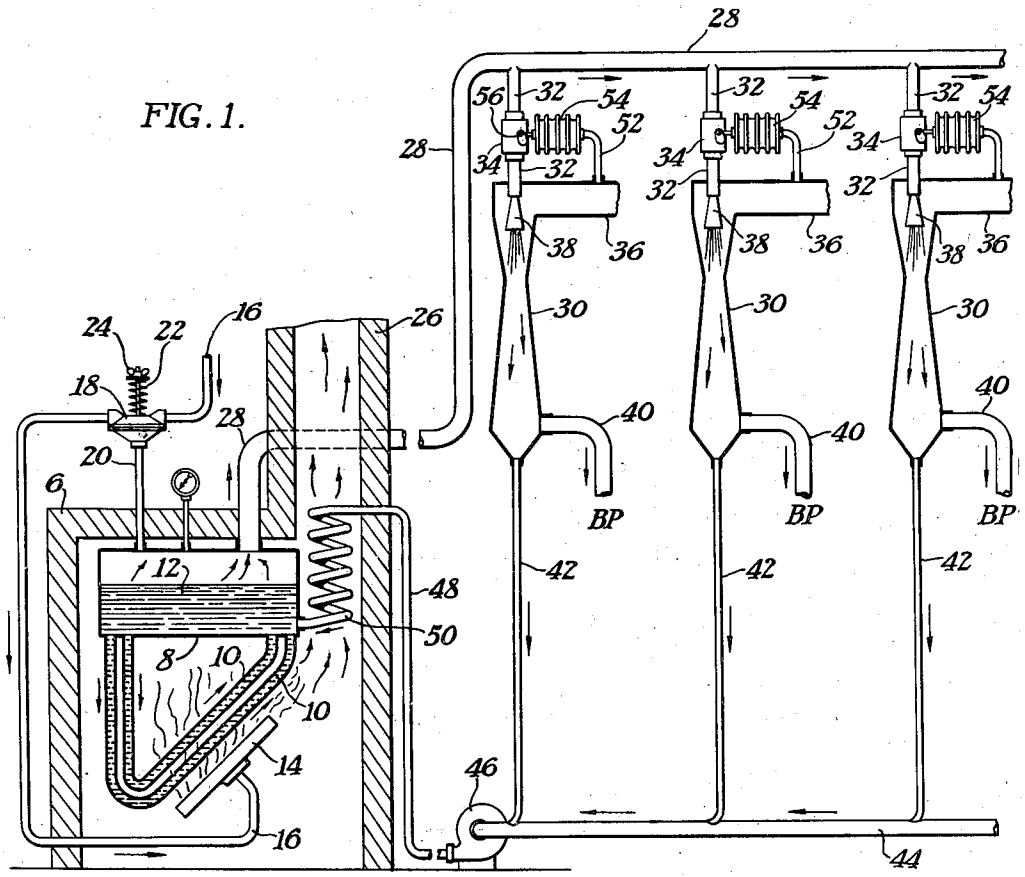
Sept. 12, 1944. K. C. D. HICKMAN 2,358,067

HIGH VACUUM PROCESS AND APPARATUS

Filed Feb. 24, 1943

FIG. 1.



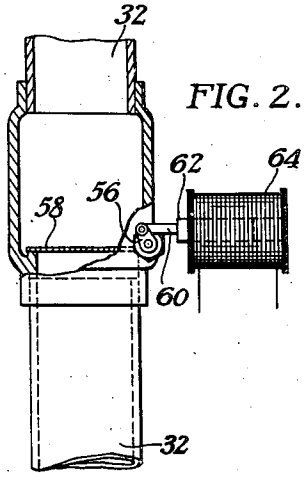


FIG. 2.

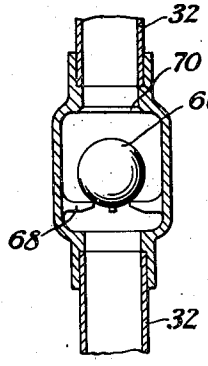


FIG. 3.

KENNETH C. D. HICKMAN
INVENTOR

BY Newton M. Perrine
Warren H. Cannon
ATTORNEYS

Patented Sept. 12, 1944 2,358,067

UNITED STATES PATENT OFFICE

2,358,067

HIGH VACUUM PROCESS AND APPARATUS

Kenneth C. D. Hickman, Rochester, N. Y., assignor to Distillation Products, Inc., Rochester, N. Y., a corporation of Delaware

Application February 24, 1943, Serial No. 476,933

15 Claims. (Cl. 230—101)

This invention relates to improved equipment for the production of high vacua, also to improved process of high vacuum production.

The conventional way of producing a high vacuum is by means of a condensation pump. The condensation pump has been improved considerably in the past thirty years; it has also increased somewhat in size. However, the condensation pump has always had as an integral unit, or as a closely attached element, a vapor generating boiler. Each pump in other words had its own boiler. It was common practice to place a pump at each seat of the vacuum operations. The pumps seldom required heat energy in excess of a fraction of 1 horsepower. Application of heat to a large number of small pump boilers is obviously inefficient, as far as heat utilization is concerned. Also such pumps were actuated and vapors generated only at such times as pumping was desired, further increasing inefficiency and loss of time waiting for the pump to start to operate.

This invention has for its object to provide improved high vacuum pumping apparatus. Another object is to provide improved high vacuum pumping apparatus and process in which a plurality of jets is actuated by vapors generated in a boiler operating on efficient principles. A still further object is to provide an improved high vacuum pumping system utilizing vapor-operated ejector pumps (including condensation pumps). Other objects will appear hereinafter.

These and other objects are accomplished by my invention which includes a high vacuum producing system comprising a plurality of ejector pumps supplied with vapors of a relatively stable low vapor pressure organic substance by a common boiler located a substantial distance from the ejector pumps, the actuating organic vapors thus being conducted in a conduit over a substantial distance from the boiler to the ejector pumps.

In the accompanying drawing wherein like numbers refer to like parts,

Fig. 1 is an elevation partly in section of an improved pumping system embodying the principles of my invention;

Fig. 2 is an elevation partly in section of a modified valve for controlling flow of actuating vapors to the ejector pumps and;

Fig. 3 is another modification of a valve for controlling flow of actuating vapor to the ejector pumps.

Referring to Fig. 1, numeral 6 designates a rectangularly shaped furnace constructed of suitable fire resistant insulating material in which is located a boiler 8 provided with a plurality of heating tubes 10 and liquid 12 serving as a source of organic vapors. Numeral 14 designates a gas burner supplied with combustible gas through conduit 16 and diaphragm valve 18. Numeral 20 designates a conduit leading from the inside of boiler 12 to diaphragm valve 18. Numeral 22 designates a spring and numeral 24 a wing nut by which the opening and closing of diaphragm valve 18 can be varied and controlled. Numeral 26 designates a chimney for furnace 6.

To the upper part of boiler 8 is connected a relatively wide aperture conduit 28 which serves to convey vapors to a plurality of distant ejector pumps 30 by way of conduit 32 and valves 34. Each ejector pump 30 is provided with a high vacuum or intake conduit 36, a jet nozzle 38, exhaust conduit 40 leading to a backing pump (not shown) and a withdrawal conduit 42 for removal of spent or used actuating fluid. These conduits 42 connect to a common header 44 which leads to the intake of return pump 46. The exhaust side of pump 46 connects to conduit 48 which terminates in boiler 8 after forming a heat recovery coil 50 in chimney 26.

Numeral 52 designates a conduit connected to the high vacuum side of the ejector pumps and to one side of a diaphragm actuated piston or bellows 54, the piston of which connects to the actuating crank 56 of valve 34.

Referring to Fig. 2 numeral 56 designates an actuating crank for valve member 58. Numeral 60 designates a shaft connected to a solenoid operated member 62. Numeral 64 designates a solenoid whereby member 62 is caused to reciprocate and open or close valve member 58. The construction of valve member 34 shown in Fig. 1 is substantially the same as that shown in Fig. 2 except that the valve in Fig. 1 is pneumatically operated by diaphragm 54 whereas the valve illustrated in Fig. 2 is electrically operated.

Referring to Fig. 3, numeral 66 designates a spherical member suspended in the position shown by three internal projections 68. Numeral 70 designates a valve seat against which sphere 66 is thrown under certain conditions to be hereinafter explained.

In operating the apparatus illustrated in Fig. 1 the boiler 12 is filled with an organic pump fluid to the approximate height indicated. Burner 14 is put into operation and valve 18 is adjusted by means of wing nut 24 to maintain a pressure of any desired predetermined value in the boiler 12. Diaphragm valve 18 is so constructed that the

vapors in the boiler 12 passing through conduit 20 exert a certain pressure on the diaphragm of the valve. By suitable adjustment the valve can be made to turn the burner 14 off when the pressure exceeds a certain value and turn the burner on when the pressure in boiler 12 falls below a certain value. Vapors thus generated in boiler 12 and automatically maintained at a desired pressure are conveyed through well insulated conduit 28 to the various ejectors 30. These ejectors are so constructed that they are automatically actuated by vapors from conduit 28 when backing pumps connected to conduit 40 are put into operation. Thus, when the pressure in conduit 40 is reduced by the backing pump the reduced pressure prevails throughout the system, including conduit 36 which leads to the receptacle being evacuated. This reduced pressure exerts its effect through conduit 52 and actuates diaphragm and piston 54. This reduction in pressure causes movement of crank 56 of valve 34 to open position. Vapors under pressure then pass at high velocity through valve 34 and jet nozzle 38. Gases in the system to be evacuated are thus drawn through conduit 36 into the jet and are forced into the high pressure end of the pump and are withdrawn by the backing pump through conduit 40. The diffuser tubes of the ejector pumps indicated by the numeral 30 are air cooled so that the organic pump fluid vapors are condensed. The condensate flows by gravity into conduit 42 thence into pump 46 and is returned by way of conduit 48 to boiler 8. Any unrecovered heat of combustion passing up the chimney or stack 26, comes into contact with the return liquid in conduit 50 and the heat is thus taken up and prevented from being wasted.

In many cases a backing pump would be unnecessary. Also in many cases it is not advisable to have automatic operation. In such cases it is quite convenient to have some type of manually or semi-manually operated valve and a convenient construction is shown in Fig. 2. Here the valve is electrically opened by energizing coil 64. The valve automatically returns to its closed position when the electricity is cut off. This enables remote control of the pumps. With this construction the electrically operated shut-off could be actuated by an operator at a desk where a suitable pressure-indicating device would be mounted to indicate when the pump should be actuated or shut off. The construction shown in Fig. 2 also permits automatic actuation. Thus, the coil 64 could be connected to a sensitive monometer which would be actuated by a reduction in pressure in conduit 52 due to starting of the backing pumps as explained in connection with Fig. 1. Reduction of pressure in the sensitive monometer would cause the coil 64 to be energized. Elevation of the pressure to normal would cut off the electricity as a result of change in the monometer. Another alternative type of valve is shown in Fig. 3 sphere 66 being in the position shown during operation of the ejectors. When the operation of the ejectors stopped, i. e., by allowing the pressure therein to rise, the inrush of gas from the atmosphere throws sphere 66 against seat 70. This automatically cuts off the flow of vapors to the ejector nozzle 38. In this modification it is obvious that the pressure in boiler 8 and conduit 28 must be below atmospheric to enable closing of the valve by the atmosphere.

In many cases it is desirable to operate boiler 8 and conduit 28 so that the pressure of the vapors therein is approximately atmospheric pressure. This has many advantages among which are the avoidance of leakage of the vapors into the atmosphere, as well as avoidance of leakage of air into the system. Also, the valve 34, boiler 8 and conduit 12 need not be constructed with so much care as regards weight and strength of materials, leaks, etc. It is also convenient due to the fact that the atmosphere can be used to actuate the automatic controls maintaining the atmospheric pressure in the boiler.

One of the essential features of my invention is the application of these principles to relatively stable, low-vapor pressure organic pump fluids. These substances are of a peculiar nature, condensing easily and being as a class unstable from a thermal standpoint as compared with substances such as mercury or steam. I prefer to utilize relatively stable organic substances which are substantially free of constituents having a vapor pressure above about 4.0 mm. or below about 1×10^{-6} mm. at room temperature. However, organic substances somewhat above and below these values can be used.

While I prefer to employ hydrocarbons as activating pump fluids because of their availability and low cost, other substances can be used with complete satisfaction. Examples are: trichlorbenzene, "Dow Therm," (a mixture of diphenyl and diphenyl oxide), ethers such as "Cellosolve," dimethyl phthalate and furfural. Hydrocarbon actuating pump fluids can be obtained from petroleum by distillation to segregate fractions having various desired vapor pressure ranges. Satisfactory pump fluids can be easily obtained by distillation of various hydrocarbon fractions on the market having distillation temperatures and vapor pressures the same as or intermediate SAE 50 lubricating oil and kerosene. The following table indicates the characteristics of specific preferred types of hydrocarbon pump fluids, and their mode of use for best results in the evacuating system described herein.

Approximate fine vacuum produced by pump, mm. Hg	Forepressure against which pump will operate, mm.	Source of operating fluid	Approx. vapor pressure at room temp. in, mm. Hg	Boiler	
				Temperature, °C.	Pressure, mm. of Hg
.01- .1	.5- 2	A, B, C, D, E	10^{-4}	210-250	20- 80
.1 - .3	2 - 4	A, B, C, D, E	10^{-3}	200-250	40-120
.3 - 1.0	4 -12	G	2×10^{-3}	180-220	60-200
1 - 4	10 -20	F, G	5×10^{-2}	170-220	100-350
4 -10	20 -60	F	1	160-240	200-760

As source of the above oils I have used:

A—50W white oil
B—Winter grade crank case oil (10W)
C—Light processing oil
D—Spindle oil
E—Ice machine oil
F—Fuel oil No. 2
G—Fuel oil No. 1.

It will be realized that there always will be a certain pressure drop from the boiler to the

ejector pumps and that this will necessitate somewhat higher boiler pressures than the above if the system is extensive or improperly insulated. This can be minimized by efficient insulation and wide aperture vapor conduits. The vapors may partially condense in which case it is desirable to have the vapor lines slope and provide receptacles for collection of condensate and return to the boiler.

I contemplate employing substantially commercial boiler practice utilizing boilers of relatively high capacity located at a distance from the ejectors and preferably situated in a separate building from the ejectors. The boiler can be of any type although tubular type boilers are preferred because of their efficiency. The boiler can be heated in any desired way but my invention enables, for the first time, the efficient vaporization of ejector pump organic working fluid by means of cheap fuels such as coal or other combustible materials. The vapors are piped from the remotely situated boiler in large pipes according to advanced power plant practice around many floors of a large factory or laboratory to the ejector pumps as described. It is contemplated that a multi-horse power installation will thus bring the technology of high vacuum organic vapor actuated pumps to industrial use on a scale never heretofore contemplated.

What I claim is:

1. A high vacuum pumping system comprising in combination a plurality of vapor-operated ejector pumps, a tube type boiler containing a relatively stable low vapor pressure organic fluid, means offering little resistance to flow of vapors for conveying vapors generated in the boiler to the ejector pumps without substantial drop in temperature, means for returning used and spent fluid from the ejector pumps to the boiler and means for heating the boiler said boiler being positioned at a point remote from the ejector pumps.

2. A high vacuum pumping system comprising in combination a plurality of vapor-operated ejector pumps, a boiler containing a relatively stable low vapor pressure organic fluid, means offering little resistance to flow of vapors for conveying vapors generated in the boiler to the ejector pumps, means responsive to a reduction or increase in amount of vapors in the boiler or vapor conveying means for maintaining the vapors in the boiler and vapor conveying means at a pressure sufficient to actuate the ejector pumps means for returning used and spent fluid from the ejector pumps to the boiler, and means for heating the boiler, said boiler being positioned in a separate building and at a point remote from the ejector pumps.

3. A high vacuum pumping system comprising in combination a plurality of vapor-operated ejector pumps, a boiler containing a relatively stable organic substance which is substantially free of constituents having vapor pressure below about 1×10^{-6} mm. or above about 4 mm. at room temperature, means for conveying vapors generated in the boiler to the ejector pumps, means responsive to a reduction or increase in amount of vapors in the boiler or vapor conveying means for maintaining the vapors in the boiler and vapor conveying means at a pressure sufficient to actuate the ejector pumps means for returning used and spent fluid from the ejector pumps to the boiler and means for heating the boiler said boiler being positioned at a point remote from the ejector pumps.

4. A high vacuum pumping system comprising in combination a plurality of vapor-operated ejector pumps, a tube type boiler containing a relatively stable organic substance which is substantially free of constituents having a vapor pressure below about 1×10^{-6} mm. or above about 4 mm. at room temperature, means for conveying vapors generated in the boiler to the ejector pumps, means for returning used and spent fluid from the ejector pumps to the boiler and means for heating the boiler said boiler being positioned in a separate building and at a point remote from the ejector pumps.

5. A high vacuum pumping system comprising in combination a plurality of vapor-operated ejector pumps, a boiler positioned at a point remote from the ejector pumps and containing a relatively stable low vapor pressure organic substance, means for conveying vapors generated in the boiler to the ejector pumps, means for returning used and spent organic substances from the ejector pumps to the boiler, means for heating the boiler, a valve controlling the flow of vapors to each ejector pump and means responsive to a reduction or increase of pressure in the ejector pump for repectively opening or closing the valve.

6. A high vacuum pumping system comprising in combination a plurality of vapor-operated ejector pumps a boiler positioned at a point remote from the ejector pumps and containing a relatively stable organic substance substantially free of materials having a vapor pressure at room temperature below about 1×10^{-6} mm. and above about 4 mm. means for conveying vapors generated in the boiler to the ejector pumps means responsive to a reduction or increase in amount of vapors in the boiler or vapor conveying means for maintaining the vapors in the boiler and vapor conveying means at a pressure sufficient to actuate the ejector pumps means for returning used and spent fluid from the ejector pumps to the boiler, means for heating the boiler, a valve controlling the flow of vapors to each ejector pump and means responsive to a reduction or increase of pressure in the ejector pump for respectively opening or closing the valve.

7. A high vacuum pumping system comprising in combination a plurality of vapor-operated ejector pumps a boiler positioned at a point remote from the ejector pumps and containing a relatively stable low vapor pressure organic substance, means for conveying vapors generated in the boiler to the ejector pumps means responsive to a reduction or increase in amount of vapors in the boiler or vapor conveying means for maintaining the vapors in the boiler and vapor conveying means at a pressure sufficient to actuate the ejector pumps means for returning used and spent organic substance from the ejector pumps to the boiler means for heating the boiler, means for automatically maintaining the pressure in the boiler at approximately atmospheric pressure, a valve controlling the flow of vapors to each ejector pump and means responsive to a reduction of pressure in each ejector pump to below atmospheric for opening, and responsive to an increase of pressure in each ejector to atmospheric for closing the valve.

8. A high vacuum pumping system comprising in combination a plurality of ejector pumps, a boiler containing a relatively stable low vapor pressure organic fluid, means for heating the boiler by combustion of coal, means for conveying working vapors from the boiler to the ejector pumps, and means for returning the used and

spent fluid to the boiler, said boiler being positioned at a point remote from the ejector pumps.

9. A high vacuum pumping system comprising in combination a plurality of ejector pumps, a boiler containing a relatively stable low vapor pressure organic substance, means for heating the boiler with a combustible substance, means for conveying working vapors from the boiler to the ejector pumps, means responsive to a reduction or increase in amount of vapors in the boiler or vapor conveying means for maintaining the vapors in the boiler and vapor conveying means at a pressure sufficient to actuate the ejector pumps and means for returning the used and spent organic substance to the boiler, said boiler being positioned at a point remote from the ejector pumps.

10. A process of evacuating by means of a plurality of ejector pumps connected to a common source of actuating vapor which comprises generating vapors of a relatively stable low vapor pressure organic substance in a boiler at a pressure sufficient to actuate the ejector pumps, conveying these vapors through a conduit to the ejector pumps, and starting or stopping the pumping action by starting or stopping the flow of actuating vapors to the ejector pumps while maintaining the pressure of the vapors in the boiler and conduit at actuating pressure during both pumping and non-pumping periods.

11. A process of evacuating by means of a plurality of ejector pumps connected to a common source of actuating vapor which comprises generating vapors of a relatively stable low vapor pressure organic substance in a boiler at a pressure sufficient to actuate the ejector pumps, conveying these vapors a substantial distance through a conduit to the ejector pumps, and starting or stopping the pumping action by starting or stopping the flow of actuating vapors to the ejector pumps while maintaining the pressure of the vapors in the boiler and conduit at actuating pressures during both pumping and non-pumping periods.

12. A process of evacuating by means of an ejector pump connected to a source of actuating vapor which comprises generating vapors of a relatively stable low vapor pressure organic substance in a boiler at a pressure sufficient to actuate the ejector pump, conveying these vapors a substantial distance through a conduit to the working fluid inlet of the ejector pump, and starting or stopping the pumping action by starting or stopping the flow of actuating vapors to the ejector pump while maintaining the pressure of the vapors in the boiler and conduit at actuating pressures during both pumping and non-pumping periods.

13. A process of evacuating by means of a plurality of ejector pumps connected to a common source of actuating vapor which comprises generating vapors of a relatively stable low vapor pressure organic substance substantially free of constituents having a vapor pressure below about 1×10^{-6} mm. or above about 4 mm. in a vapor generator at a pressure sufficient to actuate the ejector pumps, conveying these vapors a substantial distance through a conduit to the ejector pumps, and starting or stopping the flow of actuating vapors to the ejector pumps while maintaining the pressure of the vapors in the vapor generator and conduit at actuating pressures during both pumping and non-pumping periods.

14. A process of evacuating by means of a plurality of ejector pumps connected to a common source of actuating vapor positioned a substantial distance therefrom which comprises maintaining vapors of a relatively stable low vapor pressure organic substance in the vapor source at a vapor pressure closely approximating atmospheric pressure whereby leakage of working vapors from or of air into the vapor source is substantially avoided.

15. A process of evacuating by means of a plurality of ejector pumps connected to a common boiler serving as a source of activating vapor which boiler is positioned a substantial distance from the ejector pumps which comprises maintaining in the boiler vapors of a relatively stable organic substance at a vapor pressure closely approximating atmospheric pressure whereby leakage of working vapors from, or of air into the vapor source is substantially avoided, said organic substance being substantially free of substances having a vapor pressure below about 1×10^{-6} mm. or above about 4 mm. at room temperature.

KENNETH C. D. HICKMAN.