Oct. 29, 1963 H. R. NILSSON ETAL 3,108,739

REGULATING MEANS FOR ROTARY PISTON COMPRESSOR

Filed June 17, 1960 2 Sheets-Sheet 1

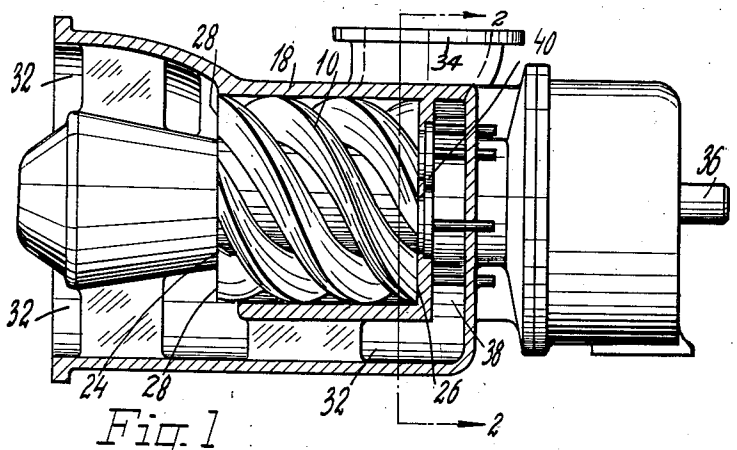


Fig. 1

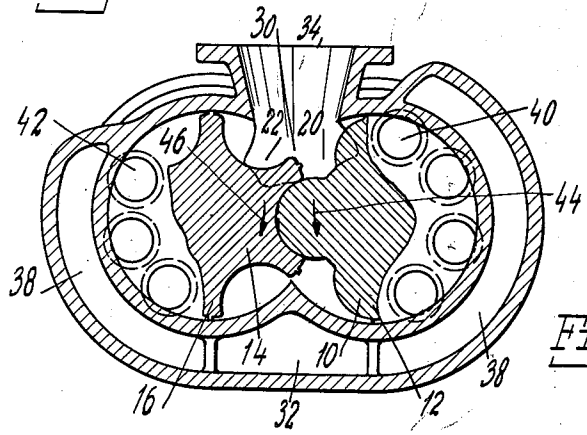
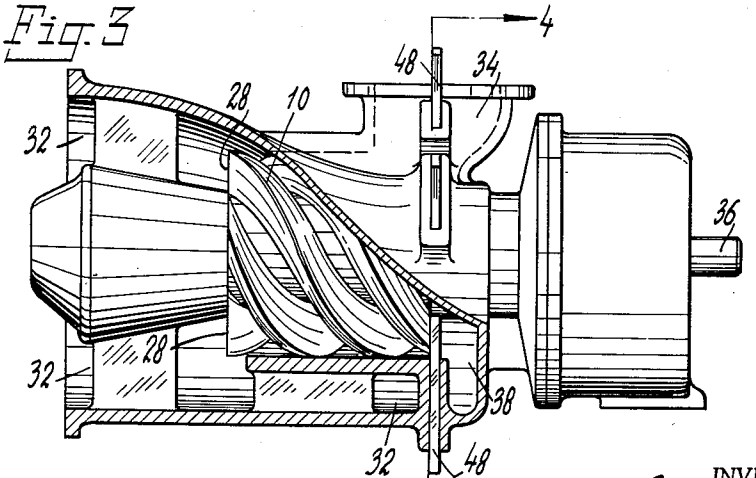


Fig. 2

Fig. 3



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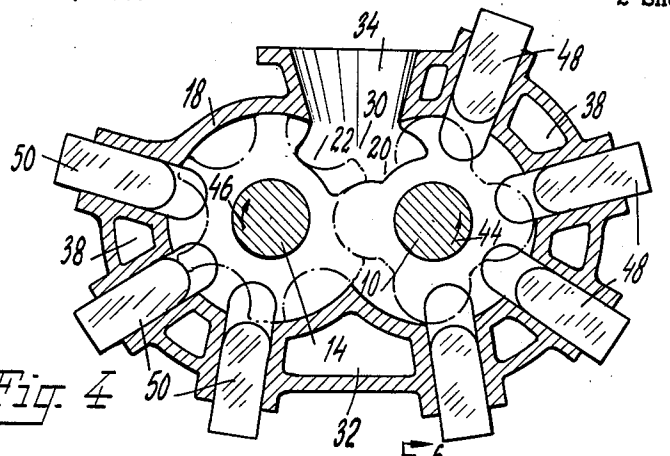


Fig. 4

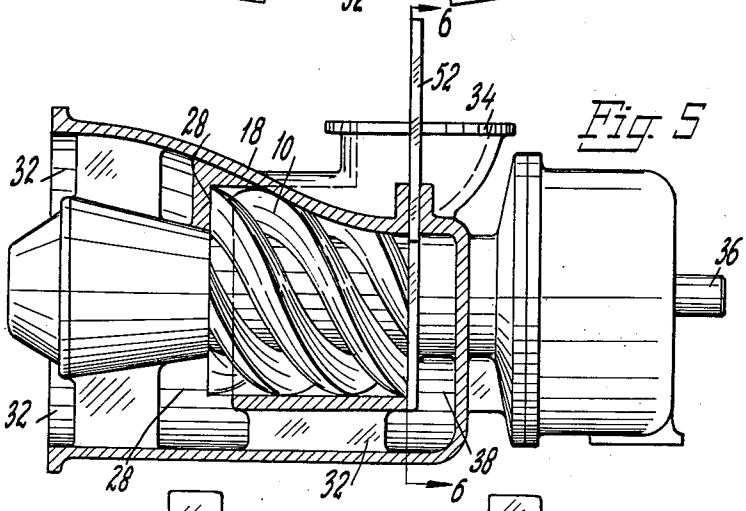


Fig. 5

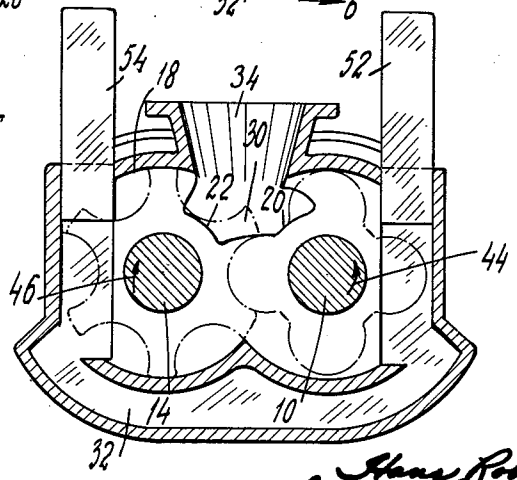


Fig. 6

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United States Patent Office 3,108,739 Patented Oct. 29, 1963

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REGULATING MEANS FOR ROTARY PISTON COMPRESSOR

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Filed June 17, 1960, Ser. No. 36,764
13 Claims. (Cl. 230—138)

The present invention relates to rotary piston, positive displacement compressors for compressing elastic fluids, and has particular reference to that type of such compressors disclosed in Nilsson, U.S. Patent No. 2,622,787, granted December 23, 1952.

Basically it is characteristic of such compressors that compression chambers are formed by the intermeshing action of the helical lands and grooves of male and female rotors mounted to rotate about coplanar axes in an appropriate housing structure, with the lands of the male rotor lying substantially outside of the pitch circle of the rotor and having a wrap angle of less than one full turn or less than 360°, while the lands of the female rotor likewise have a wrap angle of less than one full turn, lie substantially within the pitch circle of the female rotor.

It is further basically characteristic of such compressors that chevron shaped compression chambers are formed by communicating groove portions of the cooperating rotors and the confronting wall portion of the housing structure, the base ends of such chambers being defined by a fixed transverse plane, usually coincident with the high pressure end wall of the housing structure, and the apex ends being defined by the place of intermesh between the rotors, which moves axially away from the inlet ends of the rotors towards said fixed plane to cause the chambers to run out to minimum volume at said plane as the rotors revolve. The fixed plane is located at a place axially spaced from the inlet ends of the rotors where the high pressure or discharge port of the compressor is situated, the port being substantially confined to one side of the plane of the rotor axes, which may conveniently be designated the high pressure side of the compressor.

Similarly, it is basically characteristic of such compressors that on the opposite or low pressure side of the compressor, where the low pressure or inlet port of the compressor communicates with the inlet ends of the rotors, chevron shaped suction chambers are formed between rotor groove portions and confronting housing structure, which chambers expand from minimum volume when the places of intermesh defining the apex ends of the chambers are at the inlet ends of the rotors to maximum volume when the places of intermesh have moved axially away from the inlet ends of the rotors to the aforesaid fixed plane and the groove portions forming the chambers have moved out of communication with each other as the rotors revolve.

Compressors of the kind generally described above have been and are being utilized extensively in various fields of commercial application, including many fields in which part load or part capacity operation over extended periods of time is highly desirable. Operation at partial capacity is of course readily accomplished through the simple expedient of throttling the intake of the compressor, but this kind of regulation entails throttling losses with consequent loss of efficiency which makes such a kind of control undesirable for those applications where part load operation may constitute a substantial portion of the total time of operation.

In order to provide for more efficient operation at partial capacity of compressors of the helical rotor type, than can be accomplished simply by throttling the intake, various forms of valve devices have heretofore been proposed, none of which, however, have proved to be wholly satisfactory from all standpoints even though effecting some improvement in efficiency. Thus for example, capacity control valves of the kind disclosed in Lysholm, U.S. Patent No. 2,459,709, granted January 18, 1949, which are interposed between stationary housing parts and the peripheries of the moving rotors, involve difficulties of a mechanical nature such as the initial establishment of and the maintaining of the very exact clearances which are critical to the efficient operation of the machine and also require the presence of a lubricant between surfaces in direct communication with the compression chambers, a condition that could not be tolerated for some uses (in the chemical industry, for example) of so-called "dry" compressors.

Other prior proposals have, for similar and other reasons, proved to be less than wholly satisfactory and it is therefore the principal and general object of the present invention to provide new and improved regulating means for controlling the operation of compressors of the kind under consideration in a way which will enable them to be operated efficiently at variable part loads down to a relative small fraction of full load or full capacity. It is a further object to accomplish such regulation by valve means which introduce no throttling effects and losses, and which moreover are not only simple in mechanical construction but also of such nature that critical clearances between stationary and rotating parts are easily established initially and readily maintained over long periods of use.

Other and more detailed objects of the invention will become apparent as the ensuing description of suitable embodiments of apparatus for carrying the invention into effect proceeds, with reference to the accompanying drawings, in which;

FIG. 1 is a longitudinal section, partly in elevation, of a suitable embodiment of apparatus for carrying the invention into effect;

FIG. 2 is a section taken on the line 2—2 of FIG. 1;

FIG. 3 is a view similar to FIG. 1 of another embodiment of apparatus embodying the invention;

FIG. 4 is a section taken on the line 4—4 of FIG. 3;

FIG. 5 is a side elevation partly in section of still another embodiment of the invention; and

FIG. 6 is a section taken on the line 6—6 of FIG. 5.

Referring now to the drawings, and more particularly to FIGS. 1 and 2 thereof, the compressor comprises a stationary housing structure **18** having a barrel portion providing a working space composed of two intersecting cylindrical bores **20** and **22** with coplanar axes which in the embodiment illustrated are parallel. The housing structure is further provided with portions forming end walls **24** and **26** defining the axial length of the working space. A male rotor **10** provided with helical lands **12** is rotatably mounted in bore **20**, and a female rotor **14** likewise provided with helical lands **16** is rotatably mounted in bore **22** with the lands of the two rotors in intermeshing engagement. As shown, the lands and grooves of the rotors have a wrap angle of less than one full turn (less than 360°), the lands of the female rotor lying substantially entirely within the pitch circle of the rotor while the pitch circle of the male rotor lies substantially at the root circle of the lands of the rotor. Also the lands of the male rotor are convexly curved and of substantially circular profile, while the lands of the female rotor are correspondingly concave, as shown, the construction being advantageously as disclosed in Nilsson, U.S. Patent No. 2,622,787, granted December 23, 1952.

The housing structure provides a low pressure inlet channel **32** terminating in an axial inlet port **28** and further provides an outlet or discharge port **30** delivering to the discharge channel **34**. Port **30** is located at the

plane of the high pressure end wall 26 and is confined to one side of the plane through the axes of the rotors, which side may conveniently be referred to as the high pressure side of the compressor.

The compressor is driven by means of a power input shaft 36, conveniently driving the male rotor, and the rotors may be connected by timing gears so that the female rotor is driven in synchronized relation to the male rotor, such gears not being shown but being conveniently located in a gear housing appearing at the right of FIG. 1.

A part of the inlet channel 32 extends along the bottom of the compressor past the barrel portion of the housing to communicate with a valve chamber 38 located beyond hte high pressure end wall 26. Two series of separate valve means 40 and 42 are provided in the high pressure end wall to provide selective communication between the working space formed by the bores in the barrel portion of the housing and the valve chamber 38. As will be seen from the figures these valve means are of the poppet valve type opening outwardly from the working space into the valve chamber and as will be observed particularly from FIG. 2 the valve ports for the several valve means are located in spaced relation peripherally around the axes of the two rotors at radial distances therefrom corresponding to the radial distances of the grooves of the respective rotors from their axes. For reasons which will later become more clear, these valve means are hereinafter referred to as bleed valve means.

The operation of the apparatus, in accordance with the principles of the invention is as follows, it being assumed that the rotors are rotated in the directions indicated by the arrows 44 and 46 in FIG. 2. As the rotors revolve in the directions indicated, the suction chambers are formed at the bottom or low pressure side of the compressor, being initiated at zero volume at the plane of the low pressure end wall 24 and expanding in chevron shaped formation as the places of intermesh between the rotors move from the low pressure wall 24 to the high pressure wall 26. At the latter wall the communicating groove portions forming each such chamber pass out of communication with each other and the peripheral extent of the inlet port 28 is such that during the entire inlet phase of the cycle the chambers are in communication with the inlet port, so that when the grooves pass out of communication with each other they are completely filled to full capacity with working fluid. The grooves, thus filled to capacity with working fluid at inlet pressure, continue to turn until places of intermesh between grooves are established on the high pressure side of the compressor at the inlet end thereof to form the high pressure compression chambers which diminish in volume progressively as the places of intermesh move axially from the inlet to the outlet end of the compressor.

If, at the time of intermesh to form the compression chambers and during the compression portion of the cycle following that time, the valves constituting the bleed valve means are all closed, then the full quantity of fluid inducted into the compressor will be compressed and ejected through the discharge port. Under such conditions the compressor will operate at full capacity.

If, on the other hand, one or more of the bleed valves is open at the time when any given compression chamber is formed, further rotation of the rotors following that time, instead of resulting in compression in that chamber, will result in rejection of a portion of the previously inducted fluid through the open valve ports in the high pressure end wall and the return of that rejected fluid to a low pressure zone which in the examples shown constitutes the inlet passage of the compressor. Such rejection of previously inducted fluid will continue until the ends of the grooves forming the chamber pass out of registry with which ever ones of the bleed ports that are open. When that occurs, actual compression in the chamber is initiated and continues until the compression chamber comes into communication with and discharges through the high pressure discharge port.

Thus it will be seen that in accordance with the principles of the present invention, control of the capacity of the compressor is effected by means which involves no throttling or other restriction of the flow of the working fluid, with consequent elimination of losses occasioned by that kind of operation, but effects the desired control by freely admitting working fluid up to the full capacity of the compressor and thereafter freely rejecting a portion of that fluid from the compressor before work is expended thereon in compressing it. It will thus be evident that the control is effected efficiently even down to small fractional capacities.

As will be more or less evident from FIG. 2, the type of regulation which will be effected by this embodiment of the apparatus is of the step-by-step type rather than by continuously variable control. The reason for this is of course that the ends of the grooves forming the compression chambers pass out of registry in step-by-step fashion with the several ports which control the degree of reduction in the capacity of the compressor that is being effected. It is further to be noted in connection with FIG. 2 that the ports of the valve 40 cooperating with the male rotor are spaced apart peripherally further than are the ports 42 cooperating with the female rotor. The reason for this is that in the embodiment illustrated the male rotor is provided with four lands while the female rotor is provided with six. Consequently, the female rotor turns at only two-thirds the speed of the male rotor and the spacing of the valve ports as shown is required if the same timing relation is to be maintained between the ports and the grooves for each rotor. Also, since each compression chamber is formed of two communicating groove portions, one in each rotor, it will be evident that the bleeding of each compression chamber can be adequately effected by one set of bleed valve ports cooperating with one of the rotors. However, in order to provide the most unrestricted flow it is advantageous to use two series of such valve means in the form as illustrated.

Since in the embodiment illustrated the area of the exhaust port is constant, it follows that the volumes of the compression chambers will be constant at the time when they come into registry with the exhaust or discharge port. Since the capacity regulation effected in accordance with the present invention results in differing compression chamber volumes at the times when actual compression commences, it will be evident that in the structure illustrated, regulation of the capacity of the compressor will also result in a variation in the compression ratio effected. If it is desired to maintain a constant compression ratio at all capacities, or to effect other desired variations in the compression ratio, these results may readily be obtained by other means well known in the art which form no part of the present invention.

FIGS. 3 and 4 illustrate another embodiment of apparatus which in general is similar to and functions to give the same kind of regulation as the embodiment illustrated in FIGS. 1 and 2. The only essential difference in the present embodiment is the use of radially movable slide valves 48 and 50, instead of the poppet type valves shown in FIG. 1. In both of these embodiments, the faces of the valves are in sealing proximity to the end faces of the rotors, with appropriate running clearances between the parts.

FIGS. 5 and 6 illustrate a further embodiment of apparatus employing slide valves 52 and 54 similar to the slide valves 48 and 50 of the modification shown in FIG. 4 but with these valves arranged differently so as to provide for progressive regulation rather than step-by-step regulation of the kind effected by the arrangement shown in FIG. 4.

In the present arrangement only one bleed valve is pro-

vided for cooperation with each rotor, these valves being arranged to move generally tangentially with respect to the axes of the respective rotors, and controlling valve ports each of which communicates with the inlet passage 32 of the compressor. It is believed mere inspection of FIG. 6 of the drawings will be sufficient to make it apparent how the progressive regulation is effected by these valves rather than the step-by-step regulation which is effected by separate valves operating to control separate spaced apart valve ports that are passed successively by the grooves forming the compression chambers.

From the foregoing it will be evident that the principles of the invention may be carried into effect with numerous different specific forms of apparatus operating in different fashions to provide either step-by-step or continuous progressive regulation. It is accordingly to be understood that the invention is not to be considered as being limited to the forms of apparatus herein before described by way of illustration, but is to be considered as embracing all forms of apparatus falling within the scope of the appended claims.

We claim:

1. A rotary piston, positive displacement, elastic fluid compressor comprising a housing structure providing a barrel portion having intersecting bores with coplanar axes and a high pressure end wall and further providing a high pressure discharge port at said end wall, at least the major part of said port being located on one side of the plane of said axes constituting the high pressure side of the compressor and an inlet communicating with the ends of said bores remote from said high pressure end wall, male and female rotors provided with intermeshing helical lands and grooves having an effective wrap angle of less than 360° rotatably mounted in said bores and operative to sequentially form with the confronting portion of the housing structure on the low pressure side of said plane a series of chevron shaped suction chambers expanding from minimum volume at the inlet ends of the rotors to maximum volume as the places of intermesh forming the apexes of said chambers move axially away from said inlet ends as the rotors revolve until the lands and grooves move out of mesh at said high pressure end wall, said lands and grooves subsequently intermeshing at the inlet ends of the rotors on said high pressure side as the rotors revolve to sequentially form with the confronting portion of the housing structure a series of chevron shaped compression chambers running out to minimum volume at said high pressure end wall as the places of intermesh forming the apexes of said compression chambers move axially away from the inlet ends of the rotors to said high pressure end wall, and regulating means for bleeding said grooves to a low pressure zone to control the capacity of the compressor comprising bleed port means in said high pressure end wall, said port means being located to register with each of the grooves of at least one of said rotors in positions of the groove out of communication with said discharge port from the position at which the compression chamber of which the groove forms a part is at maximum volume to a position at which the volume of the last mentioned chamber has been reduced to the extent required to effect the desired regulation and bleed valve means capable of selective adjustment during operation of the compressor to close said port means to determine the volumes of said compression chambers when compression is initiated therein to thereby regulate the capacity of the compressor.

2. A compressor as defined in claim 1 including conduit means for conducting fluid bled through said ports to said zone of low pressure.

3. A compressor as defined in claim 2 in which said conduit means delivers the bled fluid to the inlet of the compressor.

4. A compressor as defined in claim 1 in which said regulating means comprises a rectilinearly movable bleed valve member for controlling each bleed port.

5. A compressor as defined in claim 4 in which each said valve member is of the poppet type.

6. A compressor as defined in claim 5 in which said port means comprises a plurality of ports spaced peripherally about the axis of at least one of said rotors.

7. A compressor as defined in claim 6 in which said port means comprises a plurality of ports spaced peripherally about the axes of both said rotors.

8. A compressor as defined in claim 4 in which each said valve member is of the slide valve type.

9. A compressor as defined in claim 8 in which each said valve member is movable generally radially with respect to the axis of the associated rotor.

10. A compressor as defined in claim 9 in which said port means comprises a plurality of ports spaced peripherally about the axis of at least one of said rotors.

11. A compressor as defined in claim 9 in which said port means comprises a plurality of ports spaced peripherally about the axes of both of said rotors.

12. A compressor as defined in claim 1 in which said regulating means comprises a bleed port extending generally tangentially with respect to at least one of said rotors and a sliding type bleed valve member movable generally tangentially to provide progressive regulation of the volumes of said compression chambers when compression therein is initiated.

13. A compressor as defined in claim 12 in which said regulating means comprises a bleed port and cooperating valve member for each rotor.

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