March 6, 1934. A. MUTSCHELLER 1,950,008

EVACUATING PROCESS

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Fig. 1.

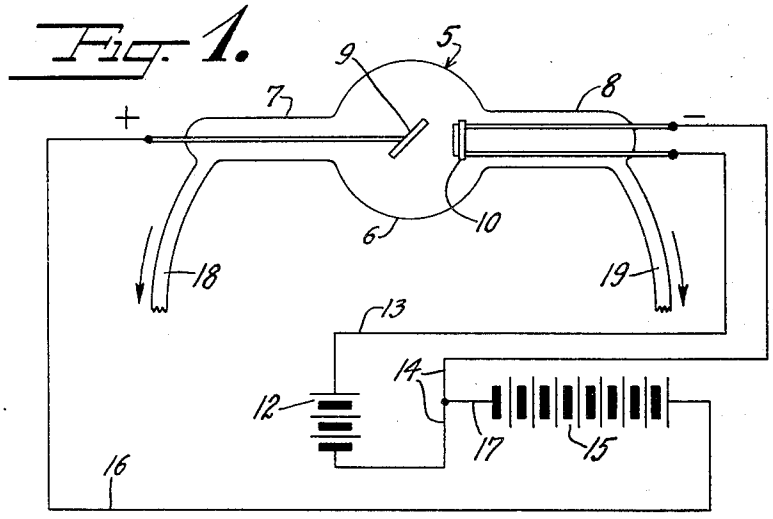
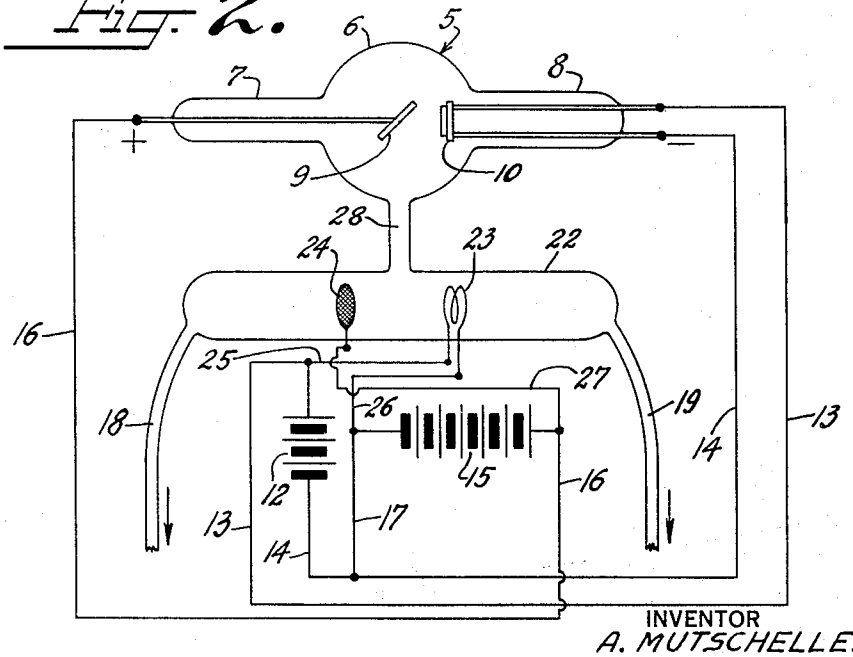



Fig. 2.




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## EVACUATING PROCESS

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2 Claims. (Cl. 250—27.5)

My invention relates to discharge devices and particularly to the evacuation of such devices requiring a substantially high degree of vacuum, as for example, X-ray tubes and thermionic rectifying valves.

The primary object of my invention is the attainment of a high degree of vacuum within the device in a shorter period of time than heretofore, and in many instances a higher degree of vacuum, which is particularly suitable for the intended purposes of the respective discharge device.

In the construction of vacuum tubes the initial step is to degasify the envelope of all occluded gases which is usually accomplished by external heating. After the electrodes are sealed within the envelope they are in turn degasified by heating the cathode and subjecting the electrodes to a substantially high potential. The discharge resulting between the electrodes accordingly heats these electrodes by the electron bombardment and liberates all occluded gases therefrom. Simultaneously with the occurrence of the discharge between the electrodes the evacuating pump is set into operation for the purpose of evacuating all gases from the interior of the envelope. After the removal of these gases and the proper degree of vacuum is obtained the envelope is then sealed off.

The evacuating pump is usually connected to one end of the envelope which presents difficulties in obtaining the desired degree of vacuum without the lapse of considerable time. This is due to two factors, namely, that the pump is not connected at the point of the envelope where the gas pressure is the least and, the distance of the point of connection of the pump from the other extremity of the envelope.

In a discharge device wherein the electrodes extend a considerable distance within the envelope thus forming electrode necks or arms a vacuum is formed by the discharge between the electrodes with the gas pressure greater within the electrode necks or arms rearwardly of each respective electrode. This is due to the ionization of the gas between the electodes with the negatively charged ions being driven to the positive electrode and vice versa. By applying the evacuating pump at these points, namely, an appreciable distance rearwardly of both electrodes at the arms or necks of the tube, not only complete evacuation of the device is obtained in a shorter period of time, but a higher uniform degree of evacuation is obtained.

In the operation of discharge devices in which the electrodes are spaced an appreciable distance apart there can be observed a dark space between the electrodes during the period of discharge. This indicates that the gas pressure is lower at these dark spots than throughout the remainder of the discharge path. A discharge device to be evacuated may, therefore, be connected to a second discharge device provided with electrodes spaced apart a distance sufficient to cause the formation of these dark spots or "Crookes dark space," as it is known, during the period of discharge. If the envelopes are connected in such a manner as to permit gaseous communication therebetween with this connection being at the point between the electrodes of the second discharge device where the formation of the dark spots occur it may be utilized as a vacuum pump in exhausting the first discharge device. The gases present in the latter will then flow into the dark spots or low pressure area of the second discharge device where it will become ionized and flow to the respective electrodes of this device.

The pumps may then be connected an appreciable distance rearwardly of these electrodes in the same manner as previously described to exhaust the gases therefrom. After completion of the exhausting to the degree of evacuation desired the first discharge device may then be sealed off thus severing the connection between the two devices.

For a better understanding of my invention reference may be had to the accompanying drawing wherein

Fig. 1 is a diagrammatical representation of one form of my invention for evacuating a discharge device, and

Fig. 2 is a diagrammatical representation of another form of my invention wherein the low pressure area or dark spot is utilized in a second discharge device as an exhaust pump.

Referring now more particularly to Fig. 1, I have shown a discharge device, such for example, as an X-ray tube 5 which is to be evacuated. The tube is provided with a bulbous portion 6 and a pair of electrode arms 7 and 8. An anode 9 and a thermionic cathode 10 extend interiorly of the respective arms 7 and 8 to the bulbous portion 6 of the envelope 5. A source of low tension energy, such as a transformer or batteries 12, is connected to the cathode by suitable connections, such as the conductors 13 and 14 for the purposes of heating the same to cause the emission of electrons therefrom.

In order to effect a discharge between the thermionic cathode 10 and the anode 9 to cause heat-

ing of the latter and the driving off of occluded gases therefrom I connect one end of a substantially high potential uni-directional source of electrical energy, such as a transformer or batteries 15, to the anode 9, by means of a conductor 16, and the opposite end of this source to the cathode 10 by means of the conductor 17 which connects with the conductor 14.

During the period of discharge, which decreases the gas pressure between the anode and cathode by ionization of the gas at this point within the envelope as well as driving off the occluded gases from the metallic electrodes, I pump the gas from the tube by means of suitable pumps (not shown) which are connected to the envelope 5 through tubes or pipes 18 and 19 at points on the electrode arms 7 and 8, an appreciable distance rearwardly of the respective electrodes. The ions which strike the respective electrodes and tend to accumulate within each of the electrode arms are accordingly drawn off by the pumps within a short period of time, resulting in the attainment of a high degree of evacuation of the envelope within a short period of time.

It is preferable that two pumps be utilized for evacuation purposes which are connected to the respective ends of the envelope. Although this, strictly speaking, is not essential it prevents a bi-pathing of the gases through the pump should a single one be employed which is connected to both ends of the tube simultaneously.

The pressure gradient being considerably lessened in each of the electrode arms, the pumps are more effective than in the methods of the prior art where evacuation is obtained by pumping entirely from one end. Moreover, a higher degree of vacuum is obtained as the ions of gas may be drawn off simultaneously from each end without danger of any bi-pathing through the pumps.

In Figure 2 I have shown a method of obtaining evacuation by utilizing the pumping effect of the "Crookes dark space".

An X-ray tube 5 which it is desired to evacuate is provided with a bulbous portion 6 and electrode arms 7 and 8. The cathode 10 in this embodiment likewise receives heating energy from the source 12 and the anode 9 and cathode receive high potential energy from the source 15 in the same manner as just described relative to Figure 1.

A second discharge device having an envelope 22 is provided with a thermionic cathode 23 and an anode 24 spaced therefrom a distance somewhat greater than the spacing between the anode 9 and cathode 10 of the device 5. This cathode 23 likewise receives heating energy from the source 12 through conductors 25 and 26 in the same manner as the cathode 10 receives its energy from this source through conductors 13 and 14. The anode 24 is also connected to the high tension source 15 through a conductor 27 as well as the cathode 23 in order to cause a discharge therebetween simultaneously with the discharge between the electrodes 9 and 10.

The envelope 5 is in gaseous communication with the envelope 22 through a connection 28 to enable the gases from the former to flow into the latter. The connection joins the envelope 22 at a point between the electrodes 23 and 24 for a purpose to be hereinafter described more fully. In the same manner as previously described relative to Fig. 1 during the discharge between the electrodes 23 and 24 the gas pressure therebetween will become considerably lessened. Furthermore, this is evidenced by the appearance of dark spots known as the "Crookes dark space" between these latter electrodes due to the potential applied therebetween and the spacing of the electrodes.

This is indicative of the lower gas pressure at these areas which is lower than that within the envelope 5. Accordingly the gases within this latter envelope flow into these low pressure areas and are ionized by the discharge within the envelope 22.

In this modification I connect the pumps to each end of the envelope 22 and simultaneously exhaust the ions which pass rearwardly of the respective electrodes from the envelope 22 and consequently from the envelope 5. Likewise it is preferable to employ two pumps to prevent bi-pathing as might follow the utilization of a single pump connected to each end of the envelope 22 for simultaneously pumping from each end. The low pressure area or "Crookes dark space" of one discharge device is thus utilized to exhaust the main discharge device and after the same is completely exhausted the latter is sealed off at the communicating passage 28 severing the connection between the two envelopes 5 and 22.

It can thus be appreciated by those skilled in the art that I have provided a novel method of evacuating discharge devices. Moreover, a higher degree of vacuum may be obtained in a shorter period of time than has been possible with methods heretofore employed in the art. By employing the pumping action of the "Crookes dark space" of a connected discharge device I obtained ionization of gases drawn from the main discharge device to be evacuated simultaneously with the liberation of occluded gases from the metallic electrodes during the passage of a discharge therebetween. This greatly enhances the rapidity of evacuation as well as the ultimate degree of vacuum obtained.

Although I have shown and described two specific embodiments of my invention I do not desire to be limited thereto as various other modifications may be possible without departing from the spirit and scope of the appended claims.

What is claimed is:

1. The method of producing a high vacuum in a thermionic discharge device, which consists in connecting a second discharge device to said first mentioned device in order to establish gaseous communication therebetween, impressing a potential upon electrodes within said first mentioned discharge device to heat the same and liberate occluded gases therefrom, establishing a discharge between electrodes within said second mentioned discharge device to reduce the gas pressure therebetween to a lesser extent than that within said first mentioned discharge device and to thereby cause the gases within the latter to flow into said second mentioned discharge device, pumping said second mentioned discharge device at points an appreciable distance rearwardly of its respective electrodes to exhaust the gases therefrom, and sealing off said first mentioned discharge device and thereby severing its connection with said second mentioned discharge device.

2. The method of producing a high vacuum in a thermionic discharge device having an envelope containing a thermionic cathode and an anode, by employing a second discharge device having its envelope connected to that of said first mentioned discharge device and provided with a thermionic cathode and an anode disposed each

side of the point of connection of the envelope with that of said first mentioned discharge device, which consists in heating the cathode of both said discharge devices to cause them to emit electrons, establishing a discharge between the electrodes of said first mentioned discharge device to cause the anode thereof to become heated by bombardment and have its occluded gases driven off, establishing a discharge between the electrodes of said second mentioned discharge device to reduce the gas pressure therebetween to an extent less than that within said first mentioned discharge device thereby causing the gases within the latter to flow through the connection between the respective envelopes to said second mentioned discharge device, pumping the envelope of said second mentioned discharge device at points an appreciable distance rearwardly of its respective electrodes to exhaust the latter, and sealing off said first mentioned discharge device thereby severing its connection with said second mentioned discharge device.

ARTHUR MUTSCHELLER.