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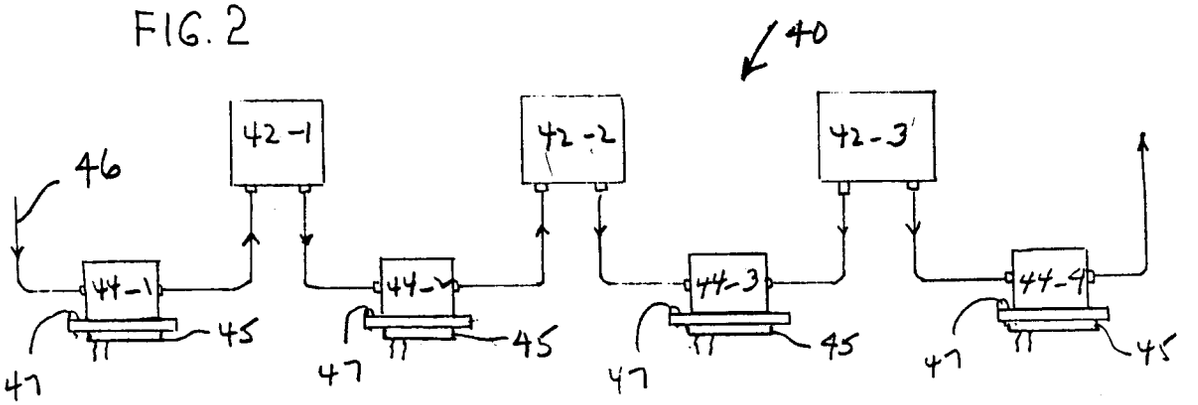
(54) Gas pumping system with liquid elimination feature.

(57) A plural pumping stage system (40) for pumping a gas flow of products inclusive of aqueous and/or organic solvent fluids is provided with evaporators (44–1,44–2,44–3,44–4) at locations before and/or after pump stages (42–1,42–2,42–3), or at an in–terstage location to evaporate any products con–densed liquid presence back into the gas flow thereby to prevent damage to pump units (42) and other components of the system, the evaporators being provided as heated section lengths (98) of the conduits (86,90,88) through which the gas flow passes, or as traps (44) inserted in these conduits and in which any liquid presence in the gas flow is trapped and collected with any collection being heated with a trap heater (45) to vaporize it back into the gas flow so ultimately all products are delivered in gas form to an end point location.

FIG. 2



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BACKGROUND OF THE INVENTION

The present invention relates to pumping systems and, more particularly, to gas pumping systems in which liquid condensation due to compression is prevented from entering a pump unit and causing pump damage and/or system malfunction.

Pumps used for handling a gas flow or transfer include, among others, diaphragm types, bellows types, vane types and in some applications, piston types. A type selected for a given use purpose can depend on a number of factors such as nature of the product to be handled, function of pressurizing or evacuating a space etc.

Need for gas handling is widespread in industry but is of particular prevalence in the biotechnology and chemical industry sectors where there exists diverse and many pumping requirements associated with sampling, transfer and sample concentration operations. In connection with these operations and regardless of the type of pump involved in a given situation, there is a common limitation that must be dealt with, viz., all the pump types enumerated above generally operate at high compression ratios which can result in condensation of vapor forms of water and less volatile organics from a gas flow into liquid state in the pumps or system piping. These pump types have very low tolerance to liquid presence in the pumping stage. Aside from the potentially destructive risk the liquid represents to the pump structure, liquid accumulation in a pumping system designed for example, for vacuum service, can effect system operating efficiency to the extent that intended vacuum values in a space cannot be achieved. The prior art has sought to deal with liquid presence in a pumping system by using cold traps to condense unwanted liquid vapor from a gas flow. Cold traps require refrigeration, are generally provided as bell jars, and do not always succeed in condensing certain organics from a gas stream since such may require considerably lower condensing temperature than the cold trap can reach.

OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a gas products flow pumping system with means and manner of operation to eliminate liquid presence therein which overcomes drawbacks of the prior art.

Another object is to provide a gas pumping system which includes evaporator sections therein located relative to system pumping stages so as to evaporate any liquid in the system to vapor before such liquid could enter into and damage a pump.

A further object is to provide a gas pumping system with liquid eliminating evaporator sections that conveniently are embodied in conduits inletting to and outletting from pump units.

A still further object is to provide a gas products flow pumping system with liquid presence elimination capacity so that overall system operation is enhanced and made more effective to its designed purpose.

Briefly stated, there is provided a plural pumping stage system for pumping a gas flow of products inclusive of aqueous and/or organic solvent fluids, the system being provided with evaporators at locations before and/or after pump stages, or at an interstage location to evaporate any condensed liquid presence back into the gas flow thereby to prevent damage to pump units and other components of the system, the evaporators being provided as heated section lengths of the conduits through which the gas flow passes, or as traps inserted in these conduits and in which any liquid presence in the gas flow is trapped and collected with any collection being heated with a trap heater to vaporize it back into the gas flow so ultimately all products are delivered in gas form to an end point location.

In accordance with the above-given as well as other objects of the invention, there is provided a pumping system for removing products inclusive of aqueous and/or organic solvent fluids as a gas flow from a space and delivering said products to a products end point location. The system includes a plurality of pump units with these pump units being staged such that products gas flow from the space passes serially through successive stages from a first to a last of the pump units through conduits interconnecting the successive ones of the pump units. An evaporator is provided in at least one a first of such interconnecting conduits and operates to vaporize any liquid form fluid present in the gas products passing through such first interconnecting conduit. This vaporization converts the liquid form to gaseous form so that all gas products entering the succeeding stage pump unit are essentially free of liquid. The evaporator is positioned below an outlet from and in inlet to the pump units the first interconnecting conduit connects.

The evaporator can be a heated length section of the interconnecting conduit, heat being provided thereto by a heater encircling the length section. It also can be a trap interposed in the interconnecting conduit and in which liquid can be trapped and collected with collected liquid being heated and vaporized by heat supplied from a heater embodied with the trap.

In another aspect, the invention provides a pumping system for removing products inclusive of aqueous and/ or organic solvent fluids as a gas

flow from a space and delivering said products to a products end point location. The system includes a plurality of separate pump units with each pump unit having an inlet and an outlet, the inlet of at least one pump unit having a communicative course connection with the space and there being a communicative course connection of the end point location with one of the pump outlets. An evaporator section is provided in both the communicative course connecting the inlet of the one pump unit and the space, and the communicative course connecting the end point location and the said one pump inlet. These evaporator sections operate to convert any liquid as may be present in the products gas flow passing therethrough to gaseous state, with the evaporators being located at an elevation below any communicative course connection to said space, any pump inlet and outlet, and said end point location.

The above, and other objects, features and advantages of the present invention will become apparent from the following description read in conjunction with the accompanying drawings, in which like reference numerals designate the same elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic depiction illustrating the principle of the invention by which an evaporator section can be placed in a location before and/or after a pumping stage to eliminate liquid presence entry to the pumping stage or at another location downstream of the pump stage, a single only pump stage being shown as sufficient for the purpose of describing the principle involved;

FIGURE 2 is a schematic showing of a plural pumping stage (three stage) system wherein the stages are serially arranged so that outlet from an earlier stage is inletted to the next stage, evaporator sections being provided before and after each pump unit;

FIGURE 3 is a schematic depiction showing three pump units arrayed in single stage configuration so that each pump unit is connected directly to a space to be evacuated, and directly to the products gas flow end point location, this arrangement employing manifolds to which pump inlets and outlets have common connection, with a single evaporator section serving as a pre-pump liquid eliminator;

FIGURE 4 is a schematic depiction of a serially arranged two-stage pump system in which the evaporator sections used are defined by conduit section lengths which section lengths are encircled by heater units to effect evaporation of liquid in the sections;

FIGURE 5 is a schematic depiction of the Figure 2 system except a single heater is employed to heat all traps in the system instead of individual trap heaters as in Figure 2; and

FIGURE 6 is a transverse sectional view of one of the evaporator sections depicted in Figure 4 illustrating the encircling character of the heaters used in that Figure 4 embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides a pumping system particularly intended for handling of gas flow such as is involved, e.g., in evacuating a space and in the course of which condensable aqueous or less volatile organic solvents are drawn therefrom, which solvents if condensed to liquid state could cause serious damage to pump units in the system. Pump types that could be involved include diaphragm, bellows, vane and piston, and the system generally would involve plural stages, e.g., three serial stages employed to evacuated a space to very low pressure of say, 2 Torr.

The invention is especially suited for use in large capacity centrifugal dryers such as a SPEEDVAC as manufactured by SAVANT Instruments, Inc. wherein biological samples are dried and copious amounts of solvent principally water are removed from specimens during the drying operation.

As will be noted from the below given description, evaporator sections or traps are used at locations intervening a space wherein solvent is present and a first encountered pump stage, intermediate pumping stages, and after a last pump stage. At locations up to a last stage pump, the evaporator sections serve to remove liquid form of solvent from gas products flow so that same is not present within a pump unit where it could damage the pump unit working components since many pump types designed for gas handling service cannot withstand the abuse liquid can wreck therein. An evaporator section or trap after a last pumping stage can be used to eliminate liquid presence in a system discharges line and the system back pressure it can produce. This is advantageous in regard to a plural stage vacuum pump system designed to evacuate a space to near complete vacuum condition since system back-pressure can impede achieving intended and needed space vacuum condition.

The presence of condensables as a potential system hazard can exist in various manners. For example, the Gel Dryer described in commonly owned patent no. 5,025,571 produces significant early surge of liquid draw from a space which must be trapped before it can enter the first stage of a

plural-stage diaphragm unit. The operation of a SPEEDVAC dryer on the other hand represents a situation wherein generally significant liquid removal is involved and to an extent that accumulation of liquid at a number of system points could occur - it is elimination of this accumulation potential that is achieved with the invention.

Figure 1 depicts the principles involved with the invention. A SPEEDVAC vacuum, centrifugal dryer 10 includes a rotor 12 on which is carried a number of specimen holders 14 containing, e.g., biological specimens which are to be dried, i.e., have solvent therein separated from the specimen composition. During drying, the rotor rotates at high speed, heat may be applied to the space 18 within the dryer enclosure, and that space is connected via line 20 to a vacuum pump unit 22, that depicted being a single-stage diaphragm pump, but it being understood that a single stage is here shown only for descriptive purpose as the invention is intended for use primarily in plural-stage and especially three or more stage systems.

Intervening the dryer 10 and pump 22 is a trap 24 located a distance below the space 18 and the inlet to pump unit 22. The trap unit is used to trap and retain any liquid solvent as is drawn from the specimen so that outlet flow from the trap and entering the pump unit is essentially gas products devoid of any liquid solvent presence that could damage the inner vitals of the pump structure. Condensable forms of solvent that are retained in the trap are evaporated therein since a e.g., electrically operated heater 26 supplies heat to the trap to vaporize same and it in such vapor state, enters the gas products stream going to the pump unit.

The gas products stream in the pump is pressurized to a certain degree and is passed out of the pump unit and into another or post pumping trap 30, this trap functioning like trap 24 to trap and collect condensables in the trap rather than allowing for possibility that condensing could occur in discharge line 32 wherein it represents a back-pressure producing presence. An impingement plate 34 can be provided inside the trap to facilitate effecting liquid separation from the gas flow, this being the same device as the baffle plate described in the above noted patent 5,025,571. Also, a heater 36 is employed to vaporize collected liquid solvent so that the solvent removed from the specimen, ultimately discharges to a solvent end point location via line 32.

By using a post pump stage located trap, the discharge to an end point location can be made at various locations, the trap 30 of course, being located below the pump outlet. By locating the traps 24, 30 below the pump stage and space being evacuated, the lines connecting same to these are self draining to collection spaces whence that are evaporated to vapor form so no liquid solvent enters a system component or the environment.

Figure 2 shows a plural (at least three) stage pumping system embodying the present invention. The system 40 includes respective first, second and third stage pump units 42-1, 42-2, and 42-3 which are arranged in serial succession so that discharge from stage one enters the next stage and so on until the discharge from the last stage is to the end point location. Pump unit 42-1 takes suction from a space (not shown) which is being evacuated through line 46. System 40 also includes a number of traps 44-1, 44-2, 44-3, and 44-4. These traps, which each has an associated heater 45 and temperature controller 47, serve the purpose described in Figure 1 and include interstage traps 44-2 and 44-3. In its broadest consideration, the invention mandates that there be in a plural, serial arranged pumping stage, a trap at least in the interstage between the first and second stages of pumping since this location is where greatest possibility of solvents condensables condensing exists.

With regard to incipient condensation possibility, it is to be noted that such can occur quite readily in a conduit simply due to the conduit having a diameter sufficiently large to promote such occurrence.

A system using plural pump units but not staged in succession but rather, the pump units being arrayed as single stage configuration, is shown in Figure 3. This system 50 includes three pump units 52 each having direct connection to a space to be evacuated, such connection being to a common manifold 53 which in turn is connected to an outlet side 54 of a trap 56, the inlet to the trap being connected by line 58 to the space (not shown). Similarly, a manifold 60 connects each pump unit outlet to the inlet of a post-pumping trap 62, the trap outlet via line 64 being to a gas end point location.

Figure 5 shows a system 70 arranged like the Figure 2 system 40 but provided with a single common heater unit 72 having a single controller 74 serving in place of the individual such units used with the Figure 2 traps. As with the other trap heaters, heater 72 is in good intimate thermally conductive contact with the trap structures to assure heat input to the trap interiors to effect evaporation of any liquid solvent collected therein.

Liquid solvent elimination need not be practiced only with trap units as shown in Figures 1-3 and 5. It also can be handled by using evaporator sections in various of the conduits in the pumping system. An example of such embodiment is shown in the Figure 4 system 80. System 80 has plural (two) pumps units 82, 84, connection to the space

being evacuated being by conduit 86 connecting the space and the inlet of pump 82. The outlet of pump 84 is via conduit 88 connected to the gas products end point location. An interstage conduit 90 connects the two pump stages. In lieu of using traps, a section length of conduit at locations where liquid solvent could exist (these being shown in dashed lines) are encircled by heaters 92 each in good close intimate contact with the encircled conduit length section structure. The heaters provide sufficient heat to vaporize any liquid state solvent as may exist in the gas flow through the length section so that by the time the gas flow passes beyond that length section, the liquid solvent renters the gas flow as a gas component too and flows onwardly in that state thereby eliminating any source cause for pump damage and/or back pressure in the system discharge line.

Figure 6 shows the construction of the heaters 92. The heater can include a case of inner and outer sheath members 93, 94 of ceramic or other material in between which are sandwich resistance heating elements 95, the sheath being in close conforming contact with the exterior of a conduit length section 98.

It will be understood that "solvents" as used herein is intended to cover a range of the liquids that can be found in specimen compositions, these including water and organic solvents. Further, the organic solvents would include those termed by one of ordinary skill in the art as being less and more volatile forms of solvents.

Having described preferred embodiments of the invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.

Claims

1. In a pumping system for removing products inclusive of aqueous and/or organic solvent fluids as a gas flow from a space and delivering said products to a products end point location, said system including a plurality of separate pump units, each such pump unit having an inlet and an outlet, the inlet of at least one pump unit having a communicative course connection with said space, there being a communicative course connection of said end point location with one of the pump outlets,

   means defining an evaporator section in both the communicative course connecting the inlet of said one pump unit and said space, and the communicative course connecting said end point location and the said one pump outlet, said means being operable to convert any liquid as may be present in the products gas flow passing therethrough to gaseous state, each evaporator section defining means being located at an elevation below any communicative course connection to said space, any pump inlet and outlet, and said end point location.

2. The pumping system of claim 1 in which each communicative course is comprised of a conduit member.

3. The pumping system of claim 2 in which the evaporator section defining means includes a length section of each conduit member, and a heater encircling said conduit section in good thermally conductive contact therewith whereby heat can be conducted from the heater into the conduit length section and therewith to vaporize liquid in the gas flow before the gas flow passes downstream of the conduit length section.

4. The pumping system of claim 2 in which the evaporator section defining means includes a trap in each conduit member to trap and collect liquid in the gas flow before the gas flow passes downstream thereof, and heater means for heating collected liquid to vaporize it whence it becomes an entrant to the gas flow passing downstream of the trap.

5. The pumping system of claim 4 in which each trap comprises a closed housing, an entry length part of the conduit member being connected to a housing inlet and an outlet length part of the conduit member being connected to a housing outlet located remote from the housing inlet.

6. The pumping system of claim 5 in which the heater means comprises a heating element embodied in structure defining a housing bottom wall.

7. The pumping system of claim 5 in which the housing includes a bottom wall structure, the heater means comprising a heater support plate on which said trap housing is received.

8. The pumping system of claim 3 further comprising means for controlling the heater means to control heat input to the conduit length section to predetermined values.

9. The pumping system of claim 4 further comprising means for controlling the heater means to control temperature in the trap to predetermined values.

10. The pumping system of claim 1 in which the plurality of pump units comprises at least three such pump units.

11. The pumping system of claim 10 in which the pump units in the plurality are staged serially such that products gas flow outletting an earlier stage pump are delivered through an interstage conduit to the inlet of the next later pump stage, and means defining an evaporator section in each interstage conduit operable to convert any liquid as may be present in interstage products gas flow to gaseous state.

12. The pumping system of claim 10 in which the pump units in the plurality are arrayed as single stage units each having its inlet in communication in common with the others to said space through a manifold intervening the inlets of each pump unit and said space, and its outlet in communication in common with the others to the end point location through a manifold intervening the outlets and said end point location, one evaporator section defining means intervening the first-mentioned manifold and said space, and another evaporator section defining means intervening the second-mentioned manifold and the end point location.

13. In a pumping system for removing products inclusive of aqueous and/or organic solvent fluids as a gas flow from a space and delivering said products a products end point location, said system including a plurality of pump units in which the pump units are staged such that products gas flow from the space passes serially through successive stages from a first to a last of the pump units through conduits interconnecting the successive ones of the pump units,

an evaporator in at least a first of such interconnecting conduits and operable to vaporize any liquid present in the gas products passing through such first interconnecting conduit to convert it to gaseous form so that all gas products entering the succeeding stage pump unit are essentially free of liquid, the evaporator being located at an elevation below an outlet from and an inlet to the pump units said first interconnecting conduit connects.

14. The pumping system of claim 13 in which the evaporator includes an interconnecting conduit length section, and a heater for heating said length section to thereby vaporize liquid in the gas flow before the gas flow passes downstream of said conduit length section.

15. The pumping system of claim 14 in which the heater encircles said conduit length section and is in good thermally conductive contact therewith.

16. The pumping system of claim 13 in which the evaporator includes a trap for trapping and collecting liquid fluid in the gas flow before the gas flow passes downstream thereof, and heater means for heating collected liquid to vaporize it whence it becomes an entrant to the gas flow passing downstream of the trap.

17. The pumping system of claim 16 further comprising gas flow impingement structure carried in said trap and upon which the gas flow impinges to effect separation of any liquid therein from the gas flow.

FIG. 1

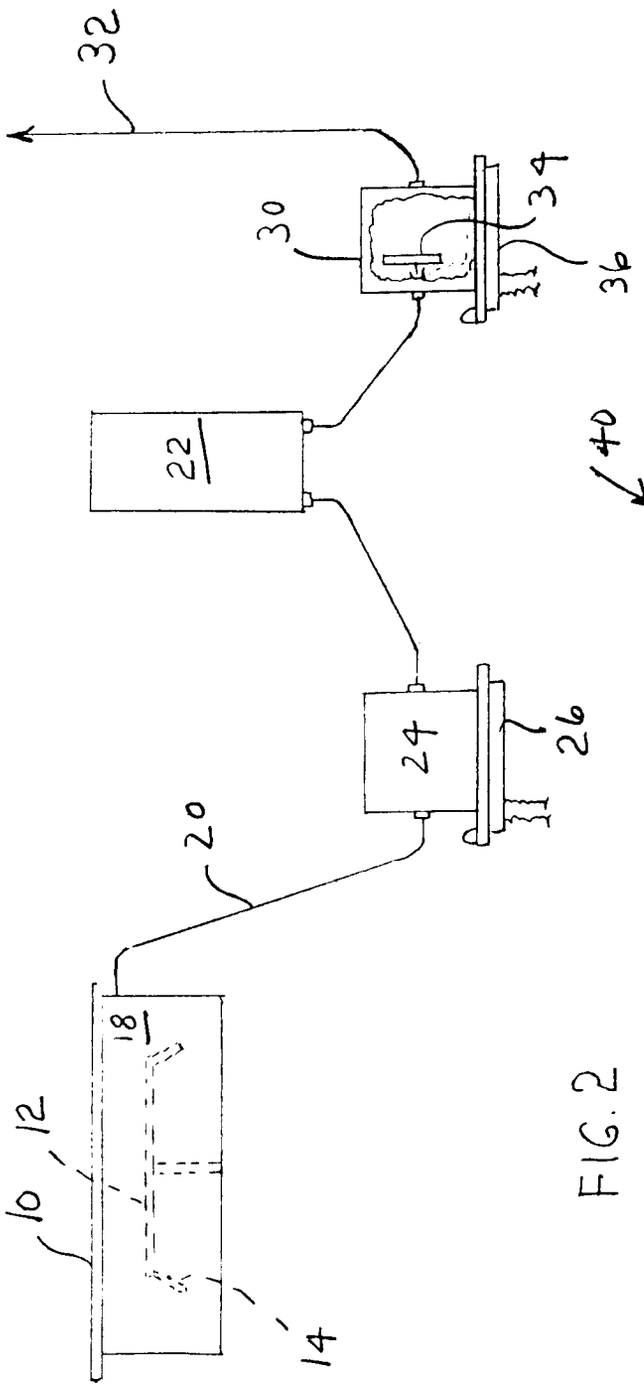
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FIG. 2

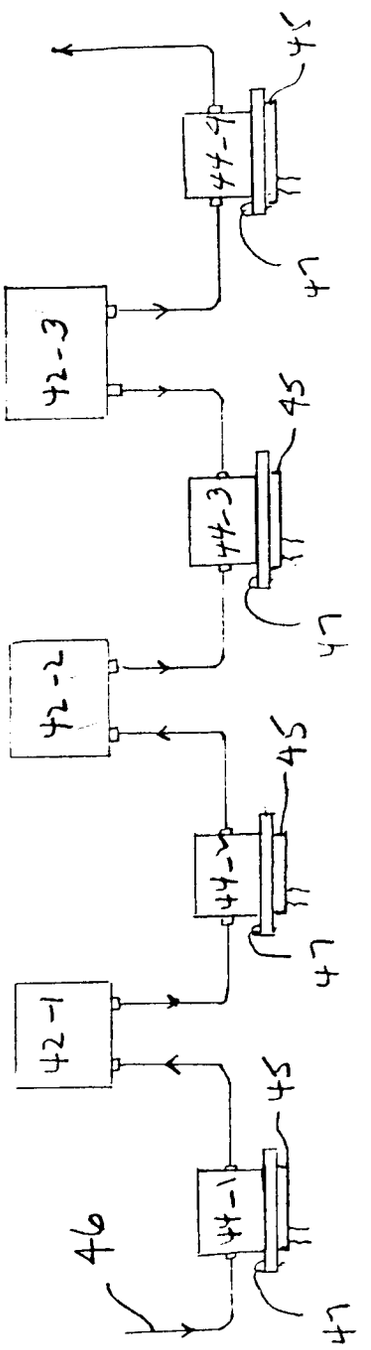
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FIG. 3

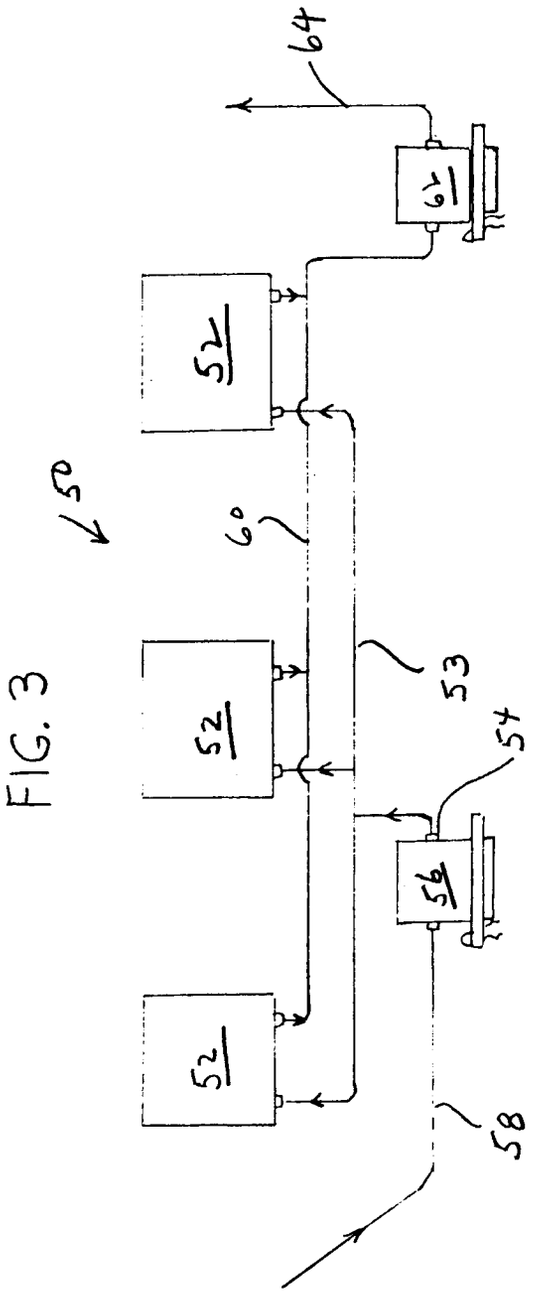


FIG. 4

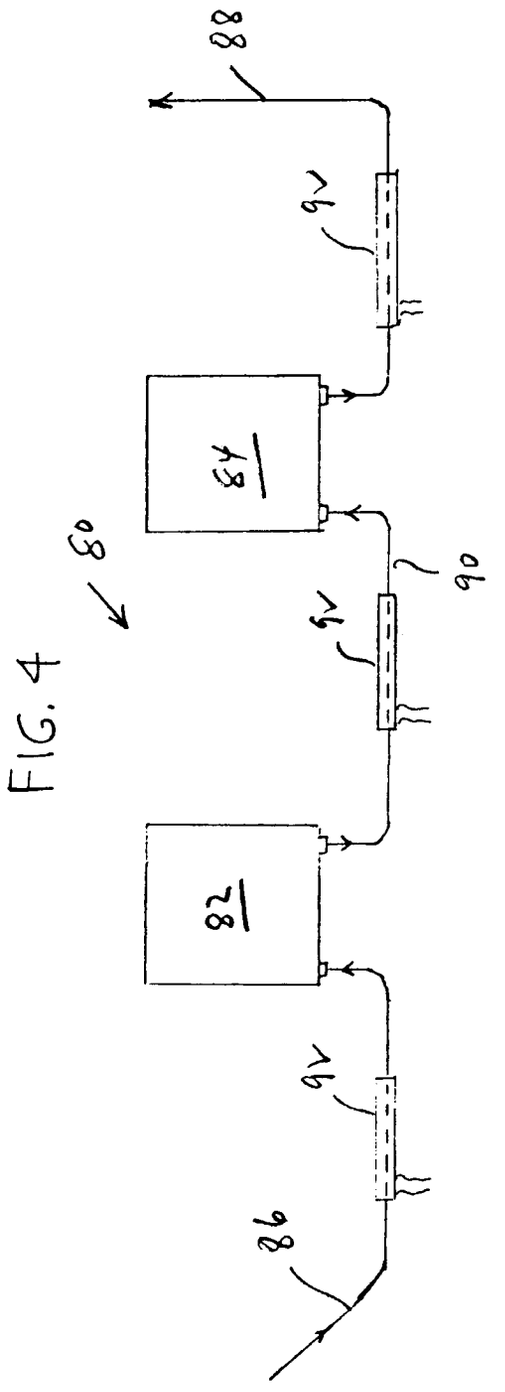


FIG.5

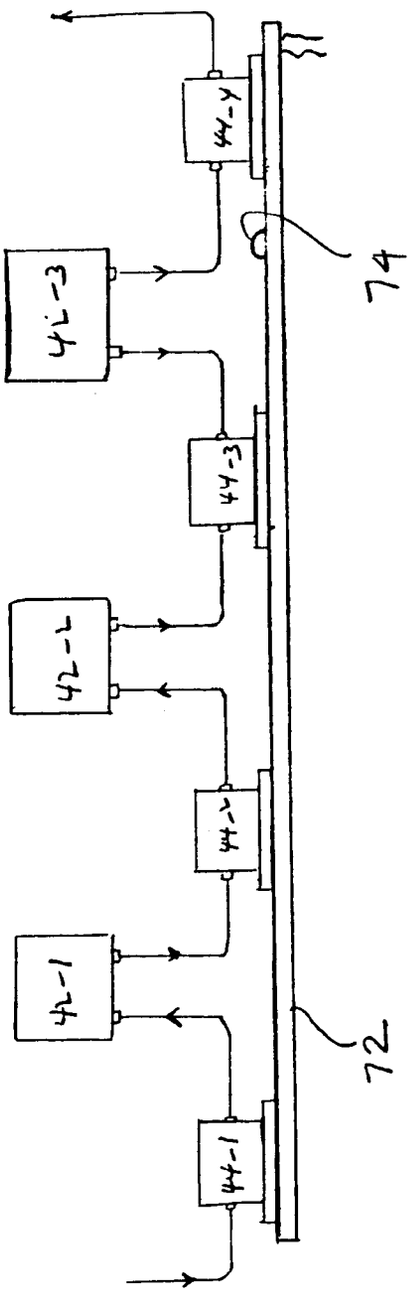
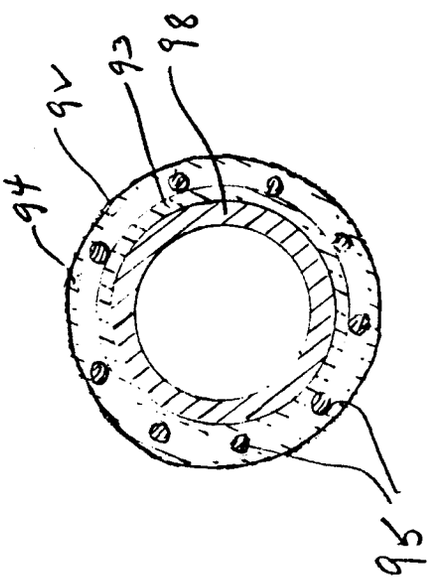


FIG.6



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EUROPEAN SEARCH REPORT

Application Number

EP 92 11 5781

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	US-A-5 025 571 (ZLOBINSKY ET AL) * the whole document *	1,2,4,5, 6,7,9, 13,16,17	F26B5/04 F04B37/20 F04C29/10
A	EP-A-0 448 750 (LEYBOLD AKTIENGESELLSCHAFT) * the whole document *	1,2,3, 10,11, 13,14,15	
A	US-A-3 630 051 (MARTIN) * the whole document *	1,10,11, 13	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F26B F04B F04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 FEBRUARY 1993	SILVIS H.

CATEGORY OF CITED DOCUMENTS

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