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2,386,299

DIFFUSION PUMP

Filed July 3, 1944

2 Sheets-Sheet 1

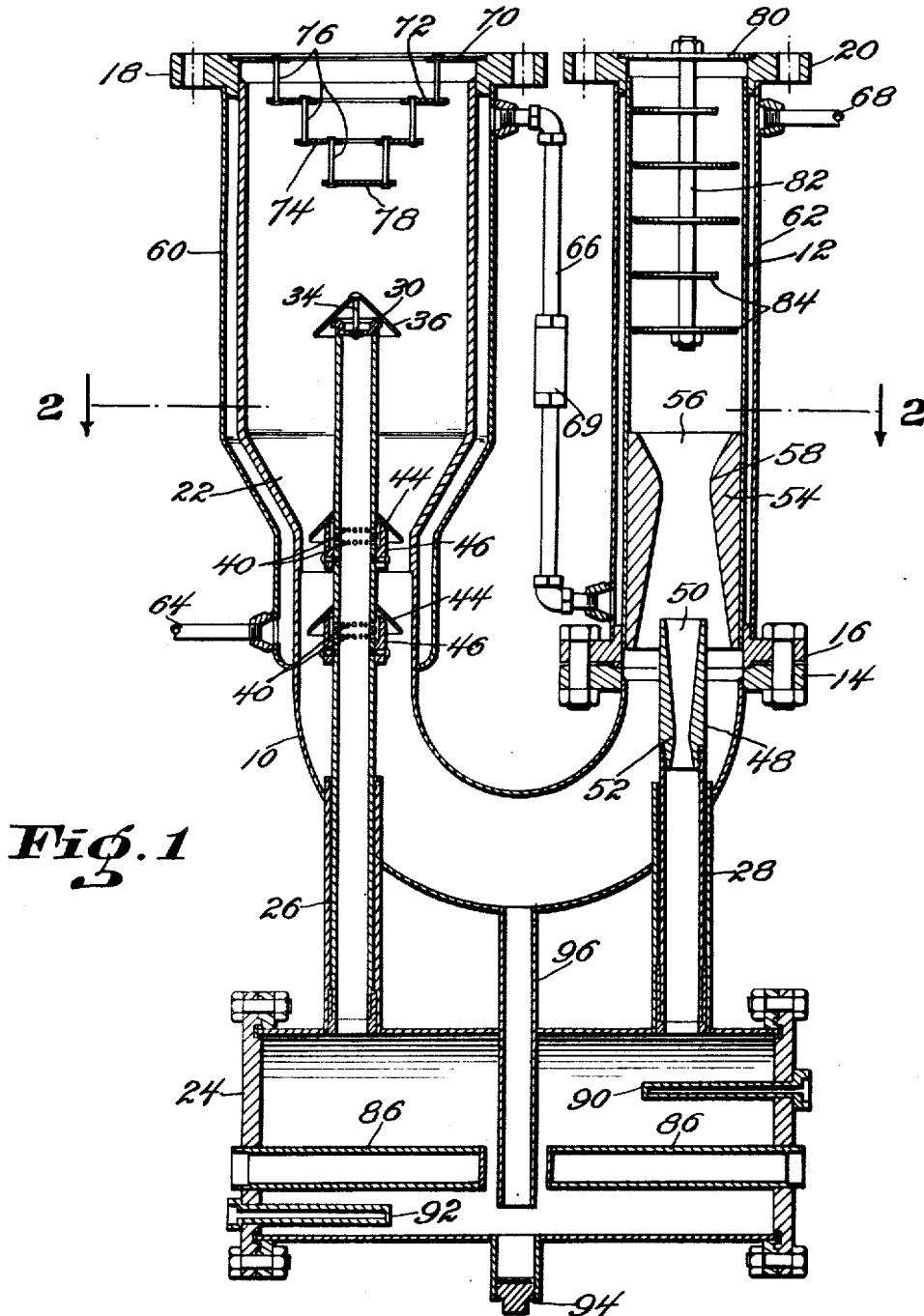


FIG. 1

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Fig. 2

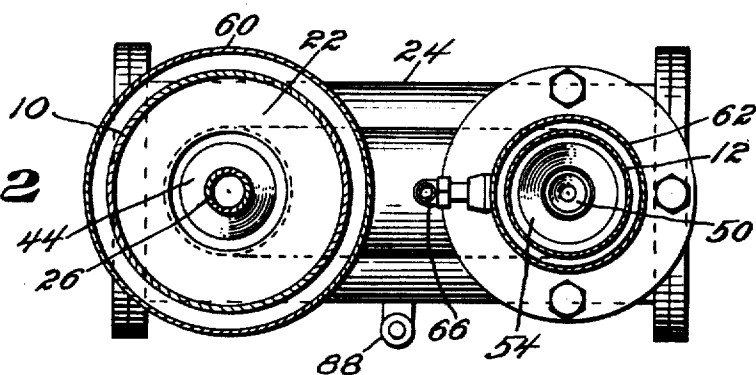


Fig. 3

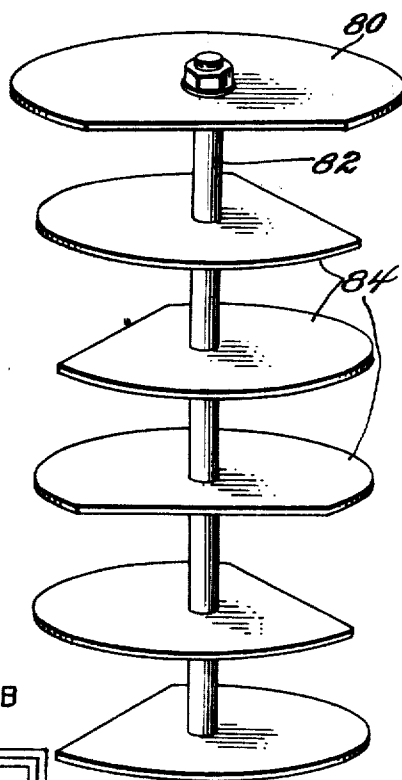
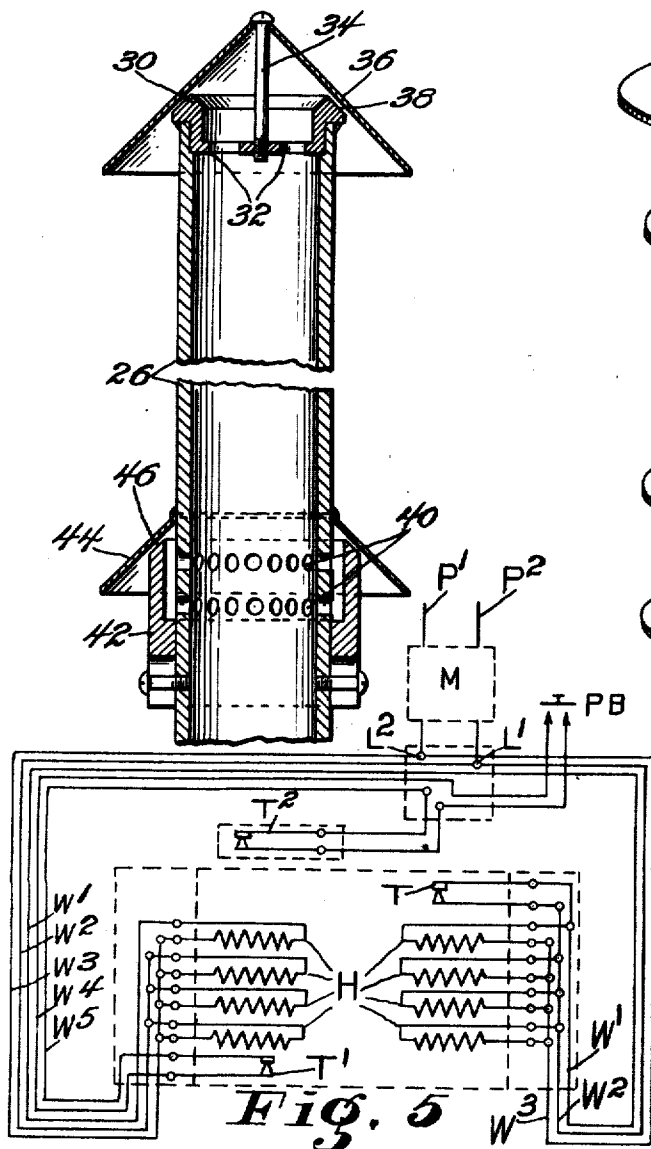


Fig. 4

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DIFFUSION PUMP

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7 Claims. (Cl. 230-101)

This invention relates to vacuum pumps and particularly to diffusion or condensation pumps useful for increasing the pumping speeds of mechanical pumps.

An object of the invention is to provide such a pump embodying novel principles of construction and operation which provide a more efficient pumping action than that obtainable with prior pumps. Another object is to provide novel electric governing means for automatically controlling the operation of such pumps.

In the accompanying drawings, which illustrate a preferred form of apparatus according to the invention:

Fig. 1 is a vertical section view of the apparatus;

Fig. 2 is a transverse section view on line 2-2 of Fig. 1;

Fig. 3 is an enlarged fragmentary section view of portions of one of the vapor chimneys of the apparatus of Fig. 1;

Fig. 4 is a side elevation view of one of the baffle units of the apparatus of Fig. 1;

Fig. 5 is a wiring diagram illustrating control circuits.

Referring to Fig. 1 of the drawings, the apparatus as shown comprises a vertically arranged generally U-shaped duct which forms the pumping passage. As shown this duct is comprised of a pair of conduit sections 10 and 12 having at their respective opposed ends flanges 14 and 16 by which they are bolted together in pressure-tight relation. The inlet end of the duct, which is the left-hand end as shown, is provided with a flange 18 by means of which the duct may be fastened into a system to be evacuated. The outlet end of the duct, which is the right-hand end as shown, is provided with a flange 20 by means of which it may be connected to the pumping port of a suitable backing pump. The inlet end portion of the duct is of enlarged diameter relative to the remainder of the duct and has, at its lower end, a frusto-conical throat portion 22 by which it is connected to the remaining portion of the duct.

A boiler 24 is provided below the duct from which a pair of chimneys 26 and 28 extend upwardly through the adjacent wall of the duct and into the pumping passage. Pumping vapors are conducted by these chimneys from the boiler into the pumping passage where they are diffused, as will hereinafter be explained.

The chimney 26 extends upwardly in the inlet branch of the duct, in spaced relation to the side walls of the duct, to a point in the enlarged

inlet end portion above the throat 22. As shown in Figs. 1 and 3, the upper end of this chimney is fitted with a cup 30 having its base web provided with vapor outlet apertures 32 and a central threaded socket for receiving the threaded end of a pin 34 from which is suspended an inverted conical deflector 36 extending over the top of the chimney. The outer edge of cup 30 is beveled outwardly and downwardly at 38 and the deflector 36 is spaced slightly above this beveled surface to provide therebetween a restricted channel. Vapors rising through the chimney into cup 30 through apertures 32 escape through this channel into the pumping passage as a continuous jet about the chimney, directed downwardly by the deflector toward throat 22.

The intermediate portion of the chimney 26 which lies within the smaller diameter portion of the duct below throat 22 is provided with a pair of vapor diffusing jets which, like the preceding jet, are of the so-called umbrella type, each comprising a pair of rings of vapor outlet apertures 40 in the chimney, a first deflector 42 bolted to the chimney below the apertures 40 and extending upwardly beyond said apertures in spaced relation to the chimney to provide an upwardly directed channel for the vapors, and a second deflector 44, of inverted frusto-conical form, fastened to the chimney above the upper edge of deflector 42 and extending outwardly and downwardly beyond the upper edge of deflector 42 and in spaced relation thereto. The upper edge of deflector 42 is beveled outwardly and downwardly at 46 to provide a smooth channel therebetween and the under surface of deflector 44 for the outflow of vapors.

The other chimney 28 is provided at its upper end with a nozzle 48 extending upwardly within the outlet branch of the duct, said nozzle having an internal, upwardly directed vapor outlet passage 50 which is provided with a restricted throat 52 between its ends and nearer the inlet end than the outlet end. The upper end of nozzle 48 extends into the mouth of a cooperating tube 54 fitted into the duct, said tube having an internal passage 56 directed upwardly and provided between its ends with a restricted throat 58 nearer the outlet end than the inlet end of said passage.

The inlet branch of the duct is encased in a water jacket 60 which extends below the jets of chimney 26, and the outlet branch of the duct, comprising section 12, is surrounded by a water jacket 62. Cooling water is fed into jacket 60 through an inlet pipe 64, from jacket 60 to jacket

62 through pipe 66, and out through outlet pipe 68. Pipe 68 has an enlarged section 69 in which is contained a thermostatic control switch for a purpose hereinafter described.

The inlet end of the duct is provided with a baffle unit comprising a first baffle ring 70 seated in an internal recess in flange 18, succeeding baffle rings 72, 74 of successively smaller inner and outer diameter concentrically suspended from the preceding baffle ring by rods 76, and a baffle plate 78 of still smaller diameter suspended from baffle ring 74 by rods 76 and underlying the opening in said ring. This arrangement of baffles has the desirable effect of forcing indrawn gases to spread laterally, between the baffles, as they enter the duct, and it is also effective to prevent escape of pumping vapors from the inlet end of the duct.

The outlet branch of the duct is provided with a baffle unit, particularly shown in Fig. 4, comprising a series of baffle plates of circular segment form mounted in longitudinally spaced relation within cylindrical duct section 12 above the tube 84. The uppermost plate 80 has its circular edge portion seated in an internal recess in flange 20, its straight edge being spaced from said flange to provide a reduced passage for the flow of gases out of the duct. From plate 80 is suspended a rod 82 upon which are mounted the lower baffle plates 84 of the unit. Plates 84 are of smaller size than the plate 80 and are so mounted on rod 82 that their circular edges closely approach the inner periphery of the duct while their straight edge provides a gap between itself and the duct wall for the outward flow of gases. Each of the plates is mounted with its straight edge between circular portions of the next adjacent plates so that the gaps between their straight edges and the inner duct wall are staggered substantially in a spiral about the diameter of the duct.

During operation pumping vapors are continually supplied to chimneys 26 and 28 by heating a suitable pumping liquid such as an oil in boiler 24. As shown, the boiler is provided near its base with a plurality of inwardly extending tubes 86, closed except at their outer ends, for the reception of cartridge type electric heating units to heat the pumping liquid. Pumping liquid is fed into the boiler through an inlet pipe 88 and maintained at a level slightly above the upper surface of tubes 86. A smaller tube 90 is provided above the tubes 86 at one end of the boiler to receive a cartridge type thermostatic switch for controlling the flow of current to the heating units according to the temperature of the vapor rising from the pumping liquid. A similar tube 92 is provided below the tubes 86 at the other end of the boiler to receive another thermostatic switch maintained at the temperature of the pumping liquid for a purpose hereinafter explained. A suitable drain 94 is provided in the base of the boiler. Pumping liquid condensing in the pumping passage is returned to the boiler through a drain pipe 96 provided in the lowermost portion of the curved bottom wall of the pump duct and extending into the boiler below the level of liquid maintained therein.

In operation, some of the vapors of the pumping liquid in the boiler rise into chimney 26 and are discharged from the several jets thereof in separate streams into the pumping passage. Vapors diffusing from the uppermost jet are directed downwardly and outwardly by deflector 36 into the enlarged inlet portion of the pumping pas-

sage, toward the inwardly slanting throat 22 of the duct. Gases from the vacuum system drawn into the inlet of the pump are directed outwardly by the inlet baffles toward the walls of the duct. This has the desirable tendency to concentrate the incoming gases toward the walls of the duct where they are more effectively entrained, as they flow downwardly, by the vapors from the first jet.

The gases entrained by the vapors diffusing from the first jet are thereby compressed into the smaller diameter duct portion below the throat 22 where they are in turn entrained and further compressed by the higher pressure vapor streams issuing from the two other jets of chimney 26. Some of the vapors from each jet condense on the cooled walls of the passage and those which do not condense are entrained by the next succeeding jet.

The multi-stage vapor diffusion jets and cooperating pumping passage inlet construction which diminishes in diameter between successive stage jets is highly effective in entraining and initially compressing the gases from the system. It is desirable, as shown, to provide an inwardly slanting throat such as throat 22 between the larger and smaller diameter duct portions toward which the vapors from the preceding jet are discharged.

Vapors from the boiler also rise into chimney 28 from which they are directed upwardly by the ejector type nozzle 48 in a first contracting then expanding stream into tube 54 in which they continue to flow upwardly toward the forepump in a stream which is first contracted then expanded due to the shape of the tube. The gases and any uncondensed vapors diffused from chimney 26 flow into the mouth of tube 54 and, intermingled with vapors from ejector nozzle 48, flow upwardly through the tube being thereby again heavily compressed.

The provision of a last stage jet of the ejector type following the multi-stage diffusion type jets at the inlet end is another important feature of the pump, greatly increasing the compression ratio and effectiveness of the pump. It is preferable to supply vapors separately to this last stage jet by providing a separate chimney for this jet which may lead from a single boiler feeding all jets, as shown, or from a separate boiler.

Vapors and gases passing out of tube 54 are caused by the outlet end baffles to flow angularly or spirally about the cooled duct wall toward the outlet to the forepump. The vapors condense on the duct walls leaving substantially only gases to escape to the forepump. The swirling or spiral movement of the vapor and gas stream produced by these baffles increases both the time and extent of contact of the vapors with the cooled walls thereby increasing their efficiency and desirably reducing their necessary length.

Pumping vapors condensing on the walls of the pumping passage flow downwardly thereon and are returned by drain pipe 96 to the boiler.

Diffusion pumps having the construction above described are very effective boosters for mechanical pumps, greatly increasing their pumping speeds and capacity. They are efficient and economical in operation and are particularly advantageous for industrial vacuum operations where the evacuation of large volume systems to extremely low pressures at high speed is required.

Pumps that have been made according to the invention as hereinabove described, when used with a forepump of ordinary pumping capacity such as twenty-five cubic feet of air per minute,

for example a 25 C. F. M. rotary oil sealed mechanical pump, readily produce pressures as low as .00001 mm. of mercury in a properly designed vacuum system free from leaks, vapors and abnormal outgassing, have a normal pumping speed range, in cubic feet of dry air per minute, from about 25 C. F. M. at 1 mm. pressure to about 2600 C. F. M. at pressures around .00001 mm., and, at pressures of about .00001 mm., have a normal compression ratio across the pump of 40,000 to 1. Their performance is considerably superior to that of any other diffusion pump of which I am aware.

For proper operation, I have found it advantageous to maintain the temperature of the pumping vapors flowing from the boiler to the pump substantially constant. To this end, I automatically control the amount of heat supplied to the pumping fluid in the boiler according to vapor temperature measured by a thermostat in the tube 99 in the upper part of the boiler. Suitable control circuits for this purpose are diagrammatically shown in Fig. 5. In this figure T represents a thermostatic switch contained within boiler tube 99 and set to open and close, at temperatures above and below a predetermined desired vapor temperature, respectively, an electric circuit through wires W¹ and W². H are cartridge type electric heaters included in the boiler tubes 88 within the pumping fluid, there being eight such heaters, four at each end of the boiler, indicated in the diagram. One terminal of each of the heaters is connected to a wire W³. The other terminal of three of the heaters of each bank of four is connected to the wire W². The other terminal of the fourth or end heater of each bank is connected to the wire W¹. Wires W² and W³ are respectively connected to the lead terminals L¹ and L² of a magnetic starter switch M which is connected to the leads P¹ and P² of a single phase power circuit.

When the magnetic switch is closed the three heaters at each end which have their terminals connected to the wires W² and W³ always receive current. However, as the wire W¹ is connected to the circuit, through wire W², only by the thermostatic switch T, the end heaters of each set which have their terminals connected across the wires W², W¹ will receive current only while the switch T is closed and are therefore cut in and out of the circuit by opening and closing of the switch T according to variations in vapor temperature.

The particular system shown is suitable for operation of 230 volt, 1200 watt cartridge heaters of standard make from a 115 volt, single phase, A. C. current. By connecting only part of the heater capacity through the thermostatic switch, extreme fluctuations in vapor temperature are avoided.

The electric system shown also includes an automatic emergency shut-off in case the pumping fluid or the pump itself become overheated for any cause. As shown, this consists of a thermostatic switch T¹ located in the boiler tube 92 which is located within the pumping liquid in the boiler and a thermostatic switch T² contained in section 89 of pipe 88 of the water cooling system, these switches being connected in series by wires W⁴ and W⁵ into the push button control circuit, PB, to the magnetic starter switch M, so that the switch closing circuit of switch M will be closed only while both the thermostatic switches T¹ and T² are closed and the switch M will open, cutting off the current to the heaters,

when either of the switches T¹ or T² opens. If an automatic shut-off control is not desired, the thermostats T¹ or T² may be connected into a circuit with a signal light or bell.

It will be understood that I have shown and described herein only a preferred embodiment of the invention and that changes may be made in details of the specific construction shown without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. In a diffusion pump, the combination of means forming a pumping passage, jet means for diffusing pumping vapor into said passage, a boiler, means for conducting a pumping vapor from said boiler to said jet means, means for heating a liquid in said boiler to supply pumping vapor to said conducting means, and thermostatic control means interposed in the path of flow of said pumping vapors to said jet and connected to said heating means to regulate the heating of said liquid by said heating means in response to changing temperatures of said vapor.

2. In a diffusion pump, the combination of means forming a pumping passage, jet means for diffusing pumping vapor into said passage, a boiler, means for conducting a pumping vapor from said boiler to said jet means, means for heating a liquid in said boiler to supply pumping vapor to said conducting means, and thermostatic control means responsive to temperature change changes within said boiler and connected to said heating means for regulating the operation thereof to maintain the temperature of the pumping vapors leaving the boiler substantially constant.

3. In a diffusion pump, the combination of means forming a pumping passage, jet means for diffusing pumping vapor into said passage, boiler means, means for conducting a pumping vapor from said boiler means to said jet means, means for heating a liquid in said boiler means to supply said pumping vapor to said conducting means, and means for automatically regulating the operation of said heating means according to the temperature of said vapor flowing to said jet means to maintain said temperature substantially constant.

4. In a diffusion pump, the combination claimed in claim 3, wherein said heating means includes an electrically operated heater and said regulating means includes a thermostatic switch connected in the electric power circuit to said heater and interposed in the path of flow of vapor from said liquid to said jet means to open and close said circuit at predetermined temperatures of said vapor.

5. A diffusion pump having, in combination, a vertically disposed duct forming a pumping passage having an inlet at the upper end, a pumping fluid boiler below said duct, a tubular vapor chimney rising from said boiler into said passage, and jet means for discharging pumping vapors from said chimney into said passage comprising a horizontal row of apertures through said chimney wall, a first deflector extending outwardly from said chimney below said apertures and thence upwardly above said apertures with its upper edge spaced from the chimney to provide an upwardly directed channel for the vapors flowing through said apertures, and a second deflector extending outwardly and downwardly from the chimney above said first deflector in spaced relation to the upper edge of said

first deflector and providing between itself and said first deflector a downwardly directed channel for the escape of vapors from between said first deflector and the chimney into said pumping passage.

6. A vapor pump as claimed in claim 5 wherein said first deflector is provided with an outwardly and downwardly sloping upper edge.

7. In a diffusion pump, the combination of duct means forming the outer wall of a pumping passage, means for diffusing pumping vapors into said passage, means for circulating a cooling medium over the outer wall of said passage adja-

cent the outlet end thereof and baffle means in said passage adjacent the outlet end thereof, said baffle means comprising a series of plates within said passage extending transversely and spaced longitudinally thereof, said plates each providing a reduced opening between the center and a side wall of said passage for the flow of a stream of vapors and gases toward said outlet end, and said plates arranged with said openings provided by successive plates staggered less than 180° about the axis of said passage to produce an angular flow of said stream along said passage wall.

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CERTIFICATE OF CORRECTION.

Patent No. 2,386,299.

October 9, 1945.

JAMES R. O. DOWNING.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 48, strike out the word "each" first occurrence; and second column, line 32, before "changes" strike out "change"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 18th day of December, A. D. 1945.

Leslie Frazer

(Seal)

First Assistant Commissioner of Patents.

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the outlet end thereof and baffle means in said passage adjacent the outlet end thereof, said baffle means comprising a series of plates within said passage extending transversely and spaced longitudinally thereof, said plates each providing a reduced opening between the center and a side wall of said passage for the flow of a stream of vapors and gases toward said outlet end, and said plates arranged with said openings provided by successive plates staggered less than 180° about the axis of said passage to produce an angular flow of said stream along said passage wall.

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