Dec. 10, 1935. E. L. SCHELLENS 2,024,065

METAL WALLED VACUUM CHAMBER OR CONTAINER AND METHOD OF MANUFACTURE THEREOF

Filed July 30, 1932 2 Sheets-Sheet 1

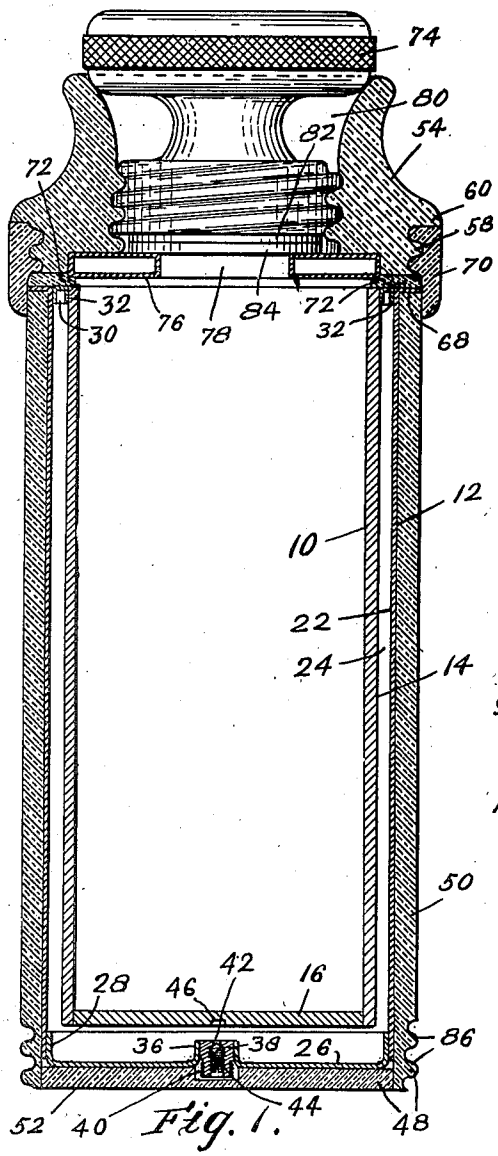


Fig. 1.

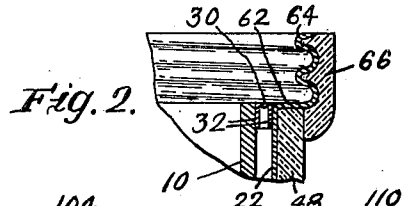


Fig. 2.

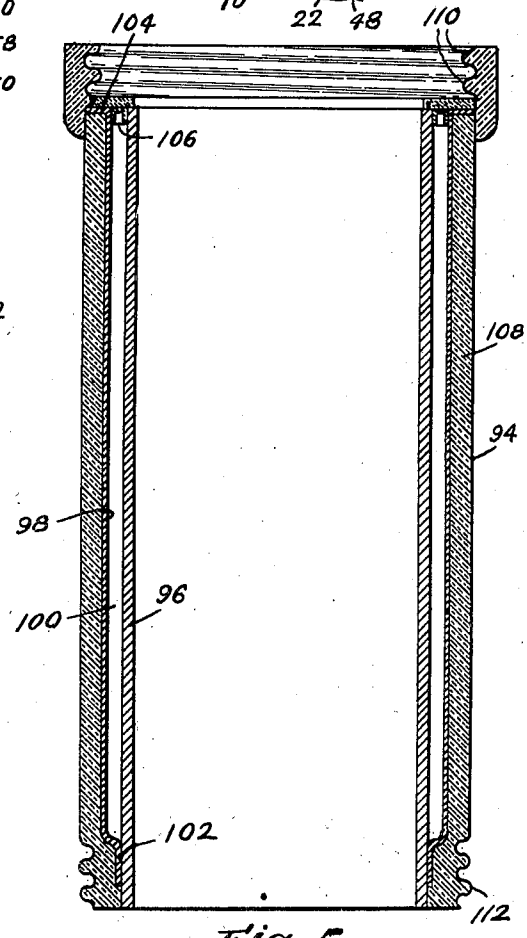


Fig. 5.

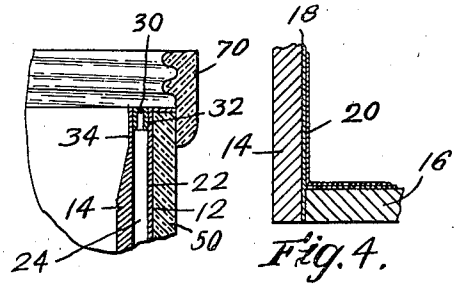


Fig. 3.

Fig. 4.

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Fig. 6.

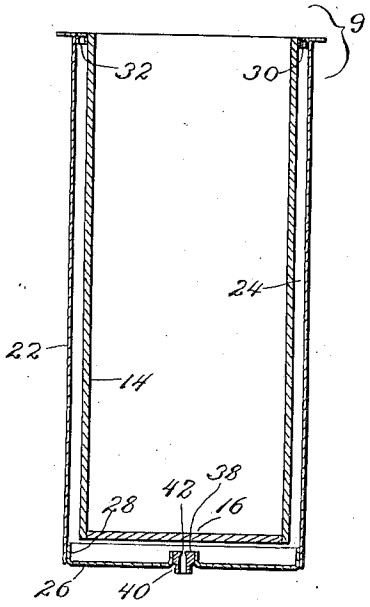


Fig. 7.

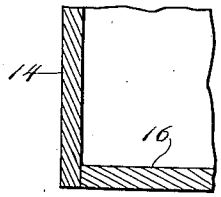


Fig. 8.

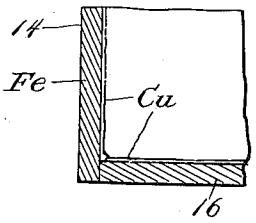


Fig. 9.

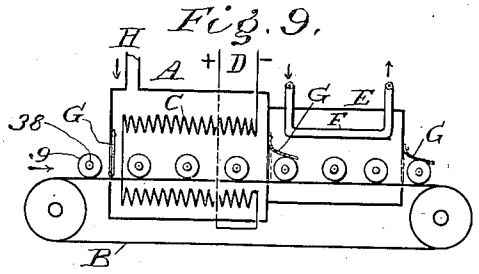


Fig. 11.

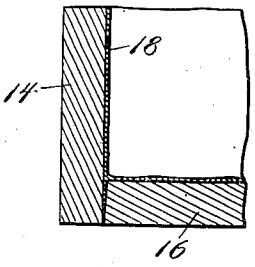
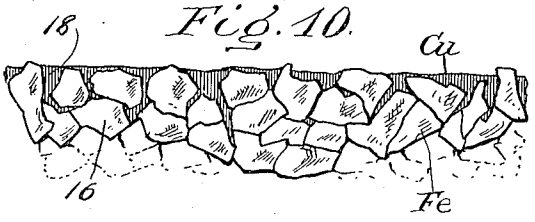


Fig. 10.



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Patented Dec. 10, 1935 2,024,065

UNITED STATES PATENT OFFICE

2,024,065

METAL WALLED VACUUM CHAMBER OR CONTAINER AND METHOD OF MANUFACTURE THEREOF

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Application July 30, 1932, Serial No. 626,384

14 Claims. (Cl. 113—112)

This invention relates to metal-walled vacuum chambers or containers, and method of manufacture thereof, wherein the essential elements are constructed largely, if not entirely, of metal so that the article is strong and for all practical purposes unbreakable. The general object of the invention is to provide a metal-walled container or other chamber which can be evacuated to serve for insulating or other purposes and in which the walls are permanently gas-impermeable to prevent gradual loss of vacuum.

A special object of the present invention is a vacuum insulated container having a large opening so that solid food in large sizes can be introduced and removed therefrom and the interior of the container readily cleaned and so constructed that the separate parts thereof can be brazed or alloyed together in a manner which insures a permanent vacuum tight seal at the joints between the separate parts.

While metal vacuum insulated containers or bottles have been proposed heretofore such a metal container is not permanently gas tight and the evacuated space of the container in time loses a considerable amount of its vacuum by leakage through the pores in the metal side walls that define the evacuated space so that the insulating value of the space becomes lessened. It is an object of the present invention to provide a metal walled vacuum insulated container with a metal sealing film that is welded to or alloyed with the metal wall and fills all pores, seams and fissures therein and thus makes the metal wall permanently tight against impairment of the evacuated space so that the insulating efficiency of the container is maintained indefinitely.

The container embodying the present invention comprises an inner container or receptacle enclosed within an outer container or shell, the space therebetween being evacuated and the top of the inner container being connected to and spaced from the top of the outer shell by a thin annular metal ring of channel cross-section that is welded to the shell and the container and supports the shell and container in spaced relation out of contact with each other and forms a closure for the evacuated space therebetween, the ring being thin and of relatively high resistance to heat conduction between the container and the shell so that the flow of heat into or out of the container is kept down. Such a construction comprises a further object of the invention.

It is highly desirable to provide the interior surface of the vacuum insulated container with a heat reflecting surface whereby to retard the loss of heat from the contents thereof. With the usual restricted-opening metal vacuum bottle it has not been practicable to electroplate and polish the inner surface of the container. In accordance with the present invention, however, the container is so constructed that the inner surface thereof can be electroplated and polished readily whereby to enhance the heat insulating property thereof; and such a construction constitutes an object of the present invention.

Another object of the invention is to provide a vacuum-insulated container with outer and inner metal side walls which enclose the evacuated heat-insulating space, the outer side wall providing an outer seal or envelope for the evacuated space and being thin so that it offers great resistance to heat flow along its length, the wall being so thin that it cannot be depended upon to withstand safely severe mechanical impact and the pressure difference on opposite sides of it, and there being a relatively thick heat-insulating pressure-resisting shell surrounding and intimately connected with and providing support for and protecting the thin metal shell. The thick insulating shell thus, in effect, constitutes the pressure-resisting casing and the outer metal wall constitutes, in effect, a vacuum tight lining or seal for the insulating shell.

A further object of the invention is a construction of a vacuum-insulated container so arranged that two or more similar containers can be connected together as a unit whereby to provide one insulated compartment for the reception, say, of liquids, and another insulated compartment, say, for the reception of solids.

Another object of the invention is the provision of a vacuum-insulated extension that is open at both ends and can be secured at one end to the top of the container and have the cover for the container secured to the other end thereof, thereby to provide a container of enhanced capacity.

A further object of the invention is the provision of a vacuum-insulated container having its inner or food containing compartment provided with a heavy wall of high thermal capacity so that it is enabled to store up a large amount of heat or cold, as the case may be, and thereby prolong the time during which the contents of the container are maintained at the desired high or low temperature.

A further object is generally to improve the construction and extend the use of vacuum-insulated containers.

Fig. 1 is a sectional elevation of a vacuum-

insulated container, or vacuum bottle, embodying the present invention.

Fig. 2 is a sectional detail illustrating a modified form of screw-threaded connection between the container and the top cover therefor.

Fig. 3 is a view similar to Fig. 2 but illustrating a modified form of connection between the inner receptacle and the outer shell.

Fig. 4 is an enlarged detail illustrating the vacuum seal and the reflecting surface of the container.

Fig. 5 is a sectional detail of a vacuum-insulated extension for the container of Fig. 1.

Fig. 6 is a sectional view corresponding to Fig. 1, but showing thereof only the assembled metal wall parts directly enclosing the chamber space.

Fig. 7, on a larger scale, for diagrammatic purposes, shows only portions of two adjoining walls of Fig. 6, before treatment.

Fig. 8 is a diagram similar to Fig. 7 and indicating the application or distribution of a supply of sealing metal or copper upon the metal or iron walls.

Fig. 9 diagrammatically illustrates the treatment of assembled chambers like Fig. 6, with copper applied as in Fig. 8, in a heating furnace in reducing atmosphere at a sealing temperature above the melting point of the copper.

Fig. 10 on a microphotographic scale indicates diagrammatically and approximately the porous character of an iron wall and the spreading and sealing action of the copper upon and into the iron surface.

Fig. 11 is a diagram similar to Figs. 7 and 8 showing the result of these steps, with copper sealing the iron walls and bonding the joint between walls, a later step, after plating over the copper, being shown in Fig. 4.

The vacuum-insulated chamber, container or vacuum bottle embodying the present invention is designed to have its parts welded or bonded together and the pores, passages and the like in its metal walls sealed by heating the assembled parts in a reducing atmosphere, such as hydrogen, in contact with a lower melting point metal, such as copper for parts composed of iron or steel, or some metal that, when fluid, is capable of melting and spreading over the surfaces of the metal with which it is in contact. The reducing atmosphere removes all oxides from the parts and the fluid bonding metal flows by capillary action into the joints between the parts and into the pores, fissures, passages and the like in the metal walls so that the parts are bonded together when they are cool and the bonding metal is solid, and the passages and the like are sealed against air leakage therethrough.

In accordance with the present invention the vacuum-insulated container 9 illustrated in Figs. 1 and 6 comprises an inner metal container or vessel 10 and an outer metal container or vessel 12, the side walls of which are spaced from the side walls of the inner container and the chamber or space therebetween is highly evacuated. The inner container 10 has a side wall that comprises essentially a cylindrical tube 14 that is open for practically its full diameter at the top so that completely free access can be had with the interior thereof. The bottom wall of the inner container comprises a disc 16 which, in the initial assembly of the parts, is frictionally retained in the open bottom of the tube 14. The tube 14 and the disc 16 are preferably, although not necessarily, composed of steel and are relatively thick and thus have high thermal storage capacity so as to impart heat to the contents of the inner container or to maintain the contents cool, as the case may be, for a substantial period of time. The bottom wall 16 is secured or alloyed with the tube 14 in the manner described, by heating the parts in a reducing atmosphere with copper present at or near the joint between the parts to a temperature above the melting point of copper whereby the copper runs into the joint by capillary action and forms a strong bond and a vacuum tight seal between the parts. In accordance with the present invention after the disc 16 has been pressed into the bottom end of the tube 14 preferably the entire inner surface of the inner container 10 has a coating of copper particles applied thereto preferably by mixing the copper particles with a solution of pyroxylin, or some other satisfactory vehicle that will cause the copper to adhere where deposited on the surface and is not detrimental to the welding process, and spraying the mixture through the open top or mouth onto the inner surface of the container 10 so that the mixture adheres both to the inner surface of the tube 14 and the bottom wall 16 and preferably covers the entire inner surfaces thereof. If necessary a greater amount of the mixture can be sprayed onto the surfaces adjacent the joint between the wall 16 and the tube 14. The receptacle 10 is then heated in the reducing atmosphere to above the melting point of the copper and the copper flows by capillary action not only into the joint between the tube and the bottom disc 16 but also into all pores, pipes and fissures of the metal surfaces and alloys therewith so that it not only bonds the disc and the tube together but forms a vacuum tight seal for all the pores in the metal walls and thereby prevents leakage of gas therethrough into the evacuated space. This vacuum sealing film is illustrated by the numeral 18 in Fig. 4. I have found that this method of sealing the wall against gas diffusion though it is highly effective by reason of the fact that the metal sealing film wets the surface of and alloys with and in effect sinks into the surface of the metal wall on which it is applied and thereby effectually closes all passages through the wall, and that a plated film or one applied in any other manner known to me is not completely gas tight. For some purposes, the bonding and sealing metal, as copper, can be electroplated on the surfaces of the walls and then fused in the reducing atmosphere, whereby it will be caused to bond to the metal and enter and seal the joints, passages and the like. The bonding metal also can be applied before the parts have been assembled so that the metal will be in the joints between the parts when they are assembled and will be fused and spread over the juxtaposed surfaces and alloy therewith in the furnace. After the copper sealing film is applied the interior of the inner receptacle is electroplated preferably by chromium, the chromium film 20, see Fig. 4, being deposited upon the copper film 18, the copper film not only constituting a vacuum seal for the metal wall but also constituting a necessary base to receive the chromium film, the electrode for the plating process being introduced through the wide open mouth of the container. After the deposition of the chromium film, the film is buffed or polished by a tool introduced through the open mouth of the container to receive a high polish which reflects the heat and retards the transmis-

sion thereof into the wall of the inner container. The electro-deposition and polishing of the chromium film can be accomplished commercially by reason of the wide opening of the inner container. The outer shell 12 comprises a thin metal tube 22 preferably of steel and of uniform diameter from end to end and opens at the top and bottom and spaced from the inner container to provide an evacuated space 24 therebetween. The shell 22 is provided with a cup-shaped metal bottom closure having a substantially flat bottom wall 26 and an upturned continuous annular flange 28 which is fitted or pressed within the open bottom end of the shell. The flange and shell are welded or bonded together by copper or the equivalent in the manner described in connection with the inner container and the inner surface of the outer shell, and the closure 26 preferably is provided with a copper vacuum-sealing film and a heat reflecting film in the manner described in connection with the inner container. The top of the inner container and the top of the outer shell are connected together and maintained in spaced relation by an endless annular metal ring 30 of inverted channel cross-section and having depending side walls of flanges 32 which are engaged with the confronting faces of the inner and outer walls 14 and 22 and are welded or bonded together in the manner heretofore described. Said spacing and connecting member 30 is preferably composed of thin metal so that the rate of heat conduction between the inner and outer walls is slow. For some purposes the top of the inner tube 14 where it joins the ring 30 can be of reduced thickness as illustrated by the numeral 34, Fig. 3, whereby to increase the length of the high resistance thermally conducting path between the shells. The ring 30 is sufficiently rigid ordinarily to maintain the inner and outer receptacles in spaced relation free from contact so that no other spacing means is rendered necessary.

The bottom closure for the outer receptacle is provided with an upturned neck 36 in which a plug 38 is welded, the plug having a screw-threaded portion 40 for connection with a vacuum pump and having a passage 42 therethrough by which the space 24 can be evacuated. The passage 42 can be closed by a screw-threaded valve 44 prior to the disconnection of the plug from the vacuum pump whereby to seal off the space 24. The screw-threaded valve 44 can then be permanently sealed by soldering. The bottom face of the disc 16 of the inner receptacle is provided with a recess 46 adapted to receive a locating tool that centers the inner receptacle with the outer receptacle during the process of welding the two receptacles and the ring 30 together. The outer receptacle is enclosed within and intimately connected with a non-metallic heat-insulating shell composed of bakelite or other artificial resin 48. Preferably the shell comprises a tube 50 which has a separate bottom closing disc 52 of the same composition cemented therein, and the shell is cemented to the outer metal shell 22. The shell 48 may be otherwise constructed, however.

The outer shell 22 is adapted to be composed of relatively thin metal so that it offers high resistance to heat flow along its length. For this purpose the shell is so thin that it can not be relied upon to withstand mechanical impact and the pressure difference on opposite sides of it. Hence the thin metal shell is intimately connected with the outer insulating shell 50 and said outer shell is sufficiently strong and rigid to resist impacts and the pressure of the atmosphere and thereby to support the thin metal shell. Thus the insulating shell constitutes the pressure-resisting shell and the metal shell in effect constitutes an imperforate lining or seal for the insulating shell. The metal and insulating shells may be intimately connected by a suitable cement or the insulating shell may be built up on the metal shell by a moulding process, using, for instance, a dry phenol condensation powder, or by coating the metal shell with a liquid solution of the insulating material.

The container is provided with a heat-insulating cap 54 which preferably is removably screw-threaded to the container. In the modification illustrated in Fig. 2, the outer shell 22 is provided with an outstanding continuous flange 62 which is in line with the top of the inner container and said flange has an upstanding annular internally screw-threaded wall 64 that receives the screw threads of the cap 54. In this modification a ring 66 of heat insulating material similar to that composing the shell 48 is screw-threaded onto and cemented to the screw threads 64 and also to the top of the shell 48. In the construction illustrated in Fig. 1 the top of the outer shell 12 is provided with an outstanding continuous flange 68 that is seated against the top of the heat insulating shell 48 and an internally screw-threaded ring 70 of heat insulating material is cemented to the top of the shell 48 and receives the cap 54. A resilient packing washer 72 is located under the cap 54 and on top of the inner and outer receptacles to seal the joint therebetween. The cap 54 is provided with a reduced internally-screw-threaded passage in which the screw-threaded closure or cover 74 is removably located. When a liquid is in the inner container it is sufficient merely to remove the cover 74 to pour out the liquid. When the inner container contains solid masses the cap 54 can be removed to permit the introduction or removal of the solid masses. The inner face of the cap 54 is provided with a hollow evacuated ring 76 which has a polished heat reflecting inner surface and is adapted to retard the transmission of heat from the interior of the container through the cap. Said disc has a passage 78 in the middle thereof through which communication can be established with the central funnel-shaped passage 80 of the cap. The cover 74 is provided with an intermediate portion of reduced diameter so that an air space between the bottom portion of the cover, and the top portion, which seats in the top portion of the passage 80, is provided, thereby retarding heat transmission through the cap and cover. The cover 74 is provided with a metal bottom plate 82 provided with a lower polished heat reflecting surface which overlies the opening 78 and bears against a resilient washer 84 which overlies the upper face of said disc 76. The lower portion of the insulating shell 48 is provided with external screw threads 86 which conform to the screw threads 58 of the cap 54 so that the screw threads 86 of one container can be screw-threaded into the top of a second container, thereby to form in effect a single container of double the capacity and wherein the bottom 52 of one container forms a top closure for the other. The upper container may contain a liquid while the lower container may contain solids. The bottom screw threads 86 also constitute means by which the container can be secured freely to some convenient support.

While the assembled metal walls may be assembled, as shown, with abutting or face contact, they may be preliminarily united instead by crimping the adjacent edges, in a usual manner, the sealing metal entering the capillary space between the crimped walls; or the walls may be welded together electrically or otherwise prior to the sealing step.

The present invention also comprehends a vacuum insulated extension **94**, see especially Fig. 5. Said extension comprises an inner metal tube **96** having a straight side wall and substantially the same diameter as the diameter of the inner receptacle **10**. A straight walled outer metal shell **98** surrounds the tube **96** and is spaced therefrom to provide an evacuated heat insulated space **100** therebetween. The bottom of the outer tube **98** is provided with a reduced neck **102** which surrounds and contacts and is welded or alloyed to the inner tube **96**. The upper end of the tube **98** is provided with an outstanding flange **104** similar to the flange **68** of Fig. 1. The upper portions of the inner and outer shells are welded to the interposed spacing and connecting ring **106** similar to the ring **30** of Fig. 1. A heat insulating shell **108** similar to the shell **48** surrounds the outer shell **98** and is provided at the top with the internal screw threads **110** and at the bottom with the external screw threads **112**. The screw threads **112** are adapted to be screw-threaded into the screw threads at the top of the container and the cap **54** of the container is adapted to be screw-threaded into the screw threads **110** so that the extension and the container are assembled as stated, and the effect produced is that of a single container of increased length. The construction of the extension can otherwise be as described in connection with the previously described container.

The diagrams Figs. 6 to 11 illustrate the principles of the method and steps in the preferred embodiment of the present invention. Fig. 6 shows the wall assemblage **9**, constituting the vacuum chamber before sealing and uniting the walls and evacuating the chamber space **24**. The inner and outer tubular walls **14** and **22** are spaced apart concentrically. At the bottom the inner wall is closed by disk **16** while the outer wall is closed below by the cupped bottom piece **26**, the outer flange **28** of which has face contact with the cylindrical wall. At the top between the tubes or cylinders is the metal ring **30** having depending flanges **32**. The bottom **26** has the central flange **36** in which is set the port piece or open plug **38** having outer threads **40** for coupling the exhausting apparatus, and an open passage **42** through it, to be closed by a plug **44** shown in Fig. 1.

This assemblage of walls, preliminarily secured by pressure or otherwise, is to be permanently sealed as described, and united at the joints, which may present abutting or face contact or crimping attachment, in any case involving crevices of capillary proportions.

The next diagram Fig. 7 shows enlarged portions of walls **14** and **16** assembled, with a capillary joint between them, but before any treatment. Fig. 8 shows the same walls **14** and **16**, for example of iron, but with an application or distribution of copper, as a layer, or in spots, or otherwise, and inside, outside or both, as already described.

Fig. 9 diagrammatically illustrates the step of heating in a reducing or hydrogen atmosphere. A series of the wall assemblages **9** is shown carried through the heating chamber A on a suitable conveyor B, the port piece **38** being open at this stage. The chamber A is conventionally shown as heated by electric coils C having exterior terminals D. The conveyor carries each assemblage slowly through the heating chamber, to give it the requisite period of exposure to the specified temperature, at or above the melting point of copper, so that the applied copper is caused to melt and flow wetly as described. From the heating chamber each product passes preferably into a cooling chamber E in which are enclosed conduits F to carry cooling fluid. Curtains G as of asbestos are indicated at each of the walls covering the entrance and exit of each chamber. Hydrogen or other reducing gas may be continuously supplied to the heating chamber or furnace by pipe H, passing thence into and from the cooling chamber. This gas chemically cleans the iron walls at and below the surface, and prevents oxidation.

The resulting condition of each wall surface when passing from the heating chamber is indicated approximately in the diagram Fig. 10 wherein, highly magnified, the copper is shown as substantially covering the surface of the iron, and entering also to a substantial depth into every passage and pore existing between or in the minute crystalline particles, the copper flowing freely over the surface in a wet condition and being drawn into the surface by the alloying attraction of the iron for the copper, or by capillary attraction of the fine passages for the fluid metal, or both; in some cases this action being so complete that the copper may pass clear through a thin wall and show at the opposite side.

Fig. 11 shows the product of these steps, the copper now forming a sealing coating or film **18**, and the surplus copper adjacent the corner having been drawn into the joint between the contacting walls **14** and **16** and effected a permanent and tight bonding and uniting thereof. If a reflecting surface is desired a chromium plate layer **20** may be applied on top of the copper, as shown in Fig. 4, copper being well adapted to the adherence of chromium.

Following the sealing and uniting of the walls the chambers are subjected to usual exhausting steps, not shown, at the completion of which the port or passage **42** is closed by plug **44** and solder applied to the plug for a final sealing.

The product of this invention may be summarized in one aspect as a gas-impermeable metal-walled vacuum chamber, having for example the form of a container, the same comprising the metal walls, as of iron, arranged to form and completely enclose an evacuated space, with a permanently stopped exhaust port; and upon said metal walls a sealing coating of a metal as copper, which has a lower melting point than the wall metal and has an alloying attraction therewith, part of said sealing metal being in an indrawn position (caused by the alloying attraction or by capillarity or both at a temperature between the melting point of the two metals) thereby occupying and closing the permeable pores and passages of the walls and sealing them gas-tight. The walls being preferably connected by joints such joints are bonded by the entry of the sealing metal into the crevices thereof. In the aspect of method the invention may be described as the process of manufacturing such a product comprising arranging the metal walls to surround completely the space within the chamber, but leaving a temporary gas port, applying upon the wall surface, in any of the ways de-

scribed, a sealing metal of substantially lower melting point than the wall metal and having an alloying attraction therewith, then heating the chamber in a reducing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to enter into and close and occupy, by capillarity or alloying attraction, or both, the permeable pores and passages of the wall metal, allowing the wall to cool to solidify the sealing metal, and thereafter evacuating the chamber space and stopping the gas port to close permanently the space. The assembling of the walls preferably precedes the sealing thereof, and any wall joints are preferably bonded in the same operation with the sealing.

The vacuum chamber of this invention is shown illustratively as adapted for heat-insulating purposes, for which it is of special advantage. The walls are of sheet metal or steel which is light or thin, of the order of 0.10 inch or less, down to a fraction thereof; as stated the wall metal is of a thinness subject to crimping for uniting the wall parts, and may sometimes even be so thin as to require reinforcing against collapse; the product being light and perhaps portable, as is the vacuum bottle described. Such character of walls tends to impair the gas tightness of untreated walls. In the preferred process the final forming or assembling of the wall parts in their permanent relation precedes the heating treatment for wall sealing, which is important, and the assembling may also precede the application of the copper or sealing metal to the walls, which is of less importance. The finished chamber walls completely enclose the evacuated space without need of packing or clamping devices.

I claim:

1. The process of manufacturing a highly gas-impermeable metal-walled vacuum chamber, comprising arranging the wall metal to form and completely enclose the chamber, leaving an exhaust port, then applying upon the chamber wall surfaces a sealing metal of substantially lower melting point than the wall metal and having an alloying attraction therewith, then heating the chamber in a non-oxidizing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to be drawn below the wall surfaces and to enter into and close the permeable pores and passages of the wall metal, allowing cooling to solidify the sealing metal, and thereafter evacuating the chamber and stopping the exhaust port.

2. The process of manufacturing a gas-impermeable metal walled vacuum chamber, comprising the preliminary steps of arranging the metal walls to form the chamber, leaving an exhaust port in one of the walls, and, applying upon the wall surfaces a sealing metal of substantially lower melting point than the wall metal and having an alloying attraction therewith, and the subsequent steps of heating the chamber in a reducing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to enter into and close the permeable pores and passages of the wall metal, followed by allowing the wall to cool to solidify the sealing metal, and thereafter evacuating the chamber and stopping the exhaust port.

3. The process of manufacturing a gas-impermeable heat-insulating metal-walled vacuum chamber, comprising arranging sheet-iron walls to form the chamber, leaving an exhaust port, then applying upon the wall surfaces a sealing metal as copper of substantially lower melting point than the wall metal and having an alloying attraction therewith, then heating the chamber in a hydrogen reducing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to enter and close the permeable pores and passages of the wall metal, allowing the wall to cool to solidify the sealing metal, and thereafter evacuating the chamber and stopping the exhaust port.

4. The process as in claim 2 and wherein the wall metal is iron, and the sealing metal is copper, and the sealing metal in fully divided form is first mixed with a volatilizable vehicle, as pyroxylin, and applied or distributed upon the wall surfaces before heating.

5. The process of manufacturing a gas-impermeable metal walled vacuum chamber, comprising the preliminary steps of assembling sheet metal wall parts in final relation to form and enclose the chamber, leaving an exhaust port, the said parts meeting at joints presenting crevices of capillary thinness, and applying upon the wall surfaces a sealing metal of substantially lower melting point than the wall metal and having an alloying attraction therewith, and applying the sealing metal also at such joints in substantial quantity, and the subsequent steps of heating the chamber in a reducing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to be drawn into and close the permeable pores and passages of the wall metal, and at the same time to enter also the crevices at the joints and be drawn into and unite with the wall metal bounding such crevices, and then allowing the wall to cool to solidify the sealing metal, thereby to seal the wall surfaces, and at the same time to seal the crevices between the wall parts and permanently to bond such joints, and thereafter evacuating the chamber and stopping the exhaust port.

6. The process of manufacturing a gas-impermeable metal walled vacuum chamber, comprising assembling sheet iron wall parts to form the chamber, leaving an exhaust port, the said parts meeting at joints presenting crevices of capillary thinness, then applying copper upon the wall surfaces and also at such joints in substantial quantity, then heating the chamber in a reducing atmosphere, as hydrogen, to a sealing temperature sufficiently above the melting point of the copper to cause it to flow wetly upon the hot iron wall surfaces and to be drawn into and close the permeable pores and passages of the walls, and at the same time to enter also the crevices at the joints and be drawn into and unite with the wall metal contiguous to such crevices, and allowing the wall to cool to solidify the copper, thereby to seal the wall surfaces, and at the same time to seal the crevices between the wall parts and permanently to bond such joints, and thereafter evacuating the chamber and stopping the exhaust port.

7. The process of manufacturing a metal walled vacuum insulated container, comprising arranging spaced metal walls, as of iron, to form the container and to enclose a vacuum space between the walls, leaving an exhaust port, and applying upon the wall surfaces and at the joints between wall parts a sealing metal, as of copper, of substantially lower melting point than the wall metal

and having an alloying attraction therewith, and thereafter heating the container in a reducing atmosphere, as hydrogen, to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surface and to be drawn into and close the permeable pores and passages of the wall metal, and at the same time to enter between the wall parts at the joints, and allowing the wall to cool to solidify the sealing metal thereby to seal the wall surfaces and to bond the joints, and finally evacuating the chamber and stopping the exhaust port.

8. The process of manufacturing a gas-tight heat insulating metal walled vacuum chamber, comprising assembling in final relation the metal walls to surround completely the space within the chamber, but leaving a temporary gas port, and applying upon the wall surfaces a sealing metal of substantially lower melting point than the wall metal and having an alloying attraction therewith, and thereafter heating the assembled chamber in a reducing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to enter into and close and occupy by attraction or capillarity the permeable pores and passages of the wall metal, allowing the wall to cool to solidify the sealing metal, and thereafter evacuating the chamber and stopping the gas port to close permanently the space within the chamber.

9. The process of manufacturing a gas-tight metal walled vacuum chamber, comprising the preliminary steps of assembling sheet metal wall parts to surround the space within the chamber, leaving an exhaust port, and applying upon the wall surfaces a sealing metal of substantially lower melting point than the wall metal and having an alloying attraction therewith, and applying the sealing metal also for the joints between the wall parts, and the subsequent steps of heating the chamber in a reducing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to be drawn into and close and occupy by attraction or capillarity the permeable pores and passages of the wall metal, and at the same time to enter the joints between the wall parts, and allowing the wall to cool to solidify the sealing metal, thereby to seal the wall surface and at the same time to bond permanently the joints, and thereafter evacuating the chamber and permanently stopping the exhaust port.

10. The process of manufacturing a gas-tight metal walled vacuum chamber of light or portable nature having walls of light sheet-metal as iron and with an evacuation port in a wall, said process, comprising applying upon the surface of the wall metal a sealing metal of substantially lower melting point than the wall metal and having an alloying attraction therewith, then heating in a non-oxidizing or reducing atmosphere to a sealing temperature sufficiently above the melting point of the sealing metal to cause it to flow wetly upon the hot wall surfaces and to enter into and close and occupy by attraction or capillarity the permeable pores and passages of the wall metal, allowing the walls to cool to solidify the sealing metal, and thereafter evacuating the completed chamber and permanently stopping the port of evacuation to close and seal the vacuum space within the chamber.

11. A gas-tight metal-walled vacuum chamber of light or portable nature, comprising sheet-metal walls as of iron arranged to form and enclose the evacuated space and in one of the walls a permanently stopped exhaust port; said metal walls being sealed to a highly gas-impermeable condition by an application thereto of a sealing metal, as copper, having a lower melting point than the wall metal and having an alloying attraction therewith, some of said applied sealing metal existing in a position below the surface of the wall metal, and occupying to an appreciable depth and molecularly closing the permeable pores and passages of the walls thus rendering the walls gas-impermeable and the chamber gas-tight; said sealing metal having been indrawn to such position, as by capillary attraction and wet penetration, at a temperature between the melting points of the two metals in a non-oxidizing atmosphere.

12. A vacuum chamber as in claim 11 and wherein the chamber walls comprise assembled wall parts in close contiguity at the joints, and with portions of the wall sealing metal occupying and bonding such joints and rendering them gas-tight.

13. A vacuum-insulated container comprising inner and outer vessel walls as of sheet-iron spaced apart to enclose an evacuated space between them, with a permanently stopped exhaust port in one of such walls; said metal vessel walls being sealed to a highly gas-impermeable condition by an application thereto of a sealing metal, as copper, having a lower melting point than the wall metal and having an alloying attraction therewith, some of said sealing metal existing in a position below the surface of the wall metal, and occupying to an appreciable depth and molecularly closing the permeable pores and passages of the walls thus rendering the walls gas-impermeable and the container space gas-tight; said sealing metal having been indrawn to such position, as by capillary attraction and wet penetration, at a temperature between the melting points of the two metals in a non-oxidizing atmosphere.

14. A vacuum-insulated container as in claim 13 and wherein the sealing metal is copper, and some of such copper substantially covers the walls, and such copper covering being exposed in uncoated condition.

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