

Sept. 4, 1956

B. H. SHORT ET AL

2,762,019

IGNITION COIL

Filed Feb. 16, 1951

2 Sheets-Sheet 1

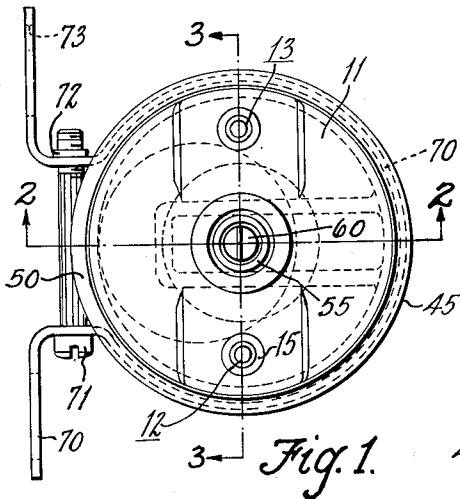


Fig. 1.

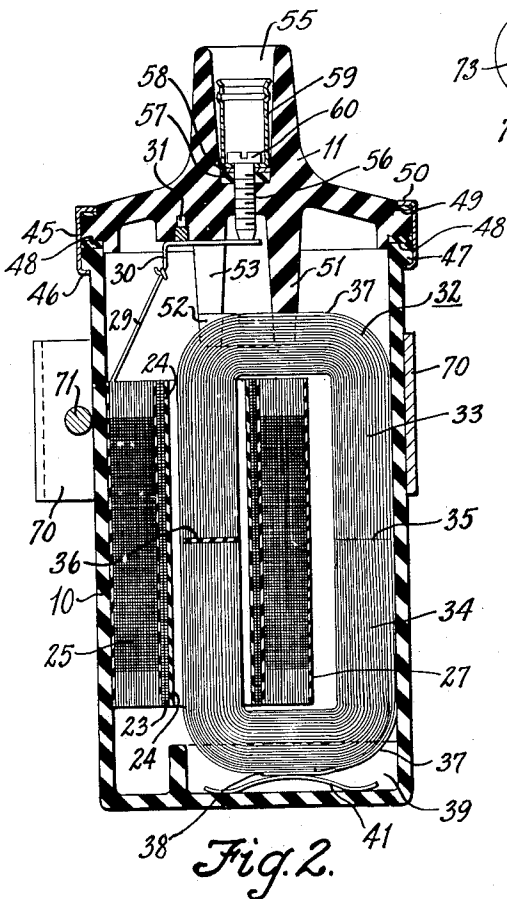


Fig. 2.

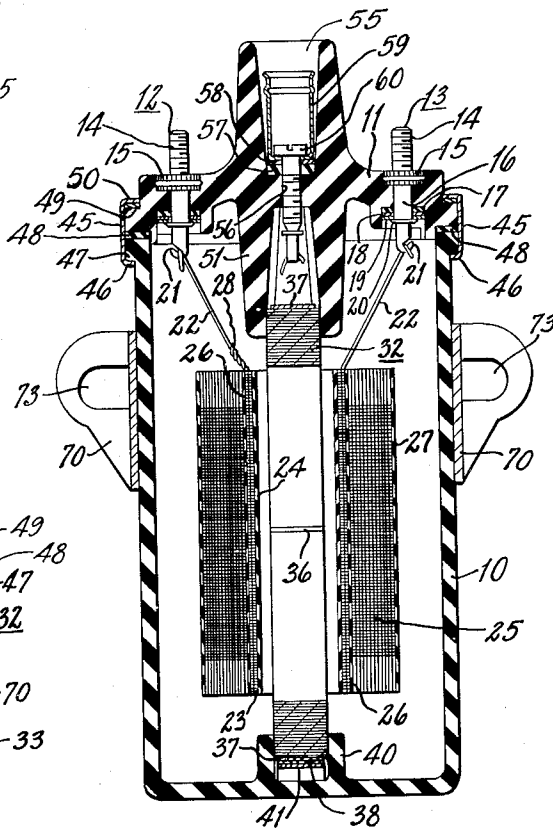


Fig. 3.

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2 Sheets-Sheet 2

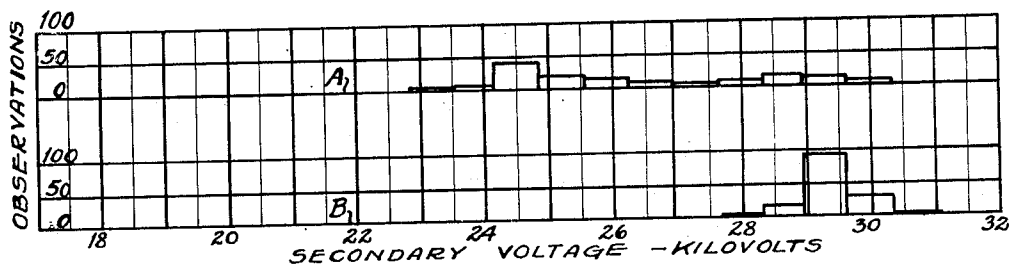


Fig. 4.

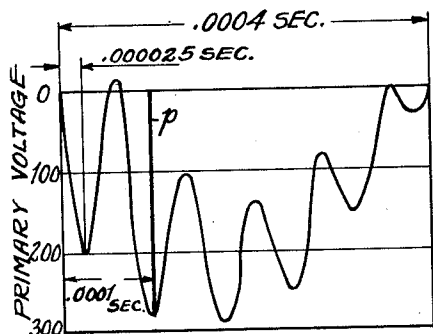


Fig. 5.

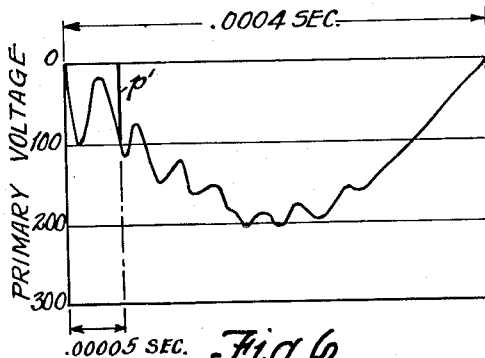


Fig. 6.

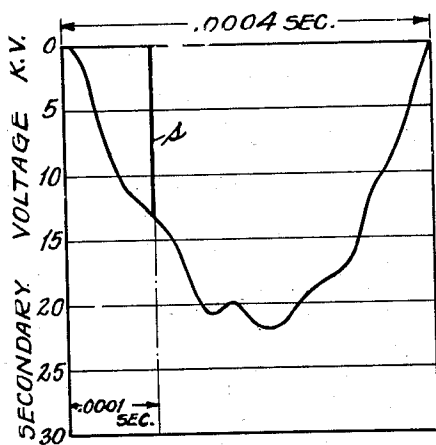


Fig. 7.

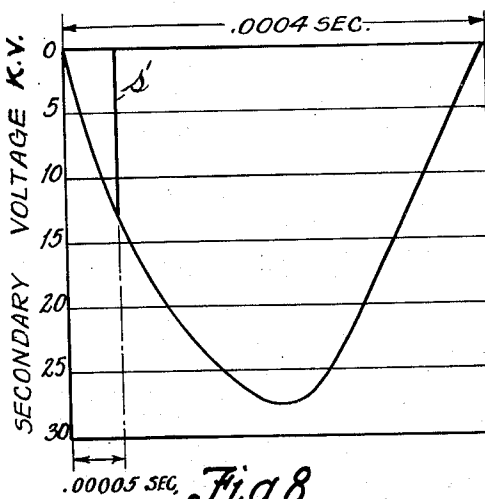


Fig. 8.

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2,762,019

IGNITION COIL

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Application February 16, 1951, Serial No. 211,262

1 Claim. (Cl. 336—92)

This invention relates to an induction coil and more particularly to an ignition coil used with the ignition apparatus of an internal combustion engine which drives an automotive vehicle.

An object of the invention is to provide an ignition coil which can be relied on to provide ignition at relatively low engine speed for an engine which requires relatively high voltage to fire the spark plugs. We have found that this object can be accomplished by windings in combination with a magnetizable core made of a ribbon of oriented silicon steel. By virtue of the use of such core, we are able to provide a secondary winding, the turns of which are more effective than heretofore to avail themselves of a larger share of coil energy than heretofore in producing a relatively higher secondary voltage while the primary voltage does not rise to such value as to cause arcing at the timer contacts although their speed of separation is relatively slow at low engine speed.

A further object of the invention is to provide a suitable housing for the coil having means for supporting the core which, in turn, supports the windings of the coil.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a plan view of a coil embodying the present invention.

Figs. 2 and 3 are sectional views taken, respectively, on the lines 2—2 and 3—3 of Fig. 1.

Fig. 4 is a chart showing the dependability of the present coil as compared with a conventional coil.

Figs. 5 and 7 are charts showing, respectively, half-cycle waves of primary and secondary voltages of a conventional coil.

Figs. 6 and 8 are charts showing, respectively, half-cycle waves of primary and secondary voltages of the present coil.

The coil housing comprises a case 10 and a cover or cap 11. Cap 11 supports low tension or primary winding terminals 12 and 13, each having a threaded portion 14 extending upwardly from a knurled disc 15, inwardly from which there extends a shank 16 surrounded by a resilient washer 17 of rubber-like compound, a normally dished resilient metal washer 18 and a plain washer 19. The terminals 12 and 13 are inserted in a mold in which thermosetting plastic material is molded and forms the cap 11. The washers 17, 18 and 19 are fixed in position as shown by staking or deforming the material of the shank 16 to form a shoulder 20, thereby clamping the washers between the shoulder 20 and the cap 11 to cause the washer 17 to be squeezed against the shank 16 in order to prevent leakage of oil contained in the case 10. Each terminal 12 and 13 has a hook 21 for receiving wires 22, said wires extending, respectively, from end turns of a primary coil 23 wound on a tube 24. Coil 23 is surrounded by a secondary coil 25 wound on a tube

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26 and having an outer covering 27. A wire 28, connected with the inner end turn of the secondary coil 25, is twisted around one of the wires 22 and is soldered thereto. A wire 29, connected with the outside end turn of the coil 25, is connected with a strap 30 attached to metal insert 31 about which the material of the cap 11 is molded.

The core 32 is formed of a winding of a ribbon of oriented silicon steel. This winding is heat-treated to relieve strain and is impregnated in varnish and baked to secure adherence of the windings. Then the core is slit to provide two U-shaped parts 33 and 34. The end surfaces of parts 33 and 34 are ground to provide, exterior to the coil windings, surfaces which abut on the line 35 and surfaces which are spaced apart a definite distance to provide a gap of definite width which receives a thin plate 36 of non-magnetizable material. The parts 33, 34 and 36 are maintained in assembly by a metal strap 37 having overlapping end portions 38 which are united in any suitable manner as by spot-welding. Obviously, the assembling of the parts of the core is done while they are assembled with the core winding. The core parts 33 and 34 are square in cross section contour. The tube 24, which receives the core, has an interior diameter such that the corner edges of the core parts 33 and 34 fit snugly within the tube 24. The core part 34 and the strap 37 are received in a pocket 39 provided by case 10 and defined by walls 40 spaced to receive the core part 34 snugly between them. The overlapping ends 38 of the strap 37 rest upon a resilient metal spring 41.

Before the cap 11 is assembled with the case 10, the two wires 22 and the wire 29 are connected, respectively, with the terminals 12 and 13 and the strap 30. Although the drawing shows the wires 22 and 29 to be straight, it will be understood that these wires are actually bent after assembling since they have length sufficient to permit making the connection shown before the cap 11 is assembled with the case 10. After these connections are made, the wires 22 and 29 are soldered to the terminals 12 and 13 and the strap 30, respectively. A metal band 45, having a flange 46, is placed around the case 10 and is moved therealong so that the flange 46 engages flange 47 of the case. A gasket 48 of rubber-like material is placed upon the case 10 and the cap 11 is placed upon the gasket 48 and a spring washer 49 is placed upon the cap 11. Then while the flange 46 is supported, the upper edge of the band 45 is spun over to form a flange 50 so that the parts included between the flanges 46 and 50 are maintained under compression, thus sealing the joint between the case 10 and the cap 11 and between the cap 11 and the flange 50.

The cap 11 is provided with a downwardly extending annular flange or skirt 51 having a cross slot 52 for snugly receiving the core part 33 and strap 37. The skirt 51 has an opening at 53 to receive the strap 30. When the cap 11 is assembled with the case 10, the skirt 51 presses down on the strap 37 and forces the core parts downwardly to depress the leaf spring 41, thereby maintaining the core in fixed position in the case. The abutting branches of the core parts 33 and 34 engage a portion of the side wall of the case diametrically opposite to the portion engaged by the winding. Since the tube 24 receives the spaced branches of the members 33 and 34 with a snug fit, the coils and the core are fixed laterally within the case. Therefore, when the coil is in service on an automotive vehicle and is subject to vibration, there is substantially no displacement of the coil and core either axially or radially of the case. The coil is supported on the vehicle by a clamp bracket 70 tightened about the coil by a screw 71 engaging a nut 72. Bracket 70 provides slots 73 for receiving mounting screws.

After assembling the core and windings therein, the

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case is filled with an insulating oil which is poured into the central socket 55 of the cap 11 and this oil runs into the case through a hole 56. After filling the case with oil, a resilient washer 57 of rubber-like material, a metal washer 58, a terminal receiving socket 59 and a screw 60 are assembled with the cap as shown. The tightening of the screw causes compression of the washer 57 so that it seals the joint between the screw and the cap 11. When the screw 60 is tightened, it engages the strap 30 to provide an electrical connection between the outside lead of the secondary coil 25 and the member 59 which is adapted to receive a metal plug attached to a wire which makes connection between the secondary winding 25 and an ignition distributor which distributes sparking impulses to spark plugs of the engine. One of the terminals 12 or 13 is connected by a switch with a current source and the other is connected with the ignition timer.

We have found that, by virtue of the ability of the oriented silicon steel core to carry more magnetic flux than the core of a conventional coil, such as shown in Hartzell Patent #2,512,796 granted June 27, 1950, a coil having improved performance can be constructed. In the first place, the core can have smaller cross sectional area than heretofore. By shaping the core as shown, the required energy can be stored in the coil with fewer primary turns according to the formula

$$\text{Energy} = \frac{1}{2} LI^2 \text{ and } L (\text{inductance}) = \frac{4\pi N^2 \mu A}{10^9 w}$$

in which N =number of primary turns, μ =equivalent permeability of entire core, A =area of air gap and w =width of air gap. Because the primary has fewer turns, the secondary will have fewer turns for a given transformation ratio. This saving in space permits a closer coupling of the secondary winding, thus giving a higher coupling coefficient. This allows a higher percentage of the energy to be transferred to the secondary winding. Also, as a result in this reduction of secondary turns, a reduction of the secondary distributed capacity is obtained. By virtue of higher coupling coefficient and reduction of the distributed capacity of the secondary, the secondary turns are more effective, upon discharge of coil energy, when the timer contacts separate, to avail themselves of a larger share of coil energy than heretofore in producing a relative higher secondary voltage while the primary voltage does not rise to such value as to cause arcing at the timer contacts although their speed of separation is relatively slow at low engine speed.

In order to compare the present coil with a conventional coil of the type shown in Hartzell, #2,512,796, both coils were constructed for operation from current sources at the same voltage, for example, 12 volts. Both were connected with ignition timers continuously operated at a speed corresponding to low engine speed. During a 12-minute period observations of secondary voltages were made every five seconds, thus making 144 observations. The blocks on line A of Fig. 4 show performance of the conventional coil. Its secondary voltage ranged from 22.8 kv. to 30.35 kv. and it put out about 24.5 kv. secondary voltage 40 times in 144 observations. The blocks on line B show the performance of the present coil. Its secondary voltage ranged from 27.7 kv. to 31.1 kv. and it put out about 29.5 kv. 90 times in 144 observations. This test showed the performance of the present coil to be more consistent than that of the conventional coil and that it can be relied on to put out at least 27.5 kv. whereas the conventional coil can be relied on to put out only 22.5 kv.

The reason for the improved performance of the present coil will be explained with reference to Figs. 5-8 which are drawn from oscillographs of waves starting with timer contact separation. Fig. 5 is the first half-cycle of the primary voltage wave of the conventional coil. The high frequency components of this wave have relatively large amplitude. Primary voltage rose to 200 v. in

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.000025 second while the timer contacts separated .0000125 inch approximately. This value of primary voltage was sufficient to cause arcing at the timer contacts so that a portion of the coil energy was dissipated. The secondary voltage available for ignition was about 22.5 kv. as shown in Fig. 7.

Fig. 6 shows the first half-cycle of the primary voltage wave of the present coil following the beginning of timer contact separation. The high frequency components of this wave have much less amplitude than that of the primary voltage wave of the conventional coil as shown in Fig. 5; and they disappear faster. The primary voltage of the present coil does not reach such value in the early stages of contact separation as to cause arcing at the contacts. Hence coil energy is not dissipated in advance of firing a spark plug. The available secondary voltage of the present coil is about 27.5 kv. as shown in Fig. 8. When the spark plug fires, the kick-back on the primary circuit of the present coil is much less than in the case of the conventional coil. Therefore, arcing at the timer contacts is substantially reduced. The amount of kick-back is proportional to the relation of primary voltage to secondary voltage at the instant of firing. Assume that both coils fire a plug at 13 kv. The primary voltage p of the conventional coil is 270 v. The primary voltage p' of the present coil is about 90 v., and the secondary voltage s' of 13 kv. is produced in .00005 second which is about one-half the time required for the conventional coil to produce secondary voltage s of 13 kv. The ratio p'/s' of the present coil is less than ratio p/s for the conventional coil.

Since contact arcing with the present coil is less than the conventional coil, it is possible to use greater primary current. A coil embodying the present invention can be constructed with primary turns of heavier gauge wire. Since coil energy increases as the square of the primary current as well as the square of the number of primary turns, the same energy can be produced with fewer primary turns and greater energy with the same number of primary turns. For example, the present coil may have a core $\frac{7}{16}$ " square in cross section with an air gap .03" wide, a primary winding of 188 turns of #23 gauge wire wound in two layers of 96 and 92 turns and a secondary of 24,910 turns of #39 gauge wire wound in 53 layers of 470 turns each. If primary current is increased from 4.25 to 5.5 amperes, for example, to obtain the same energy, the number of primary turns is 145.2. Using the same number of secondary turns, the transformation ratio is increased by 12.94%. Because the transformation ratio is greater, the secondary voltage available for ignition will be greater. By following the teaching of the present invention, it is possible to build a coil having greater secondary voltage output than at present required for automotive vehicle use; and such coil, when used, will not cause undue arcing at the timer contacts.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

An ignition coil for use in an ignition system operated by a D. C. source of relatively low voltage comprising, an insulating tube, a primary winding of turns of wire surrounding the tube, a secondary winding surrounding the primary winding, a loop-shaped laminated magnetizable core comprising two similar U-shaped parts, each part comprising continuous ribbons of oriented silicon steel bent flatwise to form parallel branches extending from a central yoke, one branch being longer than the other wherein the cross section of the core branches is substantially a square, said U-shaped parts being assembled with said windings so that the longer branches are in alignment outside of the winding with the end surfaces of the longer branches abutting, the shorter branches being within the tube which circumscribes that portion of the core

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which it surrounds, a non-magnetizable spacer located between and abutting end surfaces of the shorter branches to fill the space therebetween, a metal strap surrounding and engaging the outer surfaces of the outer ribbons of the U-shaped parts for retaining the core in assembly with respect to the windings, an enclosure comprising a case and cover, said case having interior side wall portions disposed to bear respectively against portions of the secondary winding and the strap so as to resist lateral movement of the coil and core assembly, said enclosure providing recesses respectively at the case bottom and in the cover, each recess being defined by parallel surfaces between which a yoke portion of the core snugly fits in order to resist lateral movement of the core, one of said recesses being defined by another surface engageable with the strap surrounding the core yoke, a spring within said last mentioned recess and adapted to engage the strap

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to urge the core toward said other recess surface for resisting longitudinal movement of the coil and core assembly between the case bottom and the cover when the coil is assembled, and means for securing the cover to the case.

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