Feb. 10, 1948. C. H. LARSON 2,435,747

METHOD AND APPARATUS FOR SEALING CONTAINERS

Filed June 25, 1943 2 Sheets-Sheet 1

Fig. 1.

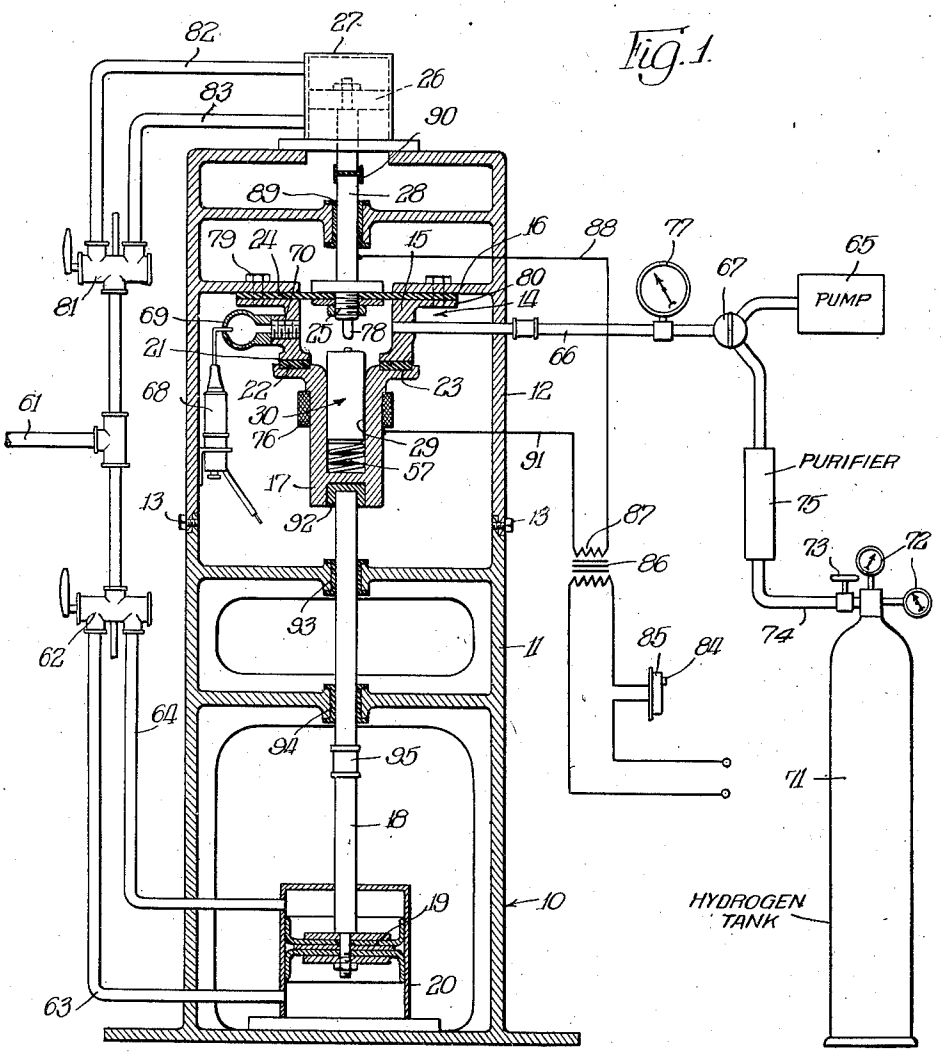
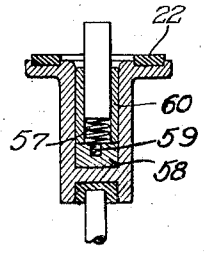


Fig. 2.



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Fig. 3.

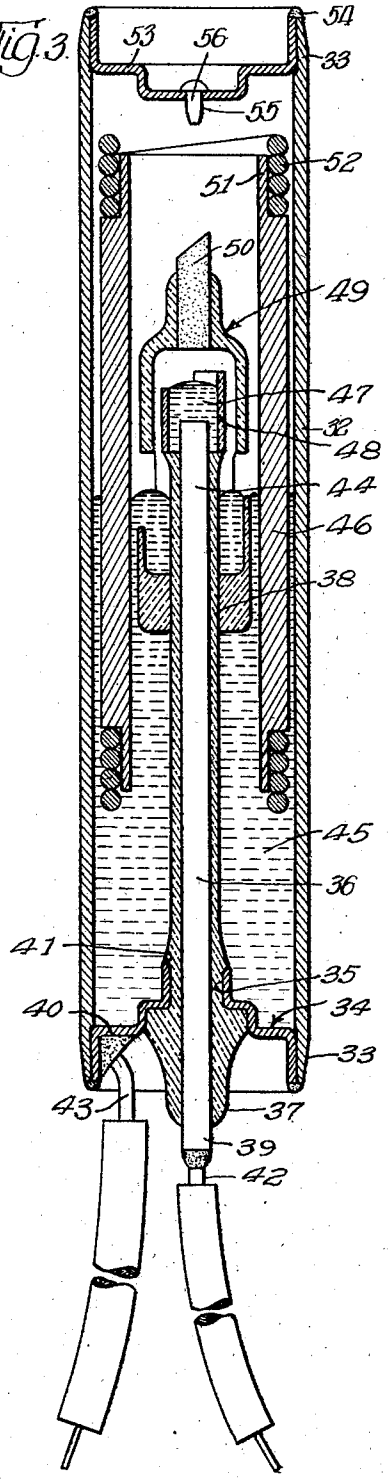


Fig. 4.

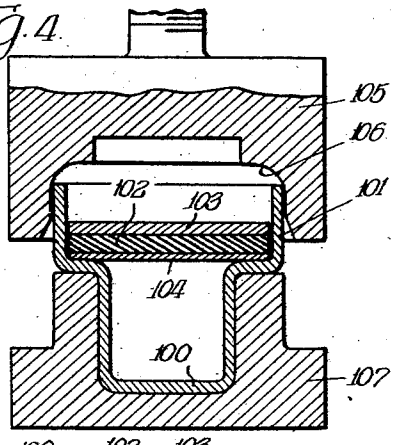


Fig. 5.

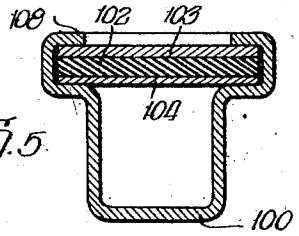
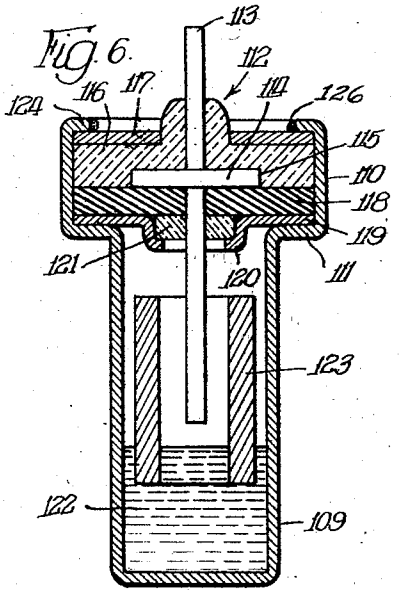


Fig. 6.



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UNITED STATES PATENT OFFICE

2,435,747

METHOD AND APPARATUS FOR SEALING CONTAINERS

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Application June 25, 1943, Serial No. 492,330

10 Claims. (Cl. 226—20)

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This invention relates, particularly, to a method and apparatus for making hermetically sealed metal switches but the invention has broad applicability and may be used advantageously wherever it is desired to seal a container with a prescribed gas fill or state of evacuation.

For convenience, the invention will be described in its application to the fabrication of metal-envelope mercury switches, which must be evacuated, thoroughly degasified, pressure filled with an inert gas, such as hydrogen, helium, argon, or the like, and then hermetically sealed. In glass-envelope, mercury switches, the sealing off is ordinarily done by fusing the upper side walls of the envelope closed after the proper gas fill has been introduced into the envelope through the open end. But in metal switches, this convenient method of forming a hermetic seal cannot readily be used.

The primary object of this invention, therefore, is to provide a method and apparatus which will facilitate the evacuation and/or pressure filling of a switch envelope or other container and the subsequent hermetic sealing of the container when the proper state of evacuation or gas fill has been obtained within the container. More specifically, it is an object of the invention to provide means for evacuating and/or pressure filling metal containers and subsequently hermetically sealing them.

Further and other advantages and objects of the invention become apparent as the disclosure proceeds and the description is read in conjunction with the accompanying drawings in which

Fig. 1 is a diagrammatic view showing a preferred form of the invention;

Fig. 2 is a fragmentary view showing the manner in which adapters may be used to accommodate containers and envelopes of different sizes;

Fig. 3 is a sectional view showing a metal-envelope mercury switch which is suitable for use with this apparatus;

Fig. 4 illustrates the manner in which a die can be substituted for the welding contact on the movable head of the machine for crimping over the upturned end of the container to form a hermetic seal;

Fig. 5 illustrates a container hermetically sealed in this manner;

Fig. 6 shows a mercury switch which is sealed by crimping rather than by welding.

But the specific illustrations shown in the drawings and hereinafter described will suggest to those skilled in the art other forms of the invention within the scope of the appended claims.

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In the preferred form of the invention, which is diagrammatically shown in Fig. 1, the machine consists of a frame generally designated 10 which may be of any convenient construction, but which is here shown, for the purpose of this disclosure, as consisting of a base member 11 and an upper member 12 which may be conveniently disassembled for access to the interior of the machine and which are normally held together by bolts 13. Access openings are provided wherever necessary or desirable.

Within the frame is a two-part chamber or enclosure generally designated 14 consisting of an upper part 15 which is fixed to a flange 16 of the member 12, and a lower part 17 which is supported through a rod 18 on a piston 19 which travels within an air cylinder 20. Downward movement of the piston 19 opens the chamber 14 at the point 21 just above the rubber gasket 22 which is recessed into the enlarged top face 23 of the part 17.

The upper part 15 of the chamber or enclosure 14 has a diaphragm wall 24 through which a movable head 25 is hermetically sealed and movement of the head 25 is controlled by a piston 26 which travels within a cylinder 27 mounted on the top wall of the frame 10 and is connected to the head 25 through a rod 28.

The lower part 17 of the chamber 14 is recessed, as shown at 29, to provide a pocket or support for the container 30 which is to be hermetically sealed after receiving the appropriate gas fill.

Before describing the method in which the machine is used to evacuate and/or gas fill a container which is then to be hermetically sealed, it will be helpful to understand the precise construction of an illustrative form of mercury switch which may be advantageously handled by the machine.

Referring, therefore, to Fig. 3, it will be seen that the switch comprises a tubular envelope 32 of non-magnetic material, preferably 18–8 stainless steel, and having both ends of the envelope beveled off as indicated at 33. A base 34 is formed, by stamping, into a cup-shaped cap as shown and it has a central opening 35 through which an electrode 36 is sealed by a heat sensitive material. Preferably the electrode 36 is made of molybdenum. It is desirable to use a heat sensitive sealing material and a metal for the base 34 which have a coefficient of expansion substantially the same as that of the molybdenum electrode. However, other combinations of material may be used for the sealing of an electrode through a

base but in any case, the sealing material is likely to be heat sensitive and must be protected when the base 34 is heat joined, as for example by torch welding, to the reduced end 33 of the switch envelope. The means for heat joining the base to the envelope without damaging the electrode seal is of no particular consequence here and does not require specific description.

A glass sleeve 38 is telescoped over and fused to the electrode 36, and since the electrode material and glass are chosen with like coefficients of expansion, the glass will adhere to the electrode without cracking even under severe temperature changes. The glass sleeve 38 is enlarged near the lower end 39 of the electrode to form a bead 37 which, with the proper application of heat may be firmly fused to the seat 40 of the base 34, with a portion of the glass overlaying and interlocked with the top margin 41 thereof, thus forming a strong and secure insulated bond for the electrode and the base 34.

Lead wires 42 and 43 are soldered to the electrode 36 and base 34, respectively, so that the switch envelope itself forms one side of an electrical circuit and the exposed end 44 of the electrode 36 forms the other side of the circuit. A ceramic cup 48 is fused to the top of the sleeve 38 and contains a body of mercury 47 which is in constant contact with the exposed end 44 of the electrode 36. A magnetically controlled displacer 46 is moved vertically within the envelope to shift the level of the main body of mercury 45, and when the mercury level rises sufficiently to cause mercury to flow over the top of the cup 48, the electrical circuit is closed, and when that condition does not exist, the circuit is open.

A time delay thimble, generally designated 49, is telescoped over the upper portion of the electrode 36 to delay the movement of mercury to and/or away from the mercury 47 in the cup 48 in proportion to the time required for gas to pass through the ceramic plug 50 mounted in the top of the thimble 49 to equalize the gas pressure differential caused by shifting of the mercury level by the displacer. Since the present invention is not concerned with the particular details of the time delay means, it will be sufficient to refer to Larson Patent No. 2,232,874 for a fuller disclosure of this structure.

The plunger or displacer 46 is preferably made of high grade magnetic iron and it is provided at both ends with a reduced portion 51 adapted to receive a non-magnetic steel spring 52 which is frictionally held on the reduced portion 51 of the displacer. The springs 52 may be made of the same material as the switch envelope 32; namely, 18-8 stainless steel in the austenitic form and the use of this material prevents the displacer 46 from adhering to the top closure 53 when it is made of cold rolled steel or other magnetic material.

In making up a metal switch of the type shown in Fig. 3, the electrode 36 is first fused to the insulating sleeve 38 and then the mercury cup 48 and time delay thimble are applied to the upper end of the electrode. The cap 34 is then slipped over the lower end of the insulated electrode and a bead is formed adjacent to the lower end 39. The electrode assembly is then inverted and the base 34 is drawn upwardly toward the end 39 of the electrode to be fused with and bonded to the bead formed at that end of the electrode. The complete sub-assembly consisting of the base 34 and the electrode bonded therethrough with the time delay structure mounted on the upper end of the electrode is then ready for being heat joined to the tubular envelope 32.

The top closure 53 is welded or otherwise heat joined to the metal-envelope 32 in a manner which forms a solid hermetic seal at the joint 54 between the cap and the envelope and the cap is provided with an opening 55 adapted to receive a loose fitting steel welding pin or brad 56, as shown in Fig. 3. When this pin is in place, it is sufficiently loose fitting so that gas may be withdrawn from the otherwise hermetically sealed envelope or introduced into the envelope without substantial delay but obviously, if desired, the head of the pin could be given a special shape to insure proper ingress and egress of the gas from the envelope during the evacuation and gas filling operation.

Referring now to Fig. 1, it will be seen that by opening the chamber 14 through the lowering of the piston 19, the switch 30 may be inserted in the pocket 29 into the base of which a spring 57 may be placed to resiliently support the switch against the pressure exerted by the head 25 when it is lowered to act on the switch. If an extremely short switch is being worked upon, a plug 58 (Fig. 2) may be dropped into the bottom of the pocket 29 and the plug should have a screw threaded opening 59 to facilitate its removal. Also, if the switch has a smaller diameter than the bore of the pocket 29, a spacer sleeve 60 may be inserted into the pocket to accurately accommodate the switch 30.

After the switch 30 is in place within the pocket 29, air, or some other fluid under pressure, is introduced into the lower part of the cylinder 20 from a source to which a pipe 61 leads through a dual valve 62 and pipe 63, the valve 62, at the same time, placing the pipe 64 leading from the upper part of the cylinder 20 in communication with the atmosphere in the conventional way. The piston thereupon urges the lower part 17 of the chamber against the upper part with a force proportional to the pressure of air within the line 61 and the rubber gasket 22 makes the chamber gas tight.

With the switch in place, the chamber is then evacuated by pump 65 which is connected to the chamber through a pipe 66 and two-way valve 67. When the proper vacuum has been drawn, as determined by a Tesla coil 68, which produces a discharge in a small glass side chamber 69 which is in communication with the interior of the chamber 14 through a bore 70, the valve 67 is turned to place the chamber 14 in communication with the gas which is to be used for filling the envelope 30. This gas, which may be hydrogen, helium, argon, or the like, may be stored in a tank 71 equipped with the usual pressure gauges 72 and reducing valve 73 and is connected to the chamber 14 through a pipe 74, a gas purifier 75 of any suitable design, the valve 67 and pipe 66.

While the pump 65 is evacuating the chamber 14, the air within the envelope is being simultaneously withdrawn with the air or gas within the chamber 14 and likewise, when the chamber 14 is subjected to the gas from the tank 71, the envelope immediately fills with such gas and acquires the same pressure as the gas within the chamber 14. During the evacuation stage, the envelope 30 may be heated by a resistance coil 76 or an induction coil may be used, if desired. Ordinarily, it will suffice to heat the envelope with its contents outside of the machine and place it into the machine while hot but resistance coil or induction coil heating in situ may be used, if

desired. If a high frequency induction coil is used, it may be located either inside or outside of the part 17 of the chamber 14.

After the switch envelope has been flushed out several times by first evacuating the chamber 14 and then pressure filling it, the final step of introducing gas at the desired pressure is performed with the pressure being shown on a gauge 77. The switch envelope is then ready for being hermetically sealed.

The head 25 carries a welding contact 78 and is hermetically sealed through the diaphragm wall 24, which is preferably made of heavy rubber and is clamped by bolts 79 between the flange or web 16 of the frame and a mating flange 80 on the upper part 15 of the chamber 14. The head is movable up and down by proper manipulation of a dual valve 81, similar in all respects to the valve 62 and connected on one side to the compressed air supply through a pipe 61 and on the other side through pipes 82 and 83 with the upper and lower sides, respectively, of the piston head 26. As is the case with the valve 62, when one side of the piston is open to the compressed air supply through a pipe 61, the other side is placed in communication with atmosphere through the valve and, of course, the valves 62 and 81 have off positions in which both sides of the pistons are shut off from the air supply.

With the proper gas fill supplied to the switch envelope 30, the valve 81 is turned to force the welding contact 78 into direct contact with the pin 56 in the top closure 53 of the envelope and an electrical circuit is then closed by pushing a button 84 to provide a correctly timed welding impulse to the contact 78. This causes the pin 56 to be welded to the cap 53 and thereby hermetically seal the envelope. The timing cycle is controlled by a timer 85 and upon closing the primary of the transformer 86 by pushing button 84, the impulse is induced in the secondary 87 of the transformer to produce the weld. As may be seen in Fig. 1, one side 88 of the secondary is connected to the head 25 through the rod 28 which is insulated from the frame by insulating members 89 and 90 and the other side 91 of the secondary is connected to the chamber base 17 which is also preferably insulated from the frame by insulators 92, 93, 94 and 95.

In the described welding procedure the head 25 carrying the electrode or contact 78 moves towards and against the container 30 a predetermined distance. The spring 57 acting against the container exerts predetermined force in opposition to the predetermined movement of the welding contact 78 and thereby serves as means to cause predetermined welding pressure to be created in response to the predetermined movement of the welding contact. Such an arrangement insures welding pressure of a desired magnitude and insures uniformity of pressure through successive welding operations.

It is also possible to use the machine and method of this invention to hermetically seal switch envelopes or other containers by a crimping process as distinguished from a welding process. This is shown in Figs. 4, 5 and 6, the latter figure showing a mercury switch structure suitable for this type of operation and the other two figures showing any type of a container which it is desired to hermetically seal.

Referring first to Fig. 4, a container 100, which is made of metal or other deformable material, is provided with an enlargement 101 adapted to receive a rubber gasket 102 sandwiched between

upper and lower metal discs 103 and 104, respectively. The top margin of the enlargement 101 extends above the disc 103 and the head 25 of the machine is, in this case, equipped with a die 105 having a rounded die face 106 which, when brought down upon the container 100, as it is supported in the form 107, crimps over the top margin of the enlargement 101 and forces the rubber gasket outwardly against the side walls of the enlargement to form a tight seal. The crimped over portion 108 sets firmly upon the top disc 103 and permanently holds the gasket 102 in sealing relationship to the container. The bottom disc 104 protects the rubber gasket from the contents of the container 100 and vice versa and also forms a seat for the gasket during its compression.

The mercury switch shown in Fig. 6 is formed in much the same manner as described for the container in Figs. 4 and 5 but in this case, the container or envelope 109 is preferably stainless steel in its austenitic form. It is also provided with an enlargement 110 at its open end thus providing a seat 111 upon which the electrode assembly generally designated 112 rests. This assembly consists of an electrode 113, preferably of molybdenum to which a metal disc 114 is welded or otherwise secured and the disc fits within a recess 115 formed in the bottom face of a ceramic or plastic insulator 116 over the top surface of which is placed an annular metal disc 117.

The lower face of the insulator 116 rests upon a rubber gasket 118 which, in turn, rests upon a metal plate 119 seated upon the ledge 111 of the envelope 109 and having a dished-out portion 120 adapted to receive and support a ceramic plug 121 which tightly fits over the electrode 113 and prevents contamination of the mercury 122 within the envelope by the rubber gasket 118.

The envelope 109 is first filled with the correct amount of mercury 122 after which the plunger or displacer 123, which is made of magnetic material, is placed in the envelope. The electrode assembly 112 is then slipped into place and the upstanding margin of the enlargement 110 is then crimped over, as shown at 124, by use of a suitable die (not shown) having a die face similar to the die face 106 shown in Fig. 4. The crimping over of the upstanding margin is accompanied by the application of pressure which forces the rubber gasket outwardly to effectively seal the interior of the envelope from the atmosphere. If desired, hard solder may be applied to the crimped-over portion of the enlargement 110 as shown at 126.

Obviously the machine and method of the invention has many applications, and can be variously embodied within the scope of the appended claims.

I claim:

1. In apparatus for making hermetically sealed containers, the combination of a two-part enclosure separable for access therein and having a pocket adapted to receive the container to be sealed, a yieldable wall forming part of the enclosure, said wall having an aperture therein, a movable head extending through said aperture from one side of the wall to the other, said head being in fluid-tight engagement with said wall around said aperture, passage means for fluid flow into and out of said enclosure whereby the enclosure may be evacuated and/or filled with a gas, and means carried by said head for sealing the container when the conditions in the enclosure have been made to duplicate those desired within the container.

2. In apparatus of the character described, a

frame, a two-part chamber, one part being fixed to the frame and the other part being movable to and from the fixed part, means for sealing the chamber when the two parts thereof are together, a diaphragm serving as a portion of the wall of said chamber, and a movable head extending through said diaphragm from one side of the diaphragm to the other in fluid-tight engagement therewith for movement towards the container in the chamber to seal the container while the container content corresponds to the chamber content.

3. In apparatus of the class described, a frame, a two-part chamber, one part being fixed to the frame and the other part being movable to and from the fixed part, means for sealing the chamber when the two parts thereof are together, passage means extending into the chamber for fluid flow into and out of the chamber whereby the chamber may be evacuated and/or filled with a gas, a diaphragm serving as a wall of said chamber, a movable head sealed to said diaphragm and extending through the diaphragm from one side of the diaphragm to the other for movement towards and away from a container in the chamber to seal the container while the container content corresponds to the gaseous content of the chamber.

4. In apparatus of the class described, a frame, a first fluid pressure-actuated means mounted from the upper portion of the frame, a second fluid-pressure-actuated means mounted from the lower portion of the frame, a two-part chamber, one part being fixed to the frame and the other part being movable to and from the fixed part by said lower fluid pressure-actuated means, passage means for fluid flow into and out of said chamber whereby the chamber may be evacuated and/or filled with a gas, a diaphragm serving as a wall of said chamber, a movable head sealed to said diaphragm and extending through the diaphragm from one side of the diaphragm to the other, said movable head being operatively connected with said first fluid pressure-actuating means, and valve means for controlling said two-fluid pressure-actuated means to cause the chamber to open and close and to cause movement of said head within the chamber.

5. In apparatus for making hermetically sealed containers the combination of, a two-part substantially fluid-tight inclosure separable for access thereinto and having a pocket adapted to receive a container to be sealed, said chamber and pocket being dimensioned in depth to permit the container to move towards and away from the pocket bottom while the two-part enclosure is closed, electrode means in said chamber adapted to be actuated from the exterior thereof for movement towards and away from the pocket bottom for sealing action on said container, yielding means in said pocket for contact with said container to urge the container away from the pocket bottom thereby to resist said movement of the electrode means with predetermined pressure, and means for causing current to flow between said electrode means and said container while the container is subject to said predetermined pressure.

6. In apparatus of the class described, a chamber composed of a multiple-part enclosure separable to open to receive an unsealed container and to close for enclosing the container, a diaphragm serving as a wall of said chamber, passage means for fluid flow into and out of said chamber whereby the chamber may be evacuated and/or filled with a gas, means extending through said diaphragm in a fluid-tight manner for actuation from the exterior of the chamber to move towards and away from said container for sealing action on the container involving pressure, means to actuate said sealing means for predetermined movement toward said container, and yielding means in said chamber acting against said container to yieldingly resist said predetermined movement with predetermined force thereby causing predetermined sealing pressure against the container in response to said predetermined movement.

7. A method of fabricating a hollow metal device of the character described including the steps of, completing the device with a small port through a metal wall thereof, placing a headed plug in said port with the head of the plug outside the port and with the stem extending into the port in a non-sealing manner, enveloping said device with said plug in place in a gaseous environment of a character corresponding to a gaseous content desired in the device, exerting pressure on said head, and simultaneously heating said head to weld the head to the device thereby to seal the device while in said environment.

8. A method of fabricating a hollow metal device of the character described including the steps of, completing the device with a small port through a metal wall thereof, placing a headed plug at said port with the stem of the plug extending into the port with fluid-passing clearance and the head of the plug outside the port, moving said device with said plug in place into a gaseous environment of a character corresponding to a gaseous content desired in the device, exerting pressure on said head, and simultaneously heating said head to weld the head to the device thereby to seal the device while in said environment.

9. A method of making hermetically sealed metal containers having a gaseous content which consists in placing a container in an enclosure with the container completely sealed except for a small opening, placing a headed welding pin in said opening with sufficient clearance around the pin to provide open communication between the interior of the container and the enclosure through said opening, establishing in said enclosure a gaseous state corresponding to a gaseous content desired within the container, and then when such state is established welding said pin to the container to hermetically seal the container.

10. In apparatus for making hermetically sealed sheet metal containers, the combination of an enclosure made in parts that are separable for access to the interior thereof and adapted to hold therein the container to be sealed, passage means for fluid flow into and out of the enclosure whereby the enclosure may be evacuated and/or filled with a gas, a flexible diaphragm serving as a wall portion of said enclosure, a sheet metal forming die within the enclosure, and means extending through the diaphragm from one side thereof to the other in a fluid-tight manner for operating said die whereby the die may be actuated through the diaphragm for sealing the container while the enclosure is closed.

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