Dec. 28, 1926. 1,612,547

E. R. STOEKLE

VAPOR ARC DEVICE

Filed May 24, 1918 2 Sheets-Sheet 1

Fig. 1.

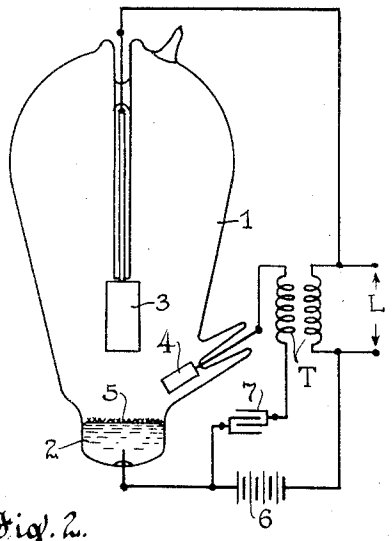


Fig. 2.

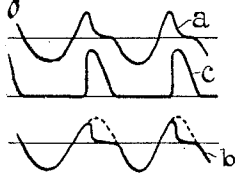


Fig. 3.

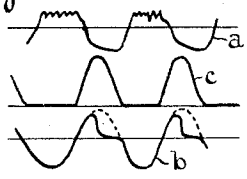


Fig. 4.

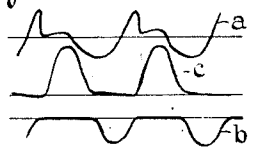


Fig. 5.

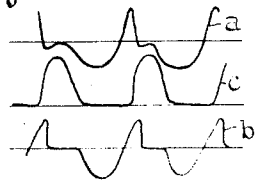


Fig. 6.

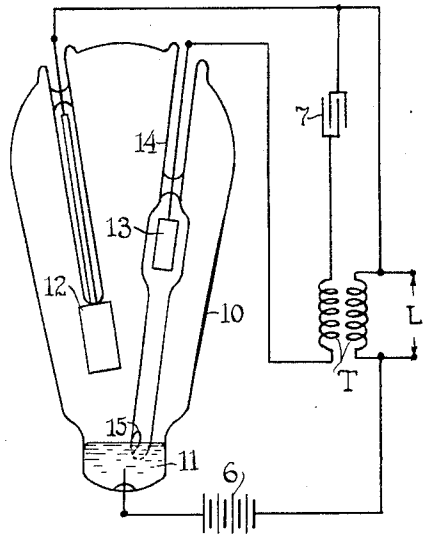
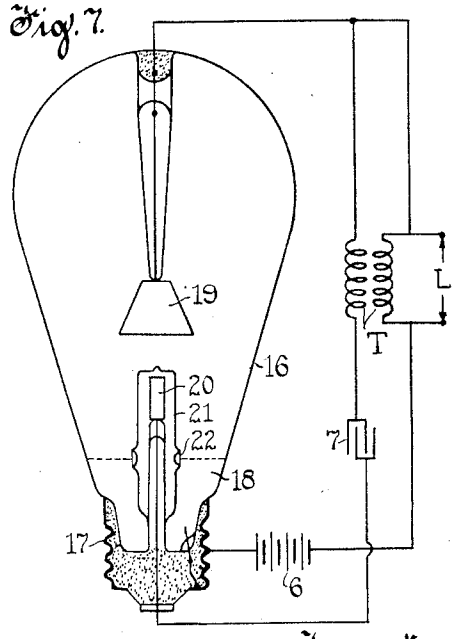


Fig. 7.



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Fig. 8.

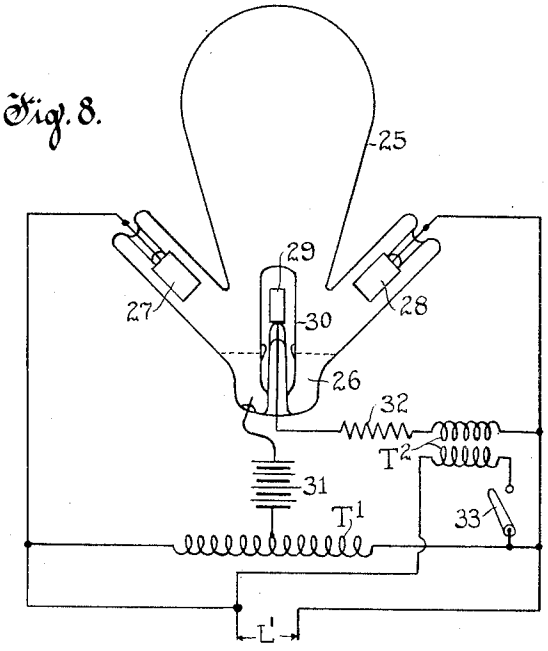
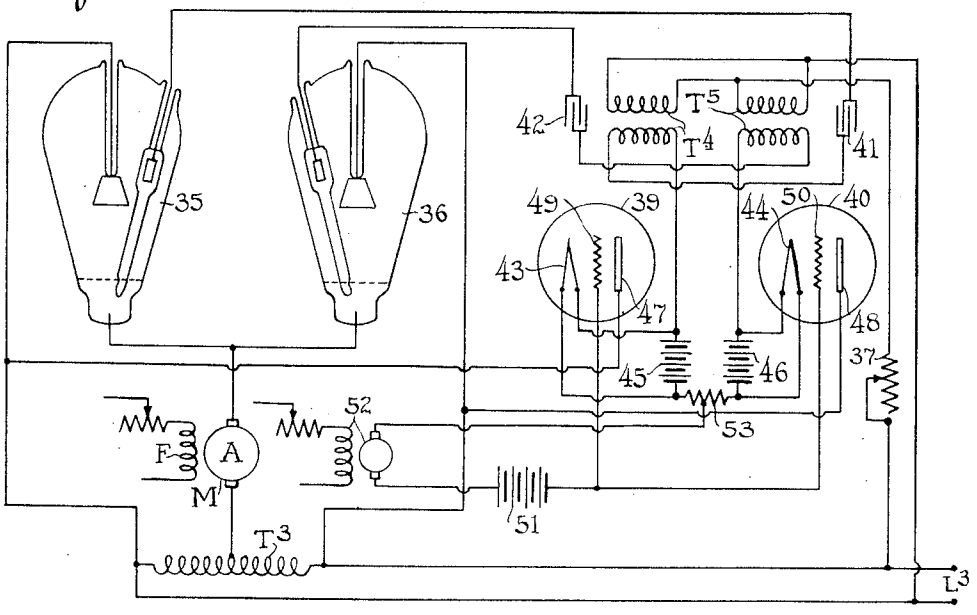


Fig. 9.



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UNITED STATES PATENT OFFICE.

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VAPOR-ARC DEVICE.

Application filed May 24, 1918. Serial No. 236,262.

This invention relates to vapor arc devices and is particularly applicable to mercury arc rectifiers.

In vapor arc devices utilizing auxiliary anodes for igniting the arcs thereof, especially in the case of well evacuated mercury arc devices, extremely high ignition potentials are required. In many instances the required ignition potential has been such as to puncture the bulbs of the devices employed. In consequence, the field of practical application of such devices has been extremely limited.

On the other hand, vapor arc devices, and particularly mercury arc rectifiers, have characteristics which would render the same very advantageous for current control purposes and the present invention has among its objects to overcome the aforesaid ignition difficulties and to otherwise adapt such devices for additional uses.

Another object is to provide a vapor arc device which will ignite substantially instantaneously with the application of the ignition potential.

Another object is to provide a vapor arc rectifier which will respond to a sufficiently low starting potential to enable starting thereof by closure of the main line switch and which may be continuously subjected to the ignition potential to maintain its arc at very much lower currents than can ordinarily be accomplished.

Another object is to provide a readily ignited vapor arc rectifier in which the arc may be ignited at different values of the impressed potential wave for producing rectified current pulses of different shapes and energy content.

According to the present invention it is proposed to introduce into the arc vessel an inert gas to be ionized by the ignition potential whereby the ignition potential may be greatly reduced and for further improvement it is proposed to provide some highly refractory material upon the surface of the mercury and in some cases to arrange the auxiliary anode in a novel relation with respect to the main anode and cathode.

The accompanying drawing illustrates certain embodiments of the invention which will now be described, it being understood that the invention is susceptible of embodiment in various other forms.

In the drawing,

Figure 1 shows schematically and diagrammatically a half wave rectifying device having the usual arrangement of electrodes, together with one circuit arrangement for said device;

Figs. 2 to 5 show oscillograph curves obtained with a rectifier such as shown in Fig. 1;

Fig. 6 shows a rectifier with a modified arrangement of electrodes;

Fig. 7 shows a modification of the device shown in Fig. 6;

Fig. 8 shows a double wave rectifying device; and,

Fig. 9 shows a motor control system employing certain of the aforesaid devices.

Referring to Fig. 1, the same shows a so-called "half-wave" rectifier comprising a glass bulb 1 having therein a well of mercury 2 constituting a cathode, a main anode 3 and an auxiliary anode 4, said bulb to be filled with an inert gas such as argon, neon or helium. Such inert gases are readily ionizable and it has been found that the presence thereof enables ignition of the arc between the anode 3 and mercury cathode 2 by impressing on the auxiliary anode 4 a much lower potential than would otherwise be required. Further, it has been found that the introduction of such gases at low pressures does not impair the efficiency of the rectifier as compared with the efficiency of a gas free rectifier of the mercury arc type.

Also, it is preferred to provide the mercury cathode with a surface coating 5 of fine particles of some highly refractory material, such for example, as alkaline earth oxides, or the rare earth oxides, as oxides of cerium and thorium, which readily give off electrons when incandescent and which are insoluble in the mercury. This coating is provided to increase the reliability of the device in starting and to overcome the so-called fatiguing of the device when used intermittently. In practice it has been found that a device lacking this coating may ignite immediately or may be slow to ignite and that after it has been used intermittently for a short time it must be allowed to remain idle for a considerable time prior to re-ignition thereof, whereas the same device when provided with such a coating will always respond substantially instantaneously and may be used

intermittently for long periods without signs of fatigue. This difference in action has not been definitely accounted for but it is believed to be largely due to the fact that in the former case the glow resulting from ionization of the gas and vapor tends to spread uniformly over the surface of the mercury without the production of any clearly defined hot points to assist the ignition, while in the latter case the coating when subjected to the ignition potential creates points having intense electric fields about the same whereby such points are subjected to an intense positive ion bombardment and become incandescent and emit electrons to assist the ignition. Also, it is believed that the fatigue of ignition of the ordinary vapor arc when used intermittently is due to a temporay displacement from the surface of the mercury of some particles which are essential to ignition and that when the mercury is coated with particles of the character described, such particles if displaced, return to the surface of the mercury in sufficient quantities to insure ready ignition.

As shown, the main anode 3 is connected to one side of a supply circuit L, while the cathode 2 is connected to the opposite side of said circuit through a battery 6 representing a load. The auxiliary anode 4 is connected to the secondary winding of a transformer T which has a primary winding connected across the supply circuit L and said secondary winding is also connected to the mercury cathode 2. The transformer T thus supplies the ignition potential to the auxiliary anode and the cathode as is the usual practice and said transformer should be designed to step up the voltage for the ignition circuit to a value determined by the product of the distance between the electrodes 2 and 4 and the pressure of the inert gas in the arc vessel. In practice it is desirable to include a capacity 7 in the ignition circuit although the same might be omitted.

The device, as above stated, serves as a half wave rectifier and in order to effect ignition of the main arc at the beginning of the positive cycle of the potential of such arc, it is desirable that the auxiliary anode 4 be supplied with its maximum positive potential at the instant when the potential on the anode 3 with respect to the cathode 2 is passing from zero value to its positive value. And assuming omission of the capacity, it is essential to ignition of the main arc under these conditions that the potential between the auxiliary anode and cathode be positive, when the potential between the main anode and cathode is positive, or in other words, that the potentials be approximately in phase. Thus since the main arc will not ignite before the ignition potential reaches a value sufficient to start a discharge, it is evident that only a portion of the positive half-wave of the alternating current will be allowed to pass through the arc, that portion being determined by the point on the A. C. wave at which the ignition of the arc takes place. This is illustrated in Fig. 2 which is a reproduction of an oscillograph record taken with a device such as shown in Fig. 1 but with the capacity omitted and with only a slightly inductive high resistance of 6700 ohms. In this figure *a* represents the ignition potential, curve *b* the main arc potential, and curve *c* the main arc current and said curves show ignition of the arc just before the arc potential reaches its positive maximum and in this connection it may be mentioned that the introduction of an inductance in the ignition circuit tends to move the ignition point still nearer to the positive peak of the main arc voltage. But when a very large inductance is used in the ignition circuit and the polarity of the transformer secondary is reversed, the large lag which is introduced will cause the positive maximum of the ignition potential to occur near the zero value of the main arc potential with the results depicted in Fig. 3. In this figure, the curves are lettered as in Fig. 2 and as will be apparent the entire positive half-wave of main arc current is obtained. On the other hand, assuming the use of a capacity in the ignition circuit, the ignition potential may be left in phase with the main arc potential, with the result of obtaining curves such as shown in Figs. 4 and 5 according to the value of the capacity 7. The curves in these figures are lettered the same as the curves in Figs. 2 and 3 and as will be apparent therefrom the capacity advances the phase of the ignition potential so that its peak value occurs nearer to the zero value of the main arc potential. Manifestly therefore these variations in phase relation of the main arc and ignition potentials may be used for controlling the average value of the rectified pulses of current. And with a continuously applied ignition potential, devices such as described will furnish rectified currents varying from a value of a few hundredths of an ampere to the maximum capacity for which the device is designed, thus greatly increasing the range of operation of the device as compared with the ordinary mercury arc rectifier.

Referring to Fig. 6, the same shows a half wave rectifier with a modified arrangement of electrodes. This device comprises a bulb 10 having therein a mercury cathode 11, a main anode 12 and an auxiliary anode 13. The main anode and cathode are similar to those of the device shown in Fig. 1, but the auxiliary anode in this instance is

enclosed in a tube 14 of glass or other insulating material, said tube projecting into the mercury and having an aperture 15 adjacent the surface of the mercury to permit the passage of an electrical discharge. Also, in this instance, the ignition potential is supplied to the auxiliary anode and main anode instead of to the auxiliary anode and cathode as in Fig. 1. And with the bulb filled with inert gas as above described, this arrangement insures a dense ionization of the gas immediately over the mercury surface and a continuous path of ionized gas and vapor from the cathode to the anode with the result of increasing the reliability of ignition.

Referring to Fig. 7, the device shown therein is a modification of the device shown in Fig. 6. This device comprises a bulb 16 having a lamp base 17, a mercury cathode 18 electrically connected to the screw shell of said lamp base, a main anode 19 and an auxiliary anode 20. The auxiliary anode is enclosed in a tube 21 of glass or other insulating material projecting upwardly from the base through the mercury whereby said auxiliary anode may be connected to the center contact of the lamp base and as in the previous structure the tube 21 is provided with apertures 22 adjacent the surface of the mercury for the passage of an electrical discharge. The circuit connections shown in this figure are the same as in Fig. 6.

Referring to Fig. 8, the same shows a so-called "double wave" rectifier with the auto-transformer connections commonly used with this type of device. This device is similar to the device shown in Fig. 7 and comprises a bulb 25 containing a mercury cathode 26, two main anodes 27 and 28 and an auxiliary anode 29 enclosed in an insulating tube 30 projecting upwardly from the base of the bulb through the mercury, as in Fig. 7. The two main anodes are connected to the opposite terminals of an auto-transformer T′ which is connected across a supply circuit L′ and the cathode is connected through a battery 31 representing a load, to an intermediate tap on the auto-transformer. The auxiliary anode is connected to the secondary of a transformer T^2 having a primary winding connected across the supply circuit L′ and said secondary winding is also connected to the auxiliary anode 29. A high resistance 32 is included in the ignition circuit to limit the flow of current therein but it is to be understood that such resistance might be replaced by a capacity as above described or the two might be used in conjunction. Further, a switch 33 is provided in the circuit of the primary winding of the transformer whereby the supply of potential to the ignition circuit may be terminated after ignition of the arc as is the usual practice in the case of double wave rectifiers. However, if it be desired to operate the device at currents below the value at which the arcs will maintain themselves, switch 33 may be left closed and the device will then continue to operate for furnishing rectified currents as low as a few hundredths of an ampere.

Referring to Fig. 9, the same shows two devices 35 and 36 of the construction disclosed in Fig. 6, employed as a double wave rectifier to supply and control a motor M. The motor has a separately excited field winding F and an armature A, the latter being connected on one side to the cathodes of the devices 35 and 36 in parallel and being connected on the other side thereof to a center tap of an auto-transformer T^3 supplied from an alternating current circuit L^3. The devices 35 and 36 have their main anodes respectively connected to end taps of the auto-transformer T^3 and accordingly said devices when ignited will alternately supply rectified currents to the motor armature in pulses. In this instance the ignition potentials for the devices 35 and 36 are supplied by transformers T^4 and T^5 respectively through thermeo-ionic relays 39 and 40 respectively. The transformers T^4 and T^5 have their primary windings connected in parallel across line L^3 through a resistance 37 and the transformer T^4 has its secondary winding connected through a capacity 41 to the auxiliary anode of device 35, while the transformer T^5 has its secondary winding connected through a capacity 42 to the auxiliary anode of device 36. The relays are respectively provided with cathodes 43 and 44 which are respectively connected to the secondary windings of transformers T^4 and T^5 and which are supplied with heating currents by batteries 45 and 46 respectively. Also, the relays are respectively provided with anodes 47 and 48 which are respectively connected to the main anodes of devices 35 and 36 whereby each transformer will impress a potential upon the main and auxiliary anodes of its respective rectifying device determinable by the discharge between the anode and cathode of its respective relay. Further, the relays are respectively provided with grids 49 and 50 supplied with potential by a battery 51 subject to the bucking action of a tachometer 52 driven by motor M. The grids are connected in parallel to the battery 51 and the battery is connected through the armature of the tachometer to the cathodes of the two relays in parallel, said cathodes being bridged by a high resistance 53 and the battery connections being made to the symmetrical point of said resistance.

Thus the system will function as follows: Assuming the motor to be in operation, any variation in the speed thereof will effect a

like variation in the speed and bucking effect of the tachometer, with the result of varying the potential impressed upon the grid-cathode circuits of the relays. If, for example, the motor speed increases, the bucking effect of the tachometer will be increased and will either increase the negative potential of the grid or reduce the positive potential thereof depending upon whether the tachometer or the battery predominates, while if the motor speed decreases a reverse effect will be obtained and such variations in potential will cause proportional but greatly amplified variations in the discharges through said relays to decrease or increase the ignition potentials of the rectifying devices according to the character and degree of speed variation of the motor. And such variations in the ignition potentials of the rectifying devices will tend to correspondingly decrease or increase the current supplied to the motor whereby said devices will function subject to the aforesaid influences of the relays and tachometer to automatically vary the current supplied to the motor to maintain a substantially constant speed thereof. Thus under such conditions the current supplied by the rectifying devices is varied by variations in magnitude of the ignition potential as distinguished from variations in the phase relation of the main and ignition potentials, as above described, and in this connection it may be noted that the current supplied to the motor might be varied by changing the phase relation of the main and ignition potentials of each device by changing the capacity included in the ignition circuits thereof. Further, the current supplied to the motor might be varied by the resistance 37 which by varying the potential of the primary windings of transformers T^4 and T^5 provide for variation of the magnitude of the ignition potentials impressed on the rectifying devices.

What I claim as new and desire to secure by Letters Patent is:

1. A vapor arc device comprising main arc and ignition electrodes including a vaporable cathode, a vessel to enclose said electrodes, a finely divided surface coating of highly refractory material for said cathode which readily emits electrons, and an inert gas within said vessel.

2. In a vapor arc device, in combination, a mercury cathode, a surface coating therefor comprising particles of highly refractory material which readily emits electrons, a main anode, an auxiliary anode and a vessel enclosing said cathode and said anodes and containing an inert gas.

3. The combination with a vapor arc device comprising a vessel containing a cathode, a main anode, an auxiliary anode and an inert gas, said anodes being shielded whereby electrical discharges therebetween are caused to pass in close proximity to said cathode, of a main circuit including said cathode and said main anode and an ignition circuit including said main and auxiliary anodes.

4. A vapor arc device comprising a vessel containing an inert gas, a vaporable cathode within said vessel having a surface coating of fine particles of a highly refractory material which readily emits electrons, and main and auxiliary anodes within said vessel, said anodes being shielded from one another whereby electrical discharges therebetween are caused to pass in close proximity to said cathode.

5. A vapor arc device comprising main arc and ignition electrodes including a vaporable cathode, a vessel to enclose said electrodes, the arrangement being such that discharge between said main arc electrodes is dependent upon continued discharge between said ignition electrodes, means subjecting said ignition electrodes to an alternating potential, said cathode having a finely divided surface coating of highly refractory material which readily emits electrons and an inert gas filler for said vessel to facilitate continued arcing between said ignition electrodes due to such potential.

In witness whereof, I have hereunto subscribed my name.

ERWIN R. STOEKLE.