

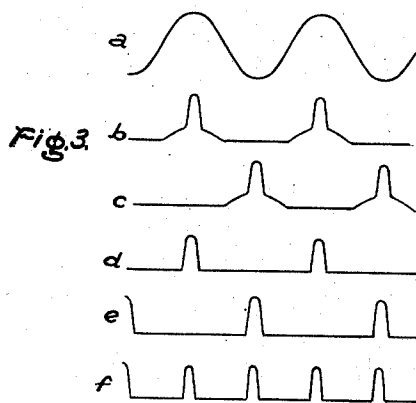
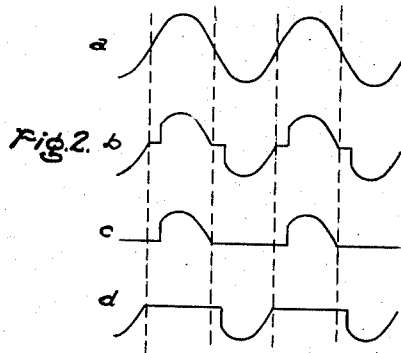
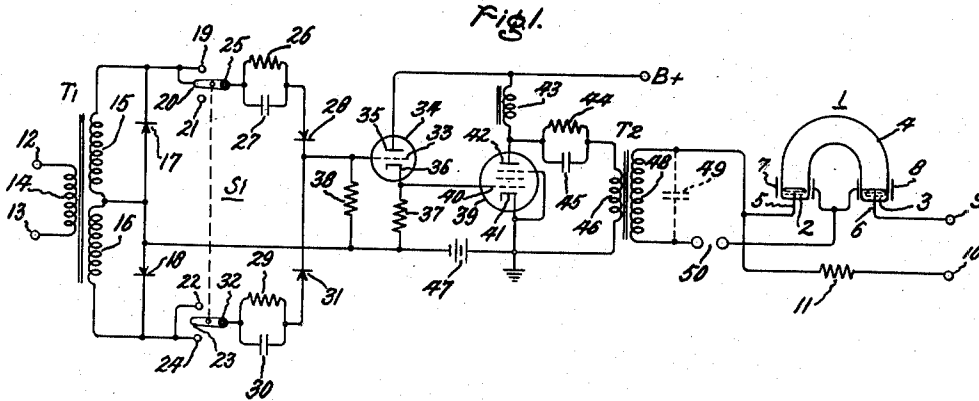
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FIRING CIRCUIT

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2,803,784

FIRING CIRCUIT

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My invention generally relates to firing circuits, and more particularly to a new and improved firing circuit for mercury vapor tube applications.

Mercury vapor tubes, such, for example, as ignition tubes, are commonly used in pairs to control large alternating current loads. Because of their ability to carry extremely high current for short periods of time, they are especially suited to the frequent switching of high current. In such applications, it is desirable that the switching cycle be controllable.

It is, therefore, a principal object of my invention to provide a new and improved firing circuit which enables control of the firing cycle of a mercury vapor discharge device.

Another object of my invention is to provide a new and improved firing circuit to fire a mercury vapor discharge device either as an electronic switch with an alternating current output or as a half-wave rectifier with a reversible polarity output.

In the attainment of the foregoing objects I provide a relatively simple and economical circuit wherein pulses may be generated once for every positive half cycle of alternating voltage supplied, once for every negative half cycle of alternating voltage supplied or once for every half cycle of alternating voltage supplied.

For further objects and advantages and for a better understanding of my invention, attention is now directed to the following description and accompanying drawings and also to the appended claims wherein those features of novelty which characterize my invention are pointed out with particularity. In the drawing,

Figure 1 is a schematic diagram of a preferred embodiment of my invention;

Figures 2 and 3 are curves useful in an understanding of the operation of the embodiment of Figure 1.

Referring to Figure 1, there is illustrated a double pool mercury vapor discharge device 1 having a pair of mercury pools 2 and 3 provided at opposite ends of an inverted U-shaped envelope 4. Electrodes 5 and 6 are respectively provided in pools 2 and 3 and a pair of starting bands 7 and 8 are provided about the necks of envelope 4 in the immediate vicinity of pools 2 and 3 respectively. A terminal 9 is connected to electrode 6 and a terminal 10 is connected through a load device 11, shown as a resistance, to terminal 5.

Referring to Figure 2, curve *a* is illustrative of a sine wave of alternating voltage which is supplied across terminals 9 and 10. If, for example, mercury vapor discharge device 1 is operated as an electronic switch, the current appearing in load 11 may appear as is shown in curve *b*. The starting time of each pulse, both negative and positive, is, of course, dependent upon the time location of the firing pulses appearing between the starting band and the electrodes. If the device is operated as a half-wave rectifier having a reversible polarity output, the current wave appearing in load 11 for one condition of polarity is shown in curve *c*, and the wave appearing in load 11 for the other condition of polarity is shown in

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curve *d*. The firing circuit of Figure 1, to be described more fully hereinafter, enables an output of firing pulses whereby the waveforms of curves *b*, *c*, or *d*, may be obtained from a double pool mercury vapor discharge device of the type shown.

In Figure 1, a pair of terminals 12 and 13 are connected across the primary winding 14 of a transformer T1. A source of alternating voltage, preferably the same source as is connected across terminals 9 and 10 is connected across terminals 12 and 13. Transformer T1 is provided with a pair of secondary windings 15 and 16 or with a single center tapped secondary winding. Windings 15 and 16 are connected together at one end, and unilateral impedance devices 17 and 18 are respectively connected across windings 15 and 16 and so poled as to conduct electrons toward the junction between the secondary windings. In a preferred embodiment of my invention transformer T1 is a peaking transformer such, for example, as the type having a partial or completely saturable core. Referring to Fig. 3, curve *a* is a graph of the alternating voltage supplied across terminals 12 and 13, and curves *b* and *c* are illustrative of the wave forms appearing across unilateral impedance devices 17 and 18 respectively.

One of the rectifiers provides direct pulses during the positive half cycle of the input wave while the other device provides direct pulses during the negative half cycle of the wave. A two gang, three-position switch, S1, is provided in the first gang with terminals 19, 20 and 21 and in the second gang with terminals 22, 23 and 24. Terminals 19 and 20 are connected together and to the junction of winding 15 and the negative terminal of device 17.

Terminals 22 and 24 are connected together and to the junction between winding 16 and the negative terminal of device 18. Terminals 21 and 23 are left open. Terminal 25 of the first gang of switch S1 is connected through the parallel circuit arrangement of a resistor 26 and a capacitor 27 to the positive pole of a unilateral impedance device 28. A counterpart of this circuit including the parallel arrangement of a resistor 29 and a capacitor 30 is connected between the positive terminal of a unilateral impedance device 31 and terminal 32 of the second gang of switch S1. The negative terminals of unilateral impedance devices 28 and 31 are connected together and to a control electrode 33 of an electron discharge device 34. Device 34 is also provided with an anode 35 and a cathode 36. A cathode resistor 37 is interconnected between cathode 36 and the junction between windings 15 and 16, and a resistor 38 is interconnected between electrode 33 and the junction between windings 15 and 16.

The resistor-capacitor networks supply a small bias to devices 28 and 31 such that only the upper, narrow portions of the peak voltages from the transformer secondary winding are impressed across resistor 38. Devices 28 and 31 are provided to permit only the positive peaks of the voltage to be applied across resistor 38.

When switch S1 is adjusted to the position shown, wherein terminals 25 and 32 are respectively connected to terminals 20 and 23, only the pulses of voltage appearing across device 17 are supplied across resistor 38. Because of the previously mentioned biasing action of the network comprising resistor 26 and capacitor 27, the pulse of voltage so appearing across resistor 38 does not include the wide low-amplitude component that appears across device 17. This wave is illustrated in curve *d* of Figure 3. Curve *e* of Figure 3 is representative of the waveform of voltage appearing across resistor 38 when switch S1 is adjusted to the position wherein terminals 25 and 32 are respectively connected to terminals 21 and 24. In this position, only those pulses of voltage appearing across device 18 are coupled across resistor 38. When switch S1 is adjusted to the third position wherein

terminals 25 and 32 are respectively connected to terminals 19 and 22, the waveform of voltage appearing across resistor 38 is the sum of waves appearing in Figures 3d and 3e and which is shown in Figure 3f.

Discharge device 34 is connected as a cathode follower, wherein its anode is supplied with a positive direct voltage from a source B+. The output is taken across cathode resistor 37 and supplied to a discharge device 39 between a control electrode 40 and a cathode 41 thereof. Device 39 is provided with an anode 42 which is connected through shunt-feed inductor 43 to the source of direct voltage, B+. The output of device 39 is taken between the anode and cathode thereof and is coupled through the parallel arrangement of a resistor 44 and a capacitor 45 across a primary winding 46 of a transformer T2. The cathode follower comprising discharge device 34, provides a low impedance driving source for device 39. A battery 47 or other source of direct voltage is connected between ground and control electrode 40 to maintain device 39 non-conductive except during the application of positive pulses.

If desired, the positive driving pulses from device 34 may be made higher than the bias voltage so as to drive device 39 into drawing grid current during a considerable portion of the positive peak, such that the device is operated as a "class C" pulse amplifier with the inherent high efficiency thereof.

The negative voltage pulses appearing at anode 42 in response to positive voltages applied to control electrode 40, are amplified in transformer T2 and appear across the secondary winding 48. A capacitance 49, illustrated in dash lines is connected across winding 48 and is representative of the secondary distributed capacitance, bushing and lead capacitance, and any added shunting capacitance necessary to bring the total capacitance to a desired value. In a typical application to provide sufficient current to start the mercury discharge device, this value is of the order of 25-50 micromicrofarads.

An arc gap 50 is serially connected between starting band 8 and one end of winding 48, and the other end of winding 48 is connected to electrode 5. Arc gap 50 is provided because in many applications the mercury vapor discharge device fires at a starting voltage which is not only dependent upon the magnitude thereof but also upon the rate of rise thereof. Consequently, by employing a spark gap between the transformer secondary and the ignitor, dependable firing is obtained without the use of an excessively high voltage from secondary winding 48.

In operation, when it is desired to operate the mercury vapor discharge device 4 as an alternating current switch, switch S1 is positioned so as to connect terminal 25 to terminal 19 and the pulses thus provided to fire the device are in substantial time correspondence with the waveform shown in Figure 3f. This results in the waveform of Figure 2b. When it is desired to operate device 4 as a half-wave rectifier having a positive polarity output, switch S1 is positioned to connect terminal 25 to terminal 20 such that the waveform of Figure 2c is obtainable across load device 11. When it is desired to operate the device as a half-wave rectifier having a negative polarity output, switch S1 is positioned to connect terminal 25 to terminal 21 and the waveform of Figure 2d is obtainable across load device 11.

While this invention has been described by a particular embodiment thereof, it will be understood that those skilled in the art may make many changes and modifications without departing from my invention. Therefore, by the appended claims I intend to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The combination of an electric discharge device 75

having two electrodes of conducting liquid, each adapted to operate either as an anode or a cathode and with one electrode acting as a cathode when the other electrode acts as an anode, and a starting electrode associated with each electrode of conducting liquid and a firing circuit energized from an alternating current supply circuit for providing voltage peaks during each half cycle of the supply circuit voltage wave comprising means for selectively impressing all of said voltage peaks on said control electrodes or only the peaks produced during half cycles of supply circuit voltage of one polarity or the other to provide conduction of said device selectively during half cycles of the supply circuit voltage of one polarity or the other or both to provide selectively a unidirectional output voltage of either polarity or an alternating voltage output.

2. In combination, a firing circuit for producing selectively peaked voltages of one polarity during half cycles of a supply circuit voltage of one polarity, the opposite polarity or both polarities comprising a pair of terminals energized from an alternating current supply circuit to provide voltages in phase opposition, a third terminal at a voltage intermediate those of said pair of terminals, oppositely-poled rectifying devices connected respectively between said pair of terminals and said intermediate terminal, a pair of output terminals, means connecting one of said output terminals with said intermediate terminal, a circuit connected between said pair of terminals comprising in series a switch, a rectifying device, a second rectifying device and a second switch, the common terminal of said last two mentioned rectifying devices providing the other output terminal and said switches providing means for connecting said output terminal selectively to either one of said first pair of terminals or simultaneously to both of said pair of terminals, an electric discharge device of the type having two electrodes of conducting liquid with either electrode adapted to serve as an anode or cathode, means connecting said electrodes in series with an alternating current supply circuit and a load circuit, a pair of electrodes associated respectively with said electrodes of conducting liquid and means energizing said starting electrodes with respect to said electrodes of conducting liquid in accordance with the voltages impressed on said output terminals.

3. A firing circuit for producing selectively peaked voltages of one polarity during half cycles of a supply circuit voltage of one polarity, the opposite polarity or both polarities comprising a pair of terminals energized from an alternating current supply circuit to provide voltages in phase opposition, a third terminal at a voltage intermediate those of said pair of terminals, oppositely poled rectifying devices connected respectively between said pair of terminals and said intermediate terminal, a pair of output terminals, means connecting one of said output terminals with said intermediate terminal, a circuit connected between said pair of terminals comprising in series a switch, a rectifying device, a second rectifying device and a second switch, the common terminal of said last two mentioned rectifying devices providing the other output terminal and said switches providing means for connecting said output terminal selectively to either one of said first pair of terminals, or simultaneously to both of said pair of terminals.

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