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METHOD AND APPARATUS FOR OBTAINING WORK FROM A COMPRESSED GAS

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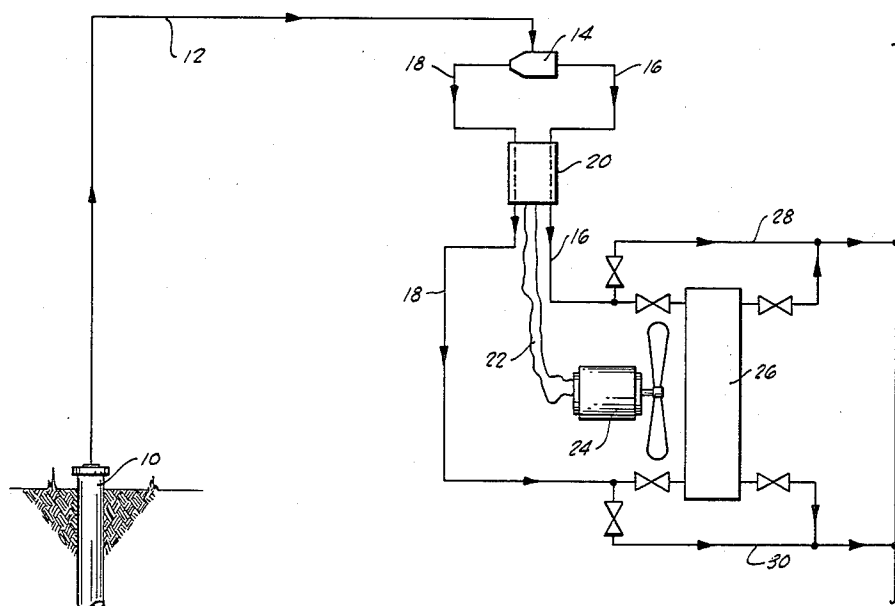


FIG. 1

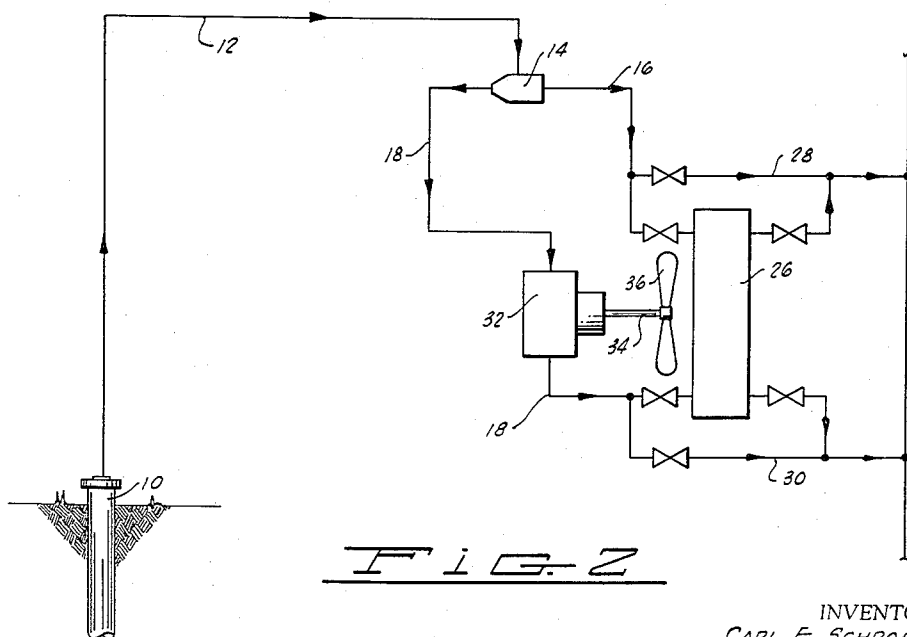


FIG. 2

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METHOD AND APPARATUS FOR OBTAINING WORK FROM A COMPRESSED GAS

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This invention relates to a method and apparatus for obtaining work from a compressed gas. More particularly, but not by way of limitation, the present invention comprises a method and apparatus for utilizing natural gas as it is discharged under pressure from a well, and for simultaneously reducing the pressure of the gas to a desirable level. In a more specific, though non-limiting aspect, the present invention provides a novel air conditioning system utilizing compressed gas as the source of energy for moving the conditioned air, as well as for the thermal control medium.

The employment of a Ranque-Hilsch vortex tube for dividing a moving stream of compressed gas into a stream of hot gas and a stream of cold gas is well known. In utilizing such tubes, a gas or vapor under pressure is introduced tangentially into a generally cylindrical tube and undergoes a vortical movement inside the tube. Within the vortex, the gas is broken up into spiralling coaxial layers. The outside layers in the vortex that are adjacent to the internal walls of the tube are more highly compressed and therefore are considerably warmer than the layers of gas at the inside of the vortex along the axis of the tube. By drawing off the hot outer layers at one end of the tube through a restricted opening, a back pressure acting along the axis of the tube is developed which forces the cooler gases at the inside of the vortex through a centrally located orifice at the opposite end of the tube. The division of temperature which is accomplished in this manner is generally dependent upon the degree to which the hot air extracted from the tube is throttled.

In the past, a great number of uses in refrigeration and heating have been made of such Ranque-Hilsch tubes with varying degrees of efficiency being obtained from the energy of the compressed gases which are introduced to the tube. For example, in United States Patent 2,698,525 to Lindenblad, a refrigeration system is disclosed in which a Hilsch vortex tube is employed to utilize the exhaust products from a refrigeration system to increase the over-all efficiency of operation of the system. In U.S. Patent 2,669,101 to Shields, the Hilsch effect has been utilized for providing a system for selectively heating or cooling the interior of aircraft or other vehicles. The Shields heating and cooling system basically comprises a Hilsch tube which splits a compressed air stream into its hot and cold components, and appropriate ducting for conveying the hot or the cold streams to the space to be warmed or cooled as desired.

The present invention comprises a method and apparatus for more efficiently utilizing a stream of compressed gas in conjunction with a Hilsch tube to perform useful work. The work which is performed by the method and apparatus of the invention may be properly characterized as an air conditioning function, since the energy of the compressed gas is utilized both to vary the temperature of an air stream, and also to drive a fan or blowing device which is utilized to set the air in motion. The method is particularly adaptable for use with a stream of natural gas as the latter material is supplied in its compressed state from a natural gas well or from another facility in which the gas is stored under pressure. In both instances it is frequently desirable to gradually and safely reduce the pressure of the gas to a convenient

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level for subsequent handling, and at the same time to expend the energy of the compressed gas usefully.

In one of its broader aspects, the present invention constitutes a method for utilizing a compressed gas which comprises passing the compressed gas into a Hilsch tube in order to separate the gas into a stream of hot gas and a stream of cold gas; then passing at least one of the latter streams through a device for converting a portion of the energy of the stream passed therethrough to work which may be utilized for driving a fan or other suitable blowing device which can be utilized to produce a current of air; and finally passing one of the streams of hot or cold gas into a heat exchange device, such as a radiator, which is positioned in the path of the air stream generated by the fan or blower so that the moving air current may be heated or cooled by contact with the radiator or its surrounding environs. In this way, the energy of the compressed gas is utilized in two levels or steps—first, to produce work to drive the fan or blower, and secondly, to heat or cool the air stream which is generated by such fan or blower.

In one embodiment of the invention, the device which is utilized to initially convert a portion of the energy of at least one of the streams into useful work which may be utilized to drive the fan or blower is a thermoelectric generator, which converts the thermal energy of either the hot gas stream, or the cold gas stream, or both, to electrical energy. This electrical energy can then be utilized to drive the motor of a fan or blower.

As an alternate embodiment of the invention, the device which is utilized for converting a part of the energy of at least one of the effluent streams from the Hilsch tube to useful work is a gas driven turbo-expander. In the operation of such a device, the cooler gas stream from the Hilsch tube is introduced to the turbo-expander where the kinetic energy of the expanding gas is utilized to drive a turbine. The isentropic expansion of the gas in the turbine results in a substantial further decrease in the temperature of the already cool gas passing therethrough. If this stream is then led to a heat exchange device or radiator placed in the path of the air stream produced by the fan or blower, a very substantial reduction in the temperature of the air stream can be realized. Of course, both the hot and cold gas streams may be conducted through a suitable conduit and valve system to the radiator so that the air conditioning system may be utilized for either heating or cooling as may be desired.

From the foregoing description, it will be apparent that the present invention provides a novel method and apparatus for efficiently obtaining useful work from a compressed gas.

An additional object of the present invention is to provide an effective air conditioning system which utilizes compressed gas as the sole source of motive power, as well as the medium which is utilized for achieving the desired temperature variation.

A further object of the present invention is to provide a novel method and apparatus for safely reducing the pressure of highly pressurized natural gas, and for deriving useful work from such gas in the process of decompression.

An additional object of the present invention is to provide a method and apparatus for obtaining a maximum amount of useful work from the potential energy available in a quantity of compressed gas.

Yet another object of the present invention is to provide an apparatus for obtaining work from a gas under pressure, which apparatus is relatively simple and inexpensive in construction, and is characterized by a long and trouble-free operating life.

Other objects and advantages of the invention will become apparent on a further reading of the following

disclosure in conjunction with a perusal of the accompanying drawings which illustrate our invention.

In the drawings:

FIG. 1 is a schematic illustration of a preferred embodiment of the apparatus of the present invention in which a thermoelectric generator is utilized to convert a portion of the energy of a stream of compressed gas to work for driving a fan or blower.

FIG. 2 is a schematic illustration of a modified embodiment of the apparatus of the present invention, in which a gas driven turbo-expander is utilized to produce work for driving a fan or blower.

Referring now to the drawings in detail and particularly to FIG. 1, a source of a compressed gas, such as a natural gas well, is indicated by reference character 10. Gas from the gas well 10 is conducted to the apparatus of the present invention by a suitable conduit 12.

The conduit 12 enters a Ranque-Hilsch tube 14 (or series of such tubes) where the compressed gas is separated into a stream of hot gas 16 and a stream of cold gas 18. The employment of the Hilsch effect for obtaining such division of a stream of compressed gas into hot and cold components is well known, and in accordance with the conventional structure of such tubes, the hot and cold gas streams are removed from opposite ends of the Hilsch tube 14 as schematically indicated in FIG. 1. From the Hilsch tube 14, the hot and cold gas streams 16 and 18, respectively, are led into a thermoelectric generator 20, where the temperature differential existing between the two streams is employed for generating an electrical current. The electrical current is passed through electrical leads 22 to a suitable fan or blower 24. In this manner, a portion of the energy of the hot and cold gas streams 16 and 18, respectively, is converted to electrical energy which is in turn converted to work in driving the motor of the fan or blower 24.

From the thermoelectric generator 20, the hot and cold gas streams, 16 and 18, respectively, are directed to a heat exchange device 26, such as a radiator or the like. In order to permit either the hot air stream 16 or the cold air stream 18 to be utilized in the heat exchange device 26, a pair of bypass conduits 28 and 30, and appropriate associated valving are provided.

In the operation of the system illustrated in FIG. 1, a portion of the thermal energy of the hot and cold gas streams is converted to electrical energy in the thermoelectric generator 20, and this electrical energy is utilized to drive the blower 24. A rapid movement of air through and across the heat exchange device 26 is thus effected. According to whether it is desired to warm the air stream moving through the radiator 26, or to cool the same, either the hot gas stream 16 or the cold gas stream 18 may be directed through the radiator. The other of the two streams is diverted through its respective bypass conduit, 28 or 30.

When the production from a natural gas well 10 is utilized as the source of compressed gas fed to the Hilsch tube 14, the additional advantage is achieved of lowering the pressure of such gas to a level such that it may be more easily handled in subsequent processing.

In the alternate embodiment of the invention shown in FIGURE 2 of the drawings, the compressed gas stream 12 is again passed into the Hilsch tube 14 where it is separated into hot and cold gas stream components 16 and 18, respectively. The cold gas stream 18 is then introduced to a turbo-expander 32 where a turbine is driven by expanding the compressed gas of the cold gas stream through the blades of an impulse turbine. In this manner, not only does the cold gas stream accomplish work in driving the turbine in such expansion, but also, the temperature of the stream is further lowered due to its isentropic expansion.

The shaft 34 of the turbine 32 is connected to a suitable fan blade 36 so that movement of air through the heat exchange device 26 may be effected. Again, the conduit

systems 28 and 30 for handling the hot and cold gas streams, respectively, are arranged to permit either of the streams to be bypassed around the heat exchange device 26 according to whether it is desired to heat or cool the air moving through the heat exchange device.

From the foregoing description, it will be apparent that the present invention provides a system for efficiently utilizing a gas under pressure for simultaneously moving a stream of air and heating or cooling such air stream as it is moved. Although the system is useful in safely and usefully lowering the pressure of natural gas from a gas well to a safe working level, and has been described by way of example with reference made to such use, it is to be noted that many other types of gases subjected to pressure by various devices may be used in the operation of the system. Other changes and innovations will occur to those skilled in the art, and insofar as such changes do not depart from an employment of the basic novel principles disclosed herein, they are considered to be encompassed by the spirit and scope of invention except as the same may be limited by the appended claims.

I claim:

1. A method of obtaining work from a gas under pressure which comprises:

- 25 passing the compressed gas into a Hilsch tube for separating the gas into a stream of cold gas and a stream of hot gas;
- passing at least one of said streams through a device for converting a portion of the energy of the stream passed therethrough to work;
- 30 using the work produced by said conversion for driving an air blowing device; and
- passing one of said streams through a heat exchange device positioned in the path of the air blown by said air-blowing device whereby the temperature of said blown air may be substantially altered by contact with said heat exchange device.

2. The method claimed in claim 1 wherein said device for converting a portion of the energy of said stream to work comprises a thermoelectric generator.

3. The method claimed in claim 1 wherein said stream of cold gas is passed through said converting device, and further characterized to include the step of further cooling said cold gas by expanding said cold gas in converting a portion of the energy thereof to work.

4. The method claimed in claim 3 wherein said device for converting a portion of the energy of said stream to work comprises a gas driven turbo-expander.

5. The method of using natural gas from a natural gas well which comprises:

- 50 passing the gas at well temperature and pressure into a Hilsch tube;
- separating the gas by means of the Hilsch tube into a high temperature gas stream and a low temperature gas stream;
- 55 passing at least one of said streams through a device for converting a portion of the energy of the stream passed therethrough to work;
- using the work produced by said conversion for driving an air-blowing device;
- 60 passing one of said streams through a heat exchange device positioned in the path of the air blown by said air-blowing device whereby the temperature of said blown air may be substantially altered by contact with said heat exchange device; and
- 65 discharging said streams into a natural gas collection pipeline.

6. Apparatus for converting the energy of a compressed gas to useful work comprising:

- 70 a Hilsch tube for separating the compressed gas into a stream of cold gas and a stream of hot gas;
- means for converting a portion of the energy of at least one of said streams to work;
- 75 conduit means for conveying said streams from said Hilsch tube to said converting means;

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an air blowing device drivingly connected to said converting means for using said work to produce an air current;

a heat exchange device interposed in the path of said air current for substantially altering the temperature of said air current;

and second conduit means for conveying at least one of said gas streams to said heat exchange means whereby heat may be exchanged between the gas stream conveyed to said heat exchange device and said air current.

7. Apparatus as claimed in claim 6 wherein said means for converting a portion of the energy of at least one of said streams to work comprises a thermoelectric generator; and said conduit means comprises a conduit for conveying said stream of cold gas to one side of said thermoelectric generator; and a conduit for conveying said stream of hot gas to the other side of said thermoelectric generator.

8. Apparatus as claimed in claim 6 wherein said means for converting a portion of the energy of at least one of said streams to work comprises a gas driven turbo-expander; and said conduit means comprises a conduit for conveying said stream of cold gas to said turbo-expander.

9. Apparatus claimed in claim 6 wherein said second conduit means comprises a conduit for conveying said stream of cold gas to said heat exchange device; a conduit for conveying said stream of hot gas to said heat exchange device; and valve means in said conduits for regulating the flow of hot and cold gas into said heat exchange device.

10. An air conditioning system for moving hot and cold streams of air through a space as desired comprising a source of compressed gas;

a Hilsch tube connected to said source for separating the compressed gas into a stream of cold gas and a stream of hot gas;

means for converting a portion of the energy of at least one of said streams to work;

conduit means for conveying said streams from said Hilsch tube to said converting means;

an air blowing device drivingly connected to said converting means for using said work to produce an air current;

a radiator interposed in the path of said air current

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for substantially altering the temperature of said air current;

a conduit for conveying said stream of cold gas to said radiator;

a conduit for conveying said stream of hot gas to said radiator; and

valve means in said conduits for regulating the flow of hot and cold gas into said radiator according to the alteration of the temperature of said air current which is desired.

11. The process of obtaining work from a gas under pressure which comprises:

passing the gas into a Hilsch tube for separating the gas into a stream of cold gas and a stream of hot gas;

passing at least one of said streams through a device for converting a portion of the energy of the stream passed therethrough to work;

using the work obtained from said converting device to accomplish useful heat exchange between at least one of said streams and a medium moved by said work into heat exchange relation to one of said streams.

12. Apparatus for converting the energy of a compressed gas to useful work comprising:

a Hilsch tube for separating the compressed gas into a stream of cold gas and a stream of hot gas;

means for converting a portion of the energy of at least one of said streams to work;

heat exchange means receiving one of said streams from said Hilsch tube; and

air moving means drivingly connected to said converting means for using said work to move air across said heat exchange means whereby the temperature of said moving air may be altered.

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