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(54) HIGH PRESSURE LIQUID BOOSTER

(71) We, LE MATERIEL TELEPHONIQUE, a French body corporate, of 46 quai Alphonse Le Gallo, 92103 Boulogne-Billancourt, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to equipment for boosting the pressure of a liquid, known as a pressurizing unit.

According to the present invention there is provided a pressurizing unit comprising a pump unit, electrical control circuitry operable to control the pump unit and having a first input coupled to an inlet of the pump unit to receive a signal indicative of the actual pressure at said pump inlet and a second input to receive a signal indicative of a minimum desired pressure at an outlet of the pump unit, the pressurizing unit having two possible states in which medium flows therethrough, these two states being produced by said electrical control circuitry in dependence upon the relative values of said minimum desired pressure and said actual inlet pressure, and one of these states being such that the pump unit is non-operational therein.

Preferably, said electrical control circuitry is arranged to provide the other of said states, in which the pump unit is operational, when the ratio of the minimum desired outlet pressure to the actual inlet pressure is less than unity, and to provide said one state, in which the pump unit is non-operational, when said ratio is greater than unity.

The pressurizing unit may be such that, when it is in use and in said one state, medium flows through the pumping unit substantially without obstruction.

The pump unit may comprise two pumps combined in a single pump body, each of the two pumps being a multi-chamber pump and comprising an immersed-rotor drive motor.

The pressurizing unit may comprise a by-pass valve operable to allow medium flowing through the pressurizing unit to by-pass a portion of the pump unit when the pressurizing unit is in said one state.

In a preferred embodiment in which the pump unit comprises two pumps, the electrical control circuitry comprises a third input coupled to said outlet of the pump unit to receive a signal indicative of the acutual pressure at said outlet, and the pressurizing unit is operable in dependence upon the electrical control circuitry to have two possible modes of operation in the other of said two possible states, a first mode in which only one of the two pumps is operational and a second mode in which both pumps become operational when the actual outlet pressure is less than or equal to the minimum desired outlet pressure, transition from the second mode to the first mode occurring if the actual outlet pressure exceeds a pressure above the minimum desired outlet pressure.

The pressurizing unit may comprise a temperature sensor coupled to the electrical control circuitry for rendering the pumping unit non-operational if the temperature of the medium being pumped rises excessively while the pressurizing unit is in operation.

Where the pump unit comprises two pumps, they may both be rendered non-operational in dependence upon the temperature of the medium circulating in either pump.

The temperature sensor may be a thermostat located in a housing in contact with the medium flow common to both pumps.

Preferably, the pressurizing unit is a single assembly adapted to be mounted either vertically against a wall or horizontally.

In one embodiment the inlet of the pump unit comprises two inlet passages and the outlet of the pump unit comprises two outlet passages, these four passages being arranged in substantially an H-form configuration in a single pump unit body.

For a better understanding of the invention and to show how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:—

Figure 1 is a perspective view of a pressurizing unit in accordance with the invention;

Figure 2 is a schematic front view of a pump unit of a pressurizing unit;

Figure 3 is an end elevation of the pump unit shown in Figure 2;

Figure 4 is a schematic top view of the pump unit shown in Figure 2;

Figure 5 is a graph of pressure against time illustrating the operation of the pressurizing unit of Figure 1;

Figure 6 is a graph similar to that of Figure 5.

In Figure 1, a pressurizing unit 1 is seen in perspective. It comprises a pumping unit 2 and an electrical control circuit contained in a control cabinet 3. A multi-conductor cable 4 connects the pumping unit 2 to the control cabinet 3.

The pumping unit 2 consists of two pump elements 6 and 7 combined in a common pump body 5. Each pump element 6 and 7 is electrically connected *via* a terminal box 24 and 24′ (protecting the motor terminals) and a cable 4 to the control cabinet 3.

The general shape of the pump body 5 is rectangular, the larger dimension being vertical in the figure. With respect to this pump body 5 viewed from the front, the pumping elements 6 and 7 are located on the left. The thickness of the pump body 5 decreases symmetrically to the left and to the right in the bottom and top regions (as seen at regions 12 and 12′) in order to provide connections for four passages 8, 9, 10 and 11 arranged in an H-configuration for connection to liquid-carrying pipes. Between the connections for each pair of adjacent fittings, for example the connections at regions 12 and 12′, the common pump body 5 is recessed to receive a pressure gauge 18 of the pressostat type. The same arrangement at the bottom of the pump body 5 allows the installation of a second pressostat 18′.

A housing 19 is provided in the pump body 5 between the protruding parts of the two pumping elements 6 and 7 to take the sensor of a thermostat, of which the external part 20 is seen.

The pump body 5 is rigidly attached to a vertical rear plate 21 to facilitate attachment of the pressurizing unit to a vertical surface, such as a wall.

In the form illustrated by Figure 1, the pumping elements 6 and 7 are two similar multi-chamber pumps with immersed-rotor motors.

Figure 2 is a front elevation of a practical pumping unit slightly different from that shown in Figure 1. In this figure, parts also shown in the previous figure have the same numbers. It is seen that the connections at regions 8′ and 11′ are made smaller than on the pumping unit shown in Figure 1. The figure shows the form of wiring used. The six electrical leads from the pressure gauges 18 and 18′ (three leads for each), the two leads of the thermostat 20, and the two groups of six leads controlling the motors from the terminal boxes 24 and 24′ of the pumping elements 6 and 7, are combined in a multi-conductor cable 4 connecting the pumping unit to the control cabinet 3 (not shown).

Figure 3 is a side elevation of the pumping unit of Figure 2, showing the vertically arranged fixing base 21, as well as fixing brackets 22 and 22′ securing the pump body 5 rigidly to the base 21. The penetration of the housing 19 of the thermocouple 20 into the common pump body 5 is also seen. The right-hand inlet and the left-hand outlet are capped and blocked-off.

Figure 4 is a schematic top view of the pumping unit of Figure 2. The item numbers are the same as in the previous figures.

The operation of the pressurizing unit is as follows:—

The circulating liquid is fed to the pressurizing unit through a pipe (not shown) connected to one of the two inlet passages, 8 or 11. It will be assumed that the bottom inlet passage 11 has been selected for the supply liquid which may be, for example, mains water. The pressure P_o of the incoming liquid is measured by the lower pressure gauge 18′ in the supply pipe. Depending on the ratio between the inlet pressure P_o and a minimum required output pressure P_m, either of two situations are possible:

In the first case, if the ratio P_o/P_m is less than one, the liquid must be pressurized in order to increase its pressure to at least P_m. The inlet pressure gauge 18′ produces an electrical signal which is received by the electrical circuit in the control cabinet 3 and which causes an electrical supply to be applied to the motor terminals in the terminal box 24′ of the first pump element 7. Pump element 7 starts. The pressure of the liquid rises in the pump body 5 above the value P_o.

On the outlet pipe whose outlet is provided *via* the connection 12 and the passage 8, the upper pressure gauge 18 measures the output pressure P_r.

If the ratio P_r/P_m is less than one (P_r being the outlet pressure) the pressure increase produced by the first pump element 7 is still less than the minimum required output value P_m. The pressure gauge

18 therefore produces a pressure demand in the form of an electrical signal which switches the power supply to the motor terminals in the terminal box 24 of the second element 6. Pump 6 starts and the pressure of the liquid at the outlet increases.

As long as the outlet pressure gauge 18 does not detect a pressure more than a value P_{r1}, where P_{r1} is a value greater than P_m, simultaneous operation of both pump elements 6 and 7 is maintained. When the ratio P_r/P_{r1} exceeds one, the outlet pressure gauge 18 transmits a stop order to the control circuit in cabinet 3. In response to the stop order, a switch controlling the motor power supply of the second pump element 6 opens. Pump element 6 therefore stops rotating. The first pump 7 only continues to operate. If the operation of this first pump element 7 alone results in a ratio P_o/P_m of more than one, a stop order is fed to a power supply switch controlling the first pump element 7.

In the second case, if the ratio P_o/P_m measured at the inlet by the inlet pressure gauge 18′ is more than one, pressurization is not required. The inlet pressure gauge 18′ thus produces a continuous "off" order leaving the first pump element 7 stopped. This is also the case for the second pump element 6, controlled by the outlet pressure gauge, if the outlet measurement indicates a ratio P_r/P_m of more than one.

When both pump elements 6 and 7 are non-operational, the hydraulic circuit in the presurizing unit merely becomes a direct passage between the inlet and outlet passages by means of the actoin of a by-pass valve in the pump body 5. The change-over of the by-pass valve to the direct passage position is initiated by the inactive state of the pump elements 6 and 7.

Figure 5 illustrates the mode of operation of the pressurizing unit. It indicates the inlet pressure P_o as a function of time. This is a sinuous curve sometimes exceeding the value P_m and sometimes dropping below this value.

The pumping unit is brought into operation only when the curve P_o is beneath the horizontal line through P_m, as indicated by the heavy lines along the abscissa.

Several safety features are also provided to meet safety regulations when the pressurising unit is used for supplying a building with water from the distribution mains which does not provide sufficient pressure at all times. If, for example, the inlet flow-rate is momentarily insufficient to meet the load demand whilst one or both pump elements are running, it could be dangerous to leave the pumps running.

In order to avoid this danger, a thermocouple is placed inside the pump body 5 which is common to both pumps and in which the liquid circulates. In the present example, a thermostat 20 placed in the housing 19 produces an electrical signal when the liquid heats above a predetermined temperature T_o. The electrical signal transmitted *via* cable 4 operates on the motor power supply switch of both pump elements 6 and 7, which immediately stop in response to the signal, thereby avoiding "stirring" of the pump elements 6 and 7 if the flow-rate drops, or pump operation without flow if the flow-rate drops to zero (e.g. at night).

In addition, this same safety device automatically interrupts pump operation if the mains water supply drops to zero for any reason, such as burst mains or in the case of the water supply being cut-off for road works, etc.

In practice, accurate regulation adapted to each installation can be easily obtained with the pressure unit in accordance with the invention. For this purpose, as shown in Figure 6, rather than impose a single value P_m as the reference value for both pressostats, resulting in excessive starting and stopping, a regulation range is imposed on the outlet pressure as will be described.

Figure 6 illustrates how the output pressure (indicated by a thick black line) as sensed by the outlet pressure gauge is controlled with time during a powered mode period of Figure 5. Throughout the whole of the period covered by Figure 6 the pressurizing unit is in a powered mode with the first pump operating continually. This powered mode is brought about because the actual inlet pressure (not shown in Figure 6) is below a value Pa_1 set at the inlet pressure gauge. Pa_1 is to all intents and purposes substantially the same value as P_m and so is not shown on Figure 5 as being any different from P_m. Another limit pressure Pa_o shown on Figure 6 is a very low pressure. When the inlet pressure drops to Pa_o both pumps are stopped to avoid damaging them. Pa_o indicates a lack of water at the inlet.

A range of outlet pressure Pr_o–Pr_1 is set on the outlet pressure gauge to control the second pump to boost the action of the first pump when required in a powered mode. Thus, when the outlet pressure drops to Pr_o (which coincides with P_m) the second pump is brought into operation to boost the auction of the first pump, and when the outlet pressure rises to Pr_1 the second pump is switched-off leaving the first pump to operate alone. In this manner the outlet pressure is maintained above P_m.

Thus in Figure 6, the first pump only is operating at instant t_o and the outlet pressure (in the outlet pipe) is at a value A well in excess of the required pressure P_m. However, this outlet pressure then drops with time. At an instant t_1 it reaches B, equal to the required pressure P_m and also the value Pr_0 for starting the second pump controlled by the outlet pressure gauge. The outlet pressure gauge orders the second pump to be started without stopping the first. The second pump, now operating, raises the outlet pressure. From B to C both pumps are operating. At C the outlet pressure curve reaches the value Pr_1, the upper reference level of the outlet pressure gauge. This interrupts the second pump. When the outlet pressure falls again at point D, the second pump starts again as described for point B.

At an instant t_d the inlet flow-rate suddenly drops whilst both pumps are operating. The inlet pressure suddenly drops to the value Pa_0. Both pumps are then automatically stopped for safety reasons. This result is the effect of passing through the limiting reference value Pa_0 on the inlet pressostat. Restoration of the inlet flow-rate allows operation to be resumed after a delay in accordance with regulations.

The operation of the illustrated and described system is completely satisfactory. It is completely automatic, reliable and in agreement with all safety regulations.

With regard to operation costs, it has a major advantage in that it operates in the powered mode only when the inlet pressure is insufficient to meet the demand, whilst formerly conventional pressure units were permanently powered. In such units, the liquid passes through a pressure-relief valve in order to drop its pressure to a constant value in order to feed the pumps at constant pressure. This represents a considerable waste of energy since it is first necessary to drop the pressure and then permanently raise it again to the required value.

The use of the illustrated and described pressure unit in conventional installations can result in power savings up to 50%.

With regard to the production cost of the pressure unit itself, it is seen that one piece of equipment is not required, i.e. a pressure-relief valve.

The common pump body can be mass-produced by casting. The pump elements are multi-chamber pumps. Each is driven by an immersed-rotor motor ensuring high reliability and silent operation. These pump elements are also mass-produced. The production cost compared with former installations of associated pumps is the same or very little more, whilst its operating costs are considerably reduced.

The pump body is machined for mounting the twin pump elements on the right or on the left, as required.

The pumping unit possesses four orifices aligned in pairs in an H-configuration. Two of these may be used selectively for the inlet, whilst the other two can be used selectively for the outlet.

The pumping unit and control cabinet assembly can be installed on a wall-mounted base or on a horizontal base.

These arrangements greatly facilitate utilization. Above all, the pressure group provides automatic regulation continuously matching demand for each individual installation.

Although the principles of the present invention are described above in relation with specific practical examples, it should be clearly understood that the said description is given as an example only.

WHAT WE CLAIM IS:—

1. A pressurizing unit comprising a pump unit, electrical control circuitry operable to control the pump unit and having a first input coupled to an inlet of the pump unit to receive a signal indicative of the actual pressure at said pump inlet and a second input to receive a signal indicative of a minimum desired pressure at an outlet of the pump unit, the pressurizing unit having two possible states in which medium flows therethrough, these two states being produced by said electrical control circuitry in dependence upon the relative values of said minimum desired pressure and said actual inlet pressure, and one of these states being such that the pump unit is non-operational therein.

2. A pressurizing unit according to claim 1, wherein said electrical control circuitry is arranged to provide the other of said states, in which the pump unit is operational, when the ratio of the minimum desired outlet pressure to the actual inlet pressure is less than unity, and to provide said one state, in which the pump unit is non-operational, when said ratio is greater than unity.

3. A pressurizing unit according to claim 1 or 2, wherein the pressurizing unit is such that, when it is in use and in said one state, medium flows through the pumping unit substantially without obstruction.

4. A pressurizing unit according to any one of the preceding claims, wherein the pump unit comprises two pumps.

5. A pressurizing unit according to claim 4, wherein the two pumps are combined in a single pump body.

6. A pressurizing unit according to claim 4 or 5, wherein each of the two pumps is a multi-chamber pump.

7. A pressurizing unit according to any one of claims 4 to 6, wherein each of the two pumps comprises an immersed-rotor drive motor.

8. A pressurizing unit according to any one of the preceding claims, and comprises

a by-pass valve operable to allow medium flowing through the pressurizing unit to by-pass a portion of the pump unit when the pressurizing unit is in said one state.

9. A pressurizing unit according to claim 4, or any one of claims 5 to 8 when appended to claim 4, wherein the electrical control circuitry comprises a third input coupled to said outlet of the pump unit to receive a signal indicative of the actual pressure at said outlet, and the pressurizing unit is operable in dependence upon the electrical control circuitry to have two possible modes of operation in the other of said two possible states, a first mode in which only one of the two pumps is operational and a second mode in which both pumps become operational when the actual outlet pressure is less than or equal to the minimum desired outlet pressure, transition from the second mode to the first mode occurring if the actual outlet pressure exceeds a pressure above the minimum desired outlet pressure.

10. A pressurizing unit according to any one of the preceding claims, and comprising a temperature sensor coupled to the electrical control circuitry for rendering the pumping unit non-operational if the temperature of the medium being pumped rises excessively while the pressurizing unit is in operation.

11. A pressurizing unit according to claim 10, when appended to claim 4 or any one of claims 5 to 9 when appended to claim 4, wherein both the two pumps can be rendered non-operational in dependence upon the temperature of the medium circulating in either pump.

12. A pressurizing unit according to claim 11, or claim 10 when appended to claim 4 or any one of claims 5 to 9 when appended to claim 4, wherein the temperature sensor is a thermostat located in a housing in contact with the medium flow common to both pumps.

13. A presurizing unit according to any one of the preceding claims, which is a single assembly adapted to be mounted vertically against a wall or horizontally.

14. A pressurizing unit according to any one of the preceding claims, wherein the inlet of the pump unit comprises two inlet passages and the outlet of the pump unit comprises two outlet passages, these four passages being arranged in substantially an H-form configuration in a single pump unit body.

15. A pressurizing unit substantially as hereinbefore described with reference to Figures 1 to 4 of the accompanying drawings.

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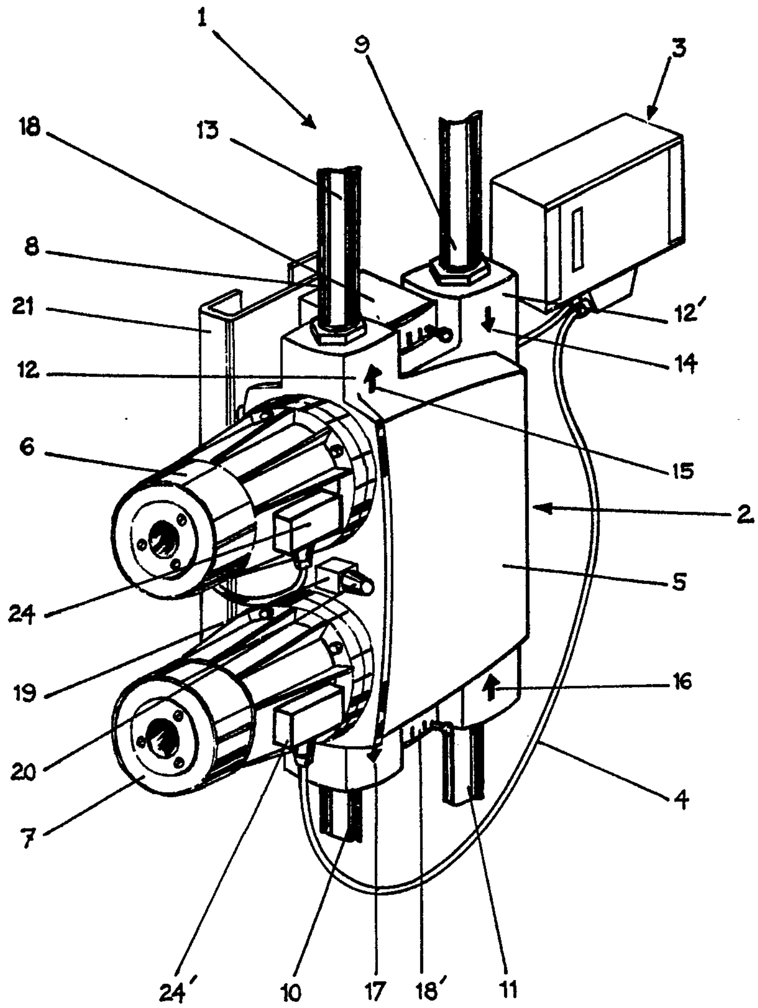
Fig. 1



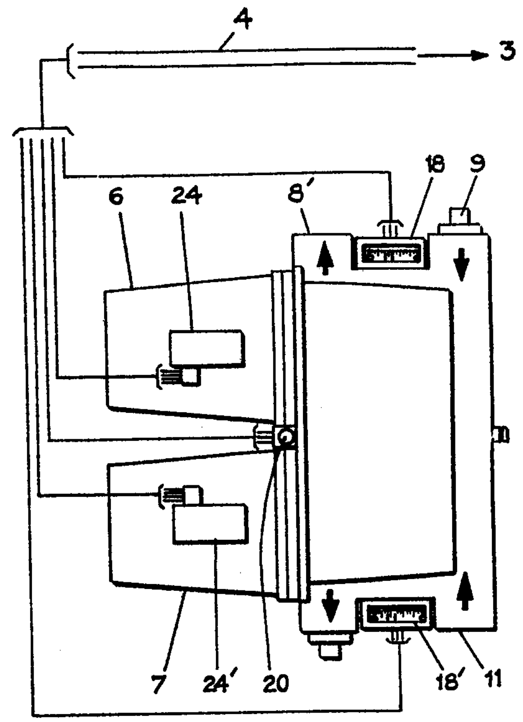


Fig. 2

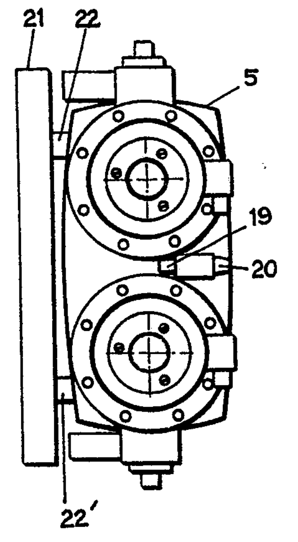


Fig.3

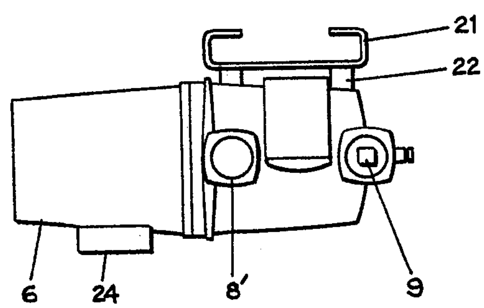


Fig. 4

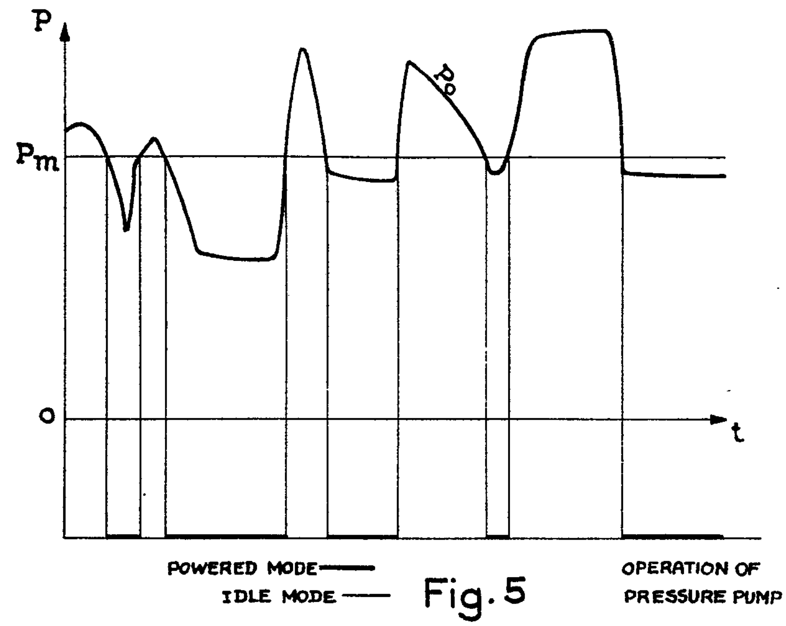

P
Pm
Po
o
t
POWERED MODE
IDLE MODE
OPERATION OF
PRESSURE PUMP

Fig. 5

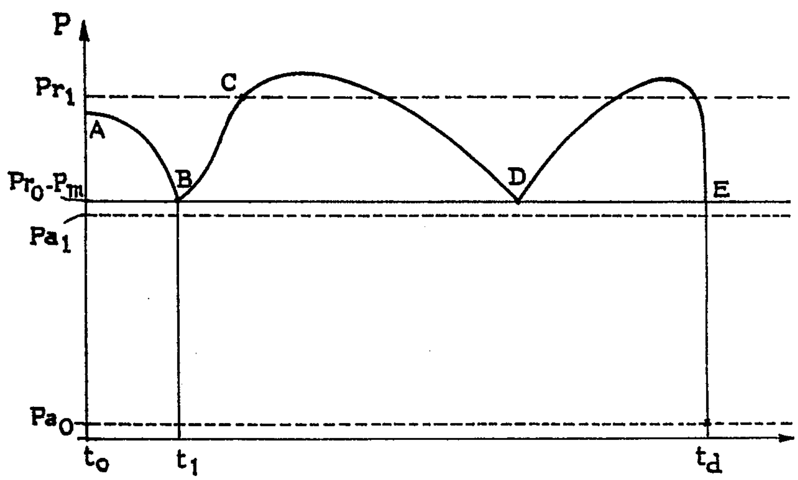

P
Pr1
Pr0-Pm
Pa1
Pa0
A
B
C
D
E
to
t1
td

Fig. 6