

Aug. 15, 1939

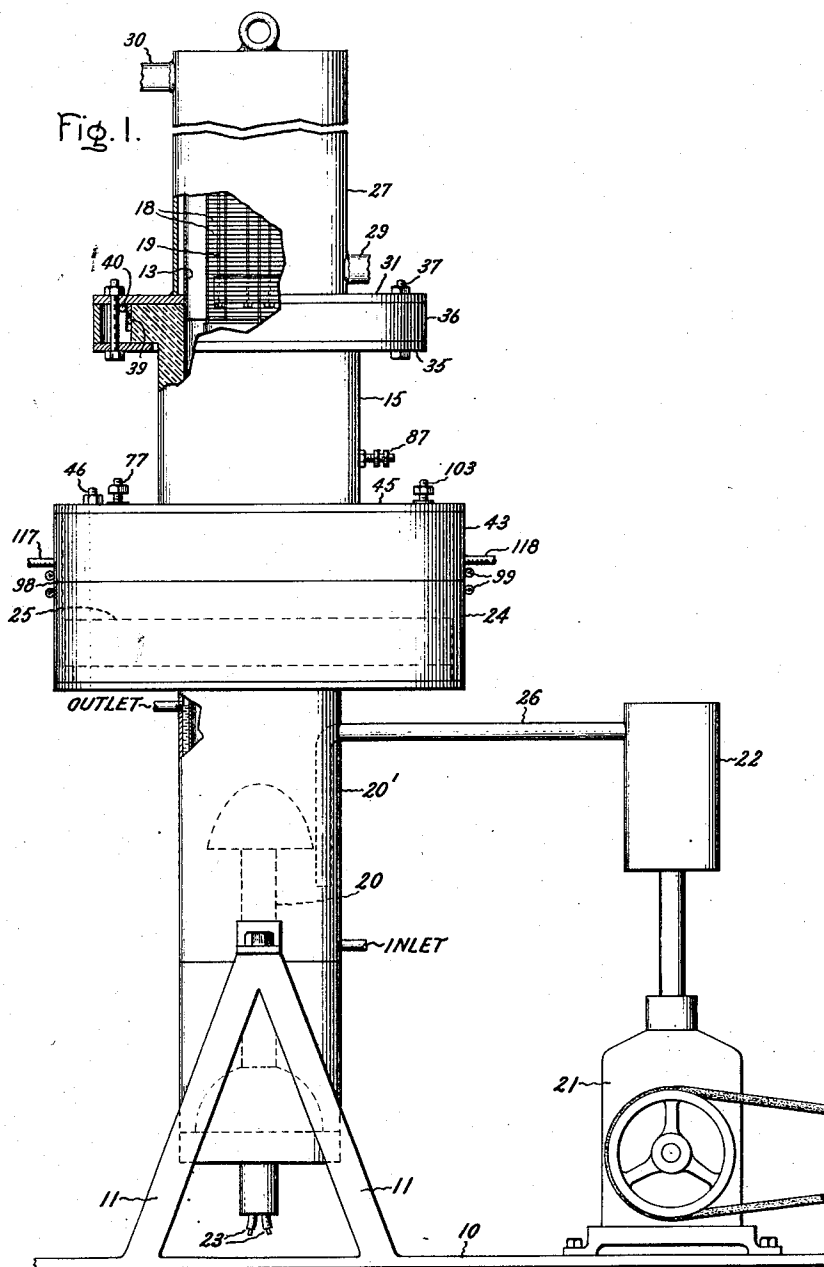
E. D. McARTHUR ET AL

2,169,879

DEMOUNTABLE DISCHARGE APPARATUS

Filed March 31, 1937

4 Sheets-Sheet 1



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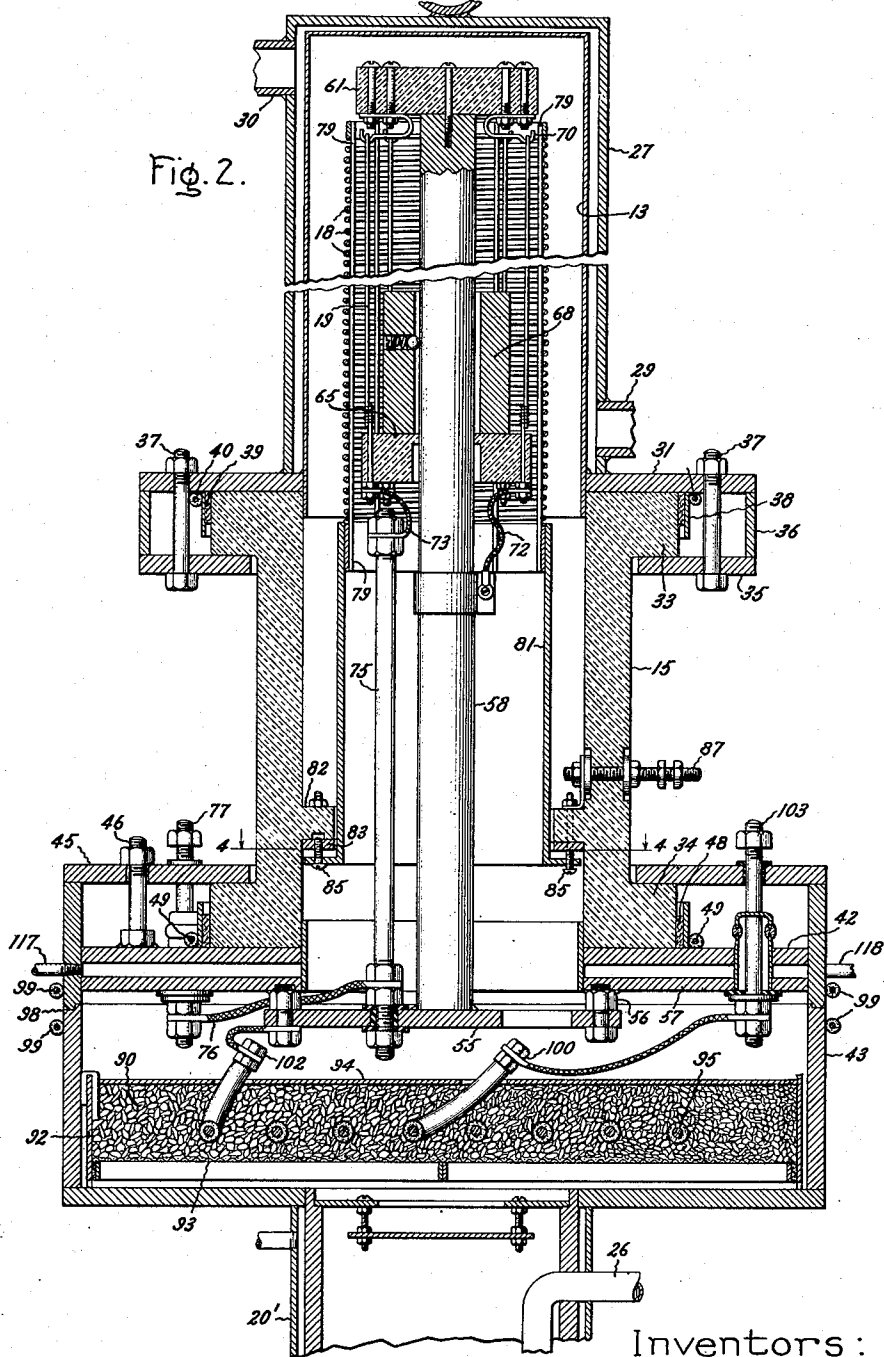
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DEMOUNTABLE DISCHARGE APPARATUS

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4 Sheets-Sheet 2



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DEMOUNTABLE DISCHARGE APPARATUS

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4 Sheets-Sheet 3

Fig. 3.

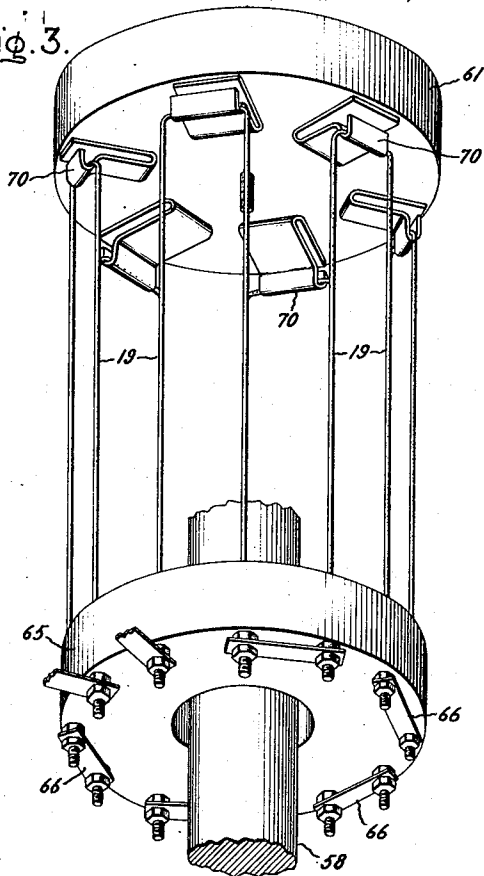


Fig. 5.

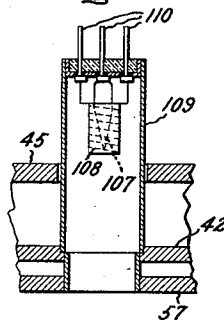


Fig. 6.

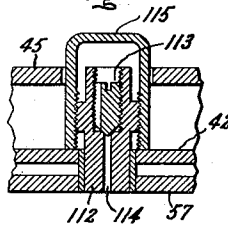
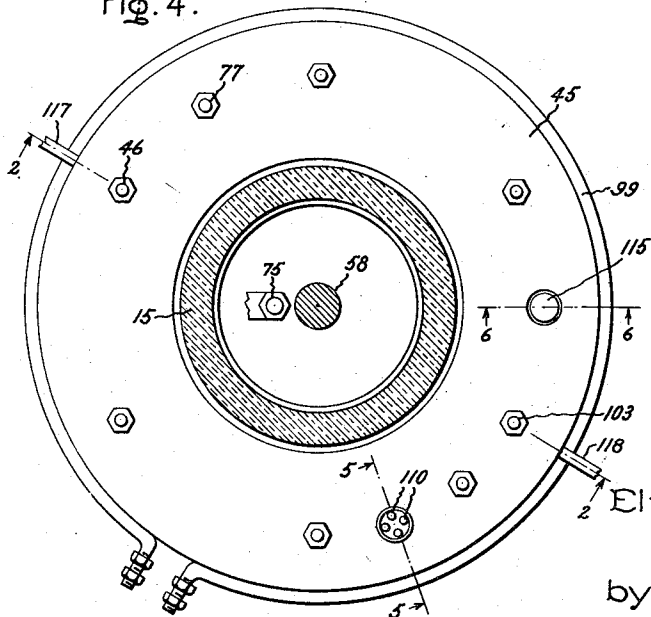


Fig. 4.



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Fig. 11.

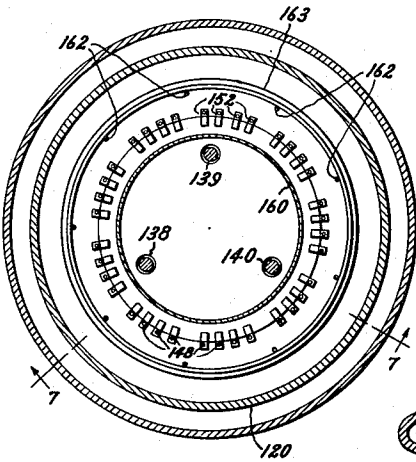


Fig. 7.

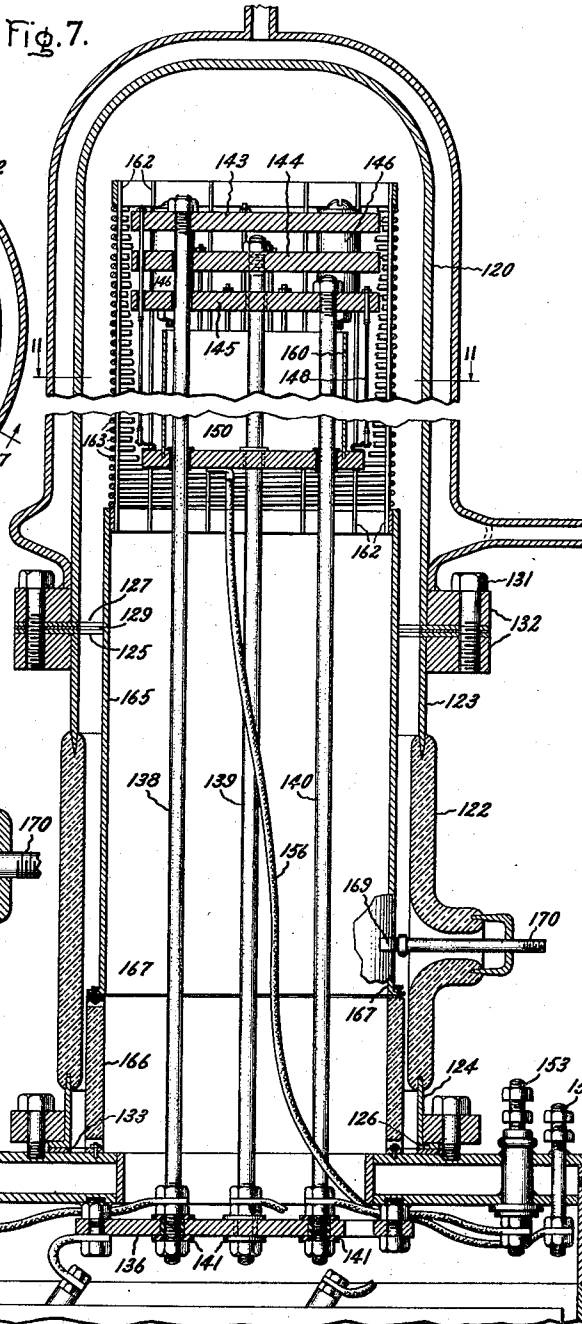


Fig. 12.

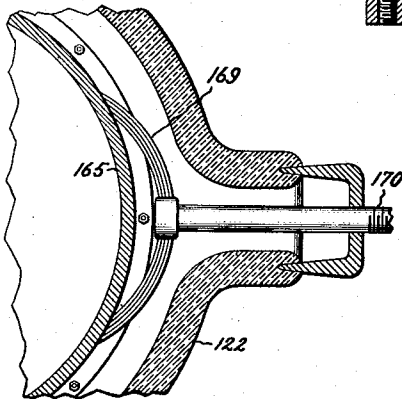


Fig. 8.

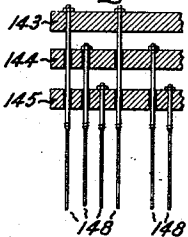


Fig. 10.

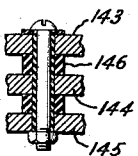
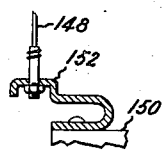


Fig. 9.



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UNITED STATES PATENT OFFICE

2,169,879

DEMOUNTABLE DISCHARGE APPARATUS

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Application March 31, 1937, Serial No. 134,046

13 Claims. (Cl. 250—27.5)

The present invention relates to electrical discharge apparatus, and more particularly to high power vacuum tubes which are adapted to be continuously evacuated by connection to a suitable evacuating system.

Vacuum tubes which are capable of transmitting power in excess of several kilowatts are characteristically of very large dimensions, on the order of several feet in length, and are correspondingly expensive to manufacture. Consequently, in order to avoid the necessity for frequent replacement of entire tubes, it is desirable that such tubes be capable of being disassembled from time to time to permit repair of separate internal parts which become defective through use.

It is an object of the present invention to provide an improved demountable vacuum discharge device built and assembled in such a fashion that it can be taken apart and repaired in the field without the aid of factory tools and facilities.

Further objects include a simple and inexpensive construction, maximum accessibility of the operative elements, and improved electrical characteristics. Included under this last heading are low electrostatic capacity between the anode and the grounded portions of the apparatus, and the substantial prevention of ionization within the device as a result of stray currents.

For purposes of convenient cooling it is conventional practice to form the anode of a high power vacuum tube as an externally exposed portion of the discharge envelope. Since this portion must be operated at a very high potential, it is necessary that it be fully insulated from the other electrodes and from the structure of the evacuating system. In the prior constructions of which we are aware the arrangement has been such as to require a number of separate insulators respectively interposed between the anode and various of the low voltage parts. The insulators employed for this use are inherently readily destructible and, in order to accomplish the full purpose of a demountable discharge device, it is necessary to make each of the insulators replaceable. This obviously involves the disadvantage of requiring a large number of demountable yet vacuum-tight connections.

It is an important feature of the present invention that the insulation of the anode from all of the remaining parts of the apparatus is provided substantially entirely by a single re-

placeable insulator which forms an integral part of the discharge envelope structure.

Another important feature comprises an arrangement of parts whereby the anode, the discharge envelope as a whole, and the control electrode may be removed from the apparatus assembly independently of the cathode and as a result of the opening of a single sealed joint.

Another feature comprises the provision of gas absorbent means in connection with the evacuating system and the disposition of such means in a containing structure adapted to serve as a base for the discharge envelope and as a convenient mount for the terminal connections of the cathode and of certain auxiliary devices.

Another feature comprises an improved cathode construction adapted to the requirements of high power vacuum operation.

Another feature comprises the use of novel shielding means in connection with the cathode structure for preventing excessive ionization due to stray electron currents.

Still other features of novelty will be brought out in the following detailed description of the invention, which description is to be read with reference to the accompanying drawings.

In the drawings Fig. 1 represents an assembly of the complete apparatus including the discharge envelope and the evacuating system; Fig. 2 is a sectional view of a discharge device illustrating one embodiment of the invention; Fig. 3 is a detailed view of the cathode structure of Fig. 2; Fig. 4 is a section taken on line 4—4, of Fig. 2; Fig. 5 is a fragmentary section taken on the line 5—5 of Fig. 4; Fig. 6 is a fragmentary section taken along line 6—6 of Fig. 4; Fig. 7 is an irregular sectional view (taken on line 7—7 of Fig. 11) of another discharge device illustrating an alternative embodiment of the invention; Fig. 8 is a fragmentary view in section of the cathode structure of Fig. 7; Fig. 9 is an enlarged detailed view of a tensioning element employed in connection with the cathode structure; Fig. 10 is a sectional view of the spacing means employed in connection with the cathode of Fig. 7; Fig. 11 is a section taken on line 11—11 of Fig. 7, and Fig. 12 is a fragmentary sectional view illustrating the grid connection for the discharge device shown in Fig. 7.

Referring particularly to Fig. 1 we have shown a demountable discharge device and the associated elements of an evacuating system as being mounted on a common base 10, the discharge device being directly supported by inclined braces 11 secured to the lower portion of its structure.

In accordance with our invention, the discharge device includes a hollow metal portion 13, closed at its upper end and adapted to serve as an anode, and an insulating portion 15 open at its lower end for connection with the evacuating system. As will be more fully explained hereinafter, the insulating portion is demountably secured both to the anode 13 and to the evacuating system so that it may be removed and replaced at will. Within the metal envelope portion there are arranged a grid 18 and a cathode 19, these electrodes being preferably supported adjacent the lower end of the insulator 15 (see Fig. 2).

The evacuating system consists essentially of a vapor diffusion pump, suitably comprising a vapor uptake pipe 20 indicated in dotted outline and a fluid cooled outer casing 20', in combination with a mechanical pump 21 connected to the diffusion pump exhaust pipe 26. Between the two pumps there may be provided a container 22 adapted to serve as a vacuum storage chamber.

The diffusion pump preferably employs as an operative medium a hydrocarbon oil such as that commercially available under the trade name "Apiezon" oil. This medium may be vaporized by heat derived, for example, from an electrical resistance heater whose terminal connections are indicated at 23. In order to prevent diffusion of the oil vapor or its products of decomposition into the main body of the discharge device, there is provided an intermediate enclosure 24 containing a gas-absorbent material indicated in dotted outline by the numeral 25.

With the arrangement which has so far been described substantially all of the operative and structural parts which are at low potential with respect to the anode are grouped into a single assembly which may be connected to ground. Since the anode is separated from this assembly by the full length of the insulator 15, its total capacity to ground may be very low, a factor of considerable importance in vacuum devices intended for radio application.

With reference to the demountable features of our apparatus it is important to note that the discharge envelope is demountable in two respects. That is, the envelope may be removed as a whole from the remaining structure to permit the repair of internal parts, or the insulating portion of the envelope may be separated from the metal anode portion to permit replacement of the former in case of breakage. These aspects of demountability will be discussed in detail in the following.

As will be apparent upon inspection of Fig. 2, the anode or metal portion 13 of the discharge envelope is provided with an external jacket 27 defining an annular chamber surrounding the anode. During operation of the device this chamber is adapted to be supplied with a cooling fluid, for example, water, by means of inlet and outlet conduits respectively indicated at 29 and 30. Adjacent the lower end of the metal wall portion there is provided an outwardly projecting flange 31 welded or otherwise secured to both the wall members 13 and 27, the former member being of such length that its edge projects substantially below the flange 31 and thereby provides a centering means.

The insulating portion of the envelope may take various forms but in the present instance is illustrated as comprising a porcelain bushing 15 provided at its upper and lower extremities with outwardly projecting flanges 33 and 34. The

upper bushing flange 33 abuts against the metal flange 31 and is maintained in substantially vacuum-tight connection therewith by means of a clamped joint comprising a clamping ring 35, a bracing member 36 and a plurality of bolts 37. In order to complete the joint and to make it in all respects vacuum-tight, there is provided a demountable hermetic seal.

This seal comprises a retaining ring 38 so arranged with respect to the flange 33 as to provide an annular channel surrounding the same. This channel is filled with a thermoplastic material 39, for example, a wax, and is in good heat exchanging relation with a heating device such as an electrical resistance heater 40. When this latter element is energized, the thermoplastic material will be softened and caused to flow in such a manner as hermetically to seal the joint between the flanges 31 and 33. This particular sealing operation may be most conveniently accomplished before the apparatus is completely assembled and with the envelope in an inverted position. It will be clear that by means of the demountable joint thus formed the anode may be removed from the apparatus assembly independently of the other elements of the discharge device.

The lower end of the insulator 15 is open to permit connection with a suitable evacuating system. In the arrangement illustrated this connection is made by joining the insulator to a base structure which comprises the upper header 42 of an enclosure 43. This enclosure forms a part of the evacuating system as will be explained in greater detail hereinafter. In order to permit the removal of the envelope in case internal repairs are required, the joint is preferably of demountable construction and may suitably comprise a clamping ring 45 and a series of bolts 46. A seal including thermoplastic material 48 and a resistance heater 49 may be employed to render the connection entirely vacuum-tight.

In addition to the improved envelope construction described in the foregoing, our invention further provides a novel cathode structure and mode of supporting the same. The cathode is preferably supported adjacent the lower end of the envelope and in the construction illustrated is mounted on a base plate 55 which is secured to the metal structure of the enclosure 43 by a welded joint between the nuts 56 and the header 57. From the base 55 the cathode structure as a whole is held in position within the metal envelope portion or anode by means of a supporting member 58 running longitudinally of the envelope. The cathode itself is most clearly illustrated in Fig. 3 and comprises an insulating mount 61, suitably of porcelain, and a plurality of series-connected filaments 19 suspended from this mount.

As illustrated, the filaments are of inverted U form and are maintained under tension by means of an insulating member 65 suspended by them and supported at their lower ends. The member 65 is freely movable longitudinally of the supporting member 58 and carries on its upper surface an annular weight 68 (see Fig. 2) which is of sufficient magnitude to maintain the desired tension on the filaments by the action of gravity. In order satisfactorily to equalize the tensions between the various filaments, each filament is provided at its upper end with an individual resilient tensioning means comprising one of the leaf springs 70.

The filaments are so secured as to be independent-

ently removable from the cathode structure in case of failure and are connected in series by means of a plurality of conducting strips 66. Each filament may suitably comprise a tungsten wire coated with thorium or with some other highly electron emissive substance.

During operation of the discharge tubes heating current is supplied to these filaments by means of flexible connections 72 and 73 (Fig. 2). The former of these is electrically connected to the supporting member 58 which may be wholly or partially of conducting material and which is grounded by being electrically connected to the metal structure associated with the enclosure 43. The flexible connection 73 is connected to a rigid conductor 75 which is supported on the base plate 55 and which connects with a lead-in conductor 76 having a terminal portion 77 accessible externally of the device.

Interposed between the anode and the cathode there is provided a control electrode (see Fig. 2) which may suitably comprise a plurality of metal stay-rods 78 and a series of spirally wound grid wires 18 supported thereon. At its lower end the grid structure is supported by connection to a metal cylinder 81 which in turn is secured to an inwardly projecting flange 82 forming a part of the insulator 15. The connection to this flange is made through the intermediation of a metal ring 83 which is attached to the flange by screws or other suitable retaining means (not shown). In order to permit accurate adjustment of the alignment of the grid with respect to the cathode filaments, adjusting screws 85 engaging with the ring 83 are provided as shown. Means for connecting the grid to an external source of potential is shown as comprising a lead-in connection 87 passing through the wall of the insulator 15 and hermetically sealed therein.

In case any of the internal parts such, for example, as the cathode becomes defective through use, it may be reached very readily by loosening the clamped joint between the insulator flange 34 and the header 42 and supplying sufficient heat to the heater 49 to soften the thermoplastic material 48. The envelope structure as a whole may then be removed independently of the cathode by lifting vertically to clear the cathode mount 61. The control electrode or grid is also removable independently of the cathode and as an incident of the removal of the envelope. Thereafter the filament or other injured part may be repaired and the discharge device reassembled, the steps of reassembling requiring no facilities other than those which would ordinarily be available in the field.

In operating a discharge device such as that which has been described in the foregoing, we consider it desirable to interpose between the envelope and the pumping elements of the evacuating system means for absorbing gaseous impurities which may be developed from time to time within the system. Such means may suitably comprise (see Fig. 2) a quantity of charcoal 90 arranged loosely in a removable tray positioned in the enclosure 43. This tray, which comprises a lateral wall 92, a sieve-like bottom 93, and a removable cover 94, is preferably of such size as to require an indirect or tortuous passage of gases between the pumping system and the interior of the envelope. In this way gaseous impurities resulting from the decomposition of the pumping medium will be forced into contact with the charcoal before they can pass into the envelope. The absorbent quality of the

charcoal will thus be used to best advantage in excluding these impurities from the discharge space.

In the preferred arrangement illustrated the charcoal trap extends outwardly beyond the normal contour of the discharge device and is but slightly spaced from the bottom and side walls of the enclosure 43. Consequently, gaseous impurities originating in the pumping system must traverse a relatively long narrow passage in contact with the perforated bottom of the charcoal tray before they can enter the discharge space. Effective trapping of the volatile hydrocarbons generated by the pumping medium is thus assured. This is a matter of considerable importance in the operation of the device since it permits the use of cathode coatings which would deteriorate rapidly in a hydrocarbon containing atmosphere. In terms of cathode efficiency, the improvement realized over the uncoated tungsten filaments which would otherwise have to be employed may be as great as nine to one.

In order that the charcoal 90 may be baked out or reconditioned during periods of disuse of the discharge device, we provide conveniently usable heating means in heat-exchanging relation therewith. This means in the present case is illustrated as comprising a resistance heater 95 embedded in the charcoal and having externally accessible terminals for connection to a suitable source of potential. The enclosure 43 in which the charcoal is contained is also made demountable to permit removal and replacement of the charcoal tray in case such an act ever becomes desirable. This demountability may be accomplished, for example, by the use of a soldered vacuum-tight joint 98 in combination with heating means illustrated as electrical resistance heaters 99 arranged in heat-exchanging relation with the joint.

The outwardly projecting portion of the enclosure 43 is employed in accordance with our invention for mounting the terminal connections of the various enclosed electrical devices. Thus, in Fig. 2 it will be seen that the conductor 100 associated with resistance heater 95 is connected with an externally accessible terminal 103 by means of a vacuum-tight seal passing through the headers 57 and 42. A similar terminal connection 77 provided for the cathode heating circuit has been already described. The opposite terminals of both the heater 95 and the cathode are grounded by being connected to the metallic structure, the grounding connection for the heater being indicated at 102.

Other aspects of this feature of the invention are illustrated in Fig. 4 where various terminals and fittings are shown projecting through the clamping ring 45, which also serves as a cover plate to protect the joint between the header 43 and the insulator 15. In addition to the cathode terminal 77 and the heater terminal 103, the upper surface of the enclosure 43 also constitutes a mount for certain auxiliary devices incidental to the convenient use of the discharge apparatus.

One such device, shown in detail in Fig. 5, comprises an ionization gauge communicating with the evacuated interior of the apparatus. This gauge comprises a cathode 107, a grid 108 and an anode 109, these various elements being provided with terminals 110 which serve to connect them to a desired source of potential. The gauge is used to determine the degree of vacuum within the enclosed space by observation of the

characteristics of the discharge passing between the cathode 107 and the anode 109.

In Fig. 6 there is shown a relief valve used to break the vacuum of the apparatus when it is desired to open the system for repairs. This valve comprises a seating member 112 sealed into the header walls 42 and 57 and a threaded plug 113 adapted to seal an opening 114 provided in the sealing member. The valve as a whole is covered with a cap 115 which also appears in Fig. 4.

In order to protect the various seals and terminal connections from the effects of heat generated within the device during its operation a cooling fluid may be circulated between the headers 42 and 57 (see Fig. 2). Such circulation is facilitated by means of inlet and outlet conduits 117 and 118 provided for that purpose.

In Fig. 7 I have illustrated an alternative modification of the invention in which the cathode is adapted to be heated from a polyphase source of power. In this construction the anode, which is designated by the numeral 120, corresponds in essential particulars to that described in connection with Fig. 2. The insulating portion of the envelope, however, differs in certain respects from the insulator 15 previously described. In the present modification the insulator comprises a glass sleeve 122 which is provided at each end with an annular metal ring sealed into the glass, these rings being numbered 123 and 124 respectively. A vacuum-tight connection between the anode and the insulating portion of the envelope is made by means of a clamped joint between a flange 127 secured to the anode structure and a flange 125 secured to the ring 123. The joint is sealed by means of a very thin deformable gasket 129 (shown in exaggerated scale) preferably comprising a combination of tin and calcium, the calcium constituting from about 0.5% to about 2.0% of the combination. When compressive force is applied to this gasket by means of bolts 131 and clamping rings 132 the gasket is slightly deformed to seal completely all leaks through the joint. After such initial deformation, however, the gasket quickly takes a permanent set which prevents its further flow under continued pressure. A similar gasket 133 (shown in exaggerated scale) may be used at the lower end of the envelope to provide a gas-tight connection between the flange 126 and the upper header 134 of the charcoal enclosure 43.

As in the embodiment previously described the cathode structure is supported on a metal base plate 136 suitably secured to the upper wall of the charcoal enclosure. In this case, however, direct support for the cathode is provided by means of three upright supporting members 138, 139, and 140 extending longitudinally of the envelope. These members are insulated from one another and from the metallic casing by insulating sleeves 141 provided for that purpose.

At the top of each support there is provided a conducting mount, these mounts taking the form of superimposed plates 143, 144 and 145 respectively. The mounts are insulated from one another by insulating spacers 146 (illustrated in section in Fig. 10) and each mount is provided with a plurality of symmetrically arranged removable filaments 148 suspended therefrom. Each filament is electrically connected to only one mount and the arrangement is such that each mount supports the same number of filaments. In order to secure optimum cooperation

with the control electrode structure, we further prefer to arrange the filaments in a plurality of spaced groups corresponding in number to the vertical stay-rods employed in the grid construction. This feature, which will be more fully explained in connection with the detailed description of the grid structure, is illustrated in Fig. 8 in which a complete group of four filaments is shown in its relation to the first members of an adjacent group. It will be noted that each third filament is connected to the same mounting plate thus assuring a symmetrical distribution of the polyphase heating currents and the avoidance of a commercial frequency hum in the tube output.

At their lower ends all of the filaments are electrically and mechanically connected to a common conducting member 150 which is freely movable longitudinally of the vertical supports and which thereby serves to maintain the filaments under tension. Tension between the individual filaments is equalized by means of individual resilient tensioning means attached to each of the filaments, such tensioning means being shown in detail in Fig. 9. The particular means there illustrated comprises a leaf spring 152 connected both to the conducting member 150 and to a filament 148.

Each of the various mounts may be separately connected to one phase of a polyphase source of potential through its corresponding supporting member. An externally accessible terminal 153 for each of the supporting members is provided by means of a vacuum-tight lead-in connection established through the upper headers 134 and 154 of the charcoal enclosure. A common return for the currents of all of the various filaments is provided by means of a wire 156 connecting with the suspended conducting member 150. The wire 156 may be grounded to the metal casing, but it is preferred also to provide a directly connected, externally accessible terminal 157. The provision of such a terminal avoids the necessity of passing the radio frequency currents through the more or less magnetic casing structure where they might be unduly attenuated.

Due to the relatively great dimensions of the hollow space enclosed by the filaments of the illustrated cathode construction, stray electrons passing diametrically across the space from one filament to another may traverse a distance much greater than the normal path from the filament to the anodes. The ionization resulting from collisions between electrons and gas molecules under these conditions may be such as seriously to interfere with the normal operation of the device. In order to avoid this difficulty we provide within the cathode an ionization shield in the form of a hollow conducting cylinder 160 (Fig. 11), this cylinder being electrically connected to the conducting member 150. The spacing of the shield from the filaments is preferably made less than the length of the normal path from the cathode to the anode, whereby electrons will be intercepted before they have traversed a sufficient distance to cause appreciable ionization. It will be understood that the weight 68 described in connection with Fig. 2 may also be so formed as to constitute an ionization shield, if desired. This means of avoiding ionization is fully described and claimed in our copending application Serial No. 216,734, filed June 30, 1938, and assigned to the General Electric Company.

The grid construction employed in the modification of Fig. 7 is generally similar to that de-

scribed in connection with Fig. 2. We consider it desirable, however, to dispose the vertical stay-rods 162 in such a way that they fall between the groups of cathode filaments. This arrangement, which is most clearly illustrated in Fig. 11, is advantageous in that the stay-rods are outside of the principal paths of current flow from the cathode to the anode and, consequently, have little effect on the current flow. As a result control of the current passing from the cathode to the anode is accomplished principally by the transversely extending grid wires 163, and a substantially smaller part of the total current is intercepted by the stay rods. (While the grid wires are shown in the drawings as being partly broken away, it will be understood that this is only to simplify the illustration.) The grid arrangement described in the foregoing is fully claimed in our aforesaid application Serial No. 216,734.

The method of grid support illustrated in Fig. 7 differs substantially from that described in connection with Fig. 2, but it should be understood that the construction of either figure may alternatively be substituted in the other without departure from the invention. In the arrangement shown the grid structure is supported on an intermediate cylinder 165 which in turn is supported independently of the envelope and adjacent its open end by means of an insulator 166 connecting with the header 134. An adjustable connection comprising screws 167 is provided between the cylinder 165 and the insulator 166 to permit proper alinement of the grid with respect to the cathode.

In order that the envelope may be removed without requiring removal of the grid, the grid is connected to an external source of potential by a frictional contact which is adapted to be disengaged as an incident of the removal of the envelope. In the particular arrangement shown (Fig. 12) this contact comprises a series of arcuate leaf springs 169 resiliently engaging the outer surface of the metal cylinder 165. These springs are supported at the inner extremity of a lead-in conductor 170 which is sealed in a vacuum-tight manner through the wall of the insulating envelope portion 122.

With the discharge devices described in the foregoing, normal repair operations require merely the opening and reassembly of a single sealed joint, viz. the joint between the envelope and the base structure. By means of this joint the envelope may be removed from the base structure independently of the cathode, this latter element being still supported by the base structure in convenient position for inspection and repair. Furthermore, the arrangement and construction of the various parts of the apparatus are such that ordinary repairs can be made in the field without returning the whole unit to the factory. Thus, such devices may advantageously be operated continuously at loads approximating their maximum capacity since a failure due to such operation can ordinarily be rectified within a few hours. For this reason and because fewer initial and replacement units will be necessary, the present invention is expected to result in substantial savings to radio broadcasting stations and to other users of other high power vacuum tubes.

It will be understood that the envelope construction of Fig. 2 may be used alternatively with that of Fig. 7, and that in other respects the elements of the two constructions may be interchanged. Furthermore, while we have illustrated

particular modifications, many changes may be made by those skilled in the art without departing from the invention. We, therefore, aim in the appended claims to cover all such equivalent modifications as come within the true spirit and scope of our disclosure.

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

1. In combination, a demountable envelope enclosing an anode and a cathode, said cathode being coated with an activating material subject to deterioration in the presence of hydrocarbon vapors, means connecting with the envelope for continuously evacuating the same, said means including a diffusion pump employing a liquid hydrocarbon operating medium, and means including a quantity of gas absorbent material interposed between the envelope and the evacuating means for preventing the passage of hydrocarbon vapors from the diffusion pump into the envelope.

2. In a demountable discharge apparatus, an elongated envelope including a hollow metal portion closing one end of the envelope, a hollow insulating portion open at both ends and comprising a substantial part of the envelope, means including a demountable vacuum-tight joint connecting said metal portion to one end of said insulating portion, an evacuating system, an enclosure connecting with said evacuating system and said envelope and supporting the envelope, said enclosure projecting laterally beyond the envelope so as to present an external wall surface transverse to the axis of the envelope, a quantity of gas absorbent material within the enclosure and interposed between the evacuating system and the envelope, means including a demountable vacuum-tight joint connecting the other end of said envelope insulating portion to said enclosure, a cathode supported within the hollow metal portion of the envelope and an externally accessible terminal connection for said cathode mounted on said transverse wall surface of said enclosure.

3. A discharge apparatus comprising an elongated envelope, electrodes enclosed within the envelope, an enclosure containing gas absorbent material and connecting with said envelope at one end thereof, said enclosure projecting laterally beyond the envelope so as to present a wall surface transverse to the axis of the envelope, externally accessible terminal connections for at least some of said enclosed electrodes mounted on said wall surface, and an evacuating system communicating with the interior of the envelope through said enclosure.

4. A vacuum discharge apparatus comprising an envelope enclosing electrodes, means for continuously evacuating said envelope including an enclosure having a demountable vacuum-tight connection with one end of the envelope, said enclosure projecting laterally beyond the normal contour of the envelope so as to present an external wall surface transverse to the axis of the envelope, a quantity of gas absorbent material within the enclosure, an electrical resistance heater associated with said absorbent material, and externally accessible terminal connections for said heater and said electrodes mounted on said transverse wall surface of said enclosure.

5. An electrical discharge apparatus comprising the combination of an envelope enclosing electrodes, an evacuating system in communication with the interior of the envelope, an enclosure containing a gas absorbent material such as charcoal interposed between the evacuating system and the envelope, an electrical resistance

heater in heat-exchanging relation with said material, and terminal connections for said heater accessible externally of said enclosure.

6. An electrical discharge apparatus comprising the combination of an envelope enclosing electrodes, an evacuating system in communication with the interior of the envelope, an enclosure interposed between the evacuating system and the envelope, a removable tray containing gas-absorbent material within the enclosure, and means including a demountable vacuum-tight joint affording access to said enclosure to permit removal and replacement of said tray.

7. In a discharge device, an elongated envelope having its longitudinal axis in a vertical position during the normal operation of the device, said envelope comprising an upper metal portion constituting an anode, and an insulating portion joining with the lower end of said metal portion, a cathode structure arranged within the anode, means including a conducting member running longitudinally of the envelope for supporting said cathode structure, means supporting said conducting member adjacent the bottom of said insulating envelope portion, a mount secured to said conducting member adjacent the upper end thereof, a plurality of filaments suspended from said mount, and common means operating through gravity to maintain all of said filaments under tension, said means comprising an element suspended by said filaments and freely movable longitudinally of said conducting member.

8. In a discharge device, an elongated envelope having its longitudinal axis in a vertical position during the normal operation of the device, said envelope comprising a metal portion at the upper end thereof constituting an anode, a polyphase cathode structure arranged within the anode, said structure including a plurality of electrically separate superposed conducting mounts, a plurality of symmetrically arranged filaments suspended from each of said mounts, each filament being electrically connected to one mount and insulated from the remaining mounts, means for rigidly positioning said mounts within the envelope and for connecting them with an external source of potential, said means including a plurality of electrically independent supports running longitudinally of the envelope and each connecting with a different one of said mounts, means including a dependent conducting member freely movable with respect to said supports and supported by said filaments for maintaining the filaments under tension, said member being electrically connected to all of the filaments, and means for connecting said member to an external source of potential.

9. A demountable discharge device including an elongated envelope comprising a metal portion constituting an anode and an insulating portion presenting an open end, means including a demountable vacuum-tight seal for removably connecting the open end of said insulating portion to a supporting structure, a cathode arranged within the metal portion of the envelope, a grid interposed between the cathode and the metal envelope portion, said cathode and said grid being supported independently of the envelope adjacent the open end thereof, and means

including a frictional contact within the envelope for connecting said grid to an external source of potential, said contact being adapted to be disengaged as an incident of the removal of said envelope from said supporting structure.

10. A discharge device comprising an envelope providing a discharge chamber, electrodes within said chamber, a hollow enclosure joined to one end of the envelope, said enclosure being of such dimensions as to project laterally beyond the contour of the envelope and to provide a wall which is transverse to the axis of the envelope in a region surrounding the said end thereof, externally accessible terminal connections for at least some of said enclosed electrodes provided on said wall, and means within the envelope and enclosure for connecting the said terminals with their associated electrodes.

11. A discharge device comprising a cylindrical envelope providing a discharge chamber, cooperating electrodes within said chamber, a hollow cylindrical enclosure having an end wall joined to one extremity of the envelope and providing a base structure therefor, the said enclosure being of larger diameter than the envelope so that the said end wall comprises a portion which projects laterally beyond the contour of the envelope, externally accessible terminal connections for at least some of said enclosed electrodes provided on the laterally projecting portion of said end wall, and means within the envelope and enclosure for connecting the said terminals with their associated electrodes.

12. A vacuum discharge apparatus comprising an elongated cylindrical envelope providing a discharge chamber therein and having an opening at one end thereof, electrodes enclosed within the envelope, a hollow enclosure connecting with the said one end of the envelope, said enclosure projecting laterally beyond the contour of the envelope so as to provide a substantially flat wall transverse to the longitudinal axis of the envelope in a region surrounding the said end thereof, means including vacuum-tight seals providing externally accessible terminal connections on said wall for at least some of said enclosed electrodes, means for connecting each of said terminals with its associated electrode, and an evacuating system communicating with the interior of the envelope through the enclosure.

13. A vacuum discharge apparatus comprising an elongated envelope having its longitudinal axis in a vertical position during the normal operation of the apparatus, electrodes enclosed within the envelope, evacuating means communicating with the envelope through an enclosure which connects with the lower end of the envelope, said enclosure being of such dimensions as to project beyond the contour of the envelope and to provide a wall which is transverse to the axis of the envelope in a region surrounding the said end thereof, means including vacuum-tight seals for mounting externally accessible terminal connections for at least some of said enclosed electrodes on said wall, and means for cooling said wall during the operation of said device.

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