Building An 8 Inch Spark Coil

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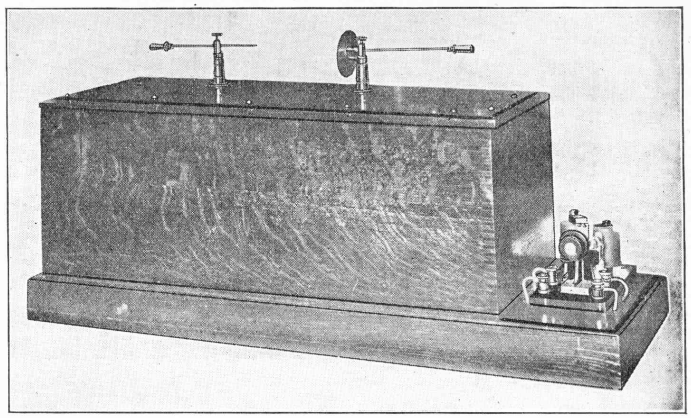


Spark coils are not used so extensively in radio and other electrical work as they once were, but dozens of experimenters often desire to build a large spark coil for operating X-ray tubes and carrying on many other interesting experiments and researches. The present article contains data for building an induction coil giving a spark 8 inches long when it is operated on battery current at 18 volts potential; the current taken by it at this voltage is about 1 amperes, or the coil consumes approximately 80 watts. On lower voltages, the length of spark produced by the coil will of course be proportionately less. Several of these coils were built exactly as here described for commercial purposes some years ago, from the author's original design; the only difference in the coils built and the one here described is that a separate or independent magnetic interrupter was utilized, as the photograph of the finished coil shows, but the writer has built coils fitted with a double spring interrupter of the type shown in the drawings, with excellent success.

Primary Winding of 8 inch Spark Coil.

Before the primary winding can be put on the annealed iron wire core will have to be either made or purchased. This core is composed of as fine iron wire as possible. and a compact bundle 23 inches long by 1-1/2 inches in diameter should be used. This core should be annealed to the highest degree possible, and this point can be ascertained by means of a small pocket compass. First, the core is magnetized by placing it inside of a coil, through which battery current is passed, or else the core may he placed in contact with a powerful magnet. What we want to measure is the retentivity of time iron for magnetism. When the current is shut off or the core separated from the magnet, the compass needle is brought near the ends and it should be barely attracted. thus showing that very little magnetism is retained by the core. If the core is not thought to be annealed sufficiently it can be further softened in one of several ways. One method is to place it on top of a coal fire in a stove or furnace until it becomes a light cherry red or nearly so; it is then removed with pincers or tongs and buried in the ashes under the grate and left to cool very slowly for several hours. Some spark coil builders anneal cores in a gas or electric stove, reducing the heat after the initial light red point has been reached about every half hour, when finally very little heat is applied to the core. This gives the same results as the first method.

After the iron wire core is sufficiently annealed it should be insulated by wrapping five layers of oiled linen or Empire cloth around it; either a wide strip or else tape may be used. Over this insulation the primary winding is wound, which consists of two layers of No. 12 B. & S. gage D.C.C. magnet wire. The primary winding when completed may he given a good coating of orange shellac or else it may be soaked in hot paraffin wax or dipped in melted sulphur. The primary core and winding is slipped into an insulating tube, as shown in time drawings.

The insulating tube, separating the primary and secondary windings, must be very substantial and is to be composed of hard rubber, glass, bakelite, fibre, or micanite. Bakelite and micanite are probably the two best choices. This insulating tube measures 23 inches long and has a 5/16 inch wall. The inside diameter of the tube is 2 inches and the outside diameter 2-5/8 inches. If the primary and core are a little small for the tube,

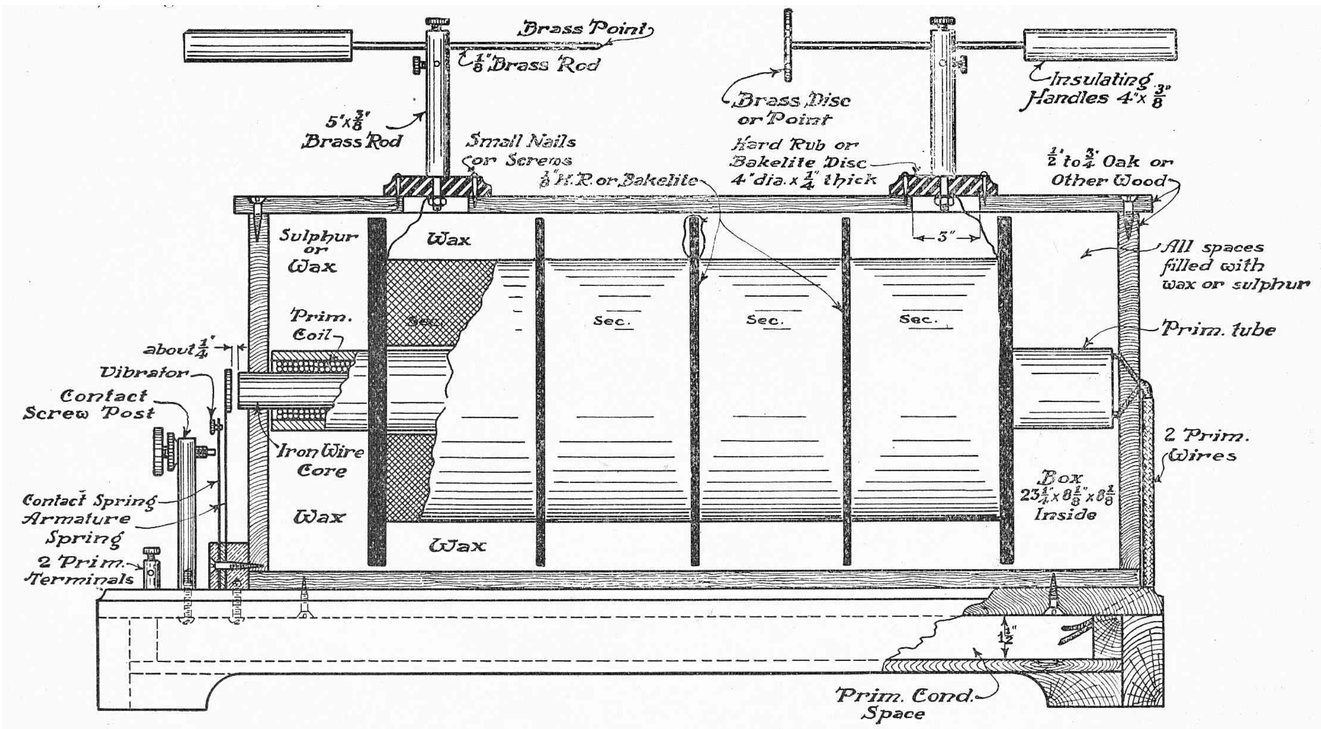


Fig. 1

they may be wrapped with a layer or two of oiled linen or waxed paper, so as to fit in the tube snugly, and also to be centrally located within it.

The Primary Condenser and Interrupter.

The tinfoil and waxed paper primary condenser for the 8 inch spark coil may be made up in several ways. In the first place many experimenters will probably not want to bother to make the large condenser which is necessary, and will endeavor to purchase one of the proper size, or several small ones which can be connected in parallel to give the necessary capacity of 2.32 microfarads. The condenser of this coil will require 8,500 square inches of paraffin paper measuring .003 inch thick, coated on both sides with charging foil; or we may use 106 sheets of paraffin paper measuring 10 inches x 12 inches, with 107 tinfoil leaves measuring 8 inches x 10 inches each. The drawing Fig. 2 shows how the condenser is built up and also the manner in which connection tabs may be brought out from different sections of leaves at the successive corners of the condenser. it is not particularly necessary to arrange the condenser with switches or drum controller, as shown in Fig. 2, but where the coil is to be operated at different voltages this feature is often desirable, as the amount of capacity shunted across the vibrator is greater as the primary voltage is increased; likewise it becomes smaller the faster the interrupter operates, so that when we have an electrolytic interrupter the speed of interruption is so rapid that no capacity at all is necessary or desirable.

The paper used in building the condenser may be ordinary white writing paper or typewriter paper which can be purchased at any stationery shop. The thickness should be checked before waxing with a micrometer. and it should be within a thousandth of an inch or less to the specifications. The paper sheets are paraffined by using a large drip pan in which several pounds of paraffin wax is melted. Care should be taken not to

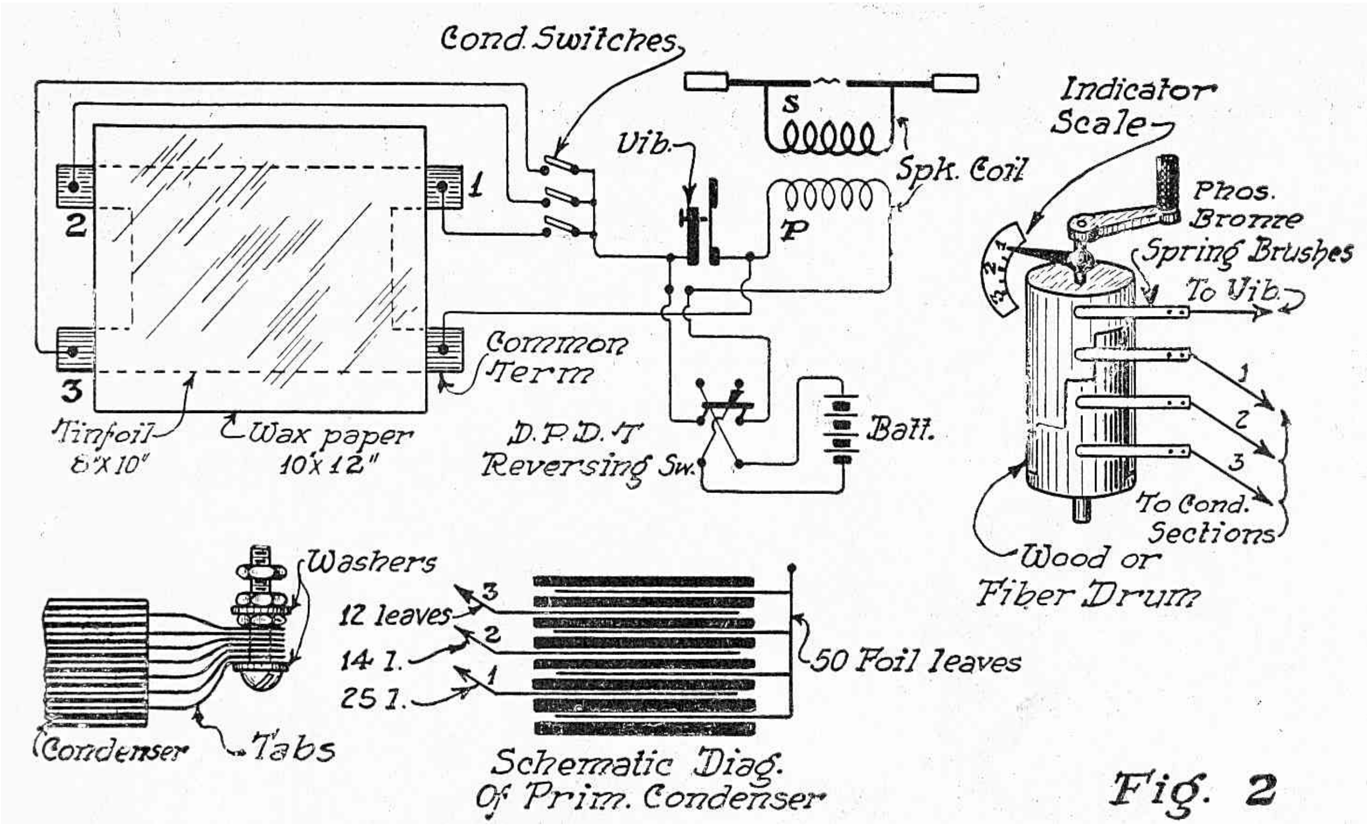
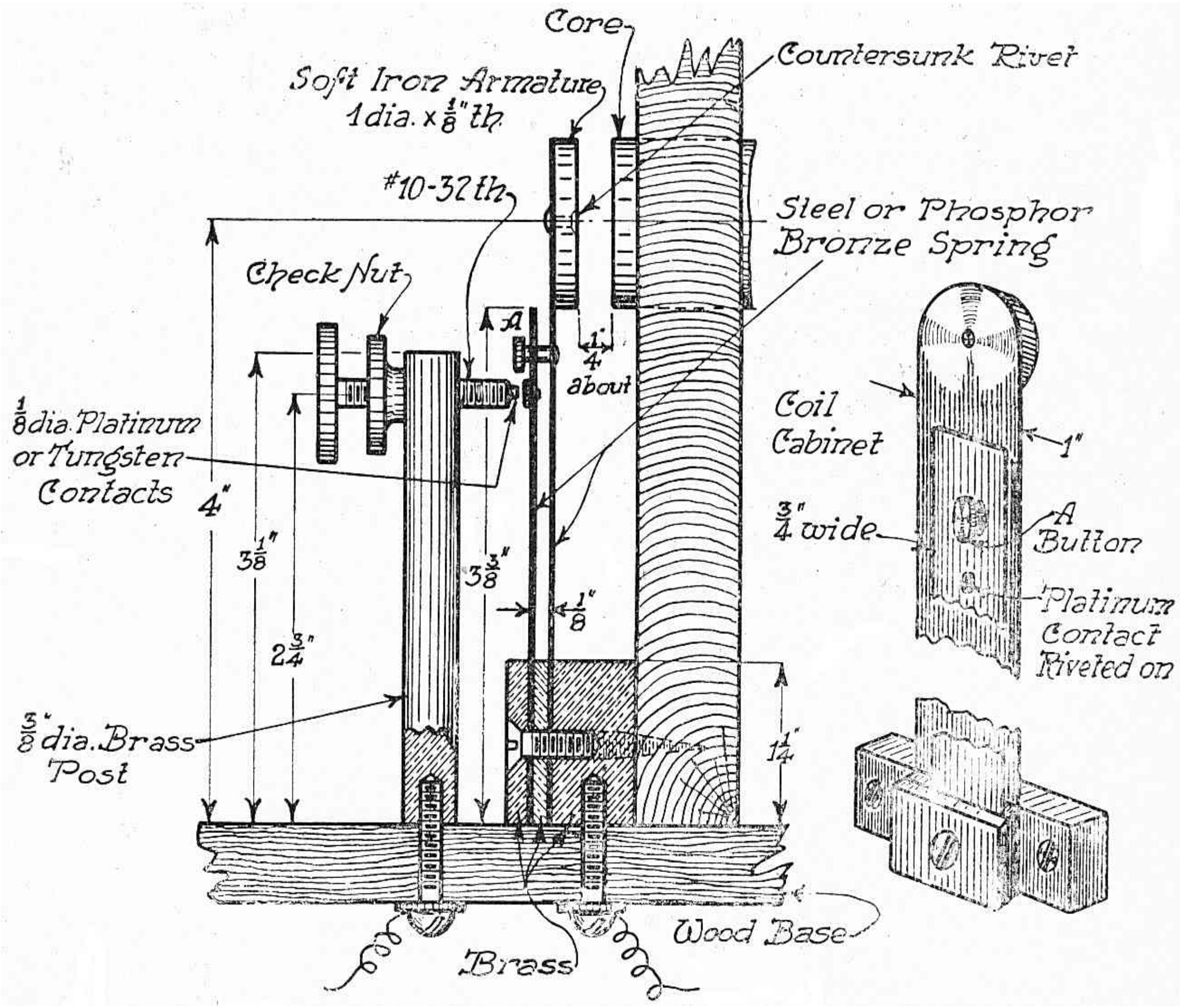


Fig. 2

overheat the paraffin as this destroys some of the insulating qualities. The paper is waxed one sheet at a time. Thin copper or aluminum foil may also be used instead of tinfoil without lowering the efficiency. The tinfoil tabs forming a terminal may be tightly connected together by means of two large washers and a machine screw with nuts. In assembling the condenser, every other tinfoil sheet is connected to the common terminal, as the diagram shows. Terminal 1 if the condenser is made adjustable, comprises all the tabs from the first 25 alternate foil sheets which are not connected to the common terminal. Terminal 2 comprises the next 14 alternate foil leaves, while terminal 3 includes the final 12 alternate foil leaves. Note that condenser switches in any case have to retain their first connections as additional capacities are switched in. The author has generally preferred the drum type controller illustrated in Fig. 2 for switching and retaining in circuit the successive condenser units.

The double spring vibrator which has been used by the writer on spark coils of all sizes up to 12 inches, is shown in Fig. 3. The contact spring may be made about half the thickness of the armature spring which carries the soft iron button at its upper end. This interrupter gives the highly desirable long make and quick break action, which results, as actual tests have proven, in giving about twice the spark length for a given coil, in comparison to the old single spring vibrator which rarely permits the core to become fully magnetized before breaking the circuit.

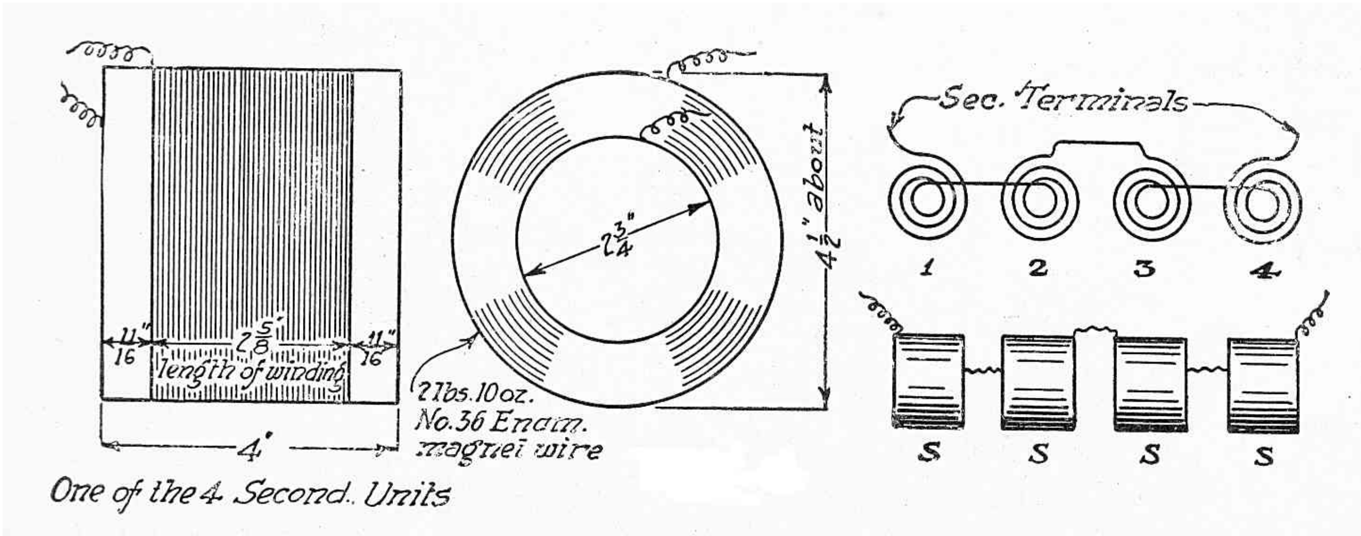
The general dimensions of the vibrator parts are given in Fig. 3 and these may be departed from to some extent without appreciably affecting the results obtained. It will be seen that the armature spring and soft iron hammer head, when it is attracted by the iron wire core projecting thru the cabinet, will move forward some distance before button A, on the rear of the spring touches the contact spring proper. The hole in the contact spring through which the stem of the button moves should be made sufficiently large so that the action is free and positive. After building the coil and trying out the interrupter, the length of the button stem may have to be changed Until the circuit is broken at the most desirable time to give the maximum secondary spark. One-eighth inch diameter platinum or tungsten contacts should be used on the contact screw and spring and in some cases where these are not available, silver may be utilized



Secondary of 8 inch Spark Coil.

For average use it has seemed like too much labor to wind the secondary of even as large coil as an 8 inch one in small pies or sections, a fraction of an inch think although this gives a very reliable coil and one not likely to break down its insulation very easily The present design which has been built and tested successfully, calls for but four secondary windings each unit measuring 4 inches long over-all. The drawing in Fig. 4 shows how the secondary units are wound and also how every other one is reversed when placed on the insulating tube during the assembly of the coil so that the current will pass around the secondary coils always ill the same direction, while the lead wires from the unit coils will he connected together so as not to engender flash-overs or short-circuits

Each of the four secondary coils should I be wound as follows: Wire required for each unit will he 2 pounds 10 ounces of No. 3 B. & S. gage enameled copper magnet wire, or a total of 10-1/2 pounds being required in winding one of these secondary units, paraffin paper 4 inches wide should be cut from sheets either purchased or waxed by the builder, the paper being .003 inch thick, measuring the parer before waxing of course. A layer of this paper should be placed between every layer of wire, the coil being wound on a wooden mandrel 2-1/4 inches in diameter, supporting the mandrel in a lathe or between two wooden uprights fastened to the work table. The outside diameter of the secondary units will measure about 4-1/2 inches. The waxed paper will extend 11/16 inch beyond the wire at each end of the layer, the length of a wire layer being 2-5/8 inches. By getting in touch with electrical winding concerns or spark coil manufacturers, these secondaries can very frequently be purchased at a labor-saving price, as it is quite a job to wind them. When all of the



secondaries have been wound, they are placed on the insulating tube, as shown in the assembly drawing Fig. 1 with insulating disks between them, the disks separating the coils being about 1/8 inch thick and composed of hard rubber, bakelite or even fibre And equivalent thickness of paraffin paper sheets has also been employed. At either end of the secondary assembly there is placed a thicker square insulating piece measuring preferably about 1/4 inch thick or more. By referring to Fig.4 it becomes evident how the two inside leads of sections 1 and 2 are connected together, then the two outside leads of sections leads of sections 2 and 3 and finally the two inside leads of sections 3 and 4. This same scheme of reversing every other coil unit on the tube so as to obviate the possibility of having a high voltage lead passing across all of the layers of wire at the end of a coil, is employed for spark coils having a greater number of sections. After the complete coil is placed in the box, the latter should be filled with woltein, paraffin, wax or sulfur.

Operation of the Spark Coil

The diagrams in Fig. 5 show several ways of operating the 8 inch spark coil. At "A" the circuit is shown for utilizing an electrolytic interrupter; it will usually be found desirable to employ an adjustable choke coil in series with the interrupter to control the current more effectively. This coil will give a 6 inch to 7 inch heavy flame at the secondary terminals when operated with an electrolytic interrupter from 110 volts D. C. or A.C. It is not desirable to operate this coil from alternating current as an open-core transformer, for it is not designed for that purpose, but it can be experimented with by using the proper adjustable choke coils or auth-transformer in the primary circuit to control the amount of current consumed. It will give a very much shorter spark with 110 volts 60 cycle A. C. passing thru the primary of course, possibly an inch or so in length.

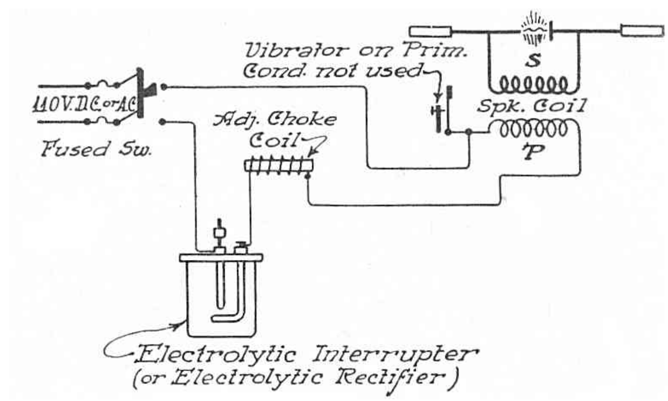


Fig 5A

An interesting experiment maybe tried out with this spark coil in connection with 110 volts A. C. 60 cycle service, using instead of an electrolytic interrupter, an electrolytic rectifier, composed of alternate aluminum or lead plates immersed in a glass jar containing a saturated solution of sodium bicarbonate. The closed core transformers as well as open core types used on many of the high voltage X-ray sets operate in this fashion. An adjustable choke coil or other means of control should be inserted in series with the rectifier and the primary of the a spark coil. When using either the electrolytic interrupter or the rectifier, it should be noted that the usual primary condenser and vibrator are left out of circuit. The rectifier clips off the half-waves of the A. C. cycle. Fig. 5-D shows spark coil being operated from 110 volts D. C. by means of a potentiometer style resistance.

Fig. 5-B shows the 8 inch spark coil connected to a glass plate condenser and Tesla or Oudin high frequency coil, several excellent types suitable for this spark coil having been described in detail by the author in the last issue of PRACTICAL ELECTRICS. Fig. 5-C shows the spark coil connected to au X-ray tube. When using a spark coil for operating X-ray tubes to the highest efficiency, the inverse current is partially eliminated by placing rectifier tubes in series with the secondary lead wires, as shown. A short spark-gap in series with one of the leads also helps to eliminate the weaker or inverse wave.

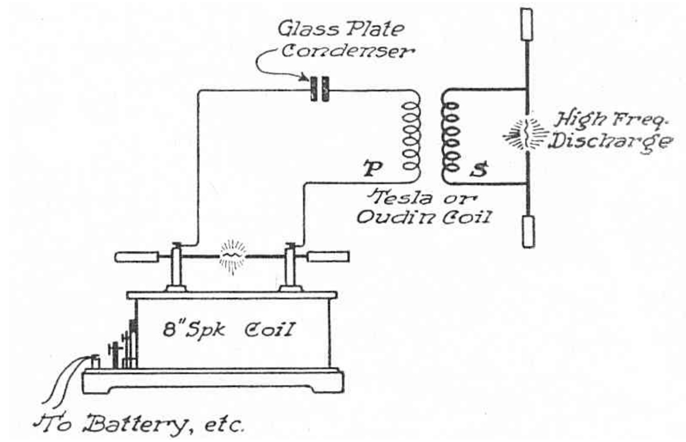


Fig 5B

In testing the length of spark from any induction coil, steel needle points should be used on both secondary terminals and care taken not to separate these beyond the sparking capacity of the coil or else the secondary will be under a severe strain and will possibly rupture its insulation. The polarity of the secondary current may be reversed with a double-pole, double-throw knife switch, or a double-pole drum controller connected in the primary circuit as shown in Fig. 2. By means of pole-test paper, commonly used for checking up the positive and negative wires on D. C. circuits, the polarity of the secondary terminals can be determined. Another way of testing the polarity of the secondary terminals is to attach two pieces of fine iron wire to the secondary terminals, and, when the spark passes between them, the one which remains cold is the positive terminal, while the one that becomes very hot is the negative. In operating X-ray tubes, the polarity will invariably be indicated at once, as, when the wrong terminal is connected to the anode of the tube, it will light up in different manner than formerly. The potential of the spark between needle points, with gap measuring 8.35 inches long is 90,000 volts. This value is for a sine wave form current such as is produced by the usual electric light and power alternator supplying current for lamps and motors. However, as the amplitude factor for the spark coil secondary current is approximately 3.23 the maximum potential of the 8.35 inch spark is approximately 290,700 volts; the value of 90,000 volts being the mean-square root value of a sine wave potential yielding a spark 8.35 inches long.

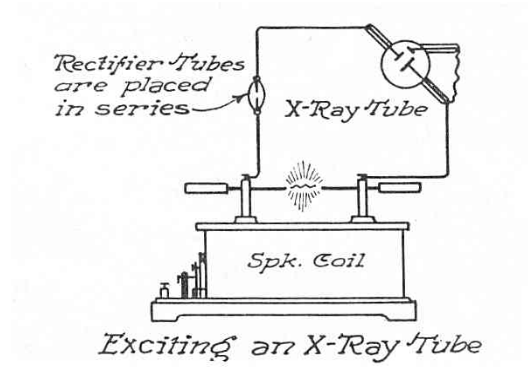


Fig 5C

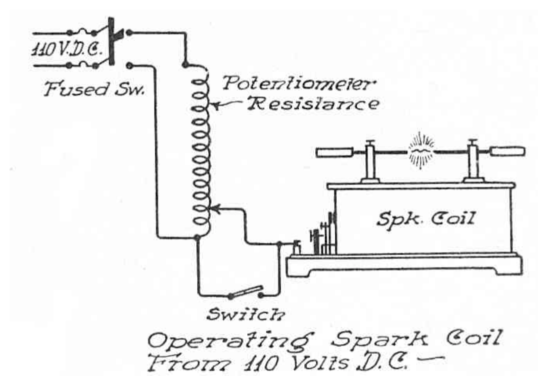


Fig 5D

Building an Independent Magnetic Interrupter

Data is given herewith, as well as in the drawing, Fig. 6, for building an independent magnetic interrupter for those who may desire to operate the 8 inch spark coil in this fashion. The principal advantage of the independent interrupter is that you can adjust the speed of interruption and maintain it, which is not always the case with the spring interrupter fitted on the end of the induction coil itself, as the magnetic pull of the spark coil core acting on the vibrator will fluctuate with the changes in the secondary load.

The two magnet coils may be purchased or else made by the constructor himself. They should have a resistance of 3 to 4 ohms. The dimensions of the magnet coil bobbins are given in Fig. 6. Each bobbin is insulated with a piece of paper wrapped around the iron core between the fibre cheeks and 14 layers of No. 20 S. C. C. copper magnet wire is wound on each spool. They should be connected in series as shown, so as to give north and south poles at the pole-pieces. All iron parts for the magnet including the iron armature, are constructed of annealed wrought iron, which can be purchased at any blacksmith's or machine supply house. The electro-magnet here described is suited for operation on 6 to 8 volts, and the method of connecting the interrupter is shown in Fig. 6. The dimensions of the main spring ,A, supporting the iron armature as well as

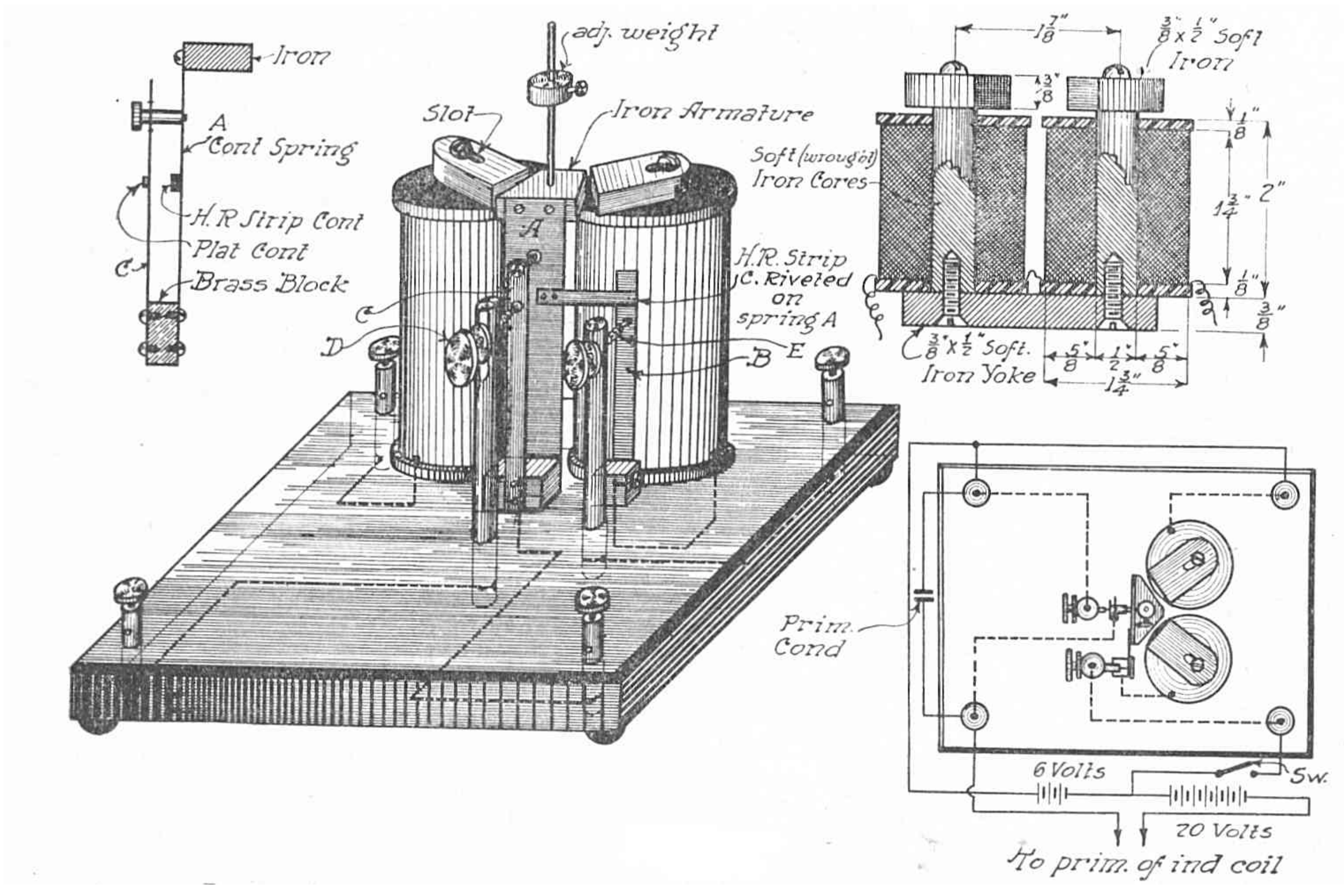


Fig. 6

the lighter spring ,C, carrying the heavier platinum contact, are proportioned like those described for the interrupter built on the end of the coil, and shown in detail in Fig. 3. On the main steel or phosphor bronze spring, A, there is riveted or otherwise secured, a small 1/16 inch thick strip of hard rubber, bakelite, or fibre. This insulating strip breaks the auxiliary contacts for the magnet circuit, as the armature spring moves forward. The brass blocks, on which the springs are separately mounted, are secured to the base' by machine screws passing up from underneath, threaded holes being tapped in the brass blocks to accommodate them. The main contacts on spring ,C, and screw, D, which may be of tungsten, platinum or even silver, should measure about 1/8 inch in diameter or more. The auxiliary contacts on spring ,B and contact screw ,E, may be ordinary small size ones taken from an old electric bell.

The primary condenser is now connected to the binding post leading to the main contact post ,D, and the base of spring ,A. The shunt interrupter circuit is taken off at a sufficient number of cells to give 6 to 8 volts. These cells, in connection with additional ones, form the main battery energizing the primary circuit of the spark coil. If desired, a small condenser may be shunted across the auxiliary contacts of the interrupter to reduce sparking. The sliding weight on the armature rod permits the speed of the interrupter to be regulated very accurately. When the weight is clamped in a high position, the frequency of interruption is lowest; when the weight is clamped in a position near the armature or removed altogether, the rate of interruption is at a maximum potential of the 8.35 inch spark is approximately 290,700 volts; the value of 90,000 volts being the mean-square root value of a sine wave potential yielding a spark 8.35 inches long.

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