

July 14, 1942.

C. V. LITTON

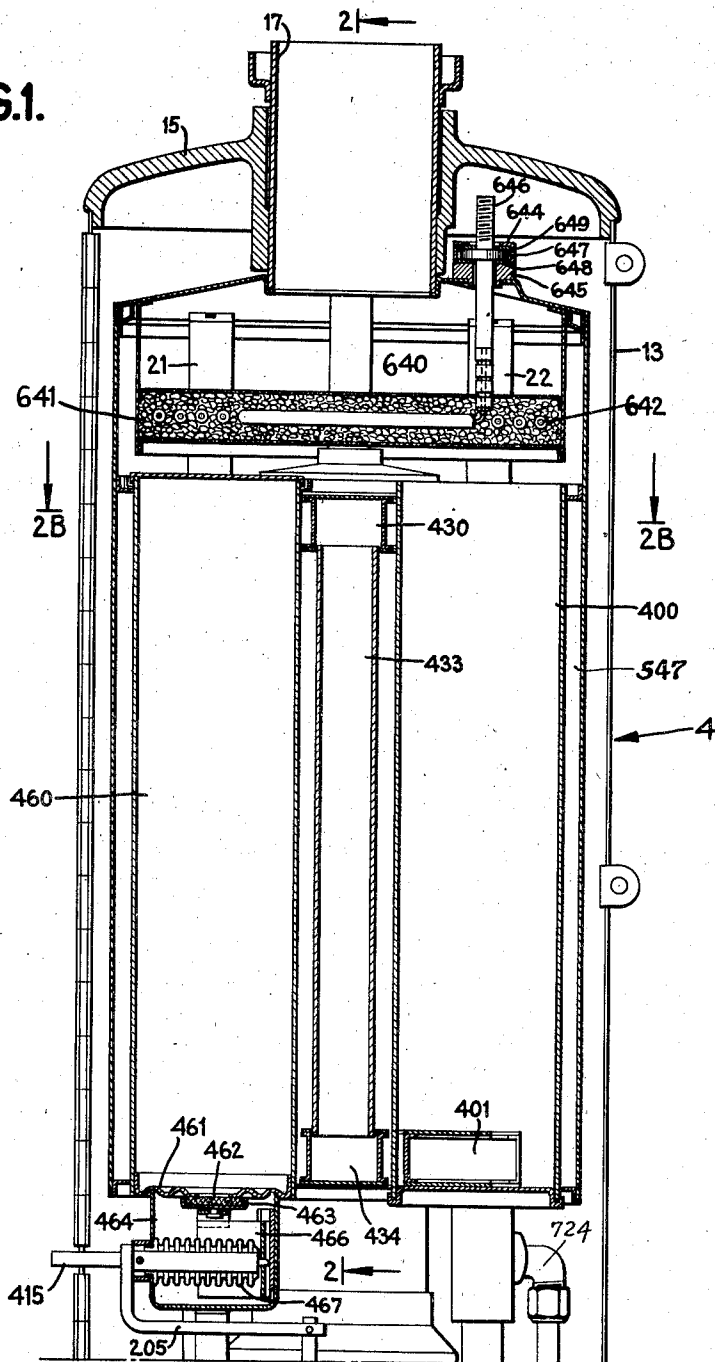
2,289,845

HIGH VACUUM PUMP

Filed Jan. 12, 1939

7 Sheets-Sheet 1

FIG. 1.



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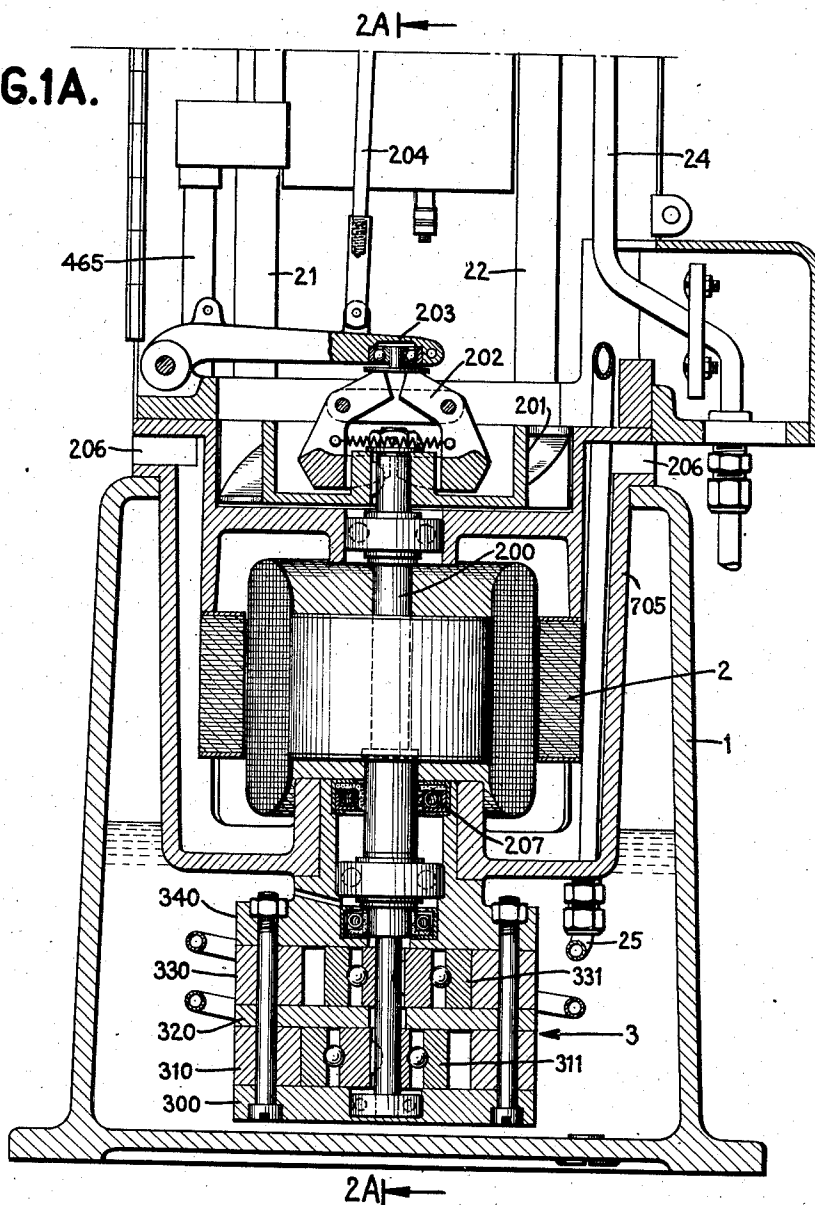
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FIG. 1A.



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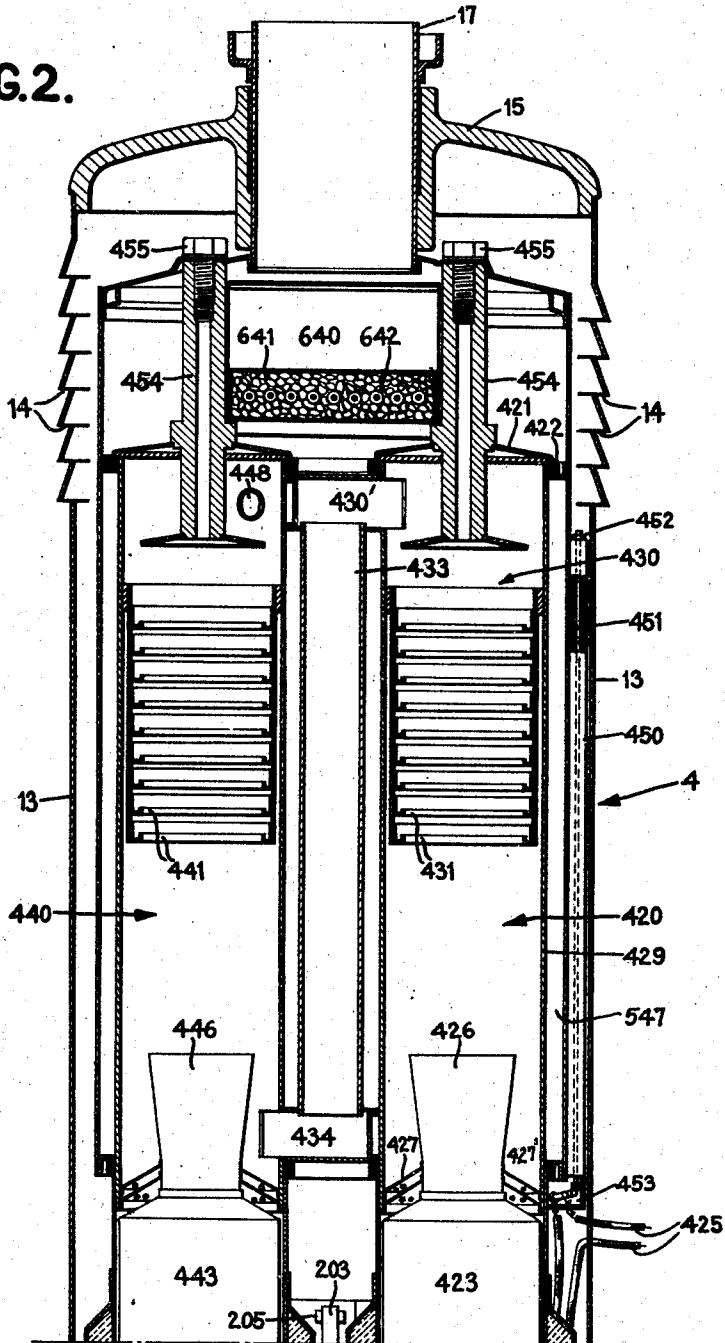
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HIGH VACUUM PUMP

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7 Sheets-Sheet 3

FIG.2.



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FIG.2A.

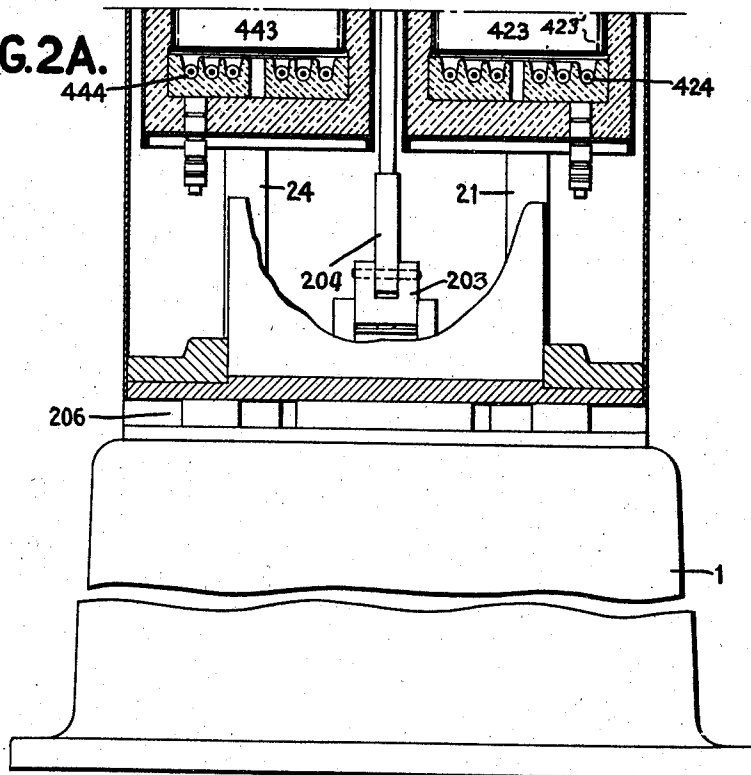
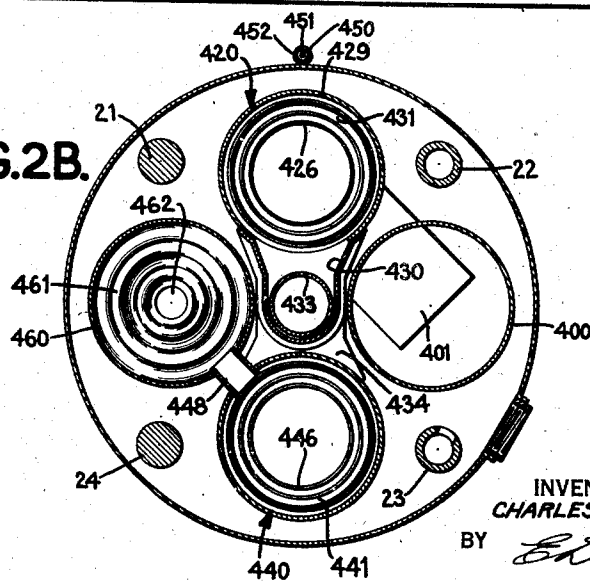


FIG.2B.



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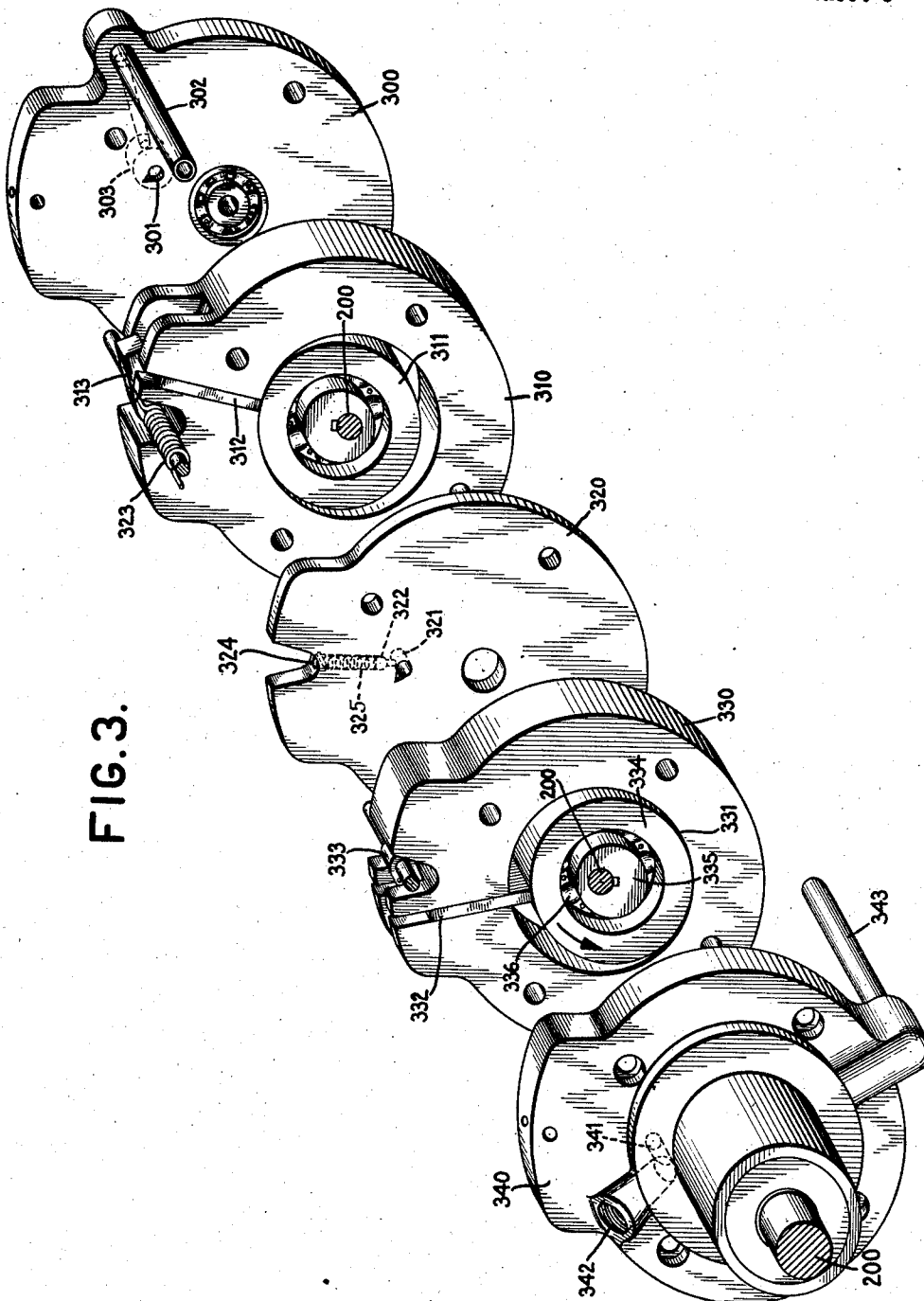
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HIGH VACUUM PUMP

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7 Sheets-Sheet 5

FIG. 3.



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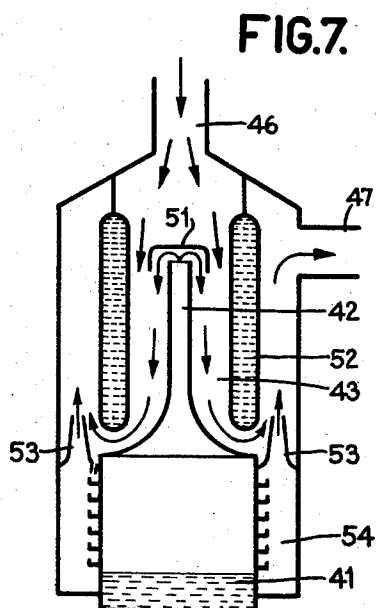
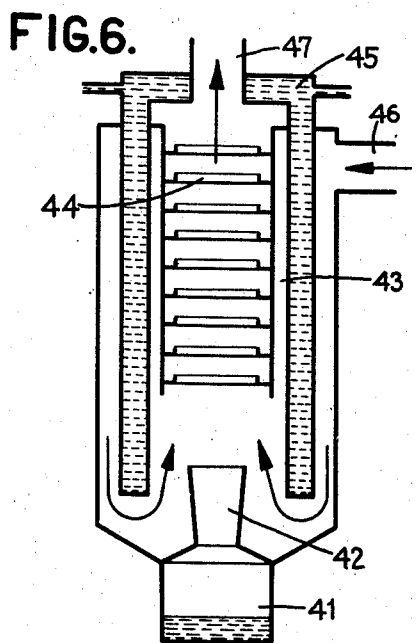
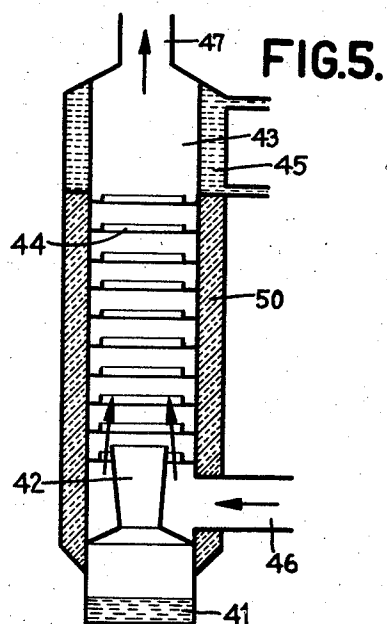
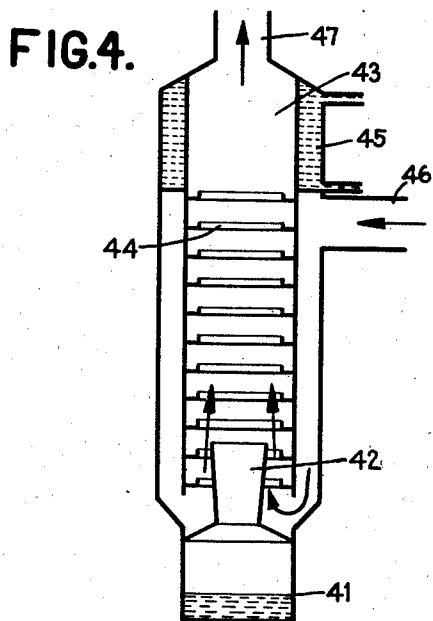
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HIGH VACUUM PUMP

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7 Sheets-Sheet 6



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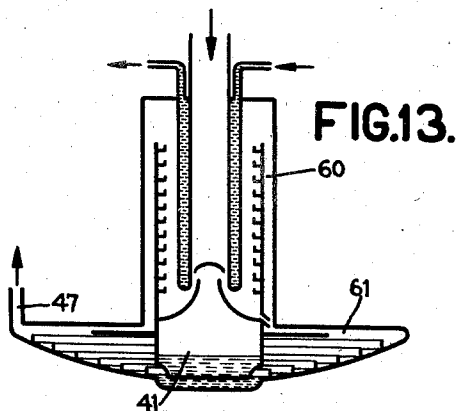
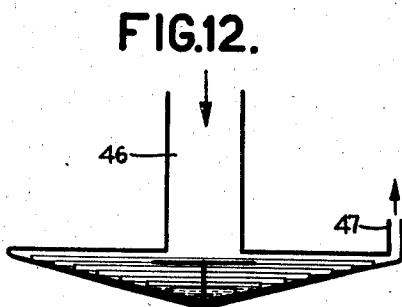
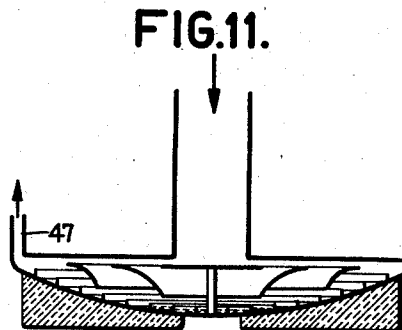
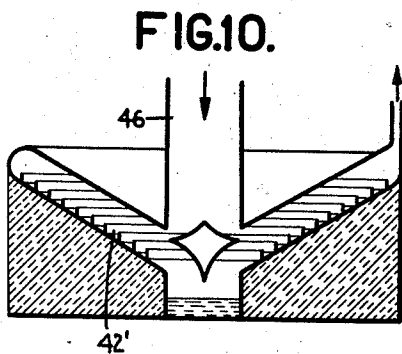
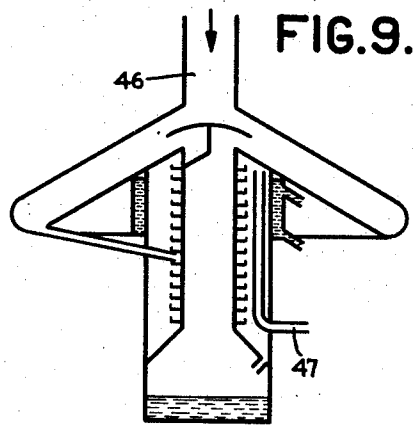
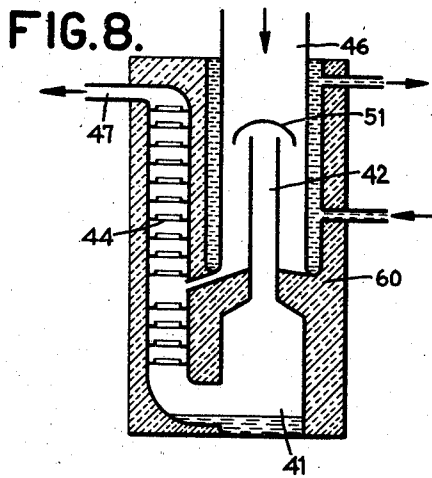
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HIGH VACUUM PUMP

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7 Sheets-Sheet 7



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UNITED STATES PATENT OFFICE

2,289,845

HIGH VACUUM PUMP

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Application January 12, 1939, Serial No. 250,470

6 Claims. (Cl. 230—101)

This invention relates to vacuum pumps and more particularly to a vacuum pump assembly comprising a vapor pump working in tandem with a mechanical vacuum pump.

My invention in its most comprehensive form features basically a vapor pump unit which may comprise one stage or two or more stages connected in series. This output of low vacuum stage of the vapor pump may be connected by a tube or pipe with the input of a rotary mechanical pump, which may consist of two rotor pump stages operated by an electric motor. The vapor pump comprises a vaporizing unit, together with vapor condensing chambers, into which is connected a connecting means from a vessel which is to be evacuated. The gas drawn from the vessel to be evacuated passes through the vapor pump and therefrom to the input of the mechanical pump. The mechanical pump comprises preferably a two-stage rotary pump, the pump being immersed in a reservoir containing sufficient oil to completely cover the mechanical parts of the pump. A valve is interposed in the tube interconnecting the vapor pump and the mechanical pump, and controlled by the operation of the latter to close the high vacuum vapor system from the mechanical pump at all times when the mechanical pumping motor is not running.

It is a principal object of my invention to provide a high vacuum pump which is compact in size and efficient in operation.

It is a further object of my invention to provide a vacuum pump arrangement in which an extremely high vacuum may be attained by use of tandem connected vapor and mechanical pump elements.

It is a still further object of my invention to provide a two-stage rotary mechanical pump compact in size and capable of operating at very high speed.

It is a further object of my invention to provide a two-stage rotary pump operating immersed in oil, in which the air or gas outlet for the pumping unit is so disposed as to minimize the absorption of air in the immersing oil.

It is a still further object of my invention to provide a rotary mechanical vacuum pump operating under oil connected in tandem with a high vacuum vapor pump, and provided with means for completely separating the vapor pump arrangement from the mechanical pump when the speed of the mechanical rotary pump is below a certain fixed level.

It is a still further object of my invention to

provide a vapor pump for cooperation with a mechanical pump in which the valve for closing the connection between these two pumps is operated by an arrangement connected through a metal bellows, e. g. a "Sylphon" bellows, so that the system may be maintained airtight.

It is a still further object of my invention to provide an oil operated vapor pump in which the oil vapor condenser unit comprises a fractionating arrangement.

It is a still further object of my invention to provide an oil vapor operated vapor pump in which the metal comprising the vapor boiler and nozzle are of such a material as to enhance the operation of the system.

It is a still further object of my invention to provide in a vapor vacuum pump a suitable charcoal trap having a heating element which may be used to de-gas the charcoal trap when necessary.

Other objects and advantages of my invention will become clear from a reading of the specific description of my invention given with reference to the accompanying drawings, in which

Figs. 1 and 1A show a cross-sectional view of a particular embodiment of my invention illustrating a two-stage vapor pump connected in tandem with a two-stage rotary mechanical pump.

Figs. 2 and 2A show a view partly in section taken at right angles to the showing of Fig. 1.

Fig. 2B is a section on the line 2B—2B of Fig. 1.

Fig. 3 is an exploded view of the mechanical pump shown in Fig. 1.

Figs. 4 to 7 illustrate diagrammatically other forms of a vapor pump in accordance with the principles of my invention, and

Figs. 8 to 13 illustrate still other forms of vapor pumps and fractionating arrangements in accordance with my invention.

Turning now to the drawings, I will first describe a preferred embodiment of my invention comprising the pump assembly unit illustrated in Figs. 1, 1A, 2, 2A, 2B and 3 of the drawings. In these figures is shown a supporting base 1 which houses the electric motor 2 and the mechanical pump, indicated generally at 3, and serves as a support for the vapor pump, indicated generally at 4, and the control element for interconnecting the vapor pump and the mechanical pump. The supporting base 1 also serves as an oil reservoir for the mechanical pump, the oil being generally maintained at a level as indicated in Fig. 1, above the level of the

mechanical pump element but below the level of the electric motor. The vapor pump may use any desired medium, but is generally designed to operate on oil or other volatile hydro-carbon compound.

The whole vapor pump assembly is enclosed in a cylindrical housing 13 provided with a series of louvers 14 at its uppermost end which serves to keep dust and dirt out of parts of the equipment and to control the draft of air therein. The vapor pump assembly is mounted by means of four supports, two of which, 21, 22, can be seen in Figs. 1 and 2B, and in which supports 21, 22, 23 and 24 may be seen in Fig. 1A. At the center of lid 15 hinged to the cover 13, is provided tube 17. This tube is open at both ends and the outer end may serve as a connection between the pump and any apparatus that is to be evacuated. The lower end of tube 17 opens into a chamber 640 which communicates directly with the open ended tubular member 400. Tubular member 400, as well as the vapor pump condensing chambers of pump assemblies 420, 440 and the tubular member 460 connected to the exhaust port for the vapor pump, are surrounded by a water jacket 547 which, however, is closed from communication with the open chamber 640. The water may be introduced to this chamber through two of the supporting rods, such as 22, 23. The water after circulating through the upper condensing chamber may be withdrawn by means of pipe 724 and circulated through pipe 25, 26, so as to serve to cool the oil surrounding the mechanical pump.

The air or other gas entering through 17, after passing down to tubular member 400, is discharged through the opening 401 into the first stage of the vapor pump assembly 420. It is possible that some oil vapor from the pump chamber 420 may escape through opening 401 back into the air stream and up to tube 17. This backing up of the oil vapor tends to cause a deposit of oil on the elements of a vacuum tube or other apparatus being evacuated at such time as the pump is not operating. One feature of the vapor pump in accordance with my invention tends to greatly minimize this condition.

Since the tubular member 400 is surrounded by the cooling water, most of the vapor escaping into tube 400 will be immediately condensed and will, therefore, be taken from any air stream. However, in order to further minimize the opportunity of any oil to escape back, I provide a trap member 641 across the opening of tube 17. This trap need be only of sufficient size to cover approximately one-half the area of the input chamber 640. This trap or cell comprises a casing preferably of mesh, filled with charcoal, which extends completely over the open end of tube 400, so that any oil escaping from tube 400 must first traverse the charcoal where it is adsorbed and removed from the gas. By making this trap cover only approximately one-half of the area of the opening the pumping speed is increased since the gas molecules do not all have to traverse through the trap by random molecular movement, as is the case when the trap is made to completely cover the opening. However, by the arrangement practically every molecule of the oil or other pumping medium which traverses backward through tube 400, strikes the charcoal and is adsorbed. Thus the device is as effective, from a standpoint of a vapor condensation, as if it covered the entire area, whereas the resistance

to incoming molecules of gas is materially reduced.

Within the charcoal trap element I provide a heating element 642. The heating element is preferably designed so as to attain a temperature of about 500° C. when 20 volts is applied across the terminals. This temperature is sufficiently high to completely out-gas the trap. Also, I provide means so that the initial potential applied to the heating element is under 25 volts, since if a higher temperature is used, serious ionization may occur which may destroy the heater unit.

This charcoal trap has been found to be capable of adsorbing all the vapors of a pumping medium for a period of at least thirty-four days, and in all probability is effective for an even greater period. At the end of this time heating may be effected to drive out all the gas, after which the trap is ready for another period. The tube need not be disconnected from the circuit during this procedure but is merely deenergized for the period of de-gassing.

Although it is not necessary to use this charcoal cell with the pump in accordance with my invention, I have found that by using this cell in conjunction with my high vacuum pump, a vacuum as low as 10^{-8} mm. of Hg may be obtained, whereas without the use of this trap the vacuum obtained was 10^{-7} mm. of Hg.

The charcoal heater element requires one lead-in bushing to carry the current. The return circuit may be made to the wall of the container. The lead-in bushing as shown, may be made without the use of metal glass seals. This bushing comprises a steel block 645 through which the leading-in rod 646 provided with a flange 647 is provided. On the bottom portion of block 645 is placed a mica disc 648, and above the flange is placed another mica disc 649. The whole unit is then compressed so that the inturned edges 644 serve to firmly hold the mica unit assembly in position. The upper part of this arrangement may then be filled with suitable varnish and whole assembly baked. This forms an air tight seal which is considerably stronger than a glass seal and will stand considerable temperature.

Returning now to the description of the pump, the vapor pump assembly 420 comprises the tube 429 mounted within the water jacket 547. This assembly is preferably of steel brazed together so that all the essential parts are welded as a unit. The open ends are then covered with lids or caps 421, which are preferably fastened in place by means of a cup-type solder joint 422. These cup-type solder joints are preferably used in connecting together all of the essential parts of the apparatus since they form an effective vacuum type seal and may be readily disconnected by merely heating the element sufficiently to melt the solder. The retaining cup holds the melted solder so that the joint may be readily reestablished.

In order to more fully seal the members, the elements are preferably coated with a metal such as copper on all the surfaces and the whole assembly is then thoroughly tinned. This tinning will serve not only to insure the vacuum tight seal, but also will prevent rust. However, if desired the whole assembly may be made of some corrosive resistant material such as chromium steel.

At the bottom end of tube 429, I provide a boiler 423. This boiler is heated by means of a heating unit 424, which is connected by means of leads 425 to a supply source, not shown. Within

the boiler 423 and fastened thereto is a nozzle 426. About the nozzle are provided a plurality of flanges 427 serving as baffles, these flanges are spot-welded or otherwise fastened to the nozzle, and are provided with small perforations 427' which will permit the return of oil to the outside of boiler 423 and thence through suitable openings 423' into the interior thereof. The perforations or holes 427' provided in the baffles 427 should be sufficiently small so that the returning oil or other medium will form substantially a gas-tight seal, to prevent gas being drawn there-through into the boiler.

The nozzle assembly is preferably made of stainless steel of very high chromium content, as it has been found that this material is very good for this purpose. Many of the metals, for example copper, exhibit a property similar to catalytic action which promotes decomposition of a hydrocarbon pumping medium. It is therefore necessary to avoid the use of copper or copper bearing alloys in the boiler and the nozzle structure. I have found that metals containing a high percentage of chromium exercise a beneficial action in this respect, in that they do not have any catalytic effect but for some reason have the property of collecting and eliminating from the liquid of the boiler, the tarry residues which normally form after extended use, and for this reason when this metal is used the medium remains clear and colorless. The steel used in my experiment was stainless steel made of 20% chromium iron. It is clear, however, that considerable departure from this precise percentage may occur without sacrifice of the beneficial effect. I have found no other metals which exhibit this effect. Even glass, which is a rather inert material does not act in this way. The extraction of these tarry substances is advantageous, because the boiling point of the liquid medium in the boiler then remains constant instead of increasing, as it does if these tarry residues are permitted to accumulate.

The high vacuum inlet 401 to pump 420 is arranged at a point below the opening of the nozzle 426. When the oils in the boiler 423 are vaporized by heating, the vapors are expelled into 429, and tend to condense therein due to the cooling effect of the water jacket. The vacuum in chamber 429, forms a thermal insulation about the tubular member 430 which constitutes a fractionating column or tower which is spaced from the walls of 429. This insulation produces a uniform temperature gradient in 430 ranging from a high temperature at its lower end to a low temperature at its upper or exhaust end. The oils having a low vapor pressure, tend to condense at a higher temperature than the lighter oils of higher vapor pressure and return to the boiler. The other oils of higher vapor pressure tend to condense at points in column 430 which correspond to their condensation temperature so that only the lighter ends reach the upper part of the column. The condensate of these lighter oils tends to return to the boiler, and upon descent to a warmer region absorbs heat liberated by the less volatile oils and tend to reevaporate. Thus the column 430 serves as a fractionating column to maintain the oils of different vapor pressure separated so that a pressure gradient inverse with respect to the temperature gradient is established. By thermally insulating the full length of chamber 429, or extending column 430 down to the neighborhood of the boiler and cooling only the upper portion

thereof, hydro-carbon oils which are solid in their natural state and have very low vapor pressures may be used, and a higher vacuum obtained.

In column 430 may be provided a series of discs on trays 431. These discs serve to catch and hold some of the condensate that forms at the point of their location, thereby tending to prevent diffusion of oil vapors back into the vacuum chamber. These trays are not essential to the operation of the pump, however.

As can readily be seen the fractionating column arrangement serves to keep the less volatile oils at the lower end of the pumping chamber and the most highly volatile oils at the top thereof. Since the more volatile oils generally have higher vapor pressures the pump maintains lowest vapor pressure at the lower end thereof adjacent the high vacuum inlet.

Furthermore the more volatile oil vapors condensed in the upper trays form a less viscous liquid than do the heavier oil vapors, and therefore tend to wash off the heavier or gummy oils and return them to the boiler. This action serves to keep the lower pressure oils in use, so that the pump maintains a low pressure after a period of continuous use.

The gases carried along with the stream of vapors are thus brought to the upper end of the tube 429 of pump 420 and through the opening 430', and to the down leading tubular member 433, from which they are discharged at 434 into the lower end of the pump 440, which constitutes a second vapor pump. This pump is provided with a heater member 444 and a boiler 443 from which project a nozzle 446 corresponding in construction to the boiler and nozzle arrangement disclosed in member 420. The gases in pump 440 are carried upwardly through a fractionating column comprising the trays 441 by the vapors expelled from nozzle 446 in a manner similar to that specifically described in connection with the pump 420. At the upper end of pump 440 the gases which were carried along by the vapors are discharged through an opening 448 into the tubular chamber 460. The gases passing downwardly through 460 are further cooled so that any vapor therein of the oil or other medium, will tend to condense in this chamber. In the bottom end of tubular member 460 is provided a closure member 461 having an aperture 462 which is adapted to be closed by a valve 463. This valve opens or closes a passageway from tube 460 into the cup shaped member 464 whence the gases discharge to the pipe 465 and are carried to the input 342 of the mechanical pump 3.

The valve member 463 is controlled by a linkage mechanism so that the valve is closed at all times that the mechanical pump is not operating at the proper speed. The linkage comprises an arm 205 connected to the control link 466 of the valve 463 through the medium of a metal bellows 467. By this arrangement a control system is provided in which the gas tight seal may be properly maintained, while permitting desired movement of the apparatus. The speed responsive control arrangement for the valve will be described in more detail with reference to the specific mechanical construction of the pump and its associated apparatus.

In the preferred arrangement I have illustrated a protective device which will operate when the temperature of the cooling water circulating about the vapor pump reaches a critical

value. This device preferably consists of a steel or other tubular metal housing 450 attached to the outer wall of the vapor pump assembly. Within this tube I provide a rod 451 of some metal which expands at a different rate than the housing, for example, of aluminum which is adjustably attached by means of a screw thread or other coupling arrangement 452. The difference in expansion between the aluminum rod and the steel housing 450 causes switch 453 to operate when the temperature rises too far, and this switch is arranged to cut the power to the heater of the vapor pump boilers and at the same time, if desired, may be caused to close another circuit to ring an alarm bell.

In order to make it possible to renew or remove the pumping medium from the boilers or inspect the same without disturbing the assembly unit, I provide tubes 454 closed at one end by means of a plug 455, e. g. of steel. The plug and tube arrangement is incorporated in the head of each vapor pump so as to be accessible from a point external to the chamber 640. A vacuum joint may be formed by screw threading the plug 455 into the tube 454, a metal or other gasket being provided for the screw head and the cooperating surface of the latter being grooved.

The mechanical pump 3 is driven by a suitable means such as an electric motor 2, preferably a three-phase motor mounted directly on shaft 200. This shaft also drives the rotor of the mechanical pump, and air circulating fan 201. Within the periphery of this fan a centrifugal operating mechanism 202 is provided. This centrifugal apparatus serves to actuate lever 203 and connecting links 204 and 205 to operate the valve 463. When the motor reaches the proper driving speed the lower end of members 202 move outwardly by centrifugal force, permitting lever 203 to drop, thus opening the valve 463 and connecting the vapor pump with the input circuit of the mechanical pump.

In order to prevent the oil from entering the motor, the oil level is maintained at a point below the level of the motor. A further protection for the motor is provided by means of a suitable covering such as 705 which entirely surrounds the motor except for openings 206 which are provided to furnish ventilating air for the motor. As a further precaution against oil which covers the mechanical pump from entering the motor, I provide a packing 207 about the shaft 200 at the point where it leaves the casing 205 and enters the chamber in which the mechanical pump is operated.

The gas emerging from the vapor pump through pipe 465 is conducted to the inlet port 341 provided in the top plate 340 of this pump through an inlet 342. Connected to plate 340 is a downwardly extending tubular member 343, which serves to conduct lubricating oil to the vacuum seal of pump 3.

The second or low pressure stage of a mechanical pump comprises the rotor assembly 331 provided in cylinder 330 of the pump. This rotor 331 is eccentrically mounted on the shaft 200 so that upon rotation of shaft 200, one edge of this rotor will contact the inner walls of cylinder 330, a controlling vane 332 is provided extending inwardly into cylinder 330 and into contact with rotor 331. A spring operated lever 333 is provided to maintain the vane continuously in contact with rotor 331. The rotor 331 is rotated in the direction indicated by the arrow

by shaft 200, the input port 341 being arranged at a point immediately adjacent the departure side of vane 332. In order that the rotor will not present undue rubbing against the walls of the ring 330 and consequent excessive wear, I prefer to construct the rotor in the form of a ring 334 having an inner ball race, and an inner positively driven member 335 between which suitable ball bearings 336 are provided. The use of this ball bearing construction causes the rotor to contact the inner wall with a rolling motion and reduces the friction that would result from a sliding contact.

The center plate 320 has an exhaust port 321 for the second stage of the pump 3. This exhaust port also serves as the input port for the first stage of the pump. The faces of the rotor 331 serve as cut-off valves for the input and exhaust ports when the rotor reaches the proper position for opening and closing these ports, and the vane 332 maintains separate the input and output portions of the pump.

The gas taken in at port 341, is compressed by rotor 331 as the rotor progresses after the port 341 has been closed. As the compression reaches a maximum value the lower face of rotor 331 moves in such a position as to open the output port 321 and the gases are expelled under pressure into the next stage of the pump.

The first stage of the pump contained in ring 310 comprises a rotor 311 similar in construction to that rotor 331, but offset on shaft 200, 180° with respect to rotor 331. A vane 312 is provided against which the operated lever 313 is pressed by a spring 323. Since the rotors 311 and 331 are 180° out of phase with each other, a single spring 323 serves to control both of the levers 333 and 313. Likewise, since vanes 332 and 312 move in opposite directions so that vane 332 is furthest depressed at the time 312 is in its most outward position, there is very little distortion of spring 323 during the operation of the pump. Consequently the pump may be operated at relatively high speeds without causing fatigue of the spring. For this reason the arrangement in which the rotors are offset at 180° increases the life of the spring mechanism. Likewise by mounting the rotors at 180° displacement, the rotary load on the shaft is more nearly balanced and consequently higher speeds may be obtained without causing undue vibration.

The output port of the first stage of rotary pump 3 is shown at 301. This port leads through a suitable opening in member 300 to the lower end of the gas exhaust tube 302. This exhaust tube is arranged so that it extends upwardly through the oil contained in the reservoir of the pump but terminates at its open end below the level of the oil. Thus the gas exhausted from the pump travels upwardly through tube 302, to a point near the surface of the oil before being exhausted. By providing the tube 302 so that the gas is discharged at a point near the surface of the oil, excessive bubbling and dissolving of the gas in the oil is reduced to a minimum. However, the discharge still takes place under the pressure of the oil so that air may not reenter the pump through the discharge tube.

Since when the pump is operating the pressure of air in the chambers of the pump is considerably below the normal air pressure, it is likely that when the pump is stopped, oil under the atmospheric pressure would be forced into

the cylinder of the pump at a high rate. In order to prevent the oil under high pressure being forced into the pump, I provide a valve mechanism comprising a small piece of fibre retained in position by screw 303 indicated at the dotted cylinder Fig. 3, so that the passage from exhaust port 301 to the oil tends to completely close as soon as pressure is exerted tending to force oil into the pump. This valve may permit the oil to slowly seep into the pump during long periods of idleness but does not permit the oil under pressure to squirt into the pump and rapidly fill it up.

A valve mechanism connected with port 321 is provided. This valve comprises a member such as a ball 322 retained in position so as to close a side opening in port 321 by means of a spring 325. This spring 325 is stiff enough so that normally an air tight seal is maintained at 322. However, under the excessive pressures engendered upon starting the pump when full of oil, the spring is compressed permitting the oil to escape through the opening 324 into the oil reservoir. Thus upon starting of the pump oil is first forced out of the cylinders through the valve 322 and then the pump will operate to force the gas through the various stages of the pump and discharge it through the tube 302.

This disclosure so far has been made with reference to a preferred embodiment of my invention illustrated in Figs. 1, 1A, 2, 2A, 2B and 3. It is apparent, however, that this description constitutes merely an example of a preferred arrangement of the apparatus and suitable modifications may be made within the spirit of my invention. For example, only one stage of vapor pump may be provided if it is considered that sufficient vacuum may be obtained thereby. Furthermore, the vapor pump may be made in many different forms without departing from the spirit of my invention. The fractionating column may be constructed in many different ways at all times bearing in mind the importance of maintaining a proper temperature gradient.

In accordance with my invention the vapor pumps are so constructed that the light constituents and absorbed gases are removed from the pumping medium. In the use of vapor pumps utilizing hydrocarbon oils, when the oils become contaminated by absorbed gases the pressure, while initially correct may rise to a value of from ten to a hundred times the pressure originally established. Furthermore, there is an absorption of vapors and gases which come into contact with the original liquid in the condensing chamber, and these gases upon being returned to the boiler are ejected along with the vapor stream resulting in an increase in pressure and a lowering of the efficiency of the pump. This latter effect is dependent upon the nature and magnitude of gases being pumped and the condition of the succeeding vacuum against which the pump is operating. I have found that by applying a fractionating arrangement as a substitute or complementary to the normal condensing chamber, thus subjecting the condensed vapor to continuous reflux, washing and reevaporation, and by further supplying a large area for this fractionation to take place upon, the elimination of absorbed gases and vapors and the lighter ends caused by decomposition of the oils, is extremely high. Furthermore, this efficiency remains high over long periods of time, for example, several months of continuous operation, permitting the constitu-

ents of lowest vapor pressure to do the highest vacuum portion of the pumping.

Also, I have found that when constructed for the purpose the device enables one to use hydrocarbons of lower vapor pressure, which are usually in a solid state at room temperature, than have heretofore been practical. Attempts in the past to use these solids has resulted in material condensing on various parts of the apparatus and remaining and increasing the deposit until it has either choked off the conduit through which exhaust gases must pass or has emptied the boiler of all of the medium material. By utilizing a fractionating column for condensation, as described herein, a mixture of solid hydrocarbons and of liquid hydrocarbons having higher vapor pressures may be used in the boiler. During operation the liquid or oily constituents are fractionally separated from the solid constituents, the former concentrating at the top or cooler half of the column.

Any of the solid components which might condense at the cool end of the column and thus remain are washed and redissolved by the reflux of the oily condensate. Furthermore, any of the oily condensate which tends to return to the boiler becomes reevaporated by the heat of condensation of the waxy component in the lower or hotter portion of the column. Thus the pumping effect is substantially the same as though only the solid or waxes were used, whereas the clogging and loss of medium is substantially the same as if the liquid were used.

A few additional embodiments of vapor pumps using the principles of my invention are illustrated in Figs. 4 to 7. These embodiments comprise generally a condensing or fractionating column which may be thermally insulated throughout its length except at the end remote from the vapor nozzle so that it may be heated throughout its length by the latent heat of condensation of the medium. The column itself will lose heat throughout its length by radiation and longitudinal conductance toward the remote or cooler end. Thus a temperature gradient is maintained along the column ranging from boiler temperature at its high end to room or water temperature at its cool end.

Referring to Fig. 4, the boiler 41 is provided at the lower end of the condensing column 43. A nozzle 42 of the boiler extends into column 43 in which are provided a plurality of fractionating trays 44. About the upper end of column 43 I provide a water cooling jacket 45. Immediately below the water cooling jacket is provided the high vacuum inlet 46. In this arrangement the high vacuum gases form an insulating chamber about the column 43. These gases enter the column at a point just below the nozzle 42 and are conducted with the vapors to the upper end of the column from whence they are discharged through the opening 47 to the air or a succeeding stage of the pump.

In Fig. 5 an alternative design of the chamber of the fractionating arrangement is disclosed. Instead of using the high vacuum intake to serve as an insulation for the column 43, as in Fig. 5, a high quality insulating material 57 is used to surround the column. The gases are taken in through the intake tube 46 and are exhausted at 47, similarly to the showing of Fig. 5.

In Fig. 6 a further modification quite similar to the type of fractionating column is disclosed in Figs. 1 and 2. However, instead of having the entire chamber surrounded by cooling water, as

in Fig. 2, the walls of the chamber 43 are made hollow and the cooling water is circulated through these hollow walls. The hollow walls of this cylinder serve to force the gases incoming through inlet 46 downwardly so that they must enter the condensing chamber at a point below the opening of nozzle 42.

Fig. 7 illustrates an additional modification which permits very high pumping speed, in which, however, heavy solids or waxes cannot be conveniently used. Nozzle 42 projects upwardly and above this nozzle is provided a baffle plate 51 which serves to force the vapors downwardly. This downward movement of the vapors draws the incoming gases downwardly through intake tube 46. These gases and vapors are conveyed around the outer walls 52 of the column 43. The walls of the column 43 are made hollow and are used to conduct the cooling waters. Because of the cooling effect the vapors are condensed at a point near the lower end of the column and very few of these vapors rise beyond the baffles 53 which are provided at the upper end of the boiler. The gases, however, are exhausted through the tube 47 provided in the side of the column. In the lower end the highly volatile products enter the outer chamber 54 provided around the boiler and serve as a second stage of the pump, the nozzle of which is provided by the baffles 53. Only in this latter stage of the pump is the fractionating tower arrangement itself used. The highly volatile products from the boiler 41 only reach the portion 54 and thus only these portions serve to operate the second stage of the pump. It is evident, however, that in this modification since there is no refluxing and washing of the heavier oils by the lighter oils, the arrangement is not satisfactory for use with waxes or other solids.

Although in each of the embodiments of my invention as herein described I have shown definite cups or reservoirs for the various oils in the fractionating column, it should be understood that if the condensing chamber is made large enough the wetting of the walls of the chamber itself by means of the oil may serve to furnish sufficient oil removal and storage so that the walls themselves will act as a reservoir.

In Figs. 8 to 13, I have illustrated a few other forms of fractionating columns which may be used for the high vacuum system in accordance with my invention. Each of these showings are illustrative of systems suitable for high speed operation and are all of comparatively simple design. In order to avoid confusion similar reference characters are used wherever possible to designate similar parts of the apparatus in the same manner as was used in Figs. 4 to 7.

In Fig. 8 the boiler 41 is provided with a long extending nozzle 42 and a suitable returning baffle 51. Suitable insulating material is provided about the lower portion of the boiler as indicated at 60. The output of the pump to the succeeding vacuum stages is indicated at 47 and the high vacuum input at 46. A plurality of trays for the fractionating column are provided as shown at 44. This arrangement in effect provides a two-stage pump in which the principal high pressure stage constitutes the fractionating column which connects with an oil reservoir which may be separately maintained from a main heating boiler 41.

In Fig. 9 a similar arrangement is provided in which the low vacuum stage 47 is connected directly with the secondary evaporating or frac-

tionating column arrangement. The gases incoming at 46 are deflected downwardly through the annular space and are conducted into this fractionating chamber. The rising gases carry the air along therewith so that it may be exhausted from tube 47.

The arrangement in accordance with Fig. 10 provides an arrangement somewhat similar to that of Fig. 9. However, in this arrangement the air is deflected upwardly together with the gases to the tower members 42'. The desired heat gradient is obtained by use of suitable insulating arrangements provided around the annular tower arrangement 42'.

In Fig. 11 is provided a simple basic arrangement in which the boiler and the fractionating column are arranged practically on the same level. The low vacuum exhaust is made from the edge of the fractionating columns at 47. This is a very extreme simplification of the fractionating column arrangement.

In Fig. 12 an arrangement similar to Fig. 11 is illustrated in which the temperature gradient is obtained by making the bottom plate heavier at the center and lighter at the edges so that the desired temperature gradient is produced by the form of the element itself.

In Fig. 13 is shown a two-stage double fractionating system. In this arrangement the vapors are first deflected so as to rise up through fractionating column 60. The gases and lighter vapors are then deflected into disc shaped portion 61 so that the remaining oil may drain back toward the outer part of the boiler 41. The gases go through this second chamber and are expelled at the exhaust opening 47.

While I have disclosed a specific preferred embodiment of my invention and a few of the alternative constructions thereof I do not intend this description to be considered as limitation on the scope of my invention. What I consider to be my invention and upon which I desire to obtain protection is embodied in the accompanying claims.

What is claimed is:

1. A high vacuum pump comprising, a vapor pump assembly including means for vaporizing a pumping medium, a condensing chamber, a nozzle for introducing said vaporized medium into said condensing chamber, means for connecting the lower end of said condenser chamber to apparatus to be exhausted, cooling means arranged about said condensing chamber, a plurality of condensate retaining means arranged about said condensing chamber above said nozzle and thermally insulated from said chamber, and a gas exhaust pipe at the upper end of said exhaust chamber.

2. A vacuum pump of the vapor condensation type, comprising a vaporizing means for vaporizing a pumping medium, a substantially vertical vapor condenser for condensing said vapors, means for introducing vapors produced by said vaporizing means into the lower end of said condenser with an upward velocity, whereby any condensate from said vapors will return toward said lower end by gravity, means for maintaining a temperature gradient in said condenser decreasing toward the upper end comprising means for thermally insulating the major portion of said condenser and means for cooling said condenser at the top, and means for retarding the return of condensate.

3. A vacuum pump comprising, a boiler arranged to be heated, a delivery tube for vapors

from said boiler, a condensing chamber surrounding and extending beyond the end of said delivery tube, openings in the walls of said chamber behind the end of said delivery tube for the admission of gases to be pumped, cups along the walls of said condensing chamber arranged so their nether surfaces come in contact with the vapor of the pumping medium, while their upper surfaces act as reservoirs for condensed medium, and means for maintaining a wide range temperature gradient along said walls, hotter at the end closest to said nozzle and cold at the end most removed from said nozzle, the cold end of said condenser being at a level higher than the hot end so that condensate will run from the cold to the hot end and said means comprising means for thermally insulating said walls from said cups, and means for returning the liquid condensate remaining at the hot end of said chamber to said boiler.

4. A vacuum pump comprising, a boiler arranged to be heated, a delivery tube for vapors from said boiler, a cup arranged to be supported at the end of said delivery tube to reverse the direction of flow of vapor from the open end of said delivery tube, so that it passes along the outer wall of said delivery tube in opposite direction from its passage along the inner wall, a first condensing and pumping chamber surrounding said delivery tube and cup, said chamber being arranged to be cooled, an inlet conduit into said chamber at a point beyond said cup, and series of openings in the walls of said chamber at its extremity closest to said boiler, means for conducting the liquid condensate from said condensing chamber to the outer surface of said delivery tube at a point removed from the liquid level in the boiler, a second condensing and pumping chamber formed by the external cooled surface of said first condensing chamber and the outer containing wall of said pump, an inlet between said first and second chambers, a series of annular cups attached to the outer walls of the said

delivery tube, over which the condensate must pass on its return to the boiler, means for conducting the vapors arising from said condensate as it passes over the surface of said cups to the second condensing and pumping chamber, means for returning this secondary condensate to the outer surface of said delivery tube, means for returning such condensate as is not re-evaporated to said boiler, and means for removing the accumulated gases and non-condensable vapors which accumulate between the outer surface of said condensing chamber and the outer containing wall of said pump.

5. A vacuum pump comprising a boiler having an output nozzle, a vaporizable medium in said boiler, an input tube connected to a point adjacent said nozzle, a second tube of larger diameter than said input tube coupled thereto, means for preventing vapor from said medium reaching said second tube comprising a charcoal trap of larger diameter than said input tube but of smaller diameter than said second tube positioned substantially coaxial with said input tube and spaced therefrom, an electric heating means in said trap, a lead extending from said heating means to the outside of said pump, and a vacuum tight seal for said lead.

6. In the process of evacuating a chamber by means of a vapor pump employing a mixture of organic waxes and oily organic compounds tending to form high pressure and low pressure vapors, the steps which comprise heating and vaporizing said mixture, passing such mixture vapor over a thermally insulated cooling surface of a condenser having a temperature gradient decreasing toward one end, the direction of the flow of the vapor in passing over said surface being toward the cooler end of said surface thereby causing separation of the low and high pressure vapors, and maintaining said low pressure vapor and said high pressure vapor separated within the condenser.

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