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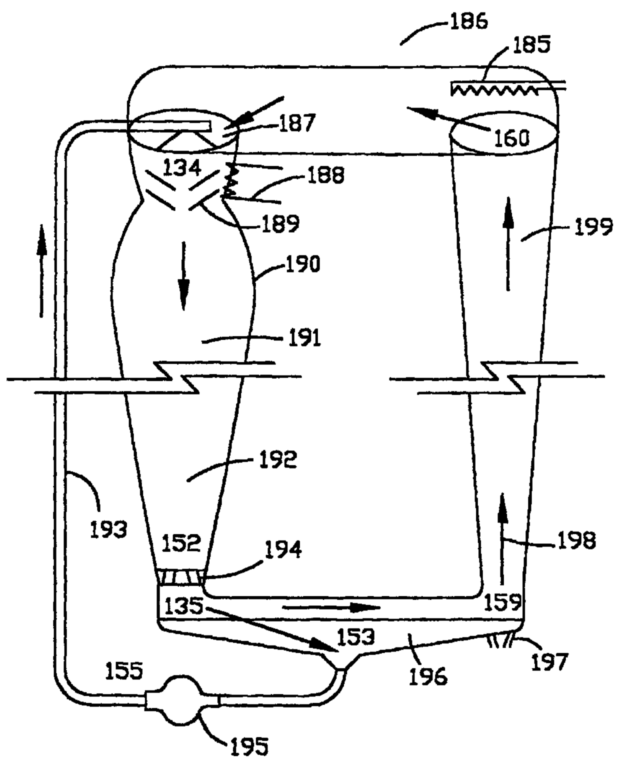

(57) Abstract: Studies of the variation in latent heat of fluids with temperature and the rate of heat increase with compression were applied to thermodynamic cycles represented in columns (190, 193, 199). This showed that heat may be circulated and that power output (194) can be boosted by catalysts. Practical layouts show that the present 45 % efficiency of thermal power stations may be doubled. The invented layouts produce power from reject heat (185, 188) and saves the water required of cooling thermal power stations.

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FUNDAMENTS AND SYSTEM FOR GENERATING POWER AND PORTABLE WATER

Field of the Invention

This invention relates to the fundamental principles of combining different types of energy and systems for converting energy into power, and more particularly for converting heat energy into electric power energy, mostly with gravitational acceleration, according to improvements of the methods and systems disclosed in South African patent number 97/1984 and patent application 98/8561 which has not been published.

Background to the Invention and the State of Art

Denotation: Represent depth below surface by z, measured positive downwards; g to denote gravitational acceleration and m to be mass. For purposes of this application the term:

"**N**" is the ratio of two energy values like two latent heat values;

"**T-s diagram**" means the presentation on a graph with scales of temperature and entropy, of the state of condition of a fluid subject to variable temperature and energy levels;

"**Work**" is one of the forms of energy;

"**Cycle**" means a thermodynamic T-s cycle as presented in a T-s diagram and/or a mass circulation system operating in a closed loop;

"**Preheating**" means to increase the energy and/or entropy of a fluid;

"**Drenching**" means the addition of low entropy fluid(s) to a high entropy fluid(s) to reduce the high entropy of the formed fluid. The lower level of the high entropy limit of the entropy state of condition can also be reached by heat extraction and/or incomplete heat supply to fluid;

"Power Cycle" includes thermodynamic cycle(s) employed to produce more output power than power consumed to complete the cycle. In the "conventional" power cycle fluid is pressurised, vaporised or gassified by the addition of heat, depressurised to do work, liquefied by the removal of heat in a continual process to form a cycle.

In this document the power cycle includes a cycle in which low entropy fluid, preheated and drenched to any convenient level, is pressurised mostly by gravity, the pressurised fluid is partly depressurised to produce power, heated to higher entropy level by addition of heat, depressurised further by elevation against gravity, fluidised or liquified by the removal of heat in a continual process to form a cycle. The entropy extent of the power cycle is conveniently reduced to a more profitable value by preheating and/or drenching to produce less netto work per cycle and to produce globally more work per co-operating countercycle of a refrigeration fluid.

"Refrigeration Cycle" means a "conventional" cycle that discards heat at high, or high and intermediate temperature(s), consumes heat at low, or low and intermediate temperature(s) and consumes and produces heat and work in circulation. Fluid(s), mostly gas or vapour at high entropy level is pressurised to a significant extent by gravity in being lowered in a column, is vaporised or liquefied to be a low entropy fluid by the release or rejection of heat, to become a liquid and/or vapour or pre-heated vapour, in order to be of decreased entropy, the low entropy fluid becomes pressurised mechanically and depressurised to a significant extent by gravity, in moving up a column, the depressurised fluid heated by receiving heat to become a gas or vapour or drenched to be a high entropy fluid, recirculated to become a continual cycle.

"Countercycle" mens a cycle running in the opposite sense compared to another cycle. In this document a countercycle includes two thermodynamic cycles operating as a combination as a power cycle and a refrigeration cycle, mostly in the sense that the refrigeration cycle prescribes the operation of the power cycle and the combined countercycle consumes heat and produces power. Commonly the temperature range of the refrigeration cycle must be cooler at the cold end and hotter at the hot end of the two thermodynamic cycles. In this document the dominance of the refrigeration cycle over the power cycle is maintained in the sense that power input to the refrigeration cycle maintains the running of countercycles, even if the two or more cycle fluids are mixed to operate at the same temperatures.

For purposes of this application Countercycle Power Production is obtained by running a power T-s cycle inside or up to the boundary of a refrigeration T-s cycle.

Heat engines and refrigeration systems are well known in the art and have been subjected to extensive theoretical analysis. Typically the systems operate on closed circuits of fluid.

With heat engines the fluid is pressurised and then heated, to cause an increase in temperature and pressure. The pressurised fluid is then made to do work, usually by driving a turbine whereafter heat and energy is removed from the system to be pressurised again. Generally, the fluid will be in a liquid state before heating and in a gaseous or superheated gas state after heating.

With refrigeration systems a fluid in gas and/or fluid state is compressed mechanically and/or mostly by gravity, which heats the fluid. Heat is removed in a heat exchanger and/or fluid mixer and discarded from the refrigeration fluid. Thereafter the compressed fluid is depressurised mostly against gravity and/or to do work and cool by evaporation. At the lower pressure the fluid is allowed to vaporise partially or in whole to consume heat at low temperature. The low pressure vapour and/or liquid is then pressurised mechanically and/or by gravity to repeat the cycle.

Typical examples of the use of heat engines are power stations, and of refrigeration systems are household refrigerators. Some mine cooling systems performs work to reduce the internal, potential, velocity and/or gravitational energy.

Although the power and refrigeration systems tend to function well, they also tend to be inefficient due to a number of factors, such as mechanical and thermodynamic inefficiencies inherent in equipment used to do work, and the need to reject heat and/or energy.

South African patent number 97/1984 discloses a method of performing work in a cyclic manner. The method being characterised in that the gas and liquid are pressurised to a significant extent by the action of gravity in columns.

State of the art features applied are hysteresis loops, velocity energy, and common T-s diagram applications.

A yet further feature of the above patent provides for heat flow into the cycle(s) to be used in energy conversion, applying countercycles of fluid at different temperature values, consuming low grade heat and even in freezing water in the process of producing electric power.

The above patent further provides for a system for performing work substantially as described above comprising a closed circuit defining a flow path, the circuit being oriented to have an upper and a lower end and such that the action of gravity will cause a predetermined pressure difference in a fluid contained therein between the ends of the flow path.

The patent therefore includes gravitational refrigeration of water and power generation in countercycles by applying fluids having dissimilar latent heat exposures. The new application claims new versions of the above which change the application of the academic principles to become practical production units as described in the examples, and displayed in the figures.

The applicant's co-pending South African complete patent application number 98/8561 has not been accepted and has not been published. It describes methods for performing work by the countercycle method including drenching of the power cycle up to 50%. The present application describes variable drenching and/or preheating up to or more than 50%, the gas and liquid being pressurised and depressurised to a significant extent by the action of gravity, the method being characterised in that the density of the fluid in the column is increased by drenching the vapour with a liquid component of the fluid or drenching it by a catalyst fluid or drenching it by any fluid. The new application includes drenching by internal countercycles of similar fluid(s) or mixtures of fluids exceeding 50% drenching.

The unpublished patent application 98/8561 further discloses a method for performing work in thermodynamic countercycle in which temperature differences for heat transfer are obtained by applying two fluids with different rates of heat increase for shaft depth increase, applied in a manner which causes heat flow at shallow depth from one fluid to the other and at greater depth to cause reverse heat flow between the fluids. This has now been extended to fluids of similar rates of heat increase and for a continuous variation in fluid mix entropies.

The proceeding definitions of terms and figures are applied onwards without limiting the invention by the abbreviated descriptions. The description of the examples and figures are local descriptions only. The basic theories will apply universally and beyond the examples.

The state of art including patent ZA 971984 is illustrated in figures 1 and in the following example which is theoretically correct but unpractical.

State of the art example : From patent ZA 971984, example 2 it is calculated that power can be produced as shown diagrammatically in figure 1 of this document. Columns or shafts of 3574 meters length numbered 2, 3, 4 and 5 are filled with C318 gas and/or vapour, C318 liquid, HFC134a liquid and HFC134 vapour and/or gas. Input heat exchanger 8 balances the power energy withdrawn at 9. Heat transfer occurs in heat exchangers 6 and 7. The power yield is 14.8 kJ/kg. The unappropriated shaft lengths and heat exchangers 6 and 7 are addressed in this text and in figures 14 and 17 of this application.

In thermodynamics most operations involving heat may be typified in the classic T-s diagram shown in figure 3 by state of condition points 20, 21, 22, 23, 24, 25 and 20.

The teams of "preheat" and "drench" are shown in figure 3. If heat is applied at 20 the fluid becomes preheated to (say) state of condition 26. If power (pressure i.e. work) is applied at 26 the state of condition change to 27 which is also a state of condition of preheat. The entropy of 20 and 21 is increased at 26 and 27. Similarly the state of condition "gas" at 24 and 25 is changed to "vapour" by withdrawing heat, to state of conditions 23, 28 and 29. The new term "drenching" implies that the high entropy of superheated gas or gas at state of conditions 24, 25 and 23 is decreased. The application of preheating and drenching eventually change the shape of the convention T-s diagram to a rectangular or square shape like 26, 27, 28, 29, 26. This T-s shape modification eliminates superheating and it is hereafter commonly applied.

Patent 97/1984 states that a refrigeration cycle encircles a power cycle(s) as shown in T-s diagrams in figures 4 and 5.

A significant point of the state of art is illustrated in figures 6, 7 and 8. The conventional condition of state T-s diagram 47 and the conventional shaft length 48 are in conflict as shown by the dotted liens between 47 and 48. The display change of 47 to 49 by rotation or inversion as defined in patent ZA 971984 brings dimensions in correspondence.

The T-X hysteresis loop in figure 18 is common but its application in figure 20 is new. Components of energy are well known. Reference to potential energy in the form of gravitational acceleration and of velocity energy created in jetting, are applied in the inventions.

Object of the Invention

It is an object of the present invention to provide methods and systems for converting heat into electric power, by extending the state of the art with improvements to and additions to the methods and systems disclosed in previous patents. It exceeds on previous patents in proposing workable power generation layouts and refrigeration layouts which invite stray heat to be converted to power in 4, 3 or 2 operating shaft layouts. This utilises detailed information of the behaviour of practical thermodynamic fluids, and applies changes in material behaviour associated with induced changes in property and entropy levels of fluids and catalysts.

Description of the Invention

The invention is expanding the state of the art information and new methods. The invention includes principles of invented theory, heat balance induction, practical designs, internal countercycles, new techniques to multiply output with the application of preheated and drenched countercycles, etc. The cycles are driven by internal heating on applying gravitational compression on reshaped and equal temperature T-s diagrams. This magnifies output as shown in figure 9. The two column countercycles are based on new interpretations of hysteresis loops subject to gravitational acceleration applying N times countercycles and controlled by regulated temperatures at the top and bottom of shafts as shown in figures 19 and 20. The preferred three column layout is utterly manageable by controlling only the pumping rate. It applies the new internal countercycle T-s diagram principle shown in figure 13. The new fluids composition in the three column layout, may consist of any single or multi-mixed substance qualifying only to safety, inflammability, specified viscosity, density etc. The latter "density" becomes a design feature in so far as, increased pressure limits the physical layout size and improves performance. Ammonia, for example can be pressurised to decrease the vapour volume from 323 litre/kg at 0.382 Mega pascal to 25 litre/kg at 4.8 Mega pascals. Carbon dioxide as a monofluid in countercycle operates at temperatures below the temperature of the surround and this invites the entry of stray energy. The design pressurising fits the state of the art knowledge on pressure underground in mines and applied in rock engineering as well as with new invented feature to supply power "on the job" without contaminating the environment. The substances ammonia and carbon dioxide lend themselves to catalyst action by water. The invention extends to all fluids.

Description and Explanation of Drawings

Figure 1 is a schematic display of four working shafts 2, 3, 4 and 5 filled with two thermodynamic fluids which are not shown. Heat energy is converted to electric power at 9. The system is continual if circulation pump 10 lifts the liquid in 4. The liquid is formed in heat exchanger 7 and evaporated in heat exchanger 6. The second fluid is condensed in reverse, in heat exchangers 7 and 6. The second fluids in column 3 is compressed by gravity to drive the generator 9 and may require vapour compressor 11. Details are contained in the state of the art example.

Figure 2 shows sections of a modified layout of columns 2, 3, 4 and 5 in display 1. Display 12 is rewarding for design since shell 13 resists the fluid system's global pressure and shells 14, 15 and 16 need to resist partial pressure only. Depending on the design pressure of the fluids, the three internal column shells may profitably be inside or alongside one another at the best remunerating choice. This also holds if only three or two columns are applied.

Figure 3 displays, the classic and known T-s diagram between state of condition points 20, 21, 22, 23, 24, 25 and 20. The T-s diagram may be preheated according to the design, say, to line 26-27. Similarly it may be drenched to line 28-29. Note that the remaining T-s diagram is the rectangle 26, 27, 28, 29 enclosing fluid only and it is void of superheated gas.

Figure 4 displays a power cycle 33 completely encircled by a refrigeration cycle 32. Consequently the power cycle action is completely dominated by the refrigeration cycle which supplies heat q_1 and absorbs reject q_2. Instability in 31 will be created if energy of any type or form, enters or leaves display 31. It can be envisaged that electricity leaves at 33 and that balance is resorted to display 31 by supplying heat energy to cycle 32 or 33.

Figure 5 displays two power cycles 34 and 35 encircled by refrigeration cycle 36. If cycles 34 and 35 are similar, twice the netto power from 34 may exceed the netto power consumed by 36. This means that netto power is produced by display 44. The former reference "twice" will hereafter be called N times.

Excessive power yield from 34 and 35 is against the first law, unless input heat is supplied at, say, 39. If heat 40 plus 41 is less than heat 39, N must be bigger than two and the netto power yielded by 44 can be increased from two times to N times if the heat shortfall at 39 is not over expropriated. Heat may be supplied to 40 and 41 up to a level that hot end heats 38, 42 and 43 are in balance. In this case N can be increased further than described above.

Figures 6 to 8 in display 46 illustrates a shaft or column 48 and two T-s diagrams. The conventional T-s diagram 47 is the same as 49 except that the signs of T and of S are reversed. In figure 8 the work column can be simulated directly with the shaft. For the conventional T-s diagram 47 the simulation lines cross.

Note: If friction is disregarded, a kilogram fluid subject to the state of condition on top of figure 48 may be freely contained and lowered to the bottom where it will gain condition of state of "shaft bottom". It may be returned to the top to its original state of condition. Reasoning shows that the enthalpy change along the length of the shaft 48 is the same as the enthalpy change along the work line of figure 8, only over one specific shaft depth, called z.

Figure 9 shows the graph of increased power yield according to the state of entropy drenching of fluid HP80, provided that the HP80 power cycle is encircled by a refrigeration cycle. The increased power yield with the association of shafts stems from the total output yield being equal to the smaller yield of a drenched cycle multiplied by the larger N number of cycles inside the refrigeration cycle.

Figures 10 to 13 expand on figure 3 rotated by 180°. The conventional cycle in figure 10 may be slit into, a power cycle 134, 135, 131, 132, 133, 134 and a refrigeration cycle 134, 135, 130, 128, 127, 134. The two cycles are creating an **internal countercycle**. The power and refrigeration cycles are shown separately in figures 11 and 12. The two cycles may be run simultaneously in vertical shafts of equal length. The first shaft is filled with gas and/or vapour component 142-143. The third shaft contains the components are 127, 128 and 129, this being the liquid shaft for pumping liquid to the top. In the intermediate shaft the components 141-134 and 149-134 are mixed on top and allowed to pressurise one the other in going down to beyond the T-s diagram to state of condition 135, up to 152. At this state of condition power may be extracted up to state of condition 135. Here the depressurised vapour may be split to complete cycle components 135-159 and 135-154.

After completing the two internal countercyles in Figure 13, power leaves the system and this must cause an energy shortfall which can conveniently be compensated for by heat input along line 153-160. In the absence of heating the system in figures 10 to 13 cause global freezing. It delivers power without compensation. Stability is reached with heat supply.

Figures 14 and 15 are displays for preferred layouts of a number of examples applied to produce the power in a three column physical layouts. The conical shafts allow the velocity energising of fluid in, for example, 172 to store velocity energy, which reduces the physical size of the layout and the total volume. It creates a better condition of state for extracting power energy. The layout in figure 14 contains liquid in 173 and 175, and vapour in the rest of the voids. Figure 15 is a display of the preferred section through a 3 column power station. It shows a layout adapted specifically to employ catalytic actions like mixing water and ammonia fluids, water and carbon dioxide, or water and compressed air. Dispersion occurs at 187, heat input at 188 and/or 185, mixing, jetting and induction of velocity energy at 189. The mixed mass 191 is pressured and accelerated before passing power generator 194. The water component in 194 is circulated with pump 195 and the vapour, like ammonia gas rises through 198 to complete all cycles.

Figure 16 illustrates a layout where horizontally flowing vapour 78 is velocity energised in 82 to increase velocity, increase pressure etc on leaving column at 81. **Velocity energy** may be applied by extracting liquid at 79, pressurising the liquid in pump 80 to change the state of condition of the vapour.

Figure 17 illustrates a power generation layout operating in **four working shafts**, 86 containing pressurised carbon dioxide liquid from 105, to be distributed by 90 to sprinkle upcoming R125 vapour (89) to be condensed by evaporation of carbon dioxide.

The carbon dioxide vapour is heavier than the F125 vapour and flows downward shaft 87 to be condensed at 99 to form liquid 105 for recycling. Carbon dioxide forms the refrigeration cycles. The R125 forms the power cycle, by being evaporated at 100 on receiving heat from CO_2, being of low density the vapour moves up column 89, cools in rising, liquifies at 94, flows down 88 to produces hydraulic power at 97 before being dispersed at 98 for re-evaporating. Since N is larger than one the generated power is **more** than the input power to the carbon dioxide. The power delivered must be compensated for by adding heat at 102, 83 and/or 101.

Figure 18 shows a known T-X loop between two fluids X_1 and X_2 which are mixed in a proportion X between 0 and 100%. If T is scaled positive downwards like z, loop line 56 is the liquid condensation equilibrium line and 57 the gas evaporation equilibrium line. In the symmetric loop in display 55,. the two boiling temperatures of the two pure fluids are the same.

Figure 19 illustrates the change in the hysteresis loop of two fluids as a result of gravitational compression from 73 at the top of a column to 74 at the bottom of the column. If the rate of temperature increase for increased pressure of the two fluids are not the same, the two hysteresis loops become rotated as shown in 63. If the loops in 63 are mirror images, and the shaft related lines pass through the centres of the loops, equal amounts of gas and liquid are formed at the top and the bottom of the shaft. Rotation may be induced as discussed later in figure 20. Heating change the operating temperature from 68-69 to 70-71. At 70 most of liquid X_1 is condensed and less of X_2 is evaporated at 71. This cause column fluid instability which may produce power. It may also cope for unequal latent heats of the two fluids.

Figure 20 is a T-X diagram to fit examples 8 or 10 with mixed fluid inside a two or four column operating systems to produce power without or with less mechanical pressurisation. Lines 23/24 and 25/26 are not of equal length. The correct temperature interval choice as modified with velocity energy will cause the result that precisely N times of a specified fluid will evaporate at top and bottom to maximise production. Apply display 77 in figure 16.

Figure 21: Shafts 117 and 111 are vertical, the first to collect gravitationally driven fluid to produce power at 115. Latter shaft 111 conveys heated vapour which is not condensing vertically, to loose temperature and joins skew shaft 109. Condensing liquid

in 109 is collected and stepwise transferred by a series of pipes numbered 116 to the vertical column 117 for drenching and accelerating fluid. Each duct is equipped with a partial filled U-tube loop to eliminate vapour gas pressure equalising in shafts 117 and 109.

In the layout in Figure 21 gasses like CO_2 and R125 will produce power without pumping since R125 will rise in 111 and 109 to cool, liquify and drench mixed fluid. The dense CO_2 vapour will complete the two cycles for delivering power by distillation as shown in figure 20.

Figure 22 shows two working vapour columns 203 and 202. The gas rotates on being heated at 206 and power is drawn off at 201. A velocity energy system sucks liquid from 204 apply jet energy at 205 and controls production.

Figure 23 shows curves of temperature, pressure and ammonia solution in water ratio which are applied in examples. The fluid mixture cycle starts at 165 and it may be pressurised isothermally in a shaft to state of condition 164. The pressurised mixture expels heat in the transition. If the expelled heat is consumed at constat pressure the fluid will change its condition of state from that at 165 to 168 or to a condition between 168 and 164 according to the handling of expelled heat.

SUMMARY

The invention applies the theory of thermodynamics, based on two laws. The first law was redefined to include mass to energy conversion in atomic reactions. The second law holds exactly when applied as defined e.g. a Carnot cycle or a single temperature entropy diagram (T-s diagram). No reference to the second law could be traced which refers to T-s countercyles. New investigations were conducted on the influence of energy other than heat and work energy together with a T-s diagram, like it's combination with velocity energy etc, acting simultaneously. The state of art is shown in figures, 1, 2 and 3. Countercycles are shown in figure 4 and multiple countercycles in figure 5. T-s cycles with temperature plotted on a positive scale and negative scale are shown in figures 6 and 8 to illustrate that a component of the state of condition of the T-s diagram can simulate fluid in a column (48). The common T-s diagram in figure 6 is inappropriate.

Heat, temperature, pressure and work specifications can split a T-s cycles as shown in figure 10. The two fractional cycles together with gravity and catalistic vapour solution are shown in figures 11 and 12, and the combination of two fractional diagrams in combination with gravity in figure 13. The oversupply work 135-152 minus input can be withdrawn with no additional reference to heat demand and supply. This work is gravitational and chemical work tendered with the implementation of thermodynamics. Running the diagrams in figure 13 shows that work can be delivered with no heat supply. This must freeze the system. To reach stability, heat must be supplied. This heat input, can be supplied at any workable position in figure 13. If input heat comes from the surround the application of the invention will freeze the surround.

Heat mass is applied in recirculation of at least one cycle of a system of countercycles in at least two working columns to convert heat energy into work energy by applying gravity and chemistry. The heat mass of the two fluid systems may be equal. One of the cycles may dominate the thermodynamic behaviour of the other. One of the fluids may liquefy when moving upwardly along one of the columns. The fluid in liquid form in the one column may drench the fluid in the other column and may evaporate the condensed fluid. The difference in the fluid densities may cause a pressure difference at the bottom of the columns. The arrangement may be such that the pressure difference may yield output power and may require heat input.

The combined mass of multi-cycles may enforce excessive enthalpy in fluid at an enforced intermediate entropy level of fluid(s) in shafts to enable heat to be converted to power.

The system may apply carbon dioxide or mostly carbon dioxide to form a countercycle converter and/or a recycling countercycle to change heat energy into work energy.

The system may operate with column(s) and fluid(s) at drenching as well as preheating of very high orders, which may equal or exceed 50%, on condition that drenching plus preheating does not exceed 100%.

The system may recirculate energy in one or more cycles in countercycles to convert heat energy into power at an efficiency of up to 100%.

The first aspect of the invention produces power generation by combining thermodynamics, catalysts and gravity in **T-s internal countercycles** and **gravitational work** as shown in figures 10 to 13. The variable catalyst action is not displayed. The preferred layout is shown in figure 15, including the positions where appropriate state of conditions numbers 134, 135, 152, 159 and 160 of figure 13 apply. State of condition point 134 in the figures does not pre-specify the entropy of point 134. The percentages drenching and preheating are therefore not pre-specified. Apply liquid in column 193 and vapour in columns 192 and 199 of figure 15. The state of condition points 159 and 160 apply in column 199 to simulate low entropy fluid. To produce power the pump 195 must be applied.

Example 1: Process Scarel: Apply the internal T-s countercycle process on the fluid consisting of **"pure" CO_2** and water as a catalyst operating at -8°C at a pressure of 2.8 MPa and 60% drench plus 40% preheat in a 286 m vertical column. The calculated results show that the minimum power yield is 1.52 kJ/kg CO_2 (4 kg cycle). To obtain **"120 megawatt"** it will be required to circulate 315.2 Ton/sec of CO_2 and the total mass of fluid in the three shafts in figure 15 must be 30047 tons of CO_2 flowing at an average speed of 3 meters per second. As shown in Figure 2 the three columns fit in a circular shaft of 28.4 m diameters.

Example 2: Process Fanie: To produce **120 megawatt** power in example 1 it requires heat input at -8°C equivalent to 120 megawatt. The input heat may be withdrawn from water stored at 10°C and cooled to become ice at 0°C. A kilogram water delivers 352 kilojoules heat to become ice. At full capacity process Fanie will produce 1225.2 ton ice per hour which becomes **0.882 million kiloliters** potable water per month, on top of the power delivery of example 1.

The second aspect of the invention specifies that **heat** must be **supplied** somewhere in figures 14 and 15 otherwise the first aspect will create operations of **indefinite freezing.** The heat may be supplied at any temperature above the state of condition points of figure 13. Most of the examples calculated start at temperatures below freezing point. The heat may originate from running water which may be frozen. If polluted water or sea water is frozen the ice is not chemically polluted. Pollution components may be separated and exploited. The ice, when melton, is consumable water to be sterilised to be potable in general.

An extension of the second aspect shows that the system in the first aspect produces a **global freezer** applicable in all applications of freezing.

The Third aspect of the invention claims that the power required for **sprinkler irrigation** may be withdrawn from the water to be sprinkled, that sprinkling with cooled irrigation water causes less evaporation from the sprinkled water and provides better quality water to the soil being sprinkled.

Example 3 Withdraw heat from flowing water applied at a sprinkler or a township to deliver **300 kilowatt** in a shaft of 40 meter depth. The 300 kilowatt is sufficient to drive a sprinkler irrigation **spill point** system or a township's power demand. Lowering of the temperature of the flowing water by **5°C** reduces the spill point water evaporation during sprinkling. More than 5°C lowering may be applied. The column diameters for power from the sprinkler system are: 1.8 m for compressed air, 1.5 m for the mix column, 0.29 m for the water column and if the two smaller columns are contained in the large column its diameter must be 2.2 m.

The Fourth aspect of the invention claims that principally the layout in figures 14, 15 and 17 implies that **energy is recirculated.** To create stability in figure 13 it is required that power may be withdrawn at 135-152 in figure 13 and the same amount of heat returned, to complete the internal countercycle associated with gravitational acceleration.

Fluid following the T-s thermal path of a theoretically closed thermodynamic cycle is in fact ideally a circulating system with specification for the boundary value input and output.

In other professions and trades the continued use of matter is called recycling. This often happens without a change in substance. In thermodynamics countercycles recycling, may yield more work without consuming proportionally more heat. The rate off flowing of one or both cycles in Figure 13 may be changed.

Instability caused by oversupplying input heat and/or producing less power will systematically increase the global temperature like a heater. Stability can be reached by disposing of heat, similar to thermal power stations.

An operating layout may be unstable and satisfying boundary conditions temporary. Recycling may be over driving power production without sufficient increases of input heat, like a refrigerator or like closing a thermal power station. The temperature level of the whole layout will then decrease, operating as a global freezing unit. Stability is reached by any of:

- consuming heat from the exterior
- input heat leaking to the set up
- cooling another layout
- stopping.

It is obvious that the fluid of an internal countercycle power station, as described above, can be recirculated or one cycle may be recycled according to design specifications and boundary conditions.

Between the conditions described above, stable energy recycling, nominal heat input and power output will cause conversion of heat into power at efficiencies approaching 100%.

The Fifth aspect of the invention is to operate preceding aspects with **fluids** which are **not hostile** to life. The most common fluids in life are water and air which are applied in example 4. Ammonia is a good catalyst which is not human friendly. For the example assume that 120 Megawatt must be produced in three columns of 96 m length, that the heat intake temperature is 4°C and drenching is 60%.

Example 4: Process Jaja: Apply the preferred layout in **figure 15** to circulate air catalysts and water compressed to **3.0 MPa**. Water is contained in 196, 193 and 187, and the air flows in 199 across heat supply 185. It becomes mixed with water in 187, compressed in 192, and delivers power in 194. The starting temperature at 187 is 4°C, allowing for heat input at 185 from reject heat at thermal power stations, water or mine ventilation. Calculations apply a 10 m/sec flow rate to show that **120 Megawatt** is generated by re-circulating **2 931 ton of water** and **1 961 ton of air** filling the 96 m tall columns. The column excavation volume is 55.3×10^3 m^3. In this example the increase in operating pressure from 3.0 MPa to 3.084 MPa apply at the 96 metre shaft bottom. The layout can be fitted in 3 shafts of average diameter 23.3 m (air), 19.2 m (mix) and 3.7 m (water), or the 3 columns in one shaft of 28 m diameter. To reduce the diameters the shaft lengths may be extended.

The Sixth aspect is that example 4 may be scaled down to be installed in operating mines for the provision of power and simultaneously airconditioning the mine.

Example 5: Process Fanie: Compare the power delivered by hydraulic means with power delivered by one of the invented methods. The latter consumes energy by lowering the temperature of the water by **5°C**. Given: **Vanderkloof dam** delivers 120 Megawatt hydroelectricity on consuming up to 217 m^3/s water at a hydraulic head approaching 96 m. The invented method tested here, applies 20% drenching to **R125 CFC gas mixed with carbon dioxide in four columns of 96 m.** Heat extracted to lower the temperature of 217 m^3/s water by 5°C equals 4542 megawatt. This is 37.85 times more than the delivery capacity of the hydroelectric installation at Vanderkloof dam.

The compared invented method applies 20% drenching to R125 to improve the output according to figure 17, and applies velocity energy to regulate the process.

The seventh aspect of the invention is to apply **catalytic action** in the production of power. It improves the efficiency of the layout as shown in examples 6 and 7.

Example 6: Show that **catalytic action** can be applied together with internal countercycle power generation. With reference to figure 23, start at state of conduction 165 for the mass composed of 15% **ammonia** gas at 0.3 MPa and 290 K, 35% liquid **water** and 50% **nitrogen** gas or other non-reacting fluid at 8.0 MPa and 290 K. According to Dalton's law the total pressure should be 8.3 MPa and after lowering by 250 m as shown in figure 15 the pressure at 198 should be 8.4 MPa. Isothermally the 15% ammonia gas should dissolve completely in the water and release 180 kilojoule heat for 1 kg fluid. According to the design most of this heat will be consumed in ammonia gas forming after power delivery. In the heated intermediate stage the heat can produce power. The liquid is recycled with pump 195 and the ammonia gas will circulate along 198 and 199 to be drenched again at 187 to complete the cycles. The exact output power at 194 will be more than 10 kJ/kg fluid, depending on the design.

Example 7 The catalytic action in example 6 will operate in a mechanical layout consisting of a compressor(s) and/or centrifuge(s) for compression, an expander(s) to produce power and heat exchanger(s) for heat input to complete the internal counteracting T-s diagram in figure 13.

The examples 6 and 7 demonstrate that the pressure and temperature sensitivity of the solubility of ammonia in water (figure 23) can be applied as shown in figure 14. The evaporation and condensation heat is successively conveyed to compressed nitrogen or other fluid to do the additional work.

The eight aspect of the invention expands on the fifth aspect, in so far as the combination of gravitational energy plus catalytically produced energy is more than gravitational energy. Catalytically supplied heat may be withdrawn by applying **centrifuges** and expanders to produce power.

The ninth aspect of the invention modifies the power T-s cycle to produce and deliver more power from the combined countercycles. **Preheating** and **drenching** reduce the entropy interval of the power cycle, and consequently more power cycles fit inside the refrigeration cycle. The reduced power cycles individually yield less power. The total output is the product of individual power cycles times N, the number of cycles. This product increases as shown in figure 9.

The tenth aspect of the invention applies the well known **hysteresis loop** between evaporation and condensation of a varying mixture of two fluids as shown in figure 18, together with the distortion of loops by gravitational action in shafts as shown in figure 19. On regulating the temperature in two shafts the distorted loop displayed in figure 19 yields various percentages of the mixed fluids X_1 and X_2, as shown by analyzing line 68 to 69 in relation with line 70 to 71. Skew displays, to advance power production as shown in figure 20, are obtained by regulating the temperature related via the velocity of flow to the pressure. The tenth aspect is implemented in preferred layout displays shown in figures 21 and 22.

Example 8 Demonstrate that power production operates in two columns as shown in figure 21. Consider CO_2 and CFC called HP80 on the assumption that no chemical reaction occurs between the fluids. To obtain equal heat masses mix CO_2 and HP80 (20% drench on 20% preheat) in the ratio 28% CO_2 and 72% HP80. Let X_1 be CO_2 and X_2 be HP80. Figure 20 shows that the vapour will contain more R125 at the bottom of the shaft and less at the top of the shaft. The fluid specific volumes of 18 and 11 l/kg confirms that CO_2 gas will move down and HP80 gas will move up, to condense and avail HP80 liquid at the top of the column to a much bigger extent than CO_2 liquid. When applied in a display as shown in figure 21 the CO_2 will be highly drenched to accelerate the operation of the system.

No formula or experience avails to calculate the output. Nominal estimates show that a mass of 269 ton in a 96 m column will produce about 1.4 megawatt power production.

Example 9: Apply fluids **carbon dioxide and R125** (chemically CHF_2CF_3) in four columns of **10 m** length and fluid mixing, as displayed in figure 17. Regulation occurs at 93 by velocity energy and power is generated at 97 from R125 and CO_2 fluid mix as well as at 83 from high entropy fluid. The R125 and CO_2 gas is self circulating due to densities. Production is regulated by liquid pump 103, power production pump 83, generator 97 and velocity pump 93, at a temperature of 280K. Calculations show equal heat masses for 1 kg CO_2 and 1.65 kg R125 if not drenched. Drenching will increase production as shown in figure 9. Full cycle power production is **72 J/kg of CO_2** circulated or 13.5 J/kg from the total mass of circulated gas and z = 10 m: It can be increased by drenching. At 10% preheat, 10% drenching and fluid flow velocity 20 m/sec the power production increases to 129 J/kg total mass or 24.2 per kg of cycle mass. A practical application of the latter case shows that **3 kilowatt** can be generated in a column of 10 m long and 2.2 m diameter. An enlarged layout of **120 megawatt** at column height of 48 m requires an encircling shaft of **77 m diameter**, which is impractical. For this capacity a column of 300 m long and diameter of 30.8 m is more proportional.

The eleventh aspect of the invention applies fluid mixing and fluid selections to **eliminate two large heat exchangers** of the state of the art displayed in figure 1. The selection of fluids yield power at 83 in figure 17 from **density differences** between vapours as shown in example 9. This is a further aspect of producing power, additive to liquid induced power production at 97 and in figure 17.

Example 10 Apply the display in figure 22 to generate power. The display shows two independently acting mechanisms. The first is liquid store 204, liquid pump 207 and at 205 a generator of velocity energy which is mostly recoverable. The second mechanism consists of heat source 206 supplying energy to vapour 203 which, as a result of heating, is of smaller density than vapour 202. In the columns the difference in density causes circulation and therefore deliver power at 201. If the rotation speed is increased from (say) 1 to 10 m/s by velocity energy, the vapour power delivery will increase ten times. Given the vapour ethylene (C_2H_4) at 265 K, 3.35 MPa having s = -1.519 which is combustible but not fired. Operations run at about -8°C and the liquid in 204 is also ethylene. Create an entropy level on leaving 205 to be on the liquid saturation line. Energy from 206 will expand the fluid gas to cause a light density in column 203. On withdrawing power at 201 the temperature and pressure drops and the gas in 203 will be drenched by fog in 202, which enhances the vapour power production induced by gravity in the columns. No data for sample calculations avail.

Example 11: Apply the reject heat of the thermal power station Lethaba (heat from coal) on applying the process described in example 4, operating at -8°C according to the example. The reject heat from the thermal process can be converted to power in total. Assume the six times 618 Megawatt Lethaba power station runs at 45% efficiency then the example referred to, will deliver an extra 4532 Megawatt and on top it will save about 58 million cubic meter water from Vaaldam applied to evaporate the power station reject heat.

The twelfth aspect of the invention involves a system to run countercycle power production inside **two only columns** for fluid flow. The columns are coupled intermediately with liquid conveyance pipes for drenching and pressure isolation, as shown in figure 21. In example 8 it was shown that the T-x behaviour in figure 20 dominates evaporation and delivers high density CO_2, well drenched, to reach power converter 115 and yield output power. The rate of power production will be influenced by velocity inducer 121. The heat input 113 in figure 21 and the velocity generator 121 dominate the production of the system.

The thirteenth aspect of the invention applies internal fluid drenching in **2 columns** as shown in figure 22. The condition of state of the two fluids in 203 and 202 impel circulation and output power generator 201 and heat input 206 establish a temperature according to production.

Display 208 is designed to operate near the vapour saturation line of a fluid and operates well if the vapour density is high, e.g. for CO_2 which can be applied to operate between +30°C and -100°C, depending on the quality of the input heat source.

The Fourteenth aspect of the invention relates to the residues left over after water extraction by freezing. This is a field by itself. Reference may be made to mineral extraction from the dead sea and to sea salt extraction at Port Elizabeth, both as a result of water removal.

The Fifteenth aspect of the invention relates to a practical design and application of the invention operating in water. The entire power station may float in water. The **mass of air** in the power station, functioning for example on water **heat**, water, a catalyst and air, can be increased to reach the air pressure required for optimal functioning. The **air mass** increases the density of the global power station. Consequently the power station will sink down the water and stabilise at the bottom of the water. On stabilisation the production of power may commence. Being stable at the bottom the power station cannot move round as a result of waves or water current during operation. If repairs have to be made, the high pressure air and/or water masses are released, the power station will float like a ship and normal open air repairs can be applied to the power station as a whole. The external water pressure counters internal pressure of the power station, yielding an economical design.

The design is normally tested at twice the open air operational pressure. If the external water pressure is three times the operational pressure the internal air pressure can be raised to (1+3)=4 times the open air design pressure, eg, design the power station for one MPa, cover the power station with 300 m of water (supplying operating heat) and operate the power station at four MPa. This reduces the physical size of the power station to a fraction of the equivalent size of a 4 MPa open air power station.

The sixteenth aspect of the invention relates to the stability of an under water power station and the stability of power generating equipment in the power station. Displays 12 in figure 2 shows high entropy fluid(s) in a fraction of the circumferential column area and low entropy fluid(s) in the other fraction of the column area. This is thermally well in rock but will cause tilting in water. Under water the circumferential column can be prevented from tilting by placing columns 14 and 15 in opposing positions in column 13 and by choosing column flow speeds in 14 and 15 to equalize the mass distribution in column 13.

DESCRIPTION OF PREFERRED EMBODIMENT OF THE INVENTION

The layout 186 in figure 15 is the preferred layout. It lends itself to scaling, power production and the freezing of water to yield potable water. An appreciable advantage of the three column layout compared to the two and four column layouts vests in the fact that evaporation and condensation of the two fluids are mechanically enforced.

The system 186 comprises three columns namely 191, 193 and 199. Column 199 contains gas, drenched vapour and/or vapour. Column 193 contains liquid, preheated liquid and/or low entropy vapour. Column 191 contains a fluid mixture consisting of liquid plus vapour and/or gas. The system 186 further includes a pump 195 for circulating liquid or low entropy fluid by force; an electric power generator 194; a drenching disperser 187 a fluid mixer 134; a heat input 185. If required velocity energy for circulation may be applied at 187 by over pressurising pump 195.

The three columns 191, 193 and 199 are filled with a mixture of a suitable fluid or pure fluid such as a refrigerants HP80 and F125 mixture or pure carbon dioxide. For ease of calculation purposes, it is assumed that column 193 and sump 196 contain liquid only.

To produce power the liquefied fluid of high density 196 is elevated with pump 195 along 193 and dispersed in 187 and 134. Partly or wholly gasified fluid 199 of low density is elevated against gravity by induced vacuum or mechanical circulation if necessary and mixed in 189, providing mechanical circulation. At 134 the action may include jetting and/or drenching.

Note that the division line 134 to 149 in Figure 12 depicts a refrigeration cycle component and lines 134 to 141 in figure 11 depict a power cycle component. The fluid state of condition points of figure 13 are indicated in figure 15 showing the work output cancelled by gravity in 159 to 160 in column 199.

The input work against gravity in figures 13 and 15 extends from 153 through pump 195 to the high pressure stage 155 and pressure is decreased by flowing against gravity to state of condition 135 to 134 at the top of column 191. For ease of calculation assume a 50% mass mixture of gas and liquid at disperser 187. One kilogram per second fluid in columns 193 and 199 result in 2 kilogram fluid per second in column 191. The state of condition of fluid in column 191 change from 134 to 152. In passing through power generation 194 the state of condition becomes 135 to be separated into liquid 154 and gas 159. This completes the power generation countercycle in figure 15 as well as the thermodynamic cycle in figure 13. Assume a shaft length of z_o from $h = mgz_o$ in which h is enthalpy change of gas from 159 to 160.

If m_1 is the mass flow rate of liquid, m_2 the mass flow rate of vapour and/or gas and z_o the column depth the analysis of work in figure 13 shows.

Work input in column 193 (153 to 187) = $-m_1gz_o$

Work input in column 199 (155 to 153) = $-m_2gz_o + hm_2 = 0$

Work output in column 191 = $m_1gz_o + m_2gz_o - hm_2$

Netto work output = $hm_2 + m_2gz_o = 0$

The theoretical analysis does not explain why work can be withdrawn from 152 to 135 in figure 13. If a catalyst is included in the fluid it will decrease the temperature of 134 and increase the temperature of 152, to produce more output power.

Dated this 9th day of march 2000 ....

CLAIMS

1. A power generating system applying **internal countercycles, catalysts** and **gravitational compression to create**, a power generating T-s cycle and a countercycling refrigerating T-s cycle, operating at entropy levels joining at one common entropy state of condition point. The sum of the power cycle plus the refrigeration cycle and gravitational compression constitute another T-s cycle as shown in figure 13. The entire T-s cycle system in figure 13 is subjected to gravitational compression inside columns containing state of condition points 159 to 160, 153 to 155 and 134 to 152 in three shafts as shown in figure 15 and example 1. The work in 132 to 133 is equal to the work in 142 to 143, and to the work in 159 to 160, and equal to gravitational work gz_o. These equalities apply to a specified value of z_o to fit the fluid state of conditions 132 to 133. Pump work applies from 155 to 153. The ideally global T-s diagram as display 139 may be distorted with mechanical intervention to change the pressure, and/or temperature and/or entropy. The preferred layouts of three column power generation system is displayed in figure 15, and operate in a continual cycle as described in the "description of preferred embodiment of the invention."

2. A power generating system as claimed in claim 1 in which the common operating state of condition **entropy** point 134 is chosen to be of **optimum operating value** for the entropy according to the thermodynamic properties of the fluid(s), in the range of **drenching** up to very low entropy values.

3. A power generating system as described in claims 1 and 2 is in a **preferred three column layout** as shown in display 186 including a regulating pump, a fluid

disperser, a heat exchanger for heat input, a generator for producing power, selected fluid(s) — not shown — and appropriate regulating, measuring, starting, etc equipment.

4. A power generating system as described in 1 to 3 in which the input heat energy may be applied at **any temperature** between the coldest and hottest conditions of state, inclusive of the extreme temperatures.

5. A power generating system as described in claims 1 to 4 combined with other factors in which catalyst(s) improve the power output and/or heat exchange as described in claim 3, in which recycling increase the power output as described in claim 5 and in which drenching and preheating improve the power yield as described in claim 6.

6. A power generating system as described in claim 1 in which fluids are **completely soluble, nominally soluble** and/or grossly insoluble in a layout as shown in figures 14 and 15 in a continual process as shown in example 4.

7. A power generating system as described in claims 1 to 6 in which the fluids are **water**, pure or mixed, catalysts and **air** as is, blended or changed to be oxygen rich, pure oxygen or pure nitrogen.

8. A power generating system as described in claims 1 to 6 in which fluids are **water** and **carbon dioxide**, plus an arbitrary production fluid acting catalytically, either to be pure or blended to curtail plant degeneration.

9. A power generating system as described in claims 1 to 7 in which the fluids are **water** and **ammonia**, either to be pure or blended, with or without the addition of other fluids like Xenon, Krypton, nitrogen, and fluids having a heavy vapour value and catalysts, etc, for the purpose of augmenting fluid **density** to improve operational efficiency.

10. A power generation system as described in clams 1 to 9 and claims following hereunder in which gravitational compression is augmented or replaced by mechanical compression.

11. A power generating system as described in claims 1 to 10 and claims following hereunder in which a **catalyst** or catalytically acting substances are applied to alter the operation of the system as shown in example 6. A fluid may operate catalytically and/or a catalyst may be added to the fluid(s).

12. A power generating system as described in claim 11 operating on two or more fluids like **ammonia, water, carbon dioxide, nitrogen** and/or **xenon,** in which a substance acts as a catalyst, and xenon and/or others to operate as a high density vapour or gas to reduce the physical size of the layout. Xenon may be replaced by any other fluid not reacting chemically in the combination of fluids, and having high density vapour and/or gas, like lead containing hydrocarbons in petrol.

13. A system for producing **potable water** from polluted water and/or sea water by applying **claim 1** and further claims on water freezing. The temperature of water is reduced according to claim 17 by converting internal and/or external energy to power. On removing power from the system in the form of heat withdrawn from water the global temperature of water may be reduced to below zero degrees Celsius, the ice formed may be removed. On melting the ice the potable water is formed and the rest of the water is of smaller mass to reject or to render minerals and./or compost or debris.

14. The system for producing potable water in as described claims 1 to 13 can be applied to change the quality of river water to better quality water for agriculture and domestic use rather than to dilute the contaminated water to increase its potability, for example the Vis river in RSA and the San Francisco river in the USA and Mexico.

15. As system for producing better **quality irrigation water** as described in claim 14 in so far as the power to drive the irrigation system may be provided from heat withdrawn from the incoming irrigation water or associated canal water.

16. A power generating system as described in clams 1 to 15, as well as in claims following hereunder, in which **energy** in any form or the sum of energy contained in T-s cycle(s), or part of the energy contained in T-s cycle(s), is **recycled** to produce more power and/or augment the temperature of the system or part of the system in a continual process.

17. A power generating system as described in claim 16 operating in a continual system to **remove heat like a freezer** and to change the heat so removed grossly into power.

18. A power generating system as described in 16 and 17 to operate as a **airconditioner** or temperature regulator on surface, inside an installation, inside a mine, in an aeroplane and/or in a space layout on a continual basis. This appeals to the improvement of the quality of life.

19. A power generation system as described in claims 1 to 18 in which power is generated from input energy and/or energy **leaking** into the system and/or **heat** generated by friction, turbulence, etc.

20 A power generation system as described in claims 1 to 15 in which **drenching** of gas and/or vapour changes the **density** and consequently the gravitational compression or vacuum of the fluid(s). The effectiveness of drenching improves if the low entropy fluid(s) is distributed as uniformly as possible throughout the combined mass of fluid(s) in a shaft. The percentage drenching is a variable designated by the fluids and design layout.

21. A power generation system as described in claim 20 in which **drenching** and preheating are applied almost exclusively to the **power cycle.**

22. A power generation system as described in 1 to 21 in which drenching is combined with preheating, as applied by claim 1.

23. A power generation system as described in all preceding and successive claims in which drenching and preheating together is applied to reduce the **operating power cycle entropy interval,** to enable more power T-s cycles to be encircled by a refrigeration T-s cycle, including common upper and/or lower temperature values for the power generation and refrigeration T-s cycles. This increases N and the netto total amount of power delivered as illustrated in figure 9.

24. A power generation system as described in claims 1 to 23 in which the well known **hysteresis** loop in figure 18 is **distorted** as shown in figure 20 by the action of gravity, temperature or pressure in machines and/or shafts as displayed in figures 17, 21 and 22.

25. A power generation system as descried in claim 24 in which modification in shaft diameter or length and/or variation in temperature and pressure and/or the rate of operations, change the evaporation and condensation and/or evaporation **fluid compositions** as demonstrated in figures 19 and 20 from state of condition points 68 and 69 at the bottom of the shaft to state of condition points 70 and 71 or inversely. Similar changes can be induced at the top of the shaft.

26. A power generation system as described in claim 25 in which the **proportional ratio** of condensing and evaporation of **liquids** advances preheating and drenching in columns, to promote power generation or regulate delivery as shown in example 8.

27. A power generation system as described in claims 24 to 26 in which the state of condition properties of fluid X_1 in figure 20 **dominates** the fluid **behaviour** of evaporation and condensation in column 117 and the state of condition properties of fluid X_2 dominates the fluid behaviour in columns 109 and 111, or inversely.

28. A power generating system applying gravitational compression in four fluid columns, or centrifugal acceleration, to compile a power T-s cycle and a refrigeration T-s countercycle in machines or in shafts and galleries, the **fluids** being **mixed** to eliminate the two main heat exchangers operating between the separated fluids applied in state of art figure 1. The layout in figure 17 in which the fluids are not specifically shown, represent a carbon dioxide liquid column in 86, **carbon dioxide** vapour in column 87, **liquid R125,** (CHF_2CF_3 refrigerant) in column 88 and R125 vapour in column 89. To operate the pump 103 elevates carbon dioxide and disperses it at 90 to form a heavy vapour 93. To vaporise CO_2 the vapour of R125 in 89 is condensed to form liquid 92 which gravitates through power generator 97 and becomes dispersed at 98 to form vapour 100. This creates thermodynamic countercycles as shown in figure 20 which are driven by pump 103. Additional power can be generated from the difference in vapour densities of R125 (light and drenched at 96) and CO_2 (heavy). Gravity lowers the temperature of R125 vapour much more than the temperature of CO_2 vapour and this drives cold condensation and evaporation at 94 and hot evaporation and condensation at 100. Input heat may vapourise R125 at 102 and/or carbon dioxide at 101. In example 9 the input heat may be received between temperatures -20°C to +100°C according to the final design, and may be equal to the power delivered.

29. A power generating system as described in 28 in which the choice of fluid characteristics and price effect the optimum design. Vapours of CO_2 and R125 have the advantage to be **self circulating vapour** in gravity driven columns. This advantage is also available with other fluid combinations, e.g. hydrocarbons like C_3H_8 and CH_4, having additional risk factors. Cost and availability influence the choice of other fluids like PH_3, fluorocarbons, G_eH_4, S_iH_4, $S_{i4}H_{10}$, S_iH_6, lead containing fluid etc. The combinations must be chemically non-reacting or reaction blocked.

30. A power generation system as described in claims 1 to 29 in which the column layout is reduced to **two columns** and ducts which are systematically connected with "drenching" pipes equipped with a U loop to prevent back flow as a result of pressure differences. The preferred layout in two dimensions is shown in figure 21. In three dimensions, shaft 109 may be chosen to spiral around shaft 117. The design may also prescribe the spiralling of shaft 111 around shaft 117.

31. The power generation system as described in 30 which applies 2 or more fluids selected according to display 63 and 122 in figures 19 and 20. Fluid(s) X_1 raises to 123 in the process to condense as a result of cooling by negative gravitational work and after 123 it substantially evaporates before reaching 115. The condensate(s) are U-tubed to drench fluid in column 117 consisting of vapour of all **fluids.** Differences in the operational latent heats accommodate larger supplies of liquid for drenching. Fluid(s) X_2 is heated and resists condensation in 111, promotes evaporation in 109 and advances condensation along 117. The design lengths of 123 to 124 and 125 to 126 provide for the value of N, to

eliminate undesirable fluid accumulation.

32. A power generation system as described in claims 30 and 31 in which **two columns** are applied as shown in display 208. **Internal drenching** and/or **catalytic action** is provided. Velocity energy and/or drenching is applied at 205, heat energy at 206 and power withdrawn at 201. A single fluid will operate on internal drenching. A mixed fluid may exist for example of **nitrogen** at 3 MPa pressure having a specific gas volume of 25.3 m^3/ton responding well to gravitational compression and heating, plus **ammonia** at 260K and 0.256 MPa pressure having a specific gas volume of 471 m^3/ton and latent heat of 1307.5 Mega joules per ton, applied with catalytic action of fog, and condensing water vapour in a layout like figure 22.

33. A power generating system in which the entire operating system is submerged in water. The water supplies the input heat for generating power in flowing past the generating system. The external water pressure may be applied to reduce the cost of building the power generating system employing opposing water pressure.

AMENDED CLAIMS

[received by the International Bureau on 18 August 2000 (18.08.00); original claims 1-33 replaced by new claims 1-29 (5 pages)]

I.CLAIMS

1. A combined cycle power generating system applying gravitational compression and decompression of a suitable fluid in a closed circuit in which input heat is transferred to the fluid at one point in the circuit and output power is extracted from the fluid at another point in the circuit, *characterized in that* the power generating system comprises a power generating cycle and a thermodynamically countercycling refrigerating cycle, *in that* the power generating cycle and the refrigerating cycle co-operate as internal countercycles of the combined cycle, *and in that* the power generating cycle and the refrigerating cycle share at least one common operating entropy state of condition point (134) of the fluid.

2. A combined cycle power generating system as claimed in claim 1, *characterised in that* the common operating entropy state of condition point (134) is selected such as to fall between a first point representing a two-phase vapour/liquid combination and a second point representing a sub-cooled liquid.

3. A combined cycle power generating system as claimed in claim 1 or 2, *characterised in that* the input heat is applied at any temperature from the coldest to the hottest conditions of state of the fluid in the circuit.

4. A combined cycle power generating system as claimed in any one of claims 1 to 3, *characterised in that* the fluid comprises a substance which is evaporated in one part of the cycle and condensed in another part thereof.

5. A combined cycle power generating system as claimed in any one of claims 1 to 4, *characterised in that* the fluid comprises at least two substances.

6. A combined cycle power generating system as claimed in claim 5, *characterised in that* the two substances are water and air.

7. A combined cycle power generating system as claimed in claim 5, *characterised in that* the two substances are water and carbon dioxide.

8. A combined cycle power generating system as claimed in claim 5, *characterised in that* the two substances are water and ammonia.

9. A combined cycle power generating system as claimed in claim 6 or claim 8, *characterised in that* the fluid comprises, in addition, a relatively high density vapour or gas for increasing the fluid density.

10. A combined cycle power generating system as claimed in claim 9, *characterised in that* the high density gas is selected from carbon dioxide and xenon.

11. A combined cycle power generating system as claimed in claim 1, *characterised in that* the gravitational compression is augmented by mechanical compression.

12. A combined cycle power generating system as claimed in claim 1, *characterized in that* gravitational compression and decompression are achieved by means of two or more columns forming part of the circuit, *and in that* the columns extend from a higher level to a lower level.

13. A combined cycle power generating system as claimed in claim 1, *characterized in that* the output power which is extracted from the system causes the temperature of the fluid to be reduced, permitting the system to be used as a freezer.

14. A combined cycle power generating system as claimed in claim 1, *characterized in that* the output power which is extracted from the system causes the temperature of the fluid to be reduced, permitting the system to be used as an air conditioner.

15. A combined cycle power generating system as claimed in claim 1, *characterized in that* in one portion of the circuit, a liquid is conveyed, *in that* in another portion of the circuit a vapour derived from the liquid is conveyed, *and in that* the gravitational compression of the vapour is enhanced by drenching thereof with a portion of the liquid.

16. A combined cycle power generating system as claimed in claim 1, *characterised in that* the circuit comprises a first substantially vertical column (109 plus 111, 203) for conveying a fluid from a lower level to a higher level, *in that* the circuit comprises a second substantially vertical column (117, 202)

for conveying the fluid from the higher level to the lower level, *in that* heat is transferred to the fluid in at least one position in the circuit *and in that* power is extracted form the fluid in at least one other position in the circuit.

17. A combined cycle power generating system as claimed in claim 16, *characterised in that* the fluid comprises two substances which are completely soluble in one another at all operating temperatures of the system.

18. A combined cycle power generating system as claimed in claim 17, *characterised in that* the latent heat of evaporation of the one substance is substantially more than the latent heat of evaporation of the other substance, so as to cause preferential condensation of the one substance to result in drenching of the vapour of the other substance, which in turn causes the fluid to self-circulate.

19. A combined cycle power generating system as claimed in claim 1, *characterised in that* the circuit comprises a first substantially vertical column (193) for conveying a liquid from a lower level to a higher level, *in that* the circuit comprises a second substantially vertical column (198 plus 199) for conveying a vapour from the lower level to the higher level, *in that* the circuit comprises a third substantially vertical column (190) for conveying a mixture of the liquid and the vapour from the higher level to the lower level, *in that* heat is transferred to the fluid at any position in the circuit *and in that* power is extracted form the mixture at the lower level in the third substantially vertical column (190).

20. A combined cycle power generating system as claimed in claim 1, *characterised in that* it is continuous *in that* it comprises a first column (199) for conveying air from a lower level to a higher level causing the air to expand as its pressure decreases, *in that* it comprises a second column (190) for conveying a mixture of air, water vapour and liquid water from the higher level to the lower level, thereby compressing the air forming part of the mixture, and *in that* it comprises a third column (193) for conveying liquid water displaced by a pump (195) from the lower level to the higher level.

21. A combined cycle power generating system as claimed in claim 1, *characterised in that* the circuit comprises a first substantially vertical column (86) for conveying a first liquid from a lower level to a higher level, *in that* the circuit comprises a second substantially vertical column (87) for conveying a first vapour derived from the first liquid from the higher level to the lower level after heating by the second fluid, *in that* the circuit comprises a third substantially vertical column (88) for conveying a second liquid from the higher level to the lower level, *in that* the circuit comprises a fourth substantially vertical column (89) for conveying a second vapour derived from the second liquid from the lower level to the higher level, *in that* heat is transferred from the first liquid to the second liquid at the lower level *and in that* power is extracted form the second liquid in the proximity of the lower level.

22. A combined cycle power generating system as claimed in claim 21, *characterised in that* the first and second liquids are selected on the basis that the variations in their boiling points caused by variations in pressure are sufficient to cause the first and second vapours to self circulate in the circuit.

23. A combined cycle power generating system as claimed in claim 1, *characterised in that* the fluid comprises two liquids which are soluble in one another *and in that* variations in the boiling point of the one substance caused by variations in pressure are substantially more than variations in the boiling point of the other substance caused by the same variations in total pressure.

24. A process for producing water of improved quality from water of undesirable quality *characterized in that* the process includes the step of removing heat from the water of undesirable quality, *in that* said heat is transferred to a suitable fluid circulating in a combined cycle power generating system which comprises a power generating cycle and a thermodynamically countercycling refrigerating cycle, *in that* the power generating cycle and the refrigerating cycle co-operate as internal countercycles of the combined cycle *and in that* the power generating cycle and the refrigerating cycle share at least one common operating entropy state of condition point (134) of the fluid.

25. A process for producing water of improved quality from water of undesirable quality as claimed in claim 24, *characterized in that* the water of undesirable quality is caused to freeze at least partially, *in that* ice is recovered from the water of undesirable quality; *and in that* the ice is allowed to thaw to yield the water of improved quality.

26. A process for producing water of improved quality from water of undesirable quality as claimed in claim 25, *characterized in that* the water of undesirable quality is river water *and in that* the water of improved quality is potable water.

27. A process for producing water of improved quality from water of undesirable quality as claimed in claim 24, *characterized in that* the water of undesirable quality is river water *and in that* the water of improved quality is irrigation water.

28. A combined cycle power generating system as claimed in claim 4, *characterised in that* the substance is carbon dioxide.

29. A combined cycle power generating system as claimed in claim 1, *characterised in that* the fluid comprises, in addition, a substance capable of increasing the mass heat conveyance of the fluid.

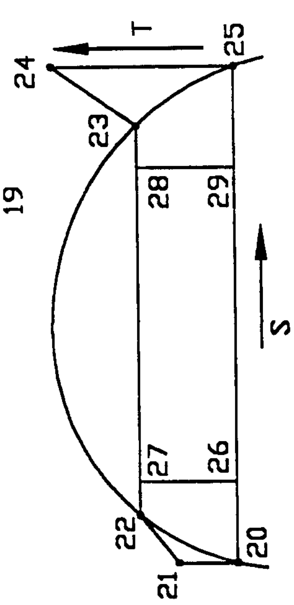

FIG. 3

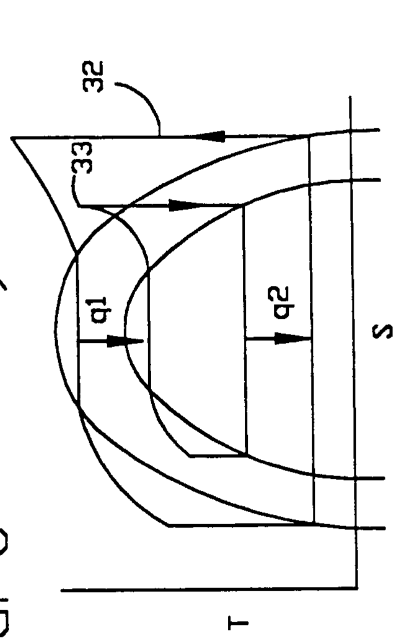

FIG. 4

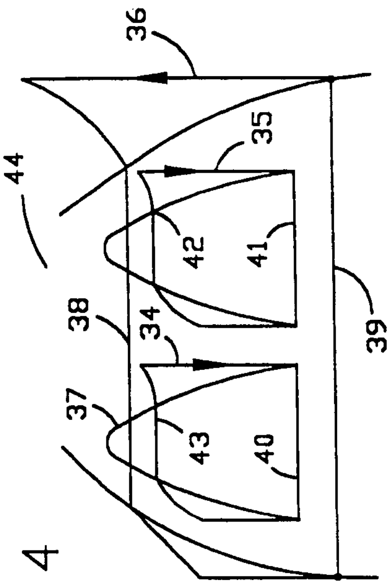

FIG. 5

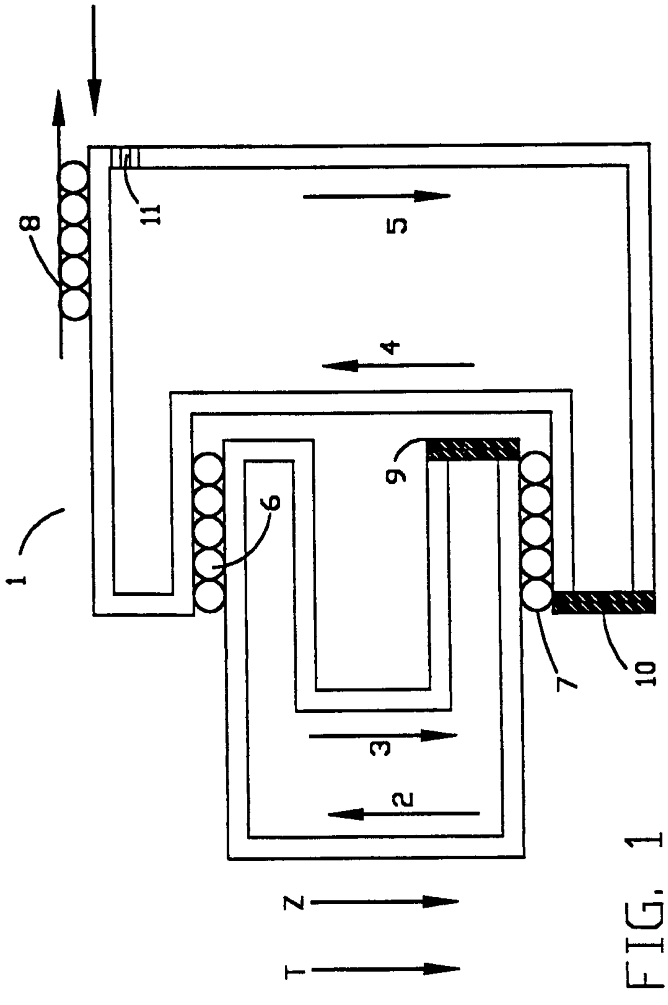

FIG. 1

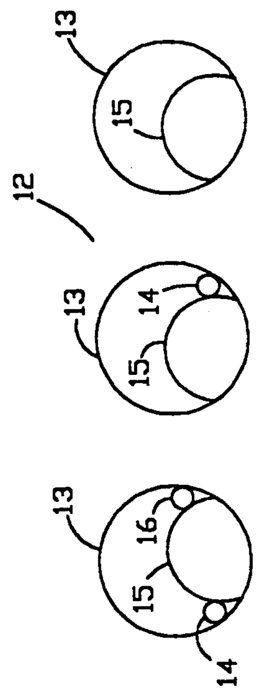

FIG. 2

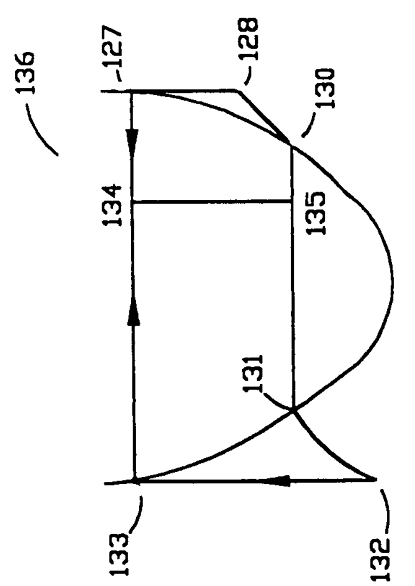

FIG. 10

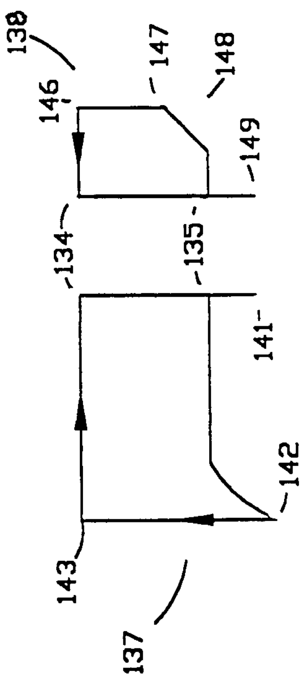

FIG. 11

FIG. 12

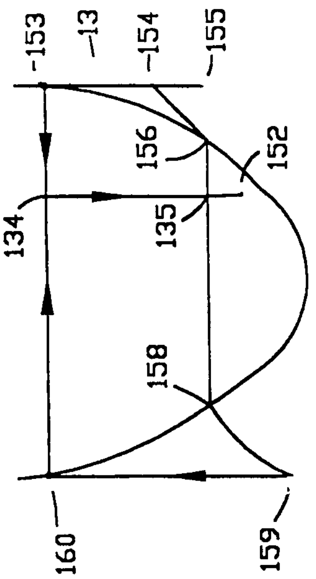

FIG. 13

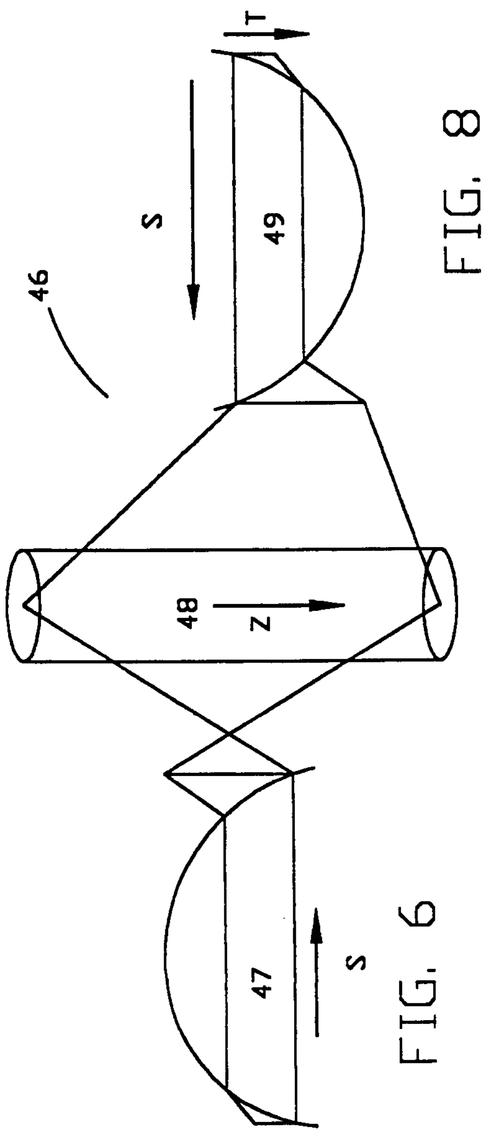

FIG. 8

FIG. 7

FIG. 6

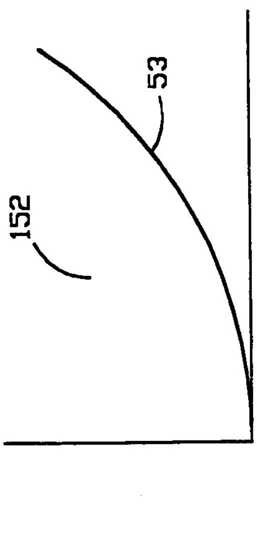

FIG. 9

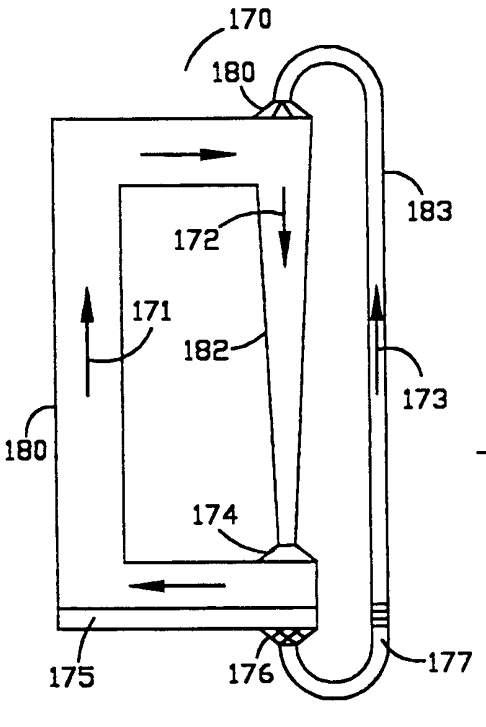

FIG. 14

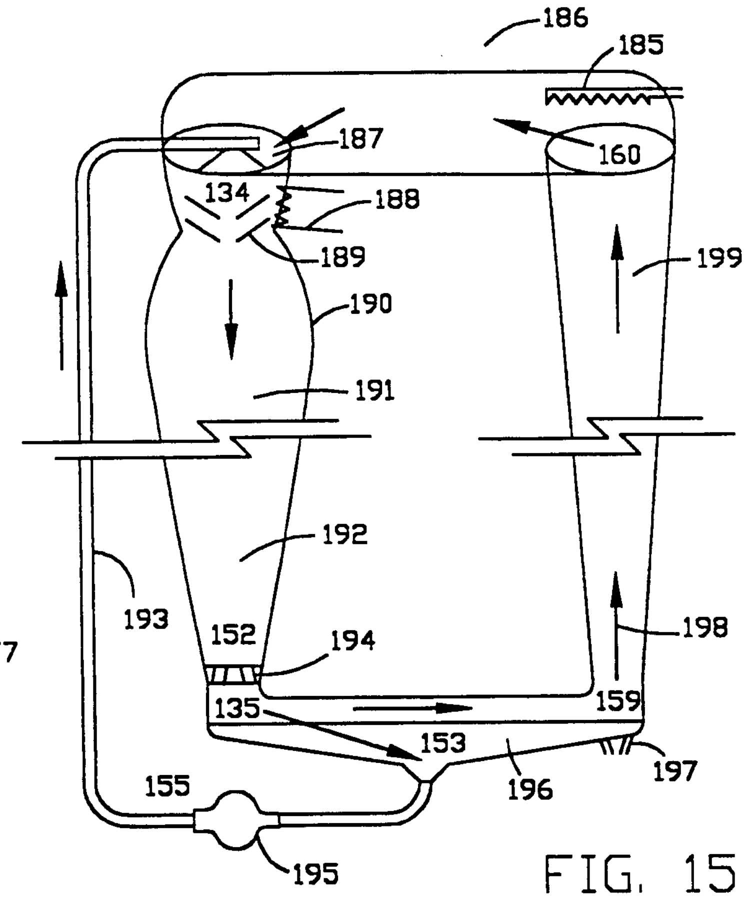

FIG. 15

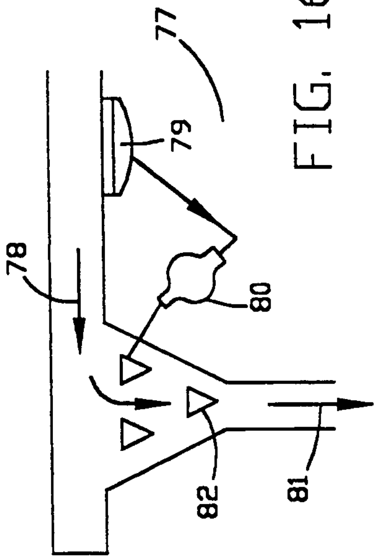

FIG. 16

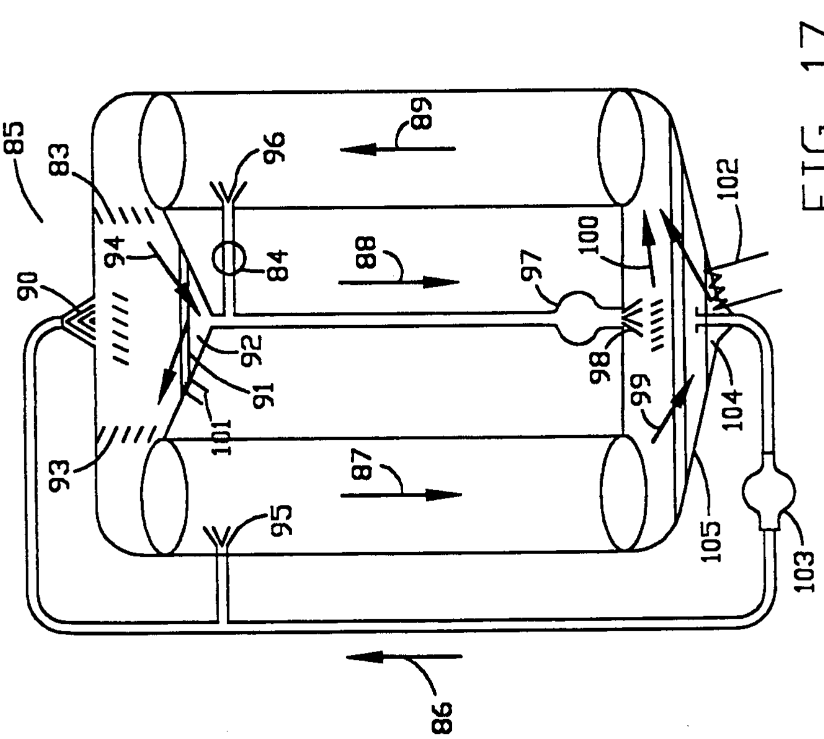

FIG. 17

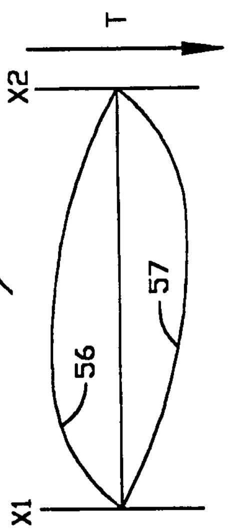

FIG. 18

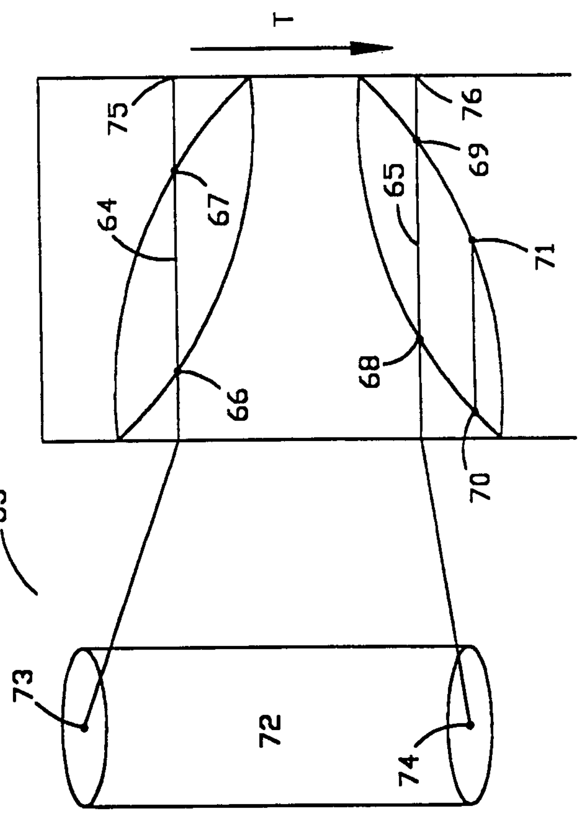

FIG. 19

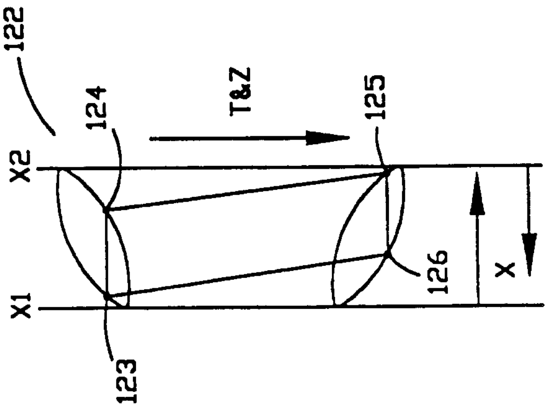

FIG. 20

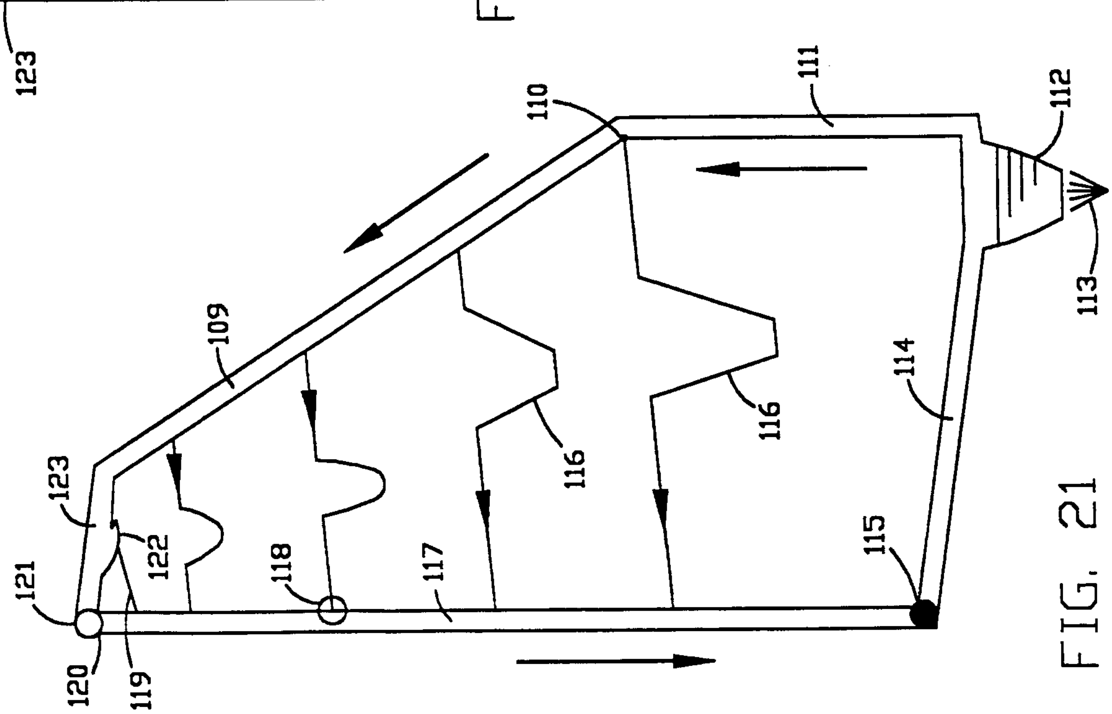

FIG. 21

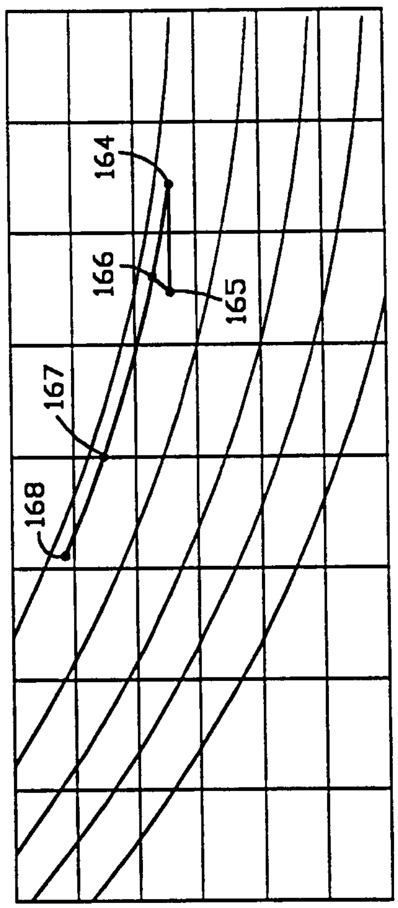

FIG. 23

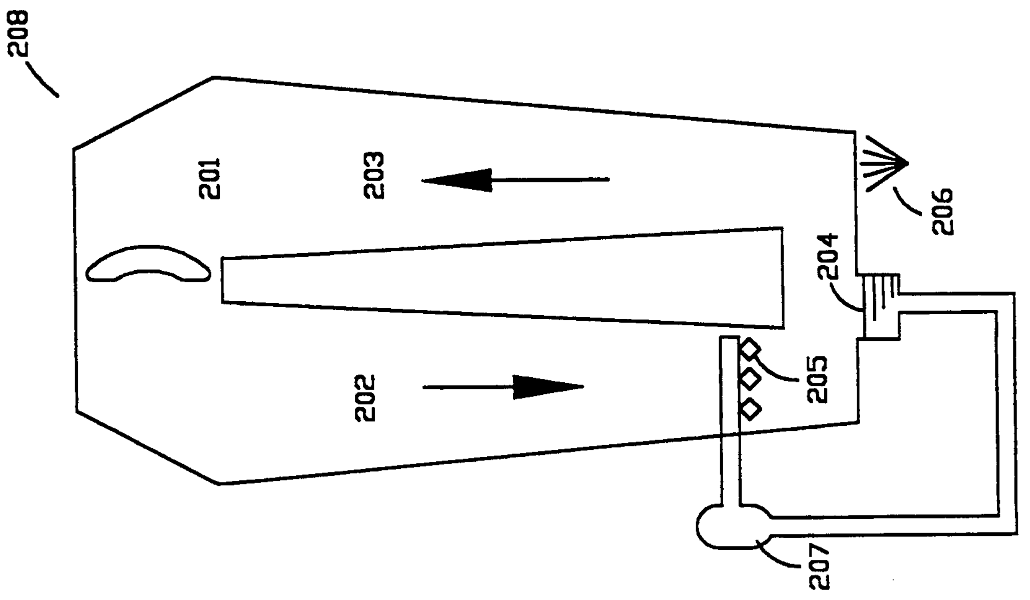

FIG. 22

INTERNATIONAL SEARCH REPORT

national Application No
PCT/ZA 00/00044

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F01K27/00 F01K25/06

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 F01K F03G

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LU 42 538 A (MARY) 17 December 1962 (1962-12-17) the whole document	1,28
A	FR 2 134 797 A (EDF) 8 December 1972 (1972-12-08) page 1, line 35 -page 3, line 20; figures	1,28
A	US 4 389 858 A (JEPSEN HENRY E) 28 June 1983 (1983-06-28) the whole document	1,28
X	US 4 116 009 A (DAUBIN SCOTT C) 26 September 1978 (1978-09-26) column 3, line 31 - line 44; figure 1	33

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

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 June 2000	28/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Van Gheel, J

INTERNATIONAL SEARCH REPORT

Information on patent family members

national Application No
PCT/ZA 00/00044

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
LU 42538	A	17-12-1962	NONE	
FR 2134797	A	08-12-1972	NONE	
US 4389858	A	28-06-1983	NONE	
US 4116009	A	26-09-1978	NONE	