July 15, 1924. 1,501,070

H. C. SNOOK

VACUUM PUMP

Filed Aug. 24, 1920

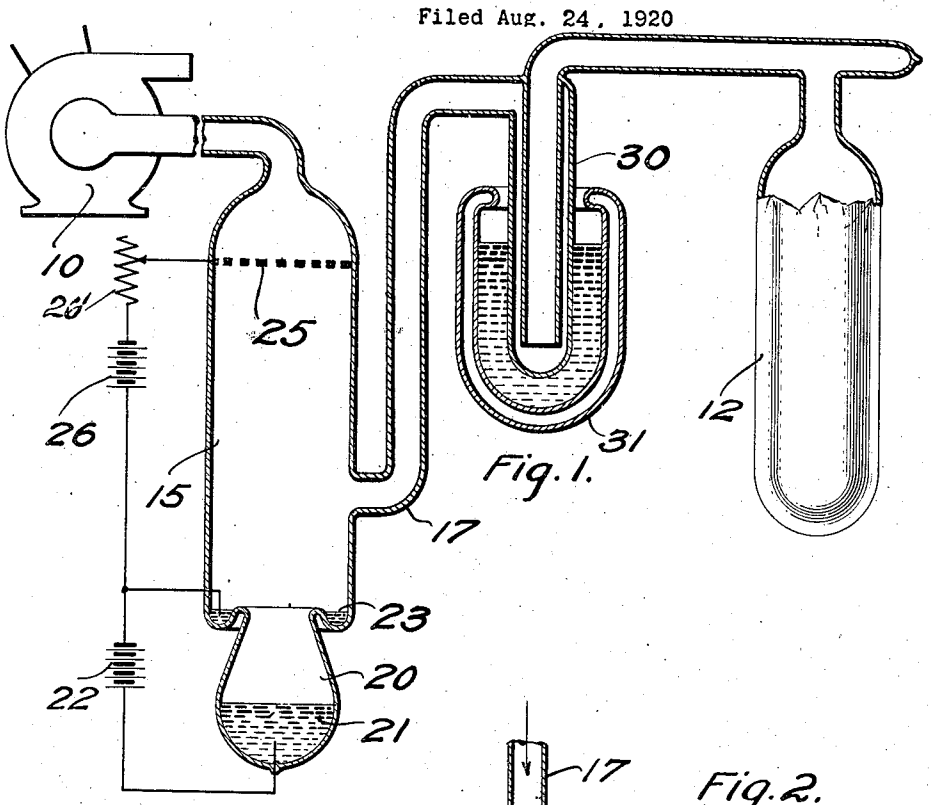


Fig. 1.

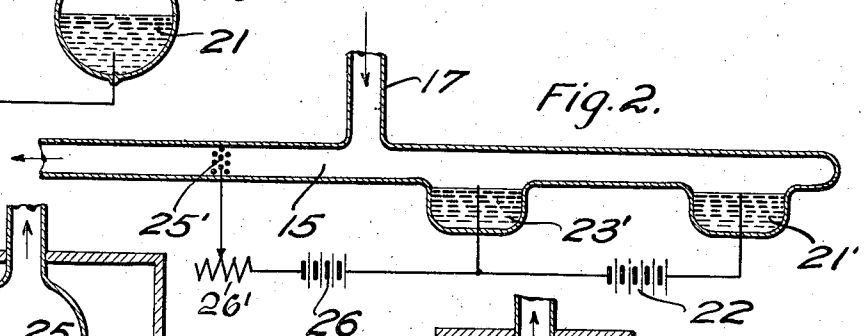


Fig. 2.

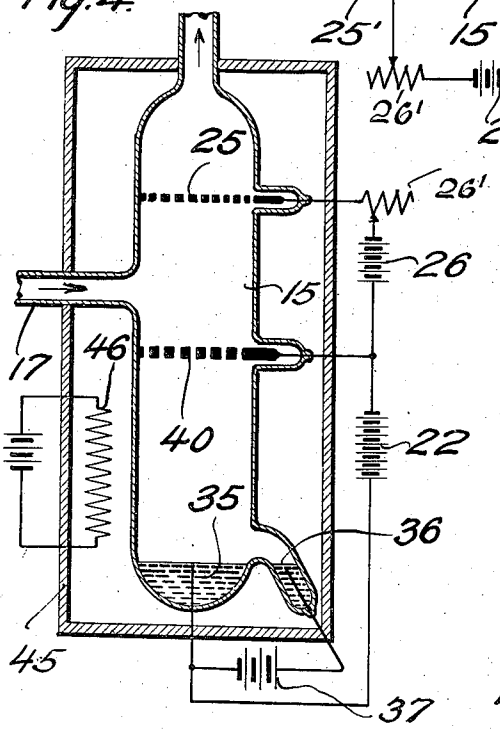


Fig. 4.

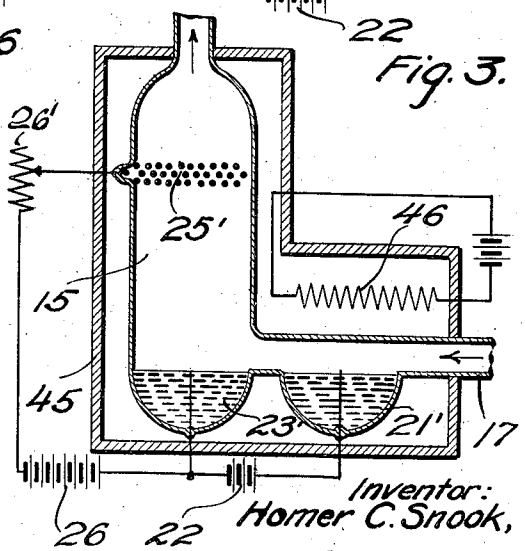


Fig. 3.

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UNITED STATES PATENT OFFICE.

HOMER C. SNOOK, OF SOUTH ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

VACUUM PUMP.

Application filed August 24, 1920. Serial No. 405,621.

To all whom it may concern:

Be it known that I, HOMER C. SNOOK, a citizen of the United States, residing at South Orange, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Vacuum Pumps, of which the following is a full, clear, concise, and exact description.

This invention relates to vacuum pumps of the entraining or aspirator type and to methods of operating the same.

In the production of the high vacua employed in vacuum tubes of the pure electron discharge type, it heretofore has been customary to connect a tube to be evacuated to a low vacuum pump, for example, a mechanical pump capable of pumping out to a pressure of 10^{-3} mm. of mercury and to produce a higher vacuum by the use of an aspirator employing mercury vapor connected between the low vacuum or roughing pump and the device being exhausted. An example of apparatus of this kind is disclosed in the application of O. E. Buckley, Serial No. 96,265, filed May 8, 1916. In pumping systems of this type the flow of vapor through the aspirator is caused by a difference of pressure between the chamber in which the vapor is evolved and the passage leading to the preliminary pump. In the flow of a gaseous medium through a passage, not all of the particles move in the direction of the axis of the tube, and it has been customary to provide special means for removing from the stream those particles which are moving transversely to the desired direction or for otherwise controlling the stream so that there will be no appreciable back flow of pumping medium in the passage leading from the container being evacuated.

The object of this invention is an improved means and method for producing and controlling the direction and velocity of a stream of particles for use in pumping.

The invention provides for ionizing a gaseous or vaporous pumping medium by means of an electron discharge, controlling the flow of the electrically charged particles through electrical forces, and utilizing the electrically charged particles for entraining gas to be removed from a vessel. According to the invention advantage is taken of the fact that on the average the mass of the positively charged particles is much greater than that of the negatively charged particles. Some of the positively charged particles are permitted to be carried by their inertia beyond the discharge path. These similarly charged particles are then subjected to a second electric field and made to do the work of entraining the gas from the devices to be evacuated.

The pumping medium is preferably a substance which will condense at the temperature of the aspirator passage at its termination so that the medium may be recovered and returned to the main body of material. It may, for example, be a substance like mercury which liquefies at room temperatures, or it may be a substance like tin, lead, cadmium or zinc which liquefy or solidify at temperatures considerably above room temperatures. It is of advantage to employ a substance like those last mentioned, which at condensing temperatures has a vapor pressure less than the pressure to be obtained in the container being evacuated.

The invention resides further in the details of apparatus and operation pointed out in the following description and claims taken in connection with the accompanying drawings, in which Fig. 1 is a diagrammatic view showing one form of apparatus employing the invention, and Figs. 2, 3 and 4 are similar views showing modifications.

Referring to the drawings by reference numerals, the primary or roughing pump 10 is connected to the bulb 12 which is to be evacuated by a system of tubing which comprises an aspirator passage 15 and a passage 17 leading from bulb 12 and entering the passage 15 at an angle as shown. At the lower part of passage 15 is a chamber 20 which may contain a suitable pumping medium such as mercury shown at 21. An annular chamber 23 above chamber 20 is also filled with mercury. A source of electromotive force 22 is connected between the bodies of mercury in chambers 23 and 20 and is so poled that the annular body of mercury in chamber 23 may serve as a cathode for an electric discharge between the two electrodes. Any suitable means (not shown) may be employed for starting the discharge.

Some of the positively charged particles traveling in the direction of cathode 23 are carried by their momentum into the pas-

sage 15. A grid-like cathode 25 at the upper end of the passage 15 is connected through a source of potential 26 to the circuit comprising the first mentioned electrodes. The field between electrodes 25 and 23 causes the charged particles which have entered passage 15 to move toward electrode 25 at a velocity which may be controlled by varying the potential applied between the electrodes 23 and 25 through the medium of the variable resistance 26'. The flow of charged particles through passage 15 serves to entrain gas coming from passage 17 and bulb 12 in a manner similar to the mercury vapor methods previously employed.

In case mercury or some substance having a vapor pressure at room temperatures higher than the pressure desired in bulb 12 is employed as a pumping medium, a trap 30 may be inserted between passage 15 and bulb 12, and trap 30 may be surrounded by a container of liquid air 31. This prevents the mercury vapor from reaching bulb 12.

In Fig. 2 is shown an arrangement in which the operation is similar to that of Fig. 1, but in which the electrodes 23' and 21', corresponding to electrodes 23 and 21, are arranged in a horizontal plane. The electrode 25' differs from electrode 25 in that it comprises a plurality of grid-like surfaces.

In Figs. 3 and 4 are shown arrangements adapted to use as a pumping medium a metal such as tin, cadmium, lithium, bismuth, elurium, lead, thalium, etc., which are solid at ordinary temperatures. The aspirator tube is shown surrounded by an oven 45 having an electric heater 46 adapted to raise the temperature of the pumping medium above its melting point. While in the drawings the oven is shown enclosing the whole of passage 15 and associated parts, it may sometimes be desirable to enclose only the chambers containing the pumping fluid.

Fig. 3 further differs from Fig. 2 in that the ionized discharge between electrodes 23' and 21' is included in the passage between passage 15 and passage 17. While in this discharge ions are passing in both directions, positively charged particles moving in the direction of passage 15 have a greater kinetic energy than the negatively charged particles. This discharge may therefore aid in the evacuation process.

In Fig. 4, electrodes 35 and 36 are connected through battery 37, and an arc discharge is maintained therebetween for the purpose of vaporizing the pumping medium. An ionized discharge then takes place between electrode 35 and electrode 40 which may or may not have the characteristics of an arc discharge. Electrode 40 is grid-like in form to permit the passage of positively charged carriers through the openings thereof and the flow of positively charged bodies between electrodes 40 and 25 is similar to that described above in connection with Fig. 1.

While various equivalents in materials, apparatus, and modes of procedure have been described, it is to be understood that the invention is generic in certain of its aspects and embraces other equivalents within the scope of the appended claims.

What is claimed is:

1. The method of pumping which comprises vaporizing a pumping medium and producing a flow of particles of said medium in response to an electric field applied thereto.

2. The method of operating a pump having an opening thereinto from a container to be evacuated, which comprises vaporizing a pumping medium and subjecting said medium to an electric field applied transversely to said opening.

3. The method of operating a pump having an opening thereinto from a container to be evacuated which comprises vaporizing a pumping medium, ionizing said vaporized medium and causing a flow of charged particles adjacent said opening.

4. The method of operating a pump having an opening thereinto from a container to be evacuated, which comprises ionizing a substance other than the gas to be removed and projecting particles of said substance across said opening.

5. The method of operating a pump having an opening thereinto from a container to be evacuated, which comprises ionizing a substance and projecting similarly charged particles of said substance across said opening to the exclusion of oppositely charged particles.

6. The method of operating a pump having an opening thereinto from a container to be evacuated, which comprises ionizing a substance and projecting positively charged particles of said substance across said opening to the exclusion of negatively charged particles.

7. The method of operating a pump having an opening thereinto from a container to be evacuated, which comprises producing an ionized discharge, projecting particles from said discharge across said opening, and controlling the velocity of said particles by an electric field.

8. The method of operating a pump having an opening thereinto from a container to be evacuated, which comprises producing an ionized discharge, projecting positively charged particles from said discharge across said opening, and controlling the velocity of said particles by an electric field.

9. The method of evacuating, which comprises creating a partial vacuum in a container and a passage leading therefrom, ionizing a pumping medium other than the

gas to be removed, and projecting particles of said pumping medium through said passage in response to an electric field in said passage to withdraw the residual gas from said container.

10. The method of evacuating, which comprises creating a partial vacuum in a container and a passage leading therefrom, ionizing a pumping medium other than the gas to be removed, and projecting particles of said pumping medium through said passage in response to an electric space current in said passage to withdraw the residual gas from said container.

11. A vacuum pump comprising a passage, an opening thereinto from a container to be evacuated, a supply of pumping medium, means for vaporizing said pumping medium, and electrical means for projecting particles of said medium across said opening.

12. A vacuum pump comprising a passage, an opening thereinto from a container to be evacuated, a supply of pumping medium, means for vaporizing said pumping medium, and means for producing an electric space current adjacent said opening.

13. In an evacuating system, a container to be evacuated, a space adapted to contain a gaseous pumping medium, means for ionizing said medium, and means for projecting charged particles therefrom in a direction to assist in the evacuation of said container.

14. In an evacuating system, a passage adapted to be connected to a container to be evacuated and to a pump, a supply of pumping medium, means for vaporizing said pumping medium, and means for producing a flow of charged particles of said medium in said passage in the direction of said pump.

15. In an evacuating system, a passage adapted to be connected to a container to be evacuated, a supply of pumping medium, means for ionizing said pumping medium, and means for producing a flow of charged particles of said pumping medium in said passage.

16. In an evacuating system, a passage adapted to be connected to a container to be evacuated and to a pump, electrodes spaced apart in said passage and adapted to be supplied with a difference of potential, a source of pumping medium and means for vaporizing said pumping medium.

17. In an evacuating system, a passage adapted to be connected to a container to be evacuated and to a pump, electrodes spaced apart in said passage and adapted to be supplied with a difference of potential, the electrode nearest said pump being grid-like in form.

18. In an evacuating system, a passage having an opening thereinto from a container to be evacuated, a vaporizable substance adjacent said passage, means for vaporizing and ionizing said substance and means for producing a flow of ionized particles thereof adjacent said opening.

19. In an evacuating system, a passage having an opening thereinto from a container to be evacuated, a vaporizable substance adjacent said passage, means for producing a flow of positively charged particles thereof adjacent said opening.

20. In an evacuating system, a cathode and an anode and means for producing a gaseous discharge therebetween, one of said electrodes having an opening to permit the passage therethrough of similarly charged particles, a third electrode, and means for producing a flow of said particles to said third electrode.

21. In an evacuating system, a cathode and an anode and means for producing a gaseous discharge therebetween, said cathode having an opening to permit the passage therethrough of positively charged particles, a third electrode, and means for producing a flow of said particles to said third electrode.

22. In a vacuum pump, a container of insulating material, a plurality of puddles of pumping medium in said container, electrical connections whereby an arc may be established between said puddles to cause the flow of charged particles, and electrical means for controlling the direction of flow of said particles.

23. In a vacuum pump, a container of insulating material, a plurality of puddles of pumping medium in said container, a source of electrical energy, circuit connections between said puddles and said source to produce an arc for causing the flow of charged particles, and electrical means for controlling the direction of flow of said particles.

24. In a vacuum pump, a central puddle of pumping material, an annular puddle of pumping material coaxial with said central puddle, a source of electrical energy and connections between said puddles and said source.

25. In combination, a containing vessel, an anode in said vessel, an annular cathode coaxial with said anode and means for connecting said electrodes with a source of electrical energy.

In witness whereof, I hereunto subscribe my name this 19th day of August A. D., 1920.

HOMER C. SNOOK.