a putty knife. After scraping, the loose carbon should be blown off with compressed air or wiped out with a rag. Never use sandpaper or any other abrasive material as it is likely to get between the cylinder wall and pistons. Scrape any foreign substance from the face of the cylinder head and the head is ready to put back on the block.

In removing carbon from the piston and block, care must be taken that no carbon gets into the water jacket nor under the valves.

Turn the motor over until No. 1 piston arrives at top center with both of the valves closed. Put rags in No. 2 cylinder and in all the water jacket holes. Scrape the carbon from the head of the piston, the valves and cylinder block and blow it off. Turn the engine over so No. 2 is up with the valves closed, and this time put rags in No. 1 and No. 4. In this way, proceed until each cylinder has been cleaned. With the end of a small screwdriver or wire, loosen the dirt in the bottom of the capscrew holes and blow it out with compressed air or with the foot pump. This is done to insure clearance for the cylinder head capscrew.

Before putting the head on, examine the valves to make sure that there is no carbon on the seats. To insure a clean seat, squirt a little motor oil under each of the valves and while each valve is seated, give it a few quarter turn oscillations with the valve grinding tool 3-Z-604.

The valves are seated by turning the engine over and feeling the valves. Until it is seated, the valve may be turned by the pressure of the fingers.

When the inlet valve of a cylinder is open, the exhaust is seated and when the piston advances past the top center after the stroke which marks the descent of the inlet valve, both valves are seated.

Clean the spark plugs. Before repalcing the head, make sure that the rags are out of all the holes and scrape any foreign matter off the top of the block.

In replacing the head, set No. 1 and No. 4 pistons on top center. If the spark plugs were removed, screw No. 4 into place. Examine the gasket, replacing with a new one if necessary. Bend back the dash shield. Position the gasket head and capscrew assembly by holding No. 4 plug with the left hand and the water outlet connection with the right. Start all the capscrews by hand before running any of them down with the wrench. Turn the engine over a few times to make sure the pistons do not hit the gasket. Run all the screws down until they seat, then draw them down a little at a time, crossing from one end to the other of the head to draw it down evenly. When the head has been tightened properly, replace the hose connection, making sure that the gasket is in position. Tighten the spark plugs and attach the wires. See wiring diagram Figure 40. Fill the radiator and test by running the engine.

This is a better method than burning. Another method is to use kerosene. Cylinders may be kept free from carbon by removing spark plugs and pouring a tablespoonful of kerosene into the cylinders once a week. This kerosene may be left in oil of the crankcase without doing any harm.

If the car has been run for sometime without removing carbon, pour about half a pint of kerosene into the cylinders. Then turn engine over by hand until the kerosene has drained through into the crankcase. The best time to do this is after the engine has been run for sometime, and all parts are warm. The oil should then be drained from the crankcase and a new supply of oil put in.

B. PRE-IGNITION. The pre-ignition, or spark knock, is the most common one. The gases are exploded too soon, tending to force piston down before it reaches the top of the compression stroke, and if there is any clearance in any of the moving parts, knocking will result. It develops when the engine is under a heavy pull, when running slowly, when speed is suddenly increased, or when climbing hills. The remedy is to retard the spark. If a car starts running through a heavy sandy or muddy road, it will be necessary to open the throttle somewhat in order that more gas and air may be drawn into the cylinders to give the increased power required. Opening the throttle results in increased compression because a greater volume of mixture is drawn into the cylinders through the enlarged throttle opening. With an increase in compression, the mixture burns more quickly and causes a pre-ignition knock unless the spark is retarded. The spark must be retarded for the same reason when the car is climbing hills.

If the commutator is set improperly, pre-ignition and knocking may also result. Set the commutator as directed on page 128.

C. LOOSE OR DEFECTIVE MECHANICAL PARTS. Some of the causes of knocks due to mechanical causes are:

(a) Loose or oversized main bearings, connecting rod bearings, wrist pin bearings, or camshaft bearings.

(b) Poorly fitting time gear.

(c) Transmission out of line.

(d) Foreign parts in crankcase.

(e) Piston striking cylinder head gasket.

If engine gives a dull thud with an accompanying jarring in the steering gear and floorboards when the engine is under a heavy load, but the thud is not noticeable when engine is accelerated with clutch out, the thud is most likely due to a poorly fitting rear main bearing.

If the knocking is not noticed on an increasing load, but on varying the speed, a single slight blow is heard and felt, either the flywheel is loose or there is too much play in the transmission assembly or end play in the main bearings. When the knock is not accompanied by a jarring in the steering column or floor boards, it is in 1 or 2 line bearings, connecting rod bearings, wrist pin or piston.

With the engine running at a fair rate of speed, cut out one cylinder at a time by holding down the vibrator armature of its coil unit, accelerating and retarding the engine to produce the knock. If the knock disappears, it is in the system of that unit which has been cut out. If, however, it is in No. 1 cylinder, No. 1 main bearing may be a loose fit. If in No. 4, it may be in the rear main bearing. A piston slap is a metallic tapping especially noticeable when the engine is cold. A wrist pin knock is a sharp click. Is usually develops when driving about 25 miles an hour. A connecting rod bearing knock is a rapid hollow pounding which becomes worse if not remedied. Loose camshaft bearings cannot be shorted out as described above but can be readily distinguished by their rattling sound and their effect on the time gears which slam badly when accelerating the motor, especially when cold. Sounds are deceiving and hard to describe, so when the trouble is located as being in a certain cylinder, it is good policy to take out the piston and connecting rod assembly and inspect it carefully.

If the trouble is located as being in No. 1, try taking up on the front bearing bolts. If this does not overcome the trouble, examine the piston and connecting rod assembly of No. 1. If, by shorting No. 2 or No. 3, the knock is still present, cut out No. 2 and No. 3 at the same time. If the knock disappears, the trouble lies in the center bearing. If the knock cannot be located as being due to one of the above causes, it is probably in the time gear or camshaft or valve. The knock may be located by listening at different points of the motor with a rod or screwdriver placed against the ear. This is particularly advantageous in hunting out valve, camshaft or gear knocks.

A leak in the exhaust manifold will sometimes cause a noise similar to a knock. If the flywheel is scraping the magneto coils, a hum will result and there will be no knock. A high spot on the time gear will cause a knock as the high spot meshes.

5. ENGINE IS SLUGGISH, AND DOES NOT DEVELOP FULL POWER.

A. CARBON ON VALVES. As the motive power is obtained by burning or exploding a highly compressed gas mixture, it follows that a certain amount of carbon will be deposited on the valve seats, piston head and combustion chamber. Small particles of burnt carbon will lodge under a valve, especially the exhaust, holding it open. As this exposes the valve seats to the heat generated by the explosion, small pits or burnt spots will in time cause the surface to be so roughened as to prevent the proper seating of the valves. This will cause a leakage of gases, resulting in loss of power and uneven running of the motor. When this occurs, grinding the valves is the only remedy.

To determine which valves need attention, turn the motor over slowly by hand and note whether the same degree of resistance is met with in each cylinder. The ones offering the least resistance are those whose valves stick. Grinding valves is the only remedy. The defective valves cause loss of compression. Carbon deposits in muffler cause back pressure. Tap the muffler lightly with a stick or hammer to loosen up the deposit of soot, which will then be blown out by the exhaust. Mud or charred oil may also stop up the muffler openings.

B. WORN OR BROKEN PISTON RINGS. This is sometimes difficult to determine in advance, especially if the valves are badly carbonized and need regrinding. By removing the cap from the breather tube, and holding the ear to the opening, you can sometimes hear the gas "blowing" past the rings. Inasmuch as the cylinder head must be removed to replace pistons or piston rings, it is advisable to examine the valves carefully before going farther.

C. LOOSE, LEAKY VALVES. These are caused by

(a) Carbon (see above).

(b) Valve springs weak. Strengthen spring by stretching it, or else put in a new spring.

(c) Loose Valve Caps. Try with oil around the joints and tighten.

(d) Insufficient Lift of Exhaust Valve.

See that there is not less than 1/64 and not more than 1/32 inch between bottom of valve stem and top of lifter, when the lifter is in lowest position and valve is on seat.

(e) Valve Push Rods Set Up Too Tight, causing the valves to hold open. With the motor hot, test the push rod clearance, and adjust accordingly.

D. VALVES NOT TIMED CORRECTLY. If inlet valves open too late, not enough charge is drawn into cylinders. The valves then will not close soon enough and some gas may be forced out again.

If inlet valves open too early, some of the burned gases may be forced back through inlet. They will then close before complete charge has been drawn into cylinders.

If exhaust valves open too late, there will be back pressure, and some of the burned gases will be forced out through the inlet valve. Moreover, if exhaust valves do not close until after beginning of suction stroke, some of the burned gases may be drawn back into the cylinder.

If exhaust valves open too soon, the burning gases will escape before end of power stroke, and power will be lost. The valve will then close before end of exhaust stroke, and not all the gases will be discharged.

E. BRAKES DRAGGING. Feel break drum after driving the car for some time without applying the brakes. If brake drums are hot, brakes are dragging, and need adjustment. See that car can be rolled easily by hand, or that it will coast down hill when the clutch is released, and does not slow down. Adjust by jacking up rear wheels and adjust until free.

F. INTAKE MANIFOLD LEAKS. Try for leaks by pouring oil on joints.

G. **MIXTURE TOO RICH.** Caused by carburetor flooding, probably due to dirt under float valve. May also be caused by dash control not set properly.

H. **MIXTURE TOO LEAN.** Incorrect carburetor adjustment. Leaks in intake manifold. Also caused by poor grade of gasoline.

I. **LACK OF LUBRICATING OIL.** Causes motor to have excessive friction and to run hot. Introduce kerosene through the spark plug holes in each cylinder and crank by hand, thus cleaning out the old oil. Drain out the kerosene and old oil at crankcase drain cock. Refill lubricating system with correct grade of oil and crank by hand until engine is thoroughly lubricated. The lack of lubrication will also result in scored cylinder walls. The remedy is to replace worn or broken rings, and rebore cylinders.

J. **LACK OF GASOLINE.** Due to stoppage in pipe, or at the strainer in the carburetor. Motor will spit back through the carburetor when throttle is opened suddenly. Poor grade gasoline has same effect.

K. **LACK OF COOLING WATER.** Radiator will become hot, and steam will come out of radiator cap.

May be due to leaky radiator, or hose connections. If impure water has been used, a deposit of lime or scale may have gathered in cylinder water jackets, or in radiator.

Sometimes the cooling water apparently boils, when it is not hot enough to do so. This will be noticed when motor is stopped after a run, and is indicated by a bubbling in the radiator. The cause is air from pockets in the cylinder, bubbling up through the water in radiator. If this noise is noticed, feel radiator.

L. **LATE OR SLUGGISH IGNITION.** This is not a common occurrence and is best detected by an almost total lack of power; also, the engine will heat readily, causing the water to boil in the radiator. If ignition is very late, the engine will pound and knock on the slightest pull. Check commutator setting. See page 128.

(a) It sometimes occurs that several strands of wire in the primary circuit (coil to battery wire) break, and while there is contact, the actual number of wires carrying the current may have been reduced so as to increase the resistance of the conductor and cause a drop of voltage which cuts down the voltage at the coil, which in turn reduces spark strength and causes slow ignition of gas.

(b) Spark Plug Points Dirty, or Too Far Apart.

(c) Spark Plugs Loose.

6. ENGINE GRADUALLY LOSES POWER—POWER DECREASE WHILE RUNNING.

Power decrease while running is due to trouble in the carburetor system or overheating. It is usually accompanied by backfire, eventually stopping the engine. If it is in the carburetor, it is due to a stoppage of the supply line; stop cock jarring closed in the gasoline tank sediment bulb; broken supply line; dirt or water in the carburetor; ventilating hole in the gasoline tank cover stopped up.

There may be a crack in the inlet manifold which is closed when cool, and open when the motor warms up. This trouble may be located by pouring oil on the doubtful spots.

If it is because of overheating, it will be noted by the water boiling in the radiator. There may be a leak between the cylinder and the water jacket which opens up as the engine becomes warm. This will cause the water in the heating system to boil. There is little likelihood of this occurring anywhere except between the gasket and the cylinder head and cylinder.

If the valves have not been timed after excessive grinding, the stems may be riding on the push rod, and while the valves would be seating on a cool engine, they would ride as the stems lengthened due to the heat.

7. IRREGULAR ACTION OF ENGINE.

By irregular action we mean that the engine misses, backfires, slows down, and at times runs all right. This trouble may originate in either the carburetor or commutator.

If the trouble lies in the carburetor, it is due to a broken spring in the air inlet gate, loose jam-nut on the needle valve, dirt in the jets, or poor flow of gas to the carburetor.

If the trouble lies in the commutator, it is due to a dirty commutator housing, loose case spring, or commutator roller loose on shaft or out of order.

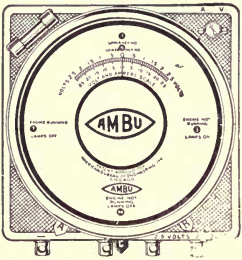
The first thing to do is to test the priming rod attached to the air intake gate to see if the spring is in good condition. Next, try the carburetor adjustment, at the same time noticing whether the needle valve is too loose. Surge the engine to remove any dirt or water from the jet.

To surge the engine, move the gas throttle up and down, accelerating and retarding the engine speed. The best way to surge the engine is to drive the car on the road so the load of the car will be on the engine. The engine should never be jumped or raced, as it is liable to score the bearings or make them egg-shaped.

If the trouble cannot be located in the carburetor, examine the commutator. See if the commutator case spring is loose. See that the commutator case moves freely and sets squarely in the recess. See that the control and the pull rod are in good condition. Next remove, examine and clean the commutator and case and roller.

Trouble Shooter

The AMBU TROUBLE SHOOTER consists of three main parts, forming a complete and invaluable system for quickly diagnosing and locating any trouble in the Electric Starting and Lighting Systems of all American made Automobiles.



These parts are:

(1) The Ambu Instrument. This is a combined ammeter and voltmeter which has a special patented set of movable dials by which trouble is quickly diagnosed. This instrument may also be used as an ordinary ammeter or voltmeter. The ammeter has three scale readings 1-0-5; 5-0-25; 100-0-500. The voltmeter readings 0.3-0-3; 3-0-30; 15-0-150. It is of a very rugged construction designed for use in the repair shop.

(2) Instruction Books, or ''Charts.'' This book on the ''Ford Standard Electrical Equipment'' is typical of the fourteen Instruction Books, or ''Charts'' for the various makes of starting and lighting systems which form a part of the AMBU Trouble Shooter. The different models produced by each maker are fully covered in these charts, there being instructions for more than 100 models of generators and motors.

Each of these ''Charts'' gives thorough, yet simple instructions, which are as easily understood as those in this book on the Ford Starting and Lighting System.

By using the ''Charts'' with the AMBU instrument, electrical troubles are easily located and eliminated. The instrument classifies the trouble and indicates the exact pages in the charts where the trouble is described, and the simplest method given for its location and removal.

The fourteen ''Charts'' are of a convenient size, 5¾ inches by 7½ inches, and contain more than 3,000 pages of accurate, systematized instructions for quickly finding and eliminating electrical troubles. They also contain over 200 circuit diagrams, arranged in the same manner as those in this book, which show the exact internal connections of the various makes and models of generators, motors, regulators, cutouts, and so on. Other useful information found in the ''Charts'' consist of tables giving the lamp equipment of the various makes and models

Trouble Shooter

of cars; instructions for increasing or decreasing the charging rate of each of the various models of generators; the correct charging rate and lamp current for all cars; instructions for adjusting cutouts and regulators; and complete descriptions of the design, construction, maintenance, and special features of the various makes and models of generators, motors, cutouts, etc.

This data is all handled in the same clear and concise manner as they are in our book, "The Ford Standard Electrical Equipment."

(3) Over 700 Wiring Diagrams, showing the complete external connections of the Starting, Lighting and Ignition circuits on cars made in the United States since 1911. All parts are placed in the same relative positions they occupy on the cars, and are clearly labeled and explained.

In addition to these three main parts, there is also a 300 page book telling all about automobile batteries, their theory, maintenance and manufacture, and giving complete and practical instructions for making any repairs, charging, etc. This book is profusely illustrated by especially made drawings and photographs.

A set of Cadmium Test Leads is also included; also a twelve chapter clearly written and easily understood course of Ignition, Starting and Lighting; a complete set of suggestions for advertising your shop in local newspapers, with the loan of cuts and illustrations; and expert consultation on any electrical subject.

Ambu is as Essential to You as an Engine is to an Automobile. The claim made by Ambu is that it is the repairman's best friend. There is indisputable evidence to prove that this claim is correct. Men who have installed the AMBU TROUBLE SHOOTER Service in their shops say they could not handle half the jobs they do now if they did not have it. Not only do they get the trade which comes from those who need efficient electrical repair service, but they are also able to make many hundreds of dollars through the sale of accessories to the car owners with whom they are brought into contact by AMBU.

If you want to be able to handle any electrical repair job, if you want to make more money and greater profit, get the AMBU plan, become an AMBU man.

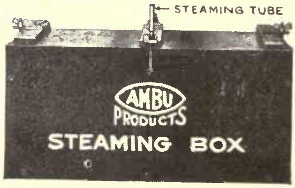
Complete Trouble Shooter..................Price on Request

American Bureau of Engineering, Inc.

Automobile Department

1603 South Michigan Ave., Chicago, Ill., U. S. A.

Battery Steamer and Still



You can easily open any battery without the use of a gas flame or blow torch if you have an AMBU BATTERY STEAMER. And while the Steamer is working away, softening the sealing compound, the repairman does some other work. From five to thirty minutes and the sealing compound is so soft that it can easily be removed with the point of a screw driver, and this will take only five minutes, because of the thorough job done by the steamer.

Steamer Cuts Dirt and Grease.

Another big advantage of the steamer is that the steam cuts all the dirt and grease on the battery box so that it can be wiped off with a cloth, making the box look like new.

Needs No Attention After Stove is Lighted.

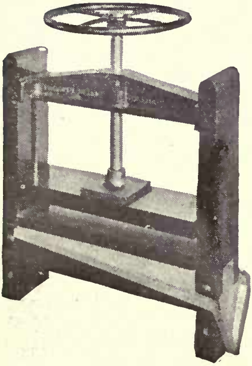
In the average battery shop the water supply tank needs to be filled but once a day. After that the stove is lighted and the entire steaming apparatus requires absolutely no attention. The level of the water in the boiler is automatically maintained at one inch. An automatic, float-controlled valve keeps the water at this level and admits just enough water to replace that which boils away. This is a tremendous advantage, as steam is quickly obtained, and a weaker flame may be used to boil the water.

When used with the condenser—see illustration—it will give five and one-half gallons distilled water in seven hours.

Price, complete	$35.00
Price without condenser	25.00
Price condenser only	12.50
Price steaming box only	12.50

F. O. B. Chicago. Order through your jobber or direct.

Battery Plate Press



The most common fault of negative battery plates is the bulging out of the active material caused by the formation of lead sulphate as the battery discharges. **This active material must be pressed back flush with the grids if the battery is to give good service again.** Moreover, both positive and negative plates become bent out of shape, and buckled, and must be straightened.

Many battery men use an ordinary iron bench vise, for this purpose, but this is a poor practice. The iron vise soon becomes corroded and rusted from the acid squeezed out of the plates. It also becomes stiff and hard to operate. Moreover, there is always danger that particles of iron will get on the plates from the vise, and iron is the worst enemy of battery plates, because it causes the battery to lose its charge quickly and it is almost impossible to remove this iron.

The **AMBU BATTERY PLATE PRESS** is designed to do away with all the disadvantages of the iron vise. Three sets of plates may be pressed at once between the large wooden jaws. No iron or any other metal can touch the plates. The upper jaw is movable and is operated by a large hand-wheel. No acid can drip on the operating screw.

A trough may be placed under the press so as to catch the acid squeezed from the plates. The trough may be drained into a stone jar and the acid saved, thus eliminating the rotted, acid soaked floor which results from the use of the iron bench vise, and which ruins shoes and clothes.

Fittings with instructions are furnished with the Press for mounting it on the wall of the shop. The press may also be mounted on a stand, which is not, however, furnished with the Press. This stand is easily made however.

The lower jar is removable, and may be lifted out and replaced if it becomes acid soaked. All parts are coated with acid-proof paint.

A complete set of transite boards of the proper thickness for placing between the plates are included in the cost price.

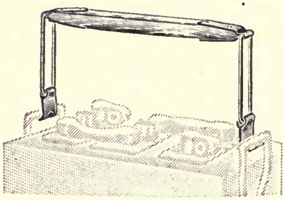
Price, with transite boards, and fittings for mounting on wall $32.50

Transite Boards only—set complete.................... 5.90

F. O. B. Chicago. Order through your Jobber, or direct from us.

AMERICAN BUREAU OF ENGINEERING, Inc.,
Automobile Department
1603 S. Michigan Avenue **Chicago, Ill., U. S. A.**

Battery Carrier



"Carry a Battery Like a Suitcase."

You would not think of carrying a heavy suitcase by holding it in front of you with both hands. Yet that is the way a battery is generally carried, not because it is heavy, but because of the way the handles are attached to the battery box.

WHAT IT IS. The Ambu Battery Carrier consists of a stout hardwood handle having a swinging steel arm at each end to which is attached a strong steel hook for engaging the handles on the battery box.

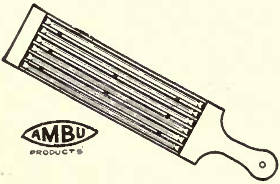
WHAT IT DOES. The construction is such that the terrific strain on the handles of the battery is lessened to a minimum. A strap with hooks should never be used because there is a side pull that soon causes the handles on the battery to give way. Enables you to carry a battery like a suitcase, with the least strain on your arms. One man can carry two batteries at once because he can hold them down at his side. Also useful in lifting a battery out of the car, and putting the battery back in the car. Shipping weight, 1 lb. each, or 2 lbs. per pair.

Price, each $1.50
Price, per pair................................ 2.50

F. O. B. Chicago. Order direct or through your jobber.

Burning Lead Mold

Here's a convenient, inexpensive lead mold which will be quite welcome to you in these days of conservation. Every battery shop has an accumulation of scrap lead from post drillings, old connecting straps, and old plates.



F. O. B. Chicago.
Order through your Jobber or direct.

Such scrap makes good burning lead, and should be saved until enough has accumulated to be melted and poured off into molds.

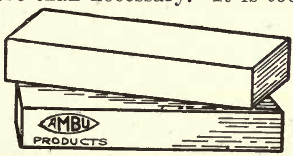
The **AMBU BURNING LEAD MOLD** is made of heavy sheet iron, die-stamped into six slots into which the lead is poured. The mold gives very handy sized bars for lead burning. The slotted iron is mounted on a strong wooden base which has a handle at one end, making it possible to handle the mold when full of hot lead. A sheet of asbestos protects the wooden base from the heat of the melted lead.

The sheet-iron construction absorbs very little heat, making it easy to pour the lead. This is a decided advantage over a cast-iron mould, which absorbs so much heat that the lead cools quickly and is hard to pour.

Price, each **$1.50**
Price, per pair **2.50**

Battery Turn Table

When you once lift a battery up on the work bench, you do not want to move it around any more than necessary. It is too heavy for easy handling. Yet in lead burning, sealing, repairing the handles, repairing the case, or painting the case, you often must be able to get at all sides of the battery.



BATTERY TURN TABLE

To eliminate the back-breaking lifting and turning around of the battery, the **AMBU BATTERY TURNTABLE** was designed. Every battery man should have at least one of these handy turntables. A battery on this turntable can be turned around with one finger.

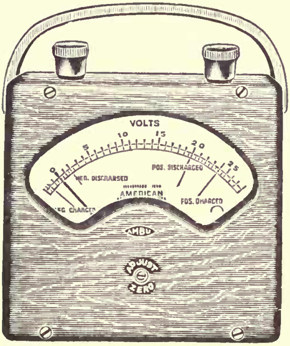
The turntable is not fastened to the work bench, and may be taken to the battery, instead of carrying the heavy battery to it.

It is made of well-seasoned hardwood and will last for years.

Price, each **$2.50**

F. O. B. Chicago. Your Jobber can supply you now. If not, write to us direct.

Cadmium Voltmeter



In order to make accurate Cadmium Tests, you must have a fine reading voltmeter. Most ordinary voltmeters are not suitable for this purpose, and to get a voltmeter of sufficient accuracy, you usually pay from $50.00 to $100.00.

The AMBU CADMIUM VOLTMETER is made especially for Cadmium Tests, and is therefore absolutely certain to give you accurate results.

A complete instruction book for making Cadmium Tests goes with each instrument.

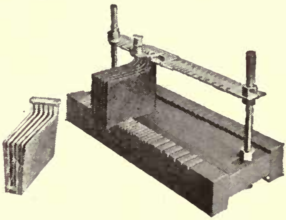
Voltmeter only..............$22.50
Voltmeter with Cadmium Leads 25.00

Your jobber can supply you now. If not write direct.

Plate Burning Racks

When you burn-in new plates, or attach a whole group of plates to a plate strap, you need a burning rack to hold the plates in position while the lead is melted in.

WHAT THEY ARE. The Ambu Plate Burning Racks have guiding slots cut in the base as well as in the iron bar, or "comb." In this way the plates are held at exactly the right distance apart, both at the top and bottom. Bases are made of hardwood. The small rack will take care of practically all ⅛ inch plates made by Willard, Gould, Philadelphia, and U. S. L. It will also accommodate all thin plates such as the Exide 3XC, Willard, and Gould. The large rack will take care of many other types, being designed to accommodate fully 95 per cent of all the types of plates which are made at present.

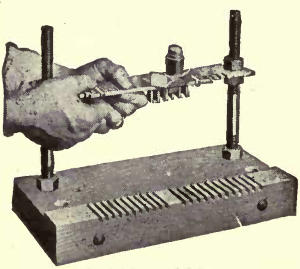


Large Rack

Special iron fittings are furnished which are placed around the plate lugs on the comb so as to hold the plates firmly in position, and to prevent the hot lead from running off.

WHAT IT DOES. Enables you to burn in plates in half the time required when using the ordinary rack. Plates are held at exactly the correct distance apart. The hot lead cannot run off. No iron touches the bottoms of the wet plates.

Shipping weight of small rack, 10 lbs. Shipping weight of large rack, 15 lbs.

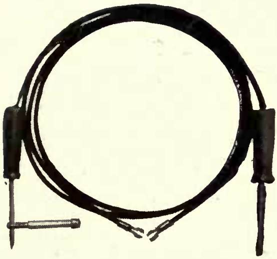


Small Rack

Price of small rack..................................$ 7.50
Price of large rack.................................. 12.50

F. O. B. Chicago. Order direct or through your jobber.

Cadmium Leads



How often you have said, "If I only had some way of knowing which set of plates is in a bad condition, without first opening up the whole battery!" That is precisely what you can do with the AMBU CADMIUM LEADS. These Cadmium Leads consist of two heavily insulated flexible wires, each five feet long, at one end of which are brass prods with wooden handles, and at the other end of which are forked terminals for attaching to the voltmeter. Fastened at right angles to one of the brass prods is a rod of chemically pure cadmium.

With these AMBU CADMIUM LEADS you can make absolutely reliable tests in a few moments, and you must have the means to make such tests if you want to know whether each set of plates is functioning properly, and able to give good service while under load. The Cadmium Test will show up a poor set of plates, be they positive or negative plates, instantly. No battery should be taken off the charging bench, or sent out of your shop until a Cadmium Test shows that both positive and negative plates are fully charged and ready to give good service.

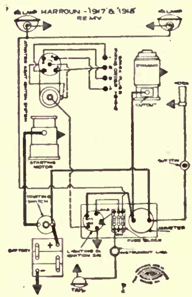
Give this matter your immediate consideration. Order now. Can be used with any voltmeter that has readings as fine as five hundredths.

CADMIUM LEADS $3.25

Order through your Jobber or direct.

1917-1918-1919

Automobile Wiring Diagrams



Ambu diagrams were the original simplified wiring diagrams. They were placed first in the hands of the garagemen as part of the Famous Ambu Electrical Trouble Shooter. They were never before obtainable except with the Trouble Shooter. Each diagram, 6x9, is printed on the strongest kraft paper in intense black ink. Easy to read, handy to refer to, and lasting for years. No symbols are used. These diagrams simplify electrical problems.

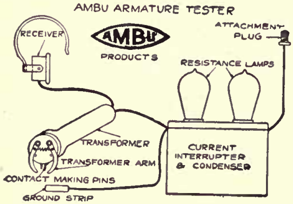
1919 Edition of wiring diagrams contains sets for cars made in 1917, 1918 and 1919. Diagram for each model of car. They are bound in loose leaf form allowing for additions of new diagrams as they appear or for diagrams of cars made previous to 1917 which may be secured in single form.

1919 Edition..$3.50
Single diagrams of all cars, 1911 to present....25c

Order through your jobber or direct.

Armature Tester

This is an accurate, positive device for quickly detecting and accurately locating open circuits, short-circuits, grounds, and reversed commutator connectors on the armatures of motors or generators which are equipped with commutators.



WILL TEST ANY SIZED ARMATURE.

Any sized armature, no matter how small or large, no matter what its resistance, may be tested with equal facility. No connections are made to the armature, and the armature need not be removed from the machine if it is possible to get at the commutator.

MAY BE USED ON ANY A. C. OR D. C. CIRCUIT.

The AMBU ARMATURE TESTER may be used on any direct or alternating current circuit, and on any voltage from 6 to 220. No change or adjustment is necessary in changing from a direct to an alternating, or from alternating to direct, current circuit. For the various voltages, it is only necessary to use lamps of the proper voltage or no lamps at all, as the case may be.

CONSTRUCTION IS VERY SIMPLE.

Current from the supply circuit is led through a current interrupter, which is bridged by a condenser. The current is sent into each consecutive pair of segments through the Contact Making Pins shown in the illustration. The two Transformer Arms shown in the illustration touch the commutator also, and lead to the telephone receiver circuit through a specially designed transformer coil.

INDICATIONS ARE POSITIVE.

The variation in the sound heard in the receiver tells what the nature of the trouble is, and just where it is. In making a test, the contact making pins are brought down on each pair of consecutive segments, the Transformer arms resting on the commutator several segments on either side of the contact making pins.

This testing is all done with one hand. An open circuit is indicated by a sudden and marked louder sound, a short-circuit by a sudden and marked dimmer sound, reversed commutator connections by louder sounds on every second pair of segments as long as they last. Grounds are located by testing between each segment and the armature core or shaft. The segment which is nearest the grounded point of the winding is indicated by a sudden dimming of the sound in the receiver.

THE AMBU ARMATURE TESTER has been in daily use in a large armature repair shop for over three years, and has been given a thorough and severe tryout. There is nothing to get out of order, no delicate or adjustable parts.

The entire outfit weighs less than seven pounds, and may be easily carried about.

Price, each $30.00

F. O. B. Chicago. Your Jobber can supply you, or order direct.