March 15, 1949. J. G. BAXTER 2,464,369

EJECTOR AND CONDENSATION PUMP

Filed Feb. 16, 1945

FIG. 1.

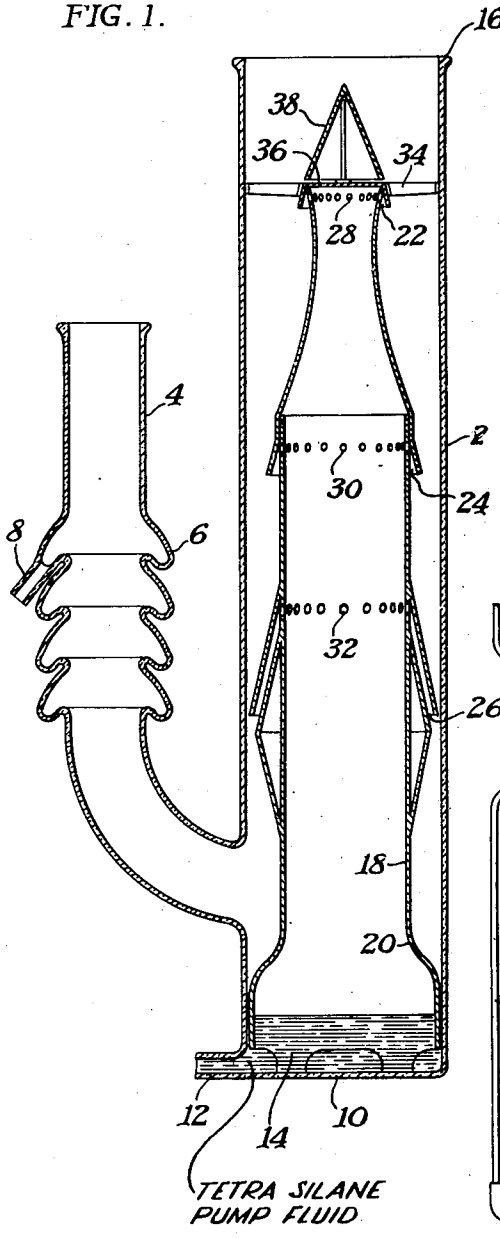
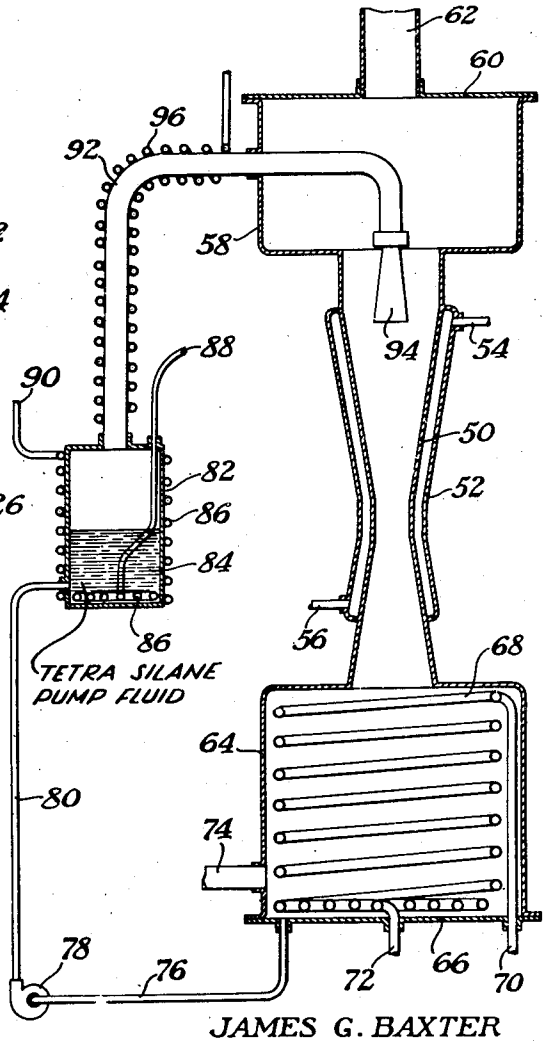


FIG. 2.



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EJECTOR AND CONDENSATION PUMP

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9 Claims. (Cl. 230—101)

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This invention relates to improved ejector and condensation pumps.

It is known to use organic fluids in condensation and ejector type pumps; see, for instance, Hickman and Kuipers U. S. patent application 44[illegible],732, filed May 20, 1942, now U. S. Patent 2,379,436, issued July 3, 1945, and Hickman, "Journal of the Franklin Institute," 221, February 1936, pages 215–235, and March, pages 383–402. The pump fluids which have heretofore been used, such as esters of phthalic and sebacic acids, have not been entirely satisfactory because: (1) they are thermally decomposed during use in a pump forming minute amounts of decomposition products which limit the vacuum which the fluid will produce; (2) after exposure to air at elevated temperatures (e. g. when air is admitted accidentally to the pump during operation), the ultimate vacuum of the fluids is not quickly reattained. This is due to the formation of decomposition products of relatively high vapor pressure which are not easily eliminated during pumping, probably because their molecular weight is not sufficiently different from that of the pump fluid itself. The ability to recondition quickly is a very desirable property for a pump fluid; (3) they tend to back-stream slightly, i. e., vapors from the jet nozzle pass backwards into the receptacle being evacuated.

This invention has for its object to provide improved condensation and ejector pumps and working fluids. Another object is to provide improved condensation and ejector pumps actuated with improved organic working fluids. Another object is to provide improved pumps actuated with organic fluids which are superior to heretofore known pump fluids in the foregoing respects. Other objects will appear hereinafter.

These and other objects are accomplished by my invention which includes an ejector or condensation type pump actuated with a tetra silane derivative. The pump in accordance with my invention involves a pumping chamber, a jet nozzle adapted to form a jet traversing the pumping chamber, a supply of the tetra silane derivative, means for vaporizing the silane derivative and for delivering the vapors to the jet nozzle whereby they pass as a high velocity stream through the pumping chamber and entrain gases to be pumped from the closed receptacle being evacuated.

In the following description I have given some of the preferred embodiments of my invention but it is to be understood these are given by way of illustration and not in limitation thereof.

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In the accompanying drawings I have illustrated two of the preferred embodiments of my invention wherein:

Fig. 1 is a vertical section of a condensation pump embodying my invention;

Fig. 2 is a vertical section of an ejector pump embodying my invention.

Referring to Fig. 1, numeral 2 designates a cylindrical pump casing to the lower portion of which is attached a conduit 4 which leads to a backing pump (not shown). Conduit 4 is provided with a plurality of fractionating lobes 6 to which is attached a conduit 8 for removing the lighter portions. Numeral 10 designates an integral base for the pump casing 2, to which is attached a conduit 12 through which pump fluid 14 may be introduced into the boiler and withdrawn therefrom. Numeral 16 designates a ground joint which is adapted to be attached to the system to be evacuated.

Numerial 18 designates a cylindrical chimney concentric with casing 2 which is provided with an expanded lower portion 20 which closely approaches the wall of casing 2 at its lower point. Numerals 22, 24 and 26 designate a plurality of ejector nozzles which are fed by vapors rising upwardly in chimney 18 and passing outwardly respectively through holes 28, 30 and 32. Numeral 34 designates a centering spider integral with umbrella jet cap 36 and numeral 38 designates a streamlining member for the gases being pumped.

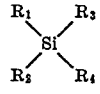
Referring to Fig. 2, numeral 50 designates a diffuser tube provided with a jacket 52 through which cooling fluid is introduced by way of conduit 54 and removed by way of conduit 56. The top of diffuser tube 50 is integral with an intake chamber 58 provided with a gas-tight cover plate 60, which is provided with an intake conduit 62 connected to the system to be evacuated (not shown). The lower part of diffuser tube 50, which may be considered the pumping chamber, is integral with condensing chamber 64 provided with a gas-tight base plate 66 and with an internal cooling coil 68 through which cooling fluid is circulated by introduction and withdrawal through conduits 70 and 72. Numeral 74 designates a conduit which connects to a backing pump (not shown). Numeral 76 designates a conduit connected with the base of the cooling chamber 64 which leads to pump 78, the exhaust side of which is connected to a conduit 80 which leads to the inside of boiler 82, which contains a supply of pumping fluid 84. Numeral 86 designates an internal and external heating coil supplied with heating fluid by introduction and withdrawal

through conduits 88 and 90. Numeral 92 designates a vapor supply tube carrying vapor from boiler 82 to ejector nozzle 94. Conduit 92 is provided with a heating coil 96 to maintain the vapors passing therethrough in a heated condition and preventing condensation.

In operating the apparatus illustrated in Fig. 1 a suitable tetra silane derivative is introduced into the lower portion of casing 2. This lower portion, which acts as a boiler, is then heated. Conduit 4 is connected to the backing pump (not shown) and the top part of casing 2 at 16 is connected to the system to be evacuated. Vapors pass upwardly through chimney 18 and issue through openings 30, 32 and 28 into jets 26, 24 and 22. These vapors are thus formed into downwardly directed jets which entrain gases from the system to be evacuated and force them successively from the upper jet to the next lower jet and eventually to conduit 4. Spent vapors condense on the inside wall of casing 2 and the liquid condensate flows downwardly between the narrow space existing between casing 2 and chimney 20 and are thus returned to the boiler where they are re-used. Pumped gases are forced into conduit 4 and are removed by the backing pump.

In operating the apparatus illustrated in Fig. 2, a supply of a suitable silane derivative is introduced into reservoir 82. Conduit 74 is connected to the backing pump and conduit 62 is connected to the system to be evacuated. Cooling fluid is circulated through coil 68 and through jacket 52. Heating fluid is circulated through heating coil 86 to heat the pump fluid in 82 to vaporizing temperature. Heating fluid is also circulated through conduit 96. Vapors thus generated pass outwardly through conduit 92 and are ejected through ejector nozzle 94. Gases from the system to be evacuated pass through conduit 62 and are entrained in the stream of vapors issuing from jet nozzle 94. The gases are thus forced along with the vapors down into condensing chamber 64. Here all the vapors are condensed and the liquid withdrawn through conduit 76 by pump 78 and returned to boiler 82 through conduit 80 for re-use. Pumped gases are removed from the cooling chamber 64 by way of conduit 74.

The improved pump fluids, as indicated, have the formula



wherein R_1 to R_4 may be alkyl or aryl groups, substituted or unsubstituted, such as butyl, octyl, decyl and phenyl groups. Tetra-n-octyl-silicane and tetra-n-decyl-silicane have been found to be particularly satisfactory as condensation pump actuating fluids, while the lower molecular weight derivatives having a molecular weight of about 116 to 400 and a boiling point at 1 mm. of about 35° to 90° C., such as those ranging from tetra methyl silicane to diheptyl dioctyl silicane, work better for pumps constructed and operated on strictly ejector principles. Some of the arylderivatives tend to have relatively high melting points and in cases where this is undesirable a mixed arylalkyl derivative will usually have a lower melting point.

These new silane compounds have exceedingly high thermal stability. For example, a sample of tetra-n-octyl silicane was refluxed at its boiling point (410° C.) in air for a period of fifteen minutes. The liquid was unchanged in color and appearance after this severe exposure to heat and air. A sample of 2-ethyl-hexyl sebacate (Octoil-S) (the best condensation pump fluid heretofore used) darkened and sebacic acid was liberated after similar exposure. Tetra-n-octyl-silicane in a 3-stage pump gave a vacuum of 1×10^{-7} mm. In the same pump Octoil-S fluid gave an ultimate vacuum of 3×10^{-7}.

The superior resistance of the silicane compounds to thermal and oxidative decomposition and their ability to rapidly re-establish pumping action after such exposure is shown by the following experiment. A three stage pump containing tetra-n-octyl silicane was permitted to pump down to a vacuum of 1.5×10^{-7} mm. The pump was then opened to the air for five minutes with the heat on. Following this drastic treatment the operating fluid pumped the system down to an ultimate vacuum of 1×10^{-7} in three hours. Octoil-S fluid, when used in the same pump under the same conditions, after similar exposure to air at the same heat input required twelve hours to pump the system down to an ultimate vacuum of 4×10^{-7}. This superior resistance of the silicon compounds to decomposition by air at elevated temperatures is of importance in the evacuation of electronic tubes where periodic admissions of air to the pumping system occur.

Tetra-n-octyl silicane was definitely superior to Octoil-S fluid in one other property, namely its negligible tendency to backstream or to wander through the pumping system. This property of a pump fluid cannot be predicted but must be determined experimentally. The superiority of the silicane fluids in this respect should again make them useful in evacuating electronic tubes where fluid wandering into the tube must be kept to a minimum.

The following example illustrates one method for preparing these derivatives, although it is apparent that any other method of preparation can be used. To a three necked flask equipped with a mercury sealed stirrer, a condenser fitted with a calcium chloride tube, and a dropping funnel also protected with a calcium chloride tube was added magnesium turnings (61 g., 2.5 mols.) and dry ether (240 cc.). n-Octyl bromide (10 g.) and a crystal of iodine were then added. The reaction was started by gentle heating with a Bunsen flame causing steady refluxing. The reaction was continued by the addition of n-octyl bromide (472 g.) (remainder of 2.5 mols.) in dry ether (240 cc.) added through the dropping funnel. Occasional cooling of the flask with cold water or with a dry ice bath was necessary. When all the alkyl halide had been added, the solution was refluxed for 30 minutes, then cooled to room temperature. Silicon chloride (69.5 g.: .42 mol.) in benzene (120 cc.) was then added slowly with stirring. During the latter stages of the addition, a copious white precipitate of magnesium chlorobromide began to separate. The contents of the flask were then refluxed for two hours. The solvent was distilled at atmospheric pressure and the contents of the flask, a white solid, were heated at a bath temperature of 145–155° C. for two hours. The flask was cooled and partially filled with ice cubes. Considerable heat was evolved. After the heat subsided, 30% sulfuric acid was added to dissolve the white magnesium basic salt. The upper layer of silane was separated. The aqueous layer was ether extracted and silane and the extract were combined. The extract was washed with water, 5% potassium carbonate and water. After drying, the solvent was removed

and crude tetra-n-octyl silicane (403 g.) was obtained.

This was distilled in a fractionating low pressure still. Low boiling forecuts were separated (B. P. 44–137° head temperature; 120–190° pot temperature; 30 microns pressure; 101 g.). Tetra-n-octyl-silicane then distilled (137–140° head temperature; 190–192° pot temperature; 259 g.). Thus 65% of the crude reaction mixture consisted of tetra-n-octyl-silicane.

What I claim is:

1. In combination a pumping chamber having an inlet and outlet conduit, a jet nozzle adapted to form a jet transversing the pumping chamber in a direction toward the outlet conduit, a supply of a compound of the formula SiR_4, in which R is selected from the group consisting of alkyl and aryl radicals, means for vaporizing said silane compound, means for delivering the vapors to the jet nozzle whereby gases in the inlet conduit are entrained in the jet of vapors and forced into the outlet conduit.

2. In combination a pumping chamber, an inlet and an outlet conduit connected to said chamber, a jet nozzle adapted to form a jet transversing the pumping chamber in a direction toward the outlet conduit, condensing means positioned near the outlet conduit, a supply of a compound of the formula SiR_4, in which R is selected from the group consisting of alkyl and aryl radicals, means for vaporizing the silane compound, means for delivering the vapors to the jet nozzle, means for conveying condensate from the condenser to the supply of silane compound whereby during operation gases in the inlet conduit are entrained in the jet of vapors and are forced into the outlet conduit and the spent silane vapors are condensed and returned to the silane compound supply for re-use.

3. In combination a pumping chamber, an inlet and an outlet conduit connected to said chamber, a jet nozzle adapted to form a jet transversing the pumping chamber in a direction toward the outlet conduit, a supply of a tetra alkyl silicane, means for vaporizing said silicane, means for delivering the vapors to the jet nozzle whereby gases in the inlet conduit are entrained in the jet of vapors and forced into the outlet conduit.

4. In combination a pumping chamber, an inlet and outlet conduit connected to said chamber, a jet nozzle adapted to form a jet transversing the pumping chamber in a direction toward the outlet conduit, a supply of tetra-octyl silicane, means for vaporizing the tetra-octyl silicane, means for delivering the vapors to the jet nozzle whereby gases in the inlet conduit are entrained in the jet of vapors of tetra-octyl silicane and forced into the outlet conduit.

5. In combination a pumping chamber, an inlet and outlet conduit connected to said chamber, a jet nozzle adapted to form a jet traversing the pumping chamber in a direction toward the outlet conduit, a supply of a tetra-alkyl silicane within the range of tetra methyl to diheptyl dioctyl silicane, means for vaporizing the silicane, means for delivering the vapors to the jet nozzle whereby gases in the inlet conduit are entrained in the jet of vapors of the silicane and forced into the outlet conduit.

6. Means for evacuating a closed system which comprises a condensation pump containing as a working fluid a compound of the formula SiR_4, in which R is selected from the group consisting of alkyl and aryl radicals.

7. Means for evacuating a closed system which comprises a condensation pump containing as a working fluid a tetra alkyl silicane.

8. Means for evacuating a closed system which comprises a condensation pump containing tetra-octyl silicane as a working fluid.

9. Means for evacuating a closed system which comprises a condensation pump containing as a working fluid a tetra-alkyl silicane within the range of tetra methyl to diheptyl dioctyl silicane.

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