Lecture – 20

Ignition System

Hello! In our reciprocating engine, for efficient combustion, we need air, fuel and fire. Regarding air, we’ve already read in the induction system, regarding fuel we’ve studied in the fuel system and for ignition, for fire, for getting spark, we need to understand the ignition system. So let us see, how fuel and air mixture, in the engine cylinders, is ignited, how the spark is generated and how do we get, efficient combustion. So let us start the, ‘Ignition System’.

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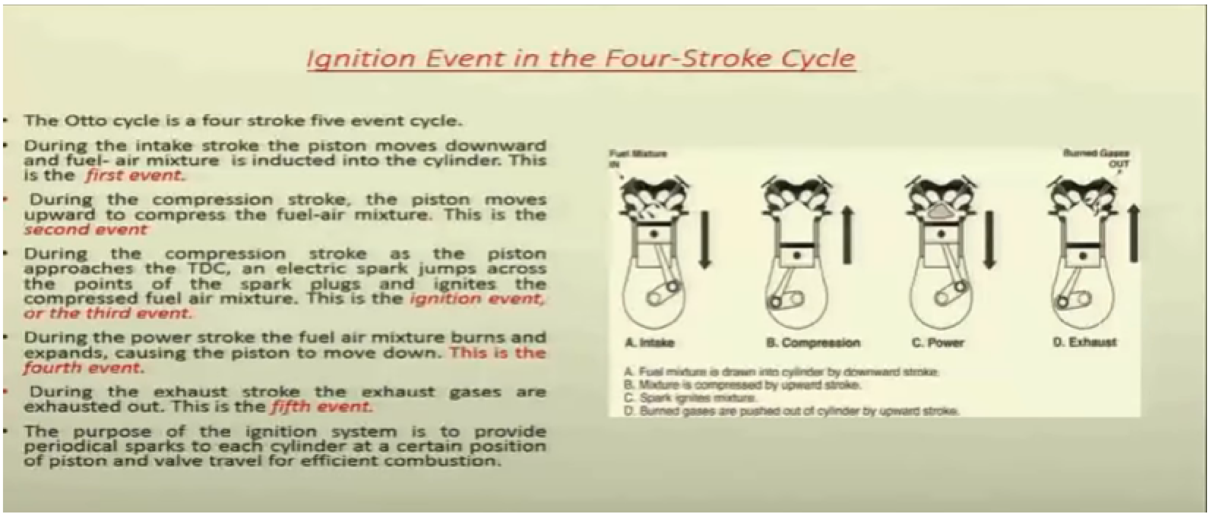

Now Ignition Even, in the Four-Stroke Cycle, we all know that, the engine is operating on Otto cycle; it is a four stroke, five event cycle. During the intake stroke, the piston moves downward and fuel-air mixture is inducted into the cylinder. So in the intake stroke, the fuel and air mixture is coming in and this is the intake stroke and the First Event. During the compression stroke, the piston moves upward to compress the fuel-air mixture. And this is the Second Event. So the first event is, the intake stroke, the second event is the compression stroke, where the piston is moving up and the fuel and air mixture is being compressed. Now where the piston is moving up, during the compression stroke, before the piston reaches top that centre, an electric spark jumps across the point of the spark plug and ignites the fuel air mixture. This is the ‘Ignition Event’ or the ‘Third Event’. So, just when the piston is moving on the compression stroke, upwards, just before the piston reaches, top that centre, a spark, jumps across the electrodes of the spark plug and the fuel air mixture in the cylinder, gets ignited. This is your Ignition Event or the Third Event. Once your fuel air mixture is ignited, due to the burning mixture and expansion, the piston moves downwards, this is your power stroke and the Fourth Event. And during the exhausted stroke, the piston is moving upward, from bottom dead centre to top dead centre, the exhaust gases, are the exhausted out and this is your Exhaust Stroke and the Fifth Event. So we’ve seen that, there are five events and Ignition is the third event. So now, what is called Ignition about? Let us see. Basically the purpose of the Ignition System is to provide periodical sparks to each cylinder, at a certain position of piston and valve travel for efficient combustion. So that is the basic purpose of your, ignition system, to provide periodical sparks, at a certain position of piston and valve travel, so that you can have proper combustion.

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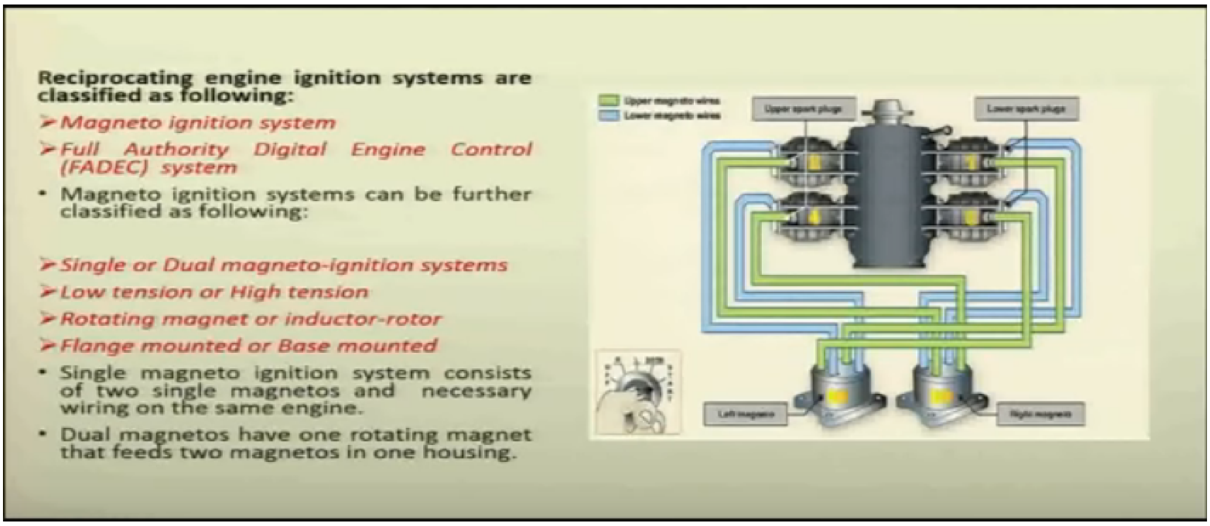

Now the reciprocation engine ignition system, they are basically classified as, Magneto Ignition system of FADEC system. FADEC system is also called, 'Full Authority Digital Engine Control system'. Whole in this lectures we are going to cover only the Magneto Ignition system, this is just to tell you, that the Ignition Systems are basically two types, Magneto Ignition and the FADEX System. Now Magneto Ignition system, it can be also classified as following: It can be, Single or Dual magneto-ignition system, it can be a Low tension or High tension system, it can be a system, where the magnet is, rotary or the inductive rotor type. And you can have the magnetos as Flange mounted or Base mounted. So different types of systems, single magneto ignition system consists of two single magnetos and necessary wiring on the same engine. So here in the diagram you can see, that there are two magnetos shown; one is your Left Magneto and the other is the Right Magneto. We will understand what magneto is, but there are two units independent units and the associated wiring. So this is called the, 'Single Ignition Magneto System', because you have independent units. In Dual Magnetos, you have one rotating magnet that feeds two magnetos and one housing. So Dual Magneto means, you have two units in one and that is your Dual Magneto, with, which has one rotating magneto only.

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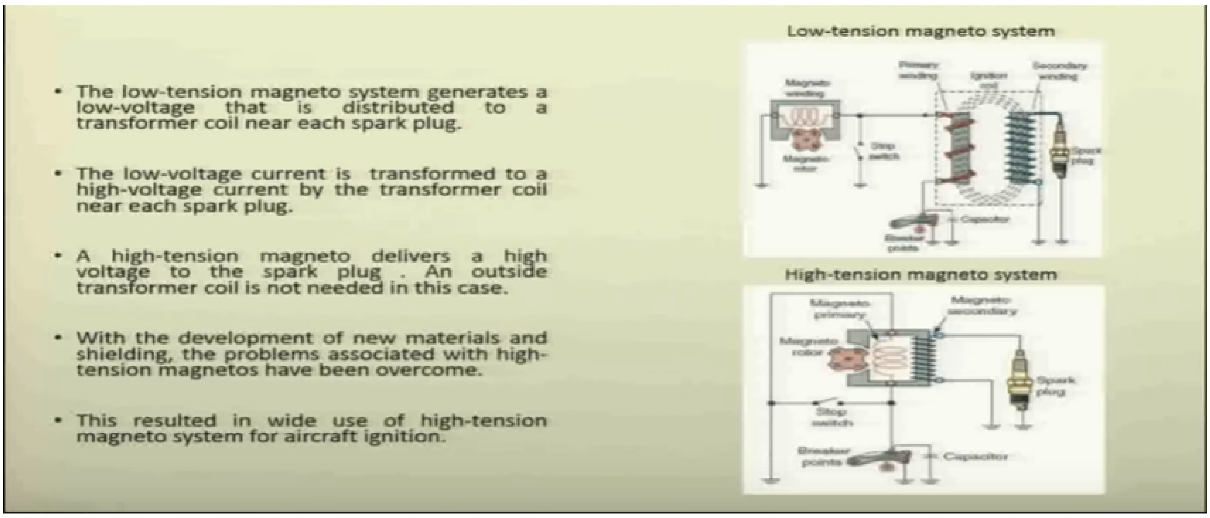

Then coming to the low tension and the high tension system, in the figure you can see, the top figure is for the Low Tension Magneto System, the bottom figure is for the High Tension Magneto System. The Low Tension Magneto System generates a low voltage that is distributed to a transformer coil near each spark plug. So in the engine, you have number of cylinders and on each cylinder you have two spark plugs. So this in the Low Tension Magneto System, you have a transformer coil near each spark plug. So the purpose is to generate, a low voltage that is distributed to a transformer coil near each spark plug. Now with the development of new materials and shielding, the problems, the associated with high-tension magnetos have been, overcome now. So earlier there were problems in the High Tension Magneto System, because of the materials, since you were generating high voltage and high voltage was being transmitted, to the spark plugs, through the leads. So now because of the improved material, those problems have been overcome. And because of that, the high tension magneto system is widely used in the aircraft ignition system.

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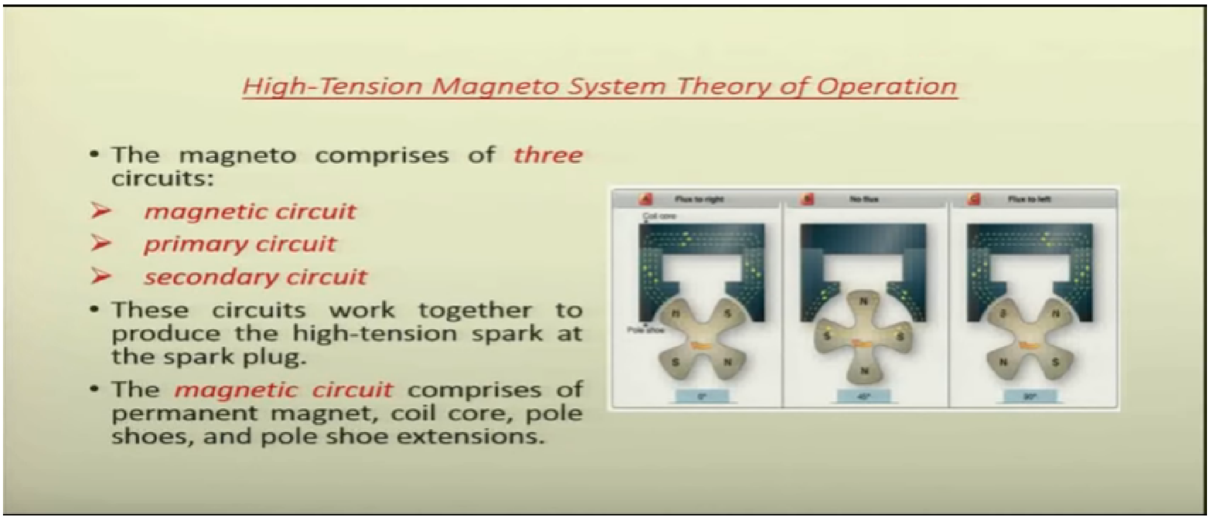

Now let us see the High Tension Magneto System, how is it operating, what is the theory behind it? The system, comprises of three units; one is the Magneto. Basically the ignition system will have a magneto. It will have the ignition harness and the Spark plugs. So let us see, how the magneto operates. The Magneto comprises of three circuits; The Magnetic Circuit, the Primary Circuit and the Secondary Circuit. So Magneto has three circuits; Primary Circuit, Secondary Circuit and a Magnetic Circuit. These circuits work together to produce, the high tension spark, at the spark plug. Now all these systems, all these circuits, they are working together to produce the high-tension spark at the spark plug. The Magnetic Circuit comprises of Permanent Magnet, here in the figure you can see. There is a permanent magnet, this is a permanent magnet, a coil core, this is you coil core, you can see here, this is your coil core, pole shoes, you can see the pole shoes here and the pole shoe extensions. So the Magnetic Circuit has got a magnet, permanent magnet, coil core, pole shoes and pole shoe extensions.

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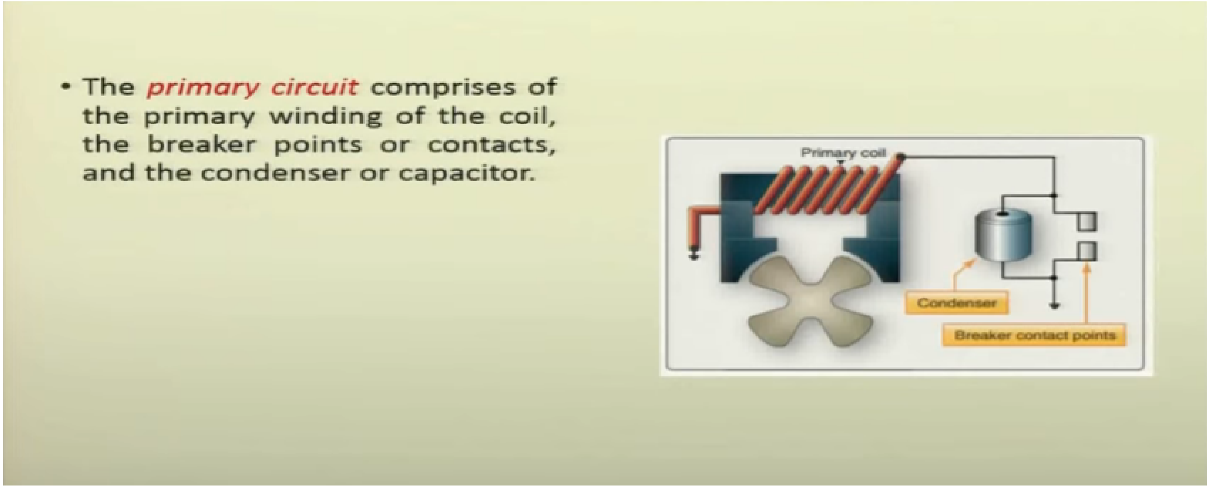

A Primary Circuit comprises of, the primary windings of the coil, the breaker points or contacts and the condenser or capacitor. And the Primary Circuit will have the primary coil, the breaker points and a capacitor. So this is your Primary Coil. We have seen that the Magneto system has got three circuits, a Magnetic circuit; magnetic circuit had a rotating magnet, permanent magnet, with a coil core, pole shoes and pole shoe extensions. In the Primary Circuit, we have a Primary Coil, Breaker Points, had a condenser or Capacitor.

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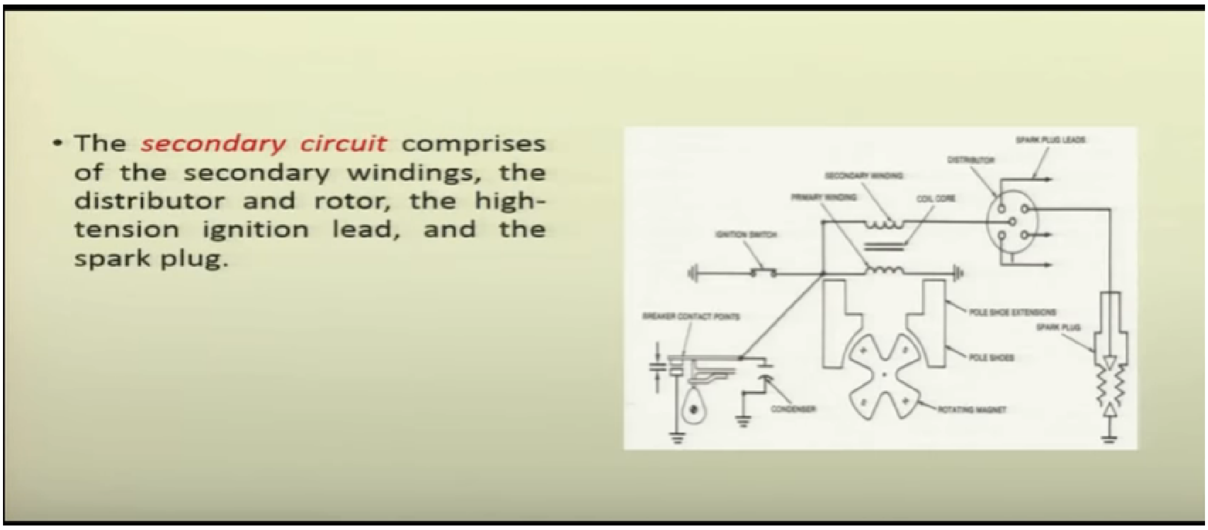

The Secondary Circuit, comprises of, the secondary windings, you can see in the figure, these are the secondary windings. The distributor and rotor, this is your distributor and rotor, the high-tension ignition leads, these are the leads, going from the distributor, the ignition leads and the spark plugs, here you have the spark plugs, this is your spark plug. So, the Secondary Circuit has the secondary winding, the distributor and rotor, high tension ignition leads and the spark plug. So in the diagram you can see some, a basic diagram, where you see, there is a rotating magnet, you have pole shoes, you have a Primary Winding, this is your ignition switch here, which controls the entire circuit, then this is your Secondary Winding, this is your coil core, here is your distributor, then you have the ignition leads and this is your, spark plug. On this side you have, the breaker contact points and the condenser across the, breaker contact points. So, this was the three circuits, in brief, in our Magneto System.

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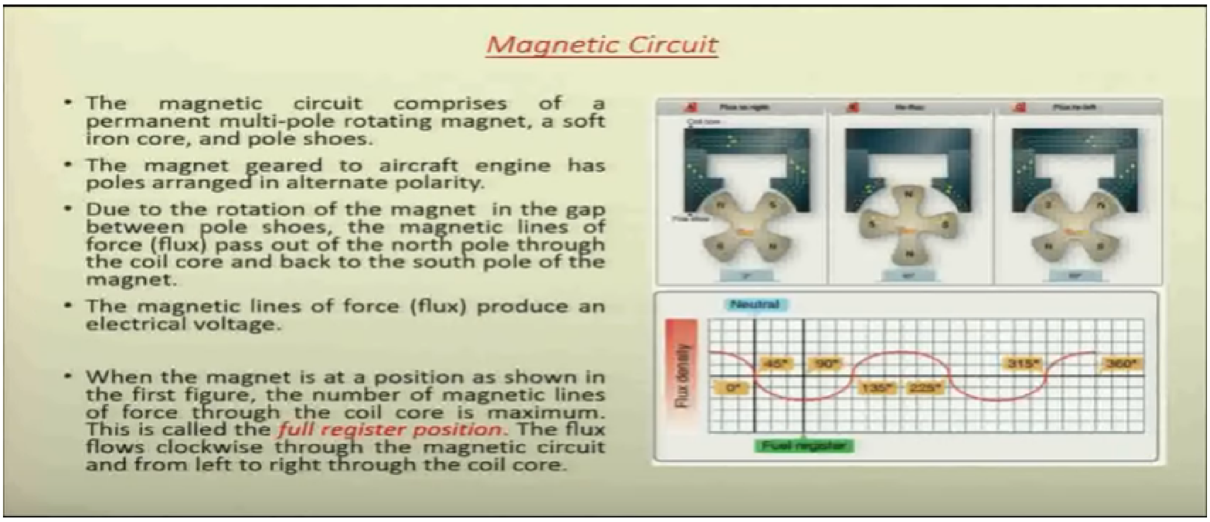

Now coming to the first circuit, 'Magnetic Circuit'. The magnetic circuit comprises of a permanent, multi-pole rotating magnet. Now it is a multi pole, you can see here, there are various poles, North, South, North, South. Multi-Poles, it is a rotating magnet, a soft iron core and pole shoes. These are your pole shoes. The magnet geared to aircraft engine has poles arranged, in alternate polarity. Now this, magnet, this is geared, this is meshed to the aircraft engine and it has poles, in out to get polarity. You can see here, you have North, then you have South, again North, and then again South, then again North. So this is, you have the alternate polarity, it is a rotary type magnet, which is geared to the aircraft engine. Due to where rotation of the magnet in the gap, between the pole shoes, the magnetic lines of the force pass out of the North Pole, through the coil core and back to the South Pole of the magnet. Now, when this magnet rotates, since this is meshed to the engine, when this magnet rotates, the magnetic lines of force, pass, come out from the North Pole, pass to the coil core and then enter the South Pole. So you can see the magnetic lines of force, moving from, left to right. The magnetic lines of force, will produce an electrical voltage. Now, because of these magnetic lines of force, you have electrical voltage produced. When the magnet is at a position as shown in the first figure; Now this is your first figure. When the position of the magnet, is in this position, where you have North Pole, aligning with the left pole shoe and the South Pole, aligning with the right pole shoe. This position, in this position, you have, the maximum lines of force, passing through the coil core. This particular position is called, 'The Full Register Position', and the flux, the magnetic field is flowing from, left to right. It is flowing clockwise, through the magnetic circuit, from left to right, through the coil core. So here, we've seen, this is, the Full Register Position. The first figure, the full register position, in which case, you have the magnetic, maximum magnetic lines of force, passing through the coil core, moving from left to right and it is called a, 'Full Register Position'.

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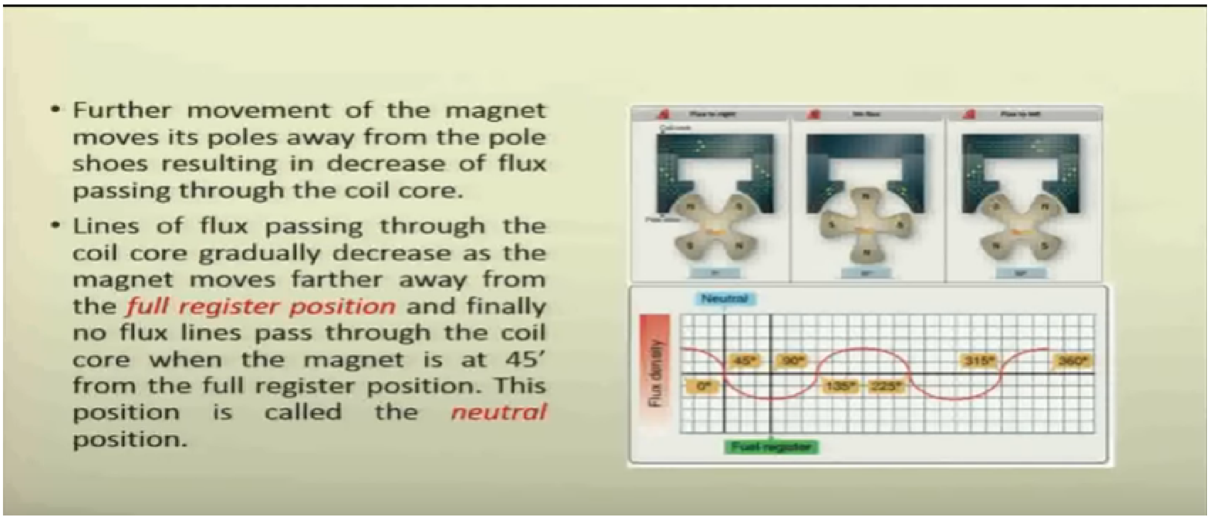

Further movement of the magnet, moves its poles sway from the pole shoes. Now when this, after this position, when the magnet, at, is rotating, when it starts rotating, it is this North pole is moving, away from the pole shoes. Because of the movement, of this North pole, away from the pole shoe, there will be decrease of the flux, passing through the coil core. Now the magnetic lines of force, magnetic lines of, which are passing through the coil core, will decrease, because, the rot, rotating, rotary magnet has, moved. Lines of force, lines of flux, passing through the coil core gradually decrease, as the magnet moves farther away from the full register position. Now, as the magnet moves away from the pole register position, your magnetic lines of flux, which are passing, through the coil core, will gradually decrease and finally, no flux lines will pass, through the coil core, when the magnet is at, 45 degrees, from the full register position. Now when the magnet is at 45 degrees from the full register position, in that case, there won't be any lines of flux, passing through the coil core. This position is called the, 'Neutral Position'. So the second figure here, this is your, neutral position, where no flux is passing. In the first position it was the full register position, where, maximum lines of flux were passing, through the coil core and it was called the full register position. The second picture, is the neutral condition, where no lines of flux are passing and the pole, of the magnet, here you see, one pole of the magnet, North pole, is exactly in the centre, between the two pole shoes.

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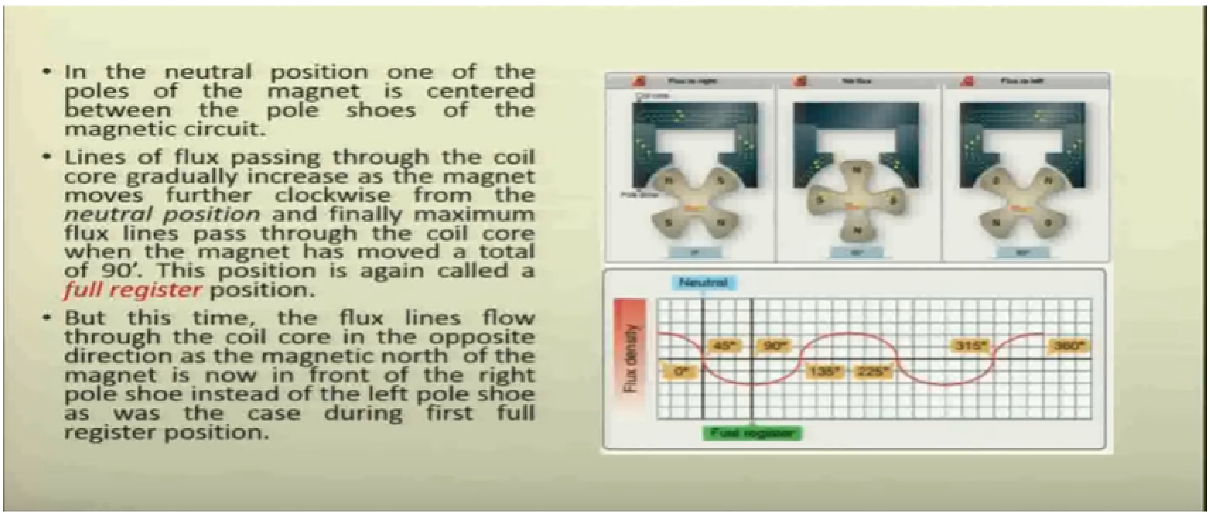

In the neutral position, one of the poles of the magnet is centred between the pole shoes of the magnetic circuit. Lines of flux passing through the coil core, gradually increase, as the magnet moves clockwise. Now magnet, when moves, this magnet will gradually move, towards the pole shoe and from zero, this will result in, increase of magnetic lines of flux, passing through the, coil core. Lines of flux, passing through the coil core, will gradually increase, as the magnet moves clockwise, from the neutral position. And finally maximum lines will pass through the coil core, when the magnet has moved a total of 90 degrees. Now, if you see the neutral position, the second picture, here the magnet pole is in the centre, as the magnet moves, this pole will gradually align with the pole shoe, on the right side and magnetic lines of field flux, which are passing, through the coil core, will gradually increase and finally a position will come, when this pole is completely aligned with the pole shoe and you will have maximum lines of field, passing through the, coil core. Again, this is the full register position, but in this case, if you see that the magnetic lines of force are from North Pole to South Pole. That is, they are moving from right to left. So in the first picture, we had the full register position, where the lines of flux were passing from left to right. In the third picture, we again have the magnetic lines of force passing through the coil core, but this time the direction is opposite, where the field is moving from right to left. So Zero degrees it was, moving from left to right, at 90 degrees, of magnet rotation, it is moving from, right to left. But this time, the flux lines, flow through the coil core in the opposite direction, as the magnetic north of the magnet is now in the front of the right pole shoe. Now you see, the magnetic north, earlier it was in the front of the left pole shoe, now it is in front of the right pole shoe. Instead of the left pole shoe, as was the case, during first full register position.

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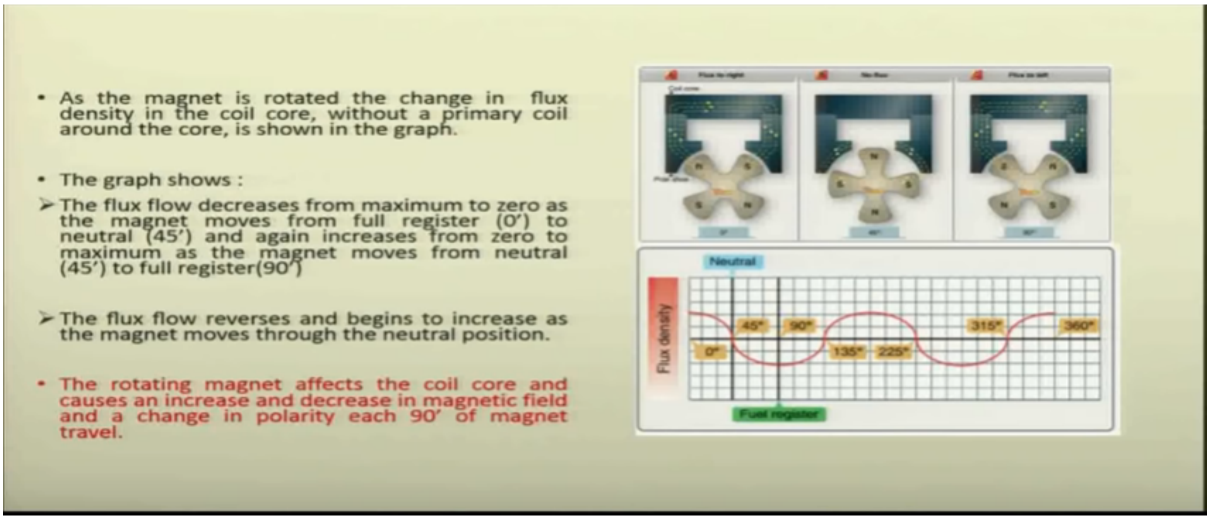

As the magnet is rotated, the change in flux density in the coil core, without a primary coil around the core, is shown in the graph. Now, if we observe this graph, in the bottom figure, this is this, are called, this is called,' A Static Flux Curve', where the, when the magnet is rotated, the change in flux density in the coil core, is reflected in this graph. Here you see, the flux is at the maximum position, the flux decreases from maximum to zero, the flux is decreasing from maximum to zero, as the magnet moves from pole register to neutral position. Now if you observe, the, this top figure, at zero, you had maximum flux passing, you have, you have, maximum flux here. And till the time the magnet reaches 45 degrees, the flux is zero. So now you see, the flux is, decreasing from maximum to minimum, it has at 45 degrees, it is completely zero. Now the proper movement of the magnet, you see, from 45 degrees to 90 degrees, the flux again starts to increase, but in the opposite direction. In this graph, if you observe that the, from 45 to 90 degrees, the flux has again started to increase, from zero it is increasing, but, in the opposite direction and at 90 degrees it is again in the pole register position, but in the opposite direction. The flux flow reverses and begins to increase, as the magnet moves to the neutral position. The rotating magnet affects the coil core and causes an increase and decrease in magnetic field and a change in polarity each 90 degrees of magnet travel. So this rotating magnet, it will affect the coil core, ‘Yes’, and it will cause an increase and decrease in magnet field. You see here, it was a decrease in magnetic field, from zero to 45 degrees, again from 45 to 90 degrees; again it was an increase in the magnetic field. So, there is that increase and decrease in magnetic field and a change in polarity, each 90 degrees of magnet travel. So every 90 degrees of magnet travel, there will be increase and decrease of magnetic fields, as well as change in polarity. So this was, about the, basic theory of operation of a, magneto, of a magnetic circuit. Let us see, how the primary circuit is operating.

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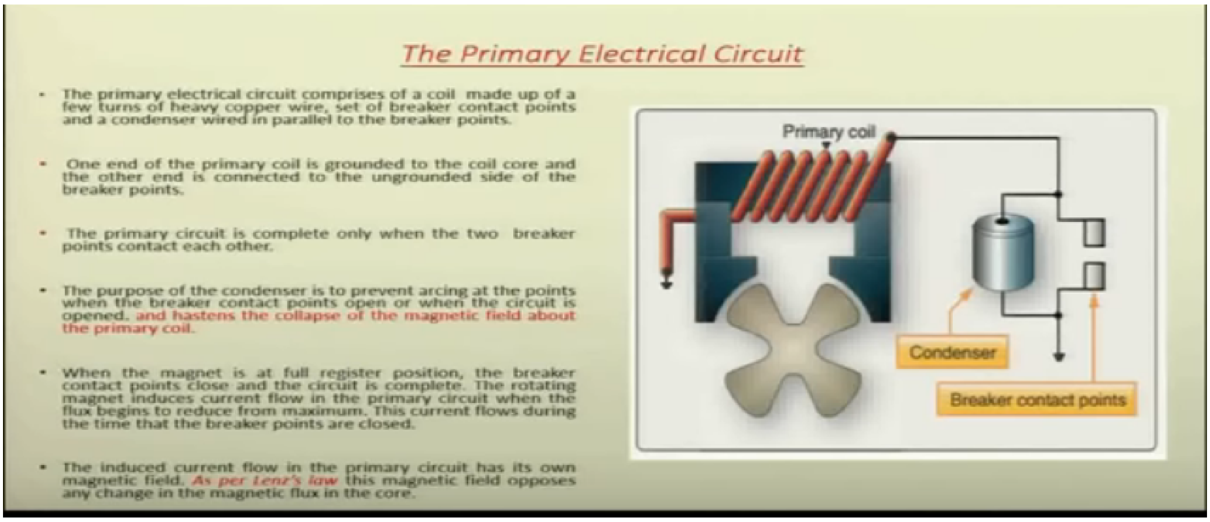

So now coming to the primary electric circuit, we have mentioned earlier, that the primary electric circuit has, a primary coil, a condenser and breaker contact points. So in the figure you can see, a primary coil here, then you see the breaker contact points and a condenser across the breaker contact points. So let us see, what the primary electric circuit is. It comprises of a coil, made up of, few turns of heavy copper wire. So you have, few turns, but heavy copper wires, then you have a set of breaker contact points and a condenser or a capacitor, which is, attached in parallel to the breaker contact points. One end of the primary coil is grounded to the coil core. This is one end, which is grounded to the coil core and the other end is connected to the, ungrounded side of the breaker points. So here in the figure you can see, this is, your ungrounded side, of the breaker point. This is, your grounded side of your breaker point, you can see this point, this contact point, this is grounded, but this is not grounded, so one end of the primary coil is connected to the ungrounded side of the breaker point. The primary circuit is complete, only when, two breaker points contact each other. Now this circuit gets completed, only when these two contact points, contact each other, then only the circuit gets completed. The purpose of the condenser or the capacitor, this capacitor, is to prevent arcing, at the points, when the breaker contact points open. So now, when these points open, there is a tendency of arcing. So inorder to prevent that arcing across, these breaker contact points, when they open, this capacitor is provided. It will also hasten the collapse of the magnetic field about the primary coil. When the magnet is at full register position, the breaker contact points close. Now when this magnet is at full register position, in the figure you can see, the magnet is at the full register position. In that condition the contact points close and the circuit gets completed. The rotating magnet because this rotating magnet will induce a current flow in the primary circuit because the magnetic lines of force are passing through the coil core and because of this primary coil, there are flux linkages and a primary current is induced in the primary coil. The rotating magnet, induces current flow, in the primary circuit, this rotating magnet will induce current flow in the primary circuit, when the flux begins to reduce from maximum. When the flux begins to reduce from maximum, the rotating magnet will induce current flow in the primary circuit. This current flows during the time, the breaker points are clo, closed. So during the time, when these breaker points are closed, this primary current, will flow, in the primary circuit. The induced current in the primary circuit, has its own magnetic field. Now this induced current, in the primary circuit, will also have its own magnetic field, But as per Lenz's law, this magnetic field will oppose, any change in the magnetic flux, in the core. So the magnetic field of this induced current, will oppose, the change in the magnetic flux, in the core.

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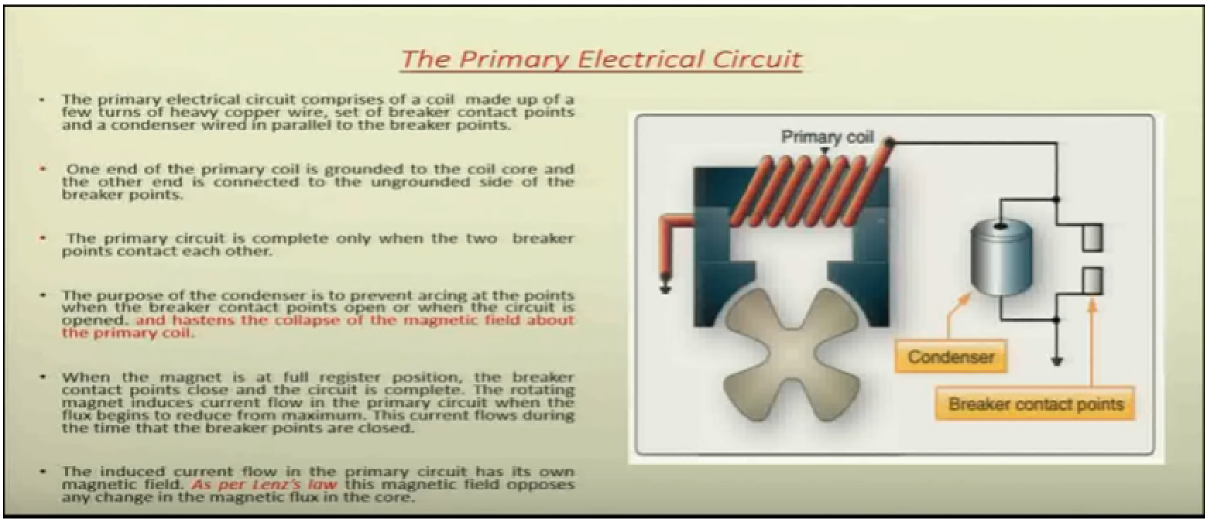

This is, as per, Lenz's law. Lenz's law states that, 'An induced current, always flows in such a direction, that its magnetism, opposes the motion or the change that induced it'. This is just to brush up our old Physics laws. The flux in the coil core normally changes as represented by the graph, but the primary current prevents this change and holds back the flux change, while the magnet turns. So we have seen in the static flux curve in our previous slide, how the flux is changing in the coil core but the primary will prevent this change and will hold back the flux change, while the magnet turns. The breaker contact points are made to open when the magnet reaches to a position, a few degrees past the neutral position. Now when the magnet reaches a few degrees just past the neutral position, the breaker contact points are made to open. Till this position, the current flowing in the primary circuit holds the flux in the core, at a high value in one direction. So till the point when the contact points are open, the current flowing in the primary circuit will hold the flux in the core, at a high value in the, one direction. The primary current is maintaining the original field in the coil core, while the magnet has already turned past neutral. Now, this primary current is maintaining the original field in the coil core, but, this magnet has already turned past the neutral. The primary current is now attempting to establish a field through the coil core in the opposite direction. Now with the primary coil holding the magnetic field on the magnetic circuit in the opposite polarity, a very high rate of flux change can be obtained by opening the primary breaker points. Now at this point, when the primary point is holding the magnetic field, of the magnetic circuit, in the opposite polarity, a very high rate of flux change can be obtained by opening the primary breaker points. Now at this point, when the primary coil is holding the magnetic field of the magnetic circuit, in the opposite polarity, then the breaker points are made to open at this point. A very high rate of flux change can be obtained. The number of degrees of rotation between the neutral position and the position where the contact points open, is called the, ‘E-gap angle or E gap, or efficiency gap’. This is very important, the point at which, the contact points are made to open, just beyond the neutral position is called the, ‘E-gap angle E gap position’.

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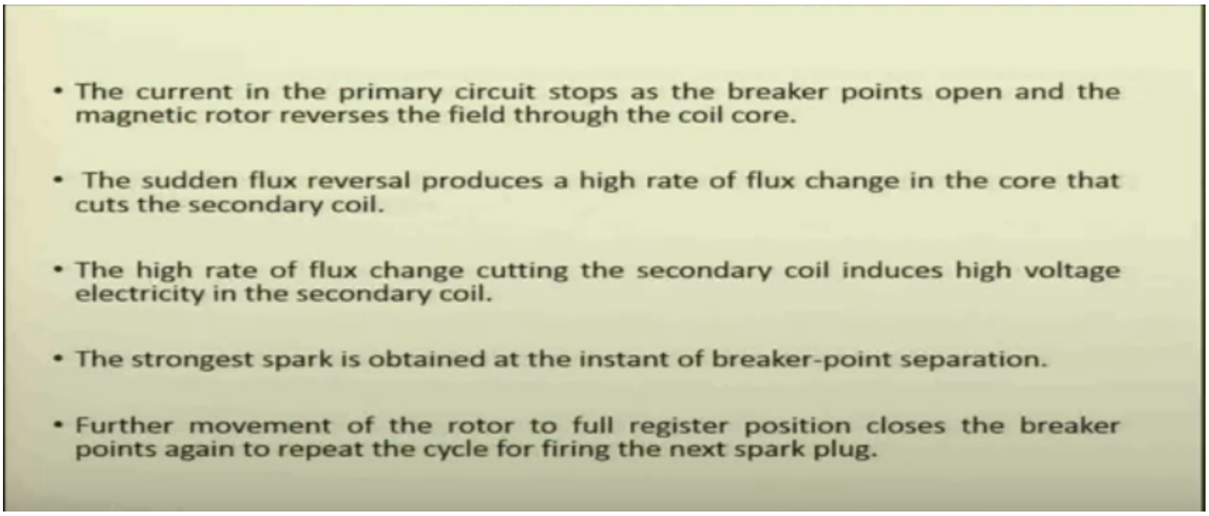

The current in the primary circuit stops, as the breaker points open. Now as the breaker points will open, the current in the primary circuit will stop and the magnetic rotor reverses the field through the coil core. Now the current in the primary circuit is stopped, because the breaker contact points are open and the magnetic rotor reverses the field through the coil core. The sudden flux reversal produces a high rate of flux change, in the core that cuts the secondary coil. The high rate of flux change cutting the secondary coil induces high voltage electricity in the secondary coil. Now because of this high rate of flux change which is cutting the secondary coil, a very high voltage is induced in the secondary coil. Because of this high voltage, in the secondary coil, the strongest spark is obtained, at the instant of breaker-point separation, movement of the rotor to the full register position, closed the breaker points again, to repeat the cycle for firing the next spark plug. Now when magnet is moved to full register position again, closes the breaker points again and the cycle is repeated for firing the next spark plug.

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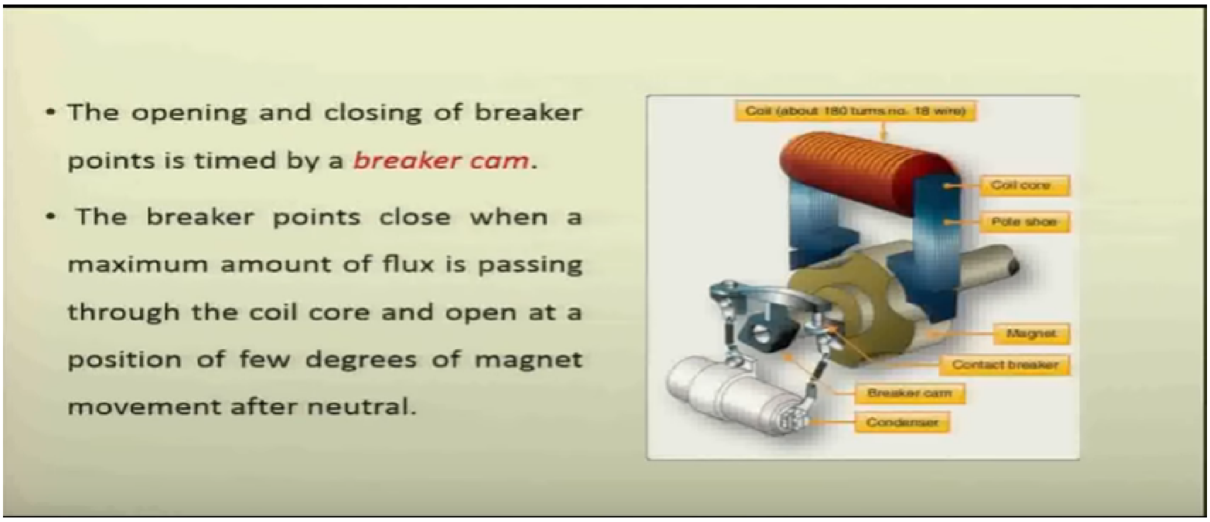

A opening and closing of breaker points is timed by a breaker cam. Now here in the figure, you can see, these are your breaker points, contact points and this is your cam here, this is your breaker cam. These points are made to open and close, by means of this breaker cam. The breaker points close when a maximum amount of flux is passing through the coil core and open at t a position, of few degrees, of magnet movement after neutral. So when your maximum amount of flux, is passing through the coil core, your contact points close and they open, when their magnet has passed neutral and is a few degrees beyond neutral.

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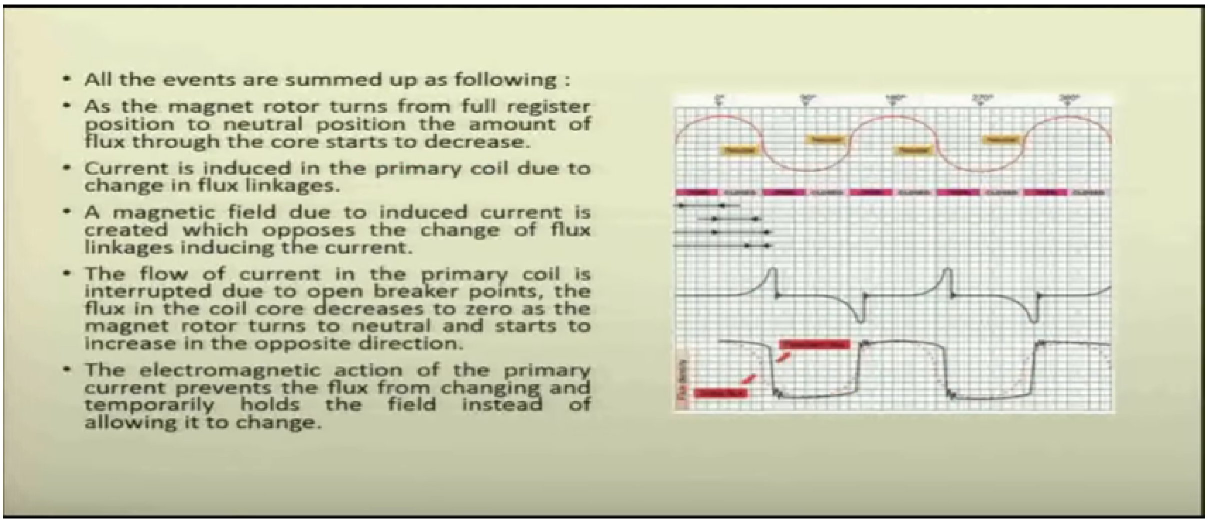

Now when all the events if we sum up, let us see all the events, whatever we have read so far. As the magnet rotor turns from full register position to neutral position. Now this is your full register position, to neutral position. You can see in the graph, in the first figure, top figure, from maximum position, full register position, to neutral position, the amount of flux to the core, starts to decrease. You can see, the amount of flux is decreasing, from maximum to minimum to neutral. Current in induced in the primary coil due to change in flux linkages. Now because of this decrease in flux, because of the change in flux linkages, current is induced in the primary coil. A magnetic field due to this induced current is created, because of this induced current a magnetic field is created, which opposes the change of flux linkages, inducing the current. So we have read as per Lenz’s law, this magnetic field, which is due to the induced current, this will oppose the change of flux linkages inducing the current. The flow of current in the primary coil is interrupted due to open breaker points, the flux in the coil core decreases to zero, as the magnet rotor turns to neutral and starts to increase in the, opposite direction. Now, when the breaker points are made to open, because of this, these open points, the flow of current in the primary coil will be interrupted. The flux in the coil core will decrease to zero, because the current in interrupted now. As the magnet rotor turns to neutral and starts to increase in the opposite direction. The electromagnetic action of the primary current prevents the flux from changing and temporarily holds the field instead of allowing it to change. Now this electromagnetic action of the primary current will prevent the flux from changing and will temporarily hold the field, instead of allowing it to change.

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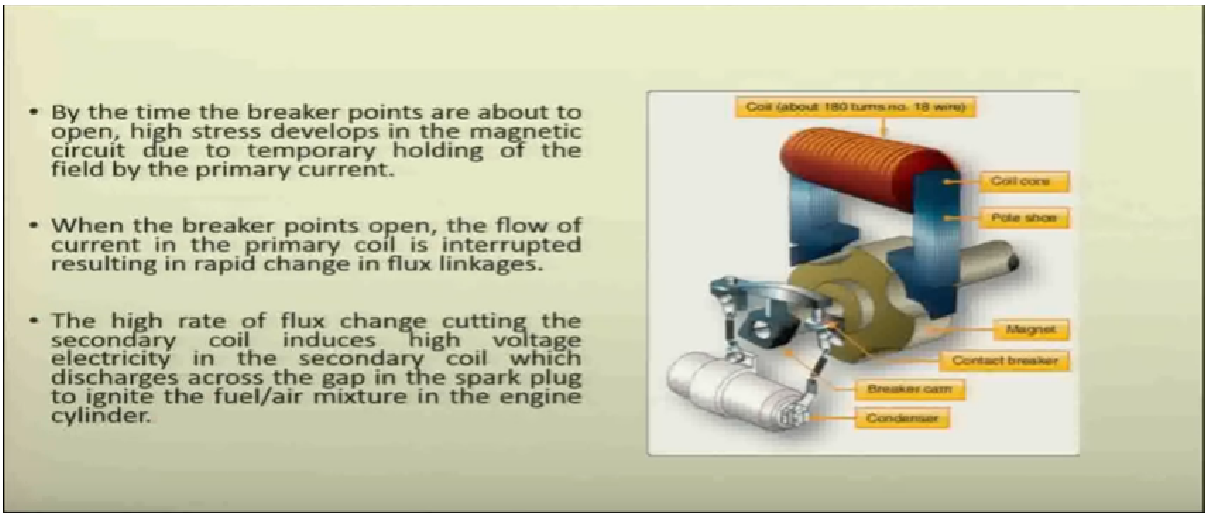

Now by the time, the breaker points are about to open, high stress develops in the magnetic circuit, due to temporary holding of the field, by the primary current. Now by the time the breaker points are about to open, by this time, high stress it developed in the magnetic circuit, because of this temporary holding of the field by the primary current. When the breaker points open, the flow of current in the primary coil is interrupted, resulting in rapid change in flux linkages. Now when these points are made to open, there is a rapid change in flux linkages and because of this, high rate of flux change, which is cutting a secondary coil a high voltage, is induced in the secondary coil, which discharges across the gap in the spark plug, to ignite the fuel/air mixture in the engine cylinder. The high rate of flux change, cutting the secondary coil, will induce high voltage electricity in the secondary coil, which will discharge across the gap in the spark plug, to ignite the fuel/air mixture in the engine cylinder. So this was about the basic theory.

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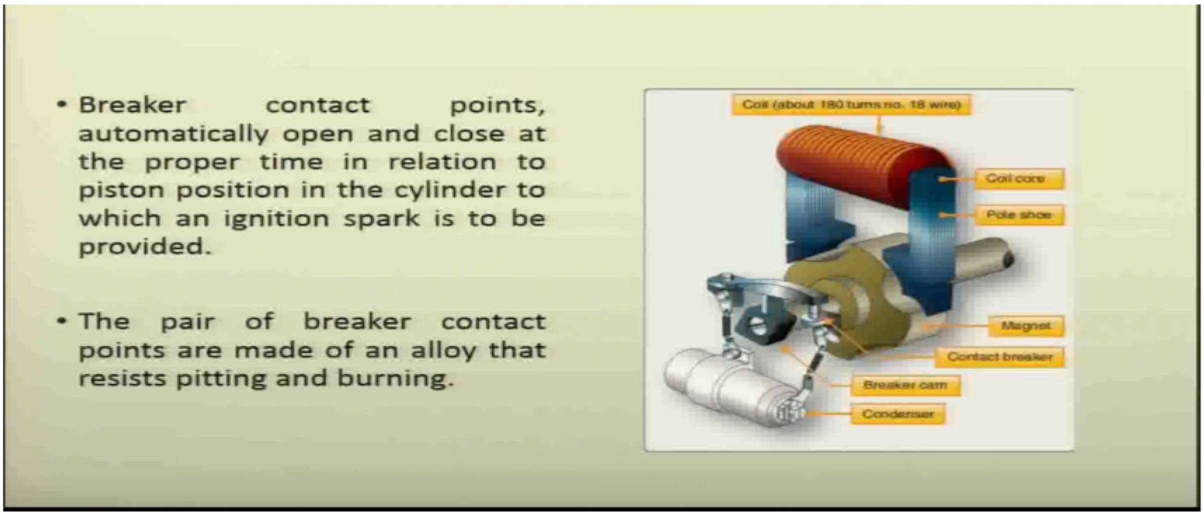

And breaker contact points automatically open and close at the proper time, in relation to piston position in the cylinder, to which, an ignition spark is to be provided. The pair of breaker contact points are made of an alloy that resists pitting and burning. So they are allow a points and they resist pitting and burning.

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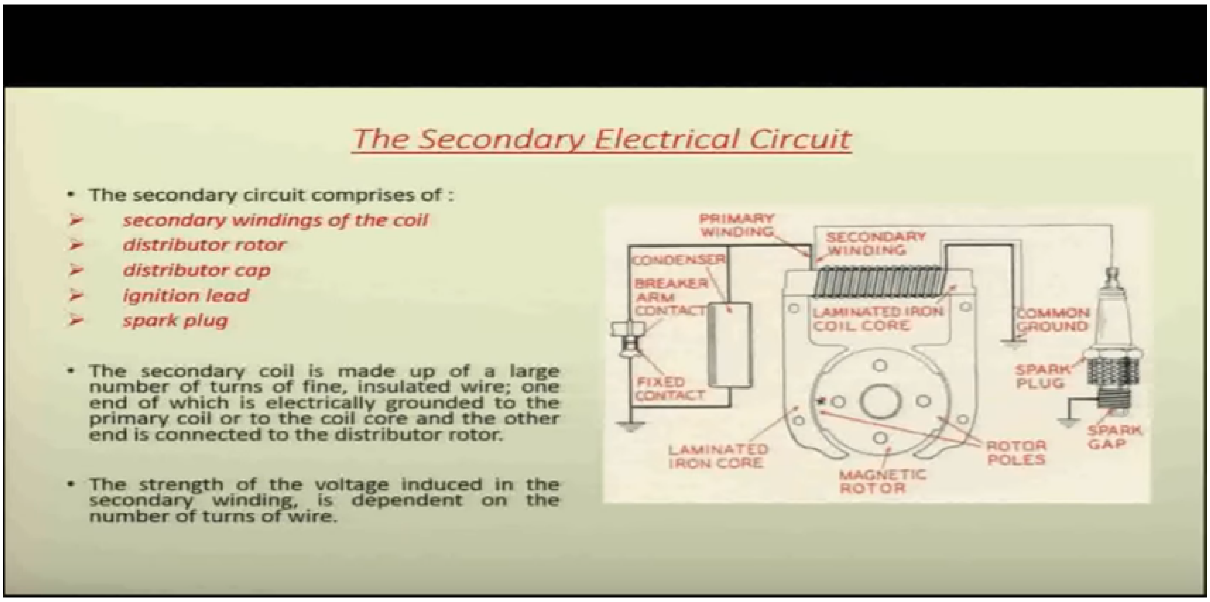

Coming to the Secondary Electrical Circuit, it comprises of, Secondary Windings of the coil. You see here, in the figure, Secondary Windings of the coil, Distributor Rotor and Distributor Cap, then Ignition Lead and the Spark Plugs. You can see here the spark plugs; you can see the ignition leads. The secondary coil is made up of a large number of turns of fine, insulated wire. So in the primary coil, we had, few turns of wire, but they were heavy copper wires, but incase of secondary coil, you have large number of turns, of fine insulated wire. One end of which is electrically grounded to the primary coil or to the coil core and the other end is connected to the distributor rotor. The strength of the voltage induced in the secondary winding, the strength of the voltage induced in the secondary winding, is dependent on the number of turns of wire. So the voltage which is induced in the secondary winding will depend on the number of turns of wire.

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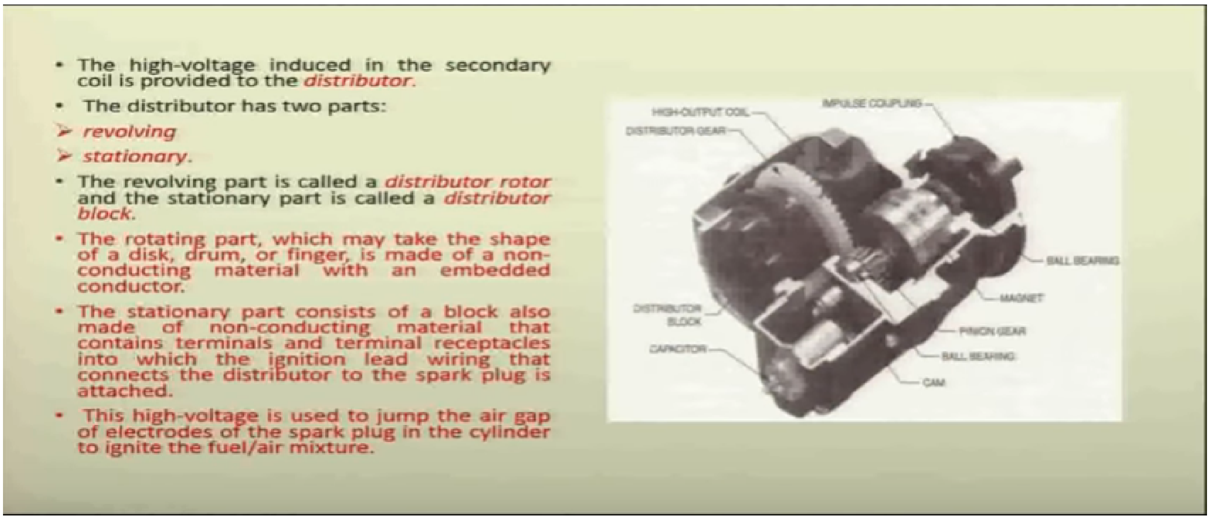

The high voltage induced n the secondary coil is provided to the distributor. The figure you can see here; this, your distributor here, you have a distributor rotor here and you have a distributor block. So the high voltage which is induced in the secondary coil is provided to the distributor. Distributor has two parts; a Revolving Part and a Stationary Part. This is your revolving part, which is called a, ‘Distributor Rotor or a Distributor Gear’. This is your Stationary Part, which is termed as, ‘The Distributor Block’. The revolving part is called a, ‘Distributor Rotor’ and a stationary part is called a, ‘Distributor Block’. The rotating part, which may take the shape of a disk, drum or finger, is made of a non-conducting material, with an embedded conductor. So this rotor is also made up of a non-conducting material, whereas this block is also made of a, non-conducting material. And the conducting, the conductors are embedded in them.

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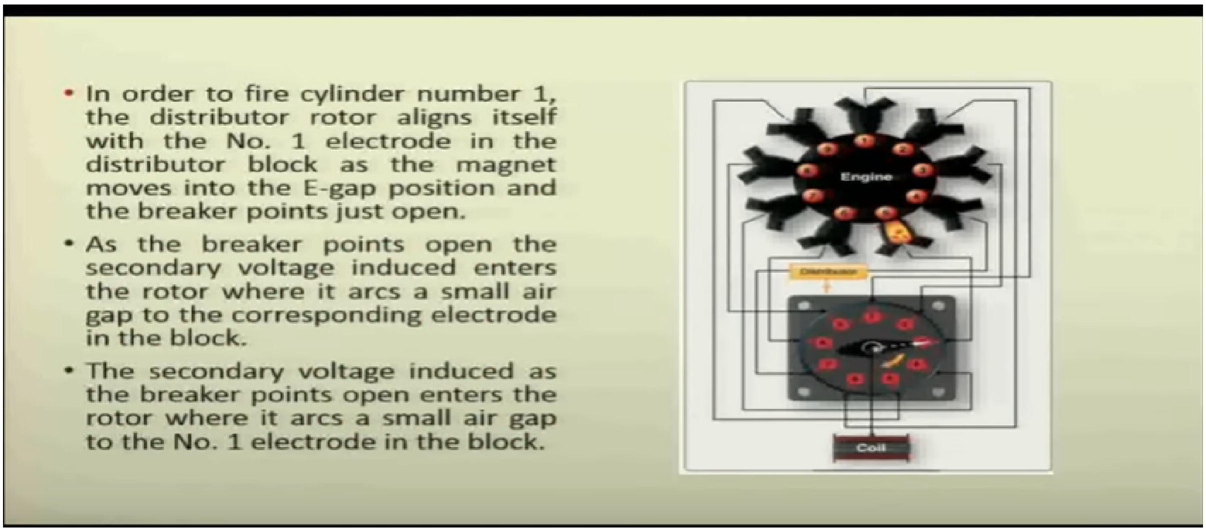

Now coming to this distributor, we have seen, in the figure you can see that, you have an engine with nine cylinders and here you have a distributor, where you have numbers nine. Inorder to fire cylinder number 1, now inorder to fire this cylinder number 1, the distributor rotor, aligns itself with number 1 electrode, in the distributor block. Now, the rotor will align, the distributor rotor will align number 1, in the block, with the number 1 electrode in the distributor block, as the magnet moves into the E-gap position and the breaker points just open. So as the magnet moves into the E-gap position and the breaker points just open, in that condition, the distributor rotor aligns itself, with the number 1 electrode in the distributor block. As the breaker points open, the secondary voltage induced enters the rotor, where it arcs a small air gap to the corresponding electrode in the block. So as the breaker points open, the secondary voltage induced, will enter the rotor and it will arc, a small gap to the corresponding electrode in the block. The secondary voltage induced as the breaker points open, enters the rotor where is arcs a small air gap to the number 1 electrode in the block.

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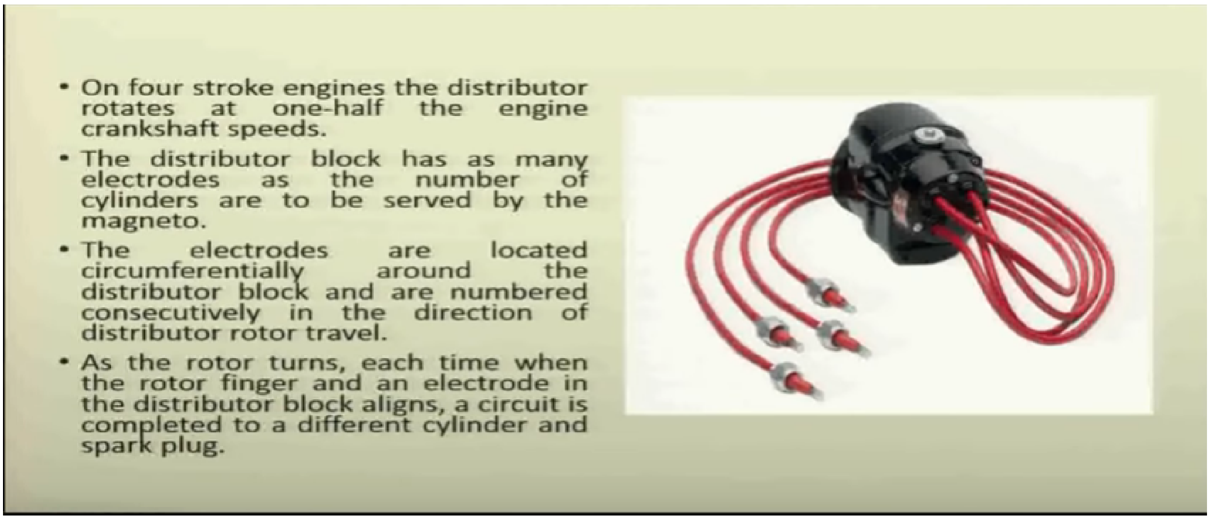

On four stroke engines, the distributor rotates at one-half the engine crankshaft speeds. Now coming to this figure, if you see, that this is your rotor here, this is meshed, with the gear on the magneto drive shaft. You can see the difference, in the sizes of the gear. This distributor will rotates a, engine crankshaft speeds. The distributor block has many electrodes, as the number of cylinders, are to be served by the magneto. So you can see here, the number of electrodes in the distributor, you have 9 here and 9 cylinders are to be fired. The electrodes are located, circumferentially around the distributor block and are numbered consecutively in the direction of distributor rotor travel. So you can see the electrodes, they are placed circumferentially and are placed and are numbered, you can see, 1, 2, 3, 4, till 9, they are numbered like this. As the rotor turns each time, when the rotor finger and an electrode in the distributor block aligns, a circuit is completed to a different cylinder and spark plug. So when the rotor turns, the rotor finger and an electrode in the distributor block aligns and a circuit gets completed to a different cylinder and spark plug. The numbers, on the distributor block indicate the magneto sparking order,

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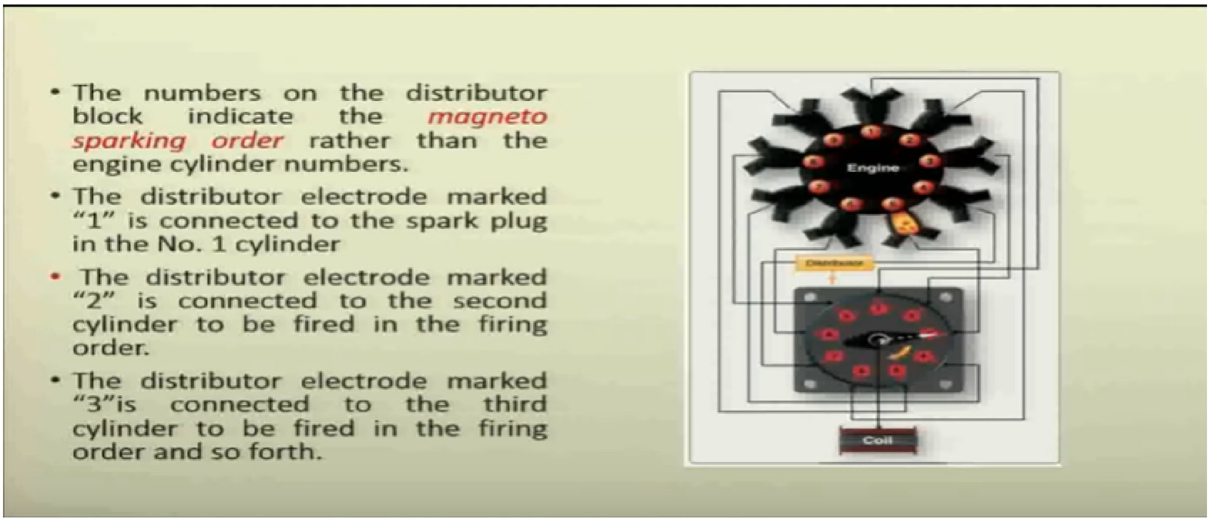

rather than the engine cylinder numbers. So the numbers which are mentioned on the distributor block, this is not the cylinder number, this is the magneto sparking order. The distributor electrode marked number "1", the distributor electrode marked number "1", this is your number 1 electrode, is connected to the spark plug, in the number 1 cylinder. So you can see, this is connected to the spark plug in the number 1cylinder. The number 1 electrode in the distributor block is connected to the spark plug, in the number 1 cylinder. The distributor electrode marked "2", is connected to the second cylinder to be fired, in the firing order. So the second electrode in the distributor block will not be connected to the cylinder number 2, but it will be connected to the second cylinder, which is to be fired in the firing order. So, for example, incase of 6 cylinder engines, you have firing order of, 1, 4, 5, 2, 3, 6, that is cylinder number 1, to be fired first, then cylinder number 4, the number 5, then 2, then number 3 and then number 6. So in that case, the second cylinder to be fired is cylinder number 4 because the firing order is 1, 4, 5, 2, 3, 6. So 4, is the second cylinder, to be fired. In that case, the second number of electrode, on the distributor block, will be connected to cylinder number 4, not cylinder number 2. And the distributor electrode marked 3, is connected to the third cylinder to be fired in the firing order and so forth. So the distributor block you have the markings, you have the numberings, as per the magneto sparking order. Now coming to Primary Capacitor; what is a primary capacitor? What is its purpose?

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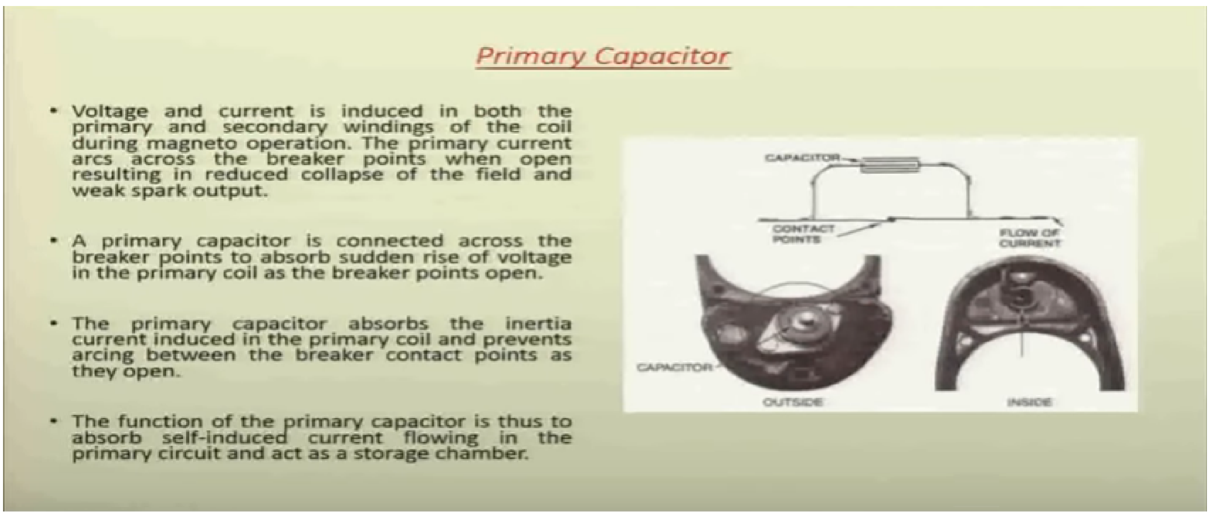

Voltage and current is induced in both the, primary and secondary windings of the coil, during magneto operation. The primary current arcs aross the breaker points, when open, resulting in reduced collapse of the field and where, weak spark output. So the primary current, this has a tendency of arcing across the breaker points. When the breaker points are made to open, this will eventually result in a reduced collapse of field and finally a weak spark output. This primary capacitor, this connected, across the break points, here in the figure you can see, these are the contact points, this is your capacitor, this is connected just parallel to the contact points, to absorb sudden rise of voltage in primary coil, as the breaker points open. So as the breaker points open, inorder to absorb that sudden rise of voltage, this capacitor is fitted. The primary capacitor absorbs the inertia current induced in the primary coil and prevents arcing between the breaker contact points as they open. The function of the primary capacitor is thus to absorb self-induced current, flowing in the primary circuit and act as a storage chamber. The capacitance of the primary capacitor used, should be of the correct value,

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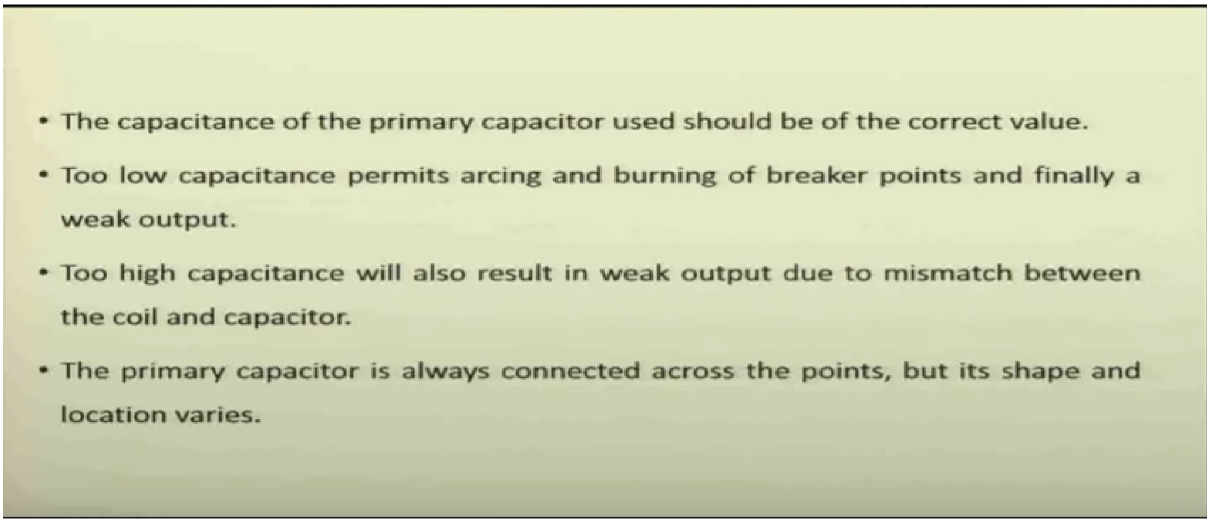

in case if too low capacitance capacitor is used, then it will permit arcing and burning of the breaker points and finally a weak output. Incase capacitor is of a very high capacitance, it will also result in weak output, due to mismatch between the coil and the capacitor. Now in both the cases, where the capacitor is of low capacitance of high capacitance, in both the cases, we will have weak output. The primary capacitor is always connected across the points, but its, but its shape and location varies. Next is, 'Ignition Harness'.

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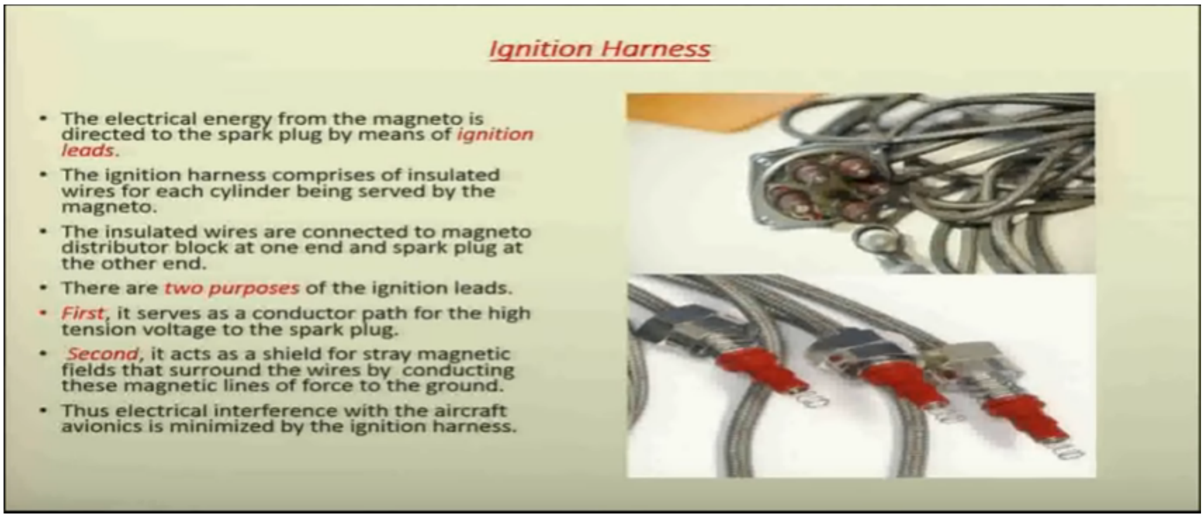

We have seen in the ignition system, the magneto, we have read about magneto. We have read about the parts in the magneto. Second is your Ignition Harness, which connects the magneto to the spark plug. The electrical energy from the magneto is directed to the spark plug, by means of Ignition leads. So these ignition leads, they connect the magneto to the spark plug and transfer the electrical energy from the magneto to the spark plug. The ignition harness comprises of insulated wires for each cylinder, being served by the magneto. So it has got insulated wires, here in the figure, you can see. You have the insulated wires. Insulated wires are connected to magneto distributor block, at one end and spark plug at the other end. So we will see, physically this, these harnesses and one end of the harness connects to the spark plug and the other end is connected to the distributor block, in the magneto. The purposes of the ignition lead are, it serves as a conductor path, for the high tension voltage, to the spark plug. Secondly it also acts as a shield, for stray magnetic fields, that surround the wires, by conducting these magnetic lines of force to the ground. So it is also acting as a shield for the stray magnetic lines of force and, and conducts these magnetic lines of force, to the ground. Thus electrical interference with aircraft avionics is minimized, by the ignition harness. So this ignition harness is solving two purposes. It is serving as a conducting path for high voltage, from the magneto, to the spark plug. It, secondly, it is also acting as a shield and minimizing electrical interference, with the avionics equipments on the aircraft. The center of the ignition lead is the high voltage carrier.

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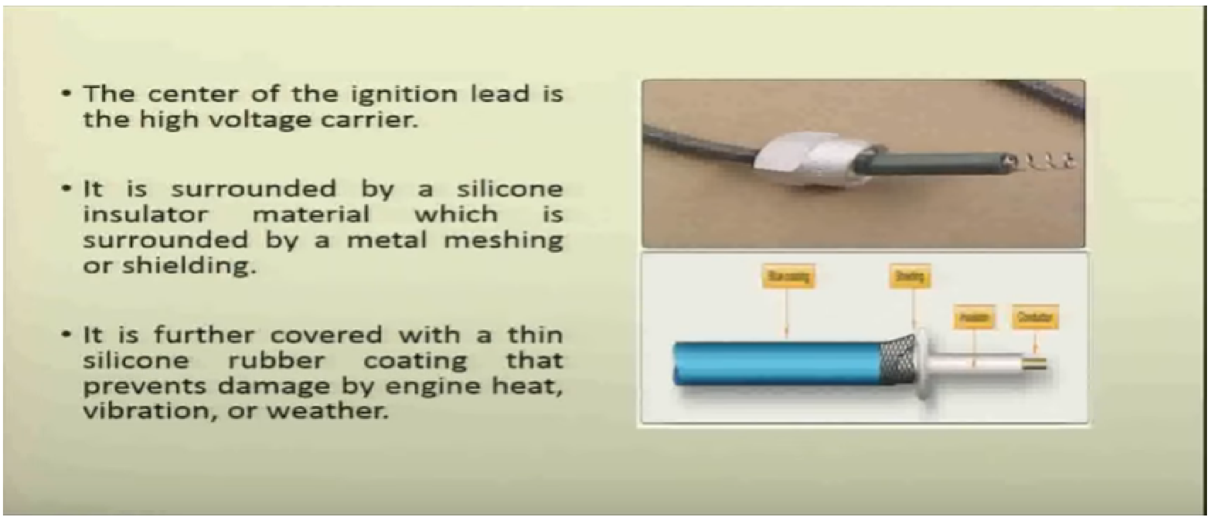

Now see, the center, here you see, in the lead, the center it is the high voltage carrier, it is surrounded by a silicone insulator material, you can see the insulator around the center electrode, center conductor, you can see a insulator. And this insulator is surrounded by a metal meshing or shielding. So inside you have a conductor, which is a high voltage carrier, just outside the conductor you have an insulator and then you have a metal meshing or shielding. It is covered with a thin silicone rubber coating that prevents damage by engine heat, vibration or weather. So this is, in that, in this figure if you see, this end of the harness or the ignition lead, connects to the spark plug, this is the end which connects to the spark plug. Coming to another important unit in the Ignition System,

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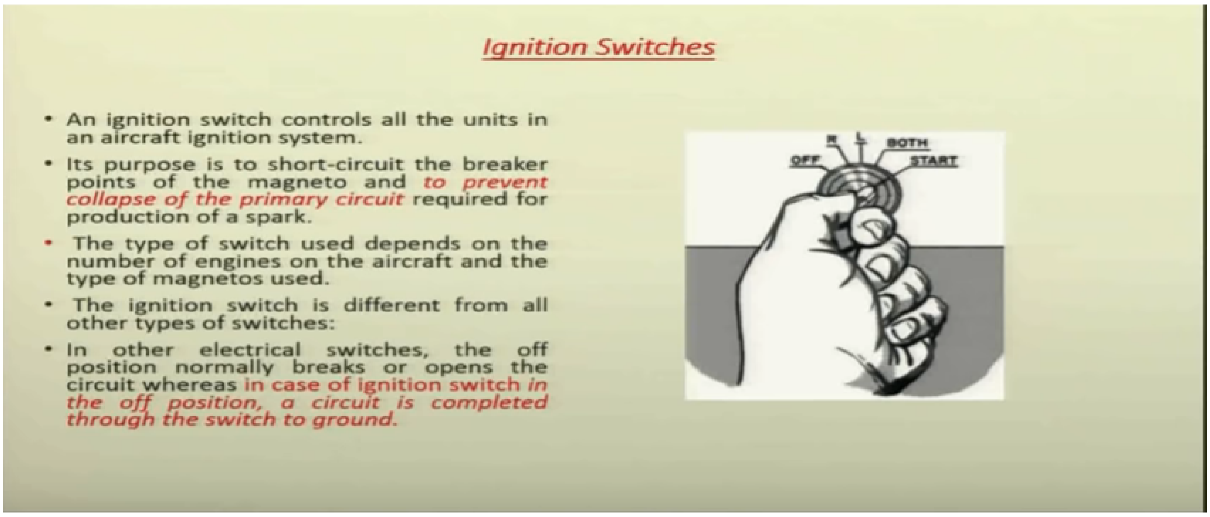

is the, 'Ignition Switch', a very important unit, which controls the entire ignition system. An ignition switch controls all the units in an aircraft ignition system. It purpose is to short-circuit the breaker points of the magneto and to prevent collapse of the primary circuit, required for production of a spark. The type of switch used depends on the number of engines on the aircraft and the type of magnetos used. So there are variety of switches available. The type of switch, which is to be used, depends on the number of engines on the aircraft being used and the type of magnetos being used. The ignition switch is different from all other types of switches. In other electrical switches, the off position, norm, normally breaks or opens the circuit. So in all other switches, the off position will normally break the circuit or open the circuit, but in case of ignition switch, in the off position, a circuit is completed through the switch to ground. So this is a very important point, in ignition switch, a circuit gets completed, through the switch to ground the off position. Whereas in normal switches, in 'off' position, the circuit breaks or opens.

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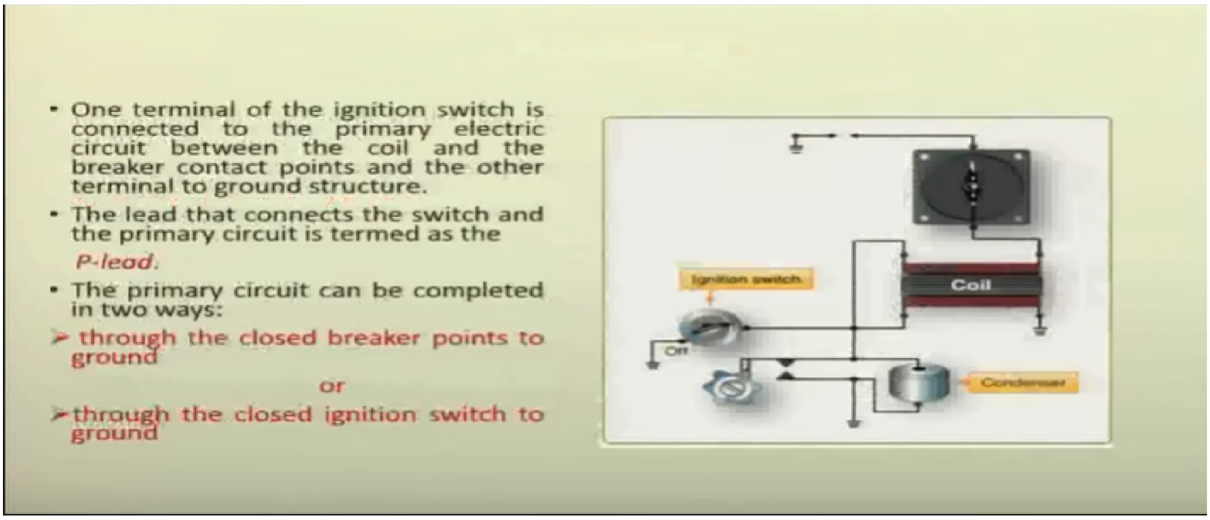

One terminal of the ignition switch is connected to the primary electric circuit. You can see here, in the figure, this is your ignition switch. One terminal is connected to the primary, of the primary circuit, of the coil, between the coil and the breaker contact points and the other terminal to the ground. You see, this is your ignition switch. One end connected to the ground and the other n, end, is connected to the primary of the coil. The lead that connects the switch and the primary circuit is termed as the, 'P-lead'. Now if we observe the figure, the primary circuit, it can be completed in two ways: through the closed breaker points, to ground. Now when these points, contact points, they touch each other, you have, the circuit completed to ground or through the closed ignition switch to ground or when the ignition switch is closed, then also you have grounding and you have a complete circuit, with the ignition switch in the 'off' position.

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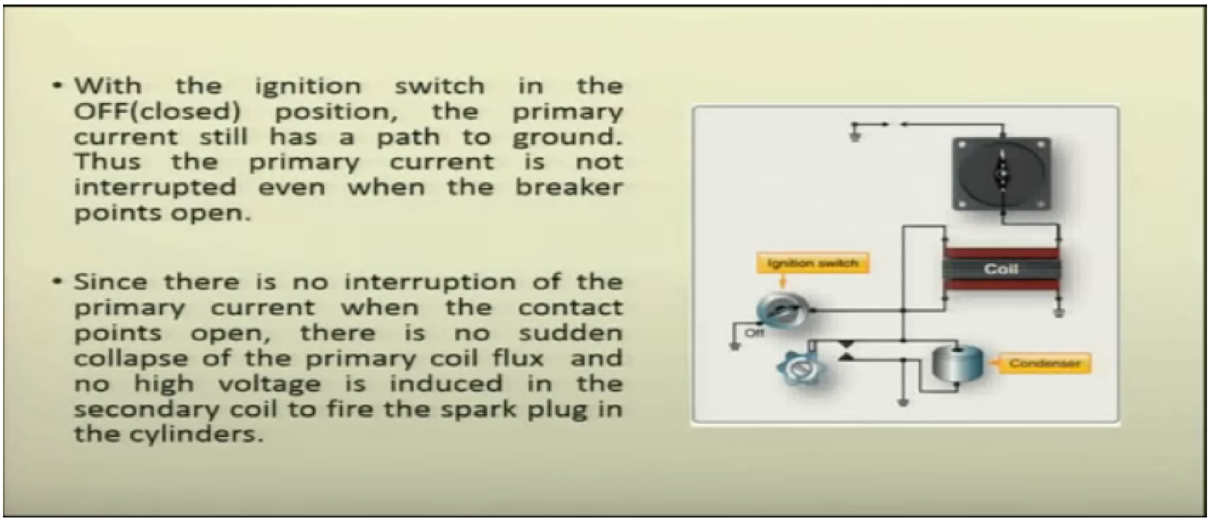

The primary current still has a path to ground. So you can see here in the figure. You have the 'OFF' position here, with the switch in the 'OFF' position, still you can have grounding here, there is a path to ground. Thus the primary current is not interrupted, even when the breaker points open. So in this case, when your switch is in the 'off' position, even when the breaker points are open, in that case also, your primary current is not interrupted. Since there is no interruption of the primary current, when the contact points open, there is no sudden collapse of the primary coil flux and no high voltage is induced in the secondary coil, to fire the spark plug in the cylinders. So since there is no interruption of the primary current, there is no high voltage induced in the secondary coil, to fire spark plugs, in the cylinders.