Sept. 4, 1928. 1,683,310

F. SHORT

APPARATUS FOR THE GENERATION AND DISTRIBUTION OF MERCURY VAPOR AND SEALING MEANS THEREFOR

Filed Sept. 2, 1924 2 Sheets-Sheet 1

Fig. 1.

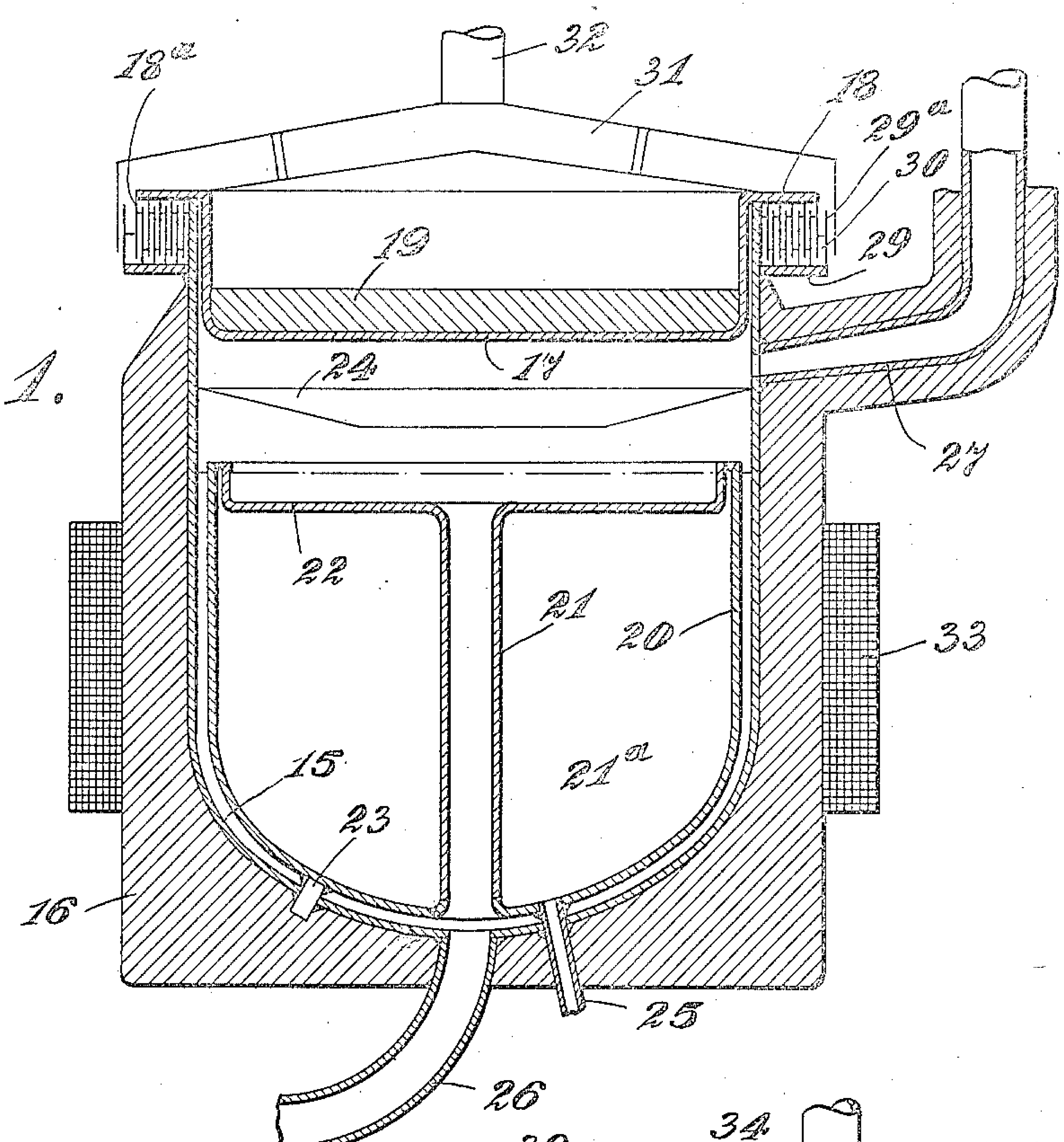
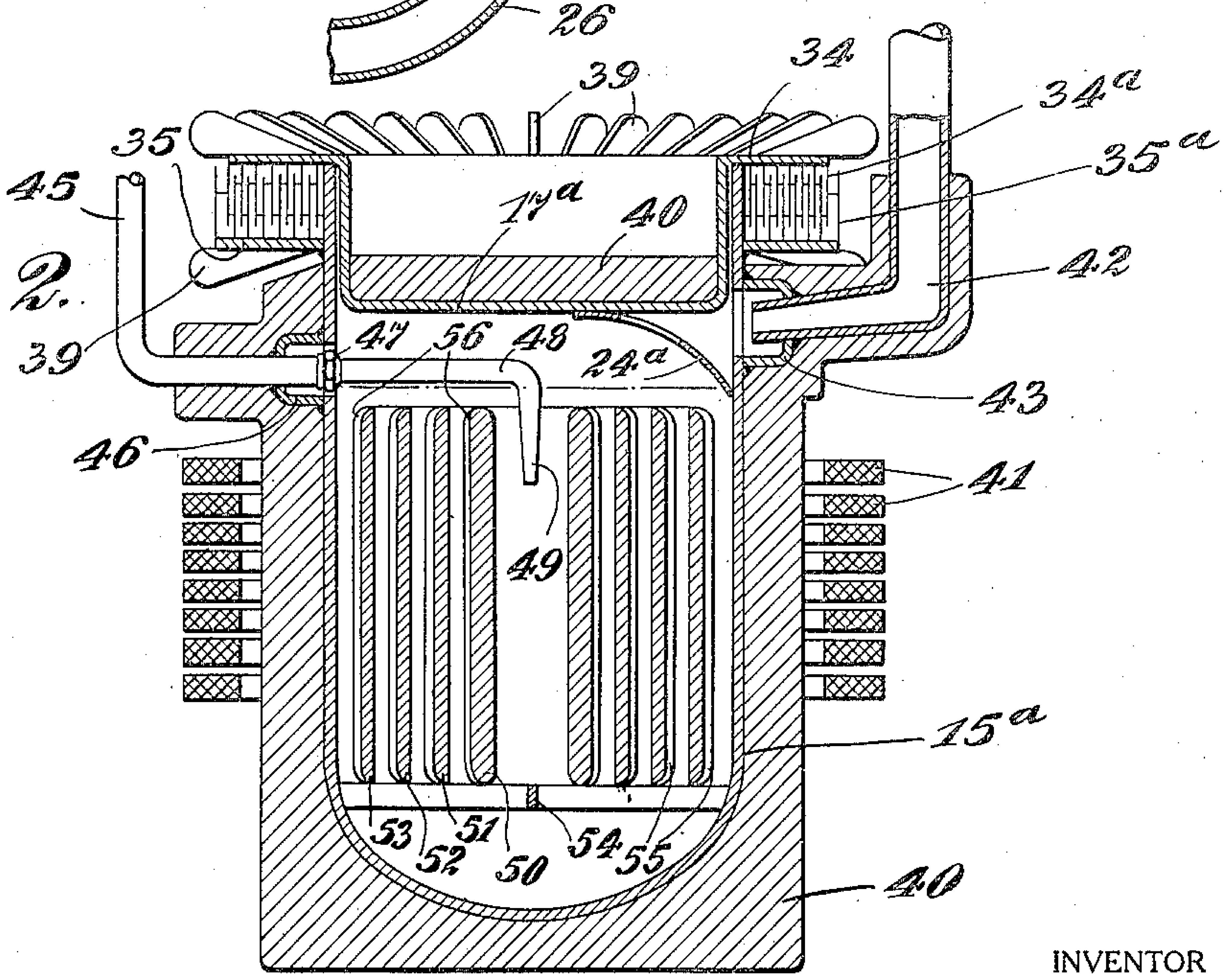


Fig. 2.



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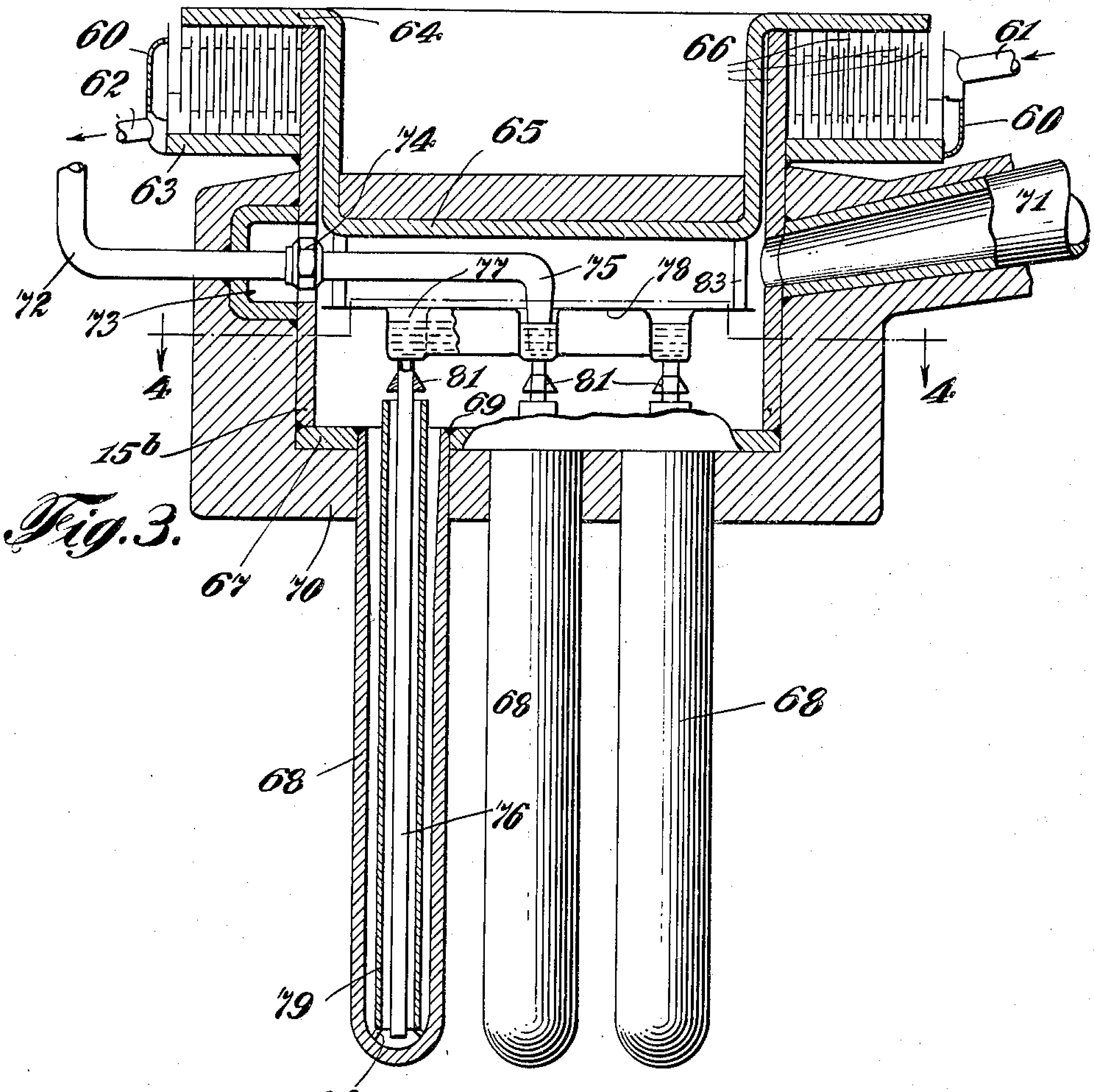

Fig. 3.

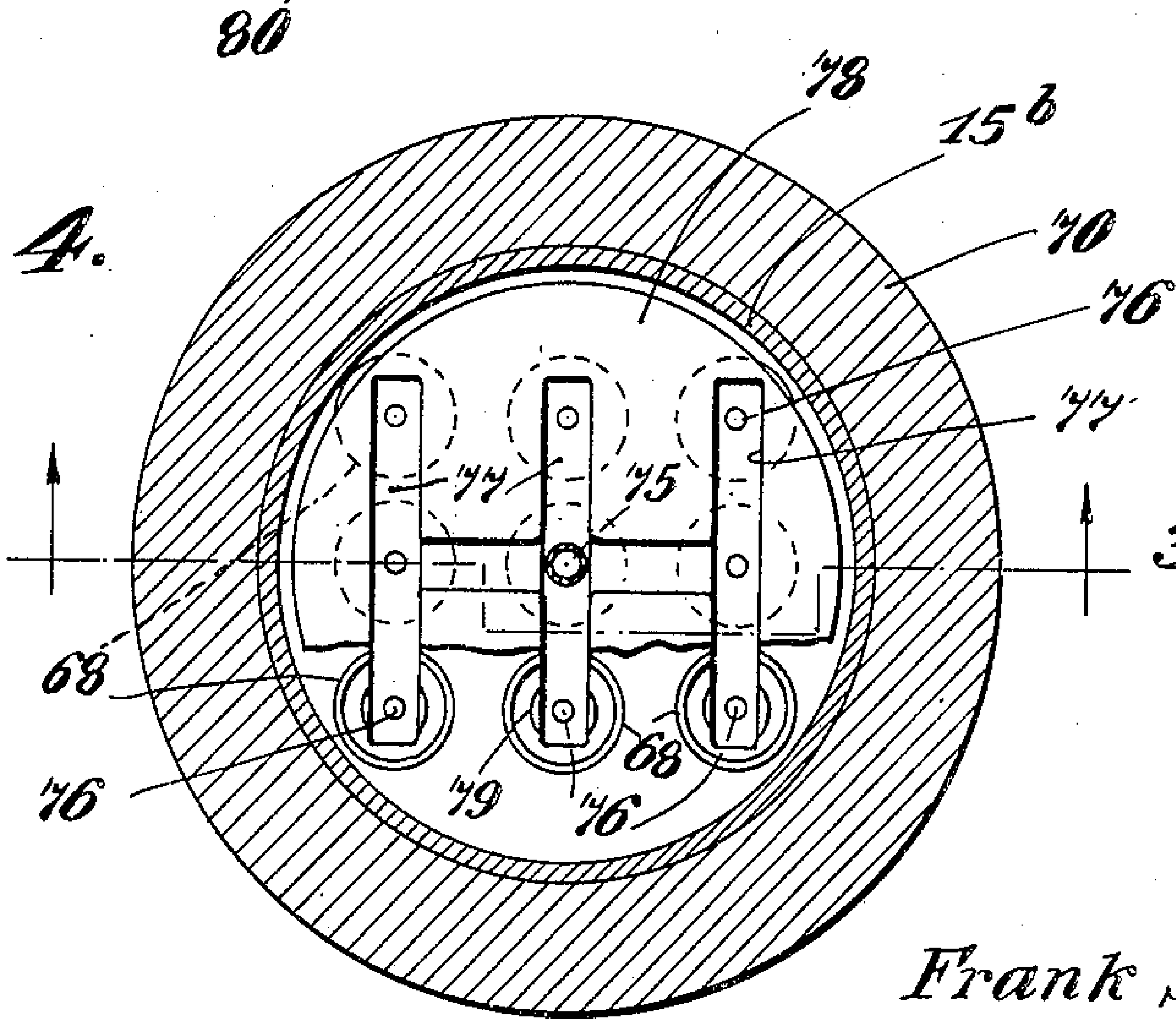

Fig. 4.

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR THE GENERATION AND DISTRIBUTION OF MERCURY VAPOR AND SEALING MEANS THEREFOR.

Application filed September 2, 1924. Serial No. 735,495.

This invention relates to vapor generators, conductors, and other apparatus used in connection with pressure systems, particularly to a novel type of sealing means therefor. The invention, while of general utility in connection with all pressure systems is especially adapted for application to the boilers, expansion joints cleanouts, and valves of a mercury vapor system. It provides an effective seal at all points of possible leakage and at the same time, permits ready access to the system for purposes of cleaning and repair.

The seal is preferably of the labyrinth type, including a pair of vertically interfitting members affording a zig-zag outlet path, the total vertical height of which is great as compared with the dimensions of the device. By partially filling the lower member of the labyrinth with mercury or other heavy liquid, leakage of gas through the successive vertical lengths of the tortuous passage is opposed by the differential weights of the displaced mercury columns and the mercury filled labyrinth forms a hermetic seal, the pressures which it will sustain being determined by the total vertical displacement of mercury in the successive traps of the labyrinth. The interfitting members may comprise mating sets of concentric members, one set being partially filled with mercury in which the edges of the cylinders of the other set are immersed.

The invention is of particular importance in connection with mercury vapor or other vacuum systems because of the fact that by using a relatively small amount of mercury in the seal, the successive traps will provide for vertical displacement of the thirty inches or so that will sustain an absolute vacuum against atmospheric pressure. Thus I am able to prevent leakage into any vacuum system and still allow a reasonable margin of safety. Conversely, the thirty inches of mercury displacement will sustain an internal pressure of two atmospheres, that is, 15 pounds above atmosphere. The same construction can be used for much higher pressures, but in such case it is preferable to provide means for substantially balancing the pressures on opposite sides of the seal and to provide a head of mercury in the seal, merely sufficient to take care of pressure variations to be met with in the particular apparatus on which it is used.

A mercury vapor boiler embodying the invention is equipped with a removable head, the seal being interposed at the joint between the head and boiler. External flanges on the body of the boiler and the boiler head may carry oppositely disposed vertical partitions which loosely interfit to afford annular spaces connected alternately at top and bottom. These are sealed by bodies of mercury or other heavy fluid forming successive U-shaped seals opposing the passage of gas through the labyrinth formed by the partitions.

The invention may be used equally well with electrically heated boilers or flame heated boilers, and may serve the purpose of preventing vapor from escaping or air from entering the vapor generating chamber of the boiler. For boiler purposes the internal pressures are usually maintained considerably lower than atmospheric and it is necessary to use merely enough mercury in the labyrinthian seal to sustain an absolute vacuum.

When the seal is used in other connections, such for instance as with an expansion joint at the coupling of a pair of vapor conductors, the internal pressure may be rather high, often more than 100 pounds per square inch, and for ordinary purposes the cost of the mercury would practically prohibit the use of a large enough labyrinth and the mercury required to seal by mercury head alone. Hence, in adapting my labyrinth seal to such couplings, I prefer to employ some supplemental regulating means which will tend to balance to some extent the pressures on the inmost and outmost mercury surfaces of the seal. If, for instance, the internal pressure varies between 90 and 110 pounds, I may apply an exterior pressure of approximately 100 pounds, thus leaving the mercury head in the seal free to take care of the variations and as explained above, a thirty inch head will take care of plus or minus 15 pounds, giving a 5 pound margin of safety for the upper and lower limits of expected variations.

A unique result of employment of a liquid mercury seal for the joints of apparatus for generating and utilizing hot mercury vapor is that the seal operates as a condenser of considerable condensing capacity, the important point being that the condensate is precisely the same chemically and physically, as the sealing liquid. Consequently, the condensate cannot react with, settle out of or float upon the sealing liquid, the result being that the functioning of the seal is entirely unaltered by the condensate.

In the accompanying drawings,

Fig. 1 is a vertical sectional view of an inductively heated mercury vapor boiler employing my novel sealing means.

Fig. 2 is a similar view of a modified type of inductively heated boiler.

Fig. 3 is a similar view through a flame heated boiler.

Fig. 4 is a sectional view in the staggered line 4—4 of Fig. 3.

The boiler of Fig. 1 comprises a round bottomed iron pot or shell 15 coated with suitable heat insulating material 16 and closed by a cover or head 17 which depends into the upper end of the pot and is formed with an exterior flange 18 resting on the upper edge of the pot. The cover may also be insulated as at 19.

Disposed within and conforming to the shape of the bottom of the pot 15 is an inner pot or drum 20, filling most of the boiler space so as to minimize the amount of idle mercury while presenting the same in thin layer of great superficial area. The inner drum 20 is provided with a central downflow passage 21 and a head 22 which is preferably welded to the upper edges of the walls of the drum to provide a relatively large annular chamber 21^a from which the mercury is excluded. To prevent floating of the drum within the pot, I employ cylindrical lugs or tubes 23 welded to and projecting radially from the drum, extending through the pot and anchored by welding. In order to accommodate for the expansion of the air within the chamber, I may provide a breather pipe 25, having an open end welded to the drum and an open end exposed to the atmosphere, such breather pipe being also welded to the pot so that there can be no leakage of air around the pipe into the system. With this type of boiler, mercury is introduced into the bottom through a pipe 26, in direct alignment with the downflow or recirculation passage 21 in the drum so that the normal convection circulation will be down through such passage and up around the exterior of the drum.

A vapor take off pipe 27 communicates with the upper end of the pot above the drum 20 and a frustro-conical downwardly inclined deflector 24 is disposed above the drum and below the vapor take-off to baffle the passage of liquid mercury particles which might be entrained with the vapor flowing to the take off pipe. In order to effectively prevent leakage between the pot and the cover, I weld an annular flange 29 around the pot slightly below its upper edge and secure thereto (preferably by welding) a series of concentric seamless cylindrical members 29^a interfitting with similar members 18^a of intermediate sizes depending from the cover flange, to form a labyrinth. The concentric annular troughs defined by members 29^a and the flange 29 are partially filled with a heavy sealing fluid such as mercury 30 in which the lower edges of the upper members are immersed.

Preferably the initial depth of the mercury is such as to bring the surfaces thereof on a level which is midway between the top edges of the bottom members and the bottom edges of the top members. Then each U-shaped trap of the labyrinth will have just enough mercury to fill one of the legs when all of the mercury in the other leg has been driven into it by the pressure.

Any mercury boiling off from the outer trough of the seal will be drawn upwardly through a hood into a conical air cooled condensing chamber 31, where most of it will be condensed and drained by gravity back into the trough. Vapors which do not condense may be carried through a pipe 32 to any appropriate condenser (not shown), condensed and returned to the system.

In normal operation the pot is filled with mercury to the level indicated in dotted lines at x in Fig. 1. The normal level of the mercury in the seal is also indicated in dotted lines while in full lines I have shown roughly the position assumed by the mercury in the seal, when the system is under partial vacuum. In this instance, it will be noted that the "legs" of the annular mercury columns which are on the boiler side of the cylinders are considerably higher than those on the atmosphere side. As a matter of fact, the legs will be at varying levels depending on the pressure of the air or vapor in the bells in the upper bends of the labyrinth, and under ordinary conditions (providing no air bubbles have leaked past the outer column) will be at progressively decreasing heights toward the center where the pressure is lowest.

For boiling the mercury, I encircle the pot with an induction coil 33. The pot 15 and the drum 20 being conductively joined by the mercury in the system act together as a single turn secondary, the current flowing in the mercury and heating the same directly by the internally generated heat, while the heat generated by the hysteresis and eddy currents in the iron shell and drum is effectively applied by conduction through their large area contact surfaces. This conductive heating of the mercury between the drum and the shell is particularly effective for initiating and maintaining convection flow of the mercury.

If the system were under absolute vacuum, it would require thirty inches aggregate difference in level of the mercury in the several legs of the seal to prevent any leakage of air. Inasmuch as the system is always maintained under partial vacuum, the greatest internal pressure difference which can occur will be the difference between an absolute vacuum and atmospheric pressure or, in other words, a variation of 15 pounds, so that by employing a mercury seal in which the various columns total a forty-inch head, I can allow a 33% safety factor. Since each of these columns is a very thin annulus, the size of seal necessary for accommodating such a head is not at all unwieldy or cumbersome.

In Fig. 2, I have illustrated a modified type of boiler. In this instance, I employ a pot 15^a and cover 17^a having a flange 34, the pot having an external flange 35 extending below the cover flange and carrying upwardly extending cylindrical partitions 35^a which mate with similar depending partitions 34^a on the cover flange 34 and cooperatively form the seal. With this type of boiler the special condensing means for vapor boiled off in the outer trough of the seal is dispensed with and the cover flange and body flange may be provided with a number of radially disposed air cooled fins 39 for maintaining the mercury in the seal below boiling point. Cover and pot are coated with suitable heat insulating material 40 and the boiler is inductively heated by the use of a plurality of flat encircling coils 41, in a manner similar to that fully explained in connection with Fig. 1. The vapor take off pipe 42 opens into an offset or pocket 43 in the upper end of the pot and liquid mercury is prevented from escaping through the offset by a deflector 24^a. The mercury return pipe 45 leads into a pocket or offset 46 approximately diametrically opposite to the vapor take off and couples at 47 with an angular discharge pipe 48 terminating in a downwardly directed discharge nozzle 49 which is located below the level of the mercury in the boiler such level being indicated at x in dotted lines.

In place of the filler drum of Fig. 1, which requires fastening means and a breather outlet, I employ a series of concentric cylindrical iron tubes 50, 51, 52 and 53. The tubes are disposed coaxially with the shell 15^a and may conveniently rest upon and be secured to a spider comprising transverse supporting bars 54 which are supported on the rounded bottom of the drum. These tubes are preferably formed with vertical fins or flutes 55 to increase their heat transmitting surface, and in some instances these flutes may touch the inner surface of the next larger cylinder. The top and bottom edges of the cylinders are preferably rounded as indicated at 56, to offer a minimum resistance to the flow of mercury and the cylinders may progressively decrease in height from the outer to the inner one in order to facilitate the recirculation of mercury down the central tube 50. In connection with such circulation, it may be noted that the jet action of the discharge nozzle will assist the normal convection flow. If at any time, a vacuum should occur in the pipe 45 the immersed nozzle 49 will permit a static column of mercury to be built up, thereby automatically increasing the pressure of the inflow as the internal pressure increases. Since the union 47 of this pipe and the nozzle is within the boiler, leakage at the union becomes of no importance. In connection with the deflectors of both Figs. 1 and 2, it may be noted that liquid mercury particles entrained in the vapor and passing along the deflectors are subjected to a sudden change of direction at the edge of the deflector, which will result in their being dropped by the vapor and returned to the main body of mercury.

The flame heated boiler of Figs. 3 and 4 is provided with a mercury seal similar to the seals described above, except that the outer trough of the seal is encircled by a cooling jacket 60 provided with an inlet 61 and outlet 62 for the admission and discharge of air or other suitable cooling fluid. In this instance, the pot 15^b for the mercury is provided with the usual flange 63 cooperating with a flange 64 of the cover 65 and the two flanges carry the interfitting cylindrical partitions 66 which form the labyrinth of the seal. The pot is comparatively shallow and preferably includes a flat bottom 67 from which depend a number of flame heated tubes 68. These tubes are welded to the pot as indicated at 69 and further anchored by the non-conducting cement 70 which protects the pot from the direct heat of the flame. An outlet pipe 71 for the mercury vapor is welded to the pot above the mercury level therein and as in Fig. 2, the inlet for return mercury includes a pipe 72 entering a pocket 73 in the wall of the pot and coupled at 74 within the pot to a discharge nozzle 75 which delivers mercury below the liquid level. Extending downwardly into each flame heated tube 68 and terminating just short of the bottom thereof is a feed tube 76 of relatively small diameter opening at its upper end into a distributing groove 77 which forms one of a connected series of grooves in a floating baffle plate 78 extending across the pot just above the liquid level therein. The general double H-shaped arrangement of connected grooves in the baffle plate may be seen in Fig. 4 but is of course subject to wide variation. Any appropriate number of the flame heated tubes 68 may be used and preferably inlet nozzle 75 discharges downwardly into one of the distributing grooves 77. Encircling the small down flow feed tubes and floating around these tubes are cylindrical recirculation tubes 79 carrying feet 80 for limiting their downward movement. Upward floating movement of the cylindrical members 79 is limited by radially projecting lugs 81 on the upper ends of the feed tubes. The circulation of mercury is down through the feed tubes 76 and up through the space between the boiler tubes 68 and floating tubes 79, the floating recirculation tubes providing a path for further downward flow of mercury when necessary. The vapor escapes around the edges of the baffle plate, such plate being held down by a series of spaced lugs, 83 projecting downwardly from the cover 65. The boiler tubes preferably have their bottom ends drawn so that there will be no need to weld any part which comes directly in contact with the flames. The thickness of the three sets of tubes is so proportioned that a minimum of mercury is allowed for proper functioning of the boiler. The flame heated boiler has a certain advantage over the electrically heated devices in that it uses a less costly fuel. All of the welds are kept from the direct action of the flame (mainly bathed in mercury) and heat expansion cannot cause difficulty with the tubes.

It is of course necessary to make the interfitting members of the seal of some metal which will not be wet by the mercury and I find iron most suitable for the purpose.

It is also desirable that the seal be constructed in a manner which will permit a minimum quantity of mercury to be used most efficiently. In other words, the mercury spaces between the partitions should be relatively thin. I find there is a limit with regard to the narrowness of these spaces beyond which it is not safe to go because the phenomenally great surface tension of the mercury causes it to depart widely from the characteristic behavior of liquids whenever it is too greatly subdivided or attenuated. If the mercury columns are too thin, air or vapor bubbling through them or even mechanical vibration will have a tendency to break the mercury continuity and separate different sections of the columns so as to render the seal irregular or inefficient in its functioning as a static head. A desirable compromise thickness for the column or space between the partitions seems to be about ⅛th of an inch, this being apparently about the least thickness of mercury that will act reliably as a freely fluid liquid.

I claim:

1. A mercury boiler including a body, a removable cover member and a mercury seal between the body and cover member, and means for preventing the loss of sealing mercury by vaporization.

2. A mercury vapor boiler including a pot, a removable pot cover, an annular flange on the cover extending beyond the walls of the pot, a flange on the pot in alignment with the cover flange, a plurality of coaxial partition members secured to each flange, interfitting with the partition members of the other flange, mercury partially filling the spaces between the lower set of partition members and immersing the lower edges of the upper set of partition members and a conduit for cooling fluid surrounding the outer partition member of the lower set.

3. A mercury vapor boiler including a pot, a removable pot cover, an annular flange on the cover extending beyond the walls of the pot, a flange on the pot in alignment with the cover flange, a plurality of coaxial partition members secured to each flange interfitting with the partition members of the other flange, mercury partially filling the spaces between the lower set of partition members and immersing the lower edges of the upper set of partition members and exterior cooling means for retaining the mercury in the seal below boiling point.

4. A mercury vapor boiler including a pot, a removable pot cover, an annular flange on the cover, extending beyond the walls of the pot, a flange on the pot in alignment with the cover flange, a plurality of concentric cylinders secured to each flange interfitting with the cylinders of the other flange, mercury partially filling the spaces between the lower set of cylinders and immersing the lower edges of the upper set of cylinders, and a hood on the cover wherein mercury vapor boiled off from the mercury in the seal is collected.

5. A mercury vapor boiler including a pot and a cover, an external annual flange on the cover extending radially beyond the pot, a flange welded to the pot below the cover flange, a plurality of concentric seamless cylindrical partitions welded to each flange and interfitting with the partitions of the opposite flange and a mercury filling the troughs defined by the partitions of the lower flange to a point above the lower edges of the partitions of the upper flange, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

6. A mercury vapor boiler including an iron pot, a removable cover member, an induction coil encircling the pot, a hollow drum within the pot spaced from the walls thereof to provide a restricted mercury space between the drum and pot, said drum having a central vertical passageway therein, said

drum, pot, and the thin, large diameter shell of mercury in said restricted space constituting a single turn secondary for the induction coil.

7. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure including a pair of members each surrounding the opening to be sealed, vertical interfitting baffle plates carried by the members and forming a labyrinth, and liquid sealing the lower bends of the labyrinth, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

8. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure, including upper and lower members, vertically disposed coaxial partitions carried by the members the partitions of the lower member defining troughs adapted to be partially filled with liquid into which the edges of the partitions of the upper member are adapted to dip, the two innermost partitions of the lower member defining a relatively wide trough, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

9. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure, including upper and lower members, vertically disposed coaxial partitions carried by the members, the partitions of the lower member defining troughs adapted to be partially filled with heavy liquid into which the edges of the partitions of the upper member are adapted to dip, the two outermost partitions of the lower member defining a relatively wide trough, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

10. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure, including upper and lower members, vertically disposed concentric partitions carried by the members, the partitions of the lower member defining troughs adapted to be partially filled with liquid into which the edges of the partitions of the upper member are adapted to dip, the inner and outer troughs of the lower member being relatively wider than the intermediate troughs, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

11. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure, including upper and lower members, vertically disposed concentric partitions carried by the members, the partitions of the lower member defining troughs adapted to be partially filled with mercury into which the edges of the partitions of the upper member are adapted to dip, the partitions of one of the members being spaced unequal distances apart, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

12. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure, including upper and lower members, vertically disposed concentric partitions carried by the members, the partitions of the lower member defining troughs adapted to be partially filled with liquid into which the edges of the partitions of the upper member are adapted to dip, the partitions of the lower member being spaced unequal distances apart, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

13. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure, including upper and lower members, vertically disposed concentric partitions carried by the members, the partitions of the lower member defining troughs adapted to be partially filled with liquid into which the edges of the partitions of the upper member are adapted to dip, the partitions of the upper member being spaced approximately equal distances apart and the partitions of the lower member being spaced unequal distances apart, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

14. Container means for hot mercury vapor having a closure and a horizontally extending seal for such closure, including upper and lower members, vertically disposed concentric partitions carried by the members, the partitions of the lower member de-

fining troughs adapted to be partially filled with liquid into which the edges of the partitions of the upper member are adapted to dip, the partitions of the upper member being spaced approximately equal distances apart and the partitions of the lower member being spaced unequal distances apart to provide relatively wide inner and outer troughs whereby the inner and outer partitions of the upper member dipping into said troughs will form U-shaped mercury columns having legs of differential thickness, the number and overlap of the partitions and the depth of the liquid being sufficient to sustain an external pressure greater than maximum atmospheric pressure, to maintain an internal vacuum when the container is permitted to become cold.

15. A system including means for generating and utilizing hot mercury vapor in combination with sealing means comprising a plurality of serially connected, liquid mercury seals affording an aggregate hydrostatic head sufficient to withstand the normal working pressure of the hot mercury vapor, said seals being arranged to condense mercury vapor entering the same and to retain the liquid mercury condensate as part of the same liquid mercury that affords the seal.

16. A mercury vapor boiler, including an iron boiler shell, an induction coil encircling the same, a hollow core shell within the boiler shell spaced from the walls thereof to provide restricted mercury space between said shells, said core shell having an interior passageway therein, said shells and the mercury in said restricted space constituting a single turn secondary for the induction coil.

17. A mercury vapor boiler, including an iron boiler shell, an induction coil encircling the same, a hollow core shell within the boiler shell spaced from the walls thereof, to provide restricted mercury space between said shells, said core shell having an interior passageway therein, said shells and the mercury in said restricted space constituting a single turn secondary for the induction coil, and a breather conduit extending gas-tight through the boiler shell and communicating with the hollow interior of the core shell.

18. Mercury boiling apparatus including a boiler shell for the liquid mercury, a hollow core shell within the boiler shell displacing the mercury from the greater portion of the latter, and cooperating with the boiler shell to provide a restricted mercury space between the shells, said core shell having an interior passageway for down flow circulation of the mercury.

19. Mercury boiling apparatus including a boiler shell for the liquid mercury, a hollow core shell within the boiler shell displacing the mercury from the greater portion of the latter, and cooperating with the boiler shell to provide a restricted mercury space between the shells, and a breather conduit extending through the boiler shell and communicating with the hollow interior of the core shell.

Signed at Poughkeepsie, in the county of Dutchess and State of New York, this 22nd day of August, A. D. 1924.

FRANK SHORT.