

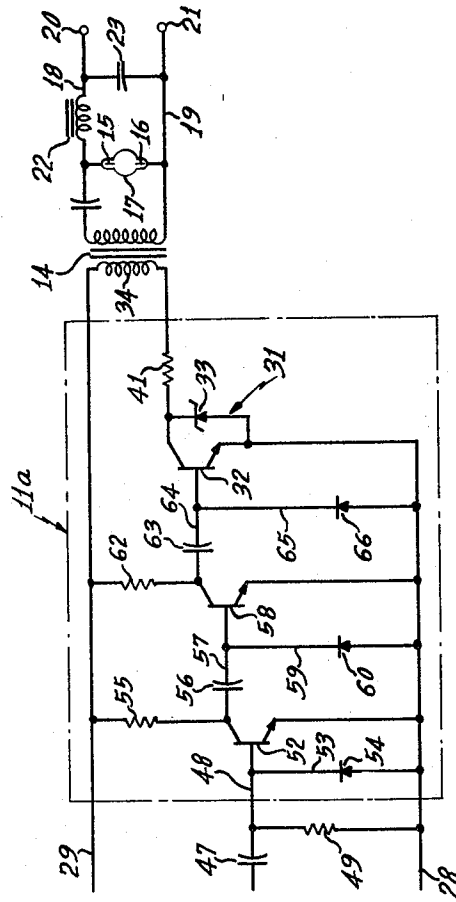
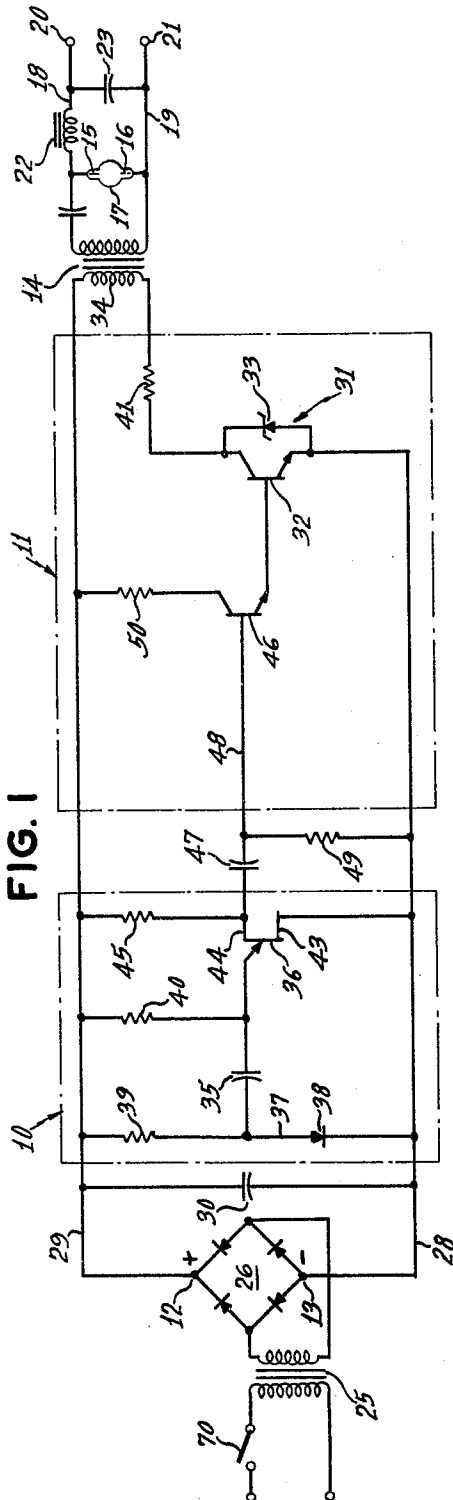
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STARTER FOR HIGH PRESSURE ARC LAMPS

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1

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STARTER FOR HIGH PRESSURE ARC LAMPS
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The present invention relates to starters for igniting high pressure arc lamps of the type having spaced electrodes in an ionizable atmosphere under pressure. The ionizable atmosphere is a gas, a vapor, or a combination such as xenon gas and mercury vapor.

In particular, the invention relates to an electronic starter utilizing semiconductors in a novel circuit to ignite a high pressure arc lamp by applying high voltage pulses across the electrodes at low frequencies.

To start the arc in a high pressure arc lamp, the atmosphere between the electrodes must be ionized sufficiently for a spark to cross the gap between the electrodes. Successive sparks increase the level of ionization and the temperature of the electrodes to a point at which the operating voltage of the lamp will produce a steady arc between the electrodes.

The atmosphere in a high pressure arc lamp is customarily ionized to start the lamp by applying high voltage in the form of either unidirectional pulses or of alternating current across the lamp electrodes. The voltage is customarily quite high—in the range of 40 to 50 kilovolts—and it has heretofore been believed that the pulses of high voltage should be applied at high frequencies in the radio frequency range or in a range above one megacycle. Some conventional starters generate a frequency of up to 40 megacycles per second.

In order to produce the high voltages at the high frequencies which have been thought to be required for starting arc lamps, it has been customary to use spark gaps, radio frequency capacitors and radio frequency transformers as the basic components form arc lamp starters.

It has now been found however that such high frequencies are not in fact necessary for starting arc lamps and that high voltage pulses in the low frequency range will effectively start an arc lamp.

In accordance with the present invention a starter circuit is provided for producing high voltage pulses in the audio frequency range and the circuit is built around a multivibrator rather than a spark gap. Since radio frequency pulses are not used it is not necessary to provide means to shield the power supply and associated elements from radio frequency feedback and radiation which are a problem with conventional starters based on the use of a spark gap. Moreover, the starter of the present invention is more dependable for successive operation than starters built around spark gaps. Specifically, the breakdown voltage of a spark gap changes with changing temperatures which renders the spark gap starter somewhat unreliable after repeated use.

It is a principle object of the present invention to provide a high pressure arc lamp starter which eliminates the spark gap as the pulse producing component and in which the problems of RF feedback and radiation are eliminated.

It is a further object of the invention to provide a starter circuit which is constructed of small, lightweight and reliable semiconductor components. This has the advantage of reducing the overall size, weight and expense of the starter as compared with previous starters.

The starter of this invention comprises generally a multivibrator circuit and an amplifier circuit to amplify the pulses produced by the multivibrator circuit. The

2

amplifier circuit is constructed with transistors which are operated in the saturated mode. Thus in addition to amplifying the pulses from the multivibrator circuit the amplifier circuit also acts as a switch. The collector of the last transistor in the amplifier circuit is connected in series with the primary coil of a high voltage step-up coupling transformer so as to alternately pass and block voltage through the primary coil in time with the pulses produced by the multivibrating circuit. The secondary coil of the coupling transformer is connected across the lamp and thus delivers pulses of stepped-up voltage through the lamp.

The invention will be more clearly understood from the following detailed description with reference to the accompanying drawings in which:

FIGURE 1 is a schematic diagram of the starter of the present invention shown in operative relationship with a high pressure arc lamp, and

FIGURE 2 is a fragmentary schematic diagram showing an alternative amplifier circuit which may be substituted for the amplifier circuit which forms a part of the starter as illustrated in FIGURE 1.

Referring now to FIGURE 1 of the drawings, the starter of this invention comprises generally a multivibrator circuit 10 and an amplifier circuit 11 adapted to operate on low voltage direct current from a source indicated by terminals 12 and 13, which are positive and negative respectively.

The starter changes the low voltage direct current into high voltage pulses which pulsate in the audio frequency range. The pulses are then applied through a step-up coupling transformer 14 to the electrodes 15 and 16 of a high pressure arc lamp 17 to start the lamp.

A high pressure arc lamp 17 of the type intended to be started by the starter of this invention contains an ionizable atmosphere, such as xenon-mercury under pressure. When the pulses from the starter have ionized the atmosphere in the lamp sufficiently to support a steady arc across the electrodes 15 and 16 the starter is shut off and the lamp is operated by a lamp operating circuit.

High pressure arc lamps may be adapted to operate with either direct or alternating current. The starter of this invention is effective for starting either type. A conventional A.C. lamp 17 is illustrated in the drawings in connection with a conventional operating circuit having conductors 18 and 19 connected respectively between the electrodes 15 and 16 and terminals 20 and 21 of an A.C. power source. A choke coil 22 shown in series in the conductor 18 and a capacitor 23 shown connected between the conductors 18 and 19 are normally included in the lamp operating circuit to protect it from high inverse voltage from the starter.

The choke coil 22 and capacitor 23 are of course unnecessary in the lamp operating circuit if the lamp 17 is the three electrode type. With the three electrode type of lamps one side of the starter would be connected to the lamp's third electrode which would not be in the lamp operating circuit. It will be appreciated, however, that no particular structure of the lamp 17 or of the lamp operating circuit are essential to the present invention and are merely described in order to present a complete picture of the environment in which the starter of this invention is intended to operate.

In the drawings the lamp 17 is indicated as being the type operating by alternating current such as conventional 115 volt 60 cycle current. In this case the same source of electric power may be used to operate the starter by reducing the voltage and rectifying the current and applying it to the terminals 12 and 13 for the starter. As illustrated in FIGURE 1 this may be accomplished by stepping down the voltage with a conventional step down transformer 25 and passing the stepped down power

through a full wave rectifier 26 which is connected to the terminals 12 and 13.

In practice a starter in accordance with this invention is operated on 20 volt direct current and produces 150 to 200 kilocycle 40 to 50 kilovolt pulses to be applied across the lamp 17. Pulses in this frequency and voltage range will be effective for starting high pressure arc lamps of at least from 80 watts to 2.5 kilowatts in size.

Direct current is delivered to the multivibrator circuit 10 and the amplifier circuit 11 by conductors 28 and 29 respectively from the negative terminal 13 and the positive terminal 12. A filtering capacitor 30 is normally connected between the conductors 28 and 29 adjacent the terminals 12 and 13 to shield the multivibrator and amplifier circuits from stray high frequency voltage from the transformer 25.

The conductor 28 extends from the negative terminal 13 to a gate element 31 of the amplifier circuit 11. The gate element 31 is formed by an NPN transistor 32 and a zener diode 33 connected between the emitter and collector of the transistor 32 with the anode side of the zener diode 33 toward the emitter of the transistor 32. The conductor 28 is connected to the side of the gate element 31 adjacent the emitter of the transistor 32 and the anode side of the zener diode 33. The other side of the gate element 31 is connected through a current limiting resistor 41 to one end of the primary coil 34 of the coupling transformer 14. The conductor 29 from the positive terminal 12 is connected to the other end of the primary coil 34.

The multivibrator circuit 10 is formed by a pulsing capacitor 35 and a unijunction transistor 36. The pulsing capacitor 35 has one side connected to a conductor 37 which extends between the conductors 28 and 29 and a diode 38 and a resistor 39 are connected in the conductor 37 on opposite sides of the connection of the capacitor 35 to the conductor 37. As shown the diode 38 is between the capacitor 35 and conductor 28 to the negative terminal 13 and the resistor 39 is between the capacitor 35 and conductor 29 to the positive terminal 12.

The other side of the pulsating capacitor 35 is connected to the emitter of the unijunction transistor 36 and the connection is tapped into the conductor 29 through a resistor 40. The two bases of the transistor 36 are indicated at 43 and 44. The base 43 is connected to the conductor 28 and the base 44 is connected through a resistor 45 to the conductor 29.

In practice the multivibrator circuit 10 is adapted to operate on 20 volt direct current and is constructed to generate pulses having a frequency of about 150 kilocycles per second. As previously mentioned the pulses from the multivibrator circuit 10 are amplified by the amplifier circuit 11 and transferred by the gate element 31 and coupling transformer 14 to the lamp 17.

The amplifying circuit 11 shown in FIGURE 1 comprises an NPN transistor 46 connected to the gate element 31 which, as previously described, is connected between the primary coil 34 of the coupling transformer 14 and the conductor 28 to the negative terminal 13.

The base 44 of the unijunction transistor 33 is connected to one side of a blocking capacitor 47 and the other side is connected by a conductor to the base of the transistor 46. The conductor 48 is tapped into the conductor 28 through a resistor 49.

In the amplifying circuit 11 the collector of the transistor 46 is connected through a resistor 50 to the conductor 29 and the emitter is connected to the base of the transistor 32 of the gate element 31.

In operation the amplifier circuit 11 operates in the saturated mode. That is the transistors 46 and 32 are alternately and sharply switched between their minimum and maximum conductive states so that the circuit operates as a switch. In practice with 20 volt direct current pulsating at a frequency of about 150 kilocycles suit-

able sizes for the capacitor 47 and resistor 49 and for the elements of the amplifier circuit 11 are:

Capacitor 47-----	0.1 microfarad 100 v. D.C.
Capacitor 49-----	10,000 ohms 1 watt.
Transistor 46-----	2N2192.
Resistor 50-----	2 kilowatts.
Transistor 32-----	2N2192.
Zener diode 33-----	20 volts 10 watts.

10 An alternative amplifying circuit 11a is illustrated in FIGURE 2. This amplifying circuit 11a is adapted to produce greater amplification and includes one more transistor than the amplifying circuit 11 so as to produce the increased amplification with smaller, less expensive transistors.

15 In the amplifying circuit 11a the conductor 48 from the blocking capacitor 47 is connected to the base of an NPN transistor 52. A tap 53 having a diode 54 therein is connected between the conductor 48 and conductor 28 adjacent the base of transistor 52 and between the base and the tap through the resistor 49.

20 The emitter of the transistor 52 is connected into the conductor 28. Its collector is connected to the conductor 29 through a resistor 55 and to one side of a capacitor 56. The other side of the capacitor 56 is connected by a conductor 57 to the base of an NPN transistor 58 and a tap 59 including a diode 60 connecting the conductor 57, and thus the adjacent side of capacitor 56 and the base of transistor 58, to the conductor 28.

30 As with transistor 52, the emitter of the transistor 58 is connected into the conductor 28. Its collector is connected to the conductor 29 through a resistor 62 and to one side of a capacitor 63, the other side of which is connected by a conductor 64 to the base of transistor 32 of the gate element 31. A tap 65 having a diode 66 therein connects the conductor 64 to the conductor 28 thereby connecting the conductor 28 through diode 63 to the base of transistor 32 and the adjacent side of capacitor 63.

40 The amplifying circuit 11a like the amplifying circuit 11 operates in the saturated mode and operates in the nature of a switch.

With either of the amplifying circuits 11 and 11a the transistor 32 of the gate element 31 operates in the saturated mode so that the gate element 31 is conductive to pass power to the primary coil 34 of coupling transformer 14 for about 313 microseconds out of every 6.6 microseconds. The coupling transformer 14 is selected to remain unsaturated by the amount of voltage applied for the period of about 313 microseconds. As shown, the lamp 17 once it is started operates on power from a lamp operating circuit connected to a power source having terminals 20 and 21. As already mentioned the high pressure arc lamp 17 intended to be ignited by the starter of this invention may be a lamp operating on either alternating or direct current. In either case the starter may be operated from the same source of electric power by the use of conventional voltage limiting devices and converters if necessary.

60 In operation the lamp operating power is turned on by a conventional switch (not shown). Next the starter is turned on by closing a conventional switch, such as a switch 70 in one of the conductors to the step down transformer 25. The starter delivers audio frequency high voltage pulses through the lamp 17 to ionize the pressurized atmosphere in the lamp to the level at which the lower lamp operating voltage will cause a steady arc between the lamp electrodes 15 and 16. Then the starter is turned off.

70 It will be appreciated that the above description is of a preferred embodiment of the high pressure arc lamp starter of this invention and that certain modifications in structure and arrangement may be made without departing from the spirit and scope of the invention defined by the following claims.

What is claimed is:

1. A starter for a high pressure arc lamp having a pair of spaced electrodes and comprising a high voltage step-up coupling transformer having a secondary coil adapted to be connected across said electrodes and having a primary coil, a source of direct current electric power having a positive and a negative terminal, a multivibrator operatively connected to said power source, means connected to amplify pulses from the multivibrator, switch means actuated by the amplified pulses to alternately pass and block electric power from the power source through the primary coil, said means connected to amplify pulses from the multivibrator comprising an NPN transistor having a base, a collector and an emitter; a capacitor connected between the multivibrator and said base; and a resistor connected between said base and the negative terminal of the power source; said collector being connected through a second resistor to the positive terminal of the power source and said emitter being connected to said switch means.

2. A starter for a high pressure arc lamp having a pair of spaced electrodes and comprising a high voltage step-up coupling transformer having a secondary coil adapted to be connected across said electrodes and having a primary coil, a source of direct current electric power having a positive and a negative terminal, a multivibrator operatively connected to said power source, means connected to amplify pulses from the multivibrator, switch means actuated by the amplified pulses to alternately pass and block electric power from the power source through the primary coil, said means connected to amplify pulses from the multivibrator comprising a first and a second NPN transistor each having a base, a col-

lector and an emitter; a first capacitor connected between the multivibrator and the base of the first transistor; a first resistor and a first diode connected respectively between the base of the first transistor and the negative terminal of the power source; a second capacitor connected between the collector of the first transistor and the base of the second transistor; a third capacitor connected between the collector of the second transistor and said switch means; a connection through a second diode between the side of the second capacitor toward the base of the third capacitor and the negative terminal of the power source; and a connection through a third diode between the side of the third capacitor toward the switch means and the negative terminal of the power source; the collectors of the first and second transistors being connected respectively through a second and a third resistor to the positive terminal of the power source, and the emitters of the first and second transistors being connected respectively to the negative terminal of the power source.

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