March 11, 1924. 1,486,648

W. A. EVANS

INDUCTION COIL

Filed Dec. 31, 1919 2 Sheets-Sheet 1

Fig. 1.

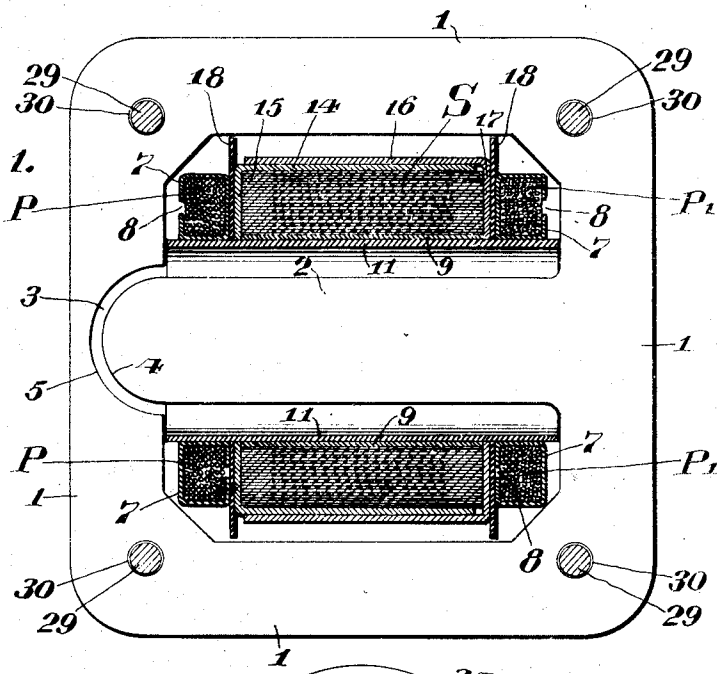


Fig. 4.

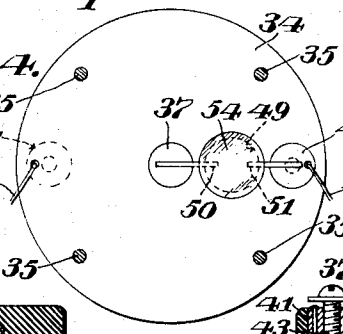


Fig. 2.

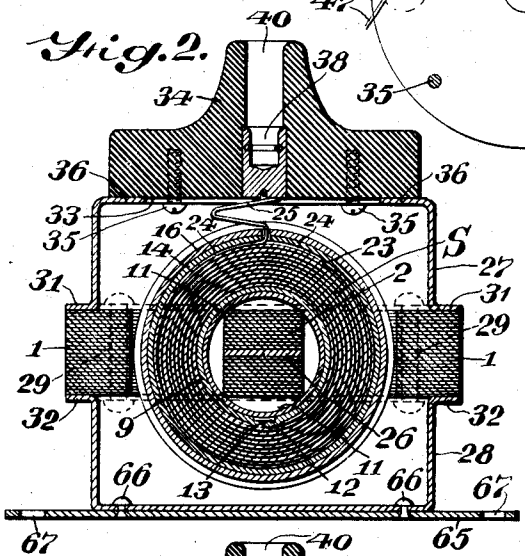


Fig. 3.

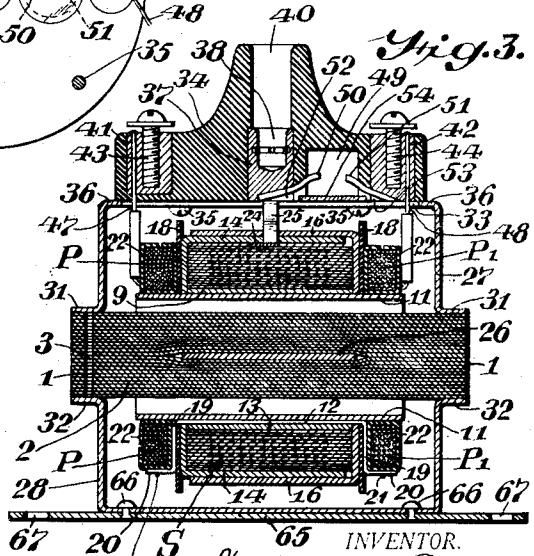
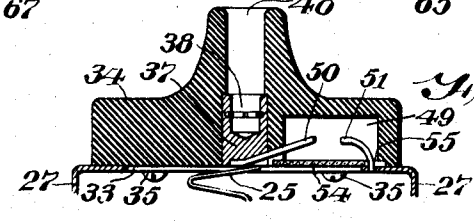


Fig. 13.



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INDUCTION COIL

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Fig. 5.

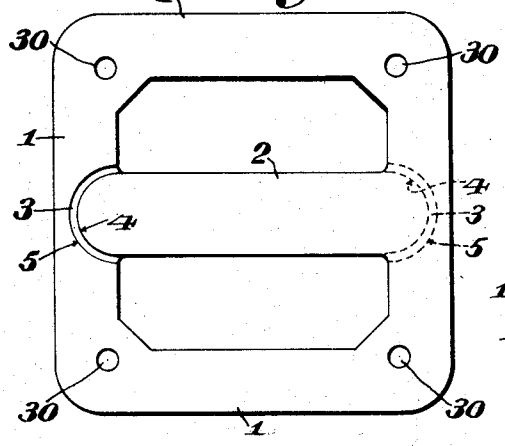


Fig. 8.

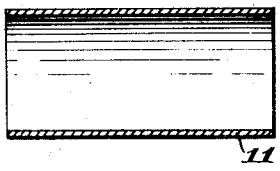


Fig. 7.

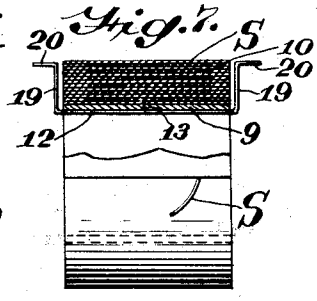


Fig. 12.

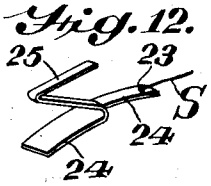


Fig. 9.

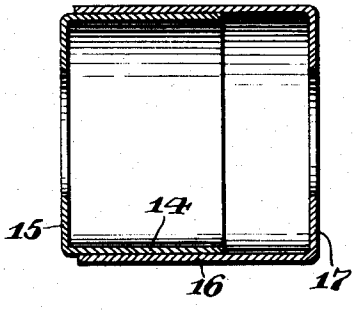


Fig. 10.

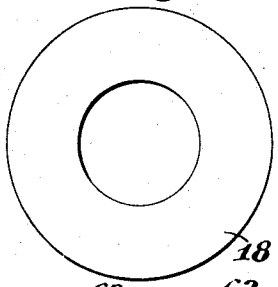


Fig. 11.

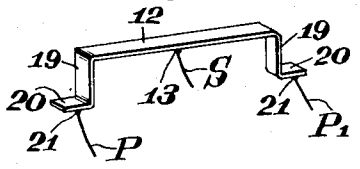


Fig. 16.

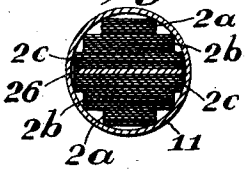


Fig. 6.

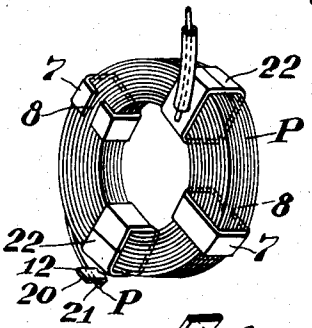


Fig. 14.

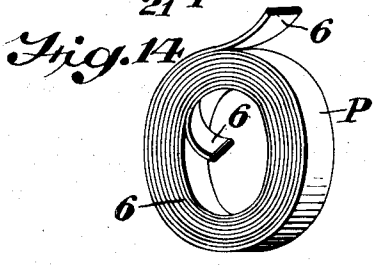


Fig. 15.

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Patented Mar. 11, 1924. 1,486,648

UNITED STATES PATENT OFFICE.

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INDUCTION COIL.

Application filed December 31, 1919. Serial No. 348,603.

To all whom it may concern:

Be it known that I, WILLIAM A. EVANS, a citizen of the United States, residing in Fort Washington, county of Montgomery, State of Pennsylvania, have invented new and useful Improvements in Induction Coils, of which the following is the specification.

My invention relates to induction coils utilizable for any suitable purpose, particularly the production of high tension current from interrupted low tension direct or unidirectional current, particularly for electrical ignition by jump spark of combustible mixtures of internal combustion engines.

My invention resides in an induction coil structure having a closed magnetic circuit comprised of superposed laminæ of iron or steel with correlated primary and secondary coils or windings preferably upon the same leg or limb of the core structure, and preferably upon a central tongue or core extending across from side to side of a continuous yoke and joined at one end integrally to the yoke and at the other separated therefrom by a short air gap.

My invention resides in an induction coil of the character referred to in which the primary winding comprises two primary coils between which is disposed the high tension or secondary winding, whereby neither the primary nor the secondary winding is overlaid by the other and whereby, particularly as regards conditions obtaining in an ignition circuit, the heat generated by the current in the primary coils is readily carried off, whereby external protecting resistance in the primary circuit may be dispensed with.

My invention resides in induction coil structure of the character referred to in which the amount of copper in both primary and secondary windings is reduced, as compared with the copper required in an induction coil of the open magnetic circuit type for similar uses.

My invention resides further in induction coil structure of the character referred to wherein the primary and secondary windings may be separately produced and assembled as a unit, and as a unit brought into operative position with respect to the laminated core structure.

My invention resides further in an induction coil structure wherein there is provided a safety spark gap both of whose terminals may be insulated from the core and casing structure; and my invention resides further in such safety gap structure in which one of the terminals of the gap is a terminal of the primary winding and the other a terminal of the secondary winding.

My invention resides in further features hereinafter described.

For an illustration of some of the various forms my invention may take, reference is to be had to the accompanying drawings, in which:

Fig. 1 is a horizontal sectional view, some parts in plan, of induction coil structure embodying my invention.

Fig. 2 is a vertical sectional view of the structure illustrated in Fig. 1, on smaller scale, with casing and other parts added.

Fig. 3 is a vertical sectional view at right angles to the section of Fig. 2.

Fig. 4 is a bottom plan view of the cap structure of Fig. 3.

Fig. 5 is a plan view of core structure showing an alternate mode of assembling the laminæ.

Fig. 6 is a perspective view of one of the primary coils.

Fig. 7 is a cross sectional view, partly in elevation, of the secondary coil unit.

Fig. 8 is a longitudinal sectional view of the spool or support for the induction coil windings.

Fig. 9 is a sectional view of the secondary coil housing members.

Fig. 10 is a plan view of one of the insulating disks.

Fig. 11 is a perspective view of connector structure.

Fig. 12 is a perspective view of the secondary terminal structure.

Fig. 13 is a vertical sectional view of a cap structure embodying a modified form of safety gap.

Fig. 14 is a perspective view of a modified form of primary coil.

Fig. 15 is a diagrammatic view of one of various circuit arrangements in which my induction coil may be employed.

Fig. 16 is a cross sectional view of a modified core structure.

Referring to the drawings, the core structure of the induction coil comprises thin sheets or laminæ of suitable iron or mild steel each of rectangular or other suitable

shape, and comprising the yoke 1 and the core or tongue 2, the latter integrally joined at one end to the yoke 1 and approaching the opposite side of the yoke more or less closely and in the example illustrated spaced therefrom by the air gap 3, whose reluctance is reduced by giving to the end of the core 2 a semi-circular or other formation whose edge is longer than the width of the tongue or core 2, this pointed or otherwise formed end 4 of the tongue 2 entering into the generally similarly shaped recess 5 in the yoke 1.

The laminæ may be so stacked that the free ends 4 of their tongues 2 all overlie each other as indicated in Fig. 1. It will be understood, however, that, as indicated in Fig. 5, alternate laminæ or alternate groups of laminæ may be so overlaid that the free end 4 of one lamina or group of laminæ lies at the left, while the free end 4 of the next lamina or group of laminæ lies to the right. In the arrangement of Fig. 5 the laminated structure is more rigid than in the case of Fig. 1, and the reluctance of the magnetic circuit is to some extent less because the air gaps 3 are bridged by the overlying neighboring laminæ or groups of laminæ.

The winding structure is preferably assembled or prepared as an independent unit and the core laminæ then assembled in succession therewith by bending the yoke 1 of each lamina in succession, preferably without causing permanent set, out of the plane of the tongue 2, which latter is then thrust through the spool 11 or other support for the windings, the rectangular yoke member 1 being then released and comes back into the plane of its tongue 2.

While in Figs. 1, 2, 3 and 5 the tongue or central core member 2 is shown as constituted of laminæ of equal width, more iron, for a given inner diameter of the spool 11, may be availed of if, as shown in Fig. 16, the laminæ be given different widths as indicated at 2^a, 2^b, and 2^c, the number of different widths being anything suitable or desired and being either greater or fewer than indicated in Fig. 16.

In the example illustrated, the primary winding comprises the two primary coils P and P^1, each separately wound and formed of suitable insulated copper or other wire, as indicated in Figs. 1, 3 and 6, or of copper or other ribbon 6, as indicated in Fig. 14, suitably insulated, as by enamel coating.

The wires, ribbon or other conductors are preferably held in place by metal clips 7 which, as indicated in Fig. 6, are applied from opposite sides of the coil P, the ends of the clips preferably separated by a gap 8. These clips may be of enamelled copper ribbon or other suitable material, or may be binding strips or ligatures of any suitable character.

The secondary coil S is preferably wound upon a spool 9, of fibre or other material, preferably insulating material, in any suitable way, as in successive layers separated by sheets of paper or other insulating material 10, these insulating sheets 10 preferably extending a substantial distance beyond each end of the winding itself, as indicated in Figs. 1, 3 and 7.

The spool or support 11 of fibre or other suitable material, preferably insulating material, is cut of suitable length and preferably substantially equal to the distance between the inner edges of opposing and parallel legs of the rectangular yoke 1.

One terminal of the secondary coil S is connected to a thin easily flexed strip or ribbon 12, Figs. 3, 7 and 11, of copper, tin or other suitable metal, the connection of the secondary winding to the member 12 being indicated in Figs. 2, 11 and 15 at 13. The strip extends freely through the spool 9, and with the spool 9 is slipped on to the spool 11, whereby the strip 12 lies between the two spools 9 and 11, and extends beyond each end of the spool 9.

There is then slipped over one end of the spool 11 and over the strip 12 the capsule member 14, Figs. 1, 3 and 9, whose end 15 extends radially to the spool 11 and abuts against one end of the spool 9. There is slipped on from the other end of the spool 9 another capsule member 16, telescoping with member 14 and having an end 17 extending radially to the spool 11 and abutting against the other end of the spool 9. There are then slipped over each end of the spool 11 and the strip 12 the washers or disks 18, Figs. 1, 3 and 10, of insulating material, preferably mica or other material of high dielectric strength and poor heat conductivity.

The free ends of the strip 12 are then bent outwardly along the washers 18 forming the radial or outwardly extending portions 19, 19, Figs. 3, 7, 11 and 15.

There are then slipped over opposite ends of the tube 9 the primary coils P and P^1, preferably axially short, which are connected in series with each other through the strip 12 for cumulative magnetizing effect upon the core structure. The extreme ends 20 of strip 12 are bent over the primary coils P, P^1, one end of each of which is soldered to an end 20 of strip 12 at 21, Figs. 3, 11 and 15. Passing around each primary coil may be the ligatures or binding members 22, Fig. 6, of insulating tape or other suitable fabric or material, and positioned preferably at or adjacent the terminals of the coil.

The remaining terminal of the secondary coil S is connected at 23, Fig. 12, to a metallic member 24 of substantially arcuate shape, overlying the outside of the secondary coil and suitably insulated therefrom

and bound thereto and having the outwardly extending resilient bent extension member 25, the latter extending through the housing members 14 and 16.

The so assembled unit comprising primary and secondary coils may then be suitably further treated, as well understood in the art, by impregnation by or submersion in a molten mixture of bees wax and rosin or equivalent material; or may be impregnated or submerged in suitable insulating enamel or varnish or other material which will adhere thereto and which upon further treatment, as by baking, will harden and bind the structure into a substantially rigid unit.

Through the spool or supporting member 11 of the coil unit are then slipped in succession the tongues 2 of the core structure laminæ as above described.

If desired, there may be driven into the tongue structure 2 between laminæ a wedge 26, Figs. 2 and 3, of wood or other suitable material, suitably to spread the tongue laminæ 2 to expand them into engagement with the inner wall of the spool 11, as indicated in Fig. 2.

Upon opposite sides of the core structure are disposed the casing members 27 and 28, preferably of sheet metal, rivets or screws 29 passing through registering holes 30 in the core laminæ and the outwardly turned flanges 31 and 32 on the casing members 27 and 28. The rivets or screws bind the laminæ firmly together and the casing members to them into a rigid unit, the yoke structure 1 intervening between the casing members and forming therewith a closed chamber housing the windings.

The casing member 27 has an opening 33 closed by the block or member 34 of insulating material, as molded insulating material such as condensite or the like, and attached to the casing member 27 by screws 35 extending through holes in the inwardly turned flange 36 on the casing member 27 and threaded into the cap or block 34.

Molded in the cap 34 is the metal insert or secondary terminal post 37 with whose inner end engages the aforesaid resilient terminal 25 of the secondary winding S; or if terminal 25 be not employed, a wire connecting with the outer end of the secondary S may be soldered or otherwise connected to post 37. The post 37 is adapted to receive in its socket 38 the end of a conductor 39, Fig. 15, preferably a flexible insulated conductor, passing out through the hole 40 in the cap 34 and connected with the distributor.

Molded in the cap 34 are the metallic inserts or primary binding posts 41 and 42 into which are threaded from the outside of the cap 34 the binding screws 43, 44, by which are secured to the posts 41 and 42 the primary circuit conductors 45 and 46, Fig. 15. To the post 41 is electrically connected one terminal 47 of the primary coil P, and to the post 42 is similarly connected one terminal 48 of the primary coil P^1, it being remembered that the other terminals of the coils P and P^1 are connected to each other through the strip 12.

There is formed in the block 34 a recess 49 into which extend the safety spark gap terminals 50 and 51, of any suitable form or structure. In the example illustrated they are wires of copper or other suitable material connected, respectively, with the secondary terminal post 37 and one of the primary binding posts, as 42. The ends of the wires 50 and 51 are secured, respectively, in slots 52 and 53 in the posts 37 and 49, and may be soldered therein or struck with a tool to expand them therein. Enclosing the recess or safety spark chamber 49 is the cover 54 of mica or other suitable material set into a recess in the block 34, preferably in such position that the outer face of the disk 54 is substantially flush with the lower face of the block 34, as viewed in Fig. 3.

Or in case the casing 27 is grounded, the safety spark structure may take the modified form indicated in Fig. 13, wherein in the recess 49 in the closing cap or block 34 are disposed the spark gap terminals 50 and 51, of which 50 is again secured as before to the high tension secondary post 37, while the terminal 51 is secured at one end to the casing 27, the mica or other disk 54 being in such case provided with a hole at 55 through which the wire 51 projects.

As illustrative of one of the various circuit arrangements in which my induction coil may be used, reference is had to Fig. 15, wherein B is a battery or source of direct current, as for example, a storage battery which may be employed for ignition purposes and for driving an electric motor for cranking or starting the internal combustion engine with which the ignition circuit is employed. One terminal of the battery B is shown as grounded or connected to the frame of the engine or motor vehicle at F, and its other terminal communicates through switch 56 and conductor 45 with the primary binding post 41, between which and the binding post 42 the primaries P, P^1 are connected in series through the strip 12. The circuit extends from the primary binding post 42 to the interrupter mechanism comprising the movable interrupter contact 57 and the stationary contact 58, the latter grounded or connected to the frame F. As well understood in the art, the contact 57 is actuated or controlled by the engine driven cam 59, in this case hexagonal, for use in connection with a six-cylinder engine. As usual, the interrupted contacts are shunted by a condenser 60.

In series in the primary circuit is shown

a resistance R, which may have high positive temperature coefficient or a substantially zero coefficient, or in fact may be any type of resistance of any suitable magnitude. While it is understood that my induction coil is preferably used in a circuit without a resistance R, that resistance is illustrated merely to indicate that it may be used when necessary or desirable.

The interrupter structure shown is of the so-called closed circuit type, but it will be understood that my invention is not limited in this respect and that any other suitable type of interrupter mechanism may be employed, such as the open circuit type, vibrator or buzzer type, etc.

When current flows through the primary coils upon closure of the interrupter mechanism, they operate cumulatively to magnetize the tongue or core 2, the magnetic circuit being completed through the two halves of the rectangular yoke structure 1 lying on either side of the tongue 2, there being a low reluctance connection between the tongue member 2 at its one end with the yoke structure 1, the air gap 3 intervening between the tongue and the yoke structure at the opposite end. When the interrupter contacts separate the primary circuit is broken and the magnetic field in the core structure collapses, introducing a high potential current in the secondary S, one of whose terminals finds a connection to the ground or frame F through the primary circuit, and whose other terminal 25 communicates through post 37 and conductor 39 with the distributor arm 61, rotating in definite relation with respect to the cam 59 and coming in succession into cooperative relation with the stationary distributor contacts or terminals 62 connected by conductors 63 with the spark plugs 64 associated with the different engine cylinders. In the example illustrated, each of the conductors 63 extends to an insulated terminal on the spark plug, the spark taking place therefrom to the body of the plug, which is grounded or connected to the frame because threaded into the engine cylinder. The secondary circuit therefore extends from the terminal 25 to the spark gaps in the plugs, and thence to ground or frame F and back through the primary circuit through the member 12 to the other terminal, and thence to the other terminal of the secondary S.

Should any of the paths from the secondary terminal 25 to the spark plugs become ruptured or of too high a resistance, a spark will leap across the safety gap between the terminals 50 and 51 and so prevent, as well understood in the art, excessive strain upon the insulation of the induction coil windings. In the example illustrated in Figs. 3 and 15, the secondary current when leaping the spark gap is in a short circuit comprising the secondary S, the safety spark gap, and one of the primary coils, as P^1, the current passing from the high tension terminal 25 to the spark gap terminal 50, across the gap to terminal 51 to primary binding post 42, through primary P^1 to member 12 directly to the other terminal of the secondary S.

In case the safety spark gap of the type shown in Fig. 13 is employed, with casing 27 grounded or connected to the frame F, the secondary current leaps from terminal 50 to terminal 51, which in such case is grounded to the frame F, and returns through the primary circuit through one of the primary coils to the member 12 and thence to the other terminal of the secondary S.

By recourse to induction coil structure of the character described, the ability to radiate the heat produced by the primary current in the primary winding is greatly enhanced, and should the induction coil be used on a closed circuit system of the character disclosed in Fig. 15, the stoppage of the engine with the interrupter contacts 57 and 58 in engagement with each other would allow the battery B continuously to discharge through the primary winding, but under these circumstances the heat generated in those windings will be carried off so readily and rapidly that no danger to the induction coil structure results from its temperature rise.

By dividing the primary winding into two coils, one at each end of the winding structure as indicated, the aforesaid dissipation of heat is facilitated. Further advantage lies in the fact that the secondary coil neither overlies nor is overlaid by the primary coil, but each of the primary coils and the secondary coil lies immediately adjacent the core or tongue which it surrounds.

Structure of the character described results in a saving of copper, particularly in the secondary coil S, where a saving of fifty per cent is effected over the equivalent straight open core induction coil for like service. Notwithstanding there is employed less copper, disposed in less than half the convolutions or turns of the straight core open magnetic circuit induction coil for like service, the secondary current is practically doubled, particularly at low interrupter speeds.

By construction of the character described, the amount of iron in the core structure is materially increased, with a saving, however, in copper as described. Notwithstanding the large amount of iron employed and its disposition in the form of a magnetic circuit almost wholly of iron, the induction coil is quick acting, because of the air gap 3, in the sense that the mag-

netism builds up quickly and collapses with sufficient suddenness to effect suitable ignition sparks over all ranges of engine speed, particularly those characteristic of the engines or motors driving motor vehicles, and over a wide range of voltage impressed on the primary circuit, as by a storage battery whose voltage varies greatly due to temperature changes, stage of charge, etc.

An induction coil of the character described has a further advantage in that it supplies ample secondary or high tension energy for effecting sparks of sufficient "fatness" or heat for igniting the combustible charges in the engine at low temperatures. If the battery B is a storage battery, its electromotive-force diminishes with fall of temperature; and the electromotive-force available in the primary circuit of the induction coil is further materially reduced, at all temperatures, when the battery is delivering a very heavy current to the electric motor which cranks or starts the engine. Notwithstanding these drops in voltage, the structure of the character described nevertheless effects efficient and satisfactory ignition sparks.

By way of example merely, and without limitation of my invention thereto, it may be stated that an induction coil of the character described suitable for ignition purposes may have its core structure built of approximately 40 laminæ of iron or "electric sheet steel", each of .015 inch thickness, and a total weight of approximately one pound, when of the form indicated in Fig. 1, each edge of the yoke 1 having a maximum length of approximately three inches. The primary coils P and P^1 together may have 160 turns, of say No. 22 B & S gauge insulated copper wire, approximately .11 lb., when a three-cell lead storage battery B is employed; and the secondary S may be of No. 38 B & S gauge copper wire, approximately 8500 turns, weighing approximately .17 lb.

The structure may obviously be of dimensions other than those of the foregoing example. In fact, I have made and successfully used for engine ignition purposes an induction coil of like structure of materially smaller dimensions.

If desired, though my invention is not limited thereto, within the closed chamber formed by the casing members 27, 28, and the core structure 1, may be placed a filling of any suitable material completely surrounding and embedding the coil or winding unit, and filling all the otherwise empty space within the chamber.

The filling may be lake or beach sand, from which there has preferably been extracted clay, metallic particles, magnetic ore, etc.; or it may be of other suitable earthy or refractory material.

Or with the joints between the laminæ of the core structure rendered liquid-tight, oil or other insulating liquid may be introduced as a filling for the chamber.

The structure may be supplied with a base plate or supporting member 65, Figs. 2 and 3, to which one of the casing members, as 28, may be secured by rivets or screws 66. The base or support 65 may be secured to any suitable structure or support by screws, rivets or equivalent means which may extend through the holes 67 in the base 65.

What I claim is:

1. Ignition apparatus comprising primary and secondary circuits, core structure comprising superposed laminæ each having a yoke portion and a transversely extending tongue, primary coils in said primary circuit spaced from each other on said tongue, a secondary coil in said secondary circuit disposed on said tongue between said primary coils, a source of uni-directional current in said primary circuit, and an interrupter of the closed circuit type in said primary circuit.

2. Ignition apparatus comprising primary and secondary circuits, an induction coil comprising core structure and primary coils connected in series with each other in said primary circuit and spaced from each other, a secondary coil having one terminal connected to said secondary circuit and another terminal to said primary circuit between said primary coils, a source of current in said primary circuit, and an interrupter in said primary circuit.

3. An induction coil comprising a core structure of superposed laminæ each comprising a yoke having an opening, a tongue integrally joined with said yoke at one end and extending across said opening toward the opposite side of the yoke, an air gap formed between said other side of the yoke and the free end of said tongue, said gap having a length from end to end in a lamina greater than the width of said tongue, and primary and secondary coils surrounding said tongue.

4. An induction coil comprising a core structure of superposed laminæ each comprising a yoke having an opening, a tongue integrally joined with said yoke at one end and having an air gap between its other end and the opposite side of said yoke, primary coils spaced from each other longitudinally of said tongue and surrounding the same, and a secondary coil disposed between said primary coils.

5. An induction coil comprising a core structure of superposed laminæ each comprising a yoke, a tongue integrally joined therewith at one end and extending toward the opposite side of the yoke, an air gap formed between said opposite side of the

yoke and the free end of said tongue, said gap having a length from end to end in a lamina greater than the width of said tongue, primary coils spaced from each other longitudinally of said tongue and surrounding the same, and a secondary coil disposed between said primary coils.

6. An induction coil comprising a core structure, primary coils spaced from each other, a member extending between said coils and electrically connecting them with each other, and a secondary coil surrounding said connecting member between said primary coils, one terminal of said secondary coil connected to said member.

7. An induction coil comprising primary and secondary windings disposed side by side, and a member effecting connection with the primary coil surrounded by said secondary coil and extending outwardly between said primary and secondary coils to the point of connection with said primary coil.

8. An induction coil comprising primary and secondary windings disposed side by side, and a member effecting connection with the primary coil surrounded by said secondary coil and extending outwardly between said primary and secondary coils to the point of connection with said primary coil, said secondary coil connected to said member.

9. An induction coil comprising a core structure and a winding unit cooperating therewith, said unit comprising a spool, a secondary coil unit thereon, housing members for said secondary coil having radial portions extending to said spool and longitudinally extending telescoping portions surrounding said secondary coil unit, and primary coils on said spool at opposite ends of said secondary coil unit and separated therefrom by said radial portions of said housing units.

10. An induction coil comprising a core structure and a winding unit cooperating therewith, said unit comprising a spool, a secondary coil unit thereon, housing members for said secondary coil having radial portions extending to said spool and longitudinally extending telescoping portions surrounding said secondary coil unit, primary coils on said spool at opposite ends of said secondary coil unit and separated therefrom by said radial portions of said housing units, and insulating disks upon said spool disposed between said primary coils and said radially extending portions of said housing units.

11. An induction coil comprising a core structure, a winding support, primary coils disposed thereon and spaced from each other, a member extending longitudinally of said winding support and connecting said coils, and a secondary coil unit on said support between said coils, said member disposed between said secondary coil unit and said winding support and extending at each end outwardly from said support between a primary coil and said secondary coil unit.

12. An induction coil comprising a core structure, a winding support, primary coils disposed thereon and spaced from each other, a secondary coil on said support between said primary coils, and a member disposed between said secondary coil and said support having portions extending outwardly between said primary coils and said secondary coil unit, and ends extending over said primary coils and connected thereto.

13. An induction coil comprising a core structure, primary coils spaced from each other, a member extending between said coils and connecting them in series with each other and a secondary coil disposed outside of said member between said secondary coils, one terminal of the secondary coil connected to said member.

14. An induction coil comprising a core structure, a winding support, primary coils disposed thereon and spaced from each other, a member extending longitudinally of said winding support and connecting said coils, and a secondary coil unit on said support between said coils, said member disposed between said secondary coil unit and said winding support, one terminal of the secondary coil connected to said member.

15. An induction coil comprising a core structure, a winding support, primary coils disposed thereon and spaced from each other, a member extending longitudinally of said winding support and connecting said coils, and a secondary coil unit on said support between said coils, said member disposed between said secondary coil unit and said winding support and extending at each end outwardly from said support between said primary coils and said secondary coil unit, one terminal of the secondary coil connected to said member.

16. An induction coil comprising a core structure, a winding support, primary coils disposed thereon and spaced from each other, a secondary coil on said support between said primary coils, and a member disposed between said secondary coil and said support having portions extending outwardly between said primary coils and said secondary coil unit, and ends extending over said primary coils and connected thereto, one terminal of the secondary coil connected to said member.

17. An induction coil comprising a core structure and a winding unit, said unit comprising a spool, primary coils disposed upon said spool adjacent opposite ends thereof, a secondary unit between said primary coils and comprising a spool surrounding said first named spool, a member connecting said primary coils and extending longitudinally

between said spools, one terminal of said secondary unit connected to the portion of said member lying between said spools.

18. The combination with an induction coil comprising a core structure, primary coils spaced from each other, and a secondary coil disposed between said primary coils, of a metal casing member having an opening, a cap closing said opening, terminals on said cap connecting with said primary coils, and a secondary terminal on said cap.

19. The combination with an induction coil comprising a core structure, primary coils spaced from each other, a secondary coil between said primary coils, a contact carried by said secondary coil on the outside thereof, of a metal casing member having an opening, a cap closing said opening, a terminal on said cap engaging said secondary contact, and primary terminals on said cap connecting with said primary coils.

20. The combination with an induction coil comprising a core structure, primary coils spaced from each other, a secondary coil between said primary coils, a member connecting said primary coils and surrounded by said secondary coil, a contact connected to said secondary coil and disposed upon the outside thereof, of a casing member having an opening, a cap closing said opening, a secondary terminal on said cap engaging said secondary contact, and primary terminals on said cap connected to the other terminals of said primary coils.

21. The combination with an induction coil comprising a core structure and primary and secondary coils, of a member of insulating material, primary and secondary terminals thereon, said terminals insulated from said core structure, and spark gap terminals carried by said insulating member and connected, respectively, to one of said primary terminals and to said secondary terminal.

22. The combination with an induction coil comprising a core structure and primary and secondary coils, of a single member of insulating material, primary and secondary terminals thereon, said terminals insulated from said core structure, and spark gap terminals carried by said insulating member and connected, respectively, to one of said primary terminals and to said secondary terminal, said insulating member having a recess in which said spark gap terminals are disposed.

23. The combination with an induction coil comprising a core structure, primary coils spaced from each other, and a secondary coil between said primary coils, of a member of insulating material, a secondary terminal carried by said member, primary terminals carried by said member and connected to said primary coils, and spark gap terminals carried by said member and connected, respectively, with said secondary terminal and one of said primary terminals.

24. The combination with an induction coil comprising a core structure, primary coils spaced from each other, a secondary coil between said primary coils, a member connecting said primary coils in series with each other, and a connection from said secondary coil to said member, of an insulating member, a terminal thereon connected with the other terminal of said secondary coil, primary terminals on said insulating member connected, respectively, with the remaining terminals of said primary coils, and spark gap terminals carried by said insulating member and connected, respectively, with said secondary terminal and one of said primary terminals.

25. The combination with an induction coil comprising core structure and primary and secondary coils, of a member of insulating material, a secondary terminal communicating with one terminal of the secondary coil, said insulating member having a recess, a spark gap terminal therein connecting with said secondary terminal, and a spark gap terminal in said recess having indirect connection with the other terminal of said secondary coil through a primary coil.

26. An induction coil comprising a stack of laminæ, each lamina having a surrounding yoke and a transversely extending tongue, primary and secondary coils surrounding the stack of tongues, sheet metal casing members secured to the core structure on opposite sides of said stack, one of said casing members having an opening in a side parallel to the planes of said laminæ, a block of insulating material closing said opening, and primary and secondary terminals carried by said block.

27. A transformer comprising superposed laminæ forming a core structure, a metallic casing member secured to said core structure, primary and secondary windings on said core structure within said casing member, said casing member having an opening in a side thereof spaced from said windings and substantially parallel to the planes of the core laminæ, a cap of insulating material secured to said casing member and closing said opening, and primary and secondary terminals carried by said cap.

28. A transformer comprising superposed laminæ forming a core structure, a metallic casing member secured to said core structure and having a side substantially parallel with said laminæ, primary and secondary windings on said core structure within said casing member, a base member secured to said side of said casing member, a second metallic casing member secured on the opposite side of said core structure, a mem-

ber of insulating material carried on the exterior of said second casing member, and primary and secondary terminals carried by said insulating member.

29. Ignition apparatus comprising primary and secondary circuits, core structure comprising superposed laminæ each having a yoke of closed figure and a transversely extending tongue integral therewith and having an air gap between the end of the tongue and a side of said yoke, primary and secondary windings on said tongue and disposed in said primary and secondary circuits, and an interrupter of the closed circuit type in said primary circuit.

In testimony whereof I have hereunto affixed my signature this 30th day of December, 1919.

WILLIAM A. EVANS.