I. LANGMUIR.

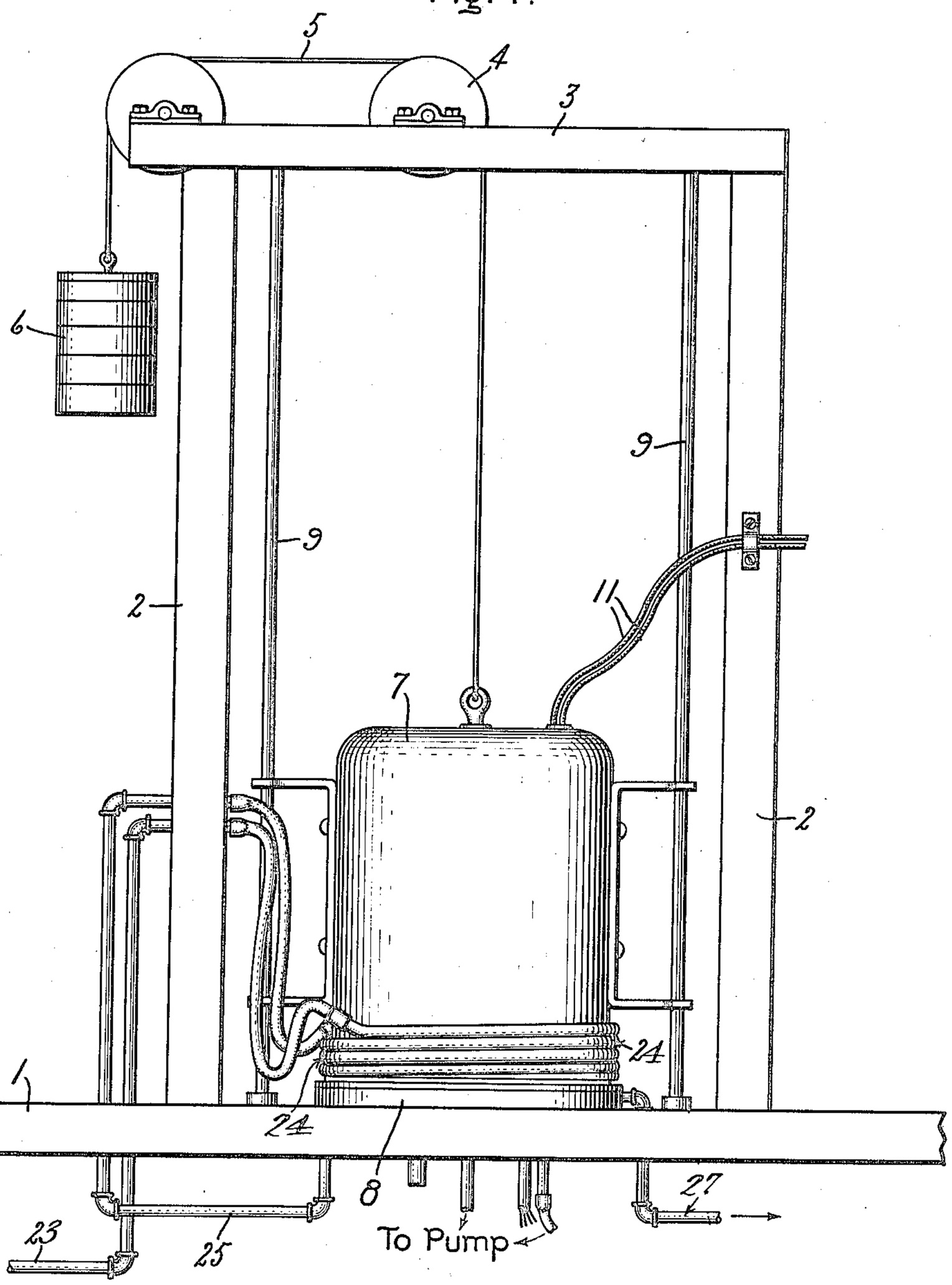
METHOD OF AND APPARATUS FOR PRODUCING EXHAUSTED VESSELS.

APPLICATION FILED OCT. 22, 1910.

994,010. Patented May 30, 1911.

2 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
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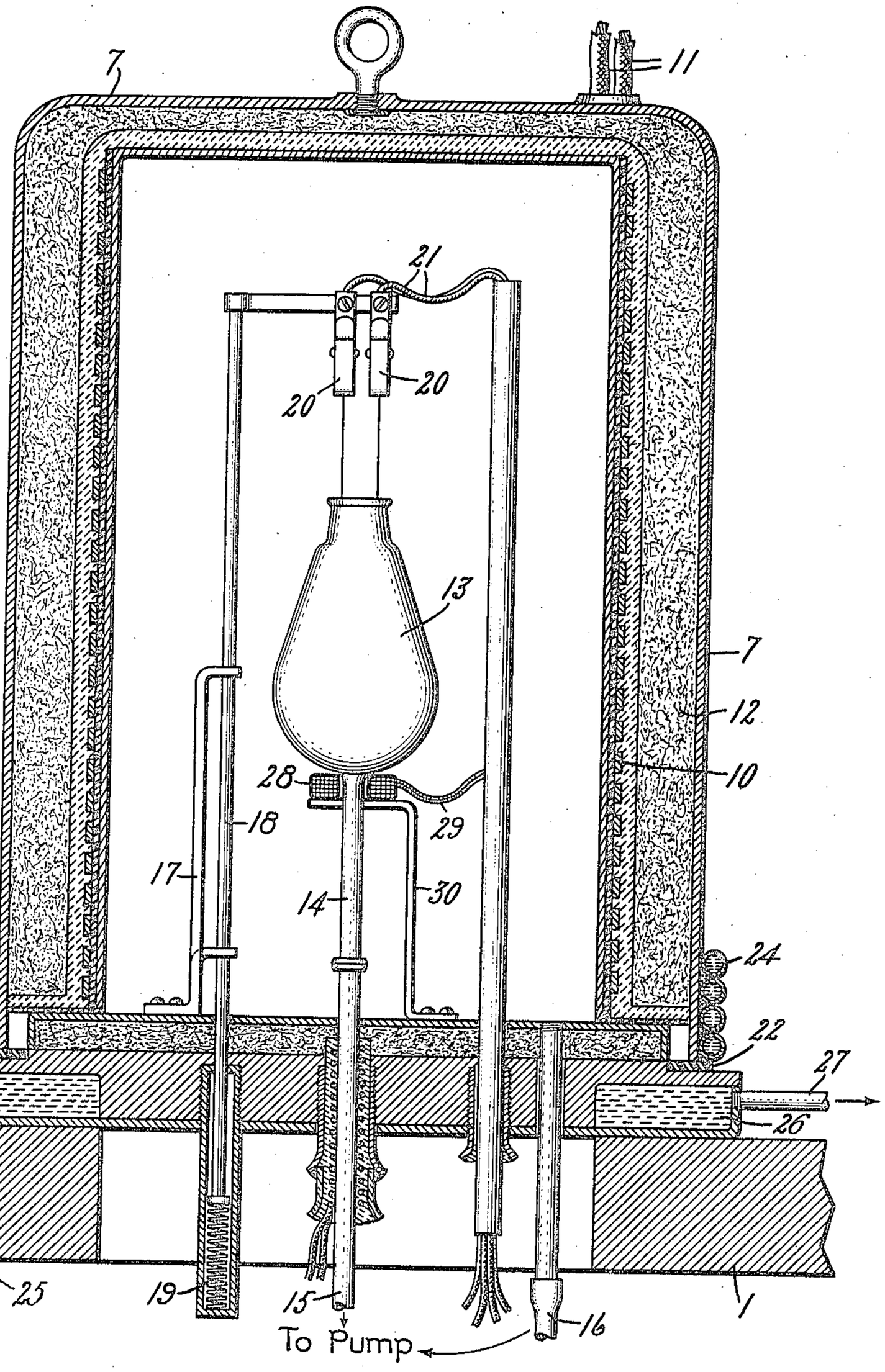
2 SHEETS—SHEET 2.

Fig. 2.



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UNITED STATES PATENT OFFICE.

IRVING LANGMUIR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

METHOD OF AND APPARATUS FOR PRODUCING EXHAUSTED VESSELS.

994,010. Specification of Letters Patent. Patented May 30, 1911.

Application filed October 22, 1910. Serial No. 588,518.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Producing Exhausted Vessels, of which the following is a specification.

My invention relates to the production of apparatus in which a very perfect vacuum is required and more particularly to exhausting incandescent lamps and similar articles in which it is desirable to secure a very perfect vacuum which will not deteriorate even though the article be heated.

It is very difficult to produce and to maintain a high vacuum in vacuum apparatus, such as incandescent lamps and similar exhausted vessels, on account of the gases and water vapor which are occluded by the material of the apparatus and which escape from the walls into the exhausted vessel and cause the vacuum to deteriorate, particularly if the apparatus is heated. This difficulty is especially noticeable in incandescent lamps on account of the objectionable results of deterioration of the vacuum, particularly if the lamps have metallic filaments, but nevertheless the vacuum of lamps exhausted in the usual manner is apt to be impaired by the occluded gases and vapor which escape from the walls of the lamps when the lamps become hot. In order to remove as much of the occluded gases and vapor as possible during exhaustion, it has been proposed to heat the apparatus or lamp while it is being exhausted, but the temperature which can be safely used is quite low on account of the tendency of the hot exhausted apparatus to collapse under atmospheric pressure.

Experiments have shown that the higher the temperature of the apparatus the more completely are the occluded gases and vapors driven out and the object of my invention is to provide a method and means by which vacuum apparatus may be heated during exhaustion to a temperature at which the walls begin to soften and to be distorted by their own weight, so that the apparatus is heated much hotter than it will ever be during operation and is raised to the highest temperature which can be attained without melting it down. In order to prevent the apparatus being subjected during exhaustion to any pressure or strain sufficient to distort it practically the same pressure is maintained within and without the apparatus during the heating and the exhaustion, preferably by heating and exhausting the apparatus in an oven which may be exhausted to keep the pressure inside and outside the apparatus substantially equal during the entire time the apparatus is at a high temperature.

It is customary to exhaust vacuum apparatus, especially lamps, through a connection or tubulature which is heated and sealed off after the apparatus is exhausted. If the tubulature exceeds a certain size it will not seal off when heated, but will puncture at some one point and permit air to enter the exhausted apparatus, hence in practice a tubulature of comparatively small bore is used so that it can be sealed off at atmospheric pressure without destroying the vacuum in the apparatus. The rate at which gases may be drawn out of the apparatus depends on the bore of the tubulature and a further object of my invention is to shorten materially the time required for exhausting by increasing the rate of flow of gases out of the apparatus while on the pump, preferably by using a tubulature much larger than can be sealed off safely under atmospheric pressure. At any time during the exhaustion of the vessel but preferably after the exhaustion is completed there is produced in any suitable manner in the tubulature a constriction of such a bore that it can be easily sealed off at atmospheric pressure without destroying the vacuum in the apparatus.

Other objects of my invention are to provide a simple, efficient and easily manipulated apparatus by means of which vacuum apparatus or lamps may be quickly and easily heated to high temperature and exhausted while so heated.

My invention will best be understood in connection with the accompanying drawings which merely for purposes of illustration show what I consider at the present time to be the best one of the various forms in which the invention may be carried out, and in which—

Figure 1 is a side elevation of an apparatus constructed in accordance with my invention and suitable for exhausting an in-

candescent lamp; and Fig. 2 is a longitudinal cross section of the device shown in Fig. 1.

In the specific form of device shown in the drawings, a table 1 is provided with uprights 2 joined at the top by a cross piece 3 carrying pulleys 4 over which runs a flexible cord 5 connected at one end to a counterweight 6 and at the other end to a cover or chamber 7 which is open at the bottom but rests upon and makes an air-tight joint with a base plate 8 mounted upon the table 1. The chamber 7 may be raised and lowered at will and is guided by means of vertical guides 9. In order to heat the vacuum apparatus during exhaustion to as high temperature as practicable so that most of the occluded gases and vapors may be driven out of the material of the apparatus the inner wall of the chamber 7 is heated in any suitable way to such a temperature that the vacuum apparatus is raised to the highest temperature which the material of the apparatus will stand. The inner walls of the chamber or cover 7 may be heated in any suitable way, but a convenient and simple way is that shown in the drawings, in which a heating coil 10 connected to any suitable source of current through flexible leads 11 is embedded in the walls of the chamber 7, preferably being embedded in some refractory material such as clay or porcelain and spaced away from the outer wall of the chamber by a layer of some suitable heat insulating material 12 which surrounds the heating coil and the material in which it is embedded. By passing a sufficient amount of current through the heating coil 10, the temperature of the apparatus within the chamber 7 may be raised to any desired point during the exhaustion of the apparatus.

As is evident from Fig. 2, the chamber 7 and base plate 8 coöperate to form a closed chamber or oven which may be opened at will and in which the apparatus to be exhausted is placed. Any suitable form of closed chamber for containing the apparatus to be exhausted may be used as long as it is so constructed that it may be exhausted to whatever degree will be necessary to prevent collapse or distortion of the heated apparatus which is being exhausted in the chamber. The particular form of chamber shown in the drawings is suitable for exhausting incandescent lamps one at a time, but in practicing the invention commercially the chamber is preferably made large enough to contain a number of lamps or similar pieces of apparatus. The particular form of vacuum apparatus shown in the drawings is an incandescent lamp 13 mounted in the chamber 7 and connected to an exhaust pump by means of a tubulature 14 sealed on to a suitable connection 15 which extends through the base 1 to some suitable exhaust pump, not shown, while a similar connection 16 extends through the base into the chamber 7 in which the lamp 13 is placed and is also connected to an exhaust pump, so that both the lamp 13 and the chamber 7 may be exhausted at will. The apparatus to be exhausted may be supported in the chamber 7 in any suitable way. In the particular device shown in the drawings an upright 17 supports and guides a slidable rod 18 which is resiliently supported on a spring 19 and carries at its upper end clamps 20 which take hold of the leading-in wires of the lamp and are electrically connected by leads 21 to some suitable source of current so that, if desired, current may be passed through the filament of the lamp during exhaustion. Since the cover or chamber 7 is removable from the base 8, an air tight joint must be made between the cover and the base and must be kept airtight, and one of the various ways in which this result may be attained is by means of a gasket or packing ring 22 engaged by the edge of the cover 7. In order to prevent injury to the gasket by too high a temperature the edge of the base and that portion of the cover which contacts with the base is cooled in some suitable manner, preferably by circulating a cooling fluid through suitable recesses in the base and through cooling coils on the edge of the cover 7. In the particular arrangement shown in the drawings, a supply pipe 23 delivers water or other suitable cooling fluid through cooling coils 24 mounted close to that edge of the cover 7 which engages the base 8, then through suitable connections 25, as shown in Fig. 1, to a recess 26 formed in the base 8 in a position to keep the edge of the base cool, the water finally escaping through an exhaust pipe 27.

In carrying out my invention with the particular form of device shown and described, the lamp 13 or other vacuum apparatus which is to be exhausted is connected to the exhaust pump by sealing its tubulature 14 to the connection 15 and the clips 20 are connected to the leading-in wires of the lamp so that the filament is electrically connected to the leads 21. The cover 7 is then fitted to the base 8 so as to make an airtight joint with the base and the lamp 13 may then be exhausted. During the exhaustion of the lamp its temperature may be raised as desired by passing current through the heating coil 10 and thereby heating the inner wall of the chamber 7.

If the apparatus which is being exhausted is made of the kind of glass commonly used for incandescent lamps it is preferably heated to between 480° and 520° C. at which temperature the walls of the apparatus are so hot that they are on the point of melting down and will yield under very slight pres-

sure, hence during the exhaustion of the apparatus the chamber or cover 7 is also exhausted through the connection 16 so that at no time is there a sufficient difference of pressure between the air inside the apparatus and the air in the chamber or cover 7 to cause the walls of the apparatus or lamp to be distorted in any way. The temperature to which the apparatus can be heated during exhaustion is limited only by the melting point of the material of which the apparatus is made, and if the apparatus is made of certain kinds of glass which melt only at very high temperatures the apparatus can be heated much higher than 520° C. during exhaustion because it will keep its shape until the temperature approaches the melting point of the glass. The exhaustion is carried to the desired limit and the apparatus is kept at the desired temperature during exhaustion, after which the current is cut off from the heating coil 10. Before air is admitted to the oven 7 both the oven and the apparatus in it are permitted to cool down to about 360° or lower, if the apparatus is made of the usual kind of glass, because the hot exhausted apparatus would collapse under atmospheric pressure if the oven were opened while the apparatus is at the temperature attained by it during the process of exhaustion. After the chamber or oven 7 has been opened, the hot apparatus is sealed off from the pump by heating and sealing the tubulature 14. Rapidity of exhaustion seems to be increased by the use of a large tubulature 14, but if the tubulature exceeds a definite size the exhausted apparatus cannot be sealed off under atmospheric pressure because the tubulature when heated will puncture instead of shrinking together to form a hermetical seal. In accordance with my invention the time required for exhausting is very much shortened by using a tubulature much larger than can be sealed off at atmospheric pressure, and in order to enable the vacuum apparatus to be sealed off when such a large tubulature is used, the tubulature 14 is heated and constricted to the usual size after the apparatus has been exhausted and while the difference in pressure between the inside and the outside of the tubulature is so slight that the tubulature will not be punctured. The constriction of the tubulature to such a size that it can be sealed off under atmospheric pressure may be accomplished by heating the tubulature in any desired way while the tubulature is in the exhausted oven or chamber 7, and then constricting it in any suitable way as by drawing it out or by causing the walls to sink in under slight pressure. One way in which the constriction may be produced in the tubulature is shown in the drawing, in which a heating coil 28 supplied with current through flexible leads 29 and mounted upon a suitable support 30 surrounds the tubulature 14 near the point where the tubulature joins the vessel to be exhausted and by means of the heating coil 28 a local heating of the tubulature may be secured sufficient to render the heated portion of the tubulature plastic.

In the preferred construction the tubulature is constricted by being drawn out slightly while it is soft. The drawing out of the tubulature may be done in various ways; preferably by so adjusting the spring 19 that when the heating coil 28 softens the tubulature more than the remainder of the apparatus the spring will not only counterbalance the weight of the lamp 13 but also exert enough of an upward pull on the tubulature to produce the required constriction. The constriction may also be produced by heating the tubulature after the exhaustion is practically completed and then varying the pressure on the outside of the tubulature in such a manner that the pressure is very low and the walls of the tubulature shrink and form a constriction instead of being punctured, as would be the case if a large exhausted tubulature were heated under atmospheric pressure.

My invention may be embodied in many other forms than that shown and described and I therefore do not limit myself to the precise arrangement disclosed, but intend to cover by the appended claims all changes and modifications within the scope of my invention.

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

1. The method of exhausting a vessel which consists in heating the vessel during exhaustion and in maintaining the medium which surrounds the vessel at substantially the same pressure as the medium inside the vessel.

2. The method of exhausting a vessel which consists in heating the vessel during exhaustion to a temperature which softens its walls and in preventing the distortion of the walls of the vessel during exhaustion.

3. The method of exhausting a vessel which consists in heating the vessel to a temperature at which the walls begin to soften, and keeping the difference of pressure between the medium inside said vessel and the medium surrounding said vessel so small that the heated walls retain their shape.

4. The method of exhausting a glass vessel which consists in heating the vessel during exhaustion to a temperature between 460° and 520° C., and shielding the walls of the vessel during exhaustion from pressure great enough to distort them.

5. The method of exhausting a vessel which consists in heating the vessel to a high temperature, and in reducing the pressure

of the medium surrounding said vessel and of the medium within said vessel to prevent collapse of the walls of said vessel.

6. The method of exhausting a vessel which consists in heating the vessel to a high temperature during exhaustion to drive off occluded gases, and reducing the pressure of the medium within and without said vessel to produce substantially the same pressure on both sides of the walls of the vessel.

7. The method of exhausting a vessel which consists in exhausting the vessel through a connection so large that said connection when exhausted cannot be sealed off under atmospheric pressure, reducing the pressure of the medium surrounding said connection below the pressure of the atmosphere, producing in said connection a constriction small enough to permit sealing off under atmospheric pressure, and sealing off said connection at said constriction.

8. The method of exhausting a vessel having a large tubulature which consists in exhausting said vessel through said tubulature, reducing the pressure of the medium around said tubulature until it is too low to cause puncturing of said tubulature, heating said tubulature locally, drawing out the heated portion of said tubulature to produce a constriction in said tubulature, and sealing off at said constriction.

9. In an apparatus for exhausting vessels, the combination of a chamber for containing the vessel to be exhausted, means for heating the vessel in said chamber, and means for exhausting both said vessel and said chamber.

10. In an apparatus for exhausting vessels, the combination of a chamber for containing the vessel to be exhausted, connections extending into said chamber for exhausting said vessel, means for heating said vessel during exhaustion, and means for exhausting both said chamber and the vessel in said chamber to keep the difference of pressure between the interior and the exterior of said vessel too small to distort said vessel.

11. In an apparatus for exhausting vessels, the combination of an oven for containing the vessel to be exhausted, means for heating the inner wall of said oven to raise the temperature of said vessel, and means for exhausting said vessel and said oven.

12. In an apparatus for exhausting vessels, the combination of a chamber for containing said vessel comprising two coöperating separable parts, means for heating the inner wall of one of said parts to heat the vessel in said chamber, and means for exhausting said chamber and the vessel in said chamber.

13. In an apparatus for exhausting vessels, the combination of a base, a movable cover coöperating with said base to form a chamber to contain the vessel to be exhausted, exhaust connections for said vessel extending through said base, means for heating the inner wall of said cover during exhaustion of said vessel, and connections for exhausting said chamber.

14. In an apparatus for exhausting vessels, the combination of a base, a removable cover coöperating with said base to form a chamber for containing the vessel to be exhausted, a heating coil embedded in the walls of said cover to heat the vessel in said chamber, cooling means for maintaining the temperature of said cover and said base within predetermined limits at their point of contact, connections for exhausting said vessel, and connections for exhausting said chamber.

15. In an apparatus for exhausting glass vessels, the combination of an air tight oven for containing the vessel to be exhausted, means for heating the vessel in said oven to about 500° C. and means for exhausting said oven during the exhaustion of said vessel.

16. In an apparatus for exhausting vessels, the combination of a chamber for containing a vessel to be exhausted, means for heating the vessel in said chamber, means for connecting the tubulature of said vessel to an exhaust pump, auxiliary heating means for heating the tubulature of said vessel at a point adjacent said vessel to produce a constriction in said tubulature, and means for exhausting said chamber during the exhaustion of said vessel.

17. In an apparatus for exhausting vessels, the combination of a chamber for containing the vessel to be exhausted, means for heating the vessel in said chamber, means for connecting the tubulature of said vessel to an exhaust pump, auxiliary heating means for heating a portion of the tubulature, means for drawing out said heated portion to produce a constriction in said tubulature, and means for exhausting said chamber.

In witness whereof, I have hereunto set my hand this 20th day of October, 1910.

IRVING LANGMUIR.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.