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METHOD OF MAKING INDUCTION COILS

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2 Sheets-Sheet 1

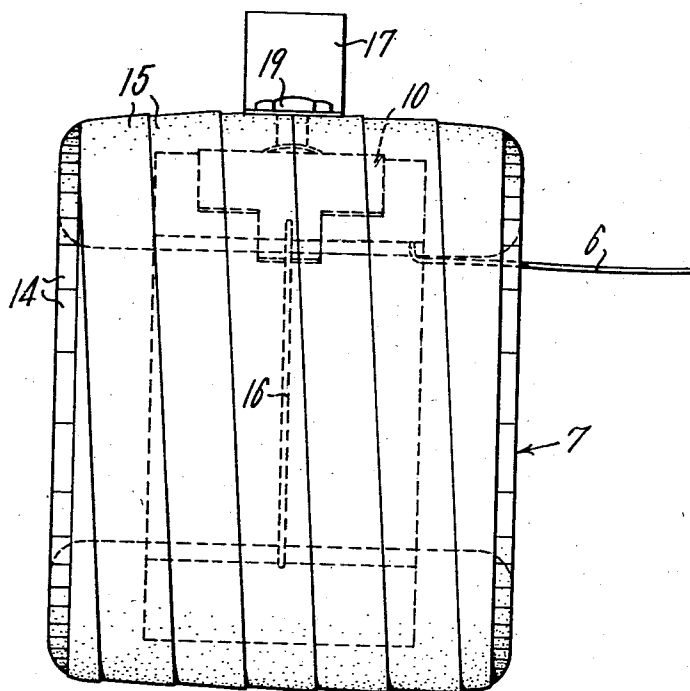


Fig. 1

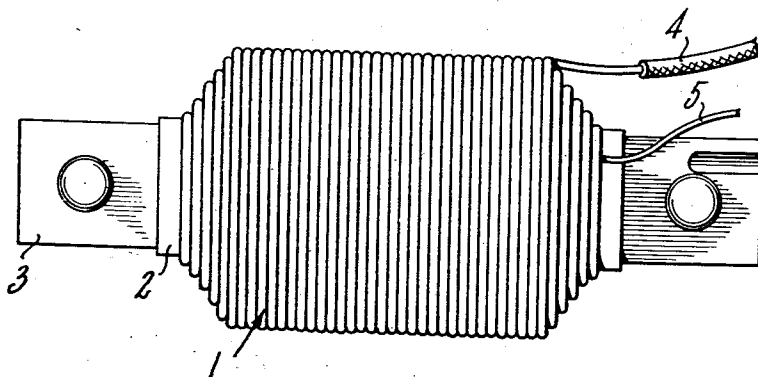


Fig. 2

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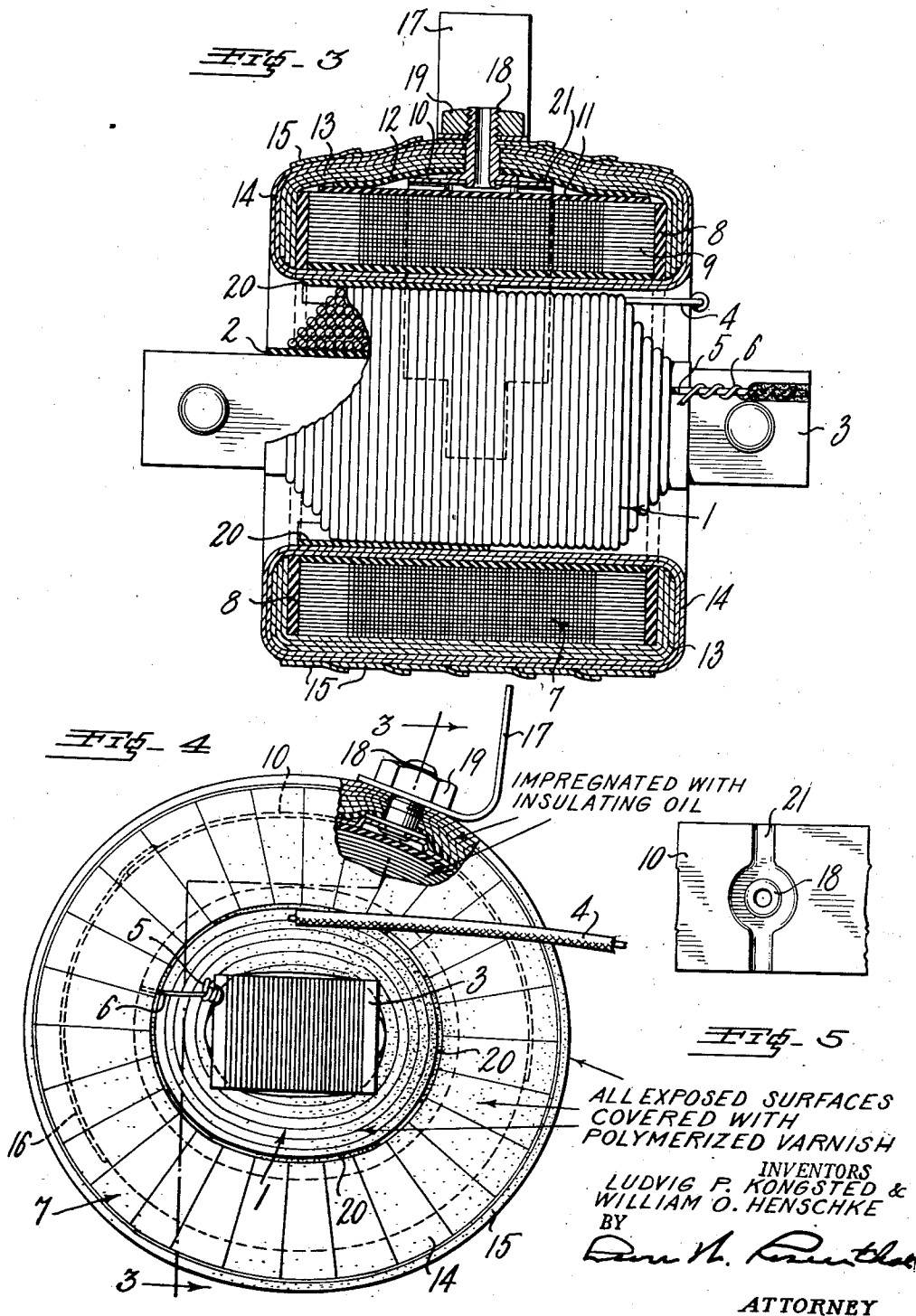
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UNITED STATES PATENT OFFICE

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METHOD OF MAKING INDUCTION COILS

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9 Claims. (Cl. 29-155.5)

This invention relates to methods of making induction coils and more particularly high tension induction coils having primary and secondary windings mounted on a magnetic core and being adapted for use in high tension ignition systems for internal combustion engines, as for instance in magnetos or battery ignition systems or in starting vibrators for such magnetos.

Such coils are often subjected to severe vibration and shock, particularly on airplanes, and furthermore they experience successive periods of heating and cooling in operation, and function in various climates and altitudes covering wide ranges of temperature, humidity and atmospheric density. In consequence, it has heretofore been difficult to prevent air, moisture, oil vapors and acid vapors from getting into such coils with the resulting effects of electrical breakdown from short circuits in the high tension windings due principally to charring, corrosion, chemical action, corona effects and ionization therein; and also it has been difficult to prevent the leakage of oil from the coil, which, in addition to leaving the high tension windings dry and therefore susceptible to breakdown, sometimes resulted in deposits on the breaker contacts and thereby accelerated the erosion, corrosion and wear thereof. Such coils have been enclosed, taped, varnished, impregnated with oil, fitted with machined end pieces, baked, treated and constructed in various other ways, but even where carefully and expensively made, perfect oil-tightness has been difficult if not impossible in quantity production of such coils.

Heretofore, in making induction coils of this general kind, one procedure was first to impregnate the secondary winding alone and then either to varnish it before assembly on the primary winding or else to varnish the completed coil after such assembly, the secondary winding alone or the assembled windings being taped before varnishing. In this procedure, the impregnation did not remain satisfactory, either because oil came out of the windings when the varnish was being baked, or else because the impregnation was purposely limited in amount or extent to prevent that. When the oil came out in baking, it not only depleted the impregnation, but it mixed with the varnish and prevented the varnish from properly curing to form an impervious coil; and when the impregnation was limited in an attempt to prevent that, or was depleted by leakage during the baking period, the secondary winding was not filled sufficiently to prevent premature electrical breakdown. In another procedure,

the outer surface of the taped assembly of the secondary and primary windings was varnished with a natural oil varnish applied and dried layer by layer in an attempt to build up a tight and strong covering. However, when this varnished coil was then impregnated, the oil generally leaked out of the winding, sometimes through weak spots in the varnish but more usually at the end flanges, which sometimes were machined in an attempt to prevent it, and also between the primary winding and the core. Under both procedures, the finished coil became pervious to air or vapors and failed to retain all its impregnating oil, and thus in operation, particularly of the severe kind aforesaid, the coil developed all or some of the enumerated defects which caused premature electrical breakdown.

In accordance with our invention, the secondary winding, preferably after one or both of its ends have been dipped into varnish or provided with insulating end rings to prevent the layers of a multilayer winding from slipping on one another, is taped through the center and over the outer surfaces. While taping, an opening, as a hollow high tension terminal for the coil, is provided for a subsequent impregnation of the interior of the winding, and the inner terminal of the winding is brought out for electrical connection. After taping, the secondary winding being dry on all exposed surfaces is slipped over the primary winding having a magnetic core. The induction coil thus formed is then varnished over all its exposed surfaces, preferably by immersion, with a synthetic-base insulating varnish which may be a polymerizing varnish, a polyvinyl varnish, or a synthetic rubber varnish, preferably a polymerizing varnish since, at present at least, that is not so apt to soften at the highest temperature of operation of the coils in the aforesaid use. The polymerizing insulating varnishes include glyptal, phenol formaldehyde and styrene varnishes, which cure at a temperature of about 260° F. for about 8 hours. The polyvinyl varnishes include polyvinyl chloride, polyvinyl acetate or mixtures of the two with plasticizers and fillers, which cure by air-drying at room temperature. The synthetic rubber varnishes include neoprene, thiokol and butadiene varnishes, which cure at temperatures generally no higher than 300° F. When dry these varnishes leave no air bubbles or soft spots that ultimately crack, chip, peel or break with consequent perviousness at those places to ingoing moisture and vapors and to outgoing oil. Having the assembled induction coil in this condition, it may then be vac-

uum-treated in the well known way to withdraw the air and moisture therefrom, and then impregnated with insulating oil principally through the hollow terminal of the secondary winding which is thereafter sealed. In this way, all interstices, at least in the high tension winding, remain filled with oil which, as is well known, further insulates the turns and prevents corona effects and ionization. In fact, since the synthetic-base varnish is strong, resilient, unbroken and impervious, the secondary winding may be subjected to a higher degree of vacuum and a higher pressure of impregnation with oil than is practical in the case of a winding unvarnished at the time, with the result that the winding may be further improved by being more completely exhausted of air and moisture and thereafter more completely filled with insulating oil. Furthermore, the secondary winding being taped as a unit, and all exposed surfaces of both windings of the induction coil being completely covered with varnish which is sufficiently resilient as not to crack, chip or break, no air, oil or vapor leaks into or out of the completed secondary winding, even when the induction coil is subjected to vibration, heating and cooling, at any usual atmospheric temperature, humidity or density, or to any other normal condition in service on airplanes at various altitudes and in various climates.

Accordingly, one object of our invention is to provide methods of making in quantity production inexpensive induction coils capable of withstanding severe operating conditions in long service with unusual freedom from electrical breakdown and leakage, involving the steps of slipping a dry and taped secondary winding into position on a primary winding having a magnetic core, then covering the induction coil so formed with a synthetic-base insulating varnish that is subsequently cured, and then vacuum-treating and oil-impregnating the secondary winding of the induction coil at least.

Another object is to provide methods of making induction coils of the oil-impregnated type which are inexpensive in quantity production and compact in construction and have a long life under severe conditions of operation, and which do not leak oil therefrom or permit the ingress of air, moisture or vapor thereinto.

Other objects and advantages will be understood from the following description of the method of making an exemplary magneto ignition coil covered with a polymerizing insulating varnish, taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows an outside view of the multilayer secondary winding of the ignition coil after taping; Fig. 2 shows an outside view of the primary winding on its magnetic core, ready for the assembly of the secondary winding thereon; Fig. 3 shows, partly in central section on line 3-3 of Fig. 4 and partly in elevation and partly broken away, the assembled ignition coil ready for immersion in a polymerizing insulating varnish in accordance with the invention; Fig. 4 shows in end elevation, partly broken away, the completed ignition coil; and Fig. 5 shows a portion of the metal strap to which the high tension terminal of the coil and the live end of the secondary winding are fastened, and in which there is formed on its bottom or inside surface a depression for the flow and spread of impregnating oil throughout the winding from the hollow terminal.

Referring to the drawings, the primary winding

1 of enamelled wire is wound in the usual way on an insulating tube 2 around the magnetic core 3 of laminated sheets of steel. The outer terminal 4 of this winding is live and is connected to the live terminal of the magneto breaker. The inner terminal 5, together with the inner terminal 6 of the secondary winding hereinafter described, are soldered to the core 3 as best shown in Fig. 3.

Advantage may be taken of the savings in time and expense in quantity production by separately winding in the usual way the secondary winding in a spaced group on a common insulating tube and then cutting the group into units of substantially fixed dimensions and numbers of turns. To this secondary winding 7 is stuck at each end with insulating adhesive an insulating washer 8 which, when the adhesive is dried, prevents the multiple layers from slipping on one another along the strips of varnished cambric 9 between the layers. A metal strap 10 is supported on a saddle 11 of insulating material and both are held in position on the outer surface of the winding 7 by strip 12 of insulating material. Other strips 13 are laid at several spaced places around the secondary winding and then varnished cambric tape 14 is wound progressively in lapped arrangement around the annular winding, over the top and through the central opening thereof, until the inside surface, the side surfaces and the outer surface are completely covered with the overlapping tape. Finally, varnished cambric tape 15 is wound in lapped arrangement around the outer circumference of the winding to hold the underlying tapes in position. Prior to such taping, the outer end 16 of the secondary winding is soldered to the strap 10, and after the taping the spring terminal plate 17 is fastened to the hollow terminal screw 18 which is fastened to the strap by means of the nut 19.

The taped secondary winding, dry on all exposed surfaces and in the form shown in Fig. 1, is slipped over the primary winding, also dry and in the form shown in Fig. 2. A series of insulating wedges 20 are forced between the windings, when in the position shown in Fig. 3, to hold the windings 1 and 7 in relative fixed position.

After adhesive tape (not shown) is wound over the projecting ends of the magnetic core 3 and also placed over the opening in the screw 18 and over the terminal plate 17, so as to prevent those parts from being subsequently varnished, the ignition coil is completely covered over all its exposed surfaces, including all spaces between the primary and secondary windings, with a polymerizing varnish, preferably by immersing the coil in a pot thereof, until all bubbling through the varnish ceases at room temperature. The coil, then removed from the pot, is drained of surplus varnish and is allowed to dry in the air for about 15 minutes. Then it is baked at a temperature of about 260° F. for about 8 hours, which causes the varnish to polymerize. Suitable polymerizing varnish, requiring this treatment and having these characteristics, is now purchasable commercially on the market from several sources. Before polymerization, it is fairly fluid and flows well over surfaces and into crevices. When polymerized, it is dry, strong and resilient, without air pockets or bubbles, so that it does not have soft spots or blisters which break, crack or chip, or otherwise leave any place for the ingress of air, moisture or vapor into the winding or for egress of oil or varnish, or the vapors thereof, from the winding.

With the ignition coil in this condition, the pieces of adhesive tape over the protecting ends of the core and the other places aforesaid are removed, and then a number of induction coils in this condition are placed in a vacuum-treating and oil-impregnating tank of well known kind and according to the well known method. In this tank all moisture and air are first withdrawn from the coils under a high degree of vacuum and at a suitable temperature for a proper period of time, whereupon the insulating oil is forced under pressure into the coil, principally into the secondary winding 7 through the terminal 18 and thence through the passages 21 formed by the depressions on the underside of the strap 10, but also into the primary winding 1 through the ends thereof and through the spaces between the laminations of the core 3. After this oil impregnation, all of the interstices of the secondary winding 7 are completely filled with oil, and the primary winding 1 is at least partly filled. Upon removal of the ignition coil from the impregnating chamber, the opening in the high tension stud is sealed by solder, and then the coil is hung up to drain off the surplus oil from its exterior and also from within the primary winding thereof. The ignition coil is then dried on its outside surfaces.

With the secondary winding 7 sealed to the exterior at the hollow stud 18 and by the polymerized varnish over all its exposed surfaces, including its inside surface and those areas around its terminal screw 18 and wire connection 6, the impregnating oil and the varnish within that winding are prevented from egress from the coil. Also air, moisture, acid vapors, oil vapors, etc., are prevented from ingress into the winding. As a result, there is substantially no air within the coil to become ionized upon the generation of high voltage within it, and substantially no corona effects occur therein, thus preventing charring and burning within the winding at any temperature of operation to which the coil is subsequently subjected. Furthermore, since there is no egress of oil or oil vapor or varnish from the ignition coil, there can be no deposit thereof from this source on the contact points of the magneto, so that erosion, corrosion and wear thereof are not accelerated from this cause. Owing to the strength and resiliency of the polymerized varnish, the aforesaid conditions are not changed by any atmospheric temperature or density in any normal climate or altitude of operation, or by any temperature variation upon successive periods of heating and cooling in operation, irrespective of vibration or shock to which the coil may be normally subjected.

The fact that minor openings may develop between the primary winding and the magnetic core is of little or no consideration, since the voltage occurring in that winding never reaches a value sufficiently high to cause ionization, corona effects, or electrical breakdown. However, providing a polymerized coating over the primary winding as well as over the secondary winding, and oil-treating the primary winding at the time the secondary winding is impregnated, further protects the secondary winding against ingress and egress of air, fumes and vapors. Furthermore, the use of means, as the washers 8, for securing the layers of the multilayer secondary winding against shifting on each other, and the insertion of the insulating wedges 20 between the primary and secondary windings, further stabilize those windings before and after the polymerization and the impregnation treatments, and there-

by still further enhance the imperviousness of the coil.

By varnishing the exterior of the ignition coil before its oil impregnation, instead of after it, a dry surface is made available for a polymerizing varnish of present commercial kind, and thus there is obtained all the advantages of a non-porous, non-cracking, non-peeling, non-chipping and resilient covering of durable character for reliably retaining the oil impregnation within the secondary winding without mixing with it during polymerization.

By polymerizing the varnish on the exterior surface of the coil before impregnation, the secondary winding is filled with insulating oil more thoroughly than heretofore occurred, and therefore air spaces therein are more thoroughly eliminated. Furthermore this more thoroughly impregnated condition of the secondary winding is maintained over long periods of severe service. These improved results are due in part at least to the fact that the strong, tight, unbroken, impervious and resilient varnish coating not only substantially prevents the ingress of air and moisture through the covering of the windings during the vacuum treatment thereof but also substantially prevents the egress of oil during the subsequent pressure impregnating treatment; and therefore a higher degree of vacuum and a higher impregnating pressure are permitted, both of which tend to more completely fill the coil with oil, and more particularly the secondary winding thereof, than was heretofore prevalent. There thus results a finished ignition coil of inexpensive manufacture in quantity production which is capable of operating without electrical breakdown and without leakage over longer periods of the severe service herein noted.

The polymerizing insulating varnish used in the preferred method specifically disclosed herein is of present commercial kind obtainable from at least several well known sources and includes glyptal, phenol formaldehyde and styrene varnishes with the characteristics herein noted. If desired, other types of synthetic-base insulating varnishes of well known types may be used instead, such as polyvinyl varnishes including polyvinyl chloride, polyvinyl acetate or mixtures of the two with plasticizers and fillers which cure by air-drying at room temperature, and also synthetic rubber varnishes including neoprene, thiol and butadiene varnishes which cure at temperatures generally no higher than 300° F. However, we have found that the polymerizing insulating varnishes are preferable for our purposes in induction coils herein specifically disclosed since they do not soften at any temperature they are likely to attain in the uses herein noted. While the polyvinyl insulating varnishes and the synthetic rubber varnishes do soften at such temperature, and therefore are not so suitable for coils in such uses, they may be more suitable for coils which do not attain such high temperatures but which are improved by the more resilient or flexible coatings produced thereby at lower temperatures in operation.

Various modifications within our invention may be made in the process of making induction coils. One or both ends of the secondary winding may be varnished over instead of sticking thereto an insulating disc to prevent the layers from sliding over each other in being forced on the primary winding. Also the secondary winding may be taped in any other suitable way so long as the exterior surface of the winding is suitably covered

and the tape is of appropriate material and in appropriate condition for the application of a synthetic-base varnish and the curing thereof. Also any other suitable manner of bringing out the terminals of the primary and secondary windings may be provided. Also any other suitable method of impregnating the secondary winding, alone or together with the primary winding, may be used with any suitable insulating material, which herein is generically termed "insulating oil." These and other modifications are intended to be covered by the broad terms of the appended claims.

Having thus described our invention, what we claim is:

1. The method of making an induction coil having primary and secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core and winding and taping the secondary winding as a separate unit with an opening thereinto, then slipping the taped secondary on the primary winding, then covering the primary and secondary windings with a synthetic-base insulating varnish and curing the varnish, then vacuum-treating the secondary winding through said opening to withdraw air and moisture therefrom, then impregnating the secondary winding with insulating oil through said opening to fill interstices in the secondary winding, and finally sealing said opening.

2. The method of making an induction coil having primary and secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core and winding and taping the secondary winding as a separate unit with an opening thereinto, then slipping the taped secondary on the primary winding, then covering the primary and secondary windings with a polymerizing insulating varnish and polymerizing the varnish, then vacuum-treating the secondary winding through said opening to withdraw air and moisture therefrom, then impregnating the secondary winding with insulating oil through said opening to fill interstices in the secondary winding, and finally sealing said opening.

3. The method of making an induction coil having primary and secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core and winding and taping the secondary winding as a separate unit with an opening thereinto, then slipping the taped secondary winding on the primary winding to form an induction coil, then covering the primary and secondary windings with a synthetic-base insulating varnish and curing the varnish, then vacuum-treating the induction coil to withdraw air and moisture from the primary and secondary windings, then impregnating the induction coil with insulating oil to fill the interstices in the secondary winding through said opening and at least some of the interstices in the primary winding through openings between it and the core, and finally sealing the opening into the secondary winding.

4. The method of making an induction coil having primary and multi-layer secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core, winding the secondary winding as a separate unit and applying insulating adhesive to at least one of its ends to hold the layers against slipping on each other, taping the secondary winding with an opening thereinto, then slipping the taped secondary winding on the primary winding, then covering the primary and secondary windings

with a synthetic-base insulating varnish and curing the varnish, then vacuum-treating the secondary winding through said opening to withdraw air and moisture therefrom, then impregnating the secondary winding with insulating oil through said opening to fill interstices in the winding, and finally sealing said opening.

5. The method of making an induction coil having primary and multilayer secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core, winding the secondary winding as a separate unit and sticking an insulating ring on one end of the secondary winding to hold its layers against slipping on each other, taping the secondary winding with an opening thereinto, then slipping the taped secondary winding on the primary winding, then covering the primary and secondary windings with a synthetic-base insulating varnish and curing the varnish, then vacuum-treating the secondary winding through said opening to withdraw air and moisture therefrom, then impregnating the secondary winding with insulating oil through said opening to fill interstices in the secondary winding, and finally sealing said opening.

6. The method of making an induction coil having primary and secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core and winding and taping the secondary winding as a separate unit with an opening thereinto, then slipping the taped secondary winding on the primary winding, then inserting an insulating wedge between the primary and secondary windings to rigidly hold them in assembled position, then covering the primary and secondary windings with a synthetic-base insulating varnish and curing the varnish, then vacuum-treating the secondary winding through said opening to withdraw air and moisture therefrom, then impregnating the secondary winding with insulating oil through said opening to fill interstices in the secondary winding, and finally sealing said opening.

7. The method of making an induction coil having a primary winding and a multilayer secondary winding mounted on a magnetic core, which comprises winding the primary winding on the core and winding the secondary winding as a separate unit, sticking an insulating ring on the end of the secondary winding to hold the layers against slipping on each other, taping the secondary winding with an opening thereinto, then slipping the taped secondary winding on the primary winding to form an induction coil, then inserting an insulating wedge between the primary and secondary windings to rigidly hold them in assembled position, then covering the primary and secondary windings with a polymerizing varnish and polymerizing the varnish, then vacuum-treating the induction coil to withdraw air and moisture from the primary and secondary windings, then impregnating the induction coil with insulating oil to fill the interstices in the secondary winding through said opening and at least some of the interstices in the primary winding through openings between it and the core, then sealing said opening in the secondary winding, and finally drawing off at least some of the insulating oil from the primary winding.

8. The method of making an ignition coil having primary and secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core and winding and taping the secondary winding as a separate unit

with an opening thereinto, then slipping the taped secondary on the primary winding, then immersing the coil in a bath of a synthetic-base insulating varnish, then curing the varnish to render it impervious to oil and vapor, then vacuum-treating the secondary winding through said opening to withdraw air and moisture therefrom, then impregnating the secondary winding with insulating oil through said opening to fill interstices in said secondary winding, and finally sealing said opening.

9. The method of making an ignition coil having primary and secondary windings mounted on a magnetic core, which comprises winding the primary winding on the core and winding and

5 taping the secondary winding as a separate unit with an opening thereinto, then slipping the taped secondary on the primary winding, then immersing the coil in a bath of a polymerizing insulating varnish, then polymerizing the varnish by heating it to a temperature of about 260° F., then vacuum-treating the secondary winding through said opening to withdraw air and moisture therefrom, then impregnating the secondary winding with insulating oil through said opening to fill interstices in said secondary winding, and finally sealing said opening.

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