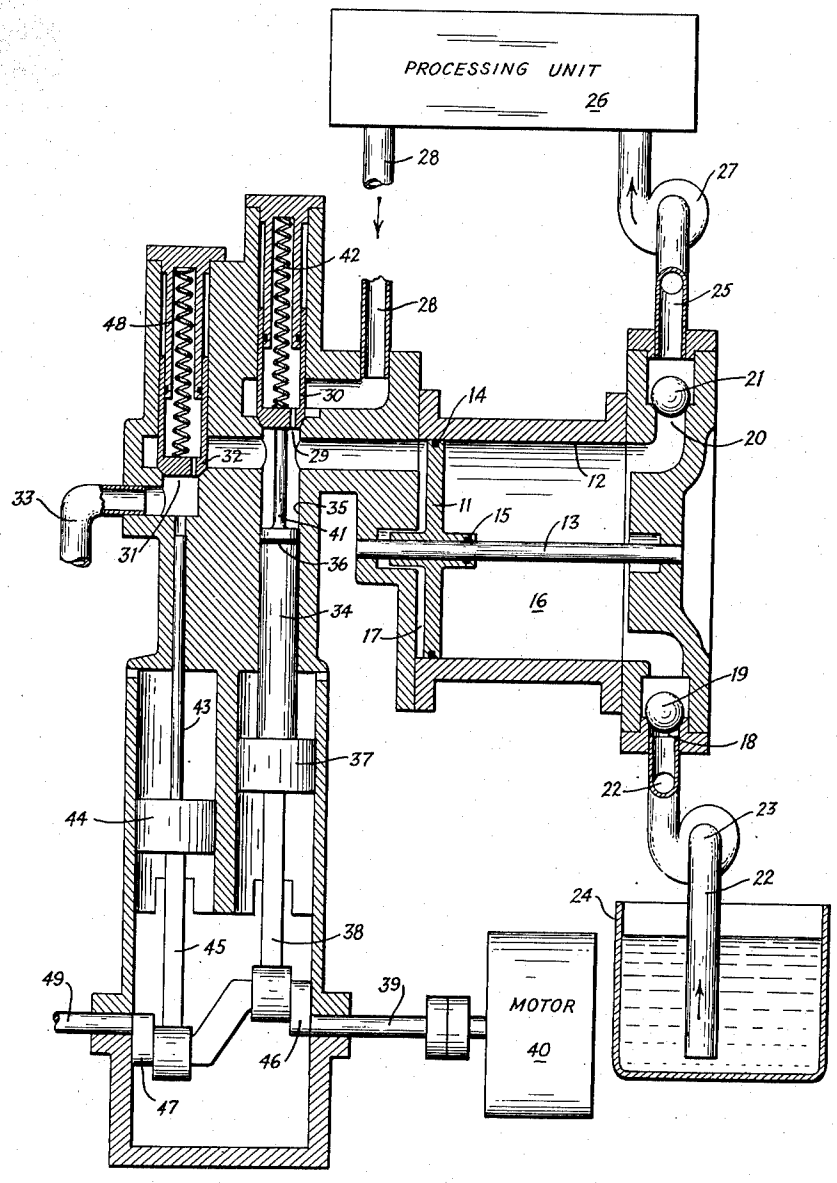
April 1, 1952 P. KOLLSMAN 2,591,441

PRESSURE ENERGY EXCHANGER

Filed Feb. 10, 1949



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Patented Apr. 1, 1952

2,591,441

UNITED STATES PATENT OFFICE

2,591,441

PRESSURE ENERGY EXCHANGER

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Application February 10, 1949, Serial No. 75,610

6 Claims. (Cl. 103—52)

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The invention provides a method of an apparatus for the direct recovery of the pressure energy imparted to fluids before or during processing.

Many processes, such as chemical processes, distillation processes, are carried out within a range of elevated pressures, and a considerable amount of mechanical energy is generally required for raising the pressure of the fluid to the pressure at which the process is carried out. If the processed fluid is discharged by simple decompression, that is by flow through a throttling passage, the pressure energy is lost. If, on the other hand, the fluid is discharged by conducting it through suitable prime movers, for example, turbines, to extract the pressure energy from the fluid, a certain percentage of the mechanical energy originally expended can be recovered. However, this form of recovery of pressure energy is not very efficient, since it is an indirect way of recovery in which considerable losses occur by reason of limited efficiency of the several mechanical units employed in the recovery. Assuming, for example, that the processed fluid is conducted through a turbine and that the turbine is used to drive some unit of the processing equipment, perhaps contributes a portion of the mechanical power for driving the pump, it is easily seen that the net recovery of energy is reduced by the losses occurring in the turbine, in the transmission of mechanical power, and in the pump.

Furthermore, the indirect form of recovery is often not practicable, for example, where the available volume of processed fluid is too small to drive a turbine of standard dimensions and design.

The invention proposes a method of direct recovery of pressure energy which offers numerous advantages over the indirect form of recovery in that no turbines or similar devices are required for converting pressure energy into mechanical energy. The invention provides for substantially complete recovery of the pressure energy and permits the recovery unit to be constructed of relatively simple elements and of relatively small size.

The various objects, features, and advantages of this invention will appear more fully from the detailed description which follows, accompanied by drawings showing, for the purpose of illustration, a preferred form of apparatus for carrying out the novel method. The invention also consists in the certain new and original steps and combination of steps as well as new and original

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features of construction and combination of elements hereinafter set forth and claimed.

Although the characteristic features of this invention which are believed to be novel will be particularly pointed out in the claims appended hereto, the invention itself, its objects and advantages, and the manner in which it may be carried out may be better understood by referring to the following description taken in connection with the accompanying drawing forming a part of it in which the figure is an illustration, partly diagrammatic, and partly in section, of an improved form of apparatus for the direct recovery of pressure energy from fluids processed under high pressure.

In the following description and in the claims various details will be identified by specific names for convenience. The names, however, are intended to be as generic in their application as the art will permit.

In the drawing accompanying, and forming part of, this specification, certain specific disclosure of the invention is made for the purpose of explanation of broader aspects of the invention, but it is understood that details may be modified in various respects without departure from the broad principles of the invention and that the invention may be applied to other structures than the ones shown.

For reasons of simplicity and convenient readability of the drawing the apparatus is not shown to scale, and particularly the wall thicknesses of the several elements are shown without regard to their actual dimensions, it being understood that the portions of the ducts and the walls sustaining full operating pressure must be constructed sufficiently heavy to withstand the operating pressure.

Since the specific nature of the process to which the fluid is subjected at elevated pressures is immaterial, the processing unit is shown only diagrammatically as having an inlet duct and an outlet duct.

As hereinbefore mentioned, the process to which the fluid is subjected may be a chemical process, may be a still operating at high pressures, for example, a still operating at substantially the critical pressure and the critical temperature, or it may be any other form of apparatus.

Referring now briefly to some characteristic steps of the method of recovering pressure energy, a volume of fluid to be processed is first confined at substantially atmospheric pressure. Then a second volume of processed fluid is compressed to the processing pressure, this second volume

being smaller than the first volume and being in pressure transferring relationship with the first volume. The second volume, however, is separated from the first volume to prevent mixing of the two. Then communication is established between the second volume and a supply of processed fluid under a pressure higher than the pressure of the first volume and simultaneously discharge of the first volume towards a processing point under processing pressure is permitted. This causes the first volume of fluid to decrease and the second volume to increase. Then both volumes are again confined. Then the second volume is decompressed and is discharged at substantially atmospheric pressure. Simultaneously, communication is established between the first volume in the source of fluid to be processed and the volumetric relationship of the two volumes initially existing is reestablished.

The drawing illustrates a simple form of pressure exchanger which extracts pressure energy from a processed liquid and utilizes the recovered pressure energy for compressing a corresponding volume of liquid to be fed into the processing unit.

The pressure exchanger basically comprises two chambers, an intake chamber and an outlet chamber. These chambers are sealed from each other to prevent mixing of fluids contained therein, but are otherwise in pressure exchanging communication or relationship. This is accomplished by providing a movable pressure transferring but fluid separating means in a passage through which both chambers communicate. This movable pressure transferring means may assume a number of convenient forms. It may be a mechanical wall such as a diaphragm, a Sylphon or a floating piston. It may also be a fluid barrier, for example, a charge of liquid such as mercury oscillating back and forth in a duct.

For reasons of simplicity a floating piston 11 is shown movable within a cylinder 12 guided by a rod 13 and sealed at 14 and 15. This floating piston need not be exceedingly strong since, as will appear from the following description, it rarely ever sustains the full operating pressure.

The floating piston 11 divides the cylinder space into an intake chamber 16 and an outlet chamber 17. The intake chamber has two ports, an intake port 18 controlled by an intake check valve 19 and an outlet port 20 controlled by an outlet check valve 21.

The intake port 18 lies at the end of a raw fluid feed duct 22 within which a low pressure feed pump 23 is arranged which supplies raw fluid from a source of supply to the pressure energy exchanger. This source of fluid supply is shown as a tank 24.

The outlet check valve lies at the entrance of a high pressure feed duct 25 leading to the processing unit 26. A low pressure circulating pump 27 may be provided in the high pressure feed duct for circulating the fluid through the processing unit. This pump is built strong enough to withstand the processing pressure. The pressure differential, however, produced by this pump can be small and need be no larger than is sufficient to overcome the fluid flow resistance encountered by the fluid in its passage from the intake chamber 16 through the processing unit 26 to the outlet chamber 17.

Processed fluid reaches the pressure exchanger through a high pressure duct 28 from the processing unit and enters the outlet chamber 17 through an inlet port 29 controlled by an inlet valve member 30. A discharge port 31 for the outlet chamber 17 is controlled by a discharge valve member 32 and the processed fluid leaves the apparatus through a low pressure duct 33.

A compressor is provided for periodically compressing and decompressing the fluid in the chambers 16 and 17. For reasons of simplicity the compressor is shown in the form of a piston 34 movable within a compressor cylinder 35 with respect to which it is sealed at 36. The piston is guided by a crosshead 37 and is operated through a connecting rod 38 from a power crankshaft 39 driven by a motor 40.

The piston 34 has a valve operating stem 41 on it adapted to bear against the inlet valve member 30 to lift the valve member off its seat against the force of the spring 42 tending to maintain the inlet valve closed.

The discharge valve member 32 is similarly operated by a valve stem 43 supported by a crosshead 44 operated from the crankshaft through a connecting rod 45. The crank 46 operating the compressor piston is offset with respect to the crank 47 operating the discharge valve member 32. A spring 48 bears against the discharge valve member 32 and tends to maintain the discharge valve closed.

The device operates as follows:

It may be assumed that at the start of the operation all the passages and chambers of the processing unit and of the pressure exchanger are filled with fluid and that the processing unit is under elevated processing pressure.

It may further be assumed that all the elements of the apparatus are in the position in which they are shown and that the motor 40 moves the crosshead 37 in an upward direction so that the piston 34 compresses the fluid in the chamber 17. In the position shown the piston has raised the pressure inside the outlet chamber 17 to the operating pressure existing in the processing unit. The pressure in the outlet chamber 17 is transmitted to the intake chamber 16 through the floating piston 11.

During the compression of the volume of fluid in the outlet chamber 17 the floating piston 11 moves from its left end position. This movement is slight if the fluid to be processed is a liquid, but a certain amount of movement takes place due to the limited compressibility of liquids, particularly if the operating pressure is high, for example, of the order of three thousand pounds per square inch employed in some distillation units.

In the position shown the pressure in the chambers 17 and 16 of the pressure exchanger is approximately equal to the pressure in the processing unit, but the chambers of the pressure exchanger remain sealed at the intake port 18 by the check valve 19, at the outlet port 20 by the check valve 21, at the inlet port 29 by the valve member 30, and at the discharge port 31 by the valve member 32.

Thus when the piston 34 rises further, the valve operating stem 41 engages the inlet valve 30 and lifts it off its seat, thereby causing processed fluid to flow from the processing unit 26 through the high pressure duct 28. This flow occurs because of the action of the circulating pump 27 which overcomes the flow resistance of the installation including the frictional resistance encountered by the floating piston 11.

The pump 27 then causes the processed fluid to fill the outlet chamber 17 thereby moving the floating piston 11 to the right. This, in turn, causes an equal volume of unprocessed fluid to

enter the processing unit through the outlet port 20 past the check valve 21.

At the time the outlet chamber 17 is filled and the intake chamber 16 is empty, the valve operating stem 41 has reached a position in which the valve member 30 is about to close the inlet port 29. The compressor piston 34 now retracts and causes the charge of fluid in both chambers of the pressure exchanger to be decompressed to substantially atmospheric pressure.

The energy available at the piston 34 during the decompression stroke is suitably transmitted to another compressor piston within the installation which passes through its compression stroke at this moment. For this reason the installation preferably comprises a series of individual pressure exchangers like the one shown connected in parallel to feed fluid to, and withdraw fluid from, the processing unit 26 at a substantially constant rate. Under such an arrangement the mechanical energy which actually has to be supplied by the motor 40 can be maintained relatively small. In fact the energy input by the motor need not be more than to compensate for actual friction and resistance losses in the system. Such additional pressure exchanger units may be connected to the crank shaft to the left of the crank 47 where the crankshaft is shown broken off at 49.

After the operating stem 43 reaches the position in which it engages and opens the discharge valve member 32, processed fluid flows out through the low pressure discharge duct 33. The fluid is forced out of the pressure energy exchanger by action of the feed pump 23 which is now effective to lift the check valve 19 off its seat and feed raw fluid into the intake chamber 16. This causes the floating piston 11 to travel to the left whereby the volume of the outlet chamber 17 is reduced and a proportional amount of processed fluid is discharged.

Although it is desirable to provide for compression and decompression of the fluid within the chambers by a separate compressing and decompressing means, such as the piston shown at 34, the compression and decompressing means may be omitted.

In an installation, thus simplified in construction, the inlet valve member 30 as well as the discharge valve member 32 would be operated against the fully differential pressure and, as a result, a certain amount of energy would be lost by fluid friction at the valves. This loss is relatively small, of the order of 1 or 2 per cent. Approximately 98 per cent of the pressure energy would still be recovered by exchange between the volumes of processed liquid and the volumes of liquid to be processed. In the simplified construction somewhat greater valve wear would be experienced by reason of high velocities of flow occurring at the valves.

In large installations, however, operating under high pressures and handling large volumes of fluid, for example, installations for the conversion of salt water into fresh water the recovery of the 1 or 2 per cent of energy may amount to a sizable gain. For example, it requires 26,000 H. P. to compress one cubic meter of water per second to the critical pressure. In an installation handling one cubic meter per second approximately 500 to 1,000 H. P. could be saved by eliminating the throttling losses at the valves by provision of a separate device for compressing and decompressing the fluid in the energy exchanger prior to opening of the valves.

It thus appears that the pressure in the pressure exchanger fluctuates between approximately atmospheric pressure or the pressure at which fluid is fed into the apparatus and is discharged and the full operating pressure of the processing unit.

It is quite apparent that the mechanical energy required for maintaining the apparatus in operation is low since the pressure energy is directly recovered. This flow of recovery is preferable, and more economical than, indirect recovery in which the processed fluid under pressure is used, for example, to drive turbine and a turbine is used to drive some other mechanical unit of the installation.

What is claimed is:

1. A device for the recovery of pressure energy of fluids processed under high pressure in a processing system, the device comprising, an intake chamber having an intake port, and an outlet port leading to said system; intake valve means controlling said intake port; outlet valve means controlling said outlet port; an outlet chamber having an inlet port for admission of fluid from said system, and a discharge port; an inlet valve member controlling said inlet port; a discharge valve member controlling said discharge port; pressure equalizing means between said two chambers, including means for sealing fluid in one chamber with respect to fluid in the other chamber; means for periodically compressing and decompressing the fluid in one of said chambers; and means operable in timed relationship with said compressing and decompressing means for operating said inlet valve member and said discharge valve member.

2. A device for the recovery of pressure energy of fluids processed under high pressure in a processing system, the device comprising, an intake chamber having an intake port, and an outlet port leading to said system; an intake check valve controlling said intake port; and outlet check valve controlling said outlet port; an outlet chamber having an inlet port for admission of fluid from said system, and a discharge port; an inlet valve member controlling said inlet port; a discharge valve member controlling said discharge port; a movable pressure equalizing wall between said chambers sealing one chamber with respect to the other but permitting equalization of pressure therebetween; means for periodically compressing and decompressing the fluid in one of said chambers; and means operable in timed relationship with said compressing and decompressing means for operating said inlet valve member and said discharge valve member.

3. A device for the recovery of pressure energy of fluids processed under high pressure in a processing system, the device comprising a cylinder; a piston movable in said cylinder subdividing the cylinder into an intake chamber and an outlet chamber, said intake chamber having an intake port and an outlet port leading to said system, said outlet chamber having an inlet port for admission of fluid from said system, and a discharge port; an intake check valve controlling said intake port; an outlet check valve controlling said outlet port; an inlet valve member controlling said inlet port; a discharge valve member controlling said discharge port; means separate and distinct from said piston for periodically compressing and decompressing the fluid in said outlet chamber; and means operable in timed relationship with said compressing and decompressing means for operating said inlet valve member and said discharge member.

4. A device for the recovery of pressure energy

of fluids processed under high pressure in a processing system, the device comprising, an intake chamber having an intake port, and an outlet port leading to said system; intake valve means controlling said intake port; outlet valve means controlling said outlet port; an outlet chamber having an inlet port for admission of fluid from said system, and a discharge port; an inlet valve member controlling said inlet port; a discharge valve member controlling said discharge port; a circulating pump in the passage between said outlet port and said inlet port, which passage includes the processing system, said pump feeding fluid towards said inlet port; pressure equalizing means between said two chambers including means for sealing fluid in one chamber with respect to fluid in the other chamber; power means separate and distinct from said pressure equalizing means for periodically compressing and decompressing the fluid in said outlet chamber and means for operating said inlet valve member and said discharge valve member in timed relationship with said power means.

5. A device for the recovery of pressure energy of fluids processed under high pressure in a processing system, the device comprising, an intake chamber having an intake port, and an outlet port leading to said system; intake valve means controlling said intake port; outlet valve means controlling said outlet port; an outlet chamber having an inlet port for admission of fluid from said system, and a discharge port; an inlet valve member controlling said inlet port; a discharge valve member controlling said discharge port; pressure equalizing means between said two chambers, including means for sealing fluid in

one chamber with respect to fluid in the other chamber; means for periodically compressing and decompressing the fluid in said outlet chamber; and means operable in timed relationship with said compressing and decompressing means for operating said inlet valve member and said discharge valve member.

6. A device for the recovery of pressure energy of fluids processed under high pressure in a processing system, the device comprising, an intake chamber having an intake port, and an outlet port leading to said system; an intake check valve controlling said intake port; and outlet check valve controlling said outlet port; an outlet chamber having an inlet port for admission of fluid from said system, and a discharge port; an inlet valve member controlling said inlet port; a discharge valve member controlling said discharge port; a movable pressure equalizing wall between said chambers sealing one chamber with respect to the other, but permitting equalization of pressure therebetween; means for periodically compressing and decompressing the fluid in said outlet chamber; and means operable in timed relationship with said compressing and decompressing means for operating said inlet valve member and said discharge valve member.

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