Sept. 14, 1965 W. E. GIFFORD 3,205,668

FLUID CONTROL APPARATUS

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Fig. 2.

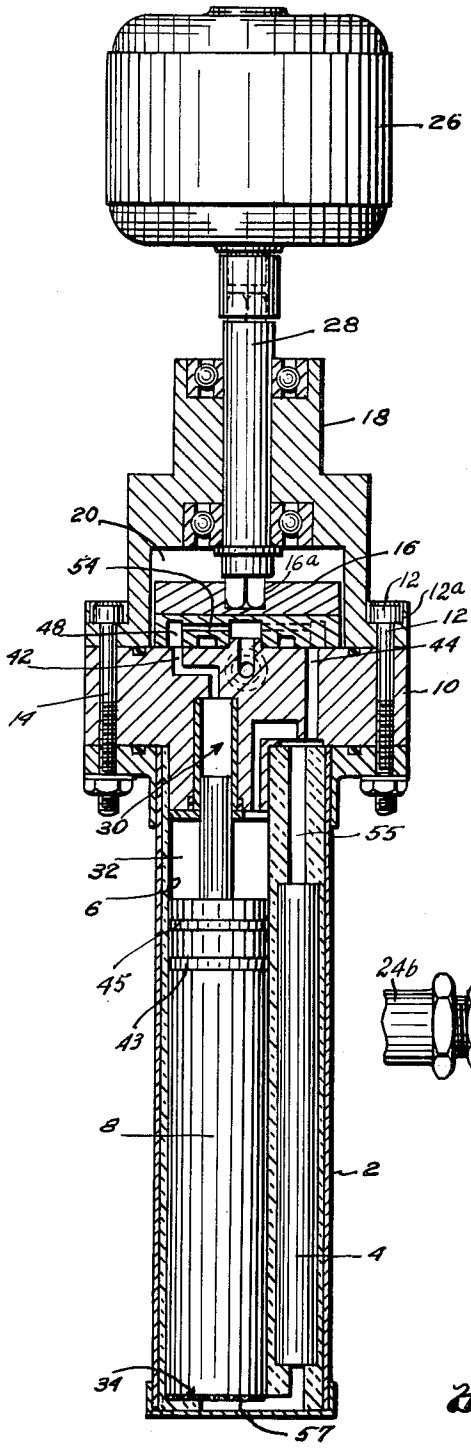

Fig. 1.

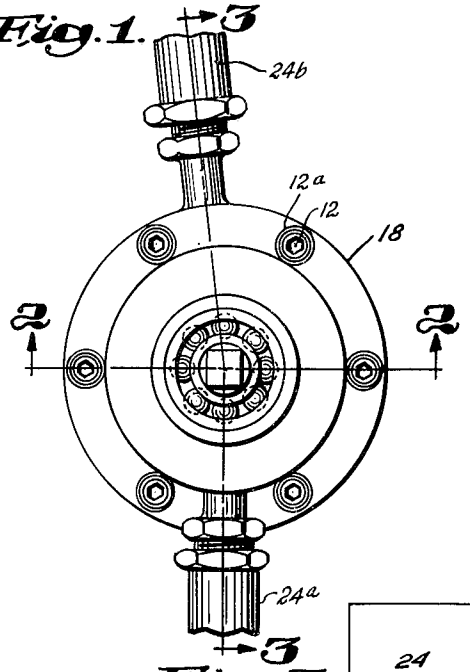

Fig. 3.

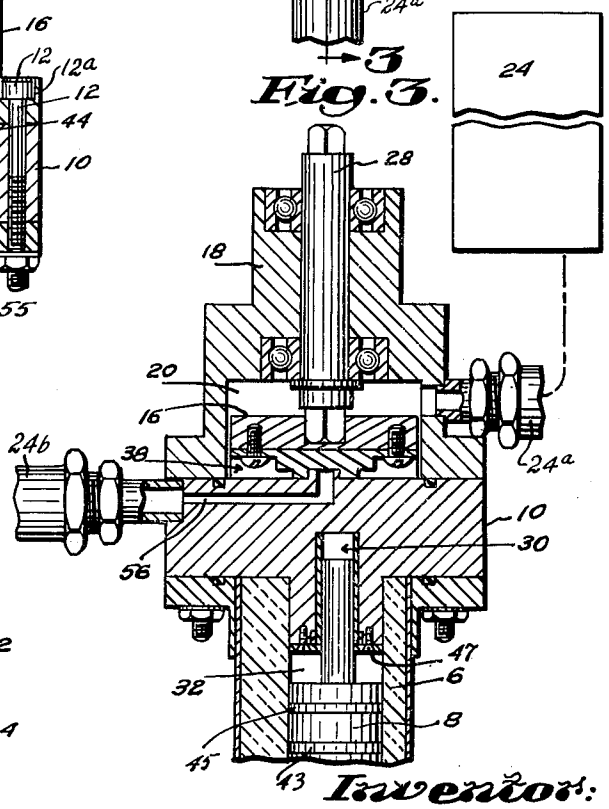

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Fig. 4.

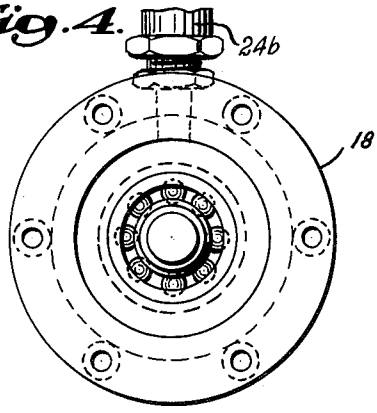


Fig. 5.

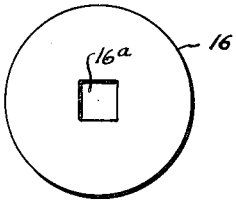


Fig. 6.

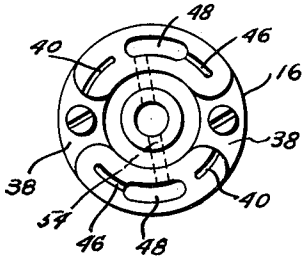


Fig. 7.

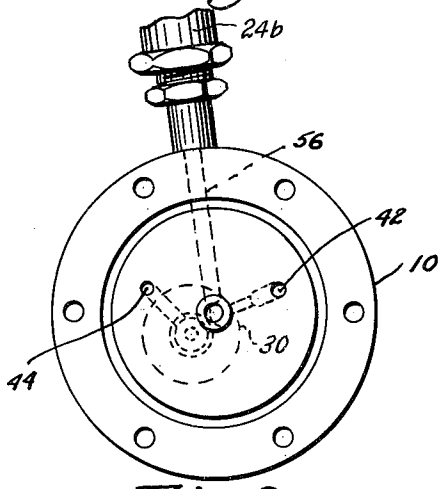


Fig. 8.

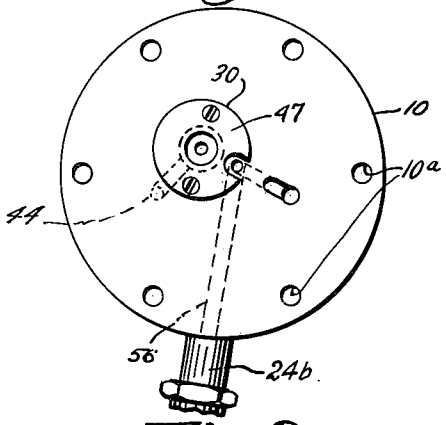
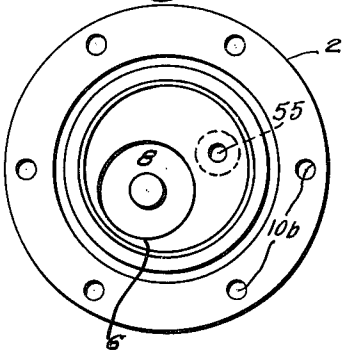


Fig. 9.



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3,205,668

FLUID CONTROL APPARATUS

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7 Claims. (Cl. 62—6)

This invention relates to a fluid control apparatus and, more particularly, to a fluid control apparatus which may be used for producing refrigeration. Reference is had specifically to producing refrigeration at relatively low temperatures utilizing a compressed fluid system wherein related quantities of a high pressure fluid such as compressed air confined as separated volumes are caused to vary in magnitude in accordance with a novel pressure balancing cycle of operation. This pressure balancing cycle of operation has been disclosed and described in detail in my co-pending application Serial No. 183,783 filed March 30, 1962, now Patent No. 3,119,237.

It is a principal object of the present invention to devise an improved fluid programming for controlling apparatus in which a novel combination of fixed and movable fluid conducting members are associated together.

In the accompanying drawings

FIGURE 1 is a plan view of a preferred embodiment of the fluid control apparatus of the invention;

FIGURE 2 is a cross section taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a cross section taken substantially on the line 3—3 of FIGURE 1;

FIGURE 4 is an inside plan view of a pressure head member;

FIGURE 5 is a plan view of one side of a novel programming member of the invention;

FIGURE 6 is a plan view of the reverse side of the programming member of FIGURE 5;

FIGURE 7 is a plan view of one side of a fixed fluid conducting member of the apparatus;

FIGURE 8 is a plan view of the opposite side of the fixed member of FIGURE 7; and

FIGURE 9 is a plan view of a special enclosure body consisting of a cylinder and regenerator housing with a displacer member therein.

In the structure shown in the drawings, numeral 2 denotes an enclosure body which consists of a cylinder and regenerator housing having therein a regenerator 4 and a cylinder portion 6 in which is a displacer 8.

Secured to an upper side of the enclosure body 2 is a fixed fluid conducting member 10. The member 10 is fastened in some convenient manner as by bolts 12 and 14 which extend through opening 10*a* of member 10 and opening 10*b* in the enclosure body numeral 2. Mounted on the fixed fluid conducting member 10 is a movable programming element 16 having an opening 16*a* and encasing the programming element 16 is a pressure head member 18 which defines a space 20 in which compressed fluid as helium or air may be continuously supplied by a source of compressed fluid 24.

The pressure head 18 has mounted therein power driving means which, in one preferred form, may consist of a motor 26 located externally of the head 18 and arranged to drive a shaft 28 which is adapted to extend through the pressure head into the recess 16*a* in the top of the programming element 16.

In the arrangement of parts described with compressed fluid being continuously supplied to the space 20, the programming element becomes constantly forced against the fixed fluid conducting element 10 and this compressed relationship of the parts is maintained while the programming element is rotated by the motor 26.

The displacer member 8 is movable to define three different volumes including a first volume 30, a second

volume 32, and a third volume 34 which is not shown in FIGURE 2 but becomes apparent when the displacer is moved upwardly.

In accordance with the invention the displacer is caused to move in a predetermined manner to introduce high pressure fluid to each of the volumes 30, 32 and 34 by means of a special duct arrangement. This duct arrangement is comprised by both the fixed fluid conducting member 10 and the programming element 16.

Considering first the portion of the duct arrangement in the programming element 16, attention is directed to FIGURE 3 wherein compressed fluid is introduced from the compressor means 24 through a conduit 24*a* into the space 20 of the pressure head 18. Element 10 may also have a low pressure or exhaust line 24*b* which may, if desired, be led back into intake side of compressor 24 in the same manner as disclosed in Patent No. 3,119,237. This high pressure fluid in a starting position of the programming element 16 enters openings as 38 at the periphery of the programming device as is indicated in FIGURE 3 and also more clearly in FIGURE 6.

From here gas in this starting position of the programming element travels into a small duct 40 best shown in FIGURE 6. The duct 40 communicates with one or the other of the two ports 42 and 44 in the fixed fluid conducting element as may be observed from an inspection of FIGURES 2 and 7.

The high pressure fluid entering one of the ports 42 will pass into the first volume 30 causing the displacer to move downwardly and increasing the magnitude of the first and second volumes 30 and 32, while decreasing the magnitude of the third volume 34 to substantially zero. This operation takes place in an arc of rotation of the programming element of approximately 45°.

In the next 45° arc of rotation of the programming device high pressure fluid is admitted through the opening 38 along the duct 40 to port 44 and causing pressure to be increased in the second and third volumes 32 and 34 while pressure remains high in the first volume 30. It will be understood that the pressure increase in volume 34 takes place through the regenerator 4.

In the third 45° arc of rotation two additional ducts 46 and 48 formed in the programming element 16 and best shown in FIGURE 6, move into register with the port 42 which allows high pressure gas to exhaust out through separate exhaust ducts 54 and 56 shown in FIGURES 2, 3 and 6.

Also during the third 45° arc of rotation as the displacer moves upwardly gas is forced from the second volume 32 down through a duct 55 and thermal regenerator 4 and heat exchanger 57 to the third volume 34. During this transfer, pressure is maintained constant all the way along by the continuous supply of high pressure fluid.

In a fourth 45° arc of rotation of the programming element 16 the ducts 46 and 48 come into register with port 44 and allow the high pressure fluid in the third volume 34 to exhaust out through heat exchanger 57, regenerator 4 and ducts 54, 55 and 56.

As a result of this, refrigeration is produced in the third volume 34 which cools the heat exchanger 57 and the bottom end of enclosure 2 due to fluid expansion. During the next 180° the same series of steps is repeated.

It will be observed that there is produced by the novel arrangement of parts disclosed several important advantages. The structure operating solely as a valve is characterized by the fact that pressure constantly exerted on the programming element results in maintaining the seal between the programming element and the fixed fluid conductor and tends to provide a better fit as irregularities between the parts are worn away. The effect

of this is that the valve does not tend to develop leaks and gives a better seal between the high and low pressure areas for a very long operating life which is particularly desirable in a refrigerating apparatus.

In the addition to this it will be seen that the combination of the programming element in the fixed fluid conducting member with the specific duct arrangement described serve to move the displacer through a series of steps. This arrangement functions to not only move the displacer, but also to supply exhaust refrigerating fluid so as to cause the third volume **34** to act as a very efficient refrigerating chamber which can be operated by the assistance of the regenerator numeral **4** at any temperature from 20° Kelvin and warmer. It will be understood that the displacer member **8** may be furnished with sealing rings such as **43** and **45** and the displacer in the volume **32** may come into contact with a seating member **47**. It should also be understood that if desired the invention may be practiced in other forms as, for example, by utilizing two or more stages and various other changes and modifications may be resorted to within the scope of the appended claims.

I claim:

1. A fluid control device comprising a fluid containing enclosure body, a fixed fluid conducting member secured at one side of the enclosure body, a movable fluid programming element supported in contact with the fixed fluid conducting member, a pressure head member for encasing the movable fluid programming element to define a space into which high pressure fluid may be continuously supplied to constantly force the programming element against the fixed fluid conducting member, power driving means mounted in the pressure head member for rotating the fluid programming device in a predetermined manner, and means for continuously supplying compressed fluid to said pressure head member.

2. A structure as defined in claim **1** in which the movable programming element cooperates with the fixed fluid conducting member to deliver and release fluid to and from a plurality of chambers in the enclosure body.

3. A structure as defined in claim **1** in which the fixed conducting member and the movable programming element are formed with cooperating ducts so arranged that during a part of the rotation of the programming element fluid is admitted to three volumes in the enclosure body and during another part of the rotation of the programming element fluid is exhausted from the said volumes.

4. A fluid control device for a refrigeration apparatus comprising a fluid containing enclosure body which consists of a cylinder and regenerator housing, a fixed fluid conducting member secured at one side of the enclosure body, a movable fluid programming element supported in contact with the fixed fluid conducting member, a pressure head member for encasing the movable programming element to define a space into which high pressure fluid may be supplied to constantly force the programming element against the fixed fluid conducting member, power driving means mounted in the pressure head for rotating the fluid programming device in a predetermined

manner, means for continuously supplying compressed fluid to said pressure head member, a free displacer mounted in the cylinder of the enclosure body and cooperating with the enclosure body and the fixed fluid conducting member to define three volumes variable with change in position of the displacer in response to fluid pressure.

5. A structure according to claim **4** in which the programming element delivers high pressure fluid to the volumes in the enclosure body in a sequence such that pressure increases and decreases in the three volumes to produce net heating in two of the volumes and cooling in the third volume.

6. A structure according to claim **4** in which the fixed fluid conducting member is formed with two ports communicating with each of the three volumes and a third exhaust port, said programming element being formed along its contacting face with circular ducts and being further formed with openings communicating with the ducts for introducing high pressure fluid through the ducts to the said ports in one position of rotation of the programming element.

7. A structure according to claim **4** in which the fixed fluid conducting element is formed with two ports, one of which communicates with a first volume and the other of which communicates with second and third volumes, an intermediate part of the fixed fluid conducting member being recessed to provide an exhaust port, said programming element being formed along its contacting face with a set of inlet ducts, a set of outlet ducts, and entranceway means communicating with the inlet ducts for introducing high pressure fluid through the inlet ducts to the said ports in two different positions of rotation of programming element whereby in a starting position of the programming device and during the first 45° arc of rotation thereof high pressure fluid is admitted to the said first volume and the displacer is moved downwardly, and during a second 45° arc of rotation of the programming device high pressure fluid is introduced into the second and third volumes while maintaining high pressure in the first volume, and during the third 45° arc of rotation high pressure fluid is exhausted from the said first volume causing the displacer to move upwardly thus causing high pressure gas to be transferred from the second volume through the regenerator to the third volume at constant high pressure, and during the fourth 45° arc of rotation of the programming device fluid in the third volume is caused to expand and moves outwardly through the regenerator into said outlet ducts of the programming device to the discharge exhaust port thereby producing refrigeration in the third volume.

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WILLIAM J. WYE, *Primary Examiner.*