R. VARLEY.

INDUCTION COIL.

APPLICATION FILED MAY 8, 1909.

986,033. Patented Mar. 7, 1911.

2 SHEETS—SHEET 1.

Fig. 1.

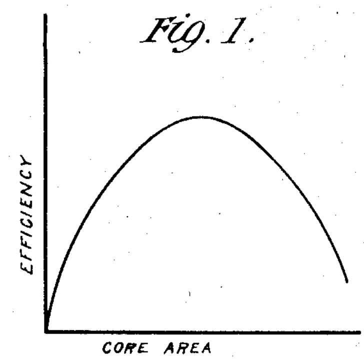
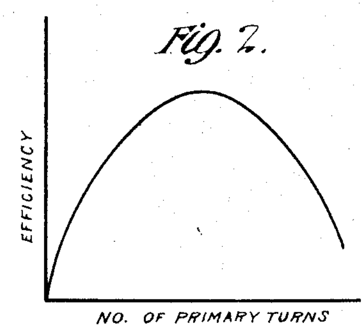


Fig. 2.



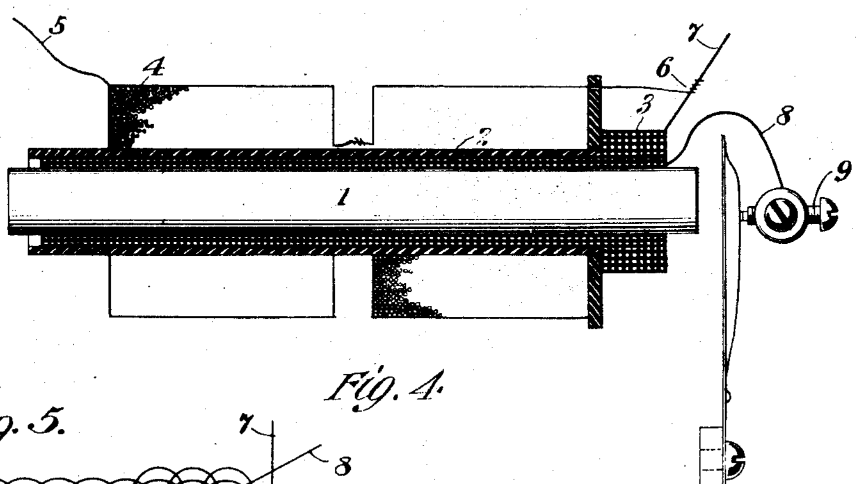
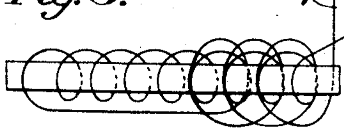


Fig. 4.

Fig. 5.



Witnesses:

Francis S. Ober

[illegible signature]

Inventor

Richard Varley

By his Attorneys

Rosenbaum Stockbridge

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APPLICATION FILED MAY 8, 190

986,033.

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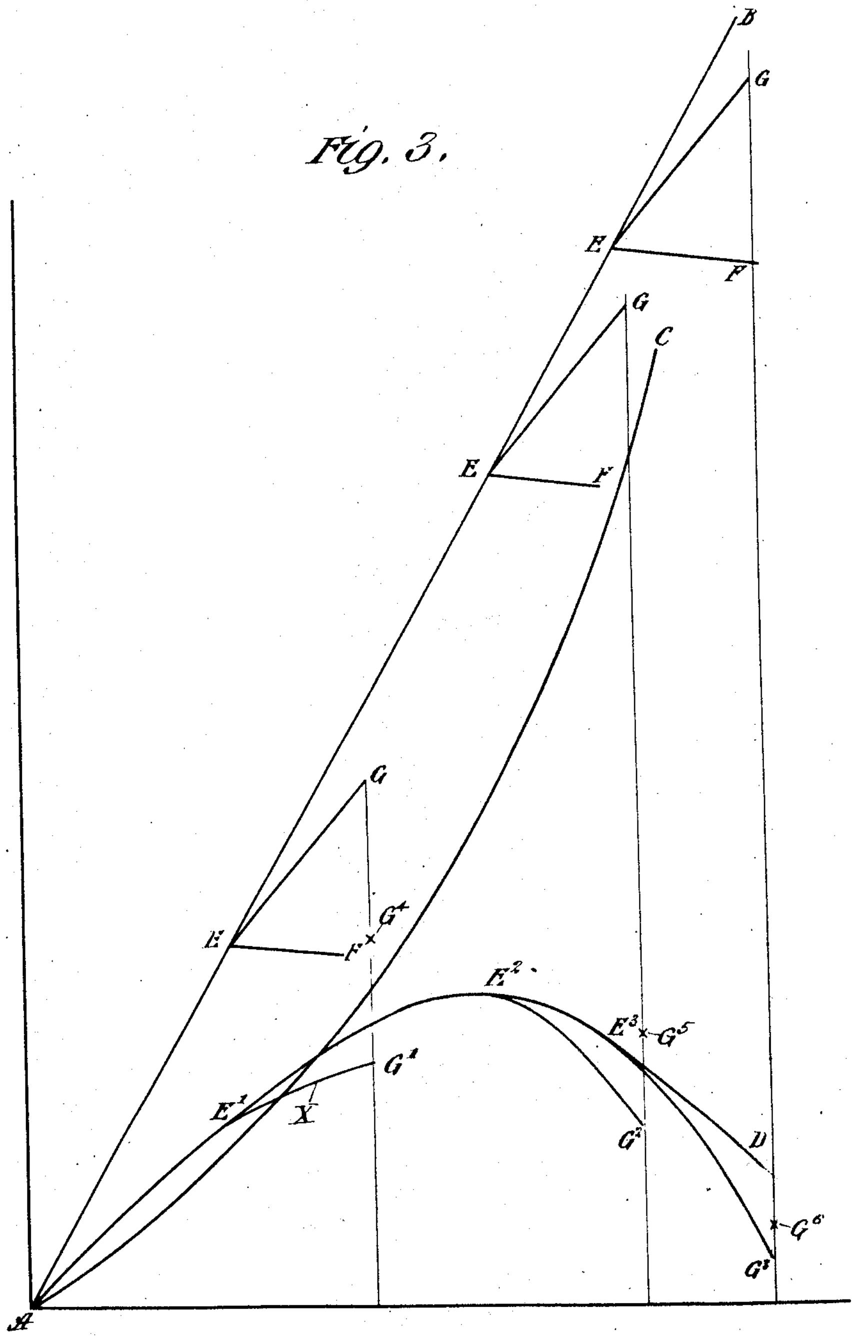
2 SHEETS—SHEET 2.

Fig. 3.



Witnesses:
Francis S. Ober
[signature]

Inventor
Richard Varley.
By his Attorneys
Rosenbaum & Stockbridge

UNITED STATES PATENT OFFICE.

RICHARD VARLEY, OF ENGLEWOOD, NEW JERSEY, ASSIGNOR TO THE AUTOCOIL COMPANY, A CORPORATION OF NEW JERSEY.

INDUCTION-COIL.

986,033. Specification of Letters Patent. Patented Mar. 7, 1911.

Application filed May 8, 1909. Serial No. 494,770.

To all whom it may concern:

Be it known that I, RICHARD VARLEY, a citizen of the United States, residing at Englewood, in the county of Bergen and State of New Jersey, have invented certain new and useful Improvements in Induction-Coils, of which the following is a full, clear, and exact description.

This invention relates to induction coils for explosion engines, being an exposition of the manner in which a coil can be constructed to obtain, so far as I am aware, the maximum or highest possible efficiency in this particular use.

An induction coil as used with an explosion engine, is merely an appliance for producing sparks at the rate of say, one or two hundred per second through compressed gases at say one hundred pounds pressure, employing a source of current having about six volts E. M. F. and a working current consumption of not over one or one and a half amperes. These factors are fixed by the following considerations. The number of sparks per second is fixed by the fact that a multiple cylinde high speed engine requires a coil having a trembler capable of repeated actuations through about 10° angular movements of the engine shaft. The pressure referred to is fixed by the compression of present explosion engines. The voltage referred to is fixed partly by the type of three cell storage battery which is universally marketed for ignition purposes, and partly by the fact that a higher E. M. F. craters platinum contacts, and cannot be practically used. The current consumption is fixed by the cratering difficulty mentioned and by the standards now attained with induction coils, which have achieved so high an efficiency that reliable ignition can be had with a mean average current consumption of 3/4 of an ampere. This being actually attained in present practice, it is clear that any very much higher current consumption would not be tolerated in the present development of the art. The foregoing results being now practically attained, improvement evidently lies in still further reducing the current consumption thus avoiding cratering, and improving the economy of operation of the coil.

It is the purpose of my present invention to obtain all these results.

In order to make clear the principles on which an ideal coil for ignition purposes may be constructed by anyone skilled in the art, it is necessary to analyze in detail the various phenomena which take place in an induction coil, together with some equations showing the inter-relation of the various controlling factors.

I will first consider the action of an induction coil separately from its trembler, that is to say, the working of the coil if the trembler were separately actuated in a perfect manner. Assuming that a coil has a core of certain size and a primary winding of a certain resistance and number of turns, it is evident that an E. M. F. of six volts acting for an interval of 1/100 of a second, creates a certain flux or field of magnetic force. The self induction of the primary winding is expressed by the formula

$$L=\frac{4\pi S^2}{Z},$$

L being the inductance, S the number of turns, and Z the magnetic reluctance. In a magnetic circuit of this character it is clear that the resultant or net flux is less as the inductance increases; but the inductance is dependent upon the reluctance as shown in the foregoing equation. In other words, increasing the cross section of the core has a certain disadvantageous effect. On the other hand, it has an advantageous effect, since the less the reluctance, the greater the flux, assuming that the inductance is constant. Calculation, borne out by practical experiments, proves that increasing the size of the core increases the field or flux up to a certain limit, after which a further increase results in diminishing the field or flux (for a given limited time constant t). The same thing for analogous reasons is true of the number of primary turns S. It is therefore obvious that for a given E. M. F. and time t, there is theoretically a best size of core and a best number of primary turns.

Now the trembler or vibrator has requirements of its own which may be briefly summed up as first, making a good contact, second, getting an abrupt and positive separation from the contact, and third, effecting a quick return to the contact. All these can be obtained by securing two factors in the induction coil core, namely, sufficiently strong magnetization, and sufficiently abrupt change of magnetization. Now the best proportions of core and primary winding to secure a flux or field as first described, are not the best proportions to secure the best action of the trembler as last described. Experiment and practice has effected what has appeared to be the most desirable combination or compromise. The coils now in use seem to be the best combination or compromise because if the size of the core is either increased or reduced or the number of primary turns is either increased or reduced, a loss of efficiency is felt. For example, increasing the number of primary turns or the size of the magnet core, makes the trembler action better, but the better trembler action is more than offset by the loss of coil efficiency due to the considerations first above mentioned in regard to the flux or field. In order to avoid too complicated mathematics, I will analyze the various effects of altering the proportions of the coil by means of graphical curves.

Figure 1 shows the effect of increasing the diameter of the core, the number of turns remaining a constant medium value.

The ordinates denote what I term—fluxing efficiency, or in other words flux or field produced by a given E. M. F. (6 volts) in a given time interval (1/100 second) as above described. The abscissas indicate core areas. It will be seen that the fluxing efficiency is a maximum at a certain core area and falls off when said area is either reduced or increased.

Fig. 2 is a curve showing the effect of changing the number of primary turns, the cross section remaining a constant medium value. It will be seen that the efficiency is best when there is a certain best number of turns, the efficiency diminishing either when the number is increased or reduced therefrom.

Fig. 3 shows the effect of loading the primary with inductance, such as an exterior coil.

Fig. 4 is a section of a coil constructed in accordance with the principles of my invention; and

Fig. 5 is a diagrammatic representation of the winding on such coil.

In Fig. 3 the ordinates indicate efficiency, as before, and the abscissas designate increased inductances due either to increasing the core area or increasing the number of turns. A—B indicates in a general way the increase of field or flux which would result from increasing either the core area or the number of primary turns, were it not for the counter or negative effects of the inductance. The flux or field increase is directly proportionate to the core area, or to the number of turns; and, as is well known, the reluctance is almost exactly inversely proportionate to the core areas in a straight bar magnet. A—C shows the negative or counter effect due to the inductance; and A—D is the resultant obtained by combining curves A—B and A—C, in other words subtracting curve A—C from curve A—B. This curve, of course, corresponds to those of Figs. 1 and 2. It is clear that there is a maximum efficiency point corresponding to the summit of this curve. E—F, is a line indicating the effect of an increased number of turns in the primary circuit but assumed to be located entirely outside the coil; in other words loading the coil with an exterior inductance. E—G, shows the effect of loading the primary winding with turns which are inefficiently positioned thereon, for example, near one of the poles. This line E—G, evidently will lie between A—B and E—F. The more efficiently located the extra windings are, the more nearly the line E—G will approach A—B in direction. The effect of combining any of the curves A, E, G with the curve A—C, is illustrated by the lines E′—G′, E² G² etc. The points G′ G², etc., denote the efficiencies secured by loading different primary windings with a given extra inductance located near a pole of the primary core. It will be noted that the most left hand point, G′, corresponds to a higher efficiency than any of the other points G², G³, etc. But this curve, denoted X for convenience, corresponds to adding a fixed number of turns to a primary winding having considerably less inductance (say 50% or more) than the apparently ideal value indicated by the summit of the curve A—D.

The gist of my invention consists in loading the primary winding with a few turns directly at the pole which actuates the trembler, the loading being done in accordance with the foregoing curves or principles. In other words, I provide a few turns of the primary winding for the direct purpose of operating the trembler, which is obviously attained. The trembler will be found to work with all the desirable characteristics heretofore referred to, even if it is placed a quarter of an inch away from the end of the core. This addition of windings alone, however, would diminish rather than increase the efficiency of the induction coil unless done in accordance with the principles above pointed out. This is clear from Fig. 3. The effect of having the trembler work properly is to definitely increase the efficiency of the coil by a certain factor. If the efficiency of the coil is at the point G′ of Fig. 3, the change of better or more regular trembler action will be to elevate the efficiency to G⁴. If on the other hand, the coil efficiency is at the point G², the effect of the better trembler will be to elevate it to the point G⁵. But G⁵ is lower than the summit of the curve A—D. In other words the coil efficiency is only made the highest possible maximum provided its core cross section and primary turns are very considerably reduced before the few extra turns at the pole are added.

To illustrate the foregoing I have shown in Fig. 4 a coil which will drive sparks through a 200 pound pressure at highest engine speeds and with a six volt battery. The coil has a core denoted 1, 5 3/8 inches long and 1/2 inch in diameter, as against 11/16 or 3/4 of an inch hitherto found best. The primary denoted 2, consists of two layers of No. 20 wire, and directly at the trembler pole there are four additional layers denoted 3, extending along one-half an inch of the length of the coil. It will be observed that this is very considerably less than the amount of primary windings usually supplied and corresponding to the summit of the curve A—D. The secondary consists of the usual bobbins of fine wire 4 filling as much volume as can be efficiently cut by the lines of force, one terminal of the secondary being designated 5, and the other 6, the latter preferably having the usual connection with the primary coil supply wire 7. The other primary supply wire 8 is electrically connected to the trembler stud 9.

Fig. 5 diagrammatically illustrates the series connection between the body or main portion of the primary coil 7 and the preferably superposed and hence greater diametered turns disposed upon said body at the trembler end thereof.

In considering the reactance effect mathematically, the secondary winding will to a small extent influence the action of the primary and hence there will be considerable complication in the equations involved. For this reason it has been deemed expedient to employ graphics, which serve to show the relationship and effect of the windings, the action of the secondary being disregarded as being relatively unimportant.

What I claim is:

1. An induction coil comprising a core and primary and secondary windings, said primary winding having a distinct group of additional turns or layers disposed upon the body proper of said primary winding at one pole of the coil, said group being in series with the coil and a trembler at such pole.

2. In an induction coil, a magnetizable core, a primary coil consisting of a plurality of turns of an electrical conductor, connected in series, said coil having a greater number of turns per unit of length of core at one end thereof than at the other, and a trembler at said first mentioned end.

3. In an induction coil, a magnetizable core, a primary coil proper mounted thereupon, said coil having a greater number of turns per unit of length of core at one end thereof than at the other, said coil being disposed along substantially the entire length of said core and having the turns thereof electrically connected in series, and a trembler at said first mentioned end.

4. In an induction coil, a magnetizable core, a primary coil proper mounted thereupon, said coil having a greater number of turns per unit of length of core at one end thereof than at the other, said coil being disposed along substantially the entire length of said core and having the turns thereof electrically connected in series, the said end of the coil having the greater number of turns per unit of length, comprising turns of greater diameter than any elsewhere disposed along the core, and a trembler at such end.

5. An induction coil comprising a core and a primary and secondary winding, said primary winding being disposed substantially uniformly along the length of said core but having a distinct group of additional turns or layers superposed upon the body of said primary winding at one end thereof adjacent a pole of the coil, said additional turns projecting laterally from the said body and being electrically connected in series therewith, and a trembler at such pole.

In witness whereof, I subscribe my signature, in the presence of two witnesses.

RICHARD VARLEY.

Witnesses:
WALDO M. CHAPIN,
WILLIAM C. LARY.