Buick

DELCO INSTRUCTION BOOK

MODELS D44-D45
D46-D47

1916

INSTRUCTIONS

FOR THE CARE AND OPERATION

of the

DELCO

ELECTRIC CRANKING, LIGHTING

. . . and . . .

IGNITION SYSTEM

On 1916 Buick Models

D 44 - D 45

D 46 - D 47

Second Edition

INDEX

PART ONE

PART TWO

Buick Models D44-45 - D46-47 Instructions

These instructions are divided into two sections, the first section being a brief non-technical explanation of the Delco System, which should be carefully read by every owner or driver of a car carrying this system. The second section is a more complete description of the system, including a number of points and suggestions, together with different tests on different parts of the system which the mechanic and repairman will have use for in properly caring for the system. This of necessity must be of a more technical nature and will not be so readily understood by many non-technical car owners.

The Buick-Delco Electric System on Models D 44-45 - D 46-47 consists of the following apparatus:

Motor Generator	No.	70
Motor Clutch	No.	11690
Ignition Coil	No.	2123
Combination Light and Ignition Switch	No.	1057

In addition to the above the system includes the necessary terminals, clips and screws for properly mounting and connecting the system. It does not, however, include the following:

The Storage Battery
Lamps
Horn
Spark Plugs

Although these are more or less dependent upon the Delco System.

MOTOR GENERATOR

The motor generator which is located on the right side of the engine is the principal part of the Delco System. This consists essentially of a dynamo with two field windings, and two windings on the armature with two commutators and corresponding sets of brushes, in order that the machine may work both as a starting motor, and as a generator for charging the battery and supplying the lights, horn and ignition. The ignition apparatus is incorporated in the forward end of the motor generator. This in no way affects the working of the generator, it being mounted in this manner simply as a convenient and accessible mounting.

The motor generator has three distinct functions to perform which are as follows:

FUNCTIONS
No. 1—Motoring the Generator
No. 2—Cranking the Engine
No. 3—Generating Electrical Energy

MOTORING THE GENERATOR

Motoring the generator is accomplished when the ignition button on the switch is pulled out. This allows current to come from the storage battery through the ammeter on the combination switch, causing it to show a discharge. The first reading of the meter will be much more than the reading after the armature is turning freely. The current discharging through the ammeter during this operation is the current required to slowly revolve the armature and what is used for the ignition. The ignition current flows only when the contacts are closed, it being an intermittent

IGNITION CURRENT

current. The maximum ignition current is obtained when the circuit is first closed and the resistance unit on the rear end of the coil is cold. The current at this time is approximately 6 amperes, but soon decreases to approximately 3½ amperes. Then as the engine is running it further decreases until at 1000 revolutions of the engine it is approximately 1 ampere.

This motoring of the generator is necessary in order that the

MESHING GEARS

starting gears may be brought into mesh, and should trouble be experienced in meshing these gears, do not try to force them, simply allow the starting pedal to come back, giving the gears time to change their relative position.

GENERATOR CLUTCH

A clicking sound will be heard during the motoring of the generator. This is caused by the over-running of the clutch in the forward end of the generator which is shown in (Fig. 1.)

The purpose of the generator clutch is to allow the armature to revolve at a higher speed than the pump shaft during the crank-

PURPOSE

ing operation and permitting the pump shaft to drive the armature when the engine is running on its own power. A spiral gear is cut on the outer face of this clutch for driving the distributor. This portion of the clutch is connected by an Oldham coupling to the pump shaft. Therefore, its relation to the pump shaft is always the same and does not throw the igniiton out of time during the cranking operation. This clutch receives

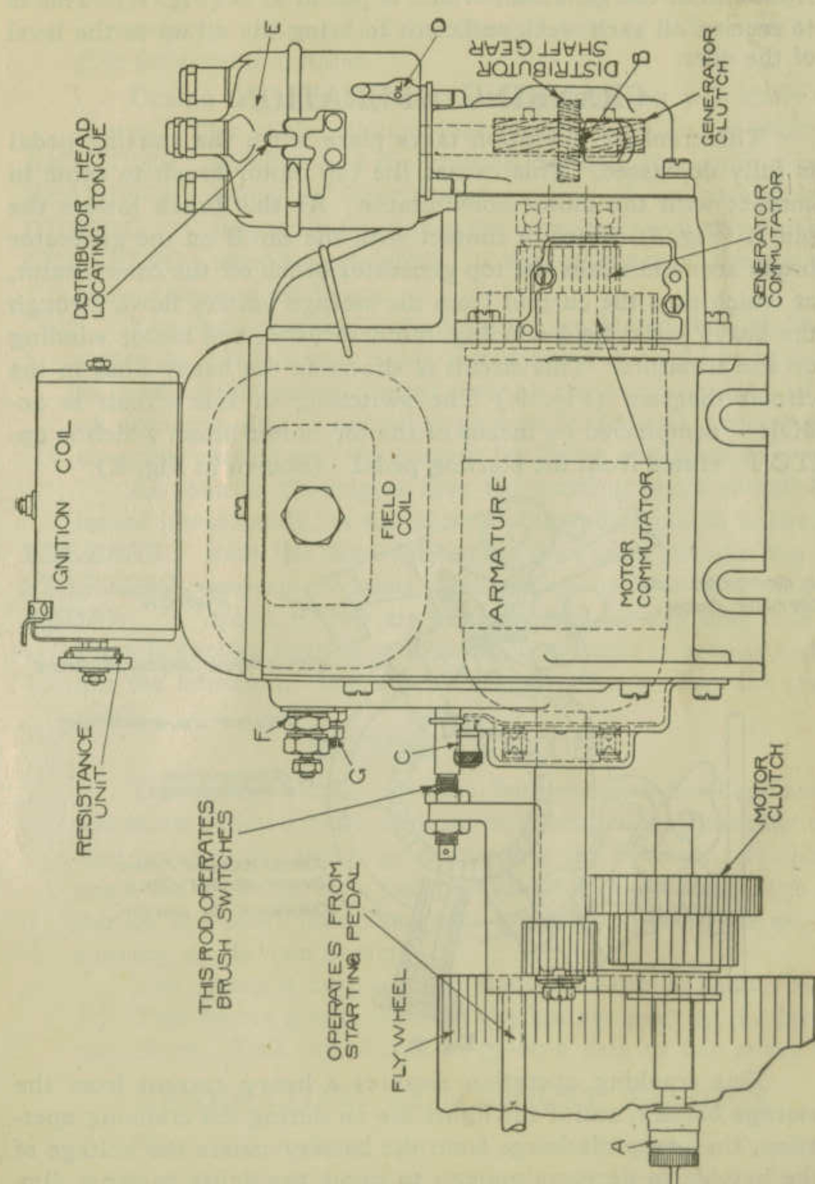

Fig. 1

NOTE.—On the later models a different oiler is used at B.

LUBRICATION lubrication from the oil that is contained in the front end of the generator which is put in at B (Fig. 1.) This is to receive oil each week sufficient to bring the oil up to the level of the oiler.

CRANKING OPERATION

The cranking operation takes place when the starting pedal is fully depressed. This causes the top motor brush to come in contact with the motor commutator. As this brush lowers the pin A (Fig. 2) comes in contact with the ear B on the generator brush arm and raises the top generator brush off the commutator, at which time the current from the storage battery flows through the heavy series field winding, motor brushes and motor winding on the armature. This circuit is shown in the heavy lines in the circuit diagram (Fig. 9.) The switching in this circuit is accomplished by means of the top motor brush which is operated from the starting pedal. (Shown in Fig. 2.)

MOTOR SWITCH

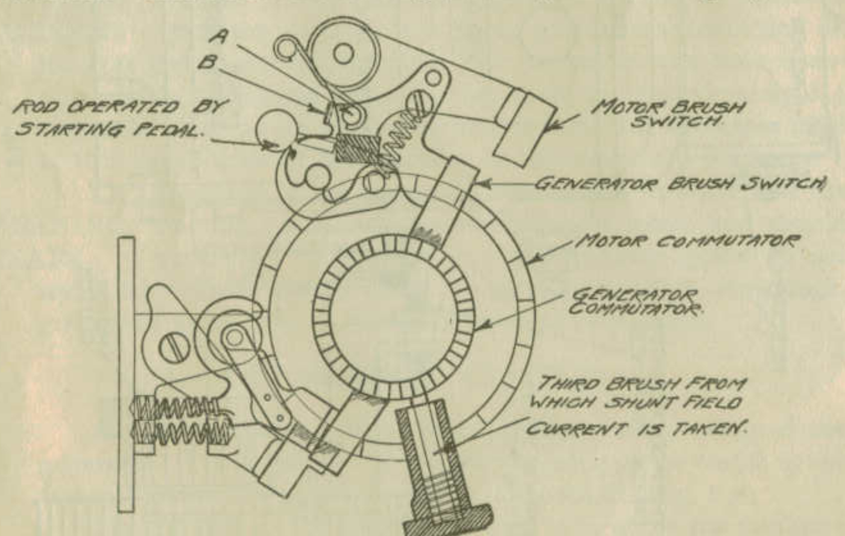

Fig. 2

This cranking operation requires a heavy current from the storage battery, and if the lights are on during the cranking operation, the heavy discharge from the battery causes the voltage of the battery to decrease enough to cause the lights to grow dim. This is noticed especially when the battery is nearly discharged; also will be more apparent with a stiff motor or with a loose or poor connection in the battery circuit.

CRANKING CURRENT It is on account of this heavy discharge current that the cranking should not be continued any longer than is necessary, although a fully charged battery will crank the engine for several minutes.

AMMETER READINGS DURING CRANKING During the cranking operation the ammeter will show a discharge. This is the current that is used both in the shunt field winding and the ignition current; the ignition current being an intermittent current of comparatively low frequency will cause the ammeter to vibrate during the cranking operation. If the lights are on the meter will show a heavier discharge.

The main cranking current is not conducted through the ammeter, as this is a very heavy current and it would be impossible to conduct this heavy current through the ammeter and still have an ammeter that is sensitive enough to indicate accurately the charging current and the current for lights and ignition.

RELEASE STARTING PEDAL As soon as the engine fires the starting pedal should be released immediately, as the overrunning motor clutch is operating from the time the engine fires until the starting gears are out of mesh. Since they operate at a very high speed, if they are held in mesh for any length of time, there is enough friction in this clutch to cause it to heat and burn out the lubricant. There is no necessity for holding the gears in mesh.

MOTOR CLUTCH

The motor clutch operates between the flywheel and the armature pinion for the purpose of getting a suitable gear reduction between the motor generator and the flywheel. It also prevents the armature from being driven at an excessively high speed during the short time the gears are meshed after the engine is running on its own power.

This clutch is lubricated by the grease cup A, shown in (Fig. 1.) This forces grease through the hollow shaft to the inside of the clutch. This cup should be given a turn or two every week.

GENERATING ELECTRICAL ENERGY

When the cranking operation is finished the top motor brush is raised off the commutator when the starting pedal is released. This throws the starting motor out of action (Fig. 2.) The top generator brush comes in contact with the generator commutator, and the armature is driven by the extension of the pump shaft.

At speeds above approximately 7 miles per hour the generator voltage is higher than the voltage of the storage battery which causes current to flow from the generator winding through

CHARGING CURRENT

the ammeter in the charge direction to the storage battery. As the speed increases up to approximately 20 miles per hour this charging current increases, but at the higher speeds the charging current decreases.

The curve on page 27 shows approximately the charging current that should be received for different speeds of the car. There will be slight variations from this due to temperature changes and conditions of the battery which will amount to as much as from 2 to 3 amperes. The regulation of the generator is explained in section 2.

LUBRICATION

There are five places to lubricate this Delco System:

No. 1—The grease cup for lubricating the motor clutch. (as described on page 7)

No. 2—Oiler for lubricating the generator clutch and forward armature bearing. (B, Fig. 1.)

No. 3—The oiler in the rear end cover for lubricating the bearing on the armature shaft. This should receive a few drops of oil every week.

No. 4—The oil hole in the distributor, at D (Fig. 1) for lubricating the top bearing of the distributor shaft. This should receive oil once a week.

No. 5—This is the inside of the distributor head. This should be lubricated with a small amount of vaseline, carefully applied two or three times during the first 2000 miles running of the car, after which it will require no attention. This is to secure a burnished track for the rotor brush on the distributor head. This grease should be sparingly applied and the head wiped clean from dust and dirt.

COMBINATION SWITCH

The combination switch (Figs. 3 and 4) is for the purpose of controlling the lights, ignition and the circuit between the generator and the storage battery. The button next to the ammeter controls both the ignition and the circuit between the generator and storage battery, the latter circuit being shown in the heavier line. This is very plainly shown on the circuit diagram, page 15. The button next to this controls the head lights. The next button controls the auxiliary lamps in the head lights.

The button on the left controls the cowl and tail lights.

THE CIRCUIT BREAKER

The circuit breaker is mounted on the combination switch as shown in (Fig. 4.) This is a protective device, which takes the place of a fuse block and fuses. It prevents the discharging of the battery or damage to the switch or wiring to the lamps, in the

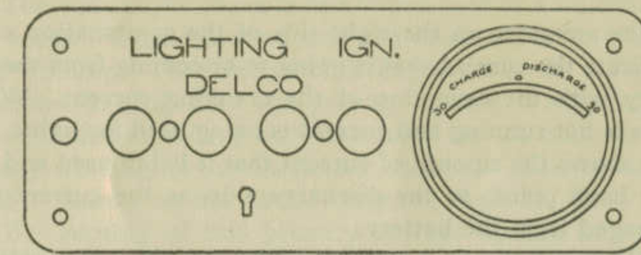

Fig. 3

event of any of the wires leading to these becoming grounded. As long as the lamps are using the normal amount of current the

GROUNDS

circuit breaker is not affected. But in the event of any of the wires becoming grounded an abnormally heavy current is conducted through the circuit breaker, thus producing a strong magnetism which attracts the pole piece and opens the contacts. This cuts off the flow of current which allows the contacts to close

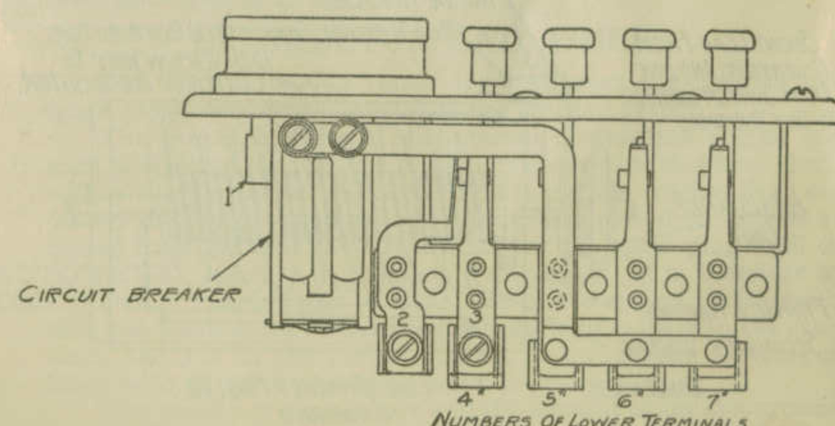

Fig. 4

again and the operation is repeated, causing the circuit breaker to pass an intermittent current and give forth a vibrating sound.

It requires 25 amperes to start the circuit breaker vibrating, but once vibrating a current of three to five amperes will cause it to continue to operate.

In case the circuit breaker vibrates repeatedly, do not attempt to increase the tension of the spring, as the vibration is an indication of a ground in the system. Remove the ground and the vibration will stop.

THE AMMETER

The ammeter on the right side of the combination switch is to indicate the current that is going to or coming from the storage battery with the exception of the cranking current. When the engine is not running and current is being used for lights, the ammeter shows the amount of current that is being used and the ammeter hand points to the discharge side, as the current is being discharged from the battery.

AMMETER READINGS

When the engine is running above generating speeds and no current is being used for lights or horn, the ammeter will show charge. This is the amount of current that is being charged into the battery. If current is being used for lights, ignition and horn in excess of the amount that is being generated, the ammeter will show a discharge as the excess current must be discharged from the battery, but at all ordinary

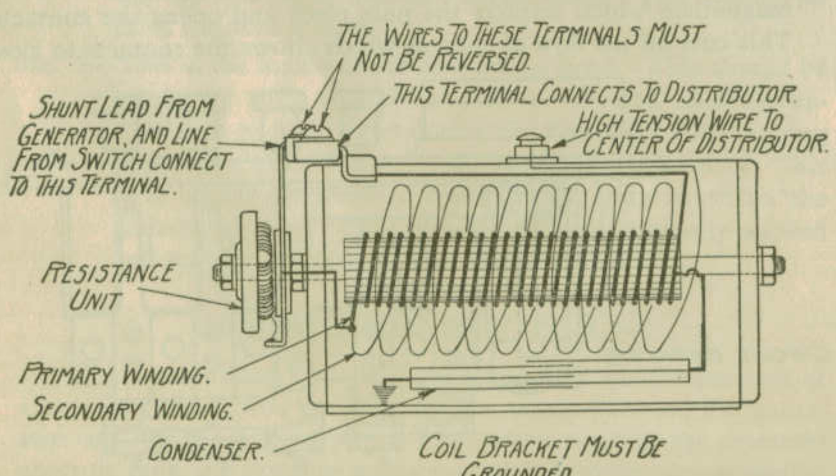

Fig. 5

speeds the ammeter will read charge. The charging rate for different car speeds when no current is being used for lights or horn, is given in the curve on page 27.

IGNITION COIL

This is mounted on top of the motor generator as shown in (Fig. 1) and is what is generally known as the ignition transformer coil. In addition to being a plain transformer coil it has incorporated in it a condenser (which is necessary for all high tension ignition systems) and has included on the rear end an ignition resistance unit.

PRIMARY CIRCUIT

The coil proper consists of a round core of a number of small iron wires. Wound around this and insulated from it is the primary winding. The circuit and arrangement of the different parts are shown in (Fig. 5.) The primary current is supplied through the combination switch and resistance on the coil, through the primary winding, to the distributor contacts. This is very plainly shown on the circuit diagram, Page 15. It is the interrupting of this primary current by the timer contacts together with the action of the condenser which causes a rapid demagnetization of the iron core of the coil that induces the high tension current in the secondary winding. This secondary winding consists of several thousand turns of very fine copper wire, the different layers of which are well insulated from each other and from the primary winding, one end of which terminates at the high tension terminal about midway on top of the coil. It is from this terminal that the high tension current is conducted to the distributor where it is distributed to the proper cylinders by the rotor shown in (Fig. 6.)

DISTRIBUTOR AND TIMER

The distributor and timer, together with the ignition coil, spark plugs and wiring constitute the ignition system.

AUTOMATIC CONTROL

The proper ignition of an internal combustion engine consists of igniting the mixture in each cylinder at such a time that it will be completely burned at the time the piston reaches dead center on the compression stroke. A definite period of time is required from the time the spark occurs at the spark plug until the mixture is completely expanded. It is therefore apparent that as the speed of the engine increases the time the spark occurs must be advanced with respect to the crank shaft, and it is for this reason that the Delco Ignition Systems are fitted with an automatic spark control.

The quality of the mixture and the amount of the compression are also factors in the time required for the burning to be complete. Thus a rich mixture burns quicker than a lean one. For this reason the engine will stand more advance with a half open throttle than with a wide open throttle, and in order to secure the proper timing of the ignition due to these variations and to retard the spark for starting, idling and carburetor adjusting, the Delco distributor also has a manual control.

MANUAL CONTROL

The automatic feature of this distributor is shown in Figs. 6 and 7. With the spark lever set at the running position on the steering wheel (which is nearly all the way down on the quadrant), the automatic feature gives the proper spark for all speeds excepting a wide open throttle at low speeds, at which time the spark lever should be slightly retarded. When the ignition is too far advanced it causes loss of power and a knocking sound within the engine. With too late a spark there is a loss of power (which is usually not noticed excepting by an experienced driver or one very familiar with the car), and heating of the engine and excessive consumption of fuel is the result.

POSITION OF SPARK LEVER

The timer contacts shown at D and C (Fig. 7) are two of the most important points of an automobile. Very little attention will keep these in perfect condition. These are tungsten metal, which is extremely hard and requires a very high temperature to melt. Under normal conditions they wear or burn very slightly and will very seldom require attention; but in

TIMER CONTACTS

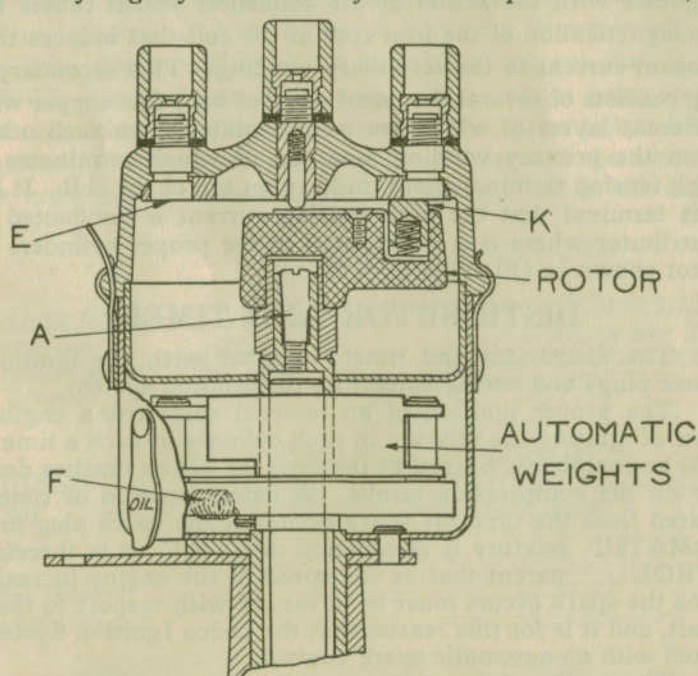

Fig. 6

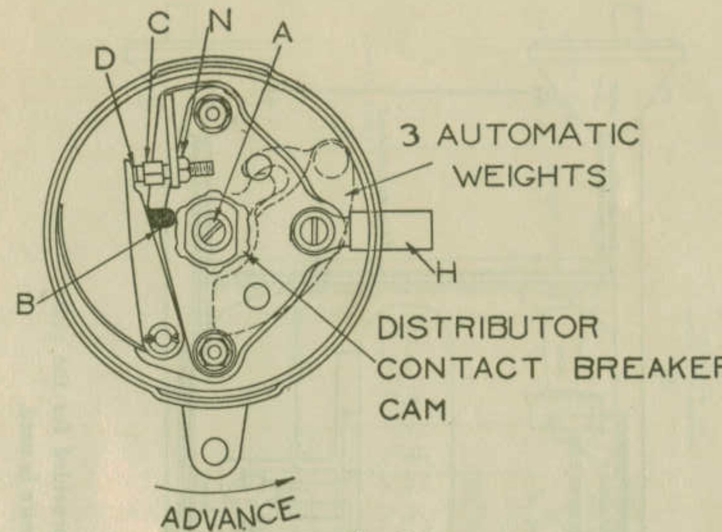

Fig. 7

the event of abnormal voltage, such as would be obtained by running with the battery removed, or with the ignition resistance unit shorted out, or with a defective condenser, these contacts burn very rapidly and in a short time will cause serious ignition trouble. The car should not be operated with the battery removed.

RUNNING WITHOUT BATTERY

It is a very easy matter to check the resistance unit by observing its heating when the ignition button is out and the contacts in the distributor are closed. If it is shorted out it will not heat up, and will cause missing at low speeds.

A defective condenser such as will cause contact trouble will cause serious missing of the ignition. Therefore, any one of these troubles are comparatively easy to locate and should be immediately remedied.

These contacts should be so adjusted that when the fibre block B is on top of one of the lobes of the cam the contacts are opened the thickness of the gauge on the distributor wrench. Adjust contacts by turning contact screw C and lock with nut N. The contacts should be dressed with fine emery cloth so that they meet squarely across the entire face.

The rotor distributes the high tension current from the center of the distributor to the proper cylinder. Care must be taken to see that the distributor head is properly located, otherwise the rotor brush will not be in contact with the terminal at the time the spark occurs. The distributor head and rotor should be lubricated as described under the heading "Lubrication." The amount of ignition current required for different speeds is described under the heading "Motoring the Generator."

LOCATE DISTRIBUTOR HEAD

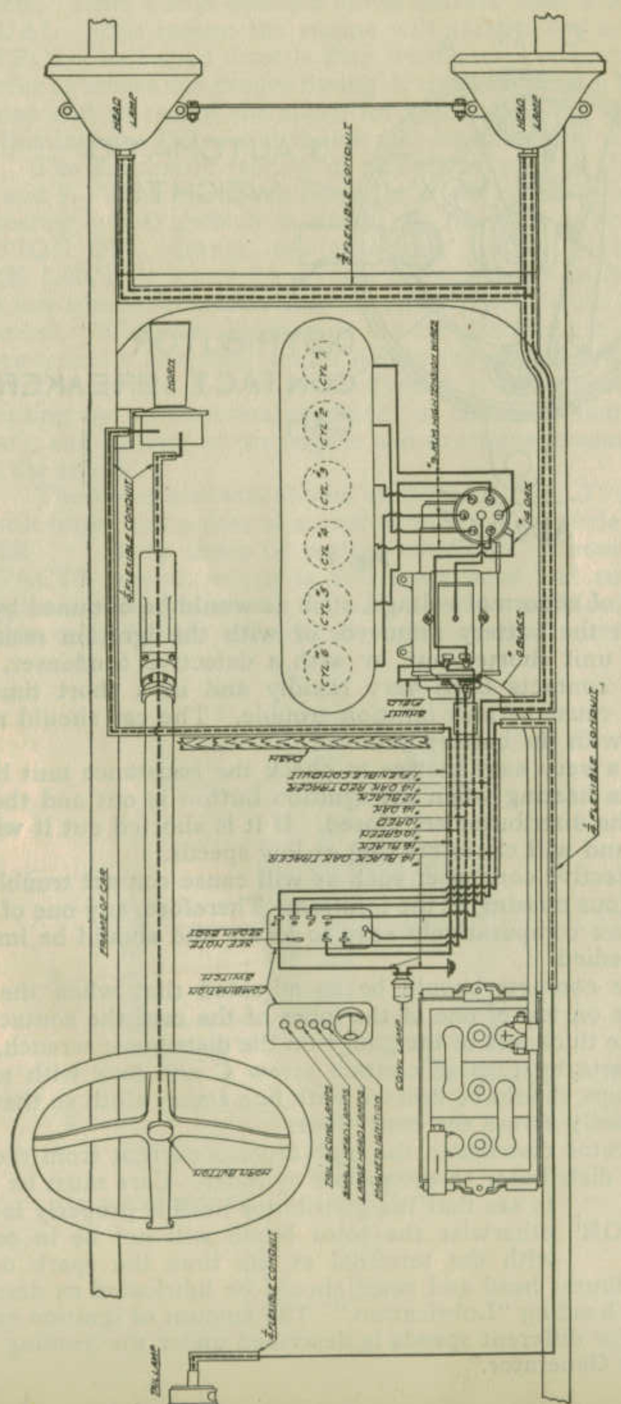

Fig. 8

NOTE.—Sedan Body. A special connection is provided for the pillar lights of the sedan body and a No. 14 red oak tracer wire is used.

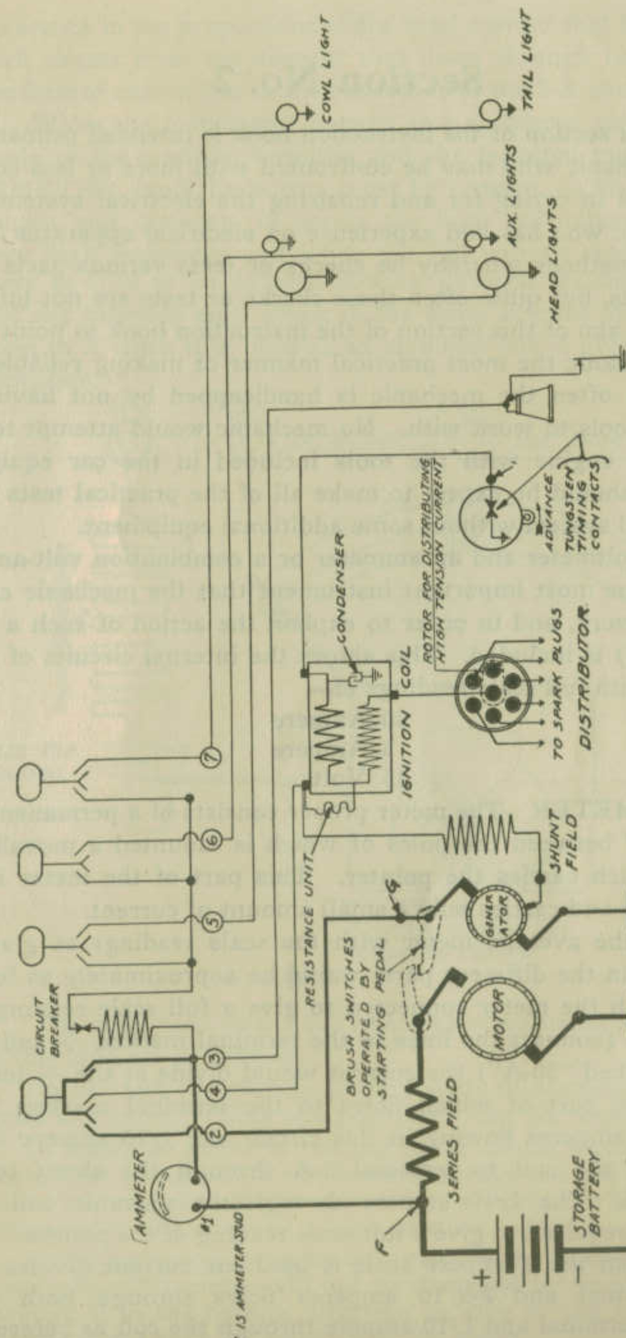

Fig. 9

Section No. 2

This section of the instruction book is intended primarily for the mechanic who may be confronted with more or less complex problems in caring for and repairing the electrical system. The mechanic who has had experience on electrical apparatus has invented methods whereby he checks or tests various parts of the apparatus, but quite often these checks or tests are not infallible. It is the aim of this section of the instruction book to point out to the mechanic the most practical manner of making reliable tests.

Too often the mechanic is handicapped by not having the proper tools to work with. No mechanic would attempt to overhaul an engine with the tools included in the car equipment, neither should he expect to make all of the practical tests on the electrical system without some additional equipment.

A voltmeter and an ammeter or a combination volt-ammeter is the one most important instrument that the mechanic can use in this work, and in order to explain the action of such a meter, (Fig. 10) is included. This shows the internal circuits of such a meter with full scale readings of—

30 Ampere
3 Ampere
15 Volts

VOLT-AMMETER The meter proper consists of a permanent magnet "M" between the poles of which is mounted a movable coil "K" which carries the pointer. This part of the meter is very sensitive and carries only a small amount of current.

In the average meter with the scale readings as given the current in the different parts would be approximately as follows:

With the meter connected to give a full scale reading of 30 amperes (connect the lines to the terminal marked + and to the one marked "30-A") the current would divide at the + terminal, the main part of which flows to the terminal marked "30-A" 29-9/10 amperes flowing in this circuit and 1/10 ampere flowing through the coil to terminal 3-A through the shunt to 30-A terminal. The 1/10 ampere through the movable coil is the amount required to give a full scale reading of the pointer.

When the 3 ampere scale is used the current divides at the + terminal and 2-9/10 amperes flows through both shunts to 3-A terminal and 1/10 ampere through the coil as before. The

difference in the proportions of the total current that flows through each circuit from the amount that flows through each circuit in the former case is due to the resistance of the 3-A shunt.

VOLTMETER When the instrument is used as a voltmeter connections are made to the positive terminal and the terminal marked "15 V" and the button must be pressed. This cuts out the shunts and connects in series the high resistance. This is a very high resistance and when the full voltage reading is taken there is 1/10 of an ampere flowing through the high resistance and the movable coil, which is the same amount of current that flows in it when it is used as an ammeter and it gives a full scale deflection.

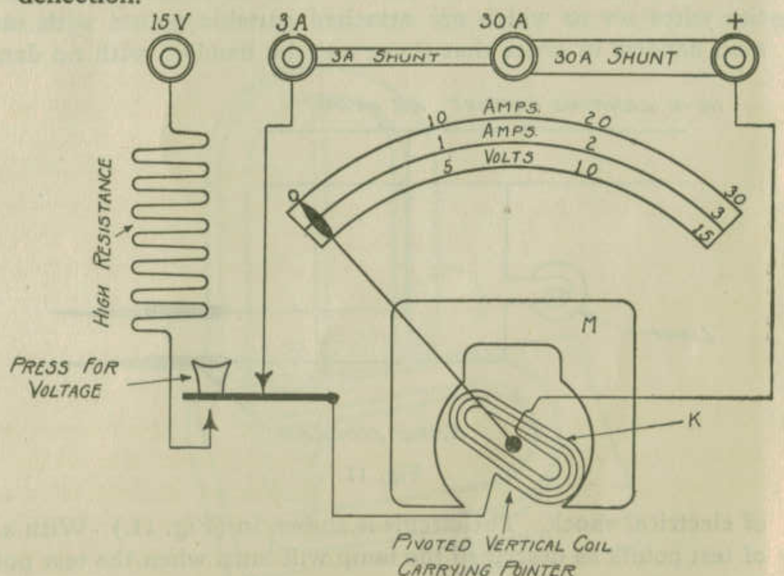

Fig. 10

The important points to remember when using an instrument of this kind are as follows:

No. 1 Do not test the storage battery with an ammeter as dry batteries are tested. (This will positively ruin the meter)

No. 2. In taking an ammeter reading in the circuit where the approximate flow of current is not known, always use the highest scale on the meter and make the connection where it can be quickly disconnected in the event of a high reading.

No. 3 If the meter reads backwards reverse the wires to the meter terminals. The meter will not be damaged by passing a current through it in the reverse direction as long as the amount of the current is not over the capacity of the meter.

No. 4 No damage will be done by connecting a voltmeter as an ammeter so long as the voltage of the system is not above the range of the voltmeter, but the ammeter should not be used as a voltmeter.

No. 5 A high-class instrument of this type will stand a momentary overload of from 200 to 400%. If the user is careful not to make his connections permanently until the current is normal, he will very seldom injure the instrument.

Next to the combination volt-ammeter the most important testing arrangement for the mechanic is a set of test points to use in connection with the electric light circuit. This is very easily made by tapping one wire of an ordinary extension lamp, splicing the wires on to which are attached suitable points with insulated handles in order that these may be handled with no danger

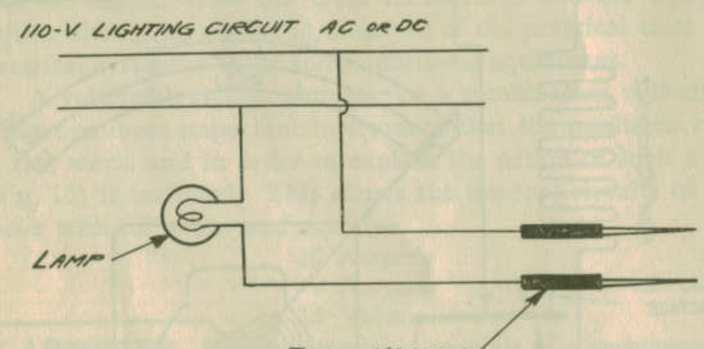

Fig. 11

of electrical shock. The circuit is shown in (Fig. 11.) With a set of test points as described the lamp will burn when the test points are together or when there is an electrical connection between the points. This will give more satisfactory results for testing for grounds, leaks or open connections than will a bell or buzzer used with dry batteries, as the voltage is higher and it requires a small amount of current to operate the lamp. With a bell or buzzer, a ground or open connection may exist, but the resistance is so high that enough current will not be forced through it by the dry batteries to operate the bell or buzzer.

ADVANTAGE OF TEST POINTS

No harm can be done to any part of the Delco apparatus by tests points as described above, when the ordinary carbon or tungsten lamp is used in testing purposes.

As stated in section one, the motor generator performs three distinctly different functions; that is—

No. 1—Motoring the Generator
No. 2—Cranking the Engine
No. 3—Generating Electrical Energy

Whenever an armature is revolved within a magnetic field a voltage is induced in the armature winding. On a motor, this voltage opposes the voltage of the applied current.

When the ignition button is first pulled out and the armature is not revolving there is of course no voltage being generated, therefore a comparatively heavy current flows. After the armature commences to revolve this current decreases, due to the voltage induced in the armature opposing that of the battery.

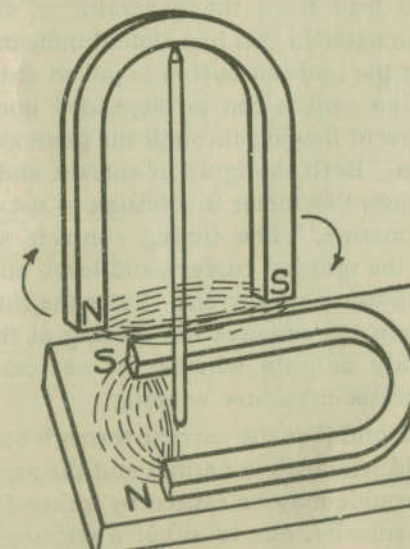

Fig. 12

Thus it can be noticed that the first reading of the ammeter will be much more than the reading after the armature is turning freely. The motoring of the generator is one of the most important operations for the mechanic to familiarize himself with, as the same wiring and parts of the generator are used during this operation as when generating. Therefore, if the apparatus will perform this operation properly, it is very sure to generate when driven by the engine.

MOTORING GENERATOR

An electric motor is caused to rotate by the magnetic attraction and repulsion between the iron core of the armature and the pole pieces which surround it in exactly the same manner as two magnets arranged as in (Fig. 12) will rotate until the unlike poles of the two magnets come to rest as near as possible to each other. During the motoring of the generator the pole pieces are magnetized by the current through the shunt field winding. The armature is magnetized by the current through the brushes and generator winding on the armature. It is necessary that current flow through both of these circuits before the armature will revolve.

AMMETER READINGS WHEN MOTORING GENERATOR

It is a familiar mistake to think that when current is passing only through the armature the armature should revolve. The shunt field current can be easily checked by disconnecting the shunt field lead from the generator at the ignition coil terminal. The ammeter in this line should indicate approximately 1¼ ampere when the ignition button is pulled out. The ammeter on the combination switch can be depended upon to determine the amount of current flowing through the generator winding during this operation. Both the ignition current and the shunt field current flow through this meter in addition to the current through the generator armature. The timing contacts should be open. This will cut off the ignition current and leave only the armature and shunt field current.

TESTS FOR MOTORING GENERATOR

Since the shunt field current is only 1¼ amperes the reading of the ammeter will readily indicate whether or not current is flowing through the generator armature winding.

Should it be found that the current through both the armature and the shunt field windings is normal and the armature still does not revolve the trouble may be caused by either (1) the armature being tight mechanically, due to either a sticking driving clutch, trouble in the bearings or foreign particles jammed between the armature and pole pieces. This can be readily tested by removing the front end cover of the generator and turning the armature from the commutator; (2) the shunt field winding or the generator armature winding may be defective in some manner, such as shorted, grounded or connected to the motor winding. (See testing armatures on page 22. Any one of these would show an abnormal reading of the ammeter in some position of the armature when the armature is revolved by hand.

If the ammeter vibrates at each revolution of the armature during the motoring of the generator, and when the engine is run-

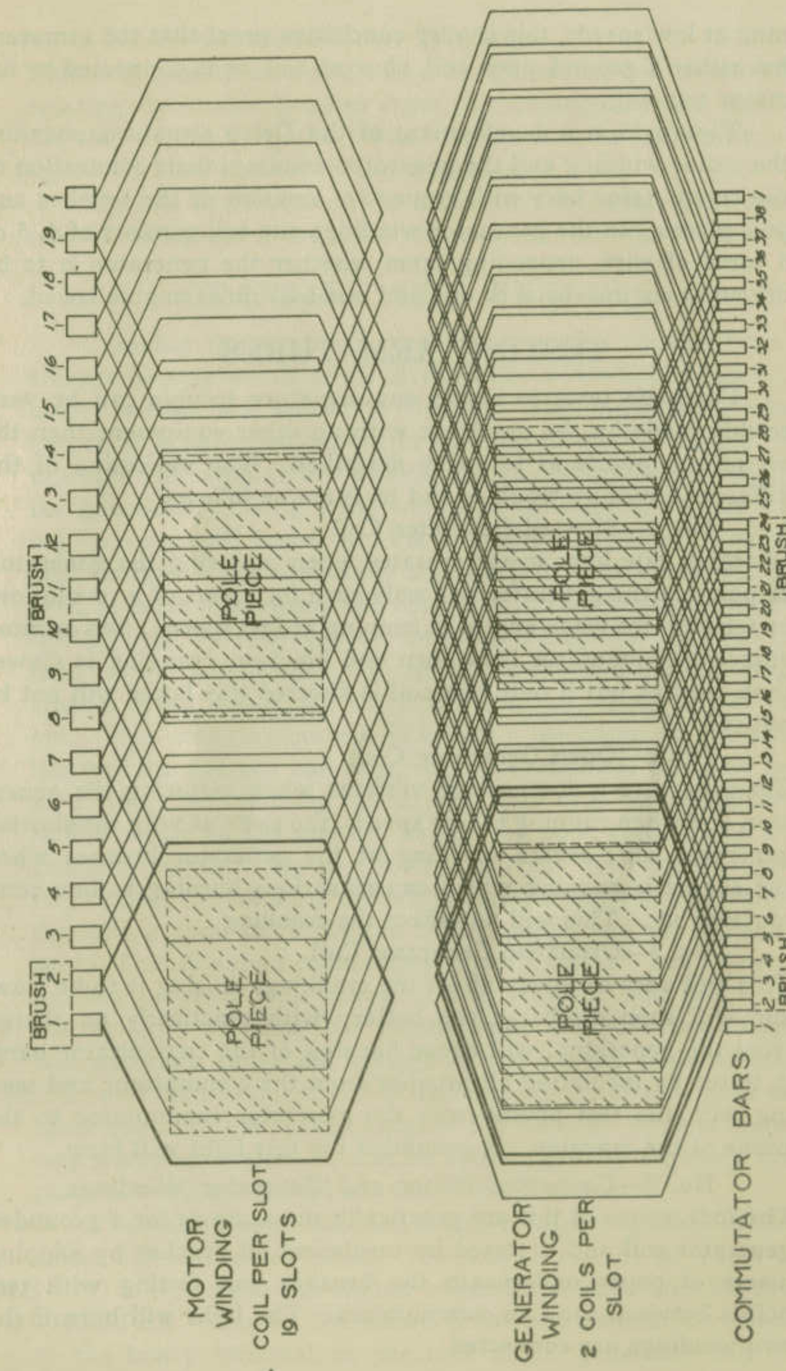

Fig. 13

ning at low speeds, this is very conclusive proof that the armature has either a ground, open coil, shorted coil, or is connected to the motor winding.

Figure 13 is a development of the Delco armature, showing the motor winding and the generator winding, their connection to the commutator bars with respective location of the brushes and pole pieces. In the generator windings one coil consists of 4, 5 or 6 turns of wire, depending upon whether the generator is to be driven at engine speed or one and one-half times engine speed.

TESTING ARMATURES

Complete tests to locate any armature trouble can be very readily made by the mechanic with no other equipment than the set of test points as formerly described. The indication of the different armature troubles and tests are as follows:

No. 1—Shorted Generator Coil

Charging rate low; meter vibrates when motoring the generator, or possibly the generator will only turn for a part of a revolution; meter vibrates when engine is running at low speeds; two or more adjacent commutator bars burn and blacken; cranking is slower than normal, but if only one coil is shorted this latter will not be noticed.

No. 2—Open Generator Coil

Charging rate is low; meter vibrates when motoring the generator, and when running at low speeds, the same as with the shorted generator coil; severe sparking at the generator brushes when the engine is running which causes serious burning at one commutator bar. This will not affect the cranking.

No. 3—Grounded Generator Coil

This will very seriously affect the cranking, causing it to be slow, and will soon discharge the battery with practically no charge from the generator; will cause burning of the commutator bars; is tested by insulating all brushes from the commutator and testing with the test points from the generator commutator to the frame of the machine. If grounded the test light will burn.

No. 4—Connected Motor and Generator Windings

The indications of this are practically the same as for a grounded generator coil and is tested by insulating all brushes by slipping pieces of paper underneath the brushes and testing with test points between the two commutators. The light will burn if the two windings are connected.

No. 5—Grounded Motor Winding

This will rapidly discharge the storage battery; is tested by insulating the motor brushes from the commutator and test with the test points from the motor commutator to the frame. The light will burn if the winding is grounded.

The last three tests can be made with the motor generator assembled complete or the armature removed from the frame.

CRANKING THE ENGINE

Cranking the engine is performed by the current from the storage battery which flows through the series field winding, the motor brushes and armature winding. This much being what is known as a series motor, but in addition to this the current flows through the combination switch and the shunt field winding on the generator, making what would be considered, strictly speaking, a compound motor for the cranking operation. The shunt field current is not absolutely necessary for this operation, but is used because it increases the efficiency of the cranking motor. It can be seen by referring to the circuit, page 15, that the shunt field current would not be in use in the event of the cranking operation being performed when the ignition button is not pulled out. This cranking current is a heavy discharge on the storage battery, the average car requiring approximately ½ horse power to perform the cranking operation. 9/10 of all cranking failures is due either to the storage battery or poor connections in the cranking circuit. The first rush of current from the storage battery during the cranking operation varies from 200 to 600 amperes, depending upon the condition of the engine and the storage battery. This is only a momentary flow of current, but a poor connection prevents this heavy flow of current and prevents the starter from breaking the engine loose. This heavy discharge will naturally cause the voltage of the battery to be decreased, and the amount that it is decreased depends to a great extent upon the condition of the charge of the battery. On a storage battery which is charged so that its specific gravity registers 1200 or more the voltage should not fall below 5 volts.

TESTS

The voltmeter is the instrument to use to quickly locate the cause for failure to crank. The starter cannot be expected to crank the engine when the voltage falls below 3 or 4 volts. Therefore, a voltmeter should be connected to the heavy terminal on the rear of the generator and to the

USE VOLTMETER

ground and the starting pedal depressed. If the voltage falls below 4 volts the trouble is either a nearly discharged battery or a poor connection, or possibly a bad cell in the battery. Any one of these can be quickly located by taking individual voltmeter readings of the different cells when the starting pedal is still depressed. If the individual cells show a normal voltage when the starting pedal is depressed then each connection in the cranking circuit should be bridged by the voltmeter connections. A reading of the voltmeter will indicate the defective connection.

Should the voltmeter indicate a normal voltage from the heavy terminal on the rear of the generator to the ground when the starting pedal is depressed and still the starting motor makes no effort to crank the car, trouble must exist within the generator, such as the motor brush not coming in contact with the motor commutator or dirt or grease on the commutator preventing electrical contact. This could also be caused by trouble in the armature windings, but is very improbable, and can be tested as described under the heading "Testing the Armature."

GENERATING ELECTRICAL ENERGY

There is really only one point in regard to the generating of electrical energy which is difficult to understand, and the best of scientists are at as much of a loss on this point as the average electrician. This one point can be expressed in the one sentence which is as follows: "Whenever the strength of the magnetic field or the amount of magnetism within a coil is changed an electro-motive force is induced or generated." This is variously expressed, but can be resolved into the same sentence as originally given. One of the most common expressions is "Whenever an electrical conductor cuts the magnetic field or cuts magnetic lines of force an electro-motive force is induced." In order to measure this electro-motive force, it is necessary to make connection from each end of the conductor to a suitable meter, by doing this a coil would be formed. Therefore, this expression means nothing different from the original expression. On account of being more readily understood this expression will be referred to in connection with the explanation of the action of the generator.

The amount of the voltage that is induced (or generated) in any conductor or coil varies directly with the rate of the cutting of the magnetic lines, e. g. If we have a generator in which the magnetic field remains constant and the generator produces 7

volts at 400 R. P. M., the voltage at 800 R. P. M. would be 14 volts, and it is on account of the variable speed of generators for automobile purposes that they must be equipped with some means of regulation for holding the voltage very nearly constant. The regulation of this generator is by what is known as third brush excitation, the theory of which is as follows:

The motor generator consists essentially of an iron frame and a field coil with two windings for magnetizing this frame. The armature, which is the revolving element, has wound in slots on its iron core a motor winding and a generator winding connected to corresponding commutators. Each commutator has a corresponding set of brushes which are for the purpose of collecting current from, or delivering current to the armature windings while the armature is revolving.

When cranking, current from the storage battery flows through the motor winding magnetizing the armature core. This acting upon the magnetism of the frame causes the turning effort.

When generating the voltage is induced in the generator winding and when the circuit is completed to the storage battery this causes the charging current to flow into the battery.

The brushes are located on the commutator in such a position that they collect the current while it is being generated in one direction. (The current flows one direction in a given coil while it is passing under one pole piece and in the other direction when passing under the opposite pole piece.)

When the ignition button on the combination switch is first pulled out the current flows from the storage battery through the generator armature winding, also through the shunt field winding. This causes the motoring of the generator. After the engine is started and is running on its own power this current still has a tendency to flow in this direction, but is opposed by the voltage generated. At very low speeds a slight discharge is obtained. At approximately 7 miles per hour the generated voltage exceeds that of the battery and charging commences. As the speed increases above this point the charging rate increases as shown by the curve (Fig. 15.) The regulation of this generator is effected

REGULATION by what is known as third brush excitation. From the foregoing explanation of the generating of electricity and from the fact that the voltage generated varies directly with the speed, it is evident in order to maintain a nearly constant voltage with a

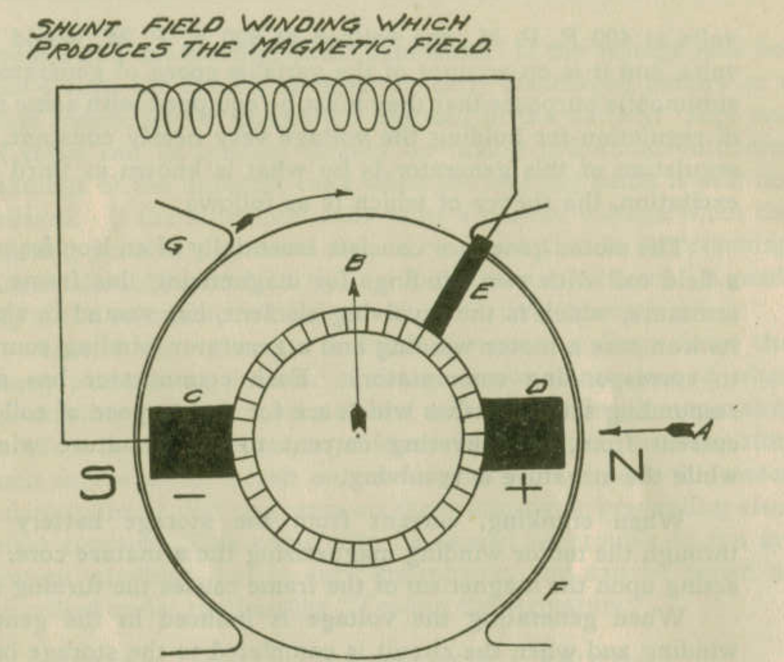

Fig. 14

variable speed, it becomes necessary to decrease the magnetic field as the speed increases.

Since the magnetic field of the generator is produced by the current in the shunt field winding it is evident that should the shunt field current decrease as the speed of the engine increases the regulation would be affected. In order to fully understand this explanation it must be borne in mind that a current of electricity always has a magnetic effect whether this is desirable or not. Referring to (Fig. 14) the theory of this regulation is as follows: The full voltage of the generator is obtained from the large brushes marked "C" and "D." When the magnetic field from the pole pieces N and S is not disturbed by any other influence each coil is generating uniformly as it passes under the pole pieces. The voltage from one commutator bar to the next one is practically uniform around the commutator. Therefore, the voltage from brush C to brush E is about 5 volts when the total voltage from brush C to brush D is 6½ volts and 5 volts is applied to the shunt field winding. This 5 volts is sufficient to cause approximately 1¼ amperes to flow in the shunt field winding.

As the speed of the generator is increased the voltage increases causing the current to be charged to the storage battery.

This charging current flows through the armature winding, producing a magnetic effect in the direction of the arrow B. This

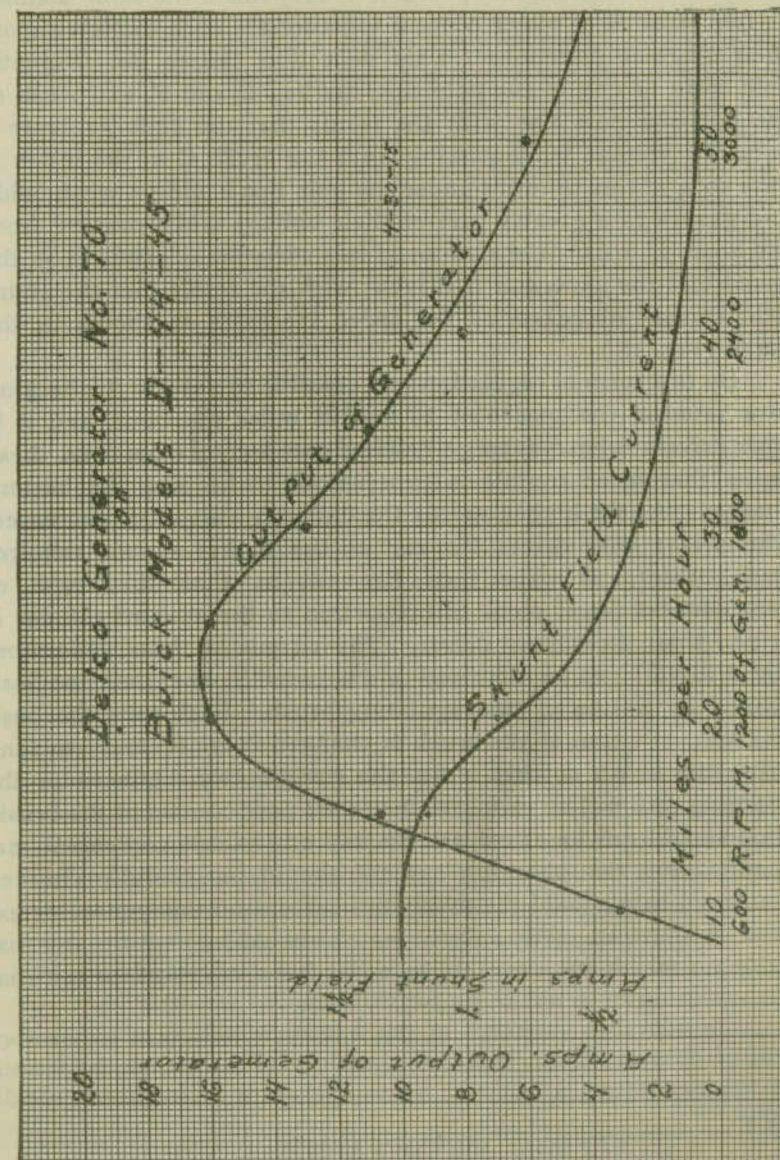

Fig. 15

magnetic effect acts upon the main magnetic field which is in the direction of the arrow A with the result that the magnetic field is twisted out of its original position in very much the same manner as two streams of water coming together are each deflected from their original directions. This deflection causes the magnetic field to be strong at the pole tips, marked G and F, and weak at the opposite pole tips with the result that the coils generate a very low voltage while passing from the brush C to the brush E (the coils at this time are under the pole tips having a weak field) and generates a greater part of their voltage while passing from the brush E to D. The amount of this variation depends upon the speed that the generator is driven; with the result that the shunt field current decreases as the speed increases as shown in the curve (Fig. 15.)

By this form of regulation it is possible to get a high charging rate between the speeds of 12 and 25 miles per hour, and it is with drivers whose average driving speed comes between these limits that more trouble is experienced in keeping the battery charged. At the higher speeds the charging current is decreased. The driver who drives his car at the higher speeds requires less current, as experience has taught that this type of driver makes fewer stops in proportion to the amount the car is driven than the slower driver. The output of these generators can be increased or decreased by changing the position of the regulating brush. Each time the position of the brush is changed it is necessary to sand paper the brush so that it fits the commutator. Otherwise the charging rate will be very low due to the poor contact of the brush. This should not be attempted by any one except competent mechanics, and this charging current should be carefully checked and in no case should the maximum current on this generator exceed 22 amperes. Also careful watch should be kept on any machine on which the charging rate has been increased to see that the commutator is not being overloaded.

REGULATING CHARGING CURRENT

Considerable variation in the output of different generators will be obtained from the curve shown in (Fig. 15), as the output of the generator is affected by temperature and battery conditions.

IGNITION RESISTANCE UNIT

The ignition resistance unit which is shown in figures 1 and 5 is for the purpose of obtaining a more nearly uniform current through the primary winding of the ignition coil at the time the distributor contacts open. It consists of a number of turns of iron wire, the resistance of which is considerably more than the resistance of the primary winding of the ignition coil. If the ignition resistance unit was not in the circuit and the coil was so constructed to give the proper spark at high speeds, the primary current at low speeds would be several times its normal value with serious results to the timer contacts. This is evident from the fact that the primary current is limited by the resistance of the coil and resistance unit and by the impedence of the coil. (Impedence is the choking effect which opposes any alternating or pulsating current magnetizing the iron core.) The impedence increases as the speed of the pulsations increase. At low speeds the resistance of the unit increases, due to the slight increase of current heating the resistance wire.

CONDENSER

The condenser consists of two long strips of folded tinfoil insulated from each other by paraffined or oiled paper, and connected as shown in (Fig. 5.) The condenser has the property of being able to hold a certain quantity of electrical energy, and like the storage battery, will discharge this energy if there is any circuit between its terminal. As the distributor contacts open the magnetism commences to die out of the iron core, this induces a voltage in both the primary and secondary windings of the coil. This induced voltage in the primary winding amounts to from 100 to 125 volts. This charges the condenser which immediately discharges itself through the primary winding of the coil in the reverse direction from which the ignition current originally flows. This discharge of the condenser causes the iron core of the coil to be quickly demagnetized and remagnetized in the reverse direction, with the result that the change of magnetism within the secondary winding is very rapid, thus producing a high voltage in the secondary winding which is necessary for ignition purposes.

In addition to rapidly demagnetizing the coil the condenser prevents sparking at the breaker contacts—thus it is evident that the action of the condenser can very seriously affect the amount of the spark from the secondary winding and the amount of sparking obtained at the timer contacts. Therefore, these are the means that are used for locating a defective condenser.

LOCATING CONDENSER TROUBLE

The action of the timer contacts can be observed by removing the distributor head and cranking the engine with the starter. A defective condenser will cause serious sparking. A slight spark will sometimes be observed with a good condenser.

The mechanic should familiarize himself with the spark obtained by removing the wire from one of the plugs and letting the spark jump to the engine. (Not to the spark plug.) A good coil will produce a spark with a maximum jump of at least ½ inch, provided other conditions are normal.

IGNITION COIL

The ignition coil is readily tested by the test points. The primary circuit is tested between the terminals on the top of the coil at the rear. The secondary winding can be tested for open circuit by testing from the high tension terminal to either of the other terminals. The test lamp will not burn when making this test on account of the high resistance of the secondary winding, but a spark can be obtained when the test point is removed from the terminal. No spark will be obtained if the winding is open.

A short in the secondary winding causes the spark obtained from a wire removed at the plug to be much weaker and will cause missing when the engine is pulling; especially at low speeds.

CHECKING THE AMMETER

Should the charging rate appear to be abnormally low with no apparent reason it is a good plan to check the ammeter by con-

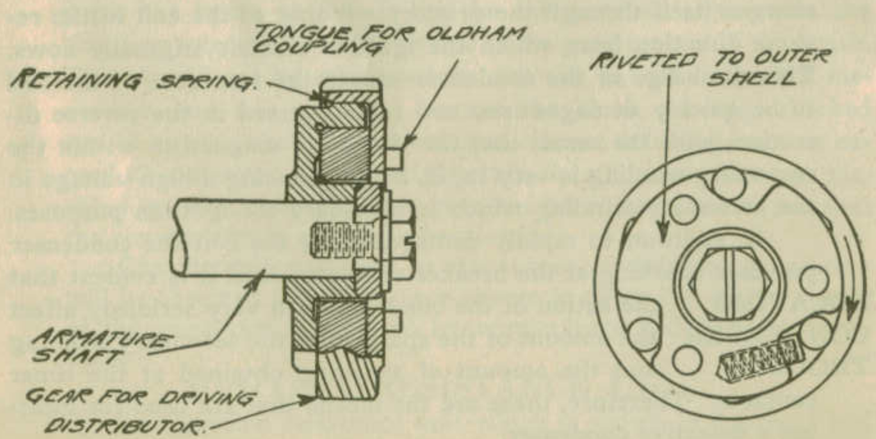

Fig. 16

necting another meter in series with it. Connect in the small line from the switch to the terminal F on the generator (Fig. 1.)

These are very reliable meters, but automobile service is extremely hard service for a sensitive ammeter.

THE GENERATOR CLUTCH

Figure 16 is two views of the generator clutch. This clutch is removed from the armature and end frame assembly by loosening the screw in the end of the armature shaft and removing the lock washer and key washer. Cut a hole in a work bench about ¼ inch larger in diameter than the armature. Insert the armature through this hole. Allow the armature and end frame to drop about two inches, being careful to have the end frame come squarely in contact with the bench. Hold the armature from below so that it will not be injured when it strikes the floor. This clutch is held together by a retaining spring wire which, when removed, allows the clutch to be disassembled for inspection.

TO TIME THE IGNITION

No. 1 Fully retard the spark lever on the steering wheel.

No. 2 Turn engine to 7 degree mark (approximately one inch from the dead center mark) on the flywheel with No. 1 cylinder on the firing stroke.

No. 3 Loosen screw on center of timing mechanism and locate the proper lobe of the cam. Turn until the rotor brush comes under the position which No. 1 high tension terminal on the distributor head occupies when the head is properly located.

No. 4 Set this lobe of the cam so that when the back lash of the distributor gears is rocked forward the contacts will be open and when the back lash is rocked backward the contacts will just close. Tighten the screw and replace rotor and head. The shaft runs clockwise when viewed from the top, and the spark occurs when the contacts open.

GENERAL REMARKS ON THE CARE OF AN ELECTRIC SYSTEM

Do not fail to heed the battery instructions contained in this book.

By all means, provide yourself with a hydrometer syringe.

The battery will require more care than all the other electrical appliances.

If at all possible provide means for charging batteries from an outside source.

Use only distilled water for filling storage batteries. It always pays in the long run.

Always have a solution of common baking soda and water handy for cleaning the battery terminals; also vaseline for applying to battery connections after cleaning to prevent the acid from again corroding the connections.

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

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

Do not use friction tape on high tension wiring or on other wiring where the grease or oil can get to it. It is much better to use linen tape and shellac. Friction tape will not insulate ignition current and will not hold when oily.

ORDERING REPAIR PARTS

Repair parts should be ordered through the dealer handling the make of car for which the part or parts are wanted.

These repair parts should be ordered by their piece numbers which are to be found in the piece part catalogues published by the motor car companies and furnished to all dealers. If it is impossible to obtain the number of the piece, it should be described as fully as possible, stating the make and model of car and where the piece is used.

STORAGE BATTERY

The 3-XC-13-1 storage battery used with the Delco Electric Cranking, Lighting and Ignition System is designed especially for it and is made by the Electric Storage Battery Co., of Philadelphia, Pa., whose products for the automobile trade are known as "Exide" batteries.

The Electric Storage Battery Co. has distributors who do battery repair work in towns of any considerable size, and "Exide Battery Depots" in the following list of cities, where complete assembled batteries and repair parts are carried in stock. These depots are fully equipped to do any kind of battery repair work:

New York City—527-541 West 23rd Street.
Philadelphia—Allegheny Avenue and 19th Street.
Boston—789 Tremont Street.
Chicago—333 West 35th Street.
Cleveland—5121 Perkins Avenue.
Atlanta—20 South Piedmont Avenue.
San Francisco—9-13 Minna Street.
Denver—1424 Wazee Street.
St. Louis—2038 Walnut Street.
Kansas City—1708-10 Main Street.
Rochester—44 Cortland Street.
Washington, D. C.—1828 "L" Street N. W.
Detroit—Garfield and Woodward Avenues.

LIST OF OFFICES

General Offices and Works—Allegheny Avenue and 19th Street, Philadelphia, Pa.
New York City—100 Broadway.
Boston—60 State Street.
Chicago—Marquette Building.
St. Louis—Fullerton Building.
Cleveland—Citizens Building.
Atlanta—Candler Building.
Denver—1424 Wazee Street.
Detroit—Hayward Building, 971 Woodward Avenue.
Pittsburg—Keystone Building.

Washington, D. C.—1828 "L" Street, N. W.
Seattle—Colman Building.
Los Angeles—Pacific Electric Building.
San Francisco—118 New Montgomery Street.
Rochester—44 Cortland Street.
Toronto—Canadian General Electric Co., Ltd.

The storage battery (Fig. 17) consists of three cells, each cell containing thirteen (13) plates—six positive and seven negative. The battery when fully charged will burn head, cowl and tail lights approximately 16 hours.

When the battery is fully charged, the electrolyte or solution in the cells should have a specific gravity of from 1.275 to 1.300, as indicated by the hydrometer syringe (Fig. 19). The gravity will lower, due to discharge, and when completely discharged, will register from 1.150 to 1.175—about 125 points less than when fully charged. If one cell regularly requires more water than the others, thus lowering the gravity, a leaky jar is indicated. Even a very slow leak will in time relieve the cell of all its electrolyte. A leaky jar should immediately be replaced with a new one.

The gravity is an indication of the state of charge of the battery. A battery discharged below a specific gravity of 1.150 will not crank over the engine, nor will it burn the lights to full candlepower when the engine is not in operation.

The battery is located under the floor boards, just back of the motor generator. Once every two weeks lift up the floor boards of the car, remove the filling plugs (Fig. 17) and observe the height of the electrolyte.

ADDING WATER

The electrolyte must always cover the plates. Replace evaporation by adding pure, fresh water. NEVER ADD ACID.

If below the bottom of the filling tubes (See Fig. 17, "keep liquid up to this line"), add pure, fresh water, bringing the liquid up to the proper height—level with the bottom of the filling tube. Ordinarily it will require only 2 or 3 tablespoonfuls of water. In hot weather it may require more, BUT KEEP IT UP TO THIS POINT. THE FILLING PLUGS MUST BE REPLACED AND SCREWED UP TIGHTLY AFTER FILLING.

IF A PLUG IS LEFT OUT OR LOOSE, THE SOLUTION MAY FLOOD OUT OF THE CELL, ESPECIALLY WHEN THE

BATTERY IS BEING CHARGED. IF A PLUG IS LOST OR BROKEN, OBTAIN A NEW ONE AT ONCE.

The water for filling the batteries must be pure
Distilled Water,
Melted Artificial Ice, or
Fresh Rain Water.

Never keep the water in metal containers, such as a bucket or can. It is best to get a bottle of distilled water from your druggist, or an ice plant. A quart will last a long time. The whole point is to keep metal particles out of the batteries. Spring water, well or hydrant water from iron pipes generally contains iron and other materials in solution, which will ultimately cause trouble if used.

If electrolyte has been spilled from the cell, replace the loss with new electrolyte and follow with an overcharge by running the engine for several hours, or charge the battery from an outside source (Fig. 18.)

The specific gravity of the electrolyte to be used for replacing the loss when spilled from the cells, or due to broken jars, should be the same as that of one of the adjacent cells. This can be determined by the use of the hydrometer syringe (Fig. 19).

The proper specific gravity of the electrolyte, when the battery is fully charged, is 1.300, as indicated by the hydrometer syringe, but a variation of from 1.275 to 1.300 is allowable. NEVER ADD ACID OR ELECTROLYTE TO THE CELLS EXCEPT TO REPLACE LOSS BY SPILLING, A BROKEN JAR OR WHEN REMOVING SEDIMENT.

When new electrolyte is required, either to replace loss from spilling or when removing sediment or replacing a broken jar, it can be made by mixing chemically pure sulphuric acid of 1.835 specific gravity, and distilled water, in proportion of two (2) parts acid to five (5) of water, by volume.

THE ACID MUST ALWAYS BE POURED SLOWLY INTO THE WATER, AND NOT THE WATER INTO THE ACID.

A glass, earthenware or other acid-proof vessel, thoroughly clean, should be used for mixing, and the electrolyte allowed to cool before using. If a lower specific gravity than 1.300 is desired, more water should be added to the acid.

SEDIMENT

The sediment which gradually accumulates in the bottom of the jars, should be removed before it reaches the bottom of the plates, as

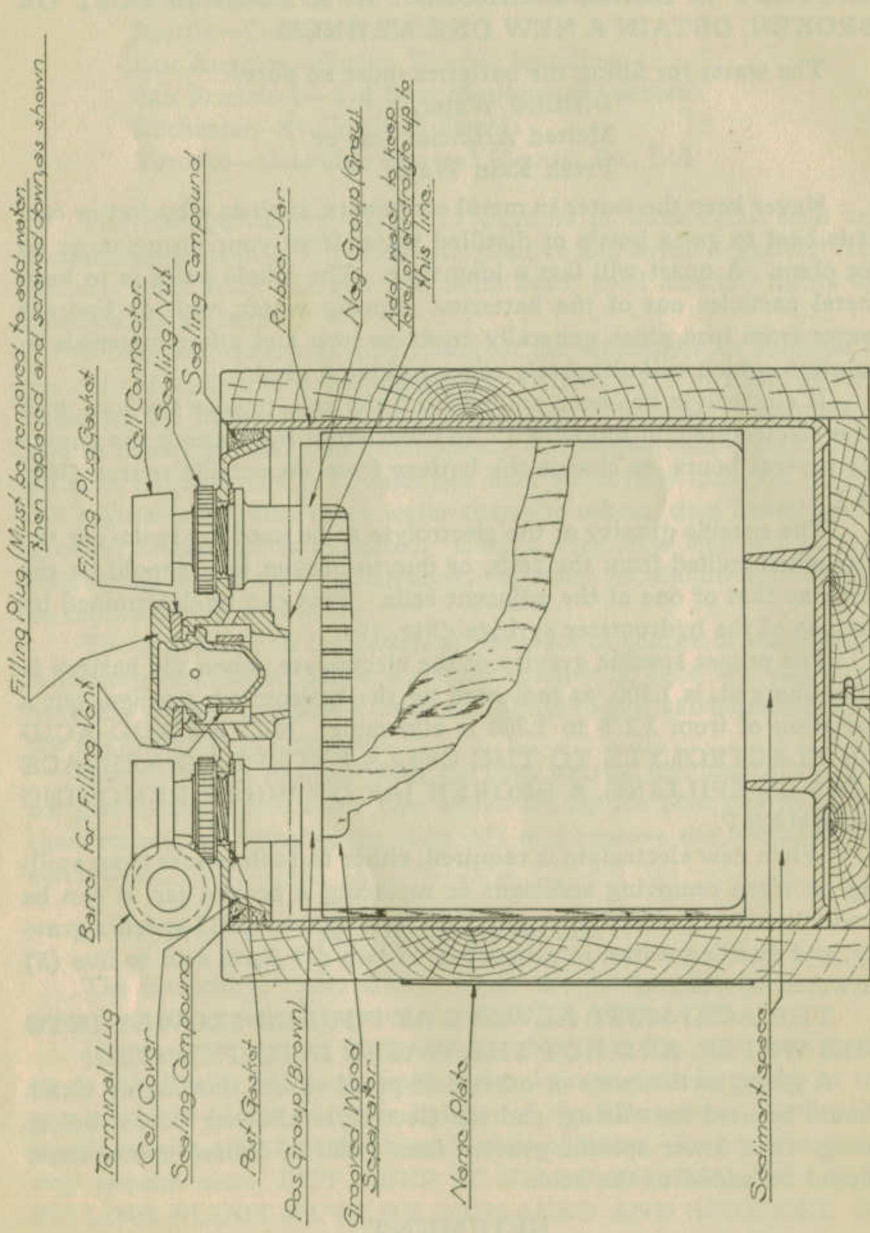

Fig. 17

it is very harmful to the battery. The necessity of cleaning is indicated by lack of capacity, excessive evaporation of the electrolyte, and excessive heating when charging.

REPAIRS

When a battery is in need of repairs, such as removal of sediment, leaky jar, broken cover, etc., better results follow if the work is done at a place where they are thoroughly familiar with storage battery practice. In such cases, it is best to communicate with the Buick Motor Company, or the Electric Storage Battery Company at its nearest office (see page 33), who will advise where to send the battery.

LAYING UP THE CAR FOR THE WINTER

If the car is not to be used for some time, say the winter months or longer, care should be taken that just before the last time the car is used, water is added to the cells, if necessary, so that it will be thoroughly mixed with the electrolyte when the car is driven. When the car is laid up, the specific gravity of the electrolyte should register from 1.275 to 1.300. With this condition there will be no danger of freezing in any climate. The specific gravity of water is 1000, and water freezes at 32 degrees Fahrenheite above zero.

The battery should be charged every two months during the "out of service" period, either by running the engine or charging from an outside source (Fig. 18). If either of the above is impossible, and there is no garage equipped for charging batteries to which it may be conveniently sent, the battery may be allowed to stand without charging during the winter, provided the specific gravity of the electrolyte registers from 1.275 to 1.300 at the time the car is laid up. Much better results and longer life from the battery will be obtained by giving the periodic charges.

The wires of the battery should be disconnected during the "out of service" period, as a slight leak in the wiring will discharge the battery.

Before putting the battery into service again, inspect and add distilled water, if necessary. If the battery has not been kept charged during the winter, it will be advisable to give a fifty-hour charge at a four ampere rate from an outside source before putting it into service again. Make sure that the terminals are free from corrosion and that good connections to the wires are made.

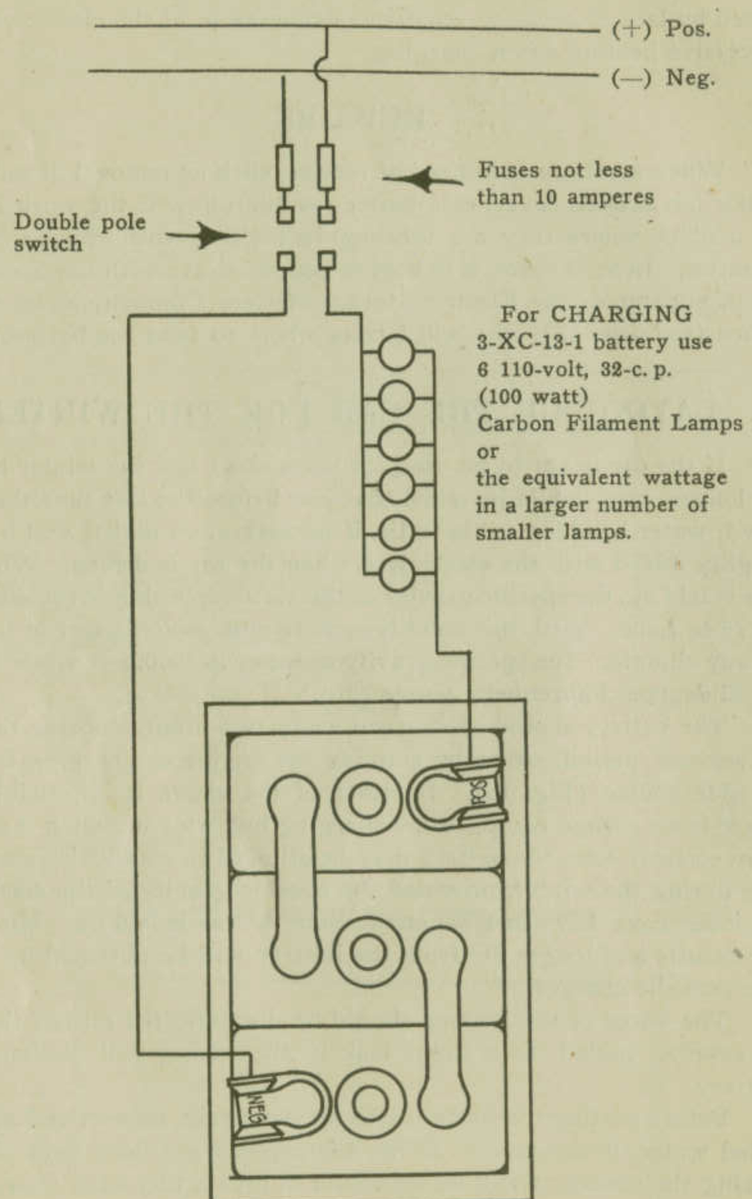

Fig. 18

CHARGING FROM AN OUTSIDE SOURCE

Battery Removed from the Car

It is necessary that the charging be done with DIRECT CURRENT. The simplest method when there is 110 or 120 volt direct current available, is to connect six, 110-volt, 32 candlepower, 100-watt carbon lamps in parallel with each other and in series with the battery to be charged; this combination giving approximately the proper charging rate—6 amperes. The positive terminal of the battery must be connected to the positive side of the charging circuit and the negative terminal to the negative side. VERY SERIOUS INJURY TO THE BATTERY WILL RESULT IF CONNECTED IN THE REVERSE DIRECTION. The terminals of the battery are stamped "Pos." and "Neg."

To determine the polarity of the charging circuit, if a suitable voltmeter is not at hand, dip the ends of the two wires "A" and "B" (Fig. 18) into a glass of water, in which a teaspoonful of salt has been dissolved, care being taken to keep the wires at least an inch apart.

When the current is turned on, fine bubbles of gas will be given off from the NEGATIVE wire.

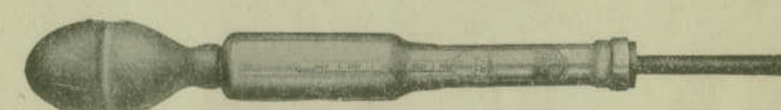

Fig. 19

THE HYDROMETER SYRINGE

To assemble, hold the glass barrel, to which is attached the rubber bulb, in a horizontal position, and insert the hydrometer, stem end first. Wet the soft rubber plug which is attached to the hard rubber pipette (nozzle) and FORCE RUBBER PLUG, grooved end first, into the end of the glass barrel as far as it will go, or until it strikes the shoulder in the barrel. It is important not to force the pipette too much in making this attachment, as the end of the pipette must not extend beyond the base of the grooves of the rubber plug—otherwise the flow of the electrolyte will be retarded in emptying the hydrometer syringe.

DIRECTIONS FOR USING

After removing the filling plug from the cover of the cell, compress the rubber bulb of the syringe and insert the pipette in the solution of the cell to be tested. Holding the instrument as nearly vertical as possible, gradually lessen the pressure on the bulb until the eletrolyte rising in the barrel causes the hydrometer to float. In general, only enough electrolyte should be drawn to float the hydrometer free of the bottom by about one-half to three-quarters of an inch. The specific gravity reading is taken on the hydrometer at the surface of the electrolyte in the glass barrel.

If the electrolyte is below the top of the plates, or so low that enough cannot be drawn into the barrel to allow of a proper reading of the hydrometer, fill the cell to the proper level (see Fig. 17) by adding pure water; then do not take a reading until the water has been thoroughly mixed with the electrolyte. This can be accomplished by running the engine for several hours.

The specific gravity of the electrolyte is an indication of the amount of charge in the battery. In a fully charged battery the specific gravity should be from 1.275 to 1.300. When the gravity registers from 1.150 to 1.175 the battery is practically discharged, and should be recharged.

Hydrometer syringes are not a part of the electric system, but can be purchased from the Buick Motor Co., or from The Electric Storage Battery Co., Philadelphia, Pa.

Buick Form D-6 / Delco Form 656 } 7-1-15-60,000