

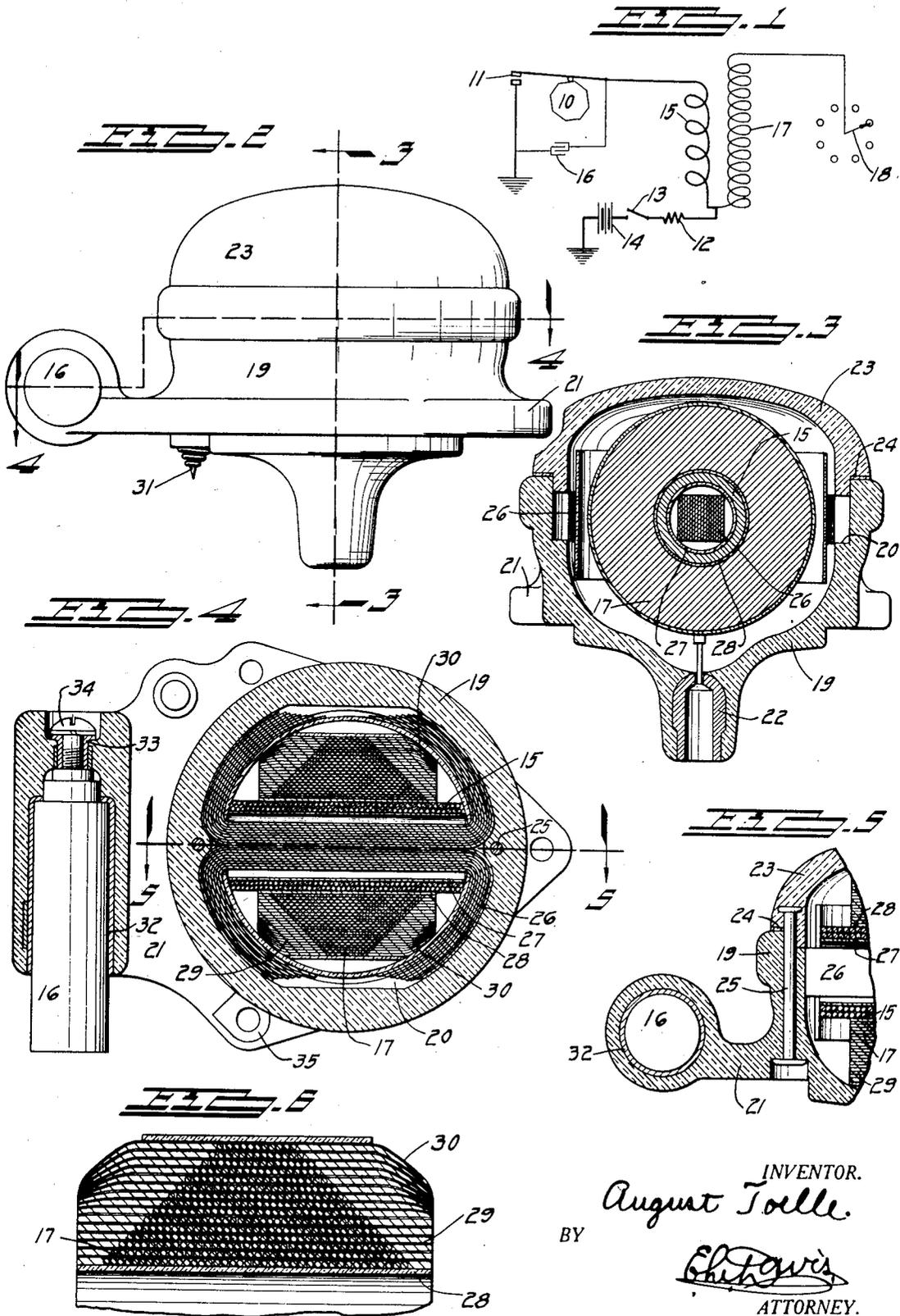
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IGNITION COIL

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IGNITION COIL

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The object of my invention is to provide an induction coil especially suitable for supplying the high-voltage electricity required for ignition in high-speed multicylinder automobile engines. The invention herein resides in the novel arrangement of the various elements comprising the coil, whereby a material increase in manufacturing efficiency and incidentally in electrical efficiency is obtained.

Ordinarily, an increase in the efficiency of a piece of electrical apparatus which requires only the small amount of current required to operate an ignition coil would not be a material factor in the design of an automobile so that in this installation, the reduced current consumption of my coil is not particularly important. The feature of utmost importance which arises from this increased efficiency is that a perfectly satisfactory coil suitable for use on high-speed multicylinder motors can be designed at a substantial saving in cost of production. It is well known that supplying ignition current for medium-speed engines is a comparatively simple problem because the duration of time for building up the magnetic field is sufficiently long to permit the storing up of the required energy in the coil. In high-speed eight to twelve cylinder engines the interval is too brief to permit of storing sufficient energy in the magnetic circuit to cause a spark in the spark plugs. For this reason it has heretofore been the practice with high-speed engines of eight cylinders or more operating at comparatively high compressions to provide two ignition coils, one for each unit of four or more cylinders so that the period available for storing energy in the coil or establishing the magnetic circuit is doubled.

The increased efficiency of my coil directly results in a higher permissible speed of operation so that a single unit of my design may be substituted in place of the two coils heretofore provided for such engines. The primary purpose of producing a coil of higher efficiency is therefore to lessen the cost of the installation and not particularly to reduce the current consumption of the coil. The reasons for this result will be brought out

later in the specification, at which time it should be kept in mind that although this unit is considerably smaller than the usual ignition coil, its capacity is equivalent to the ordinary coil and in fact the capacity of all such coils is determined by the electromotive force required to cause a spark at the spark plug points of the engine in the short interval of time available for this purpose, depending upon the speed of the motor.

A further object of my invention is to provide a secondary winding formed by winding a plurality of layers of wire alternated with layers of insulating paper, the paper overlapping the ends of each succeeding layer of wire to an increasing extent, which winding is connected in the circuit so that the potential increases in the succeeding layers, whereby a correspondingly increased insulation is provided between each layer of wire and the core as the potential therein increases.

Other features will appear from the detailed description of this device, among which may be mentioned that this unit is especially simple to construct, is waterproof so that weather will not affect its operation, and is amply proportioned so that even though the primary current is accidentally left on while the engine is not operating, the coil will not be damaged.

With these and other objects in view, my invention consists in the arrangement, construction and combination of the various parts of my improved device, as described in the specification, claimed in my claims and illustrated in the accompanying drawing, in which:

Figure 1 shows a wiring diagram, illustrating the electrical connections required for installing this device on an eight-cylinder motor.

Figure 2 shows a full sized plan view of my improved coil.

Figure 3 shows a sectional view, taken on the line 3—3 of Figure 2.

Figure 4 shows a sectional view, taken on the line 4—4 of Figure 2.

Figure 5 shows a sectional view, taken on the line 5—5 of Figure 4, and

Figure 6 shows an enlarged view, illustrating the manner in which the secondary circuit of the coil is wound.

Before taking up the detailed description of this device, it may be well to mention that this coil is conventional in so far as it consists of an open magnetic circuit in which a primary winding of comparatively few turns together with a secondary winding of many turns is disposed. The primary winding is connected in series with the usual ignition battery and distributor breaker points and a condenser is shunted across the breaker points. The secondary winding is connected to the spark plugs through an ordinary distributor rotor in the usual manner.

The operation of the coil is conventional in that the current from the battery causes the magnetic circuit to be established, the rapid decay of which, in obedience to well known physical laws, as the breaker points open generates E. M. F.'s of great enough difference of potential to cause sparks at the spark plugs, the strength of the magnetic field, hysteresis, and eddy current losses in the core, the disposition of the secondary winding in the field, and the distributed capacity in the secondary winding being factors limiting the total available energy.

The departures from conventional coil construction, whereby an increase in efficiency is obtained, relate to the disposition of the secondary winding in the magnetic circuit, this winding being located in the region of highest flux density. The novel shape of this secondary winding permits the majority of its turns to be located at the point of highest flux density in the magnetic circuit. The direct result of this novel arrangement is that I am able to provide a coil with a secondary winding of extremely low impedance, resulting in an output high enough to give the desired results.

The specific construction employed for accomplishing these results may be better understood by referring to the accompanying drawing in which the reference numeral 10 is used to indicate a distributor rotor which is gear driven by the motor with which my coil is to be used. A pair of breaker contact points 11 are opened and allowed to close upon rotation of the cam 10, these points being included in the primary circuit together with a fixed resistance 12, ignition switch 13, battery 14, and a primary winding 15 in my improved coil. A condenser 16 is shunted across the breaker contact points 11 in the usual manner. One end of a secondary winding 17 in my coil is connected to one end of the primary winding 15, both being grounded through the battery while the other end of the secondary winding extends to a rotor element 18 which is driven in synchronism with the cam 10. The high-tension current generated in the secondary winding is dis-

tributed by the rotor 18 to the several spark plugs of the motor in the ordinary manner. My coil proper, however, consists only of the primary and secondary windings together with a laminated core for effecting a magnetic circuit therearound.

Referring now to Figures 2, 3 and 4, it will be seen that I have provided a two-part housing which is molded from a phenolic resin compound, the lower half of the housing being numbered 19 and being of cup-shaped form and having an annular shoulder 20 spaced slightly below the upper edge of its rim. A mounting flange 21 extends from the intermediate portion of this housing, while a high-tension output terminal 22 is molded integrally with the extreme bottom portion thereof. I have also provided a cup-shaped cover 23 which is adapted to be piloted in the rim of the housing 19 and a gasket 24 is disposed between this cover and the housing to form a water and air-tight enclosure in which my coil is disposed. The cover 23 is fixedly secured in place by means of a pair of rivets 25, as shown in Figure 5.

It will be noted from Figure 4 that the iron core of my coil assembly consists of a plurality of flat strip-like laminations 26 which extend diametrically across the annular opening in the housing 19 and which laminations are grouped in two parts with both ends of these groups being bent circumferentially around in opposite directions so as to almost but not quite meet each other. A circumferential magnetic circuit having a pair of diametrically opposed air gaps therein is thus provided, each portion of which is connected by a magnetic core extending diametrically therebetween and perpendicular to a line joining the air gaps. The positioning of air gaps is important in the functioning of the coil, as will later be brought out. It will also be noted that the bent-back portions of these laminations 26, forming an annular ring, fit down into the rim of the housing 19 and bear against the shoulder 20. The cover 23 is clamped directly against the laminations so that they are rigidly held within the enclosure formed by the housing 19 and cover 23.

Around the intermediate portion of the laminations 26 I have provided a dielectric tube 27 upon which tube the primary winding 15 is wound, this winding and tube extending the full diametric length of the core. A second and somewhat shorter dielectric tube 28 is disposed around the periphery of the winding 15 and around this tube the secondary winding 17 of my coil is disposed. It will be noted from Figures 4 and 6 that the inner layers of this winding are about two-thirds the length of the primary winding and that they extend substantially the full length of the tube 28. Each succeeding layer of this secondary winding is of lesser

length than the layer beneath so that a radial section through any portion of the coil shows the wire distributed in a flat-topped pyramidal shape. If desired, the wire may be wound in groups of layers of equal length, it only being important that the general shape of the coil be as just described.

It will further be noted that each layer of wire in the secondary winding 17 is alternated with a layer of paper 29 and that all of these paper layers are of the same length. Now, the beginning end of the first layer of the coil is grounded so that the potential of the induced current therein increases with each succeeding layer, but as each succeeding layer is somewhat shorter than the one beneath the paper layers being of uniform length form an insulation of increasing thickness between the high-potential layers of the winding and the bent-back portions of the core laminations. When this coil is assembled in place, the ends of the laminations may be bent back against the corners of the coil and actually flatten this portion, as shown at 30, without reducing the insulation thereof. In this case the spark to ground the coil will ordinarily travel from one end of a particular layer of wire out between the layers of paper to the core laminations, which will be seen to be constant whether or not the corner of the coil is flattened.

From the foregoing, it will be seen that the secondary winding assumes a shape, the purpose of which is to allow the major portion of the coil turns to be located in that region in the magnetic circuit having the greatest flux density. The effective coupling between the windings is thereby increased so that a smaller number of secondary turns for the same voltage output is permissible. This feature of my coil contributes materially to the smaller size of this device.

The method of assembling my coil is almost self-evident and requires very little skill, it being only necessary to wind the two windings and then place one inside of the other and slip the both over the bundle of laminations. The ends of the laminations are then bent back around the coil and the whole inserted into the housing 19. The several winding terminals are connected to suitable terminals molded in the housing, the outer end of the secondary winding being connected to the terminal 22. The inner end of the secondary winding is connected to one end of the primary winding and both are connected by means of encased leads with the battery through the resistance 12 and switch 13. The other end of the primary winding is connected to a coil spring 31 which is molded in the flange 21. The free end of this spring is pointed so as to automatically make contact upon assembling the coil in position on the engine.

In the device shown, the condenser 16 has

been installed in a cylindrical pocket formed in the flange 21, this pocket having a metallic sleeve 32 and a metallic grommet 33 molded therein in axial alignment with each other but spaced apart so as to be insulated from each other. The grommet 33 is connected by means of an encased lead with the side of the primary winding which is connected to the breaker arm while the sleeve 32 is connected by an encased lead with a terminal 35 to be thus grounded along with the stationary breaker point of the distributor. Thus, the condenser 16 which is provided with a metallic case will be both held in position and the electrical connections made by simply inserting a single screw 34 in the grommet 33 and threading it into the end of the condenser.

The exact size of the windings, the number of turns and other details will not be given as the construction is subject to many variations and inasmuch as the design of any coil for high-speed ignition must of necessity be a compromise subject to considerable variation. The specific novel features of this coil all coact with each other to produce an improved coil having more desirable characteristics than heretofore obtainable. This result is believed attainable irrespective of the size of the coil constructed.

However, in the design of ignition coils certain requirements must be met. For instance, ignition coils for low-compression slow-speed engines are required to develop an output voltage only sufficient to strike across about $\frac{1}{16}$ of an inch air gap, while ignition coils for high-speed high-compression motors must have an increased voltage, due to the 5 to 6 atmospheres of pressure under which the spark plugs operate. For this reason the voltage of such coils must be increased two to three times the ordinary striking voltage in order to ionize the air across the spark gap in the limited time available. It has been found that an output voltage of between 12000 and 15000 volts is required to insure operation of the coil under all conditions, the time lag due to ionization being particularly noticeable in cold dry weather. The applicant obtains the increased output, not by simply making the coil excessively large but by his novel magnetic core construction and secondary winding. While it is not claimed that this coil is 100 per cent efficient, still it is of considerably higher efficiency than formerly obtainable, which increase results from the predetermined arrangement and proportion of the parts therein.

The ideal induction coil of this type should have a very low inductance because the speed of the coil is controlled by the inductance. A single coil to operate an eight-cylinder engine at 4000 R. P. M. should have an inductance of no more than .006 to .007 henrys.

The coil should also have a low resistance in the primary winding; the current strength at the time the breaker points open should be as high as possible, and the field strength should be a maximum. It is at once apparent that all of these ideal conditions cannot be incorporated into the same device. Nevertheless, due to the specific construction employed a more advantageous combination can be chosen than is possible with any conventional type coil known to the applicant. For instance, the inductance of this coil is reduced to .006 by providing a small number of primary turns having a relatively high-current strength, the inductance equalling the number of primary turns times the flux in lines divided by the current strength in amperes times 10^9 . The use of this small number of turns is made possible by the construction of the core and the unique disposition of the secondary winding in the magnetic circuit.

Still further, the current strength in the primary circuit at the moment the contact points open is relatively high. This current depends upon the resistance of the primary winding, the battery voltage and the frequency required and at high frequencies the voltage in the primary winding does not attain the battery voltage, due to the resistance and inductance. The low resistance and inductance of my primary winding causes the current strength to build up at an abnormally fast rate, thereby providing a high-current strength even when the frequency is very great. It is for this reason that I am enabled to use only one coil on eight-cylinder high-speed engines that formerly required two coils, one for each bank of four cylinders.

Just as it is very important to establish the magnetic circuit in the shortest time possible, it is even more important that the collapsing of the circuit be almost instantaneous to thereby increase the E. M. F. in the primary circuit as much as possible and likewise increase the output secondary voltage. A low inductance facilitates the collapsing of this circuit.

However, a low inductance has heretofore been associated only with induction coils having an open magnetic circuit. In such coils the number of primary turns must be increased from five to ten times that required with a closed circuit and this increase in the number of turns directly increases the resistance so that the time element required to build up the primary circuit is thereby materially increased. It is apparent that if a closed magnetic circuit is provided, the high inductance so slows up the establishment and collapsing of the circuit that the coil would be inoperative. Inversely, if an open magnetic circuit is provided, then the inductive effect of the circuit is reduced so that excessively large primary and secondary windings are

required. The applicant has provided a magnetic circuit having an air gap considerably larger than the conventional air gap employed and while the field strength is somewhat less than in the conventional coil, this reduced inductive action is offset by his disposition of the major portion of his secondary winding at a point intermediate of the ends of the coil where the flux density is at a maximum to thereby increase the number of effective turns on the secondary winding. The applicant contributes his greater efficiency to the novel design of his laminated core and its relation to the particular shape of secondary winding employed.

In this connection, it may be well to mention that the applicant is aware that numerous transformers have been suggested in which the core is composed of laminations bent back upon themselves, usually having the ends thereof overlapping to form a closed magnetic circuit. However, all of these devices, to the applicant's knowledge, relate solely to transformers and not to induction coils. Although both transformers and induction coils depend upon induction, still the problems connected with each are so different that they are considered as independent devices. A transformer operates only upon alternating current while an induction coil operates only upon direct current. Still further, in all types of transformers the magnetic intensity is controlled by the ampere turns per inch of length and is equal at all points in the circuit. Consequently, induction is not a factor in this device so that the disposition of the secondary winding should theoretically be wound uniformly over the entire magnetic circuit, as in the ordinary torus ring. In an induction coil the intensity of the magnetic circuit is not uniform but reaches a maximum midway between the ends of the primary winding. Thus, while the novel secondary winding provided herein will increase the efficiency of induction coils, still such winding would be detrimental if used in connection with a transformer. These limitations have been mentioned to show that the construction herein is applicable only to induction coils.

Among the many advantages arising from the use of my improved device, it may be well to mention that I have provided an ignition coil a single unit of which is satisfactory for supplying the entire ignition current for operating eight-cylinder motors at speeds upwards of 4000 R. P. M. which requirement was formerly accomplished by the use of two individual spark coils. Still further, the higher efficiency obtained with this device automatically reduces the size thereof for a given output so that a material reduction in cost is obtained thereby. Still further, for the reason that the coil is especially

easy to construct and assemble, the manufacturing cost is still further reduced.

Some changes may be made in the arrangement, construction and combination of the various parts of my improved device without departing from the spirit of my invention and it is my intention to cover by my claims such changes as may reasonably be included within the scope thereof.

10 I claim as my invention:

1. An induction coil for internal-combustion engine ignition system characterized by its low time constant and high efficiency comprising, a cylindrical low tension primary coil winding, a high tension secondary winding wound in layers around said primary coil having each succeeding layer somewhat less in length than the layer beneath to thus form a coil of such shape that a radial section therethrough will show the wire arranged in a pyramidal shape, a ring of insulation disposed between each of said secondary layers, all of said insulating rings having a uniform length whereby the outer edges of said insulating rings will extend beyond each succeeding secondary layer to a greater extent, and a plurality of flat strip core laminations extending through said primary winding, both ends of each lamination being bent back around the secondary winding in a circumferential path having the axes of said windings forming a diameter thereof, and each lamination being of such length that an air gap is provided between its bent-back ends, whereby a progressively thicker section of insulation is provided between the edges of each succeeding secondary coil and said laminations.

2. A device, as claimed in claim 1 wherein a cup-shaped dielectric housing is adapted to receive the arcuate ends of said laminations, and a dielectric cover is arranged to clamp down upon the laminations, to thus both form an enclosure for said windings and retain said bent-back ends in their circumferential shape.

3. An induction coil for internal-combustion engine ignition systems characterized by its low time constant and high efficiency comprising, a cylindrical layer-wound primary coil, a secondary layer-wound coil disposed around said primary coil having a maximum length substantially two-thirds the length of said primary coil, and each succeeding layer of said secondary coil being somewhat less in length than the layer beneath to thus form a coil of such shape that a radial section therethrough will show the wire arranged in a flat-topped pyramidal shape, and a ring of insulation disposed between each of said secondary layers, all of said insulating rings having a uniform length whereby the outer edges of said insulating rings will extend beyond each succeeding secondary layer to a greater extent, and a plurality of

flat strip core laminations extending through said primary winding, both ends of each lamination being bent back around the secondary coil, whereby a progressively thicker section of insulation is provided between the edges of each succeeding secondary coil, the layer and bent-back portions of said laminations.

4. A secondary high tension winding especially adapted for use in connection with induction coils having a substantially closed metallic circuit comprising, a multiple layer-wound coil having each succeeding layer somewhat less in length than the layer beneath to thus form a coil of such shape that a radial section therethrough will show the wire arranged in a flat-topped pyramidal shape, and rings of insulation disposed one between each of said layers, all of said insulating rings having a uniform length whereby the outer edges of said rings will extend beyond each succeeding layer to a greater extent, whereby a progressively thicker section of insulation is provided adjacent to the edges of each succeeding layer, for the purpose described.

5. An induction coil for internal-combustion engine ignition systems comprising, a primary coil winding, a secondary coil winding, said primary coil and secondary coil windings having a plurality of core laminations extending therethrough, said laminations being bent back around the coils to form an arcuate ferric path therearound, and a dielectric housing enclosing said coils and laminations having a portion into which said laminations extend to thereby fixedly secure the coils and laminations in position in said housing.

6. A device, as claimed in claim 5, wherein said housing comprises a cup-shaped dielectric member having a recess around its rim which receives said laminations, and a dielectric cover arranged to clamp down over said laminations to thus both form an enclosure for said coils and to retain said laminations and coils within said housing.

7. A device, as claimed in claim 5, wherein both ends of said laminations are bent back around the primary and secondary coils, said ends each coacting with the recess in said housing to fixedly secure the coils in place.

8. A device, as claimed in claim 5, wherein the core laminations are bent back around the primary and secondary coils to form a circular ferric path therearound, which bent back portions are secured in a circular recess in said housing.

9. An induction coil for internal-combustion engine ignition systems, characterized by its small time constant and high efficiency comprising, a cylindrically shaped primary coil winding, a secondary coil winding disposed around said primary coil having each succeeding layer somewhat less in length than

the layer beneath to thus form a coil of such shape that the radial section therethrough will show the wire arranged in a pyramidal shape, a plurality of core laminations extending through said primary coil, both ends of each of said laminations being bent back around the secondary coil to form an arcuate ferric path therearound with the length of each lamination being such that an air gap is provided between its bent back ends in position aligned with the center of said coils, and a dielectric housing having a cylindrical recess therein into which said bent back portions of the laminations are fixedly retained in an arcuate position.

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