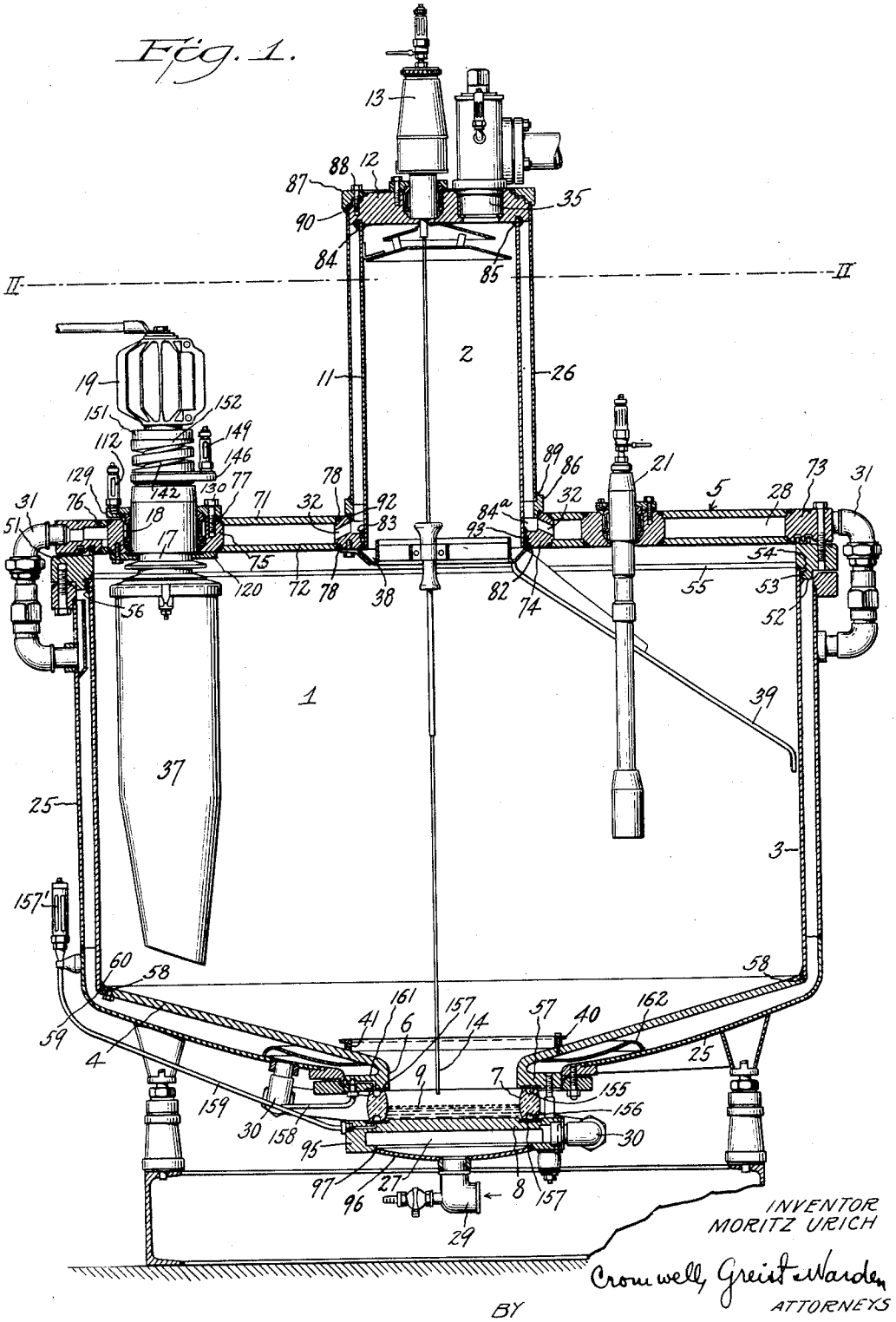
March 21, 1933. M. URICH 1,902,110

VAPOR DISCHARGE DEVICE

Original Filed July 31, 1929 3 Sheets-Sheet 1

Fig. 1.



March 21, 1933. M. URICH 1,902,110

VAPOR DISCHARGE DEVICE

Original Filed July 31, 1929 3 Sheets-Sheet 2

Fig. 2.

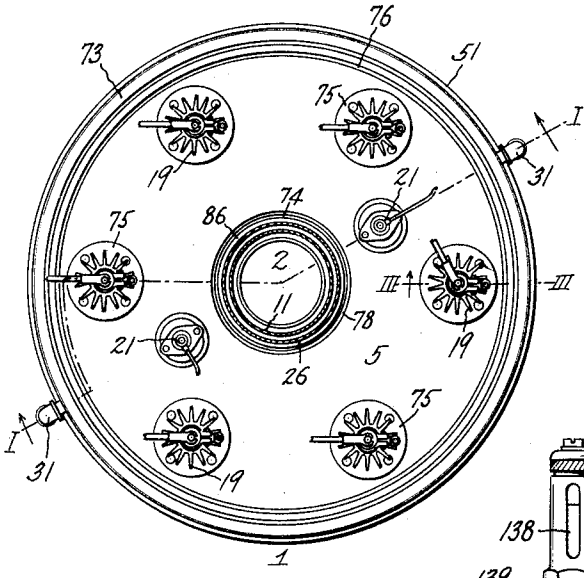


Fig. 3.

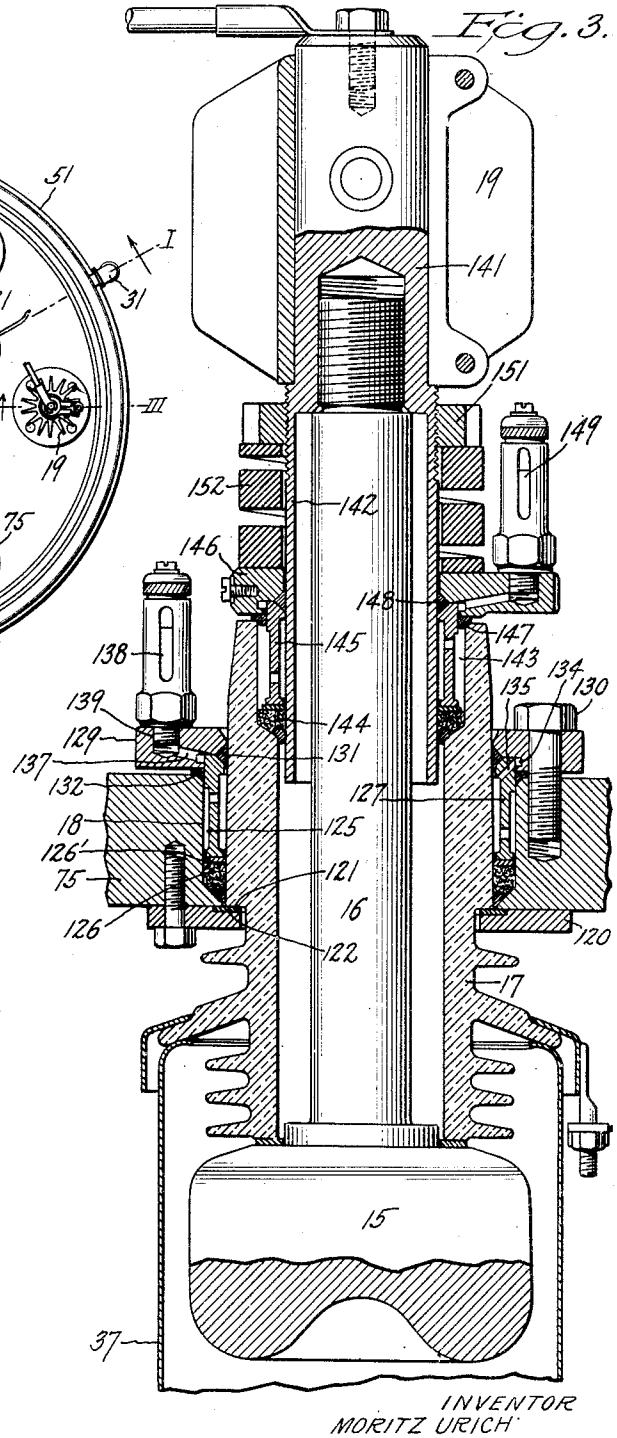
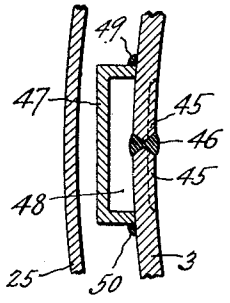


Fig. 5.



INVENTOR
MORITZ URICH

BY Cromwell, Greist & Warden
ATTORNEYS

March 21, 1933. M. URICH 1,902,110

VAPOR DISCHARGE DEVICE

Original Filed July 31, 1929 3 Sheets-Sheet 3

Fig. 4.

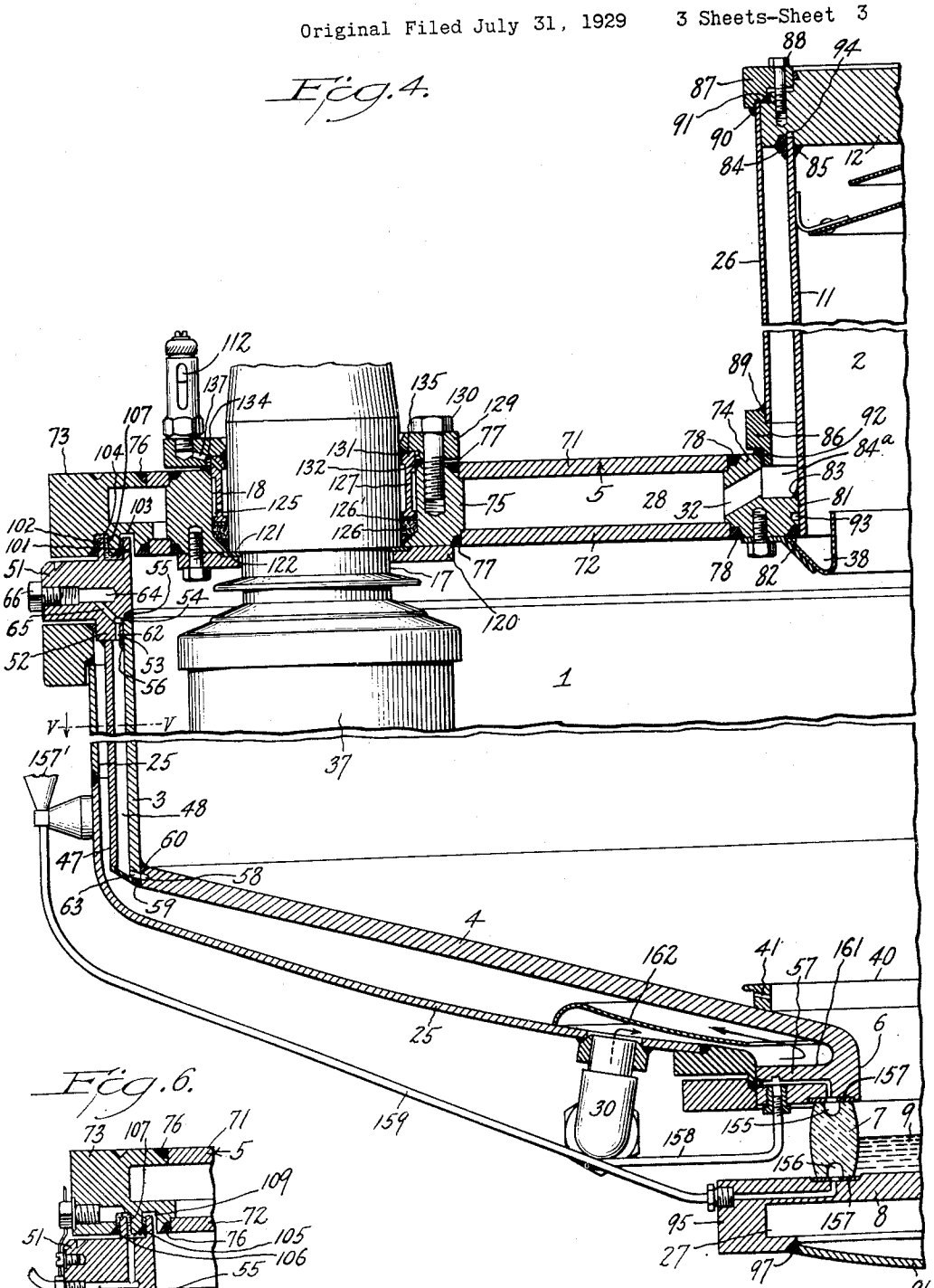


Fig. 6.

INVENTOR
MORITZ URICH

BY Cromwell, Greist & Warden
ATTORNEYS

Patented Mar. 21, 1933 1,902,110

UNITED STATES PATENT OFFICE

MORITZ URICH, OF BADEN, SWITZERLAND, ASSIGNOR TO AKTIENGESELLSCHAFT BROWN BOVERI & CIE, OF BADEN, SWITZERLAND, A JOINT-STOCK COMPANY OF SWITZERLAND

VAPOR DISCHARGE DEVICE

Application filed July 31, 1929, Serial No. 382,451. Renewed January 24, 1933.

This invention relates to vapor discharge devices such as mercury vapor rectifiers and it has among its objects an improved construction of metal tank rectifiers permitting economies in manufacture and securing better operating performance. The objects and features of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawings wherein,

Fig. 1 is a vertical sectional view along the line I—I of Fig. 2, of a metal tank rectifier embodying my invention;

Fig. 2 is a plan view of the rectifier shown in Fig. 1;

Fig. 3 is a detail vertical sectional view of the anode mounting along line III—III of Fig. 2;

Fig. 4 is a detail vertical sectional view of the tank structure of the rectifier shown in Fig. 1;

Fig. 5 is a horizontal fragmentary sectional view of the welded vertical joint of the tank along line V—V of Fig. 4; and,

Fig. 6 is a detail vertical sectional view of the joint between the cover and the side walls of the tank.

The invention will be described as applied to a high power mercury arc rectifier of the metal tank type shown in the drawings, although in its broad aspects it is not limited thereto.

It comprises a hermetically closed vessel including a main arc chamber 1 and a condensing chamber 2 on the top thereof. The arc chamber 1 is made of a steel cylinder 3 with a frustoconically shaped bottom plate 4 and a substantially horizontal top plate 5. The bottom plate 4 has a central opening 6 which leads to the mercury container 7 formed of a short cylinder of insulating material such as porcelain that is closed at its bottom by a metallic cathode plate 8. A quantity of mercury 9 within this container serves as the cathode of the rectifier. The anode plate 4 is likewise provided with a central opening over which is mounted the condensing chamber 2 referred to above. This condensing chamber is formed of a main cylinder 11 that is closed at its upper end by a metallic cover plate 12 on which is mounted the ignition coil 13 by means of which the ignition electrode 14 is withdrawn from contact with the mercury cathode 9 to produce a current interrupting arc at the surface of the cathode and thus start the operation of the rectifier.

Mounted circumferentially on the anode plate around the condensing chamber 2 are a plurality of anodes 15, usually six or a multiple of six in number, depending on the capacity of the rectifier. Each anode 15 is made in the form of a solid, heavy member of steel having rounded edges with a short re-entrant portion at the lower end thereof. Each anode is carried by a stem or lead 16 extending upwardly through the insulating bushing 17 mounted within a suitable opening 18 in the anode plate. The upper end of each anode stem is provided with a suitable heat radiating member 19 for dissipating the heat generated at the anode during the rectifying action, so as to maintain the anodes at the proper operating temperature. In addition to the main anodes there are also mounted on the anode plate 5 a pair of auxiliary anodes 21 by means of which a rectifying arc may be maintained at the surface of the cathode independently of the operation of the main anodes 15.

The anode cylinder 3 and the bottom plate 4 thereof are surrounded by a cooling jacket 25 through which water is circulated. The cylinder 11 of the condensing chamber 2 is likewise surrounded by a cooling jacket 26 for circulating cooling water therethrough. The cathode bottom plate 8 is made hollow and provided with a cooling space 27 through which water may be circulated. Similarly, the anode plate 5 is made hollow and provided with cooling spaces 28 through which water may be circulated. The several cooling spaces are ordinarily connected in a cooling circuit, the water being usually admitted to the hollow space 27 of the cathode through the inlet 29, and the water therefrom is led through the connecting pipe 30 to the bottom of the cooling jacket 25 to the main cylinder 3, wherefrom it passes through the connect-

ing pipes 31 to the hollow spaces 28 of the anode plate 5 from whence it flows through the communicating openings 32 at the center, into the cooling jacket 26 of the condensing chamber 2, wherefrom it is discharged after passing therethrough.

The several parts of the rectifier structure described above are tightly joined to each other to provide a hermetical enclosure and the interior of the vessel is highly evacuated, as by means of a vacuum pump (not shown) connected to a valved exhaust opening 35 on the top of the condensing chamber. For satisfactory operation of the rectifier the cathode 9 must be held insulated from the remainder of the body of the rectifier vessel. It is also important to protect the anodes of the rectifier against the influences tending to destroy the valve action of the anodes, and to this end each of the anodes is enclosed in a relatively long, narrow shield 37 of metal, opening downwardly so as to prevent emanations from the cathode from reaching the space near the anodes.

There is also shown provided immediately underneath the opening into the condensing chamber 2 a small collecting gutter 38 of metal for collecting the condensed mercury trickling downwardly on the walls of the condensing chamber, the mercury being conveyed by a small pipe 39 out of the path of the main arc to near the side wall of the main arc chamber from where it is permitted to trickle downwardly together with the mercury condensing on the side walls of the chamber. The condensed mercury flows downwardly against the opening 6 and is returned to the pool 9 forming the cathode.

A strain ring 40 of metal with strain openings 41 is mounted on the bottom plate 4 in front of the cathode opening 6 and serves to collect impurities and solid particles gathered up by the mercury trickling down towards the cathode, the impurities being retained and the mercury being permitted to pass through the openings 41 towards the cathode 9.

The problem of constructing an operative and satisfactory high power metal tank rectifier baffled the electrical art for many years and even up to the present, the construction of satisfactory high power metal tank rectifiers is extremely difficult. The matter of greatest importance for satisfactory rectifiers is the provision of hermetically closed large metal vessels capable of maintaining the high degree of vacuum which is absolutely essential for the maintenance of the rectifier action, and avoidance of destructive back-firing. In addition, it has been found that the entire interior of the vessel and all the parts which come in contact with the mercury vapor, must be maintained free from impurities or what may be described as in a perfectly sterile condition. These requirements, coupled with the obscure phenomena that appear to be responsible for the back-firing in rectifiers, make the task of the practical construction of satisfactory rectifier vessels extremely difficult.

The rectifier shown in the drawings embodies a number of features which greatly simplify the difficulties in constructing such apparatus and eliminate to a large extent the underlying causes responsible for much of the trouble encountered with the prior art constructions.

One of the features of my invention resides in the novel construction of the rectifier vessel itself. The only practical way found heretofore for making the large hermetically tight steel vessels required for a mercury arc rectifier is to form the several parts of sheet steel and weld together the sheet parts into a closed vessel. For the operativeness of the device it is of course essential that the welded joints be perfectly tight and capable of preventing leakage into the vessel against the normal vacuum within the interior of about 1/800,000 of an atmosphere. In making such vacuum tight welded joints one has to depend entirely on the skill of the operator and as the welding itself is an extremely erratic process and difficult to control, one can never be sure whether the welded joints are good or not until they have been practically tested against vacuum tightness.

Prior to my invention, in order to make sure of the vacuum tightness of the vessel it has been the practice to assemble the entire vessel structure and examine minutely the entire vessel with regard to the tightness of the welded joints. The usual procedure was to place the entire vessel into a container with water and pump into the interior of the vessel compressed air. If the vessel was tight, no bubbles would be formed under the water. The formation of bubbles indicated that the vessel was leaking at some point and the entire vessel had to be scrutinized to determine the point of leakage. This was often done by the soap water test, soap water being applied over the individual portions of the vessel and compressed air pumped into the interior of the vessel. On the tight portions of the vessel no soap bubbles would form, and the formation of soap bubbles indicated the points where the vessel was not tight. As a rule, these points of leakage occurred at the welded joints of the vessel parts, the main body of the sheet metal being almost always air-tight.

This system of testing the vessel joints for air tightness was not only cumbersome, expensive and slow, but proved also to be dangerous to the men working adjacent to the rectifying vessel. Very often the tank would burst under the action of the compressed air pumped into the interior, and like in a boiler explosion, the parts thrown apart by the com-

pressed air would hit persons near the vessel causing serious injury to them.

The vessel construction of my invention permits the construction of welded large metal tank rectifier vessels and the examination of the individual parts and the individual joints for vacuum tightness without necessitating the assembly of the entire vessel structure for the purpose of examination.

According to my invention, the entire vessel is made of a sufficient number of detachable parts so as to permit each part to be readily cleaned and examined for cleanliness before assembling it into the closed vessel structure. Because of the requirement for vacuum tightness, the individual parts are made of rolled iron or some similar material that has passed through the rolling operation, the rolling action closing up any pores that the material might have had originally and thereby substantially assuring that there will be no leakage through the body of the material used for the parts. As a rule, such rolled sheet material cannot be directly formed into the shape and size required for the vessel. I accordingly weld the sheet metal parts into the required shape and size and make the individual joints with what I term "hollow welds." This hollow weld is made essentially by welding the sections to be joined on opposite sides and leaving a hollow space or groove between the two welds.

I then test each individual part so made for the vacuum tightness of its welded joints without going to the trouble of assembling the entire vessel as was done heretofore. The procedure followed by me consists essentially in pumping compressed air or similar substance into the hollow spaces of the welds of the individual parts and applying soap water over the welded joints. If the weld is satisfactory and vacuum tight, no soap bubbles will form on either side of the weld and the joint is then assuredly vacuum tight. If soap bubbles are formed in any of the parts of the weld, the weld can be readily repaired as the part is disassembled and readily accessible, until a completely vacuum tight weld has been obtained. In this manner defects at a welded joint are readily detected and the individual parts of the rectifier vessel made in themselves perfectly air-tight.

In the prior art constructions it was often necessary to repeat the performance of assembling the vessel and testing it for vacuum tightness a number of times, once a joint of one part of the vessel showing a fault, and then a different point of the vessel showing a fault, and then again imperfections developing in the repair of the faults previously detected, and so on. Such procedure would often require days in detecting one fault after another, it being necessary to assemble the entire vessel each time for a test and then take it apart and reassemble it until all the faults, sometimes large in number, have been found and corrected. By my invention all these difficulties are removed and furthermore, the danger to the persons working on the manufacture of the device and in the surroundings thereof is eliminated.

Furthermore, welds made and tested according to my invention are inherently of a higher vacuum tightness as each weld consists at least of two air-tight joints on both sides of the hollow weld groove.

It is of course understood that the method of testing the individual parts and the individual joints of such parts for vacuum tightness, as described above, is not the only one suitable for carrying out my invention. In its broad aspects this feature of my invention contemplates the testing of the vacuum tightness of the individual welded joints of the vessel by making such welded joints in the form of hollow spaces or channels and determining the air-tightness of such hollow channels in any approved and satisfactory way in which the air-tightness of a hollow vessel can be determined.

I shall now describe the construction and procedure of my invention in connection with the exemplification shown in the drawing. The main and most difficult part of the vessel is the enclosure forming the main rectifier chamber 1. The cylindrical part 3 of this enclosure is formed of a substantially rectangular sheet of iron suitably bent into cylindrical shape and joined lengthwise where the longitudinal edges 45 meet by a hollow weld referred to before and shown in detail in Figs. 4 and 5. To this end, the edges themselves are directly welded to each other by a layer of filler material 46 such as iron, the material being deposited along the edges in any of the forms usually approved for welding operations.

As shown in the drawings, the abutting edges of the sheet metal cylinder 3 are preferably slightly tapered on both sides so as to facilitate the deposit of the filler material, and a layer of the filler material is applied on both sides of the tapered edges. When this operation is completed, there is welded over the outside of the longitudinal weld 46 a channel shaped strip of iron 47 forming a longitudinal hollow channel 48 over the outside of the weld 46, the channel shaped member being welded at 49 and 50 to each of the abutting edges of the cylinder sheet 3. This channel shaped member 47 with its welded joints 49 and 50, together with the welded joints 46 form the hollow longitudinal welded joint of the cylinder 3. To the top of the cylinder 3 so formed there is welded the top flange 51. This top cylinder flange is made in the form of a heavy steel ring adapted to fit directly above the opening of the sheet

cylinder 3 and to be joined thereto, the flange having for this purpose a downward extension 52 as shown in Figs. 4 and 6.

The upper edge of the sheet metal cylinder 3 fits into a somewhat enlarged opening 53 at the lower side of the flange 51, the side walls of said opening constituting shoulders against which the cooperating portions at the upper end of the cylinder 3 abut. At the corner where the aforementioned side walls of the flange opening 52 meet, there is provided in the flange a hollow circular groove 54 which surrounds the upper end of the cylinder 3 and constitutes the weld channel by means of which the vacuum tightness of the joint between the flange and the cylinder 3 is determined.

The flange 51 and the cylinder 3 are joined to each other by circular welds at the place 55 where the inner side of the cylinder 3 meets the abutting flange wall and at the place 56 where the outer wall of the cylinder 3 meets the lower extension 52 of the flange 51. There is thus formed a hollow welded joint between the upper end of the cylinder and the upper cylinder flange 51, with a hollow circular channel 54 extending through the entire length of the welded joint and with two welded junctions 55, 56 on both sides of the hollow weld channel 54.

The abutting wall 54 of the cylinder 3 is slightly dished or fustoconically shaped and may be made either by directly pressing a flat sheet metal plate into the desired shape as shown in the drawing, or by suitably cutting an annular plate section and welding it together along two radially abutting edges. In the exemplification shown in the drawings the bottom plate 4 is made of a single plate pressed into the form shown in the drawings, the central portion of the plate being provided with an opening and having the central portion forged to form a flange 57 for securing the cathode cylinder thereto. The outer periphery of the bottom wall 4 is provided with a circular hollow weld groove 58 and the wall portions of both sides of the cathode are welded at 59 and 60 to the lower outer and lower inner edges of the cylinder 3 of the vessel.

There are further provided communicating connections between the longitudinal hollow channel 48 of the longitudinal welded joint of the cylinder 3 and the two circular weld grooves 54 and 58 through the perforations 62 and 63, respectively, in the flange extension 52 and the edge of the cylindrical wall 3, at the points above and below the longitudinal weld channel 48.

In the practical manufacture, the flange 51 and the bottom wall 4 are welded to the cylindrical wall 3 as explained above, and the hollow weld channel piece 47 is then welded in place so as to provide a hermetically closed communicating connection between the upper weld channel 54 and the lower weld channel 58. An external communicating connection with the hollow spaces formed by the weld channels is provided through a bore 64 drilled into the flange 51 over the outside rim thereof, and a connecting bore 65 between the channel 54 and the bore 64. The perforation 64 is threaded at its outer end and is adapted to receive the threaded bolt 66 by means of which the hollow spaces of the welds may be closed up or to receive a pipe connection through which a suitable pressure fluid may be pumped or applied to the channels for determining the vacuum tightness of the joints.

The cylindrical vessel part so made may be readily tested for the vacuum tightness of the joints by connecting to the threaded end of the perforation 64 a compressed air supply admitting air of a given pressure into the hollow spaces formed between the circumferential and longitudinal welds of the vessel. Compressed air will then fill the circular channel 54, the longitudinal channel 48 and the circular channel 58 of the welds. Soap water applied over these welds will readily indicate whether there is any fault at any particular point of the welds, soap bubbles forming at the points where the welds are not tight. If a fault is found, the fault may be readily corrected and the test repeated right in place until the welded joints are all perfect and all leaks are eliminated. This work can be done on the cylindrical part of the vessel alone without assembling it with the other parts, thereby greatly simplifying the manufacture of the rectifying vessel. After the welded joints have thus been found to be satisfactory, the air is released from the hollow weld channels and the channel space is permanently closed up by means of the bolt 66 threaded over the opening into the channel space.

Combined with this main rectifying cylinder is the hollow cover 5 on the top thereof. For the satisfactory operation of the rectifier it is important to keep the cover at a relatively low temperature so as to secure effective condensation of the vapor within the rectifier chamber and maintain the seals around the anode lead-ins in operative condition. In the construction shown in the drawings, the hollow anode plate 5 is formed by welding an upper sheet metal plate 71 and a lower sheet metal plate 72 to the members forming the outer flange ring 73, the inner flange ring 74, and the anode lead-in bushings 75, into a single, integral, unitary structure. When prepared for welding the outer flange ring 73 and the inner flange ring 74 have approximately the shape shown in the drawings except that the sealing grooves on the lower side of the flange ring

73 are turned in place after the plate has been completely welded.

The members forming the anode bushing rings 75 have the outer contour as shown in the drawing in Fig. 4, the inside of these members being solid and the anode openings 18 being made after the plate has been completely welded.

The upper and lower plates 71 are prepared with openings and cut so as to fit between the rings 73 and 74 and over the anode bushing members 75, and the several parts are then welded to one another along the joints 76, 77, 78, suitable filler material being deposited in the grooves provided at the points of junction so as to secure a good fusion of the parts and a hermetically tight weld. In this way there is formed an anode plate with a hollow space between the upper and lower sheets 71 and 72, the hollow space enclosing the anode bushing member 75 and permitting the circulation of water therethrough for cooling the anode plate and the parts going therethrough as explained before.

The central ring 74 of the anode plate has a central opening 81 to which is welded at 82, 83, the lower end of the cylinder 11 constituting the condensing chamber. The upper end of the cylinder 11 is similarly joined to the condensing chamber cover plate 12 by a weld at 84 and eventually also at 85, although on account of the small size of this joint the inner weld 85 may as a rule be dispensed with, a single outside weld 84 being usually sufficient. The upper side of the central ring 74 is provided with an enlarged opening 84*a* which constitutes a communicating channel through which water from the anode plate passes into the condensing chamber jacket 26. This condensing chamber jacket has at its lower end a flange ring 86 fitting over the opening 84 of the central anode plate ring 74, and the upper end of the condensing chamber jacket 26 is provided with a flange ring 87 fitting over the circumference of the condensing chamber cover 12 adapted to be clamped to it by means of bolts 88. The flange ring 86 is preferably welded to the condensing chamber jacket 26 at 89 and the upper flange ring 87 may be similarly welded to the jacket 26 at 90.

The openings 32 through which the anode plate communicates with the condensing chamber jacket 26 are made by drilling a number of holes in the central anode plate ring 74. The condensing jacket 26 is arranged so as to be detachably removable from the condensing chamber walls 11 after unscrewing the bolts 88, which hold it in place. A good, tight connection is provided between the condensing jacket and the adjacent portions of the anode top plate and the condensing chamber by means of packing rings 91 and 92 wedged between the engaging surfaces of the condensing jacket parts and the condensing chamber top and anode plate ring 74. By screwing down the bolts 88 the engaging surfaces are tightened against the rubber packing rings 91 so as to provide a tight joint at these places.

The anode plate may be readily tested for the vacuum tightness of the joints by simply plugging up the holes 32 at the center and admitting air under pressure into the hollow space while at the same time applying soap water over the various welded joints, thereby detecting any faulty welds. In a similar way, the weld between the condensing chamber cylinder 11 and the central anode plate ring 74 may be tested by means of the hollow weld groove 93 provided between the welded joints 82 and 83.

Where trouble is experienced in making a tight welded joint between the relatively small condensing chamber cover 12 and the upper end of the condensing chamber cylinder 11, the tightness of this welded joint may likewise be tested and secured by providing a hollow weld groove 94 between the welded joints 84 and 85 of the condensing chamber and cover plate. Usually I find it unnecessary to check up separately the tightness of the welded joints of the anode plate 5 and of the condensing chamber cylinder 11. Instead I proceed as follows: I complete the anode plate and weld in place the condensing chamber cylinder 11 and complete the jacket for the condensing chamber and screw it in place. I then admit compressed air into the hollow spaces within the anode plate and the condensing chamber jacket through one of the water inlet openings after having plugged up the other openings and apply the soap water test to the welds. This enables quick detection of any faults in the welds between the condensing chamber and the anode plate and of the anode plate itself, without necessitating separate testing of the welds of the anode plate per se and of the welds of the condensing chamber to the anode plate and to the condensing chamber cover.

The cathode plate 8 is likewise made by welding several parts together to form a hollow body, the plate consisting of an upper member 95 forming a short cylinder, to the lower open end of which has been welded the bottom wall 96 along the annular joint 97. The hollow cooling space for the cathode plate is thus provided in an economical way while securing a rigid and substantial construction.

A distinct feature of the construction shown in the drawings is the new form of joint between the anode plate flange 73 and the flange 51 of the cylindrical vessel 3. The essential requirement is of course that the joint shall be vacuum tight just as the other

joints of the vessel. The provision of a vacuum tight joint of such enormous length as that between the circumference of the anode plate and the abutting portion of the cylinder flange 51, suitable for mercury arc rectifiers, is however an extremely complicated and difficult matter. The ordinary packing materials generally used for securing detachable vacuum tight joints between metal parts cannot indiscriminately be used on mercury arc rectifiers because materials that tend to vaporize under the high temperature at which these vessel portions operate, would quickly destroy the vacuum within the interior of the vessel and produce backfire or in general render the apparatus inoperative. Many of the workers engaged in the construction of mercury arc rectifiers attempted to reduce this difficulty of large detachable vacuum tight joints by eliminating the detachable joint between the anode plate cover and the top end of the vessel, making the top of the vessel with the side walls thereof as a single solid unit. Such construction of course reduces the difficulty of providing the large detachable vacuum tight joints but renders it more difficult to clean the individual parts of the rectifier before assembling, and to maintain them in the required highly "sterile" condition referred to before, and necessary for avoiding backfire troubles or other disturbances in the operation of the rectifier.

In the rectifiers of the type shown in the drawings it has been the practice to use a mercury seal at the joint between the anode plate and the top of the cylindrical rectifying chamber. This mercury seal is obtained by providing a hollow channel along the joint with tightly pressed sealed surfaces on both sides of the hollow channel, the hollow channel being filled with mercury so as to provide a liquid vacuum tight seal over the solid sealing surfaces. In order to make such seals possible there must of course be provided a solid sealing joint between the abutting surfaces on the side of the sealing channel leading to the rectifier chamber, of such nature as to prevent the mercury from being drawn into the rectifying chamber under the action of the vacuum therein.

Various materials had been tried in the past to provide such a solid sealing joint between the abutting surface portions but heretofore the only satisfactory type of joint consisted of an asbestos packing clamped between the adjacent steel surfaces of the cover and the cylinder flange. As long as the opening that is to be sealed is relatively small the provision of such asbestos packing rings does not meet any serious difficulties. However, with the large dimensions of high capacity rectifiers which are now being chiefly constructed, it was almost impossible to provide an asbestos packing ring of the enormous diameter required to seal up the joints between the anode plate and the cylinder flange 51. Asbestos packings of the type suitable for mercury arc rectifiers have little coherence and become readily disjointed, introducing small leakage channels through which the mercury filling the hollow sealing space gradually leaks into the vessel, often destroying the operativeness of the rectifier and causing endless trouble in its operation.

There are on the market a number of organic packing materials that do not have the aforementioned disadvantages of asbestos packings. Chief among these materials is rubber, which by itself constitutes an excellent packing substance for sealing up the inside joints of mercury seals. However, rubber and similar organic packing materials proved to be very unsatisfactory in mercury arc rectifiers when used at the joints which open directly into the interior of the vessel because such materials develop large quantities of vapors when operated at the temperatures at which the associated parts of the vessel are practically maintained, the developed vapors destroying the vacuum within the vessel and producing backfire.

In the construction shown in the drawings there is employed a novel type of sealing joint between the anode plate and the vessel which makes it possible to use rubber packing while preventing direct exposure of the rubber packing to the interior of the evacuated space and thereby largely eliminating the undesirable effects resulting from direct exposure of rubber packing to the vacuum space of the vessel. This is made possible by so constructing the joints that in the course of the operation of the vessel a seal of mercury forms itself over the edge of the rubber packing which would ordinarily be exposed to the interior of the vessel so that in fact, not the rubber packing but a mercury seal forms the enclosure of the evacuated space at the sealing joints.

As seen in Figs. 4 and 6, the inner edge of the cylinder flange 51 is provided at its upper horizontal face with two annular upwardly extending sealing rings 101 and 102. The adjacent horizontal surface of the anode flange 73 is provided with correspondingly shaped grooves 103, 104, the sealing rings extending into the grooves. Between the outer lower surfaces of the sealing rings 101, 102, and the adjacent lower ring portions of the anode top flange 73 there are placed two rubber rings 105. 106, so that on clamping the top plate against the flange 51 a tight joint will be produced between the rubber rings 105, 106 and the portions on the top flange 103 and cylinder flange 51 in engagement therewith. An annular hollow sealing channel 107 is thereby formed between the two rubber rings 105, 106, which hollow sealing channel is filled with mercury that constitutes

the vacuum seal between the interior of the vessel and the outside thereof.

The inner sealing ring 101 of the seal so obtained extends for a certain height above the upper edge of the inner rubber ring 105 and forms a hollow annular trap 109. When the top is first assembled in place on the cylinder this hollow trap 109 is empty and the upper edge of the rubber ring 105 is directly exposed to the interior of the vessel. As is well known, metal tank mercury arc rectifiers require a certain forming period during which the entire vessel is heated while at the same time a strong evacuation is carried on so as to drive off all the gases from the parts of the vessel opening into the interior of the chamber. During this formative period the rubber ring 105 will give off a good many excess gases and vapors which will be evacuated, but in the course of the formation there will slowly be formed condensed mercury in the hollow trap 109 above the rubber ring until the entire annular groove of the trap 109 is filled with a layer of mercury which thus acts as a self-forming, self-maintaining protective layer between the rubber ring 105 and the interior of the vessel. As the adjacent parts of the vessel portions are strongly cooled, there will always be condensed mercury at these portions of the vessel and there will usually be sufficient mercury in the trap 109 to eliminate the possibility of any serious damage to the vacuum condition of the vessel by reason of the use of rubber as the internal packing ring for the mercury seal of the anode plate.

The above described anode plate seal construction is very simple to manufacture and gives highly satisfactory results and has been found to be much more economical than the constructions used prior thereto.

The construction shown is also of advantage when using an asbestos packing ring as the internal packing ring 105 as with this circular sealing ring construction it is much easier to secure a good packing between the sealing edges of the anode plate and the cylinder flange 51 than with the constructions of the prior art.

While I have described the use of the novel sealing arrangement in connection with rubber packing rings it is of course understood that my invention is not restricted to the use of this material and that other materials of similar characteristics may be used instead.

In Fig. 6 there is also shown communicating channels 111 drilled into the flange 51 of the anode plate by means of which the effectiveness of the mercury seal 107 is checked up, a small gauge such as shown at 112 being connected to said opening. The level of the mercury in the gauge indicates whether there is enough mercury in the hollow space 103 to secure sufficient sealing action. Should any mercury leak through into the interior of the vessel, the level of the mercury in the gauge will drop down, indicating the leak and warning that repair is necessary. An automatic alarm and release arrangement could of course be used for this purpose.

The construction of the anode seals of the rectifier shown in the drawing likewise embodies improvements which are of great advantage over the prior art.

As shown in Fig. 3, the anode bushing 17 is held in place within its associated opening 18 in the anode plate by means of a suitably sectionalized retaining ring 120 secured to the under side of the anode plate around the plate opening 18. The anode bushing 17 has its upper end somewhat enlarged to provide a shoulder 121 which rests on this anode retaining ring, a washer 122 of packing material such as asbestos being interposed between the bushing shoulder and the ring. The opening 18 of the anode plate through which the bushing 17 extends is made somewhat wider than the part of the bushing passing therethrough to provide a sealing space 125 which tapers down at the bottom to substantially the width of the bushing 17 itself. The bottom of this sealing space 125 is filled with a suitable packing 126 such as asbestos down, with a layer of somewhat more solid packing material such as an asbestos cord 126′ constituting the lower foundation for the packing. This circular packing 126 is compressed and held in the compressed state by means of a stuffing bushing 127, the upper end of which extends above the upper level of the anode plate 5. A loose flange ring 129 is mounted over the top of the stuffing bushing 127 and is arranged to be drawn down against the anode plate 5 by means of bolts 130 disposed circumferentially along the flange.

Packing rings 131 and 132 are clamped by the flange 129 against the stuffing bushing 127 on one side and against the anode bushing and anode plate on the other side, respectively, so as to provide a tight enclosure at the upper side of the sealing space 125 around the anode insulator bushing 17.

The stuffing bushing flange 129 is provided with a groove or channel 134 along the upper outer edge of the stuffing bushing 127 and the bushing itself has a bore 135 through which communication is provided between the groove 134 and the sealing space 125. This groove 134 in turn is connected through a bore 137 in the bushing flange 129, with a mercury gauge 138 in the form of a little mercury-filled tube threaded into an opening 139 on the top of the flange and communicating with the bore 137. The sealing space 125 is filled with mercury by pouring it into the bore 137 by way of the opening 139 and a continuous check-up of the presence of the mercury

within the sealing space 125 is maintained by a mercury gauge 138 in the same way as in the mercury seal of the anode plate joint described before. The arrangement of the mercury gauge on the stuffing bushing flange around the anode porcelain bushing 17 makes possible a very substantial simplification of the manufacture of this very sensitive seal and effects a reduction in the time and cost of the manufacture of these parts. In addition, it reduces the space required for mounting the individual anodes of the anode plate, thereby enabling closer mounting of the anodes than with the prior art constructions.

The anode stem 16 extends over the interior of the anode bushing 17 and is threaded at its upper end projecting above the bushing, the threaded portion being secured within the radiator core 141 that is provided with a downward cylindrical extension 142 surrounding the anode stem 16. The upper end of the anode bushing 17 has an enlarged opening providing a sealing space 143 for the inner anode seal. The lower end of this sealing space 143 is closed up by a packing 144 similar to the packing 126, a stuffing bushing 145 with a flange 146 and rubber packing rings 147, 148 completing the enclosure of the inner anode sealing space 143. This sealing space is filled with mercury and the mercury continuously maintained therein by means of a mercury gauge 149 in the way described in connection with gauge 138.

The anode 15 itself is held clamped against the lower end of the bushing 16 by the action of the nut 151 threaded around the upper end of the core extension 142, a spring 152 being interposed between the nut and the flange 146 to prevent cracking of the bushing and to take up expansion of the parts under variations of temperature.

As seen in Figs. 1 and 4, the cathode insulator 7 has flat upper and lower sealing surfaces pressed against flat sealing surfaces at the lower end of the flange 57 of the bottom plate of the rectifying chamber and on the cathode plate 8. Circular sealing grooves 155, 156 are provided along the upper and lower sealing surfaces of the cathode insulator 7, these grooves being provided in the insulator itself or on the sealing surfaces of the metal parts that are in engagement therewith. These sealing grooves 155, 156 are held tight and enclosed by means of packing rings 157 and the spaces within the grooves are filled with mercury, the mercury being maintained within the grooves and checked up by means of gauges 157′ connected through tubings 158, 159 with the sealing grooves 155, 156, respectively.

As the cathode sealing surfaces are rather extensive and the energy losses at the cathode are relatively large, the portions of the vessel adjacent to the cathode sealing grooves 155, 156, and the associated sealing surfaces are so arranged as to be exposed to efficient cooling action. As seen in the drawings, the cathode plate 8 is made so that the entire part of the plate 8 underlying the seal with the lower end of the cathode insulator 7 is cooled by water circulated through the hollow cathode plate. In the preferred arrangement, I usually lead the cooling water first into the hollow cathode plate space 27 so as to obtain the greatest cooling action at this part of the vessel. In like manner, the flange 57 at the center of the bottom wall 4 of the rectifying chamber is so shaped as to cause the cooling water to circulate directly over the upper side 161 of the flange portion that is in engagement with the upper sealing surface of the insulating ring 7.

There is further provided a circular deflector sheet 162 within the central portion of the water jacket 25 on the under side of the bottom plate 4, the deflector being so arranged that the relatively cool water entering the lower end of the jacket first passes over the cooling surface 161 of the upper mercury seal 155 of the cathode ring before contacting with the walls of the chamber bottom 4. A very effective cooling action at the sensitive cathode seal is thus maintained without complications in the construction or in the layout of the cooling system for the rectifier.

The construction of the rectifier described above and the various features thereof were reached only as the result of years of development work in the face of countless difficulties which very often jeopardized the entire development of this important power apparatus. As explained before, the entire rectifier vessel of the present invention may be built of separate parts made up with welded joints, the individual parts being arranged for testing of the vacuum tightness of their joints without necessitating the assembly of the parts into a complete, enclosed vessel. The individual parts so made are assembled into a unitary, hermetically closed structure readily maintained in vacuum tight condition by the liquid seals at the detachable joining surfaces. The entire vessel may thus be made of parts which are readily inspected and permit very close cleaning and sterilizing of the interior portions of the vessel. All the joints are extremely simple and readily manufactured and readily maintained in operative condition.

The various features of the invention described and claimed herein are not limited to the particular constructional details referred to in the specification for the purpose of exemplification as many other modifications thereof will suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad construction commensurate with the scope of the invention within the art.

I claim:

1. An evacuated space-discharge device comprising a metallic rectifying vessel having a plurality of detachable sections hermetically joined one to the other, seals of liquids at the junctions of said sections, at least one of said sections having a hollow welded joint on its interior wall.

2. An evacuated space-discharge device comprising an evacuated metallic rectifying vessel having a plurality of sections detachably joined one to the other, seals of liquid at the junction surfaces of said sections, the individual metal portions constituting the walls of said vessel being double-walled to provide hollow spaces around the surfaces exposed to the interior of the chamber, and means whereby the individual sections may be examined for vacuum tightness by determining the vacuum tightness of the hollow space surrounding the inner wall of the respective section.

3. An evacuated space-discharge device comprising a hermetically closed evacuated metallic rectifier vessel comprising a plurality of adjoining metallic sections, seals of liquid at the junctions of said sections, at least one of said sections having on its interior wall a welded joint, said welded joint forming a hollow channel having welded junctions on the sides of said channel, and means for testing the vacuum tightness of the hollow channel formed between the welded junctions.

4. An evacuated space-discharge device comprising a hermetically closed metallic rectifier vessel having a sheet metal cylinder, and a bottom plate united to said cylinder by a welded joint exposed to the interior space of said vessel, said welded joint comprising a hollow channel at the junction points of said sections with welded junctions on both sides of said channel, and means for determining the vacuum tightness of the hollow space of said channel.

5. An evacuated discharge device comprising, a hermetically closed metallic vacuum vessel comprising a wall section formed of a sheet metal cylinder having a longitudinal joint on its interior side, a welded junction on one side of said joint, a welded junction on the other side of said joint, said welded junctions being spaced from each other to provide a hollow groove therebetween, and a connection for determining the vacuum tightness of said hollow groove.

6. An evacuated space-discharge device comprising an evacuated metallic vessel having a cylindrical wall section, longitudinal welds on said cylindrical section exposed to the space in the interior of said vessel, said longitudinal welds comprising a welded junction, on the inner side of said cylinder and a welded junction on the outer side of said cylinder opposite said first welded junction, said welded junctions being relatively spaced from each other to provide a hollow groove extending throughout the length of said junctions, and a connection to said hollow space for determining the vacuum tightness thereof.

7. An evacuated space-discharge device comprising a rectifying vessel having sheet metal sections joined one to the other to form a vacuum tight enclosure, welded junctions between some of the adjacent sheet metal sections exposed to the interior of said enclosure, and longitudinally extending hermetically closed grooves along said welded junctions.

8. An evacuated space-discharge device comprising a rectifying vessel having sheet metal sections joined one to the other to form a vacuum tight enclosure, welded junctions between some of the adjacent sheet metal sections on the interior sides thereof, longitudinally extending hermetically closed grooves along said welded junctions, and a connection to said grooves for determining the vacuum tightness of the hollow spaces therein.

9. A mercury arc rectifier, comprising a rectifying vessel having sheet metal sections joined one to the other to form a vacuum tight enclosure, joints between some of the adjacent sheet metal sections having longitudinal welded junctions on the inner side of the metallic sheet body exposed to the interior of the enclosure, and similar junctions on the other side of said metallic sheet body, said welded junctions on both sides of the sheet body being spaced from each other and arranged to form a hollow longitudinal groove extending along the junction, and a connection for determining the vacuum tightness of the hollow channel formed between said welded junctions.

10. The method of constructing a hermetically closed evacuated rectifying vessel which comprises constructing a plurality of vessel sections adapted to be detachably joined one to the other to form a closed vessel, making at least some of said sections of welded sheet metal bodies, with a hermetically closed hollow space around the welded joints, and determining the vacuum tightness of the hollow space so provided prior to the assembling of the individual parts into the complete vessel.

11. The method of constructing a metallic hermetically closed evacuated vessel of the vacuum type for electrical space discharge devices which comprises the construction of a plurality of vessel sections of sheet metal, making at least some of said section by welding sheet metal bodies to each other, with longitudinal hollow grooves extending along the welded joints of said sections, and determining the vacuum tightness of the welded joints so made by determining the vacuum tightness of the hollow grooves along said welded

joints independently of the determination of the hermetical tightness of the assembled vessel as a whole.

12. An evacuated discharge device comprising an evacuated vessel having a pair of vessel sections adapted to be detachably joined to each other along cooperating junction surfaces, said junction surfaces being substantially flat and parallel to each other, one of said junction surfaces having a pair of upstanding projections, the other of said junction surfaces having a pair of grooves adapted to receive said upstanding projections, a strip of packing material disposed near the bottom of the groove formed by said upstanding projections, a second strip of packing material disposed around said upstanding projections on the side facing the exterior of said vessel, means for clamping said parts to each other to hold said packing strips under compression, and a layer of fluid sealing material in the space between said packing strips within the groove formed by said projections.

13. An electrical space discharge device comprising an evacuated discharge vessel having a tubular vessel section, said tubular vessel section having on its inner walls welded joints running in circumferential and longitudinal directions, said welded joints forming hollow channels having welded junctions on both sides of the channels, the channels of said circumferential and longitudinal joints being inter-connected to constitute an intercommunicating hollow space, and a connection for determining the vacuum-tightness of said intercommunicating hollow space.

14. An evacuated discharge device comprising a hermetically closed vessel, an electrode seal therefor comprising a metallic vessel section having a tubular opening, a hollow insulating bushing extending through said opening, an electrode lead sealed through the interior of said bushing, a packing strip on the interior side of said tubular opening, a stuffing bushing surrounding said insulator bushing for compressing said packing strip and holding it in engagement with the surfaces of said insulating bushing and the adjacent wall section of said tubular opening, a flange surrounding the upper end of said stuffing bushing, means for clamping said flange over said stuffing bushing, packing rings on the inner and outer sides of the upper end of said stuffing bushing to provide an enclosed annular channel around said insulating bushing within said tubular opening, a sealing liquid container disposed on said flange having a duct connection extending through said flange between the inner and outer packing ring into said annular channel for maintaining therein a liquid seal.

In testimony whereof I have hereunto subscribed my name this 9th day of July A. D. 1929, at Zürich, Switzerland.

MORITZ URICH.