I. LANGMUIR.

VACUUM PUMP.

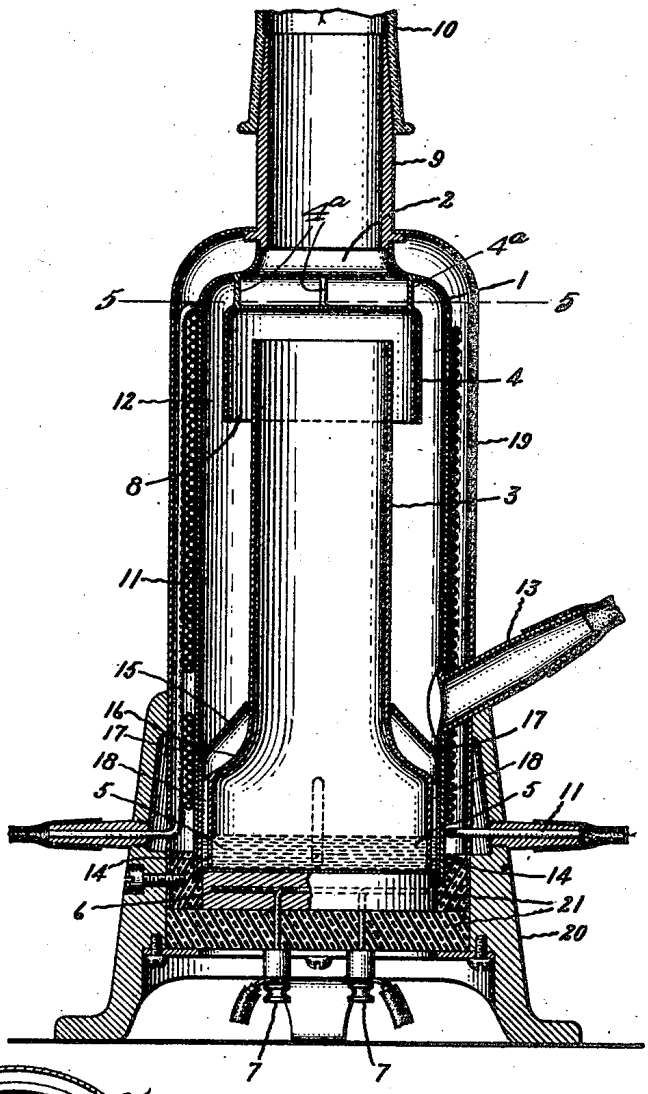
APPLICATION FILED AUG. 24, 1916.

1,320,874.

Patented Nov. 4, 1919.

2 SHEETS—SHEET 1.

Fig. 1.



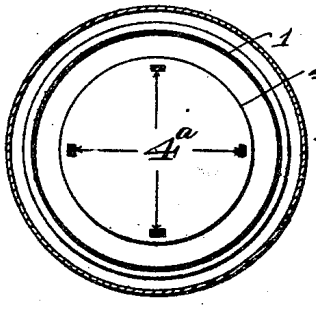


Fig. 5.

Inventor:
Irving Langmuir;
by Albert G. Davis
His Attorney

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2 SHEETS—SHEET 2.

Fig. 2.

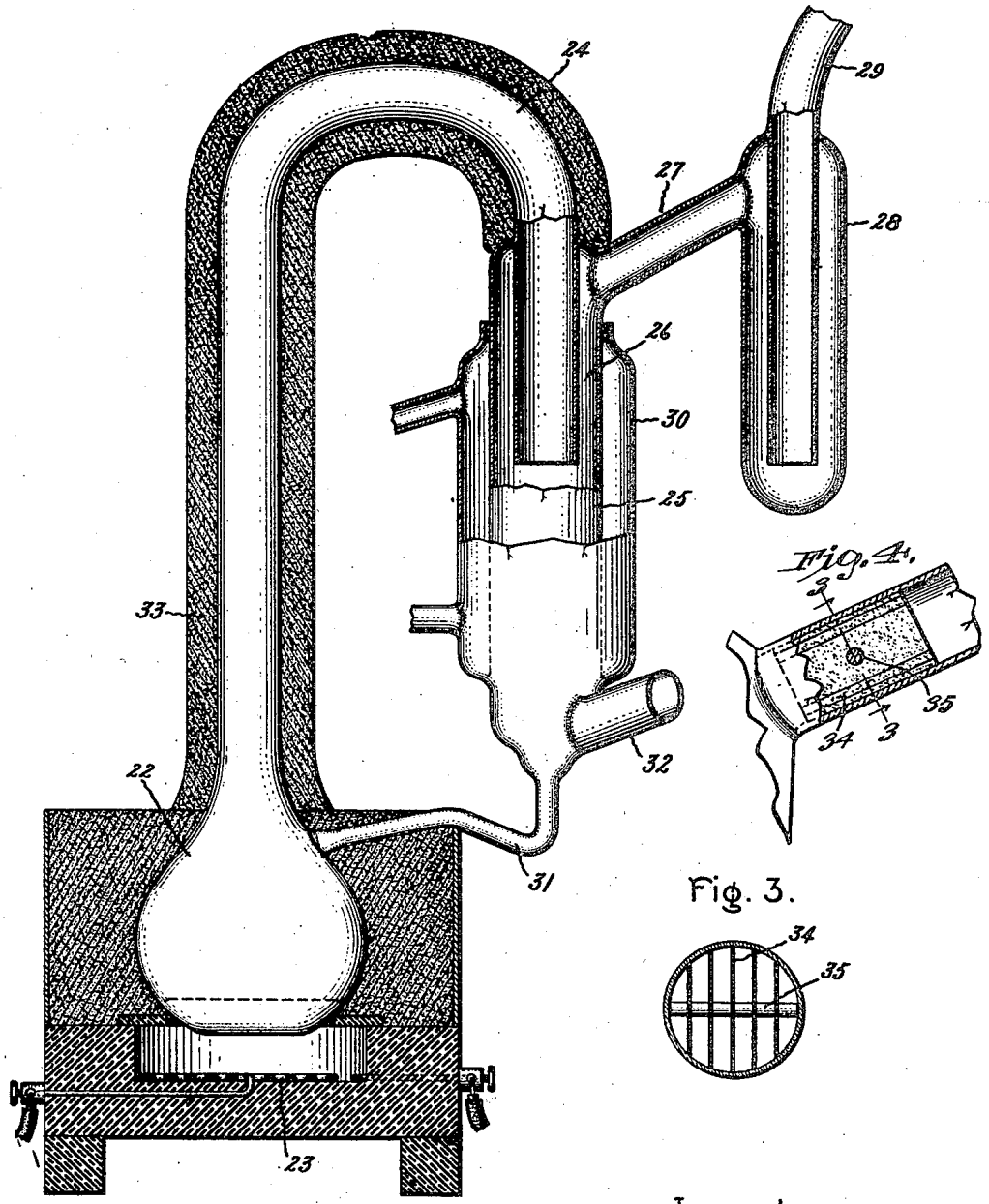

Fig. 4.

Fig. 3.

Inventor:
Irving Langmuir,
by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

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

VACUUM-PUMP.

1,320,874. Specification of Letters Patent. Patented Nov. 4, 1919.

Application filed August 24, 1916. Serial No. 116,624.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Vacuum-Pumps, of which the following is a specification.

My present invention relates to pumps for obtaining high vacua in inclosed receptacles such as bulbs for incandescent lamps, vapor rectifiers, X-ray tubes, electron discharge devices, etc., of the type described and claimed in my prior application, Serial No. 76,054, filed February 3, 1916.

The object of my invention is to provide improved forms of pumps of the type described in my prior application whereby the operation of such apparatus will be rendered more efficient. A further object of my invention is to simplify the construction of an apparatus of this nature.

The features of my invention which I consider novel are pointed out with particularity in the appended claims; the invention itself, however, both as to its organization and what I consider its probable method of operation will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figures 1 and 2 show partly in elevation and partly in section two modifications of my device, Fig. 3 shows a cross-sectional view and Fig. 4 a longitudinal section of a modified form of conduit connecting my device with the vessel which is to be exhausted and Fig. 5 is a cross sectional view on the line 5—5 of Fig. 1.

The pump indicated in Fig. 1 comprises a cylindrical metal vessel 1 contracted at the top to form a mouth 2. Within this vessel is located a tubular member or conduit 3 which is flared outwardly at the bottom so as to snugly fit the interior wall of the vessel 1. A cylindrical cap 4 is suspended by means of the supports 4^a from the mouth of the vessel 1 over the upper end of the conduit 3. The lower part of the vessel 1 contains mercury 5 and a heating coil 6 provided with terminals 7 may be utilized to vaporize the mercury and produce a blast of mercury vapor upwardly through the tube 3. This stream of mercury vapor is directed downwardly by the cap 4 through the annular space 8 between the tube 3 and the cap 4. A member 9 which is fitted by a gas-tight joint to the neck 2 of the vessel 1 furnishes a connection between the device and the neck 10 of the vessel which is to be exhausted. The mercury vapor when it emerges from the annular space 8 into the annular condensing chamber surrounding conduit 3 tends to flow outwardly and strike the wall of the vessel 1, which wall may be kept cooled by means of water circulating into the coiled pipe 11, surrounding the wall of the vessel 1 as indicated, and soldered thereto to provide a good heat conductive contact. The gas or vapor from the vessel 10 will pass through the annular conduit 12 which surrounds the cap 4, come in contact with the stream of mercury vapor at the lower end of that conduit, and be driven toward the lower part of the condensing chamber. It may be removed from the lower part of the condensing chamber by means of a pump connected thereto through tube 13. The mercury vapor will strike the cooled wall of vessel 1 and be condensed and thus be prevented from flowing toward the vessel which is being exhausted. All of the condensed mercury will fall to the bottom of the vessel 1 and will be returned through the openings 14 in the bottom of the tubular member 3 to the main body of mercury. A baffle 15 which is in good contact with the wall of the vessel 1, but which makes imperfect contact with the tubular member 3, is provided as shown in order that the falling mercury will not strike the heated surface at 16 of the tubular member and be reevaporated. This baffle will keep comparatively cool by reason of its good contact with the wall of vessel 1. Holes 17 around the periphery of this baffle will allow the mercury to flow down through the grooves 18 to the openings 14 and thus back to the main body of the mercury. The entire device may be inclosed in a casing 19 and be supported by a metallic base 20 from

which the parts which are heated may be separated by heat insulation members 21. It will be noted that with the construction herein shown the mercury which may be condensed upon the wall of the vessel 1 will fall to the bottom thereof away from the point where the passages 8 and 12 join. In the form of pump shown in my prior application the stream of mercury vapor is directed upwardly and part of the mercury which is condensed falls and is collected in a groove around the heated central conduit and at a point between where the two passages join and the vessel which is being exhausted. With this construction it is possible for some of the mercury to reëvaporate and flow toward the vessel which is being exhausted in opposition to the gas which is being removed. By the construction which I have described above this difficulty is overcome.

The form of my invention shown in Fig. 2 is similar in its operation to that shown in Fig. 1. In this case a bulb 22, which may be of glass, contains the mercury and the mercury vapor which is produced therein by means of a heating element 23, passes through the curved tube 24 into the condensing chamber 25. The annular space 26 between this tube and the condensing chamber communicates with the conduit 27, which in turn is connected to the trap 28 while another conduit 29 furnishes communication between this trap and the vessel to be exhausted. The walls of the condensing chamber 25 may be kept cooled by means of water circulating in jacket 30 surrounding the condensing chamber. The condensed mercury falls to the bottom of the condensing chamber and is returned to the bulb 22 through the tube 31. The conduit 32 communicates with any convenient form of exhaust pump which is capable of producing a vacuum somewhat lower than the vapor pressure of mercury at the temperature at which the bulb 22 is maintained. The bulb 22 and tube 24 may be covered with asbestos or other heat insulating material 33.

In the operation of a device of this character there will be a slight flow of mercury vapor through the conduit 27 to the trap 28 at a pressure about two microns, that is, a pressure corresponding to the vapor pressure of mercury at ordinary temperatures. By cooling the trap 28 with liquid air this vapor may be condensed therein. The gas which is being pumped out of the receptacle has to flow through conduit 27 in opposition to this stream of mercury vapor and the larger this conduit is made the greater will be the opposition offered by the mercury vapor to the flow of the stream of gas which is being removed. By sub-dividing the conduit through which the gas is removed, however, into a plurality of narrow passages, as, for example, by means of diaphragms 34, separated by spacing blocks 35, as indicated in Figs. 3 and 4, this difficulty may be overcome to a large extent since a large part of the pressure of the mercury vapor will be expended upon the walls of the passages instead of in opposing the flow of gas away from the receptacle.

While I have shown and described the preferred forms of my invention I do not wish to be limited to the particular forms described as it will be apparent that many modifications therein may be made without departing from the scope of my invention as set forth in the appended claims. I have described the operation of my pumps with mercury vapor as I find that this is especially suitable for operation at very low pressures. Its operation, however, does not depend upon the use of mercury as the necessary stream of vapor may be derived from other liquids.

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

1. An apparatus for obtaining a high vacuum in a closed receptacle comprising means for producing a stream of vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of vapor may flow downwardly into the condensing chamber, a second conduit connecting with the receptacle which is to be exhausted and the condensing chamber and means for preventing vapor from flowing through the second conduit toward the receptacle which is to be exhausted.

2. An apparatus for exhausting closed receptacles comprising means for producing a stream of mercury vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of mercury vapor flows downwardly into the condensing chamber, a second conduit communicating with the receptacle which is to be exhausted and with the condensing chamber, and means for preventing mercury vapor from flowing through the second conduit toward the receptacle which is to be exhausted.

3. An apparatus for exhausting closed receptacles comprising means for producing a stream of vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of vapor flows downwardly into the condensing chamber, a second conduit communicating with the receptacle which is to be exhausted and the condensing chamber, and means for condensing the vapor near the point where the second conduit joins the condensing chamber.

4. An apparatus for exhausting closed receptacles comprising means for producing

a stream of mercury vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of mercury vapor flows downwardly into the condensing chamber, a second conduit communicating with the receptacle which is to be exhausted and with the condensing chamber, and means for condensing the mercury vapor near the point where the second conduit connects with the condensing chamber in such a way as to prevent mercury vapor from flowing from the condensing chamber into the second conduit.

5. An apparatus for removing gas or vapor from a receptacle comprising means for producing a stream of vapor, said apparatus being arranged to form a condensing chamber, a conduit through which a stream of vapor flows downwardly into the condensing chamber, a second conduit communicating with the receptacle from which the gas or vapor is to be removed, and opening downwardly into the condensing chamber, and means for cooling the wall of the condensing chamber near the point where it communicates with the second conduit.

6. An apparatus for exhausting closed receptacles comprising means for producing a stream of mercury vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of mercury vapor flows downwardly into the condensing chamber, a second conduit communicating with the receptacle which is to be exhausted and which also opens downwardly into the condensing chamber, and means for preventing the mercury vapor from flowing through the second conduit toward the receptacle which is to be exhausted.

7. An apparatus for exhausting closed receptacles comprising means for producing a stream of mercury vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of mercury vapor flows downwardly into the condensing chamber, an annular conduit surrounding the first conduit and providing communication between the receptacle which is to be exhausted and the condensing chamber, and means for preventing mercury from flowing through said annular conduit into the vessel which is to be exhausted.

8. An apparatus for exhausting closed receptacles comprising a vessel adapted to contain mercury, means for heating the lower part of said vessel to vaporize the mercury, a conduit through which the stream of mercury vapor thus produced is directed downwardly into a portion of the apparatus arranged to form a condensing chamber, a second annular conduit surrounding the first conduit and furnishing communication between the vessel which is to be exhausted and the condensing chamber, and means for cooling the wall of the condensing chamber near the point where it communicates with the second conduit.

9. An apparatus for exhausting closed receptacles comprising means for producing a stream of mercury vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of mercury vapor flows to the condensing chamber, a second conduit communicating with the receptacle to be exhausted and the condensing chamber, means for preventing mercury vapor from flowing through the second conduit toward the receptacle which is to be exhausted and a conduit through which gas may be removed from the condensing chamber, the whole being so arranged that the mercury condensed in the condensing chamber will tend to move away from the conduit which communicates with the receptacle to be exhausted.

10. An apparatus for exhausting closed receptacles comprising means for producing a stream of vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of vapor flows to the condensing chamber, a second conduit communicating with the receptacle to be exhausted and the condensing chamber, means for preventing the vapor from flowing through the second conduit toward the receptacle which is to be exhausted and a conduit through which gas may be removed from the condensing chamber, the whole being so arranged that the vapor condensed in the condensing chamber will tend to move away from the conduit which communicates with the receptacle to be exhausted and toward the conduit through which gas may be removed.

11. An apparatus for exhausting closed receptacles comprising means for producing a stream of mercury vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of mercury vapor flows to the condensing chamber, a second conduit communicating with the receptacle which is to be exhausted and with the condensing chamber, means for condensing the mercury vapor near the point where the second conduit joins the condensing chamber and a third conduit through which gas may be removed from the condensing chamber, the whole being so arranged that the condensed mercury will tend to move away from the second conduit and toward the third conduit.

12. An apparatus for exhausting closed receptacles comprising means for producing a stream of vapor, said apparatus being arranged to form a condensing chamber, a conduit through which the stream of vapor flows to the condensing chamber, a second

conduit communicating with the receptacle which is to be exhausted and with the condensing chamber, said second conduit throughout a portion of its length being sub-divided into a plurality of narrow passages and means for preventing vapor from flowing through the second conduit toward the vessel which is being exhausted.

13. An apparatus comprising a conduit through which a stream of vapor tends to flow in opposition to a stream of gas, said conduit being divided into a plurality of small passages in order to minimize the opposition offered by the vapor to the gas.

In witness whereof, I have hereunto set my hand this 23rd day of August, 1916.

IRVING LANGMUIR.

Witness:
BENJAMIN B. HULL.