

June 7, 1949.

W. G. MAYER

2,472,115

TRIGGERED SPARK GAP

Filed June 25, 1943

FIG. 1.

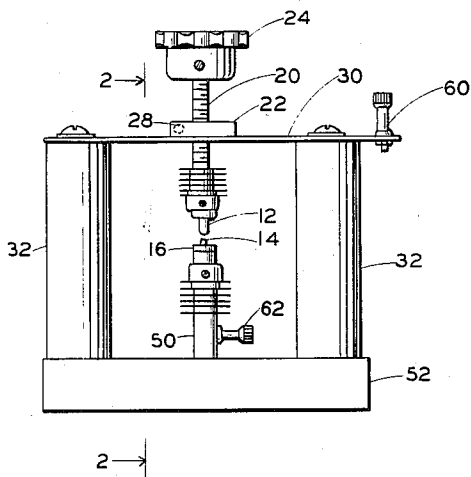


FIG. 3.

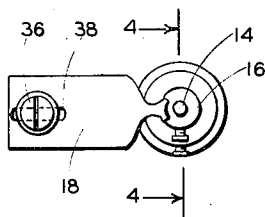


FIG. 4.

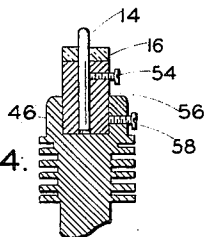


FIG. 5.

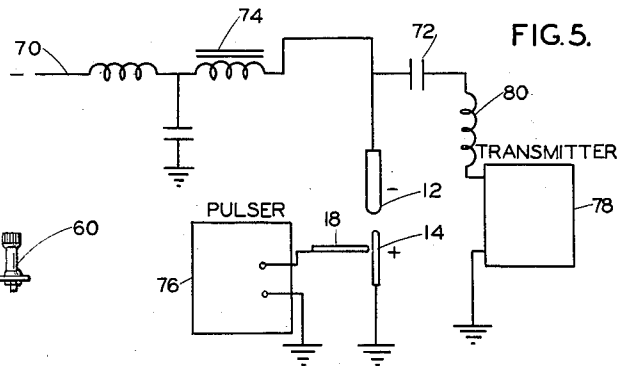
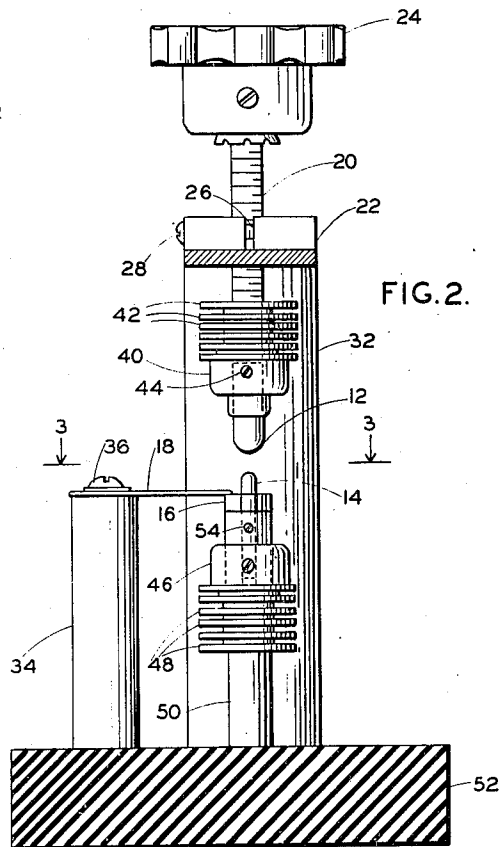


FIG. 2.



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2,472,115

TRIGGERED SPARK GAP

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Application June 25, 1943, Serial No. 492,232

5 Claims. (Cl. 250—38)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to spark gap modulators or keyers, and more particularly to such a spark gap in which the timing of the spark is controlled by means of a third, or triggering, electrode.

Stationary gaps have been used to modulate or key a pulse transmitter, but suffer from the disadvantage that the spark, and consequently the resulting pulse, is aperiodic. To provide periodicity it has been proposed to use a rotary spark gap, but it has been found that even with a rotary gap a slave sweep oscilloscope is needed because of an error of, say, 50 to 100 microseconds in the control. Moreover, there is the added complication and expense of a motor and mechanical mounting for high speed rotation.

The primary object of the present invention is to generally improve spark gap modulators or keyers. A more particular object is to overcome the foregoing disadvantages and to provide a stationary spark gap in which the main pulse is very accurately controlled by a triggering pulse. A more detailed object is to provide a triggered spark gap in which there is practically no wear at the triggering electrode. Still further objects are to provide a triggered spark gap which is simple; cheap; readily adjustable; and useable over wide ranges of potential and pulse frequency.

To accomplish the foregoing and such other objects as will hereinafter appear, my invention consists in the spark gap elements, and their relation one to the other, as hereinafter are more particularly described in the specification and sought to be defined in the claims. The specification is accompanied by a drawing in which

Figure 1 is a front elevation of a triggered spark gap embodying features of my invention;

Figure 2 is a transverse section drawn to an enlarged scale taken approximately in the plane of the line 2—2 of Figure 1;

Figure 3 is a plan view of the triggering electrode looking in the direction of the arrows 3—3 in Figure 2;

Figure 4 is a vertical section through the lower electrode taken approximately in the plane of the line 4—4 of Figure 3;

Figure 5 is a schematic wiring diagram explanatory of a typical circuit using the triggered spark gap.

Referring to the drawing, and more particularly to Figures 1 and 2, the spark gap comprises main electrodes 12 and 14, with a gap therebe-

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tween. The electrodes are preferably coaxially arranged, as shown. In accordance with a feature of the present invention, an insulation washer 16 surrounds the electrode 14 near the gap. The washer is preferably made of glass or other ceramic. A triggering electrode 18 is positioned with its working end resting upon the washer 16 near the main electrode 14.

The complete structure is preferably provided with means affording adjustment of the spacing between the main electrodes. In the present case, the upper electrode 12 is carried at the lower end of an adjusting screw 20, which is threadedly received in a stationary nut 22. A knob 24 of insulating material carried at the upper end of screw 20, facilitates adjustment of the main gap. It is desirable to provide means to lock the adjustment and, in the present case, the nut 22 is a block of metal split at 26 and provided with a clamping screw 28. Block 22 is carried on a cross-bar 30, supported by insulation pedestals 32. It will be understood that the solid end of block 22 is brazed or otherwise secured to cross-bar 30, while at least one of the split sides of the block is left free to permit clamping movement under the action of clamping screw 28.

The spacing between the triggering electrode 18 and the cooperating main electrode 14 is also preferably made adjustable. Referring to Figures 2 and 3 it will be seen that triggering electrode 18 is carried on an insulation pedestal 34, and is fixed in position by means of a screw 36. Screw 36 passes through a slot 38 in electrode 18, and this slot permits movement of the triggering electrode toward or away from the main electrode.

It will be noted that the main electrodes 12 and 14 are substantially different in diameter. The large diameter electrode 12 is used as a cathode, thereby reducing the rate of consumption of the same. As the cathode is consumed, the main gap may be readjusted to desired size by means of the adjusting screw 20 and knob 24, previously referred to. The smaller diameter electrode 14 is used as an anode, and it is this electrode that is surrounded by the glass washer 16. The triggering electrode 18 may be a flat strip of metal, as shown, and its inner or working end is preferably curved on an arc concentric with the anode 14. I have found that a triggering electrode which only partly surrounds the main electrode is superior to the use of a ring wholly surrounding the main electrode. However, it is not necessary to reduce the arc of the triggering electrode to the comparatively small fish-tail shape shown in Figure 3 of the drawing. In fact, a ring almost but not completely surrounding the main electrode is

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satisfactory, although not as good as the illustrated fish-tail shape. I have found that the ring should be at least split or cut open at one point, and that it is not desirable to use a completely closed ring.

The triggering electrode is preferably held in contact with the glass washer. I have found that the presence of the glass washer, with the triggering electrode resting thereon, makes considerable difference in the successful operation of the gap, although the exact reasons for the improvement are still obscure and must be deemed an empirical discovery.

The electrodes are all preferably made of a suitable high temperature metal. Tungsten is very satisfactory for the main electrodes 12 and 14, and molybdenum is most satisfactory for the triggering electrode 18, but tantalum or tungsten may also be used for the triggering electrode. Despite the use of such high temperature metals, there is a tendency toward volatilization and consumption of the electrode material. This tendency may be inhibited by holding down the temperature of the electrodes. With this object in view, the main electrode 12 is socketed in a larger body 40 of a preferably heat-conductive and electrically-conductive metal, such as copper or aluminum. To provide maximum cooling surface, the body 40 is preferably cut to form a series of relatively thin cooling fins 42. The body 40 is secured to the lower end of the adjusting screw 20, and the cathode 12 is preferably detachably received in body 40, it being releasably held by suitable means, such as set screw 44, so that it may be replaced when consumed.

The anode 14 is similarly removably socketed in a larger body of metal 46, which is also preferably heat-conductive and electrically-conductive (typically copper or aluminum), and which may be cut to provide cooling fins 48. This body may be formed integrally at the upper end of a post 50, the lower end of which is secured to the insulation base 52 of the spark gap. The electrode 14 is held by a set screw 54, as is best shown in Figure 4, and in this case the set screw serves the additional function of affording axial adjustment of the position of electrode 14. Inasmuch as this electrode is used as the anode, there is substantially no consumption of the same, but axial adjustment is desirable in order to make it possible to adjust the axial distance between the working end of the electrode 14 and the working end of the triggering electrode 18. From another viewpoint, it may be said that the adjustment is intended to control the spacing of the glass washer 16 from the end of electrode 14, this spacing being important to secure best operation. Inasmuch as the triggering electrode is kept in contact with the glass washer, both adjustments amount to the same thing.

In the particular structure here shown, the electrode 14 is carried in an intermediate holder 56 (see Fig. 4), which in turn is set into the main holder 46, and is there locked in position by a set screw 58. However, it is equally satisfactory to make the entire holder out of one piece of metal, that is, to make the parts 46 and 56 integral.

No special means is here shown to cool the triggering electrode 18, other than the formation of this electrode at the end of a relatively wide plate of metal, thus providing a substantial cooling surface. In any case, cooling of the triggering electrode is not very important with my improvement, because the triggering electrode runs cool, and is only very slowly, if at all, consumed. Under

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optimum adjustment the gap will run with no visible spark between the triggering electrode and the cooperating main electrode, the only visible spark being the main spark between the main electrodes.

External connection to the upper electrode is made by means of a binding post 60 (see Figure 1), carried on the top of cross-bar 30. Connection to the lower electrode is made by means of a binding post 62 mounted on metal post 50. Connection to the triggering electrode 18 may be made by means of the screw 36 previously referred to, or by means of another binding post, not shown.

The upper end of the lower electrode or anode is preferably rounded, as shown in the drawing. The lower end of the upper electrode or cathode may be left square, or may be rounded as shown, if desired. The shape is not too important because after long wear the upper electrode becomes concave because of consumption of electrode material.

For purposes of illustration, but not in limitation of the invention, one example of a circuit using the triggered spark gap is shown in Figure 5. Referring to that figure, high voltage D. C. may be supplied at 70, and is used to charge a relatively large storage condenser 72. A choke 74 in series with the D.-C. supply serves the dual function of boosting the available charging potential and also of insuring termination of the spark when the condenser discharges. The available potential is selected to be high, but not high enough to break down the main spark gap. The triggering electrode 18 is supplied with a control pulse from a suitable pulse generator 76. This potential is high, but only a fraction of that available for the main gap 12-14. The pulse provided by breakdown of the main gap is used to modulate a transmitter 78. The circuit of Figure 5 is primarily a test circuit. For actual transmission purposes, the condenser 72 and choke 80 may be replaced with an artificial line or a network of limited impedance to shape or square the pulse. If desired, the connection between the artificial line and the transmitter may be made through a so-called "pulse-transformer," that is, a transformer designed to successfully transmit a square pulse.

With the present spark gap it has been found that the control pulse controls the accuracy of the main pulse (that is, so-called "jitter" is held down) to within a few one-hundredths of a microsecond. Such gaps have already been run and are still running on a very long life test at 14,000 volts (including the voltage-doubling action of the choke) with a 1 microsecond pulse, at a rate of 200 pulses per second.

There is practically no visible spark between the triggering electrode and the main electrode, which probably explains the negligible wear of the triggering electrode. It produces an ionization or slight corona which immediately leads to breakdown of the main gap.

In a particular spark gap which I used with considerable success, the upper electrode was a $\frac{1}{4}$ " tungsten rod used as a cathode; the lower electrode was a $\frac{1}{16}$ " tungsten rod used as an anode; the triggering electrode was a molybdenum plate 0.02 inch thick; and the glass washer was $\frac{3}{8}$ " in diameter and $\frac{1}{8}$ " thick. The main gap was approximately $\frac{1}{8}$ " in length, and the trigger gap was approximately $\frac{1}{16}$ " in length. The anode projected above the glass washer $\frac{1}{8}$ ". As an example of the control effect, it may be stated that the gap may be made to break down at 8,500

volts initial potential (not counting the double action of the choke), although it would require 18,000 volts to break down the same gap when not using the triggering electrode. It should be understood that these specific dimensions are given by way of example, and not in limitation of the invention.

It is believed that the construction, operation and method of using my improved spark gap, as well as the advantages thereof, will be apparent from the foregoing detailed description. The gap is simple; cheap; readily adjustable; and usable over wide ranges of potential and pulse frequency. There is practically no wear of the triggering electrode, and any wear of the cathode is readily made up by adjustment. There is practically no "jitter," for the accuracy of control is kept to within a few one-hundredths of a micro-second. How the glass washer influences the operation of the gap is still obscure, but there is no question about the benefit of this improvement.

It will be apparent that while I have shown and described my invention in a preferred form, changes and modifications may be made in the structure disclosed without departing from the spirit of the invention as sought to be described in the following claims. In the claims I have for convenience used the term "glass" but this is not intended to exclude the use of other equivalent ceramics, and other high temperature insulation, such as Mycalex and mica.

I claim:

1. A triggered spark gap operable in air comprising main electrodes with a gap therebetween, a ceramic washer surrounding one of said electrodes near said gap, and a triggering electrode having its working end adjacent the aforesaid ceramic washer near the electrode carrying said ceramic washer, said working end being substantially an arc of less than 360° substantially coaxial with said last mentioned electrode.

2. A triggered spark gap operable in air comprising coaxially arranged first and second main electrodes disposed end to end with a gap therebetween, a glass washer surrounding said first main electrode near said gap, and a flat metal triggering electrode positioned transversely of the main electrodes and having its working end adjacent the aforesaid glass washer and partially but not wholly surrounding said first main electrode.

3. A triggered spark gap operable in air comprising two main electrodes with a gap therebetween and a triggering electrode having its working end adjacent one of the main electrodes and spaced from the spark path between said main electrodes, a source of high-voltage across said main electrodes, which source alone is of insufficient magnitude to break down the gap and cause spark discharge between said main electrodes, a source of voltage between the triggering electrode and the adjacent main electrode of sufficient magnitude to cause corona but not spark discharge therebetween, so as to thereby trigger a spark discharge between the main electrodes.

4. A triggered spark gap as defined in claim 3 wherein the triggering electrode is disposed substantially perpendicularly to the adjacent main electrode and said triggering electrode includes a working end which is of substantially arcuate configuration of less than 360° and is substantially coaxially positioned relative to the said adjacent main electrode.

5. A triggered spark gap as defined in claim 3 which includes a washer of ceramic material positioned about the main electrode adjacent to the triggering electrode and which washer is proximate to the working end of the said triggering electrode.

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