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## EUROPEAN PATENT APPLICATION

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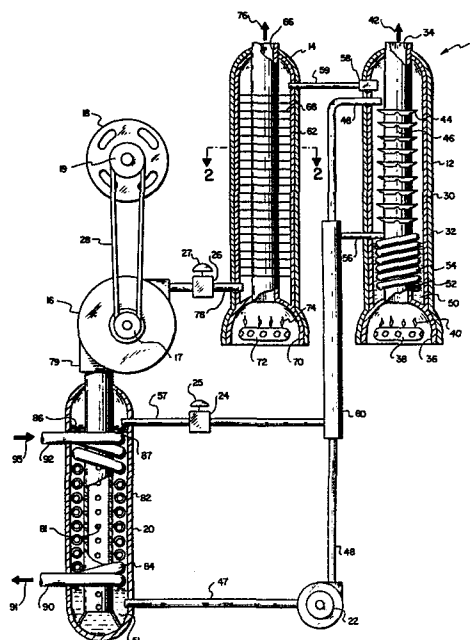
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### Externally cooled absorption engine apparatus and method.

An externally cooled, absorption engine apparatus (10) and method, the apparatus including a closed cycle system having a first fluid and a second fluid (50), the first fluid constituting a working fluid and having a relatively lower boiling point while the second fluid constitutes a solvent for the first fluid and has a relatively higher boiling point and a relatively high degree of absorptivity for the first fluid. The apparatus further includes a distillation column (12), a superheater (14), a mechanical expansion engine (16), an externally cooled absorption column (20), and heat exchange apparatus (60). The distillation column (12) separates the first fluid or working fluid from the solvent (50) with heat energy supplied by an external combustion source (38) and the superheater (14) increases the thermal energy thereof prior to passing the working fluid through the mechanical expansion engine (16). The mechanical expansion engine converts thermal energy in the working fluid vapour to mechanical energy. Importantly, the backpressure to the mechanical expansion engine (16) is significantly lowered by absorbing the working fluid with solvent (50) from the distillation column and the efficiency of the same is substantially enhanced by cooling the solvent and also by removing heat of absorption through an external coolant source (84).



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EXTERNALLY COOLED ABSORPTION ENGINE  
APPARATUS AND METHOD

Background

This invention relates to an external combustion engine apparatus and, more particularly, to a closed cycle, two-fluid, externally cooled, vapor standard engine apparatus and method.

A conventional external combustion engine receives energy from an external combustion source to vaporize a single working fluid. The working fluid is utilized in an expansion engine apparatus where the thermal energy of the working fluid is converted to mechanical energy. In a closed cycle system, the working fluid is condensed after passing through the mechanical expansion engine and returned to the boiler where it is again vaporized. While certain savings are realized by returning the working fluid to the boiler, it is well-known that unless extensive condenser apparatus is provided, a substantial backpressure exists in the working fluid thereby lowering the efficiency of the mechanical expansion engine.

Dual fluid systems are known in the art and generally incorporate a lower boiling point working fluid and a higher boiling point solvent. The solvent is chosen so that it has a relatively high degree of absorptivity for the working fluid. One such system is the well-known ammonia/water system which is used for numerous applications, primarily in the field of refrigeration. However, until the present invention, none of the prior art systems has utilized a closed vapor standard heat engine to convert thermal energy into mechanical energy whereby the working fluid is distilled from a solution consisting of working fluid and solvent and thereafter superheated prior to being passed into the mechanical expansion engine. The exhausted working fluid is absorbed in solvent with the heat of absorption being recovered by an external cooling source.

It, therefore, would be a significant advancement in the art to provide a closed cycle, vapor standard heat engine for converting thermal energy from an external combustion source to mechanical energy utilizing a dual fluid system.

5 It would also be an advancement in the art to provide a dual fluid system whereby a solvent fluid has a high degree of absorptivity for a working fluid and wherein the heat of absorption of the system is recovered through an external cooling source. Such a novel apparatus and method is

10 disclosed and claimed herein.

Brief Summary and Objects of the Invention

The present invention relates to a closed cycle, dual fluid, externally cooled, vapor standard engine which utilizes heat energy from an external combustion source to

15 distill a working fluid from an absorption solution of working fluid in solvent. Additional heat energy is added to the vaporized working fluid in a superheater to thereby provide an expanded, high-pressure gas. The gas is expanded in a mechanical expansion engine thereby converting the

20 thermal energy therein to mechanical energy. Backpressure of the system downstream of the mechanical expansion engine is significantly reduced by absorbing the working fluid with solvent from the distiller while recovering the heat of absorption therefrom thereby creating an unusually low

25 backpressure in the system downstream of the mechanical expansion engine. The resulting solution is pumped through a countercurrent heat exchanger to remove heat energy from the solvent prior to introducing the solvent into the absorption apparatus and returning the solution to the distiller

30 apparatus.

It is, therefore, a primary object of this invention to provide improvements in closed cycle, vapor standard heat engines.

Another object of this invention is to provide an improved method for converting thermal energy into mechanical energy.

Another object of this invention is to provide a closed  
5 cycle, vapor standard heat engine wherein a first, working  
fluid is vaporized in a distiller and superheated prior to  
being introduced into a mechanical expansion engine and the  
backpressure downstream of the mechanical expansion engine  
is reduced by absorbing the working fluid with solvent from  
10 the distiller apparatus.

Another object of this invention is to provide a closed  
cycle, vapor standard engine apparatus wherein thermal  
energy produced in the absorption apparatus is removed  
externally through a heat exchanger apparatus.

15 Another object of this invention is to provide a novel  
apparatus for absorbing working fluid downstream of the  
mechanical expansion engine and removing the heat of  
absorption generated thereby.

These and other objects and features of the present  
20 invention will become more fully apparent from the following  
description and appended claims taken in conjunction with  
the accompanying drawing.

#### Brief Description of the Drawing

Figure 1 is a schematic illustration of the apparatus of  
25 the present invention with portions shown in cross-section  
and also broken away for ease of illustration and  
understanding; and

Figure 2 is a cross-section taken along the lines 2-2 of  
Figure 1.

#### 30 Detailed Description of the Preferred Embodiments

This invention is best understood by reference to the  
drawing wherein like parts are designated with like numerals  
throughout.

### General Discussion

Distillation is a well-known method for separating the various components of a solution. The process depends upon the distribution of all the substances therein between the gaseous phase and the liquid phase, and is applied to cases where both components are present in both phases. Distillation differs from absorption and desorption in that a new substance is not introduced into the mixture in order to provide the second phase. Instead, the new phase is created from the original solution by vaporization or condensation. Distillation is, therefore, concerned with the separation of solutions where all of the components are appreciably volatile. A well-known example in this category is the separation by distillation of the components of a liquid solution of ammonia (working fluid) and water (solvent). The application of heat to the solution results in a partial vaporization of the solution creating a gaseous phase consisting of water and ammonia, and since the gaseous phase will be richer in ammonia than in the residual liquid of the solution, a certain amount of separation will have resulted. By appropriate manipulation of the phases and/or by repeated vaporizations and condensations, it is ordinarily possible to make as complete a separation as may be desired thereby recovering both components of the original solution in as pure a state as desirable.

In distillation, therefore, the new phase differs from the original phase by its heat content. Heat may be readily added or removed without difficulty, however, of course, the cost in doing this must inevitably be considered. Much technical literature is available on multi-component systems, particularly binary liquid-vapor equilibrium diagrams. The relationship between pressure, temperature, and composition of the mixture has been thoroughly studied and analyzed for numerous compositions. This is particularly true for the well-known ammonia/ water systems.

In summary, therefore, distillation is conventionally achieved by distilling a combined dual fluid solution in an insulated, high-pressure distiller to produce the vapor (working fluid) from the absorption solution, leaving the solvent-rich second fluid (solvent) as a bottom product in the distiller. Heat energy is transferred into the solution to create the separation with the vaporized fluid being conducted through a one-way valve where it may be subjected to additional input of heat energy, as desired. For example, additional heat energy can be imparted to the vaporized working fluid by a superheater arrangement also utilizing heat energy from an external combustion source.

A conventional mechanical expansion engine apparatus may be utilized for the purpose of converting the thermal energy content of the heated working fluid vapor into mechanical energy. Numerous devices are utilized for this purpose and are provided primarily in the form of turbines, and the like. The mechanical energy derived therefrom may be used for various purposes including the generation of electrical energy. Importantly, an absorption apparatus is provided downstream of the mechanical expansion engine apparatus for the purpose of absorbing the working fluid therein and thereby substantially reduce the backpressure to the mechanical expansion engine for the purpose of enhancing the mechanical efficiency. The solubility of the working fluid into the solvent is generally determined by the partial pressures involved as well as the temperatures of the solutions. Accordingly, it is useful to lower the temperature of the solvent prior to introducing the solvent into the absorption apparatus. Additionally, it is well-known that the solution of a gas generally results in the evolution of heat so that it is useful to remove the thermal energy generated thereby to enhance the absorption of the working fluid in the solvent.

Referring now more particularly to Figure 1, the externally cooled absorption engine apparatus of this invention is shown generally at 10 and includes a distiller 12, a superheater 14, a mechanical expansion engine 16, an absorption apparatus 20, and a heat exchanger 60. Additional equipment includes a generator 18, a pump 22, and control valves 24 and 26. Each of control valves 24 and 26 are controlled by controllers 25 and 27, respectively.

With particular reference to distiller 12, distiller 12 is fabricated as a cylindrical column 30 surrounded by an insulative sheath 32 and includes a coaxial flue 34 extending upwardly and in spaced relationship through column 30 from a combustion chamber 36. A burner 38 provides the necessary heat energy in combustion chamber 36 as indicated schematically by flames 40. The heat energy produced thereby is conducted upwardly through flue 34 where it is vented as cooled exhaust gas 42 to the atmosphere. Flue 34 thereby serves as a heat exchange surface for conducting the heat energy into the interior of column 30.

Column 30 is generally segregated into an upper distillation section and a lower, after heater section for a solvent 50 as will be set forth more fully hereinafter. The upper, distillation section includes a plurality of frustoconical distributor rings 44 mounted on the external surface of flue 34. Each of distributor rings 44 serves as a serial catchment basis for solution introduced through inlet 48. The incoming solution is distributed over the external surface of flue 34 by passing downwardly and serially to the next succeeding distributor ring 44 through a plurality of apertures 46 adjacent flue 34. In this manner, thermal energy is efficiently transferred into the solution 51 to thereby vaporize the working fluid therefrom. Vaporized working fluid passes upwardly through cylindrical column 30 and through check valve 58 where it is introduced by conduit

59 into the countercurrent heat exchange apparatus of superheater 14.

After passing serially through each of distributor rings 44, the working fluid is substantially vaporized from solution 51 so that the residual liquid becomes relatively pure solvent 50. Solvent 50 collects as a pool in the after heater section of the base of distiller 12. The lower end of flue 34 is surrounded in heat exchange relationship with a coil 54 of tubing having an inlet 52 therein. Solvent 50 from adjacent the lower end of distiller 12 is drawn through coils 54 in heat exchange relationship with the lower end of flue 34 prior to being directed by conduit 56 into countercurrent heat exchanger 60. It should be noted that additional heat energy is imparted to solvent 50 by the use of heat exchange coils 54 so that solvent 50 is not only cooled in countercurrent heat exchanger 60 but transfers that heat energy to solution 51 passing upwardly through conduit 48 prior to introduction into distiller 12. Solvent 50 is then controlled by valve 24 and introduced by inlet 57 into the upper end of the absorption column 20.

With particular reference also to Figure 2, superheater 14 is configured as a generally cylindrical column 62 surrounded by an insulative layer 64 and includes a coaxial flue 66 extending upwardly therethrough in spaced relationship to column 62. A combustion chamber 70 includes a burner 72 and is interconnected to flue 66 so that the heat energy produced therein, indicated schematically by flames 74, passes upwardly through flue 66 and is exhausted as cooled exhaust 76. The annular space between flue 66 and cylindrical shell 62 is transected by a plurality of annular disks 68 having apertures 69 therein. Disks 68 serve as heat transfer fins for transferring heat energy from flue 66 into the working fluid vapor in the surrounding annular space. Apertures 69 causes thorough mixing and intimate heat



exchange contact between the working fluid vapor and disks 68 in its passage downwardly through superheater 14 to exit conduit 78. In this manner, additional heat energy is imparted to the working fluid by superheater 14 thereby  
5 increasing the efficiency of the mechanical expansion engine through which the working fluid is passed.

Control valve 26 is operated by controller 27 and controls the introduction of high-pressure, high temperature working fluid vapor into mechanical expansion engine  
10 16. Mechanical expansion engine 16 is configured as a conventional mechanical expansion engine, preferably in the form of a turbine, or the like and converts the thermal energy of working fluid vapor into mechanical energy. The mechanical energy is then transmitted to a generator 18 by  
15 means of a flexible belt 28 cooperating between sheaves 17 and 19. Generator 18, in turn, converts the mechanical energy into electrical energy. However, other conventional devices may be incorporated for the purpose of utilizing the mechanical energy developed by mechanical expansion engine  
20 16.

Downstream of mechanical expansion engine 16 the working fluid exhausted therefrom is directed by a plenum 79 into an absorption column 20. In particular, plenum 79 extends downwardly into absorption column 20 as a coaxial,  
25 perforated cylinder having a plurality of apertures 81. The perforated column of plenum 79 is spaced from the internal wall of the cylindrical column 82 of absorption column 20 and the annular space thereabout is filled with a heat exchange coil 84 extending between an inlet 92 and outlet 90. The  
30 upper end of absorption column 82 includes a distributor screen 86 having a plurality of holes 87 for the purpose of distributing solvent 50 downwardly over heat exchange coils 84. The downwardly passing solvent combines with working fluid vapor passing through apertures 81 to create the

solution 51. Thereafter, solution 51 is withdrawn through conduit 47 and pumped by high pressure pump 22 through countercurrent heat exchanger 60 prior to being introduced through inlet 48 into distiller 12.

5       The heat of absorption generated by the foregoing absorption process is recovered by being transferred to fluid passing through heat exchange coils 84. For example, a cold, coolant 93 is introduced through inlet 92 and is withdrawn therefrom as a heated coolant 91 through outlet 90.  
10   Advantageously, the recovered heat of absorption carried by heated coolant 91 may be utilized as a heat source for any suitable process or apparatus (not shown).

      Countercurrent heat exchanger 60 is used to transfer heat energy from the relatively hot solvent 50 from the after  
15   heater section of distiller 12 into the relatively cool solution 51 from absorption column 20 thereby providing a relatively cool solvent for introduction into the upper end of absorption column 20. Correspondingly, the resulting, relatively hot solution 51 is introduced through inlet 48  
20   into distiller 12. In this manner, less thermal energy is required by distiller 12 to produce the working fluid vapor. Additionally, a substantially lower backpressure is provided in absorption column 20 since the incoming solvent through inlet 57 is substantially reduced in temperature.  
25   Importantly, additional efficiencies are obtained by cooling the resulting solution 51 which, in turn, contributes greatly to the cooling of incoming solvent 50 in countercurrent heat exchanger 60.

      The invention may be embodied in other specific forms  
30   without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive and the scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing

description. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

- 1 -

CLAIMS

1. A closed cycle, vapour standard engine (10) characterised in that it comprises:

5 a closed cycle system comprising a first, working fluid having a first, lower boiling point and a second, solvent fluid (50) having a second, higher boiling point, said second fluid having a relatively high degree of absorptivity for the first fluid;

10 distillation means (12) adapted to separate the first fluid from the second fluid by selectively vapourizing the first fluid with heat energy (40) from an external combustion source (38);

superheater means (14) adapted to superheat the vapourized first fluid;

15 mechanical expansion engine means (16) downstream of the superheater means, the mechanical expansion engine means being adapted to convert thermal energy of the first fluid into mechanical energy; and

20 an externally cooled absorption means (20) downstream of the mechanical expansion engine means, the absorption means being adapted to provide absorption of the first fluid from the mechanical expansion engine means with the second fluid thereby reducing backpressure in the first

fluid, the absorbed first fluid in the second fluid comprising a third, solution fluid (51).

2. A closed cycle, vapour standard engine according to claim 1 characterised in that the distillation means (12) comprises an after-heater for said second fluid comprising a heat exchange coil (54) having an inlet (52) immersed in the second fluid.

3. A closed cycle, vapour standard engine according to claim 1 or claim 2 characterised in that the absorption means (20) comprises heat exchange means (84) for absorbing heat of absorption produced when the first fluid is absorbed by the second fluid (50), the heat exchange means (84) being adapted to conduct an external fluid in heat exchange relationship with the solution (51).

4. A closed cycle, vapour standard engine according to any one of claims 1 to 3 characterised in that it comprises a countercurrent heat exchanger (60) for cooling incoming solvent (50) to the absorption means (20) with cooled solution (51) produced in the absorption means, the cooled solution being heated by the solvent and thereafter returned to the distiller, thereby increasing the thermal efficiency of the distiller.

5. A closed cycle, externally cooled absorption engine apparatus characterised in that it comprises:

a closed cycle system containing a first, working fluid and a second, solvent fluid (50), the first fluid having a first, relatively low boiling point, the second fluid having a second, relatively higher boiling point and a relatively high degree of absorptivity for the first fluid, the absorbed fluid in the second fluid comprising a third, solution fluid (51);

distiller means (12) adapted to selectively vapourize the first fluid to thereby separate the first fluid from the third fluid and leave a residue of second fluid in the distiller;

superheater means (14) adapted to increase the thermal energy of the vapourized first fluid from the distiller means;

5 mechanical expansion engine means (16) downstream of the superheater means, the mechanical expansion engine means being adapted to convert thermal energy of the first fluid from the superheater means into mechanical energy;

10 externally cooled absorption means (20) downstream of the mechanical engine expansion means, the absorption means being adapted to lower the backpressure to the first fluid from the mechanical expansion engine means by absorbing the first fluid with the second fluid to form the third fluid, the absorption means being externally cooled to increase the efficiency of the absorption means; and

15 heat exchange means (60) adapted to remove heat energy from solvent from the distiller means prior to introducing the solvent into the absorption means while heating solution from the absorption means prior to introducing the solution into the distiller means.

6. A method for converting thermal energy into mechanical energy characterised in that it comprises:

25 obtaining a dual fluid system comprising a first fluid having a relatively lower boiling point as a working fluid and a second fluid (50) having a relatively higher boiling point as a solvent for the first fluid, the second fluid having a relatively high degree of absorptivity for the first fluid, the combined first fluid and second fluid forming a third fluid solution (51);

30 enclosing the dual fluid system within a closed system comprising a distiller (12), a superheater (14), a mechanical expansion engine means (16), and an absorption column (20);

35 distilling the third fluid in the distiller thereby separating the first fluid from the second fluid and

creating a working fluid;

superheating the working fluid in the superheater means;

5 converting thermal energy in the working fluid into mechanical energy by passing the working fluid through the mechanical expansion engine means; and

10 absorbing the working fluid from the mechanical expansion engine means with solvent from the distiller thereby increasing the efficiency of the mechanical engine expansion means by reducing the backpressure thereto.

7. A method according to claim 6 characterised in that the absorbing step further comprises increasing the efficiency of the absorber means by externally cooling the absorber means by removing heat of absorption produced  
15 upon absorbing the working fluid in the solvent.

8. A method according to claim 6 or claim 7 characterised in that the absorbing step further comprises increasing the efficiency of the absorption means by cooling solvent from the distillation means with cooled  
20 solution from the absorption means in heat exchange means (60) and correspondingly increasing the efficiency of the distiller means by heating the solution prior to introducing the same into the distiller means in the heat exchange means.

25 9. A method according to claim 8 characterised in that the heating step further comprises passing the solvent through an after-heater (54) in the distiller prior to passing the solvent through the heat exchange means.

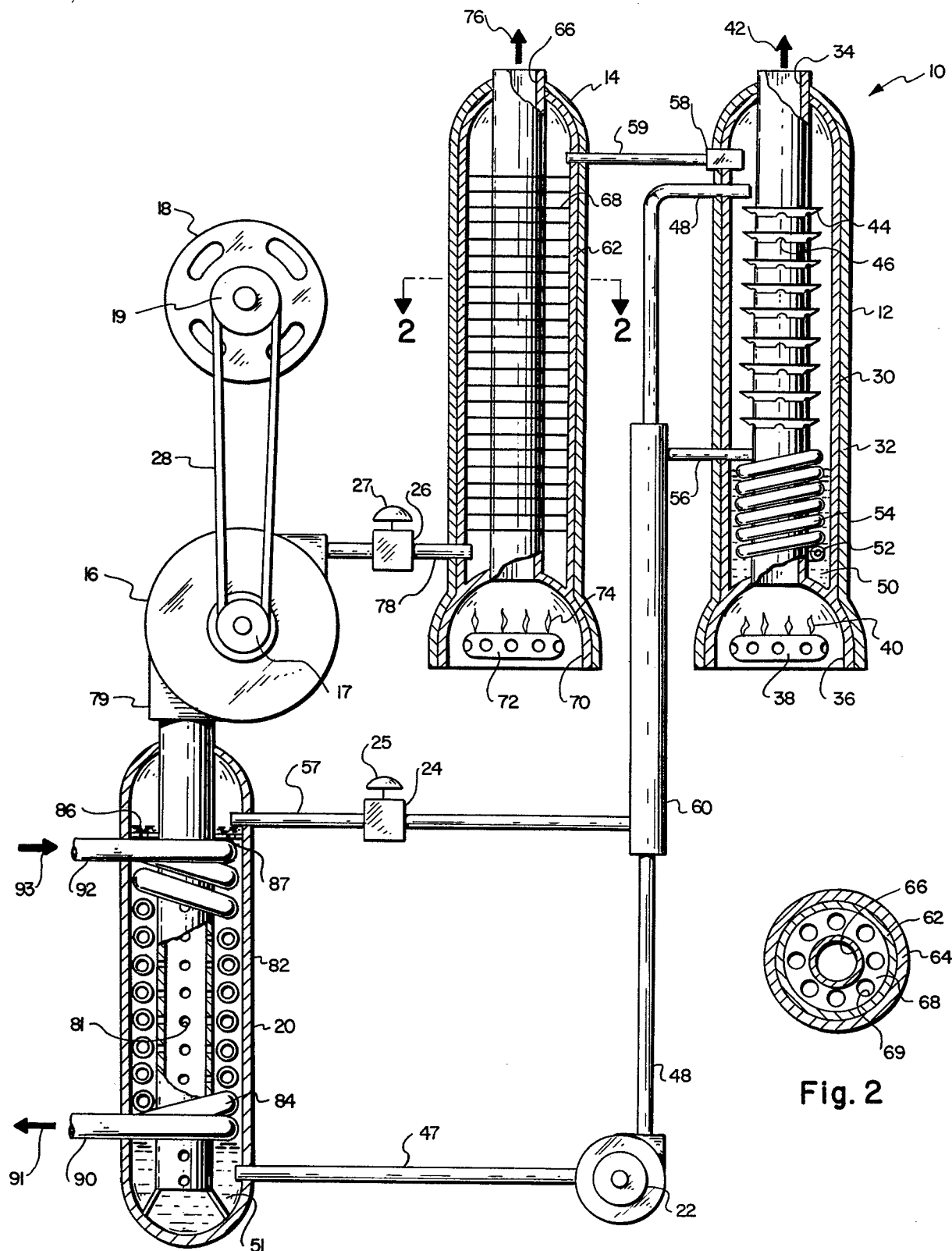


Fig. 1





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# EUROPEAN SEARCH REPORT

0078351  
Application number

EP 81 30 5181.0

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. <sup>3</sup> )
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
Y	DE - C - 929 066 (H. BACHL) * page 1, line 1 to page 2, line 65; fig. *	1,5,6	F 01 K 25/06 F 02 G 1/04
A	* page 2, lines 46 to 54; fig. * --	4,8	
Y	US - A - 4 195 485 (V.C. BRINKERHOFF) * claim 1; abstract; column 1, line 56 to column 2, line 3; column 3, line 33 to column 6, line 29; fig. 1 *	1,5,6	
A	US - A - 3 940 939 (J.P. DAVIS) * abstract *	1	
A	CH - A - 319 718 (H. BACHL) * whole document *		F 01 K 21/00 F 01 K 23/00 F 01 K 25/00
A	US - A - 4 183 218 (D.H. EBERLY) * abstract; column 2, lines 61 to 67 *	5,6	F 02 G 1/00 F 25 B 15/04
A	Patent Abstracts of Japan, Vol. 5, No.155, 30. September 1981 page 103M90 & JP - A - 56 - 83504		
A	US - A - 4 009 575 (T. HARTMAN et al.) * whole document *		
<input checked="" type="checkbox"/> The present search report has been drawn up for all claims			<b>TECHNICAL FIELDS SEARCHED (Int.Cl. <sup>3</sup>)</b>  <b>CATEGORY OF CITED DOCUMENTS</b> X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons  &: member of the same patent family, corresponding document
Place of search Berlin		Date of completion of the search 10-05-1982	Examiner CANNICI