A thermodynamic power system, including in combination a membrane compressor comprising wall means which define an enclosure with a membrane or membranes in the enclosure dividing the same into inlet and outlet sides. Conduit means connect the inlet side of the membrane compressor to a source of gas. Each membrane is constructed so as to permit the passage of gas molecules from the inlet side to the outlet side and prohibits the passage of gas molecules from the outlet side to the inlet side. Conduit means connect the outlet side of the membrane compressor to a work performing mechanism to drive the same. The disclosure also relates to the method of doing work in accordance with the terms of the invention. Methods of making permeable membranes, in particular membranes having unidirectional characteristics, are included.
FIG. 1

FIG. 2

INVENTOR.

ARTHUR H. SCHULTZ

BY

Woodling et al.
FIG. 7
Chapter 1

Thermodynamic Power System and Methods

Preface and Definitions

The intent of specifications relating to the processes is to describe the invention so that one skilled in the art may put the invention into practice. For the purpose of this specification, one skilled in the art is assumed to be an engineer, scientist, or layman familiar with college level thermodynamics, and college level physics. However, due to the unique nature of the invention and to simplify and shorten explanation, several new words and phrases have been coined. Other than these newly coined words and phrases, terminology is common to college level thermodynamics and physics.

These newly coined expressions are:

1. "Unidirectional permeability" is the characteristic of a material which will allow passage of fluid molecules through said material in one direction in larger quantity than in the opposing direction. 2. "Unidirectionally permeable membrane" is a membrane having the characteristic of unidirectional permeability.

3. "Membrane compressor" is a piece of hardware which has, as its purpose, the pumping of a fluid from a region of low pressure to higher pressure and which exhibits the following characteristics:
   a. It has a chamber with inlet and discharge connections for fluids.
   b. It has unidirectionally permeable membranes secured and supported in it in such fashion that from the inlet to the discharge of the compressor fluids pass through the membranes to regions of progressively higher pressure.

4. "Reverse throttling process" is the true reverse of the throttling process described in college level thermodynamic texts; ideally it is the compression of a gas or vapor without change of fluid temperature and is the thermodynamic description for the processing of a compressible fluid through the membrane compressor.

5. "Schultz thermodynamic cycle" is a closed thermodynamic cycle in which the contained compressible fluid is recirculated in sequence through hardware as follows:
   a. Through a useful work or refrigeration producing turbine where the pressure and temperature of the working fluid is reduced. The work produced by the turbine according to texts, is equal to the change of enthalpy of the fluid from the inlet to discharge of the turbine. The turbine is cited here for example only; a reciprocating engine or any other similarly functioning device may be used in place of the turbine.
   b. The heat exchanger, where heat is absorbed by the working fluid from the local environment. Examples of heat sources are the atmosphere, the ocean, or the soil. It might even be the human body. The heating process of the working fluid occurs at constant pressure. The heat addition to the working fluid is equal to the difference of enthalpy of the working fluid between the inlet and discharge of the heat exchanger.
   c. The membrane compressor, where the working fluid is compressed by unidirectional permeability. Basically, the process of compression is a reverse throttling process. The enthalpy at the inlet of the membrane compressor is equal to the enthalpy at the discharge of the membrane compressor for the working fluid. The enthalpy of the working fluid at the discharge of the heat exchanger is equal to the enthalpy at the discharge of the membrane compressor in the ideal case for the working fluid.
   d. The turbine for a repeat of the cycle.

Body of Specifications

According to the kinetic theory of gases, each molecule of a gas, as long as it has temperature bounces off adjacent molecules or molecular structures. At ordinary pressures, for example, that of ambient air at common temperatures, the space between molecules is rather large when compared to the linear dimensions, such as length and breadth, of a molecule.
outlet side 27 of the membrane compressor and serves to transport the high pressure gas to a work performing mechanism 34. This work performing mechanism may assume many variations; however, for the present illustration, it can be assumed to be a gas turbine wherein the gases from the outlet side of the membrane compressor perform work and energy is extracted in the conventional manner. The outlet side of the work performing mechanism is connected by conduit means 36 wherein the gas on the downstream side of the turbine which is at a lower temperature and pressure is then transported to a heat exchanger 38. The heat exchanger may take heat from many sources, for example, the outside surroundings and this heat can be absorbed by the closed cycle gas. The outside surroundings may be the atmosphere, water, or the earth for example. The heat exchanger 38 brings the closed cycle gas temperature near to that of its surroundings. The conduit means 29 then returns the gas from the heat exchanger 38 to the inlet side 26 of the membrane compresor. It will be appreciated by those skilled in the art, that if the heat exchanger were in a suitably insulated container, the cycle would develop refrigeration at the heat exchanger. The cycle may be altered to flow the fluid through the membrane compressor thence through the heat exchanger, thence through the work producing device and thence back to membrane compressor.

It is possible to utilize atmospheric air in an open cycle of the apparatus with the heat exchanger removed. Difficulties, however, would be involved with such an open cycle because the membrane compressor would quite possibly be clogged with atmospheric contaminants.

The useful power output of the cycle ideally would be the change in enthalpy isentropically through the engine or turbine per unit time which would also be equal to the heat addition per unit time at the heat exchanger. In the ideal process, the membrane compressor would act isothermally. Since there would be no temperature change through the membrane, the internal energy, flow work, and enthalpy would remain equal for the inlet and discharge of the membrane compressor.

The principle followed in constructing the membrane 24 is the principle that when many materials are stressed, they go through elastic deformation, appreciable plastic deformation and then failure. At failure, the material has extensive deformity which it retains in large part after fracture.

The remainder of the specification will be devoted to a description of methods of making permeable membranes and in particular membranes having unidirectional characteristics.

METHODOLOGY NUMBER 1

The 1st method of producing membranes of desired permeability is through piercing the film with high velocity neutrons. See Fig. 3. With this method, neutrons from a radiation source 41 are directed through the film 42 held in the carriage 43 which is movable in all directions transverse to the neutron beam. The carriage, therefore, may be moved according to a schedule to expose various parts of the film. A radiant heater 44 provides a source of heat to achieve desired membrane plasticity. The intensity of the heat is adjustable. The carriage and the clamps are cooled to help control temperature. Below the membrane is a windmill 45 delicately supported in a manner similar to a radiometer. Its identification is number 45 of the drawing and its purpose is to detect molecular currents as unidirectional permeability occurs. The process occurs under high vacuum which is contacted by the closed vessel 46. Of course, certain auxiliary equipment such as vacuum pumps, controlled metering such as a valve or variable restriction, etc., must also be provided though not shown.

METHODOLOGY NUMBER 2

Method number 2 is to produce the desired permeability by shooting electrons through the film. See Fig. 4. With this method, there is a source of electrons 51 which may scan the film 52, either by beam deflection or carriage 53 movement.

There is a radiant heater 54 for conditioning the film 52 and the cooled carriage 53 which clamps and transports the film. Below the film is a positively charged cooled anode 55. It is a screen or grid to allow passage of molecules. Below the anode is a molecular flow windmill 56 similar to that described in "Method Number 1" above. The process occurs under high vacuum which is contained by the vessel 57. Auxiliary equipment common to maintaining conditions of vacuum and voltage, etc., is not shown.

METHODOLOGY NUMBER 3

Now method number 3 is to shoot high energy positively charged ions through the film. See Fig. 5. With this method, positively charged ions are produced at a source 61 and propelled toward the film 62 located on the movable cooled carriage 63. Below the film is a grid or screen like cooled cathode 64 to allow passage of particles. Below the cathode is a molecular windmill 65 to detect the flow. The process occurs under high vacuum contained by the vessel 66. There is also an adjustable radiant heater 67 to condition the film. Common auxiliary items such as vacuum pump and electrical power source, are not shown.

METHODOLOGY NUMBER 4

Method Number 4 is to shoot heated molecules of gases through films using pressure difference. See Fig. 6. With this method, there is a pressurized source 71 of gas admitted to conditioning chamber 72 containing a temperature control element 73 thence to nozzle 74. From the conditioning chamber, the molecules travel through the nozzle 74 toward and through the membrane 75 held in the cooled movable carriage 76. There is a radiant heat source 77 for conditioning the film. The process occurs under high vacuum contained by vessel 78. Common auxiliary equipment such as a vacuum pump is not shown. There is also a molecular windmill 79 to detect flow.

METHODOLOGY NUMBER 5

Method Number 5 is to combine elements of methods 3 and 4 to use both pressure and electrical forces to propel the gas ions through the film. See Fig. 7. With this method, there is a source of gas molecules 81. The gas molecules are admitted to conditioning chamber 82, containing a temperature control element 83, thence through nozzle 84, ionizing element 85 and through anodic accelerator 86. The ions by virtue of their velocity are then driven through a film 87 held in movable cooled carriage 88 to cooled screen or grid anode 89. Below the anode is the molecular windmill 90 to detect unidirectional flow. Auxiliary vacuum pump, etc. are not shown. The process occurs at high vacuum conditions contained by vessel 91. There is also a radiant heat source 92 to condition the membrane.

All the methods of making unidirectional permeable membranes herein described are based on impacting a film with a missile, to distort the film and create sub-microscopic trap doors. Please note that the carriage may be arranged in a manner that there is a roll of film which is unwound to allow the film to traverse the impacting beam and then be wound onto another roll. Such an arrangement of rolls of film will produce higher productivity of permeated membrane.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

1 claim:

1. A thermodynamic power system including, in combination, a membrane compressor comprising wall means defining an enclosure, an unidirectionally permeable membrane in said enclosure dividing same into inlet and outlet sides, conduit
means connecting said inlet side of said membrane compressor to a source of gas, said membrane comprising means for permitting passage of gas molecules through said membrane from said inlet side to said outlet side and prohibiting passage from said outlet side through said membrane to said inlet side, work performing mechanism, conduit means connecting said outlet side of said membrane compressor to said work performing mechanism to drive the same.

2. A system as claimed in claim 1, wherein a heat exchanger is provided, conduit means connecting the outlet side of the work performing mechanism to said heat exchanger and the inlet side of the membrane compressor to the outlet side of said heat exchanger whereby a closed system is formed.

3. A system as claimed in claim 1, wherein the order of fluid flow is from membrane compressor to heat exchanger, thence through work producing device thence return to membrane compressor.

4. A system as claimed in claim 1, wherein said gas is air.

5. A system is claimed in claim 2, wherein said gas is air.

6. A closed thermodynamic power system including, in combination, a membrane compressor comprising wall means defining an enclosure, an unidirectionally permeable membrane in said enclosure dividing same into inlet and outlet sides, a work performing mechanism, conduit means connecting the outlet side of said membrane compressor to said work performing mechanism and then said work performing mechanism to the inlet side of said membrane in a closed loop, gas molecules in said closed loop, said unidirectionally permeable membrane comprising means for allowing said gas molecules through the same in one direction toward said work performing mechanism in larger quantities than in the opposite direction, said gas molecules being successively recycled by being first compressed without change of fluid temperature, then isentropically expanded and then undergoing constant pressure heating.