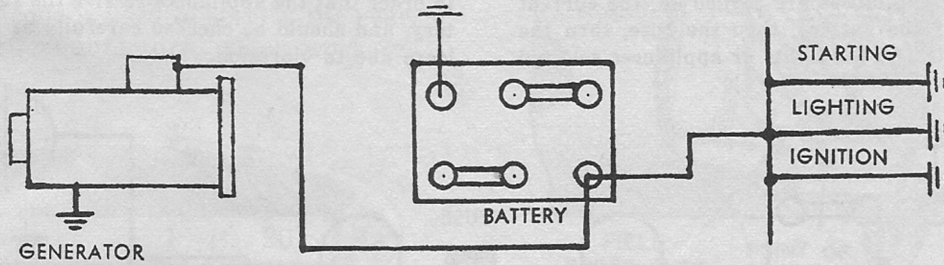
SERVICE BULLETIN No. 38-41

THE ELECTRICAL SYSTEM OF THE CAR

We have received many requests from the trade for a description of the fundamentals of the automotive electrical system. In this and the following bulletin we will describe the system in its simplest form, without the various control apparatus that have been presented in previous bulletins.

Tne electrical system of the car can be subdivided into three main branches: STARTING, LIGHTING and IGNITION, with the battery as the heart of the whole system.

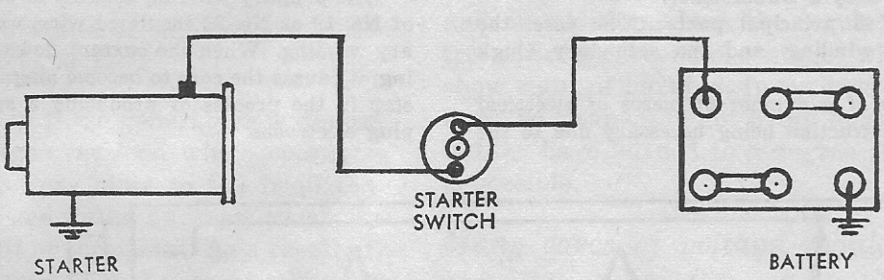
It furnishes electrical energy to the system in the same manner as the heart in the human body sends the blood stream to all parts of the body. The electrical energy stored in the battery, however, would soon be exhausted if there were not some means of renewing and replenishing this energy. For this purpose the generator is used, and here again there is the similarity to the human body where the lungs constantly purify the blood stream and furnish new strength to it.



STARTING

The starting circuit of the car is simple. It consists of: BATTERY, STARTER CABLE, STARTER SWITCH, STARTER, GROUND (OR RETURN WIRE).

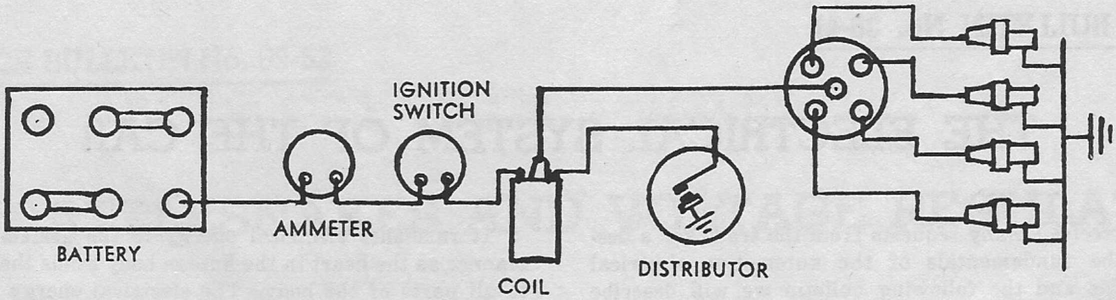
As will be seen from the diagram, when the starter switch is depressed current flows from one post of the battery, thru the heavy starter cable, thru the starter switch, thru the starter, thru the frame of the car which is used as a return path for the current, thru the flexible ground strap or cable and to the other post of the battery. The amount of current flowing through the starter system is quite high, an average of 200 amperes. It is therefore of utmost importance to eliminate all loose or corroded connections, as they increase the resistance (opposition to flow of current) of the system, thus putting a greater strain on the battery and causing it to run down. The various tests for this purpose are given in the preceding bulletins.



IGNITION

The ignition circuit of the car consists of: BATTERY, AMMETER, IGNITION SWITCH, COIL, CONDENSER, DISTRIBUTOR (Distributor Head, Rotor, Breaker Points), IGNITION WIRES, SPARK PLUGS.

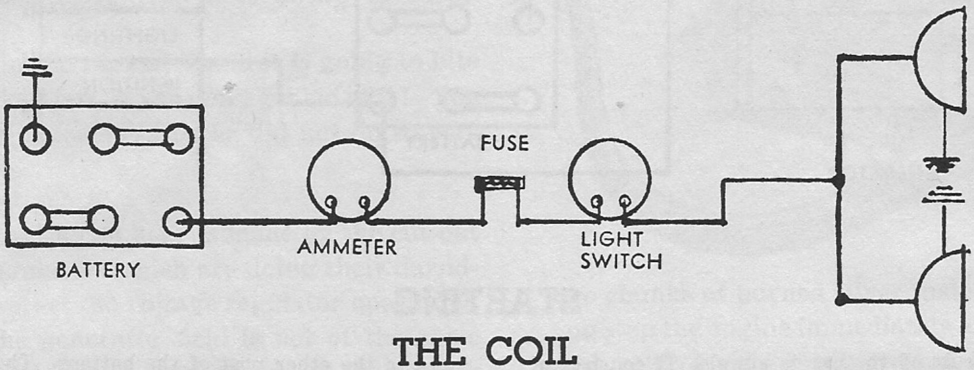
The current flows from one post of the battery thru the ammeter, thru the ignition switch, thru the primary winding of the coil, thru the breaker points, to ground and back to other post of battery. At the same time a secondary (high-tension) current is set up in the coil. This current flows from the high tension terminal of the coil, thru the distributor head, thru the rotor, thru the high tension wire, thru the spark plug and thence to ground.



LIGHTING

The lighting circuit of the car consists of: BATTERY, AMMETER, FUSE, SWITCH, LEADS, LIGHTS, HORN, etc.

When the lights or appliances are turned on, the current flows from one post of the battery, thru the fuse, thru the ammeter, thru the switch, to the lights or appliances selected by turning the corresponding switch lever to the frame (ground) and back again to the other post of the battery. All connections throughout this system must be absolutely tight in order that the appliances receive the full energy of the battery, and should be checked carefully as they tend to become loose due to vibration.



THE COIL

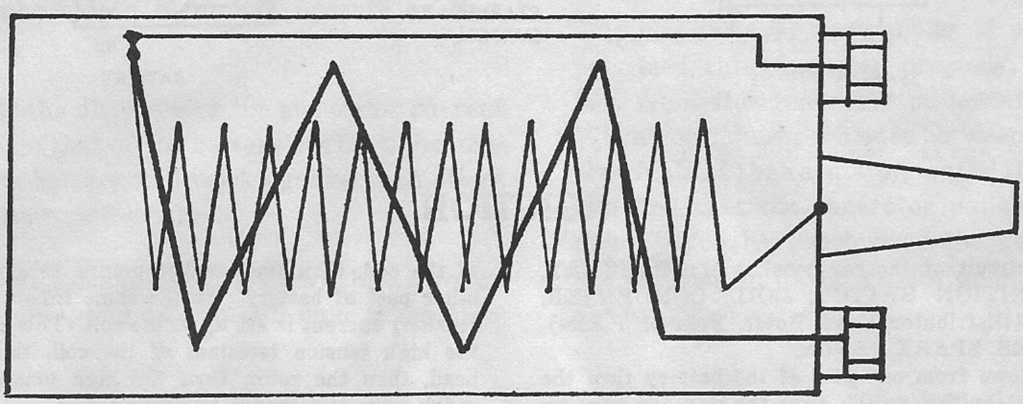
In order that a spark may jump between the electrodes of the spark plug under compression, a high voltage (10,000 volts or over) is required. As the source of electrical energy in the car is the battery which produces only 6 volts, a transforming device is required in order to raise the 6 volts furnished to the high voltage required. The coil in conjunction with the breaker points and the condenser performs this function, so that the coil is really a transformer.

The coil consists of 3 principal parts: The core, the primary (low tension) winding, and the secondary (high tension) winding.

The core is made up of a number of pieces of electrical iron, this laminated construction being necessary due to the fact that the core must be able to demagnetize quickly, which it could not do if it were made of a solid piece of metal.

The secondary winding is made up of a great number of turns of very fine insulated wire, and is usually wound around the core. It is in this winding that the 6 volts furnished by the battery becomes transformed into high voltage. How this is done will be explained under "Operation of the Coil".

The primary winding consists of comparatively few layers of No. 19 or No. 20 insulated wire, wound around the secondary winding. When the current flows thru the primary winding, it causes the core to become magnetized, which is the first step in the process of producing a spark between the spark plug electrodes.

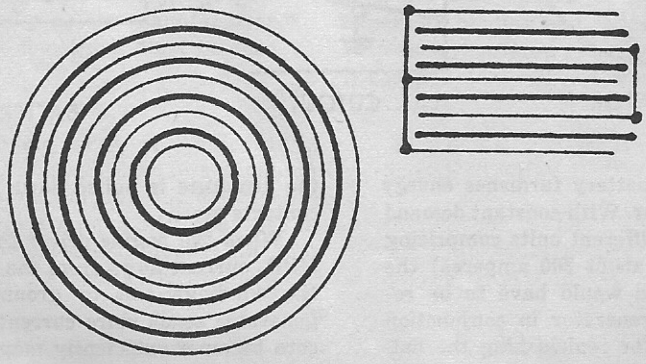


SERVICE BULLETIN No. 39-42

THE ELECTRICAL SYSTEM OF THE CAR

PART II

THE CONDENSER



The condenser is made up of alternate layers of tinfoil and a special type of insulating tissue. As will be seen from the drawing, there is no continuous path for the electrical current from one terminal of the condenser to the other.

The functioning of the condenser depends upon its capacity or the ability to become charged with electricity when current is applied to the plates of the condenser, but only when adjacent plates do not touch each other. A condenser in which the insulation between two plates is punctured and permits electrical connection between adjacent layers of plates becomes defective.

THE BREAKER POINTS

The breaker points are the means utilized in order to make and break the flow of current through the primary winding of the coil. In other words the breaker points are really a switch in the primary circuit of the coil and are operated by the cam in the distributor, which has alternate flats and corners.

The breaker points consist of the movable breaker arm and the stationary breaker arm or screw. The movable breaker arm is a suitably formed metal stamping with a bushing at one end, used as a bearing, and a tungsten contact at the other end. The stationary breaker arm is also a metal stamping with a means for fastening at one end and a tungsten contact at the other end. In cars using a screw for this purpose, a post is provided in the breaker plate for holding this screw, and the screw also has a tungsten contact at one end. When the bumper of the breaker arm is opposite a flat part of the cam, the points make contact with each other, or are closed. When the cam revolves and a corner of it hits the bumper of the breaker arm it causes the points to separate or open.

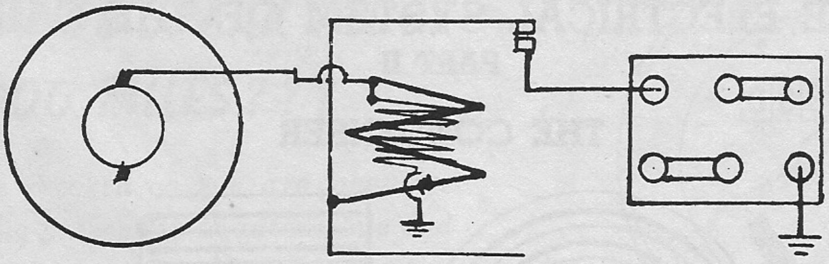
OPERATION OF THE COIL

When the breaker points close, current flows through the primary winding of the coil, causing the core to become strongly magnetized. The period during which the points are closed, is called the saturation period, as the core is then being saturated with magnetism. Also, during this period a magnetic field is built up around the primary and secondary windings. However, due to certain fundamental laws governing the relation between magnetism and electrical current, the saturation period is comparatively slow in reaching its maximum, or "peak." It has been found that the core will demagnetize much more rapidly than it will magnetize, and that the quicker it will demagnetize the higher a voltage will be induced in the secondary winding. In other words, if a spark is to be made to jump across the spark electrodes, it is essential that some agency be employed that would cause the core to change suddenly from being a strong magnet to being no magnet. For this purpose the condenser is utilized. As soon as the breaker points open, the magnetism in the core changes in such a manner as to cause a surge of current through the primary winding in the same direction as it has been flowing. This surge of current charges the condenser which is connected across the breaker points just as a battery is charged. The condenser however, immediately discharges and sends a rush of current through the primary winding in the opposite direction, and this reversed current is what causes a good spark to jump across the spark plug electrodes, because it demagnetizes the core instantly and allows the secondary winding to develop a high voltage.

Another, no less important function of the condenser is the quenching of the arc across the breaker points. Whenever a circuit is broken a spark occurs at the break, in this case the breaker points. When the breaker points open and a surge of current takes place as described above, there is a tendency to cause a heavy arc between the breaker points, which would burn them if allowed to take place. With the condenser connected across the breaker points this surge of current is absorbed by it and thus the excessive arcing is prevented.

And so this cycle of magnetization and demagnetization of the core, charge and discharge of condenser occurs each time the breaker points close and open, and each time this happens there is a high tension current produced by the coil, delivered to the distributor and distributed through the rotor and high tension wires to the spark plugs.

THE GENERATOR & GENERATOR RELAY (CUTOUT)



As explained before, the storage battery furnishes energy to the entire electrical system of the car. With constant demand being made upon the battery by the different units comprising the system (the starter alone draws about 200 amperes) the battery would soon be exhausted and would have to be recharged at frequent intervals. The generator in conjunction with the cutout provides the means for replenishing the battery and for replacing the energy drained from it.

The Generator is mechanically connected to the engine and when driven by it, produces electrical energy. The amount of energy produced by the generator depends upon the speed at which it is driven and its output is controlled by third brush regulation. There are three brushes around the commutator of the generator, the two main brushes are fixed and the third or "control" brush is movable. Moving the third brush in the direction of the commutator rotation increases the amperage delivered by the generator; moving this brush in the direction opposite to commutator rotation decreases the amperage.

In later types the output is governed by voltage regulators, described in preceding bulletins.

The cutout is a relay switch that connects and disconnects the battery from the generator. It has two windings, a core which is magnetized by the windings and an armature operated by the core when it is magnetized. One of the windings is made up of a great number of turns of fine wire and wound next to the core; the other winding is made up of a few turns of heavy wire, and is wound around the fine winding. The armature has a silver contact at one end, and a corresponding silver contact on a post, located in such a manner that when the armature is pulled down by the magnetized core the two contacts meet.

When the engine drives the generator at a speed below 15 MPH, current flows from the generator to the cutout, through the windings and to ground. As the speed increases the generator sends more current through the windings, until the core becomes sufficiently magnetized to operate the armature and close the contact points. The closing of the points provides a path from the generator to the battery, and the ammeter on the instrument board will show "charge." Part of this current is used to operate the ignition system, lights, etc., and the balance is delivered to the battery, which in this way regains energy it lost when the car was being started, or when lights were used with the car parked, etc. The reading given by the ammeter is the actual current delivered to the battery, or the total current put out by the generator, less the current used up in the operating units.

As the engine speeds up beyond a certain point, this point varying in different types of generators, the output of the generator will decrease. In later types, having only two brushes, the output is not cut down at high speed.

When the engine slows down again, the generator output decreases accordingly until the ammeter begins to show a slight discharge, showing that the generator voltage is now lower than the battery voltage and that current flows from the battery to the generator. When the ammeter shows 2 or 3 amperes on the "Discharge" side, the points on the cutout will open, thus disconnecting the battery from the generator, as otherwise the battery current would continue flowing to the generator and cause the battery to become discharged.

SERVICE BULLETIN No. 6-37

WHAT IS "CAM ANGLE"?

"Cam Angle" is a term used more and more frequently as the science of motor tune-up advances. Many mysterious ailments of the ignition system can be traced to incorrect cam angle, as will be explained below.

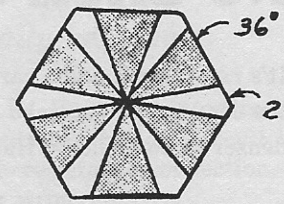
"Cam Angle" is simply the number of degrees through which the distributor cam rotates while the breaker points are closed. In a six cylinder motor, for instance, during one complete revolution of the distributor shaft, the cam rotates through a circle of 360 degrees, and the points go through six cycles of opening and closing. Dividing 360 by 6 we find for each of these cycles the cam rotates through 60 degrees. If the points are open for 24 degrees, for instance, they will be closed for 36 degrees (60—24 = 36), and the cam angle, which is also known as "degrees of dwell," is 36 degrees. The cam angles vary in different distributors and are established by the manufacturers of these distributors. The cam angle thus determines the length of time the current flows through the primary winding of the coil and saturates the coil.

The fact is often overlooked that the condenser must operate in synchronism with the coil, becoming charged at the proper time and discharging through the coil at the moment when the discharge will be most effective in collapsing the coil magnetism to produce a good firing spark, at the same time counteracting the arcing tendency between the points. If this synchronism is disrupted by the wrong cam angle, the coil and condenser will not act in unison, the motor will "miss" and the points will burn.

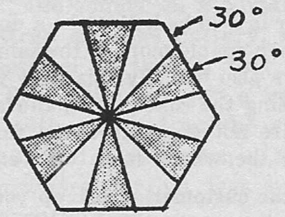
The effects of incorrect cam angle are as follows:

1. **Cam angle too small** (points set with a wide gap). The points open too slowly causing excessive arcing and burning. The points do not stay closed long enough to allow the coil enough time for full saturation, and the motor misses at high speeds.

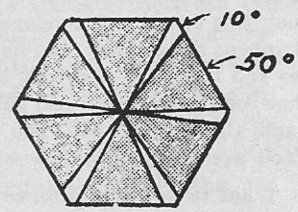
2. **Cam angle too large** (points set with a small gap). The points are opened and closed with a hammerlike action, causing bouncing of the points and erratic coil action. Besides, the coil and condenser do not get a chance to discharge completely, and the coil "chokes up," and causes rough motor operation at the lower speeds and misses at high speed. The points will burn and the surfaces will show marks of pounding.



CORRECT CAM ANGLE

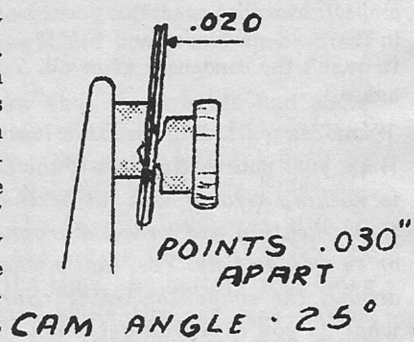


CAM ANGLE TOO SMALL



CAM ANGLE TOO LARGE

To obtain the correct cam angle the points must be adjusted with precision. The safest method is to use the oscillograph. However, if a feeler gauge is used, extreme care must be taken that the spacing of the points is actually what the gauge shows. This is especially true in the case where old points are being adjusted, as can be seen from the illustration. Here the gauge shows a gap of .020" while the points are really .030" apart, changing the cam angle from 34 degrees to 25 degrees, bringing in the troubles shown above under "cam angle too small."



Complaints are often made—"I put in a new coil, condenser and points, and the motor still misses and the points burn out." In many cases these compaints can be charged directly to incorrect cam angle.

SERVICE BULLETIN No. 61-50

SHOULD I USE A HEATING PAD FOR MY ACHING BACK *OR FOR MY CONDENSER TESTER?*

It's raining out and a car drives in with ignition trouble. You fuss around a bit and think it's the condenser. You take it off the car, pull out your condenser tester and find that the condenser is bad. Glory, Hallelujah! You hit it right on the nose!

So you go to your stock and grab a brand new condenser. Just to make sure, you try it on the tester and, believe it or not, this brand new condenser is also bad. Must be a dud, that happens sometimes! You have a couple more of the same type, so you try those and they are also bad. By this time you are hot under the collar and cursing the condenser manufacturer and all his relatives. You are not going to stand for *that!* You are going to throw out the whole damn line, etc., etc.

What to do? You alibi to the customer, crank up your own car and run over to a friendly service station who carries another manufacturer's line and ask him to lend you a condenser. This guy also has a condenser tester, although different from yours, so you have him test his condenser on it, and it tests OK.

Fine, now you are all set. You shoot back to the customer and tell him that everything will be OK in a minute. You put in the *good* condenser and *!?*!? — it doesn't fix the trouble. It wasn't the condenser after all. You've got to start all over again.

What caused this mess, this loss of time, this red face? Why, just your little Neon Tube Condenser Tester. There is nothing wrong with all of the condensers you tested that a heating pad wrapped around the tester for an hour or so wouldn't fix. Yes, that's what I said: a heating pad around the condenser tester! *Sure, it sounds crazy, but what do you expect to get when someone sold you a crazy contraption for a condenser tester? Let me get serious now and tell you all about it.*

Before the war, there were quite a few makes of Neon Tube Condenser Testers on the market. The manufacturers of these testers had no problems; they did not sell condensers, so the trouble afterwards was in your lap, and the laps of the condenser manufacturers. Your problem and ours is that a neon tube is entirely too sensitive for testing condensers. It is so sensitive in fact that on a rainy or even muggy day, the amount of moisture that collects on the tester leads and its internal connections is sufficient to produce flashes in the neon tube which you interpret as an indication of a bad condenser.

Here are a couple of actual cases that clearly demonstrate the danger of using Neon Tube Condenser Testers. One of our men happened to be present while one of these testers was being used by a customer. *Every condenser in the customer's stock tested bad on this tester.* Our man took the tester across the street to an armature rewinder and put it into an armature drying oven for awhile, after which all the condensers that were previously rejected by the tester now tested OK.

Another case is that of one manufacturer of such testers, who found that his testers condemned complete stocks of perfect condensers. He recommended that the tester be wrapped in a heating pad for a length of time to dry it out before any tests were made. Needless to say, this finished that condenser tester and pretty soon all other neon tube condenser testers died out.

However, in the past year (1949), this type of tester came to life again: it costs very little to make and it can be sold to the mechanic for as low as $9.95. This low price makes it attractive, of course, as reliable and authoritative condenser testers cost the mechanic around $50.00. Besides, it looks mighty pretty, with the tube flashing on and off. But here's the catch: you pay $9.95 for a condenser tester that does not test. It condemns good condensers and passes bad ones.

It condemns good condensers because a neon tube is too sensitive for checking condensers in the first place. In the second place, the construction of the neon tube condenser tester is such that the neon tube will often register the amount of moisture on the tester instead of indicating the condition of the condenser.

It passes bad condensers. The condition which really affects condenser operation in the distributor is an imperfect connection inside the condenser, called "damping" or high resistance. This condition will absolutely make the condenser inoperative, yet on a neon tube condenser tester, a condenser with a high resistance internal connection will test OK.

Do you know what this means to you? The tester may tell that the condenser is N.G., so you will replace it, but the trouble will still be in the car. On the other hand, it may call a condenser OK, while it is actually bad. Relying on this test, you may proceed to rip out other parts and change them, *but the trouble will still be in the car.*

To sum it up: the ordinary type of Neon Tube Condenser is entirely impractical for condenser testing. At the present time we know of just one make of Neon Tube Tester, the Electro-Products Trouble Shooter, in which the neon tube has been desensitized to an extent that it will not condemn good condensers. However, even this tester will still pass condensers with high resistance internal connections.

There are reliable condenser testers made by well known equipment manufacturers. They are all of the Meter type and check all phases of condenser performance. They cost around $50.00 but do what they are supposed to do: reject a bad condenser and pass a good one.