J. A. WILLIAMS.

IGNITION APPARATUS.

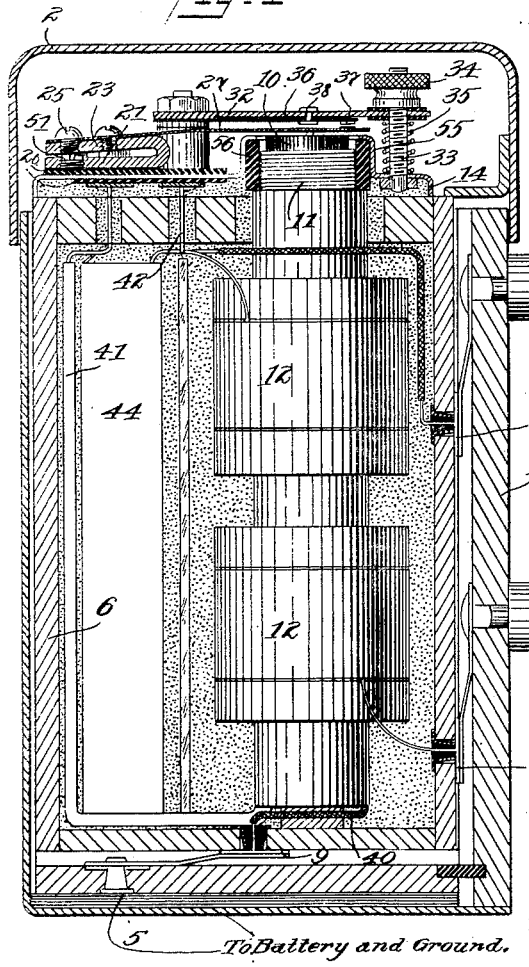
APPLICATION FILED MAR. 5, 1913.

1,092,417.

Patented Apr. 7, 1914.

2 SHEETS—SHEET 1.

Fig. 1



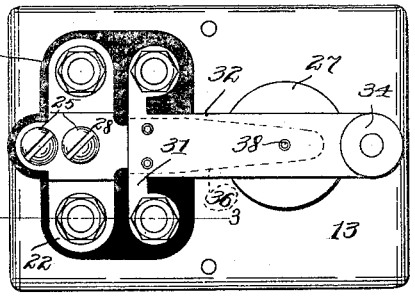
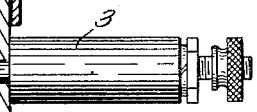
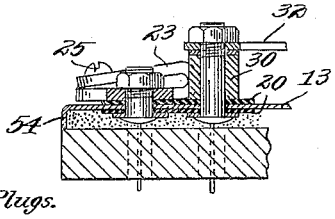


Fig. 2





To Spark Plugs.

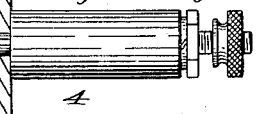


Fig. 3

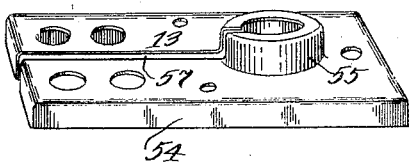


Fig. 4

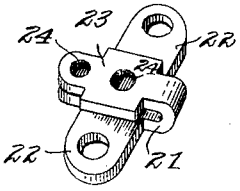


Fig. 5

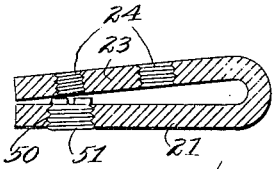


Fig. 6

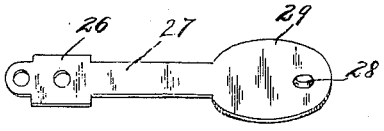


Fig. 7

Witnesses:

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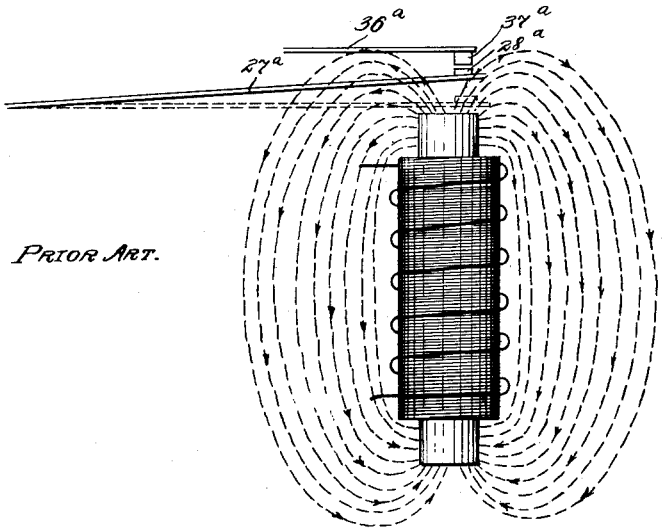
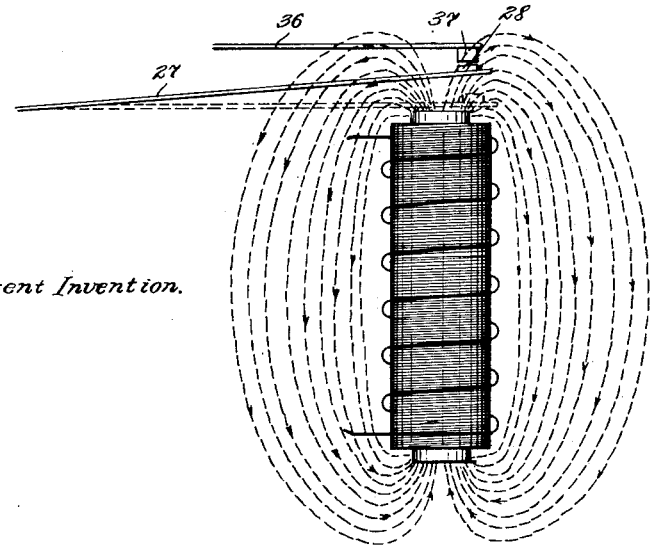
2 SHEETS—SHEET 2.



Prior Art.

Fig. 2.



Present Invention.

Fig. 3.

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UNITED STATES PATENT OFFICE.

JOSEPH A. WILLIAMS, OF CLEVELAND, OHIO.

IGNITION APPARATUS.

1,092,417. Specification of Letters Patent. Patented Apr. 7, 1914.

Application filed March 5, 1913. Serial No. 752,147.

To all whom it may concern:

Be it known that I, JOSEPH A. WILLIAMS, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in Ignition Apparatus, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings.

This invention relates to ignition apparatus for internal combustion engines, and particularly to the induction coil and its adjuncts by means of which such ignition is most usually effected, it being understood that the induction coil referred to is one of the "jump spark" type; as contradistinguished from the "wipe spark" type.

The high speed at which internal combustion engines are frequently operated at the present day necessitates the very accurate timing of the electric spark in order to effect the explosion of the mixture at the most opportune instant, while on the other hand, the magnetic and mechanical lag of the ignition devices, particularly the induction coil, causes the spark to take place an appreciable time after the making of contact by the engine-driven timer. It is customary in the case of multicylinder engines to employ a separate coil for each cylinder, wherefore the lag of all the coils ought to be very accurately equal so that the charges in the different cylinders shall be exploded at proper times as regards the positions of their pistons. The difference in the lag of different coils as hitherto made, while very small in actual amount, is sufficient to cause serious irregularity in the operation of the engine. Accordingly, it is customary for the manufacturers of ignition apparatus to adjust their coils very accurately so that the spark shall take place at the same phase instant in all cylinders, delicate and refined measuring apparatus being employed for the purpose. Unfortunately, however, the lag of the coils has also depended largely upon the adjustment of the back-contact-point so that any change in the position of the usual adjusting screw in an effort to obtain a "fatter" or "thinner" spark changes the relation of spark and piston. This adjusting screw is, for some reason, one of the first things which is resorted to when, for any reason, the engine fails to operate properly, and thus the manufacturer's careful work may be entirely lost. Finally, of course, if after this mal-adjustment the ignition apparatus should fail to operate properly, the owner would blame the ignition people rather than his own meddling, thereby bringing the manufacturers into disrepute.

Accordingly, the object of the present invention is the provision of an ignition coil for internal combustion engines having a new, improved, and simplified vibrator construction; the provision of a device of this character in which the strength of the magnetic field in which the vibrative reed or tongue is located shall always be substantially proportioned to the tension upon such reed or tongue throughout the entire range of its movement; the provision of an ignition coil for internal combustion engines or the like wherein the lag may easily be adjusted by any man knowing the proper method and possessing the requisite tools, but without the probability of being tampered with by unskilled persons; the provision of a device of this character wherein the important adjustment devices shall be so hidden and concealed as largely to escape attention and, if discovered, to be very difficult of access; the provision of a device of this character of greater simplicity and fewer number of parts than devices of the same type hitherto employed; while further objects and advantages of the invention will become apparent as the description proceeds.

Generally speaking, my invention may be defined as consisting of the combinations of parts recited in the claims hereto annexed and illustrated in the drawings accompanying and forming part of this application, wherein:

Figure 1 is a longitudinal cross-sectional view through an induction coil equipped with my improvements; Fig. 2 is a plan view of the vibrator; Fig. 3 is a detail cross sectional view taken upon the line 3—3 of Fig. 2; Fig. 4 is a perspective view of the cover of the coil; Fig. 5 is a perspective view of the adjustable vibrator support; Fig. 6 is a longitudinal cross sectional view of the support illustrating the adjusting means; Fig. 7 is a perspective view of the vibrating tongue or reed; Fig. 8 is a map of the magnetic field hitherto customarily employed showing the relation of the reed thereto; and Fig. 9 is a similar map of the field employed with my improved device and its relation to the reed.

Describing the parts by reference charac-

ters, 1 represents the inclosing casing and 2 the cover therefor, said box being provided with binding posts 3 and 4 for connection to the timer and to the spark plugs respectively, and with a third connection 5 for attachment to the battery and ground. 6 indicates a smaller oblong box adapted to be received within the casing 1 and having contact plates 7, 8 and 9 on its exterior adapted to be engaged by suitable springs carried by the various connections of the casing. Mounted in a longitudinal position within the box is an induction coil comprising a soft iron core 10 having a primary winding thereon, a part of the coils of which are shown at 11, and also having a secondary coil wound thereon, here shown as segregated into two spools 12—12. The length of the core 10 is such as to cause it to project through one end of the box 6 which is suitably apertured for the purpose as shown in Fig. 1, this arrangement being commonly adopted to permit the operation of the vibrating reed. The apertured end of the box 6 is preferably covered by means of a thin plate of non-magnetic sheet metal to which the vibrator parts are secured. Rigidly secured to the upper surface of this plate at one side of the core 10, and insulated from the plate in any suitable manner as by the hard rubber plates 20—20 shown, is my improved vibrator support. This support is made of a ductile metal such as brass and comprises a base portion 21 having laterally projecting ears 22—22 whereby it is secured to the plate 13, and also having an elongated extension folded over as at 23 so as to overlie the base portion and form a top portion. The free end of the top portion 23 preferably lies closely adjacent to the base portion 21, as shown in Figs. 1, 3, and 6, and is formed with threaded apertures 24 for the reception of screws 25 whereby the tongue 26 of a spring steel reed 27 may be secured thereto. This reed is made thin and flexible and has a circular head 29 overlying the end of the core 10 and an extended resilient shank 28. The head 29 is also provided with a contact point 28.

Secured to the plate 13 at each side of the base portion 21 is an upright post 30 (Fig. 3) to the upper ends of which are attached the laterally projecting ears 31 of a bridge member 32. This bridge member projects across the end of the core 10 outside of the reed and has its free end apertured for the reception of the threaded post 33 having thereon the adjusting nut 34. The bridge 32 is pressed upwardly against the bottom of this nut by means of a spiral spring 35 surrounding the post. Secured to the lower face of the bridge 32 and spaced very slightly therefrom is the back-spring 36 having at its free end a contact 37 adapted to engage the contact 28 hereinbefore mentioned. A rivet 38 passes through both back-spring and bridge, but is made of sufficient length to permit the spring a limited amount of movement.

One terminal of the primary coil is attached to the contact 9, as indicated at 40, the other is connected to one of the points 28 or 37 by means of the lead 41. In the present instance this lead is attached to the vibrator support 21 and thence to the point 28. The opposite point, in this case the point 37, is connected, through the agency of the lead 42, with one of the terminals of the secondary coil, and thence with the contact plate 7 and binding post 3. The opposite terminal of the secondary coil is attached to the contact plate 8 and binding post 4. I have illustrated a condenser 44 as connected between the points 28 and 37 by having its terminals attached to the leads 41 and 42, as is usual in induction coils. I have described my mechanism thus in detail so as to set forth clearly one form of construction with which my improvements may be used successfully, but without limiting myself to that construction.

Each time that the timer (not shown) carried by the engine makes circuit-closing contact, an impulse will flow from the battery (not shown) through the primary of the coil and through the contacts 28 and 37, the core 10 will become magnetized, the reed 27 will be attracted thereto and the primary circuit interrupted, causing a pulsation of energy in the primary circuit which produces a similar pulsation in the secondary circuit, whereby a spark is generated between the terminals of the spark plug and the charge in the appropriate cylinder is exploded. It is unnecessary to consider whether more than one stroke of the vibrator be effected during the period that the timer circuit is closed, since this will depend upon the speed of the engine, the period of the vibrator, and the angular extent of the timer contact; the important point is that the first disconnection of the contact points 28 and 37 does not take place until an appreciable time after the completion of the primary circuit by reason of the mechanical and magnetic lag already mentioned, and that this delay must be very exactly equal in the case of all coils, otherwise the cylinders will be exploded irregularly.

The electrical lag depends almost entirely upon the inductance of the circuits and is substantially unalterable after the instrument is finished. The mechanical lag depends upon the inertia and stiffness of the spring and upon the initial tension under which the same is placed. The inertia and stiffness of the reed may be varied by varying the weight of the same and by varying the width and thickness of its shank as will

be well understood. In practice, however, these reeds are all made alike to a specification discovered by experiment as hereafter described and further adjustment is effected by varying the angle of the reed shank thereby changing the tension upon the reed. The greater this tension, the greater must become the strength of magnetization of the core before sufficient force can be developed to attract the reed and interrupt the circuit. According to my invention this adjustment is effected merely by shifting angularly more or less the free end of the portion 23 of the reed-support by means of a suitable set screw. At the same time I desire to locate this set screw so as to afford the least possible chance for ignorant, careless, or unintentional displacement. To this end, I form the base portion of the reed support with a threaded aperture 50 substantially in line with the rearmost aperture 24, and in this aperture 50 I mount an adjusting stud 51 having its upper face slotted for the reception of a screw-driver. This stud is accessible only by removing the screw 25 thereabove, as clearly indicated in Figs. 1 and 6, and even when this screw is removed it is impossible for any person not fully acquainted with the device to appreciate the fact that the stud constitutes an important adjustment, or to understand the method of operating the same to effect the adjustment. The result is that the angle between the upper and lower portions of the vibrator support can be adjusted at the factory without danger that it will be disarranged by incompetent hands. An increase in the angle between the reed shank and the plate 13 increases the lag of the spark since it increases the resistance of the reed to the attraction of the core and necessitates the building up of a more intense magnetic field before the circuit will be broken.

The office of the screw 34 is to permit the adjustment of the point 37 toward the point 28 as the same burn or wear away. It is necessary of course that the points should be in contact when no current passes through the primary since otherwise the coil could not be energized, and further the arrangement could be such as to permit the separation of the contact points as soon as the core has become sufficiently magnetized. According to my invention, however, the adjustment of the screw 34 has no effect upon the lag of the spark and practically no effect upon the intensity thereof. This result is attained by the balancing of the reed tension against the magnetic field in the manner now to be explained.

It is a well known fact that the ends of a magnet or solenoid are connected exteriorly by curved lines of magnetic force. It is also well known that if a solenoid be provided with an iron core of greater length than the windings, the lines of force will begin to diverge from the core immediately at the end of the windings, thereby rendering the field intensity at the end of the core materially weaker than the field within the windings. Furthermore this arrangement causes the inclination of the lines of force at the end of the core to be very great so that the field intensity changes very rapidly with changes in the distance from the end of the core. All of these conditions are clearly shown in Fig. 8. Hitherto, however, the importance of these considerations appears not to have been appreciated, manufacturers having confined the primary windings of the coil to a point within the box 6 and extended a portion of the naked core for the operation of the vibrator. The disadvantages of this construction have been two-fold: first, the leakage of the lines of force between the end of the windings and the face of the reed has so weakened the field piercing the reed as to necessitate the employment of a very weak reed-tension, thereby interfering with the proper contact of the interrupter-points; and second, the high degree of inclination of the lines of force has caused the field strength to increase more rapidly than the displacement-tension of the reed, thereby causing the lag of the spark to depend in great measure upon the adjustment of the screw 34. In other words if the reed 27^a shown in Fig. 8 be adjusted so as to press only lightly against the back spring 36^a and the core be energized, the reed will be attracted as soon as the intensity of the field traversing that reed has become sufficient to overcome the reed-tension. If the screw 34^a be advanced the strain upon the reed will be increased in proportion to its displacement from its point of rest and the field force necessary to attract it increased in like ratio, but the field strength actually exerted upon it will have increased even more rapidly owing to the inclination of the lines of force, and the reed will be attracted upon a less degree of magnetization of the core than in the former case, thus decreasing the lag of the spark and also decreasing its intensity.

According to my invention I extend the primary winding substantially to the end of the core as shown at 11 in Fig. 1, or, if not to the very end of the core, sufficiently near thereto to accomplish the result of increasing the field intensity at this point and decreasing the slope of the lines as shown in Fig. 9. I also adjust the stiffness of the reed with respect to the intensity-gradient of the field so that the increase in the restoring force of the reed due to its deflection is substantially proportional to the resulting increase in field intensity throughout all of the range of ordinary adjustment of the reed. In other words, to paraphrase the

preceding paragraph, if the reed 27 (Fig. 9) be adjusted so as to press only lightly against the back-spring 36 and the coil be energized, the reed will be attracted as soon as the intensity of the field traversing that reed has become sufficient to overcome the reed tension. If the screw 34 be advanced the strain upon the reed will be increased in proportion to its displacement from its point of rest but the field intensity will be increased in like proportion with the result that neither the lag nor the intensity of the spark is changed in any way. The consequence is that an engine operator can adjust the screw 34 to his heart's content without interfering with the regularity of sparking the various cylinders. In addition the greater actual intensity of the field permits the employment of a reed of greater stiffness which will make better contact between the points 28 and 37. Of course, if the angle of the reed shank be changed, either by bending the same or by changing the angle of its support, the lag of the spark will be changed since the absolute intensity of the field necessary to displace it will have been changed. This adjustment, as already explained, is effected by moving the stud 51 and is a delicate operation.

It is impossible to lay down any dimensions or mode of manufacture which will give in all cases the desired result as the inclination of the lines of force at each point depends to some extent upon the length and dimensions of the core, the shape and arrangement of the windings, and the intensity of magnetization. Also the stiffness of the spring depends upon many factors as is well known. It is possible, however, to obtain such a balance between all these factors that both the spark lag and the spark intensity will be substantially unaffected by the wearing away of the points or the adjustment of the screw 34.

The amount of magnetization of the coil is influenced to some extent by the amount of travel of the back spring, since this spring follows the reed for an appreciable distance and maintains contact for a short time after the field intensity has become sufficient to attract the reed. This, however, is always an effect of the back spring and is entirely independent of the actions now disclosed and claimed.

Another and minor feature of my invention relates to the construction of the plate 13. Hitherto a flat metal plate has generally been employed with various joints and an awkward method of securing the same. According to my invention I form this plate of thin sheet metal by pressing it to proper form, as shown in Fig. 4. This plate preferably consists of a flat sheet having its marginal portion bent laterally to form depending flanges 54 and having the portion adjacent to the core 10 bulged outwardly as at 55 to form a hollow open ended boss. This boss is made of sufficient size to receive a ring 56 of rubber or like insulating material. One side of the plate is completely severed by a slot 57 running from the boss 15 to the edge of the plate so as to prevent the formation of eddy currents.

While I have described my invention in considerable detail and particularly the construction of one form of induction coil with which the same may be employed it will be understood that this description is not intended to form a limitation upon me and that the meaning and scope of my invention is to be ascertained only from the claims hereto annexed as interpreted in the light of the prior art.

Having thus described my invention, what I claim is:—

1. In an ignition coil, the combination, with a soft iron core having windings thereon, of a flexible reed mounted adjacent to said core, and movable toward and from the same, the stiffness of said reed being substantially proportional to the distance-gradient of the field in which it is supported.

2. In an ignition coil, the combination, with a soft iron core having primary and secondary windings thereon, of a flexible reed having a head of magnetic material mounted adjacent to the end of said core and vibratable toward and from the same, the distance of the primary windings from the end of the core being so chosen relatively to the stiffness of the reed that the change in field intensity along the core axis shall be substantially proportional to the change in restoring force of said reed throughout the entire range of ordinary adjustment of said reed, and means for changing the angle between the reed-shank and the core-axis.

3. In an ignition coil, the combination, with a soft iron core having windings thereon and a flexible reed mounted adjacent to said core and having a head of magnetic material vibratable toward and from said core, of a contact point carried by the side of said reed away from said core, a second contact point independent of said reed and adapted to engage said first point, and means for moving said second point toward and from said core, said windings being so arranged with relation to the end of said core that the number of lines of magnetic force piercing said head shall be substantially proportional to the pressure of said contact points against each other throughout substantially all of the range of adjustment of said second contact point.

4. In an ignition coil, the combination, with a soft iron core having magnetizing windings thereon and a flexible reed hav-

ing a shank secured at one side of said core and a head of magnetic material adjacent to said core, of a contact point carried by said reed, a second contact point supported independently of said reed and adapted to be engaged by said first contact point when said reed is at rest and to be disengaged when said head is attracted by said core, the windings on said core being so arranged relatively to the end of the core and to the stiffness of the reed that the intensity of the field traversing the reed-head will increase substantially proportionately with the restoring force acting upon said reed due to a deflection from its normal position, and means for changing the angle between the reed-shank and the core-axis whereby the absolute intensity of the field required to displace the reed may be varied.

5. In an ignition coil, the combination with a soft iron core having windings thereon and a flexible reed mounted adjacent to said core and having a head of magnetic material vibratable toward and from said core, of a contact point carried by the side of said reed away from said core, a second contact point independent of said reed and adapted to engage said first point, means for moving said second point toward and from said core, said windings being so arranged with relation to the end of said core that the number of lines of magnetic force piercing said head shall be substantially proportional to the pressure of said contact points against each other throughout substantially all of the range of adjustment of said second contact point, and means for changing the angle between the reed-shank and the core-axis whereby the pressure of contact of said contact points may be increased for all positions of their relative adjustment and the field intensity necessary to their separation likewise increased.

6. In an ignition apparatus, the combination, with an electro-magnetic core and a reed vibratable in proximity thereto, of a sheet metal supporting member comprising a base portion and an attaching portion, said attaching portion being formed by bending upwardly an extension of said base portion so as to overlie the latter, the metal of said member being of a ductile nature to permit relative angular movement of said portions about their attached side, means for securing said base member transversely of said core with the axis of adjustment also transverse thereto, means securing said reed to said attaching portion, and an adjusting screw carried by said base portion and bearing against said upper portion, whereby the angle therebetween may be varied, said upper portion being apertured for permitting access to said screw.

7. In an ignition apparatus, the combination, with an electro-magnetic core member and an attaching surface at one side thereof, of a supporting member secured to said attaching surface, said attaching member having a base portion and a top portion angularly adjustable with respect thereto, a flexible vibrating reed secured to said top portion and overlying the end of said core, an electric contact carried by said reed, a fixed contact coöperating with said first contact, an adjusting device for varying the angle between the portions of said supporting member, and means for shielding said adjusting device from unauthorized manipulation.

8. In ignition apparatus, the combination, with an electro-magnetic core member and an attaching surface substantially perpendicular thereto, of a supporting member secured to said attaching surface at one side of said core, said attaching member having a base portion and a top portion angularly adjustable with respect thereto, a flexible vibrating reed secured to said top portion and overlying the end of said core, a circuit breaking contact carried by said reed, and adjusting means carried by one of said portions and accessible only through an aperture in the other of said portions.

9. In ignition apparatus, the combination, with an electro-magnetic core member and an attaching surface substantially perpendicular thereto, of a supporting member secured to said attaching surface at one side of said core, said attaching member having a base portion and a top portion angularly adjustable with respect thereto, a flexible vibrating reed secured to said top portion and overlying the end of said core, a circuit breaking contact carried by said reed, adjusting means carried by one of said portions and accessible only through an aperture in the other of said portions, said aperture being smaller than said adjusting means, and means for closing said aperture.

10. In ignition apparatus, the combination, with an electro-magnetic core member and an attaching surface substantially perpendicular thereto, of a supporting member secured to said attaching surface at one side of said core, said attaching member having a base portion and a top portion angularly adjustable with respect thereto, a flexible vibrating reed secured to said top portion and overlying the end of said core, a circuit breaking contact carried by said reed, both of said portions having substantially alined apertures therein, a threaded stud mounted in the aperture of said base portion and having a slotted end presented toward the aperture of the top portion and accessible only through such aperture, and means adapted to be inserted in the aperture of said top portion so as simultaneously to prevent access to said stud and secure said reed in place.

11. In an ignition apparatus, the combination, with an electro-magnetic core member and an attaching surface substantially perpendicular thereto, of a supporting member secured to said attaching surface at one side of said core, said attaching member having a base portion and a top portion integral therewith formed by folding an extension of the base portion so as to cause it to overlie the same, said metal being of a flexible ductile nature to permit relative angular movement of said portions about their point of attachment and said base member having a threaded aperture at a point removed from such point of attachment, said upper portion also having a threaded aperture substantially in alinement with said base aperture, an adjusting stud threaded into said base aperture, and having a slotted end presented toward the aperture in said upper portion, said stud being arranged to press against the lower face of said upper portion, a flexible vibrating reed secured to said upper portion and overlying the end of said core, a circuit-breaking contact carried by said reed, and threaded means adapted to be inserted in said upper aperture to cover said stud and secure said reed.

12. In an induction coil for internal combustion engine ignition, the combination, with a soft iron core having primary and secondary coils thereon and a vibrating interrupter magnetically operated by the end of said core, said core being provided with a winding of primary wire substantially to the extreme end which is nearest said vibrator, of means for adjusting the vibrator toward and from the core.

13. A supporting member comprising a base portion and an attaching portion, said portions being angularly adjustable with respect to each other, and adjusting means carried by one of said portions and accessible only through an aperture in the other of said portions.

14. A supporting member comprising a base portion and an attaching portion, said portions being angularly adjustable with respect to each other, adjusting means carried by one of said portions and accessible only through an aperture in the other said portions, said aperture being smaller than said adjusting means, and means for closing said aperture.

15. A supporting member comprising a base portion and an attaching portion, said portions being angularly adjustable with respect to each other, and both of said portions having threaded apertures therein, certain of said apertures being in substantial alinement with each other, a threaded stud mounted in the aperture of one of said portions and accessible only through the aperture of the opposite portion, and a threaded member adapted to be mounted in the aperture of said last portion and to cover and prevent access to said stud.

16. A supporting member comprising a base portion and an attaching portion, said portions being angularly adjustable with respect to each other, and both of said portions having substantially alined apertures therein, a threaded stud mounted in the aperture of said base portion and having a slotted end presented toward the aperture of the attaching portion, and means adapted to close the aperture of the last portion so as to prevent access to said stud.

17. A supporting member comprising a base portion and an attaching portion, said portions being angularly adjustable with respect to each other, said base member having a threaded aperture at a point removed from the pivotal axis between said base and upper portions, and said upper portion having a threaded aperture substantially in alinement with said base aperture, an adjusting stud threaded into the aperture in said base portion and having a slotted end presented toward the aperture in said upper portion, said stud being arranged to press against a portion of the lower face of said upper portion, and threaded means adapted to be inserted in the aperture in said upper portion whereby said stud is covered.

18. A supporting member comprising a base portion and an attaching portion, said attaching portion being formed by bending upwardly an extension of the base portion so as to cause it to overlie the latter, said metal being of a flexible, ductile nature to permit relative angular movement of said portions about their attached side and said base member having a threaded aperture at a point removed from the pivotal axis between said base and upper portions, said upper portion also having an aperture substantially in alinement with said base aperture, an adjusting stud threaded into the aperture in said base portion and having a slotted end presented toward the aperture in said upper portion, said stud being arranged to press against the lower face of said upper portion, and threaded means adapted to be inserted in the aperture in said upper portion whereby said stud is covered.

In testimony whereof, I hereunto affix my signature in the presence of two witnesses.

JOSEPH A. WILLIAMS.

Witnesses:
HAROLD E. SMITH,
BRENNAN B. WEST.