

May 3, 1938.

S. HIRSCH

2,115,927

HIGH VOLTAGE ELECTRON DISCHARGE DEVICE

Filed Feb. 21, 1934

2 Sheets-Sheet 1

Fig. 1.

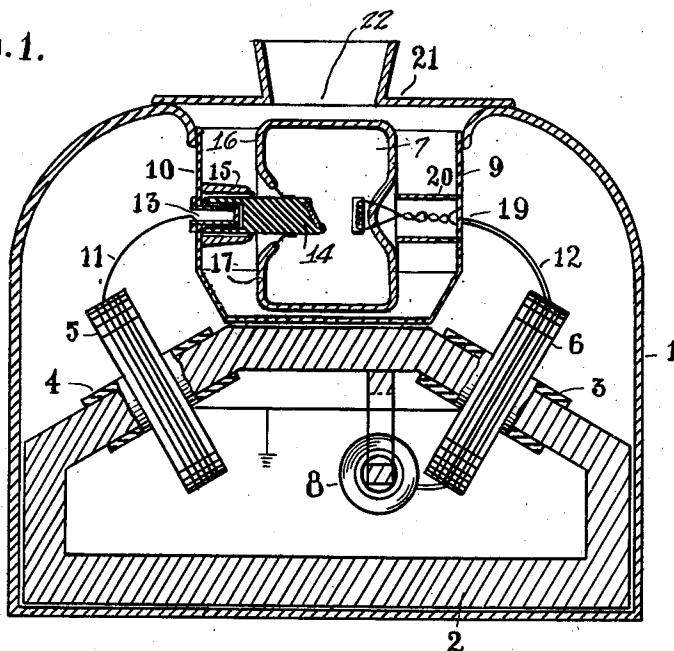
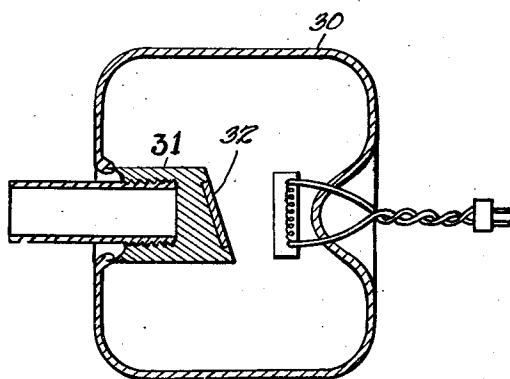


Fig. 2.



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2 Sheets-Sheet 2

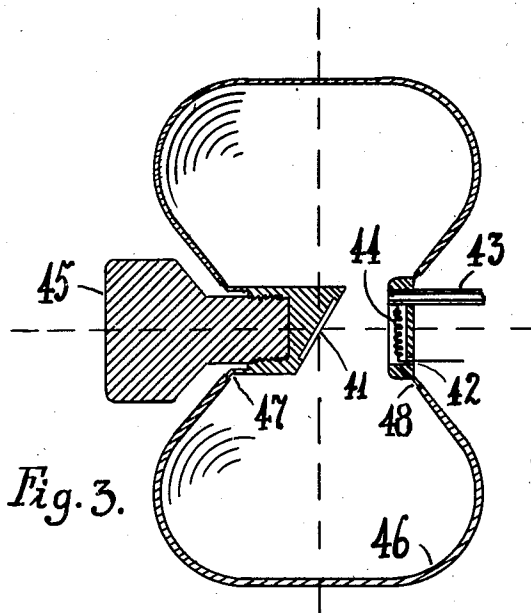


Fig. 3.

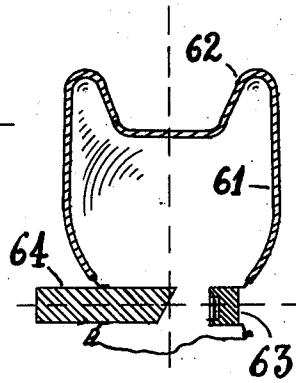


Fig. 5.

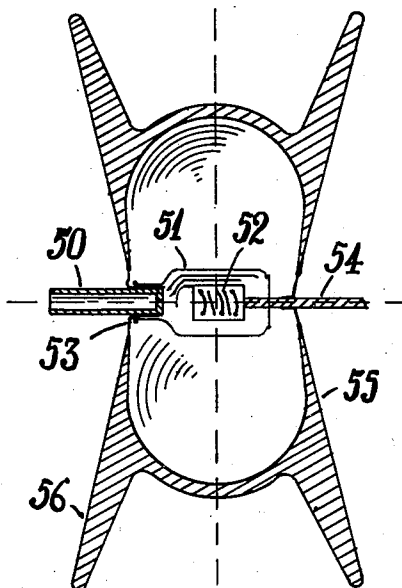


Fig. 4.

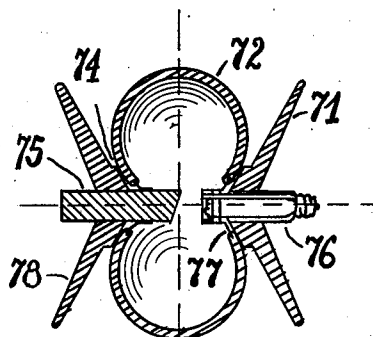


Fig. 6.

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UNITED STATES PATENT OFFICE

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HIGH VOLTAGE ELECTRON DISCHARGE
DEVICE

Samuel Hirsch, New York, N. Y.

Application February 21, 1934, Serial No. 712,441

5 Claims. (Cl. 250—35)

This is a continuation in part of my pending application Serial No. 651,316 filed January 12, 1933.

More definitely stated, my invention consists in a novel design of evacuated discharge tubes used for the purpose of producing various kinds of electronic discharges such as X-rays, cathode or Lenard rays or the various ionic discharges through which charged nuclei, neutrons, deutons, etc., are produced. My new design offers special advantages in all those cases when either it is desirable that the discharge tube should be exceptionally small or short in length or when it is necessary to produce extremely high acceleration of electrons or ions through the application of correspondingly high voltages to the electrodes of the discharge tube.

Tubes of this kind, as constructed according to the designs of the prior art, were developed with their greatest dimension lengthwise in the direction of the discharge. Thus the length of an X-ray tube, a cathode ray tube, a valve tube or other similar tube was governed by the voltage to be applied to it. The crosswise or lateral dimension then being always considerably less than the lengthwise dimension resulted in that almost entirely the insulating strength of the air in a straight line was depended upon to prevent sparking over; the path over which a discharge can thus take place is then nearly a straight line path and the bulb of the laterally extending portion of the tube did not enter appreciably as a factor for increasing the length of the discharge path over that in a practically straight line from one electrode to the other. In this sense, therefore, the length of the insulative or glass part of the discharge tube was governed by the voltage which it had to stand without sparking over taking place through the air.

In a tube of my invention the free ends of the electrodes may be brought closer together than the straight linear sparking distance between the electrodes in air. This is due to the fact that the lateral dimension of the bulb is increased to such an extent, that the discharge from the non-insulated portions of the electrodes either through air or through a cooling and insulating medium is not in a straight line but around the laterally extending portions, such as the enlarged bulb, fins or the body, of the tube. This expedient, therefore, allows the bringing closer together of the exposed or non-insulated terminals of the tube, at the rate at which the diameter of the bulb of the tube is increased or so long as the path of a possible discharge through air re-

mains essentially of the same length as the straight line path that the applied voltage would otherwise jump.

The form or shape of discharge tubes of the prior art is lengthwise or "tubular" with the direction of the greatest field intensity and of the discharge along the greatest dimension of the tube; the form or shape of discharge tubes of my invention is flat, pancake—or in cross-section dumbbell-like with the direction of the discharge or of the greatest field intensity along the smaller dimension. The bulb or the laterally extending portion of the tube therefore serves then as a voltage barrier or as a means for increasing the creepage and sparking path length between the voltage carrying points in air, between which in the absence of the barrier or bulb of the tube, there would be sparking over by the applied voltages.

Yet there are further advantages embodied in the construction of my invention. Thus the cooling of the electrodes, especially of the anode, was hitherto effected through the application of a cooling fluid which is caused to be circulated through or around the target upon which the discharge is directed, or through the conduction of heat along the stem of the target. But in the tube of the longitudinal design of the prior art, the anode stem is necessarily quite long and hence the cooling function is definitely limited. With the design of my invention it is possible to make the anode stem much shorter to the extent that the target upon which the heat is generated and the heat absorbing mechanism, radiator, etc., may be brought very much closer together and hence the distance of travel for the heat is markedly reduced and the efficiency and rapidity of the cooling is thereby increased in proportion.

A further advantage of my invention resides in the fact that instead of a glass connecting tube between the pump and the tube which is sealed into the body of the tube for the purpose of evacuation, it is feasible to make a metallic tubular vacuum tight connection usually between the cathode and the pump. Thus a copper or other suitable metal tube is soldered or welded into the metal of the cathode or the anode. From there on it leads to the pump. Thus there are avoided the difficulties of sealing a glass connection between the tube and the pump and also there is avoided any danger of strain on the glass connection tube as used in the prior art which under the circumstances can usually not be very well annealed. A metallic tube is elastic and flexible and the sealing-off process, after evacuation,

is simply carried out by pinching the tube flat and then fusing the flattened portion with a hot flame. When thus sealed off, the protruding end can then be bent out of the way and if desired an electrical connection can be made to and through it to the electrode.

With regard to the form or shape of the discharge vessel I have discovered that from increasing the lateral dimension, i. e. that at right angle to the direction of the greatest field intensity over that in the direction of the field, there results an increased peripheral space which performs a very advantageous function during the time of the discharge. At the moment when an electrical field is produced between the discharge electrodes there exists between these electrodes a smaller gas pressure than in other parts of the discharge vessel. This is so in particular when the degree of evacuation is not quite as high as it normally should be. Then the gas particles present in the discharge vessel are repelled from the discharge space and they crowd together either in the electrode stems or in the peripheral space at right angle to the greatest field intensity. Therefore, this enlarged peripheral space resulting from the larger diameter of the glass vessel in a plane at right angle to the greatest field intensity will increase the chance of thus crowding more gas particles into a space where they do not interfere with the normal pure electronic discharge. The form and shape of the discharge vessel conforming to my invention, therefore, either allows the operation of a discharge tube at a higher voltage and load or the presence of a larger amount of gas without causing any disturbances as in comparison with tubes of the prior art.

The discharge tubes of the prior art are usually made with glass walls of a thickness sufficient to withstand the external pressure and the thickness of the wall is then not utilized to any marked extent for supporting the tube. Thus the discharge tubes are then supported by the ends in insulating clamps or mountings which do not set up any electrical or mechanical strain on the glass. In tubes of my invention the glass walls are normally made considerably thicker whereby, I found, the danger of puncturing and of accidental breaking are considerably lessened. In many instances I found it advantageous to support my tubes not as is usual at the ends but to place the supporting member around the largest portion of the bulb in the zone of greatest extension.

In Fig. 1 is shown, in cross section, an X-ray tube 7 supported in the reentrant portion of a housing containing a high tension transformer, a filament heating transformer and conductors to the terminals of the tube.

Fig. 2 shows more specifically a square or rectangular form of an X-ray tube of the type housed in the said transformer housing shown in Fig. 1. The anode 31 is provided with a tubular cooling extension which affords good cooling to the seal-in joint with the glass while one of the conventional cooling mechanisms can be placed into the extension.

In Fig. 3 is shown, in cross section, a bilaterally reentrant glass vessel 46, sealed to it the anode 41 through the feathered edge 47 and the cooling and heat absorbing body 45 is shown screwed into the body of the said anode. The cathode 44 is shown with a straight coil filament, a metal tube 43 soldered into the body of the said cathode but open into the space to be evacuated and an in-

sulated conductor 42 to the said filament. This filament is therefore heated by the current applied to the insulated conductor 42 and the tubing 43. The shape of the cathode shown is flat and it is sealed on to the glass vessel through a feathered flange 48 being part of the body of the cathode.

The X-ray generating potential is applied to the cathode such as to tube 43 and the anode part 45. The sparking path is then around the glass vessel 46 and the maximum voltage that can be applied to this tube is approximately that which can be applied to an ordinary tube equal in length to the distance from the metal part 45 around the bulb 46 to the cathode parts. The body of the tube therefore serves as a barrier for a voltage the sparking distance of which is greater than the straight line distance between the anode part 45 and the cathode. Also the path for creepage is around the body of the vessel and hence much longer than in the straight line type of tube. The effectiveness of this barrier depends on the insulative strength of the glass of the vessel and the evacuated space within it.

A valve tube is shown, also in cross section, in Fig. 4 consisting of a filamentary cathode 52 and a cylindrical anode 51 surrounding it; these are supported on stems 54 and 59 respectively which may be insulated and which are sealed into the glass vessel 55 in the aforescribed manner. The glass vessel 55 is provided with extension rings or fins which are for the purpose of still further increasing the electrical barrier function of my invention. These fins may be solid as shown in Fig. 4, or they may be hollow and part of the evacuated space within the vessel as is shown in Fig. 5. Here 63 is an X-ray cathode and 64 is an X-ray anode in the sense illustrated in Fig. 3.

Still another method of carrying out my invention is shown, also in cross section in Fig. 6. Here 76 is an X-ray cathode, 75 an X-ray anode, 72 is the body of a glass vessel into which the electrodes are sealed as described. 71 and 78 are two electrical barrier discs made of glass or other high dielectric material. These discs are in contact with the glass vessel 72 and are either united with the glass vessel by fusion or through a cement of good dielectric strength so that an electrical discharge from the anode 75 to the cathode 76 can not take place except from the anode 75 around the barrier disc 78, the body of the vessel 72 and the disc 71 to the cathode 76, or in the reversed direction.

This method of construction is therefore suitable to construct discharge tubes of more or less spherical shape and with short terminals. Then the principle of my invention is applied by placing the two discs 78 and 71 over the terminal ends of the tube and uniting them with the body of it with a good non conducting cement and thus the possibility of applying higher voltages according to my invention are realized.

Having thus described several ways in which the principle of my invention can be carried out, I do not confine myself only to the exact details shown thereof but to the scope of the claims.

I claim:

1. A pan-cake-type highly evacuated X-ray tube to be operated at high voltage comprising an envelope of dielectric substance having substantially parallel flat end walls and a cylindrical middle portion of a diameter greater than the distance between said walls, said flat walls and said cylindrical portions joining in rounded portions,

X-ray discharge electrodes mounted centrally in opposite end walls, whereby the said flat end portions constitute dielectric barriers to lines of force.

5 2. A pan-cake-type highly evacuated discharge tube to be operated at high voltage comprising an envelope of dielectric substance, having substantially parallel flat end walls and a cylindrical middle portion of a diameter greater than the distance between said walls, said flat walls and said cylindrical portions joining in rounded portions, electron discharging and receiving electrodes mounted centrally in opposite end walls, whereby the said flat end portions constitute dielectric barriers to lines of force.

10 3. An X-ray tube comprising a highly evacuated envelope of high dielectric substance having flattened substantially parallel end walls and a cylindrical middle portion joining said end walls in rounded portions, an X-ray cathode and an X-ray anode mounted centrally and oppositely in said flat end portions, the distance between said end portions being less than the diameter of said middle portion and the active portion of one of said electrodes being located substantially in the center of said envelope, whereby the said flattened end walls and the evacuated space in said envelope constitute dielectric barriers to lines of force when said tube is energized with high voltage current.

30 4. An X-ray tube comprising a highly evacuated envelope of high dielectric substance having

flattened substantially parallel end walls and a connecting middle portion joining said end walls as an integral part of said envelope, the flattened end walls having a diameter greater than the distance between said end walls and having an anode and a cathode oppositely and centrally mounted in said end walls, the said anode having a target face and a part for transmitting heat to a cooling medium outside said envelope and a solid mass of heat conducting metal connecting between said target and said heat transmitting part and said connecting metal being less in length than the distance between said flattened end portions of said tube, whereby the heat generated on said target is readily transmitted to a cooling medium.

5. An electron discharge type X-ray tube comprising an evacuated envelope having a tubular middle portion of material having high dielectric properties and substantially flattened, end portions joining said middle portion in a rounded continuous portion of said envelope and having in the center thereof cone-shaped inwardly pointing portions in each of which one of a pair of X-ray electrodes is mounted, the distance between opposite walls of said tubular middle portion being greater than the distance between said end portions whereby the wall of said envelope constitutes a barrier to voltages applied to said X-ray tube.

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