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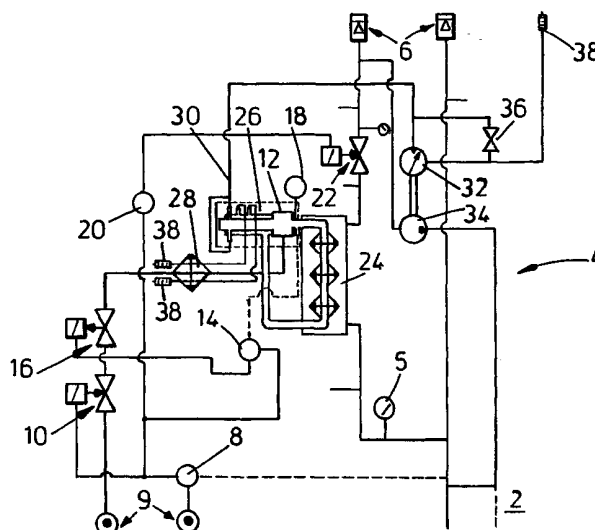
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(54) Title: IMPROVEMENTS IN AND RELATING TO HEAT TRANSFER SYSTEMS AND NOVEL APPLICATIONS FOR SUCH SYSTEMS



(57) Abstract: A method and apparatus for transferring heat to or from a medium wherein a gas, such as air, is delivered to a vortex generator (12) for the generation of a stream of hot and a stream of cold air and the hot or cold air stream is transported to a heat exchanger (24) for exchanging heat energy with a medium in contact therewith. The hot and cold waste air stream may be transported from the vortex tube to a pump (32, 34) to drive the pump and assist the flow of source air through the heat exchanger and/or may include a return conduit to transporting the source air from the heat exchanger around at least part of the vortex generator, for example, by means of a hollow sleeve (26). The invention may be used for a wide range of applications, such as recovery of condensate, refrigeration, air conditioning, heating, distillation or gas transfer.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Title: Improvements in and relating to heat transfer systems and novel applications for such systems.

DESCRIPTION

The present invention relates to an improved heat transfer system and describes novel applications for the use of heat transfer systems.

The use of a vortex tube to provide a source of cool air is well documented in the art. Compressed air is fed into a tube where it is allowed to expand thereby creating a centrifugal field which results in the air separating out into a warm stream situated around the periphery part of the tube with a cool core of air forming in the middle of the tube. The cooled air flows in the opposite direction to the air at the periphery of the tube that becomes heated.

A number of applications that utilize the cool air produced from the vortex have been described in the prior art, such as condensate recovery or removal. However, the systems employed for utilizing the cool stream do have a number of drawbacks, particularly in relation to the energy that is wasted by the system.

Generally, solvent recovery and gas transfer in industrial environments, such as the recovery of volatile solvents in the chemical industry, have required the use of an electrical supply to provide the source of heat or cold which, with the presence of flammable solvents, has to be protected to eliminate the possibility of a source of ignition. Additionally, such systems require extensive pipework for transportation of the cooling water and difficulties often arise with the pumping of liquids to high levels such as in the vent stacks. Many of the present systems also experience difficulties in

maintaining the heat or cold energy from the point of source to the application, which may be some distance away.

It is an object of the present invention to provide an improved heat transfer system of greater efficiency than the systems of the prior art.

A further object of the present invention to provide an improved system that is more environmentally friendly than the systems of the prior art.

Yet a further object of the present invention is to provide a number of novel applications for the use of the heat transfer systems.

Accordingly, a first aspect of the present invention provides an apparatus for transferring heat to or from a medium, the apparatus comprising a gas inlet for delivering gas to a vortex generator for generation of a stream of hot and a stream of cold gas and an outlet for transporting the hot or cold stream of gas, deemed the source gas stream to a heat exchanger for exchanging heat energy with a medium in contact therewith, the other stream being deemed the waste gas stream wherein the apparatus has one or both of the following features:

- (a) a conduit for transporting the waste gas stream from the vortex tube to a pump to drive the pump thereby assisting the flow of the source gas stream through the heat exchanger; and/or
- (b) a return conduit for transporting the source gas stream from the heat exchanger around at least part of the vortex generator.

A second aspect of the present invention provides a method for transferring heat to or from a medium, the method comprising the steps of:

- (a) delivering a gas to a vortex tube for generating a stream of hot and a stream of cold gas;

- (b) transporting the cold or hot gas stream, deemed the source gas stream, from the vortex tube to a heat exchanger for exchanging heat energy with a medium in contact therewith; and
- (c) transporting the other gas stream, deemed the waste gas stream, from the vortex tube to a pump to drive the pump and pull the source gas stream through the heat exchanger.

A third aspect of the present invention provides a method for transferring heat to or from a medium, the method comprising the steps of:

- (a) delivering a gas to a vortex tube for generating a stream of hot and a stream of cold gas;
- (b) transporting the hot or cold gas stream, deemed the source gas stream, from the vortex tube to a heat exchanger for exchanging heat energy with a medium in contact therewith; and
- (c) transporting the source gas stream from the heat exchanger around at least part of the vortex tube.

The gas is preferably air but may be any other suitable gas, such as nitrogen.

Preferably, the apparatus includes a conduit for transporting the waste gas stream from the vortex tube to drive a pump and a return conduit for transporting the source gas stream from the heat exchanger around the vortex tube. Preferably, a hollow sleeve surrounds at least part of the generator for transporting the source gas stream therearound.

A fourth aspect of the present invention provides a vortex generator, the generator comprising an inner tube having an inlet and an outlet and a generator head,

the generator having a hollow sleeve that surrounds at least a part of the inner tube, the sleeve having an inlet and an outlet.

Preferably, the inner tube of the vortex generator is finned to increase the surface area thereof. The generator head is also preferably provided with finning.

The inner tube is preferably provided with at least two outlets, one for the source gas stream and one for the waste gas stream. More preferably, three outlets are provided wherein two of the outlets are for the passage of the waste gas stream. More preferably still, these outlets are provided at the sides of the tube, tangential to each other.

Additionally, the groove depth and angles are preferably adjusted to achieve greater extremes of temperature, ranging from 160°C to - 50°C. In particular, the width of the spinning chamber denotes the angle of which the air or other gas enters the chamber. The depth and shape of the spinning chamber also determines the velocity and flow pattern.

The apparatus and method of the present invention can be used for a wide number of applications. One example is the recovery of condensate from a storage tank holding a volatile substance. In this manner, the vapour from the tank is released into a vent stack. The cold source gas stream from the vortex tube is passed through the heat exchanger, preferably with the assistance of the pump driven by the waste hot gas stream, to cool the vapour causing it to condense and fall back into the tank. Excess vapour will be dramatically reduced, if not totally eliminated.

Preferably, the apparatus is only operational when required, i.e. when the vapour pressure in the tank is above a predetermined critical level. It is preferable to include a pneumatic pressure switch to control the tank pressure that causes operation of a

pneumatic valve to switch on the air or other gas supply to the vortex tube when the critical pressure level is reached.

More preferably, the vent stack is provided with at least two vent valves wherein one is set at a higher pressure than the other, thereby allowing one to be the predominant flow. The pressure switch is set at a lower pressure than the vent valves so that when pressure in the tank and vent stack increases the pressure switch reacts thereby sending a signal to cause operation of the vortex tube.

It is preferable to include a temperature controller to ensure that the temperature in the system is not too low, thereby preventing freezing of any moisture within the system. Preferably, the controller takes a reading from the cold gas/air stream of the vortex tube and if the temperature falls below a predetermined critical level, a signal is sent to a pneumatic valve that regulates the supply of air or other gas to the vortex tube.

The heat exchanger may be in any one of a number of forms, such as a plate exchanger or a shell and tube condenser. Alternatively, a heat exchanger may be incorporated into a vent stack, for example, a tube running from the vortex tube is inserted into the vent stack through which the source gas stream is fed.

The pump driven by the waste gas stream may pull vapour through the heat exchanger to return cooled vapour to the stack or directly to the tank. The waste cold gas stream may also be driven through the tank itself, for example, by the provision of a heat exchanger in the tank, to condition the medium in the tank. Preferably, the speed of the pump is controllable, for example, by bleeding excess air or other gas through a control valve.

Preferably, silencers are included within the apparatus to reduce noise output.

It is to be appreciated that the materials for the different components of the apparatus will be dependent upon their requirements. For example, the materials could vary between metals, ceramics and plastics for differing hot and cold applications, to give more efficient operation of the system.

Other applications for the use of the cold source gas stream from the vortex tube include refrigeration, air conditioning, cooling control cabinets or regulators and pre-cooling of gases to temperature condition a stream of gas prior to introduction into a system. Coils containing the cool gas may also be immersed into a tank to cool a medium therein or a pipe may be inserted within a pipe to cool the medium within the pipe.

A further surprising effect has been found in that the waste warm gas stream produced by the vortex effect may be utilised for heating purposes.

Accordingly, a fifth aspect of the present invention provides an apparatus for heating a medium, the apparatus comprising a gas inlet for supplying gas to a vortex tube for the generation of a stream of hot and a stream of cold gas and an outlet for transporting the hot gas stream from the vortex tube to a medium to effect heating thereof.

A sixth aspect of the present invention provides a method for heating a medium, the method comprising the steps of supplying gas to a vortex tube for the generation of a stream of hot and a stream of cold gas, collecting the hot gas stream from the tube and transporting the hot gas stream to a medium to effect heating thereof.

The heat expelled from the vortex tube may be utilised as a direct source of heat. Alternatively, the hot air or other gas may be directed into a piece of tubing. The tubing may be any size or shape, for example, a straight, bent or helical tube. Preferably, the temperature of the tubing is controlled by the inclusion of a gasflow control valve at the

end of the tubing. By adjusting the hot gas flow through the tubing, the temperature may be adjusted to that required, with the heat being transmitted throughout the length of the tubing.

The hot air or other gas stream from the vortex tube may be used for any number of applications. For example, the hot air stream may be used for heating a solid, liquid or gas contained within a vessel, with the tubing being passed through and back out of the vessel. The hot air stream may also be utilised to increase the flow of a medium through a vessel or pipe. For example, the tubing may be passed through a pipe containing the medium or the tubing may encase a pipe containing the medium, thereby effecting heating thereof to increase the flow of the medium through the pipe.

Alternatively, the hot air or other gas stream may be used for the heating of a gas pressure regulator. The hot tubing is coiled around a regulator body such that the heat is transferred to the body to have the desired heating effect of maintaining free flow of gas through the pressure regulator.

The present invention also provides the novel application of using both the hot and cold gas streams produced from supplying compressed air or other gas to a vortex tube.

One example is to provide a distillation system wherein the hot air or other gas stream provides a heat source to cause evaporation of a substance and the cold air or other gas stream causes condensation of the substance. For example, in the purification of a contaminated solvent wherein the hot air stream causes evaporation of the solvent to leave the contaminant behind. The cold air stream is then used to condense the solvent to allow collection of the purified solvent in a second vessel.

Alternatively, the cold and hot air or other gas streams may be used to effect gas transfer. For example, the warm air stream is used to heat up another gas provided in a first vessel thereby increasing the vapour pressure thereof whilst the cold air stream is directed to a second vessel thereby cooling the vessel and reducing the vapour pressure. The pressure differential set up between the vessels allows the transfer of said other gas therebetween, for example, through a pipework system.

Preferably, pumping means are provided to aid movement of the vapour between the vessels.

Additionally, the hot and cold air or other gas streams may be utilised in a drier system wherein the hot air gas stream regenerates a drier bed and the cold gas/air stream either is fed back to the compressor feed or is passed through a heat exchanger to condition the gas being processed in the online drier thereby increasing the absorption effect on the drier.

For a better understanding of the present invention and to show more clearly how it may be carried into effect reference will now be made by way of example only to accompanying drawings in which:-

Figure 1 is a circuit diagram of a heat transfer system according to one embodiment of the present invention;

Figure 2 is a circuit diagram of a heat transfer system according to another embodiment of the present invention;

Figure 3 is schematic diagram of one embodiment of a vortex generator for a heat transfer system according to the present invention;

Figures 4 to 6 are schematic diagrams of heat transfer systems for use in relation to hot applications;

Figure 7 is a schematic diagram of a heat transfer system for heating a medium in a vessel;

Figures 8a and 8b are schematic diagrams of a heat transfer system for improving the flow of a medium through a pipe;

Figure 9 is a schematic diagram of a heat transfer system for heating a regulator;

Figure 10 is a schematic diagram of a heat transfer system for use in the recovery or purification of solvents;

Figure 11 is a schematic diagram of a heat transfer system for use in the transfer of gases; and

Figure 12 is a circuit diagram illustrating the use of a heat transfer system within a gas drier system.

The system of the present invention may be used for a wide range of applications, such as the recovery of vapours from a storage tank by subjecting the vapour to cool air generated by a vortex generator. The system has a number of novel features over systems of the prior art that result in the system being more efficient and environmentally friendly.

Figure 1 of the accompanying drawings illustrates a heat transfer system according to one embodiment of the present invention having a storage tank 2 for holding a volatile substance, with a vent stack 4. The pressure of the vapour within the tank changes with the temperature of the system and due to other factors. Previously, excess vapour was expelled through the vent stack to the atmosphere to prevent the tank from over pressurisation. The system of the present invention, in addition to a temperature controller, incorporates a pneumatic pressure switch to control the tank pressure and allow the operation of a pneumatic valve to control the operation of the cool air supply to

the vent stack. This allows the cooling system to operate only when the pressure of the tank rises above a set pressure and therefore only run when required. Additionally, the waste air from the hot side of the vortex is used to drive an air pump incorporated into the system which pulls the vapour through a heat exchanger and conditions the vapour returning to the tank. The cooling effect of the cold vapour returning to the tank also conditions the vapour inside the tank thus having a cooling effect to reduce the vapour pressure within the tank.

Referring to Figure 1, vapour feeds from the tank 2 via the vent stack. Generally, when the pressure in the tank and stack reach a set pressure indicated by a pressure gauge 5 the vac/vent valves on the vent stack operate to allow vapour to be vented to the atmosphere until the pressure has dropped to a satisfactory level when the vac/vent valves becomes re-seated to close the vent. In the present system, the vac/vent valves 6 are still present but the valve on the original vent stack is set at a pressure of 35 mbar and the vac/vent valve on the side vent stack is set at a lower pressure, such as around 25 mbar, to allow this to be the predominant flow. A pressure switch 8 is provided that is set at a lower pressure than the vac/vent valves so that when the pressure in the tank and vent stack increases the pressure switch reacts. When a predetermined set pressure is reached in the system, the pressure switch sends a signal 9, such as an air signal in the case of a pneumatic pressure switch, to a pneumatic valve 10 which in turn switches the air supply to the vortex generator 12.

The system also includes a temperature controller 14 to ensure that the temperature of the system is not too low, since this would allow freezing of any moisture within the system to occur. The controller takes a reading from the cold exit of the vortex tube and if the temperature falls below a predetermined set point, an air signal is

sent to a pneumatic valve 16. This valve, which is normally open, would then regulate the supply of air to the vortex tube and thereby allows the temperature of the system to be controlled. The temperature on the cold side of the vortex is indicated on the temperature indicator 18.

Additionally, when the pressure switch 8 is activated, an air signal is sent to a pneumatic timer 20 which then starts to count a predetermined amount of time before sending an air signal to a pneumatic valve 22 that opens the stack to the vac/vent valve. In this manner, the system is allowed to cool prior to the vent line opening, thereby preventing the escape of vapour during the time required to cool the system.

The air supply to the vortex generator 12 starts the operation of the cooling system. The air is fed into the vortex tube to provide a hot and cold stream of air on the outlet. The cold air, the temperature of which is indicated on the indicator 18, passes into a heat exchanger 24, in the form of a plate exchanger, and the resultant exchange of cold with the incoming vapour cools the vapour and causes it to return down the vent stack to the tank.

The system of the present invention also utilises the waste cold air that exits the heat exchanger 24 to further improve the efficiency of the system. The cold air is fed into a sleeve 26 that is positioned over a finned area of the vortex tube 12. The finned area increases the surface contact area whereby the cold air has the effect of removing heat from the tube thereby reducing the temperature of the cold air being expelled from the tube and increasing the efficiency of the system. The cold air in the sleeve is then expelled therefrom and passes into a heat exchanger 28 to exchange the cold with the incoming warmer air.

A further modification to the heat transfer system according to the present invention is the utilisation of the waste hot air that exits the vortex tube 30. The hot air is used as a drive medium for an air pump 32, 34. The pump has the effect of pulling the vapour through the heat exchanger 24 to return cooled vapour to the stack 4 or directly to the tank 2, thereby conditioning the vapour within the stack or having a cooling effect of the vapour within the tank to reduce the pressure in the tank. The speed of the air pump is controlled by the bleeding of the excess air through a control valve 36.

The waste air from the system is fed through silencers 38 to reduce the noise output. An additional utilisation of the waste cold is to pass the cold through a heat exchanger inserted into the tank itself to thereby condition the vapour/liquid mixture in the tank (not shown).

The type of heat exchanger provided in the system may be in the form of a conventional plate exchanger, as shown in Figure 1 or a shell and tube condensor (not shown). Alternatively, an exchanger may be incorporated into the vent stack, as illustrated in Figure 2 of the accompanying drawings, in which identical features already described in relation to Figure 1 are given the same reference numeral. The system has a tube 42 inserted into the vent stack 40 through which the cold air supply is fed.

Figure 3 of the accompanying drawings illustrates a preferred vortex generator for incorporating into a system of the present invention, the generator having a number of novel features over those of the prior art to increase the efficiency of the device. Firstly, the body of the vortex tube is finned 50 to assist with heat exchange to the atmosphere and thereby provide a greater cooling effect of the air passed through the vortex. The tube is machined to provide the finning around the tube. Additionally, a sleeve or sheath 52 is provided around the finning to allow the utilisation of the waste

cold from the vortex tube which is passed through the sleeve to further cool the body of the tube thereby again enhancing the cooling effect of the system (see above).

Further features of the vortex generator include the re-positioning of the take off point 54 from the hot side of the tube. The heat is taken off at two points on the side of the tube that are tangential to each other rather than being at its usual end position. Internal finning 56 on the external core of the generator head 58 has been machined to allow the latent heat in the incoming air to be exchanged with the orifice body to prevent build up of moisture droplets on the surface area of the drive head. The head has also been further modified by adjusting the groove depth and angles to improve the efficiency of the vortex. The width of the spinning chamber determines the angle at which the air enters the chamber and the depth and shape of the chamber determines the velocity and flow pattern. These alterations have enabled temperatures of + 160°C to - 50°C to be achieved which are far greater than the temperature extremes previously obtained using a conventional vortex generator.

It is to be appreciated that the materials for the different parts may vary depending upon requirements, such as the temperature extremes of the system. For example, the materials could vary between metals, ceramics and plastics for differing hot and cold applications, to give more efficient operation of the system.

The system of the present invention may be used for a number of applications that require a cold supply of air, such as recovery of high volatile substances, for example petroleum. In the petroleum industry products are lost through evaporation to the atmosphere. The figure for these losses is generally considered to be in the region of 12,000 litres per year per petrol station. The present invention allows the efficient recovery of these products thereby providing a considerable cost saving and positive

environmental impact. An important feature of the system is that no electrical supply is required to the system such that, with the correct earthing, the system can be made intrinsically safe.

A heat transfer system as hereinbefore described may be used for other applications that require a cool air supply. For example, the cool air from the vortex may be used to provide cooling for all applications of refrigeration, particularly in the chemical and food industry. The cool air supply may provide a system for the conditioning of air temperatures or cooling control cabinets. The system may also be used for the cooling of regulators to provide temperature conditioning of samples or for the pre-cooling of gases to temperature condition a stream of gas prior to introduction into a system, for example, cooling of a gas stream prior to a molecular sieve drying system to give more efficient operation thereof. Coils containing the cold air supply may also be immersed into a tank to cool a fluid or alternatively a pipe may be inserted within a pipe for cooling a fluid within the pipe. Furthermore, the cold air supply may also be used to condition a sample prior to release into an analyser, for example, for cooling samples prior to introduction into analytical equipment.

It has also been surprisingly found that the heat generated within the vortex may be used as a heat source for heating a medium remote from the vortex.

Figures 4 to 6 of the accompanying drawings shows the use of the vortex tube for hot applications wherein the hot air of the vortex is utilised rather than being wasted. The heat expelled can be utilised from the tube as a direct source of heat by directing the hot air onto the application. Alternatively the hot air can be directed into a tube. Figure 4 demonstrates how an air supply 80 is fed into a vortex tube 78 which has been modified in its construction to give a system capable of higher temperatures than

previously achieved (see above). The temperature is able to exceed 160° C and could, through stacking of the vortex units, be taken considerably higher. A piece of tubing 84 extends from the hot exit 82 of the vortex tube 78. It has been found that the vortex effect can be extended through the length of the tubing attached to the hot end of the vortex tube even if the tubing is varied in size and shape. The changes made to the vortex generator head as hereinbefore described have improved the efficiency of the system requiring a much lower flow of air to reach the required temperatures. Examples of the shape of tubing include a helical coil (see Figure 4) or a bent piece of tubing (see Figures 5 and 6). The temperature is controlled by the insertion of an airflow control valve 86 at the end of the coil. By adjusting the hot air flow from the tube the temperature can be adjusted to the required temperature, with the heat being transmitted throughout the length of the coil.

There are numerous applications for this type of heating system and the benefits are again an intrinsically safe system with the only requirement of an air supply.

For example, Figure 7 of the accompanying drawings shows an application for the heating of a solid, gas or liquid in a vessel such as a cylinder, container or pressure vessel. The vortex tube 90 is fed by an air supply 92 which is linked into a coil or element 94 inserted into the vessel 96. The method of entry into and out of the vessel can be engineered to the required position dependant on the type of cylinder. When the air supply is switched on the hot exhaust from the tube 98 passes through the coil 94 having the desired heating affect on the contents of the vessel 96. The temperature in the vessel is controlled by the airflow control valve 100 on the exit from the coil.

A specific example of the use of such a system would be in a chemical/gas environment. The coil could be passed through a pressure vessel or container and the

heating affect would heat the product (solid, liquid or gas) to a required temperature. This arrangement could also be applied to the cold side of the vortex tube to cool a product within a cylinder.

Figures 8a and 8b of the accompanying drawings illustrate the use of the hot air supply for the movement of a medium through a tube where the flow of the medium depends on the temperature. The air supply 110 is introduced into the vortex tube 112. The hot side of the vortex 114 is passed either on the inside (see Figure 8a) or outside (see Figure 8b) of a tube 116. The medium in the tube 116 is then heated by the exchange of heat with the hot air to improve the movement of the medium through the system. This system requires no direct contact with the medium and again is an intrinsically safe method of operation. The temperature is controlled by the air control valve 118 on the end of the line. Again the shape of the system does not have to be in a straight line, the tubes can be shaped to any required form.

Figure 9 of the accompanying drawings shows the use of this system for the heating of a regulator to prevent freezing in certain applications. The hot side 120 of the vortex 122 is introduced into the line coiled around the regulator body 124 and the heat is transferred into the body of the regulator 124 to have the desired heating affect. The gas 126 that is being introduced into the regulator is warmed as it passes through the regulator and the temperature is controlled by the air control valve 128 to the required value.

The present invention also describes the novel application of using both the hot and cold air produced from supplying compressed air to a vortex tube. For example, many solvents that are used in industry have to be disposed of when contaminated. The present invention uses the hot and cold source of air provided by the vortex generator to

operate a distillation system. The heat source can provide a safe and effective method of causing evaporation of the contaminated solvent to leave the contaminant in the original vessel. This presumes that the solvent has a different boiling point to the contaminant, as is often the case. For example, cleaning solvents used to remove oil contamination wherein the solvent has a much lower boiling point than the oil. The cold source of air can then be used to condense the solvent into a second vessel.

Figure 10 of the accompanying drawings illustrates a system for solvent purification. The solvent is contained within a first vessel 130 within a unit. An air supply 132 is fed into the vortex tube 134 and the resultant warm air supply 136 is directed into the first unit to warm up the solvent. The solvent vaporises and passes through the pipework 138 into a second unit, which is cooled by the cold air supply 140 from the vortex. The cooling effect causes the solvent to condense and fall into a collecting vessel 142 and is removed to storage from the vessel 146. This system leaves the impurities in the first vessel 130. The facility to pump would be given by the pumping system 144.

Furthermore, in the gas industry, the transfer of gases is required for various flammable liquifiable gases. The present invention describes how a vortex system may be used as an intrinsically safe method of heating and cooling the gases to allow transfer. Figure 11 of the accompanying drawings illustrates such a gas transfer system. The gas is contained within a first vessel 162. The supply of clean air 164 to the vortex tube 166 provides a warm air supply 168 which is used to heat up the gas by directing the supply into the unit. The gas contained within the vessel 162 warms up and the vapour pressure increases. The cold air supply 170 generated by the vortex is directed into a second unit 172 to cool down the vessel. This results in a decrease in vapour pressure in this vessel.

The pressure differential set up would then allow the transfer of gases through the pipework system 174. The facility to pump the gases would be given by pumping means 176.

Another application is the utilisation of the vortex within a drier system. The utilisation of a purified gas stream to pass through the vortex would provide a hot gas for the regeneration of drier bed, with the waste cold being fed back to the compressor feed. The cold could also be utilised in the same system, by use of a heat exchanger, for the conditioning of the gas being processed in the online drier, the cooling effect improves the absorption capabilities of the drier.

Referring to Figure 12, the system shows the use of the vortex in a gas drying system where an electrical source is normally required to provide the heat to regenerate the drier beds. The benefit, in this system, is that the vortex can be driven by the process gas eliminating the requirement for an electrical supply.

The process gas inlet 180 is fed through a heat exchanger 182 into the drier system. The orientation of the valves depends on the drier on line. The valves are pneumatic and are controlled by a timer system set at the required lengths of time for a particular application.

The drier operates with one bed on line and the other on regeneration. In order to regenerate a bed heat is required to drive off the impurity from the bed. The waste gas is normally vented direct to atmosphere.

In this system a side stream is taken from the purified gas through a valve 184 to a three-way valve 186. When the heat is required for regeneration the stream is directed through to the vortex tube 188 and the resultant hot air is fed to the drier to regenerate the bed. The waste hot gas exiting the drier is then passed through to an air mover 190.

The cold gas from the vortex is passed through to a heat exchanger which is used to cool the inlet gas prior to entering the drier. The cooler the gas entering the drier the better the absorption affect of the drier. The cold air is pulled through the heat exchanger by the affect of the air mover pulling a vacuum and this assists on the through put of gas through the exchanger.

At the end of the heating cycle the purified gas is then isolated from the vortex and the purified stream is fed direct into the bed. This supplies gas at an ambient temperature in order to cool the bed prior to coming on line.

The bed then changes over and the opposite bed is regenerated. The example of this in the accompanying Figure 12 is Bed 200 on line with Bed 300 on regeneration.

The gas 180 passes through the heat exchanger 182 with the inlet valve open 192. The gas passes into the bed 200 with valves 194 and 196 shut and valve 198 open to allow the waste gas to escape from the other bed.

The gas passes through bed 200 and with valve 202 open the gas then passes through to the process. Valves 204 and 206 are isolated at this point and valve 208 is open to allow the hot gas from the vortex to pass into bed 300.

A side stream of the purified gas is passed through valve 184 to the three-way valve 186. For the heating cycle, the stream is directed to the vortex tube 188. The resulting hot gas is passed through valve 208 and into bed 300. The waste gas passes through valve 198 and out to the air mover 190 as the driving gas. The gas then exits the system through a silencer 210.

The waste cold 212 from the vortex 188 is pulled through the heat exchanger 182 by the effect of the air mover 190, which cools the incoming gas.

When the heating cycle has finished the three-way valve changes so that the stream is directed through to the drier bed 300. This cools the bed prior to coming on line. The beds then change over and the procedure is repeated for the other bed.

This system can be used for a simple air drier or can be used for other types of gases. Depending on the characteristics of the gas being processed it may be necessary to drive the vortex from an independent air supply. The benefits of the vortex however still make the system beneficial for problem gases.

One of the main advantages of using a heat transfer system as hereinbefore described is that the system provides an intrinsically safe method for the provision of a hot and cold source for various applications. On the cold side temperatures considerably below 0° C can be obtained whilst on the hot side temperatures considerably above 0°C can be obtained. These differing temperature streams can be used to provide the source of heat and cold energy for various applications such as those outlined herein. The outlet temperatures can be adjusted to give the requirements for each particular system.

CLAIMS

1. An apparatus for transferring heat to or from a medium, the apparatus comprising a gas inlet for delivering gas to a vortex generator (12) for generation of a stream of hot and a stream of cold gas and an outlet for transporting the hot or cold stream of gas, deemed the source gas stream, to a heat exchanger (24) for exchanging heat energy with a medium in contact therewith, the other stream being deemed the waste gas stream, wherein the apparatus has one or both of the following features:
 - (a) a conduit for transporting the waste gas stream from the vortex generator to a pump (32, 34) to drive the pump thereby assisting the flow of the source gas stream through the heat exchanger; and/or
 - (b) a return conduit for transporting the source gas stream from the heat exchanger around at least part of the vortex generator.
2. An apparatus as claimed in claim 1, wherein the return conduit transports the source gas stream to a hollow sleeve (26) surrounding at least part of the vortex generator.
3. An apparatus as claimed in claim 1 or 2, wherein the vortex generator comprises an inner tube (12) having an inlet and an outlet and a generator head, the generator having a hollow sleeve (26) that surrounds at least a part of the inner tube, the sleeve having an inlet and an outlet.
4. An apparatus as claimed in claim 3 wherein the inner tube of the vortex generator is finned.

5. An apparatus as claimed in claim 3 or claim 4 wherein the generator head is finned.
6. An apparatus as claimed in claim 3, 4 or 5 wherein the inner tube has at least two outlets, one for the source gas stream and one for the waste gas stream.
7. An apparatus as claimed in claim 6 wherein the inner tube has three outlets, two of the outlets being for passage of the waste gas stream.
8. An apparatus as claimed in claim 7 wherein the outlets for passage of the waste gas stream are provided at the sides of the tube, tangential to each other.
9. The use of an apparatus as claimed in any one of claims 1 to 8 for the recovery of condensate from a storage tank (2) holding a volatile substance.
10. The use of an apparatus as claimed in claim 9 wherein the vapour from the tank is released into a vent stack (4) and a cold source gas stream from the vortex tube (12) is passed through the heat exchanger (24) to cool the vapour in the vent stack thereby causing it to condense and fall back into the tank.
11. The use of an apparatus as claimed in claim 9 or 10 wherein the apparatus is only operational when the vapour pressure in the tank is above a predetermined critical level.
12. The use of an apparatus as claimed in claim 11 wherein a pressure switch (8) is provided to control the tank pressure and cause operation of a valve (10) to switch on the gas supply to the vortex tube (12) when the critical pressure level is reached.
13. The use of an apparatus as claimed in claim 12 wherein the vent stack (4) is provided with at least two valves, one valve being set at a higher pressure than the other to allow one to be the predominant flow.

14. The use of an apparatus as claimed in claim 13 wherein the pressure switch is set at a lower pressure than the vent valves.

15. The use of an apparatus as claimed in any one of claims 9 to 14 wherein a temperature controller (14) is provided to ensure that the temperature of the apparatus is not too low.

16. The use of an apparatus as claimed in any one of claims 10 to 15 wherein the heat exchanger is incorporated into the vent stack.

17. The use of an apparatus as claimed in any one of claims 9 to 16 wherein the source cold gas stream is driven through the tank itself by the provision of a heat exchanger in the tank.

18. The use of an apparatus as claimed in any of one claims 1 to 8 for supplying a source cold gas stream for refrigeration, air conditioning, cooling control cabinets or regulators or pre-cooling of gases.

19. The use of an apparatus as claimed in any one of claims 1 to 8 as a distillation system wherein the waste hot gas stream provides a heat source for evaporation of a substance and the source cold gas stream causes condensation of the substance.

20. The use of an apparatus as claimed in claim 19 for the purification of a contaminated solvent.

21. The use of an apparatus as claimed in any one of claims 1 to 8 to effect gas transfer between two or more vessels in fluid communication with each other wherein the waste hot gas stream heats up another gas in the first vessel and the source cold gas stream cools down a second vessel thereby setting up a pressure differential between the vessels to effect transfer of said other gas therebetween.

22. The use of an apparatus as claimed in any one of claims 1 to 8 in a drier system wherein the waste hot gas stream regenerates a drier bed and the source cold gas stream is fed back to a compressor feed or is passed through a heat exchanger to condition a gas being processed in the online drier.

23. A method for transferring heat to or from a medium, the method comprising the steps of:

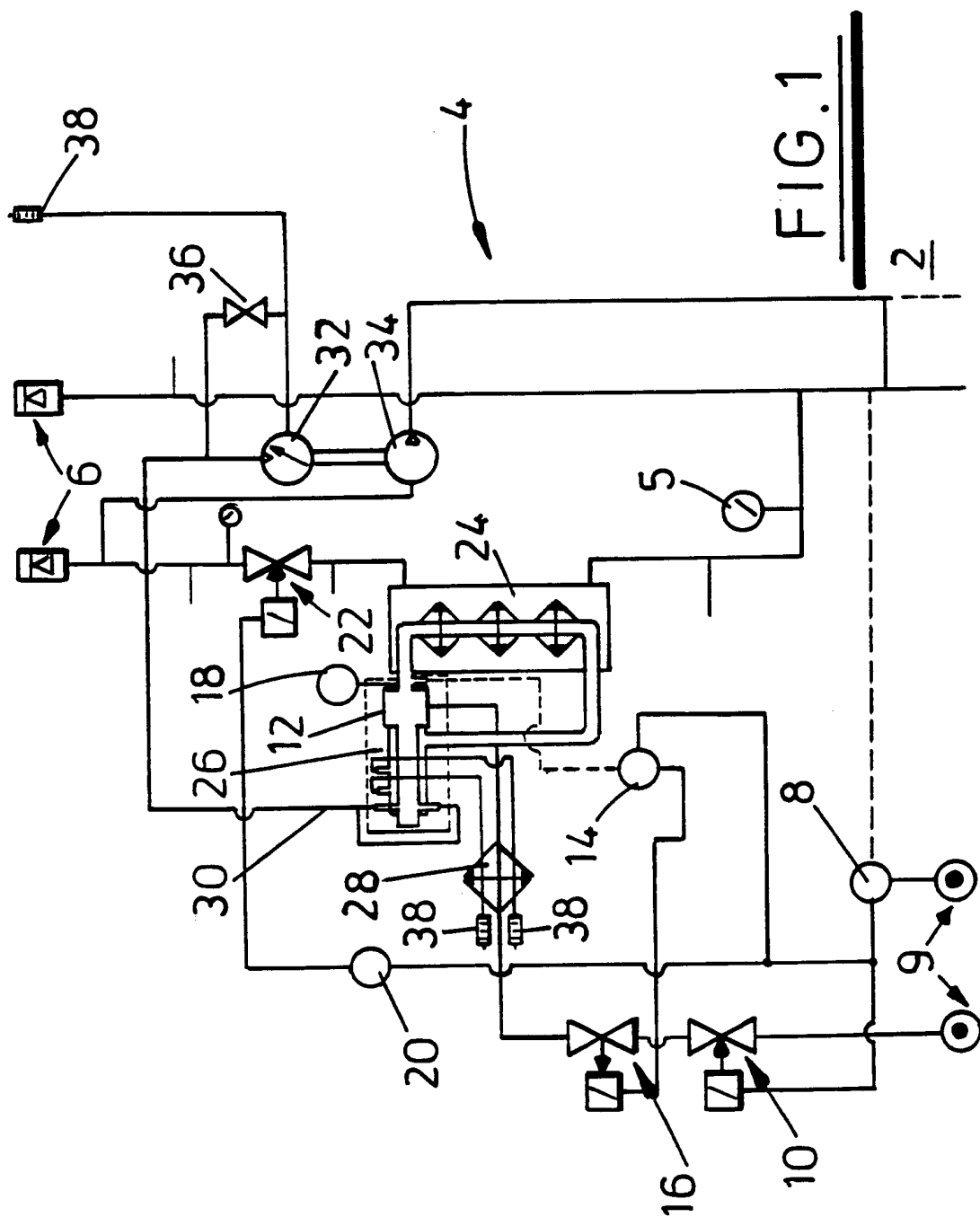
- (a) delivering gas to a vortex tube for generating a stream of hot and a stream of cold gas;
- (b) transporting the cold or hot gas stream, deemed the source gas stream, from the vortex tube to a heat exchanger for exchanging heat energy with a medium in contact therewith; and
- (c) transporting the other gas stream, deemed the waste gas stream, from the vortex tube to a pump to drive the pump and pull the source gas stream through the heat exchanger.

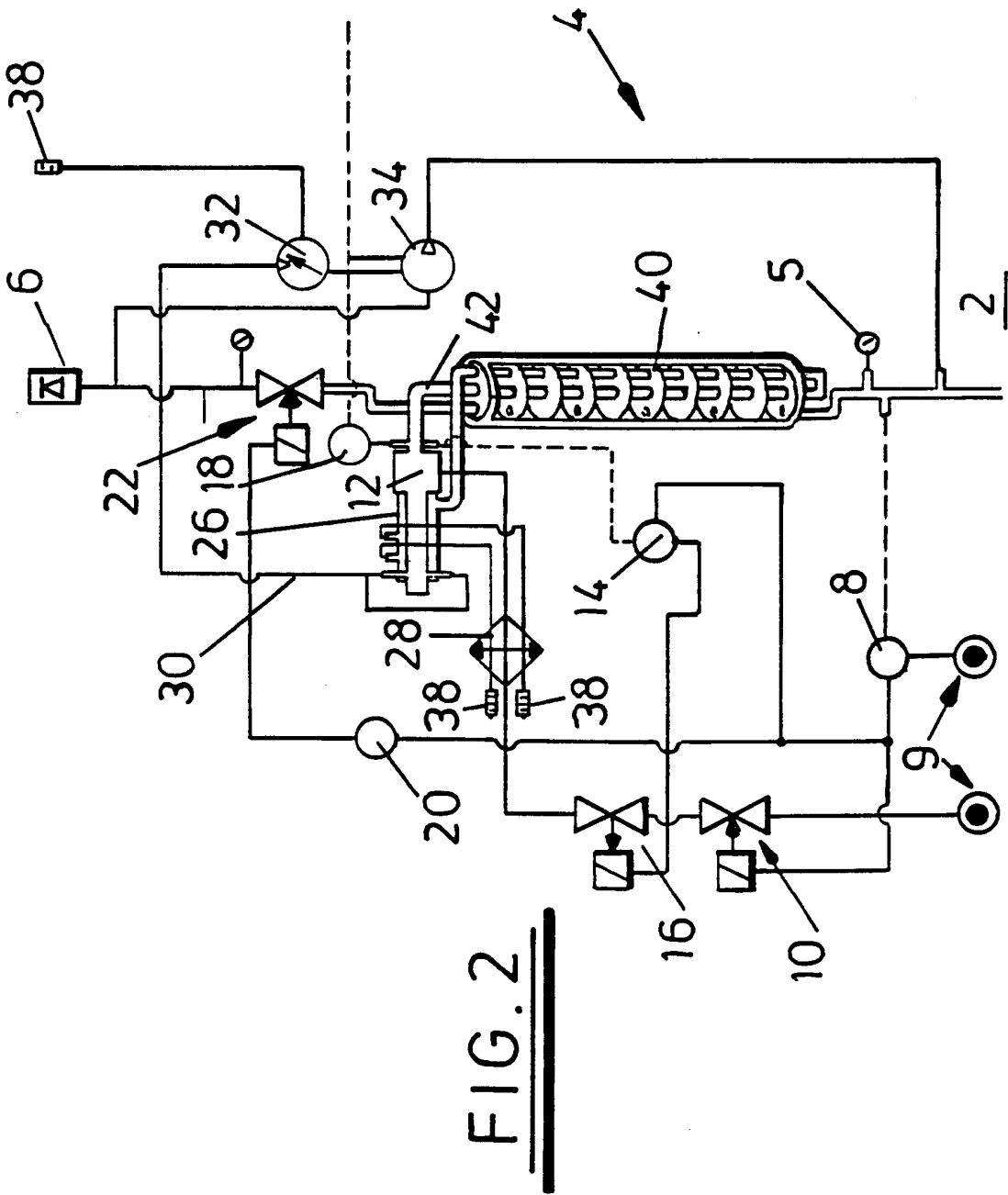
24. A method for transferring heat to or from a medium, the method comprising the steps of:

- (a) delivering gas to a vortex tube for generating a stream of hot and a stream of cold gas;
- (b) transporting the hot or cold gas stream, deemed the source gas stream, from the vortex tube to a heat exchanger for exchanging heat energy with a medium in contact therewith; and
- (c) transporting the source gas stream from the heat exchanger around at least part of the vortex tube.

25. An apparatus for heating a medium, the apparatus comprising a gas inlet for supplying gas (80) to a vortex tube (78) for the generation of a stream of hot and a stream of cold gas and an outlet (82) for transporting the hot gas from the vortex tube to a medium to effect heating thereof.
26. An apparatus as claimed in claim 25 wherein the heat expelled from the tube is used as a direct source of heat.
27. An apparatus as claimed in claim 27 wherein the hot gas stream is directed into a piece of tubing (84) to provide indirect heating.
28. An apparatus as claimed in claim 27 wherein a gasflow control valve (86) is included in the tubing (84) to control the temperature of the tube.
29. The use of an apparatus as claimed in any one of claims 25 to 28 for heating a solid, liquid or gas contained within a vessel.
30. The use of an apparatus as claimed in claim 29 wherein the hot gas stream increases the flow of a medium through the vessel.
31. The use of an apparatus as claimed in any one of claims 25 to 28 for heating of a gas pressure regulator wherein the hot gas stream is passed around a regulator body to transfer heat thereto thereby maintaining free flow of gas through the pressure regulator.
32. A method for heating a medium, the method comprising the steps of supplying gas (80) to a vortex tube (78) for generation of a stream of hot and a stream of cold gas, collecting the hot gas stream from the tube and transporting the hot gas to a medium to effect heating thereof.

33. A vortex generator comprising an inner tube having an inlet and an outlet and a generator head, the generator having a hollow sleeve that surrounds at least part of the inner tube, the sleeve having an inlet and an outlet.





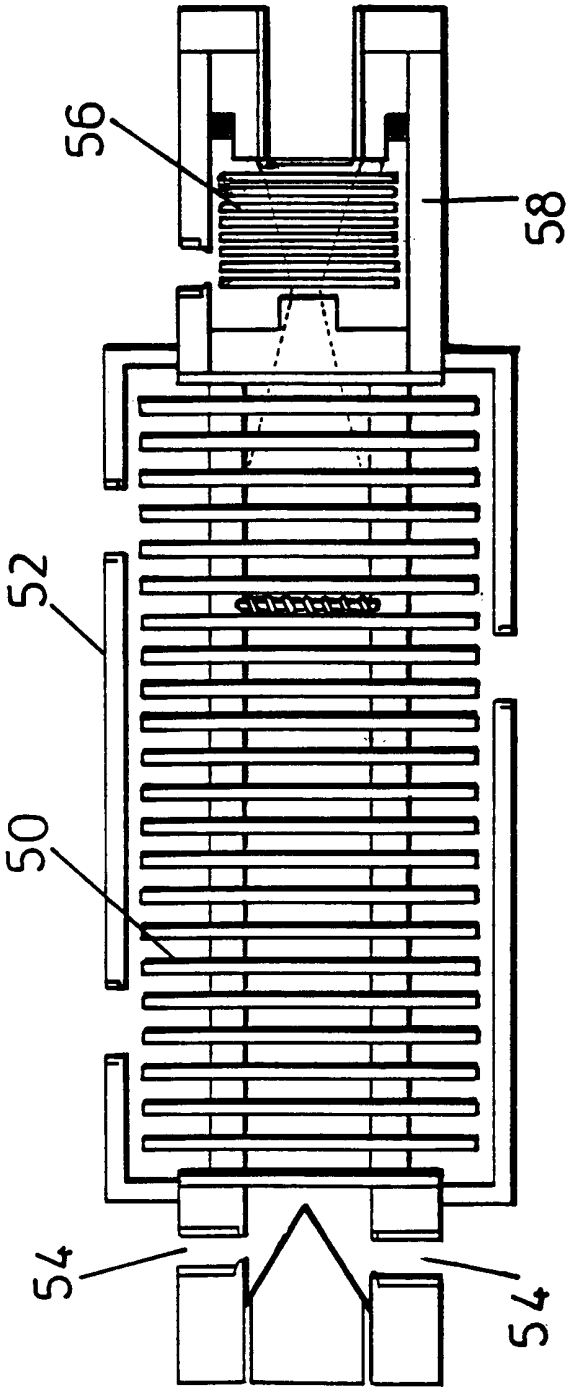
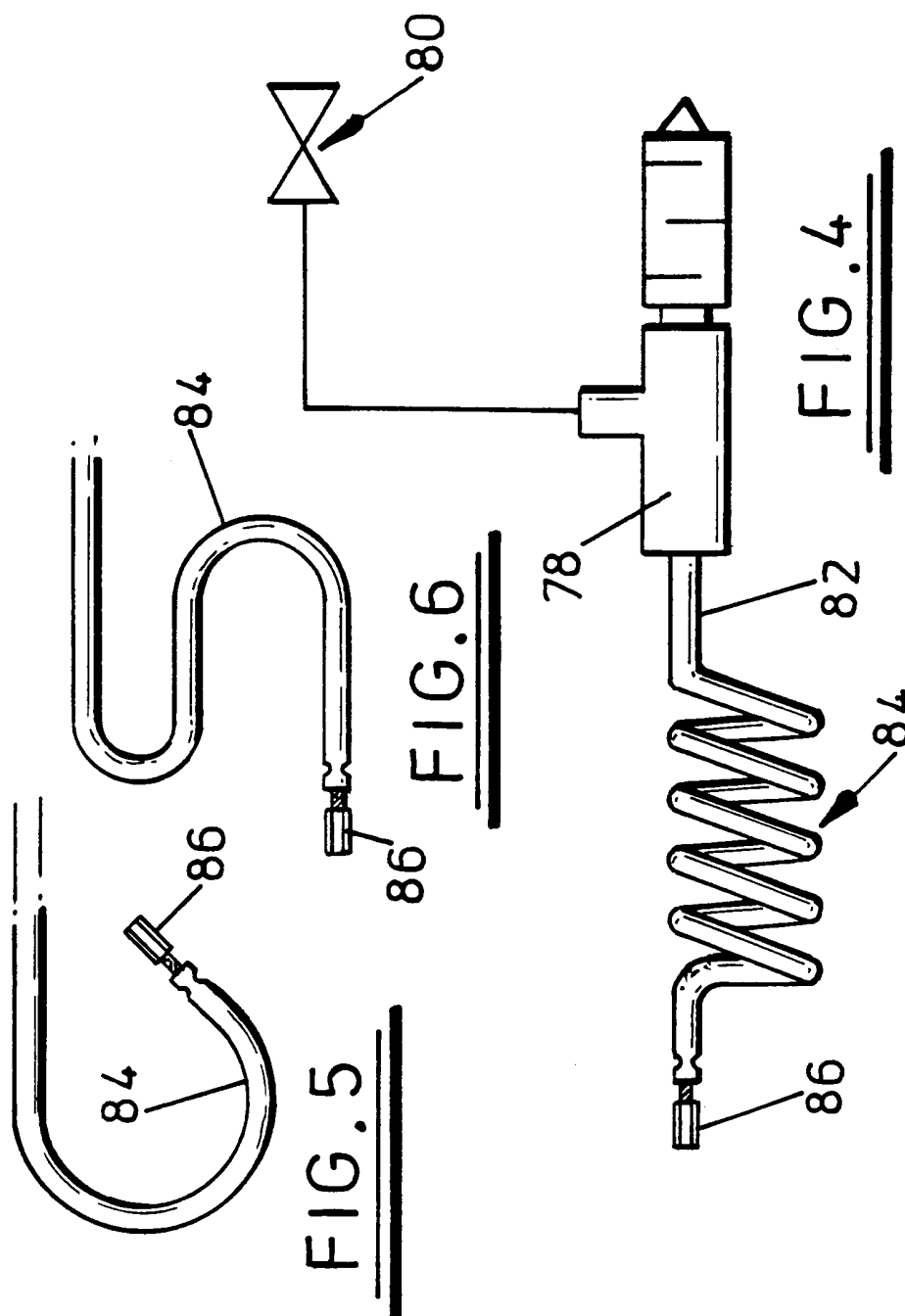
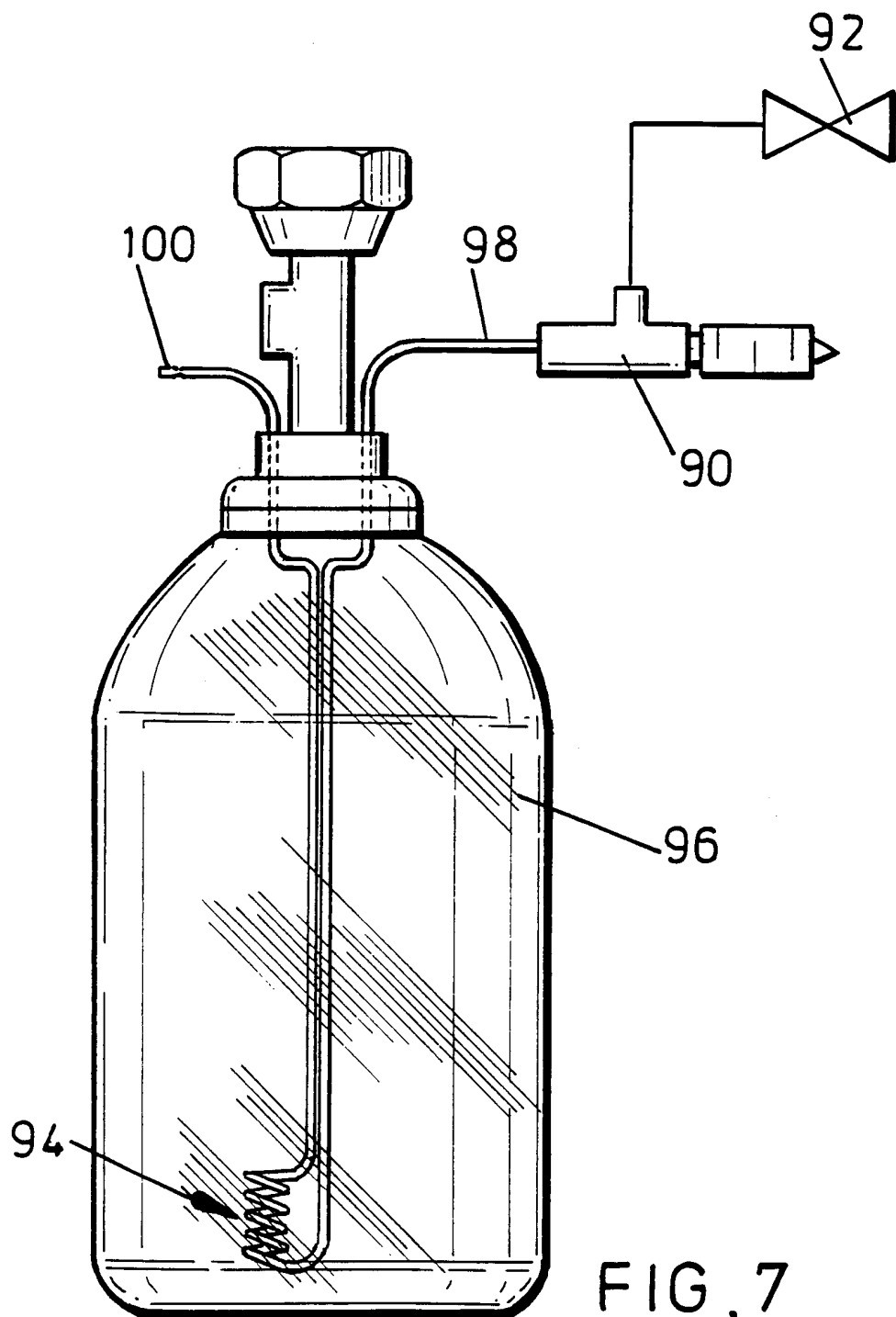
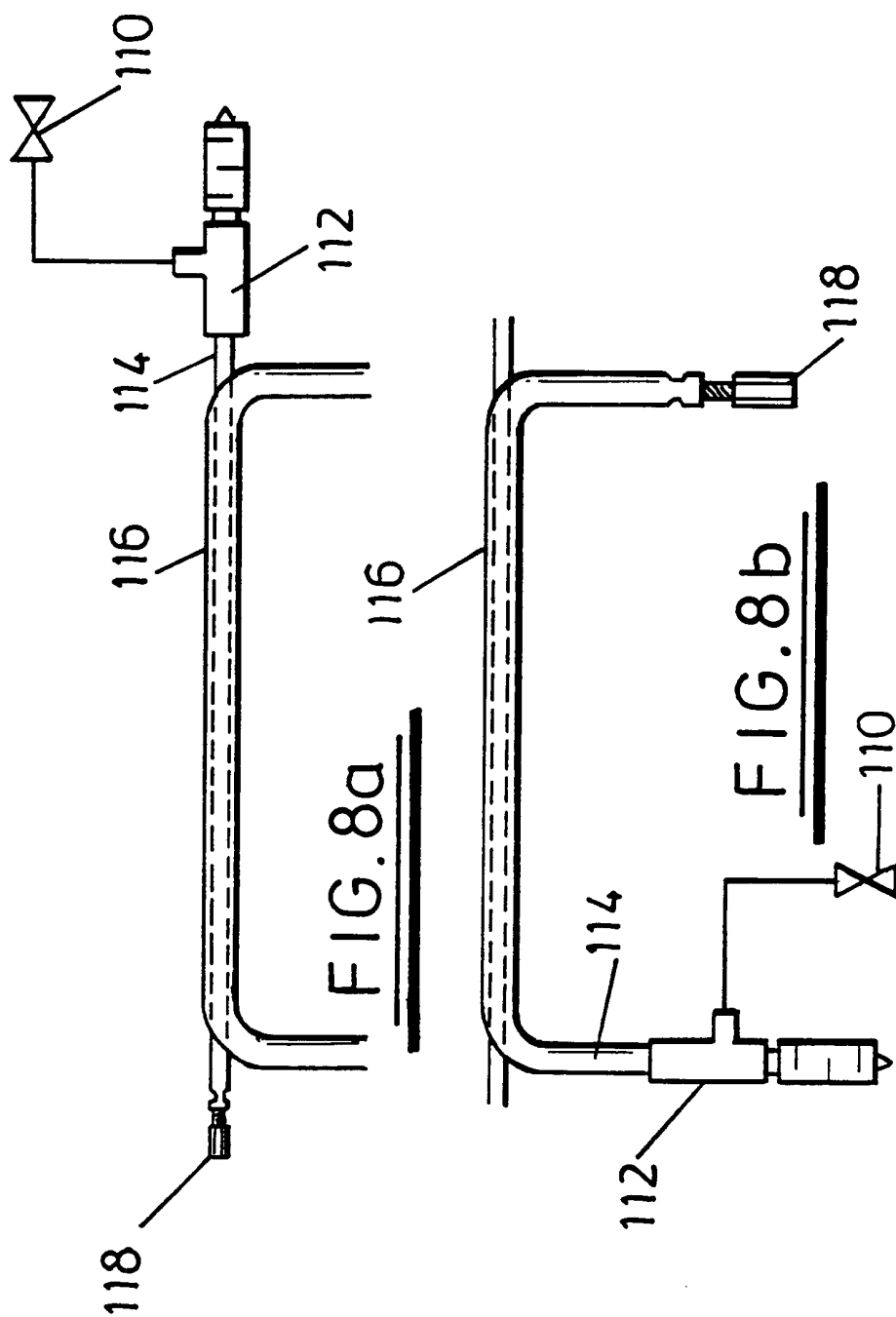
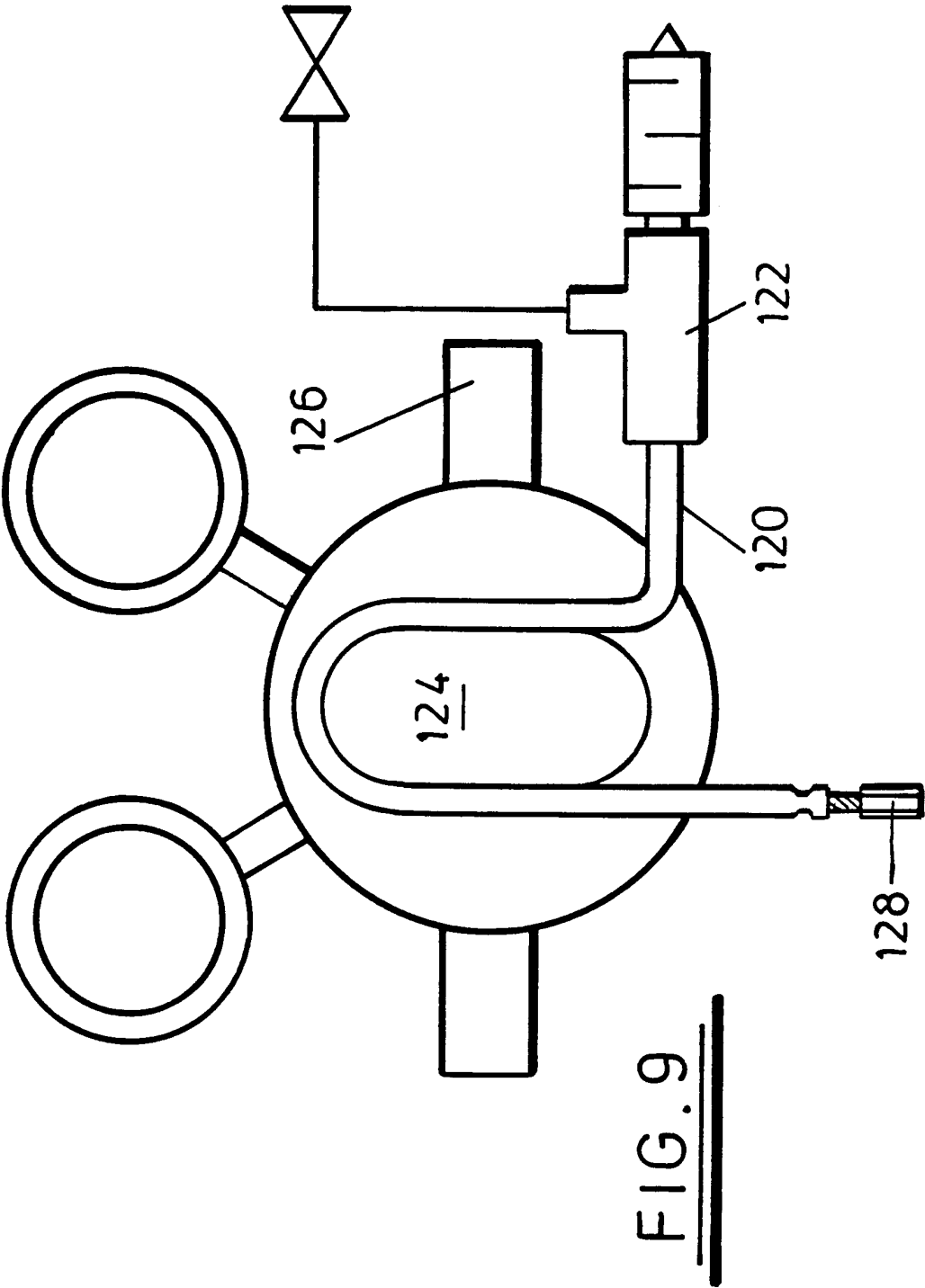


FIG. 3









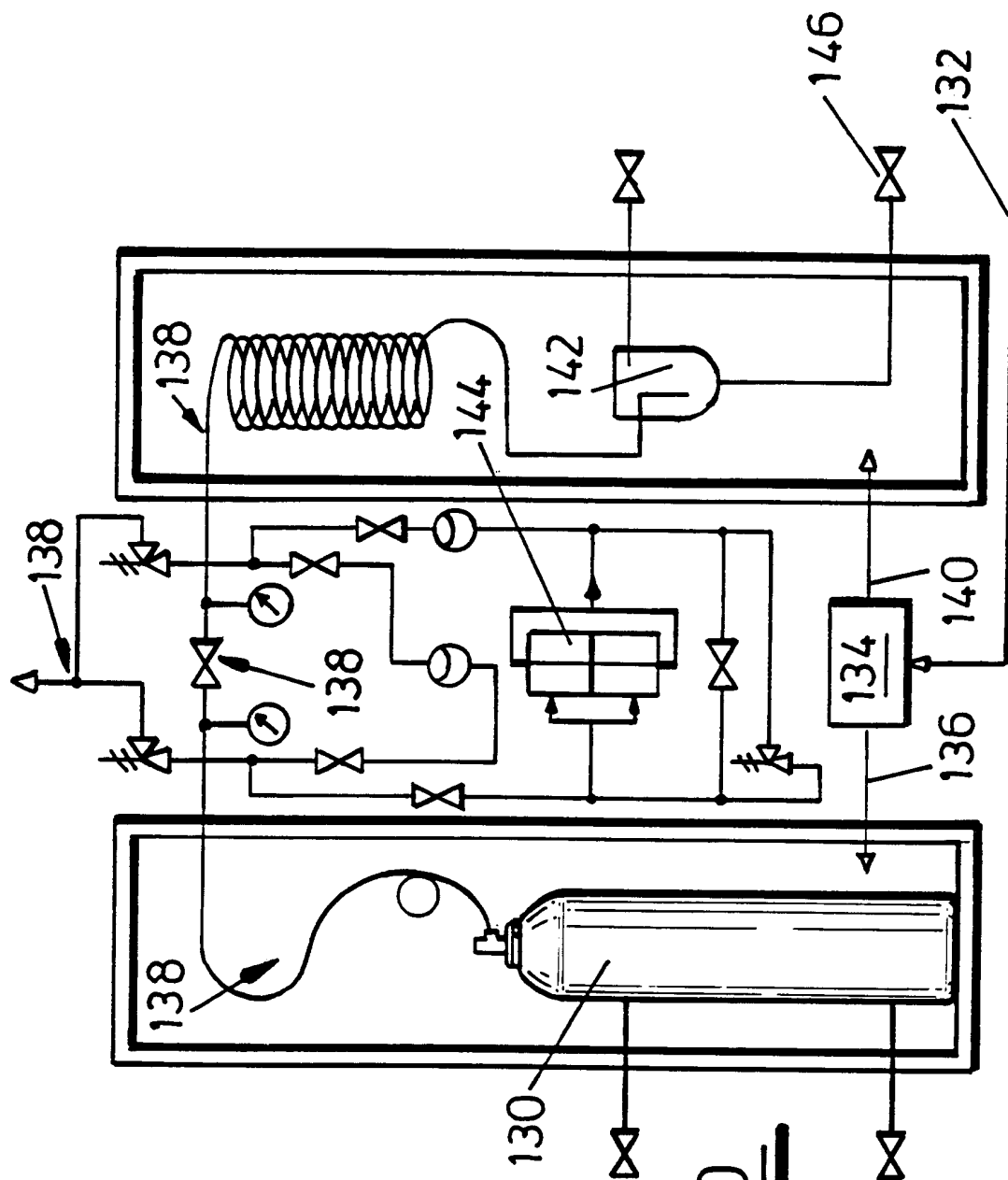


FIG. 10

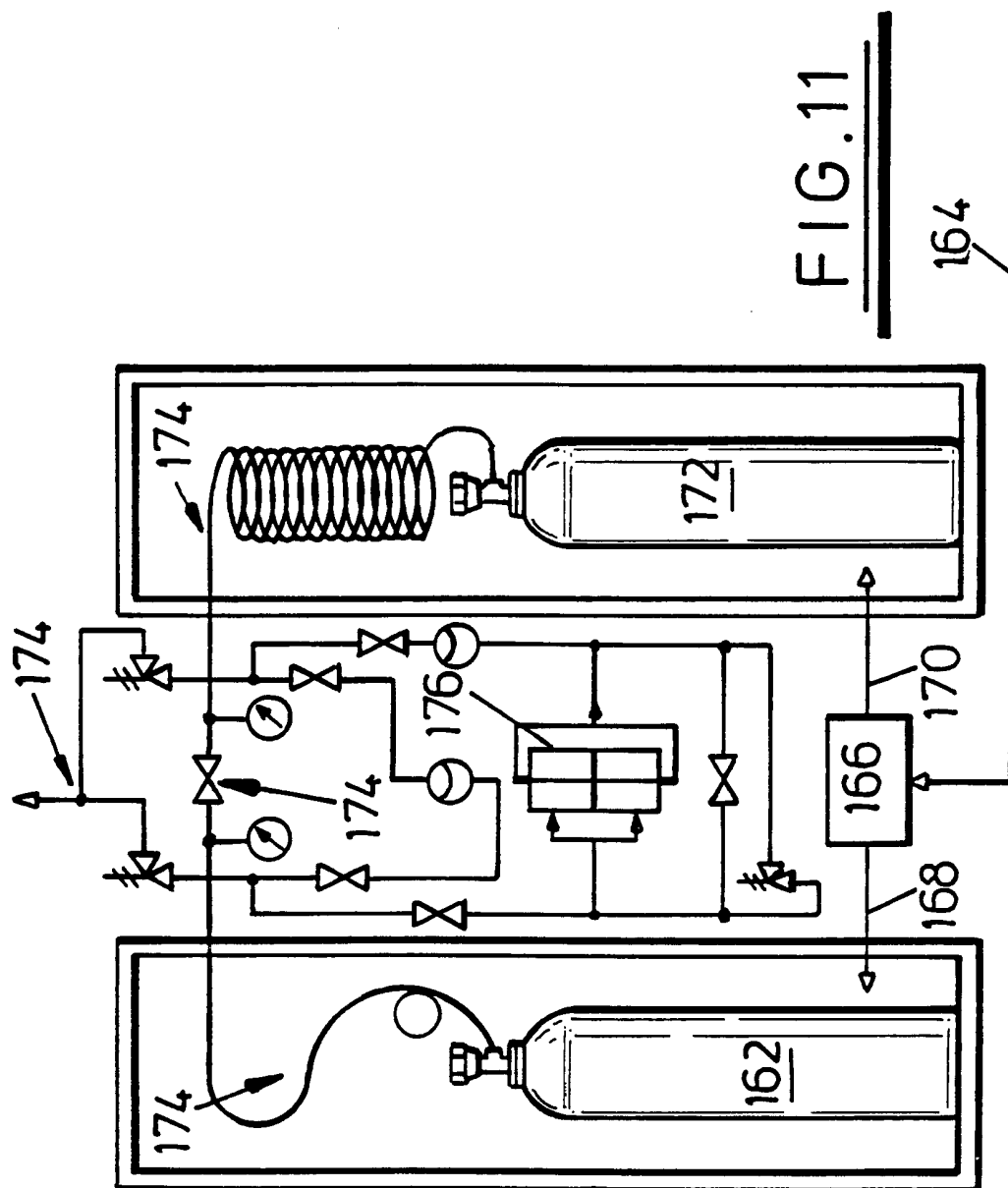


FIG. 11

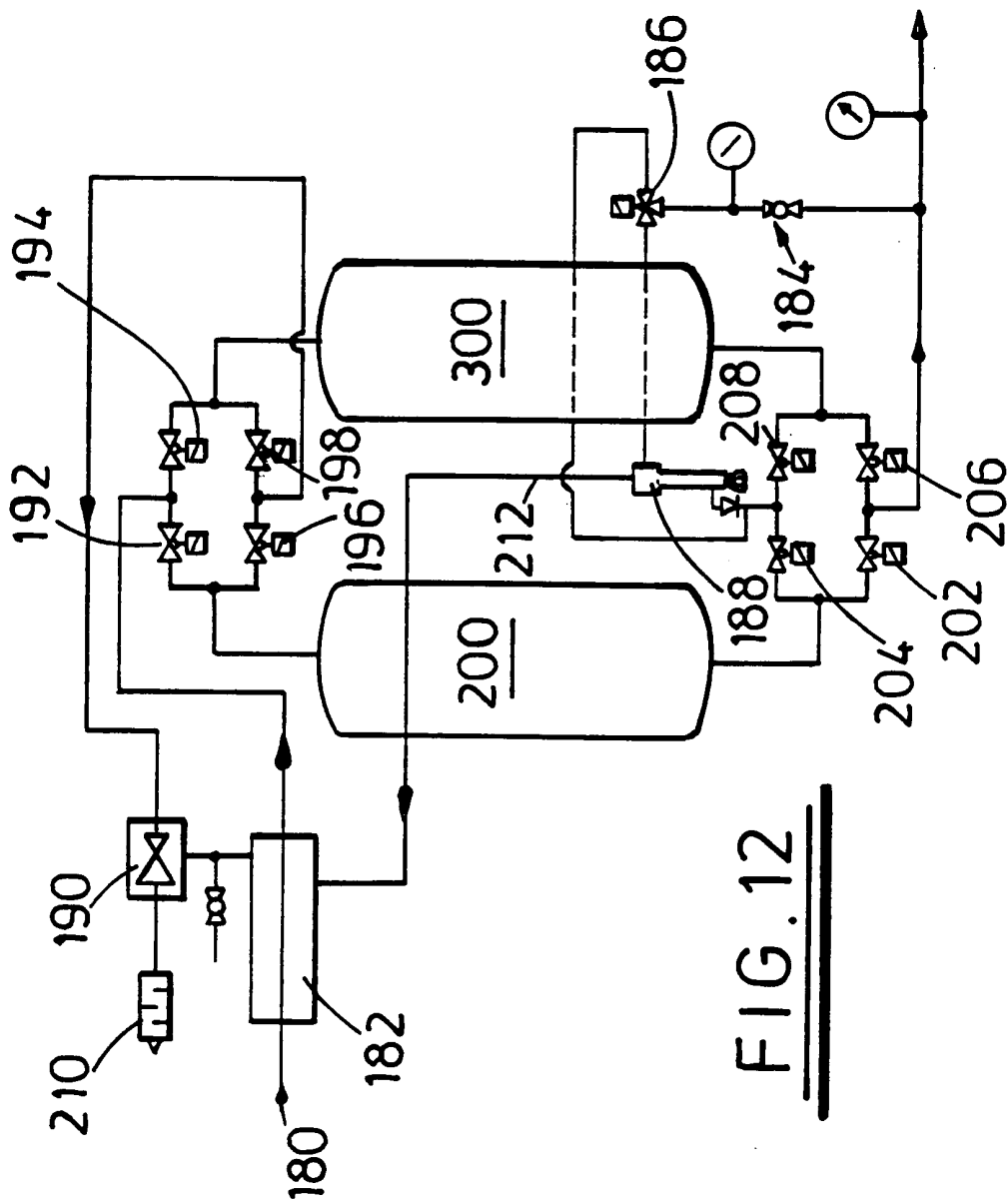


FIG. 12

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/03907

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F25B9/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	abstract	4,5
A	figure 1	9,19,21, 22,25,32
Y	DE 91 13 973 U (HKK HANSEATISCHES KREATIV KONTOR GMBH) 13 February 1992 (1992-02-13) page 4, paragraph 3 --- -/--	4,5

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

11 January 2001

Date of mailing of the international search report

22/01/2001

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INTERNATIONAL SEARCH REPORT

Internat Application No
PCT/GB 00/03907

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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