

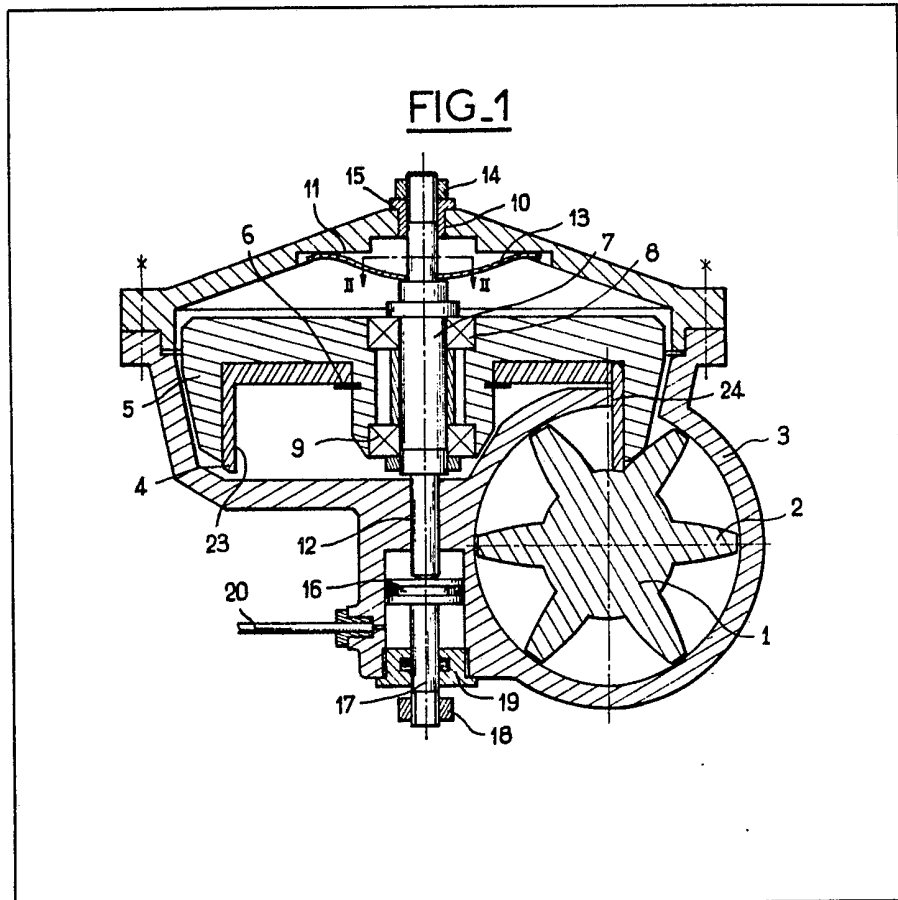
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(54) **Regulating the delivery of single-screw compressors and expanders**

(57) To regulate the delivery of compressors and expansion machines of the type constituted by a screw 1 having a plurality of threads 2, at least one pinion 4 provided with teeth in cooperating relation with the threads,

and a casing 3 which surrounds the screw at least to a partial extent and is provided with a passage for the pinion teeth, at least one low-pressure port and at least one high-pressure port, the pinion is displaced from its work position in a direction substantially parallel to the axis of rotation of the pinion by e.g. a piston 16.



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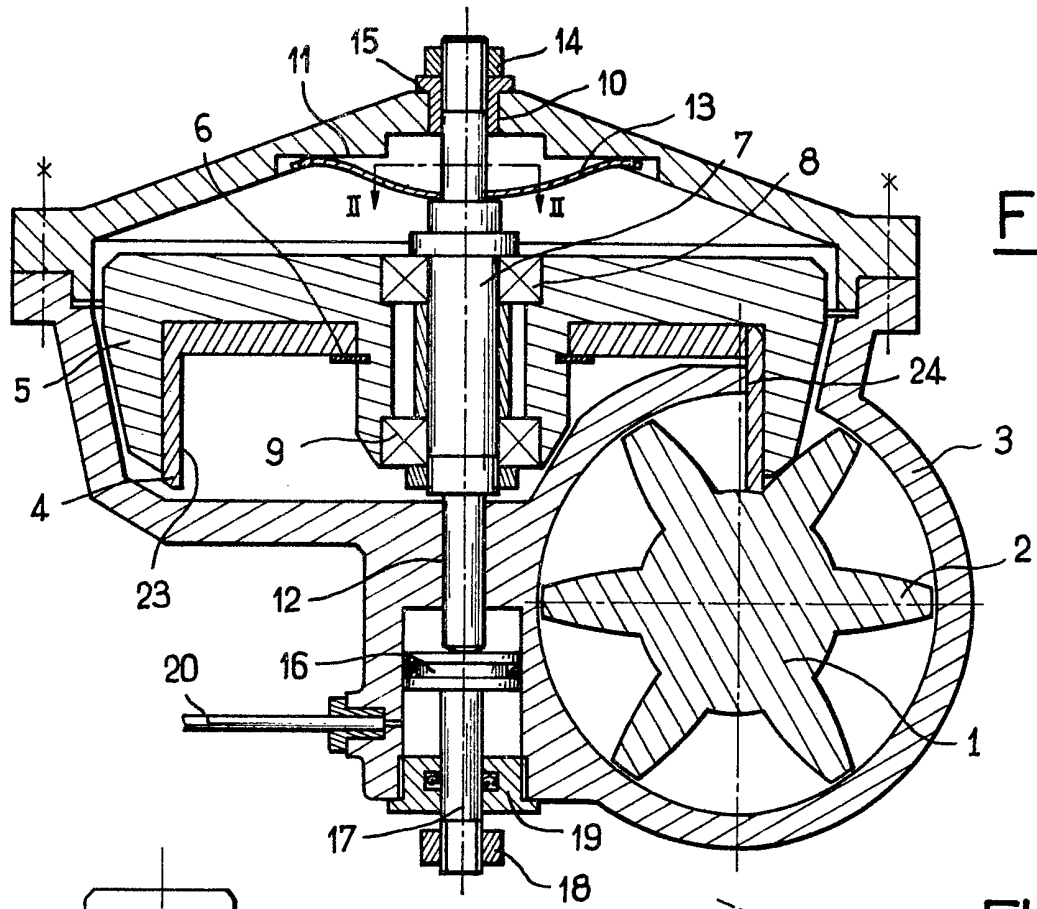


FIG. 1

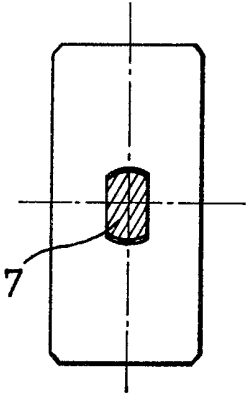


FIG. 2

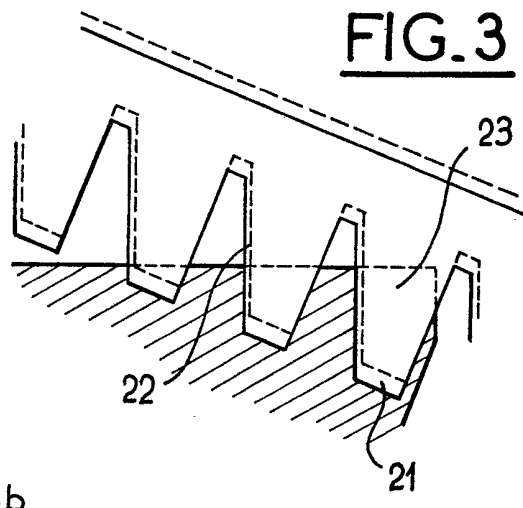


FIG. 3

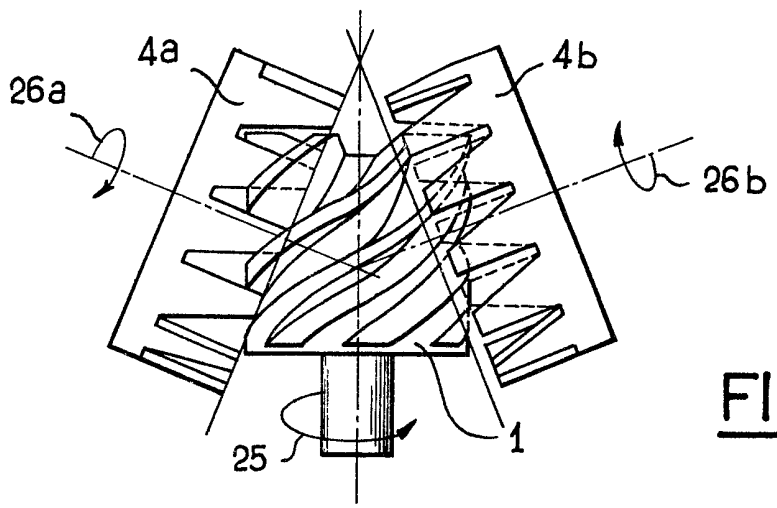


FIG. 4

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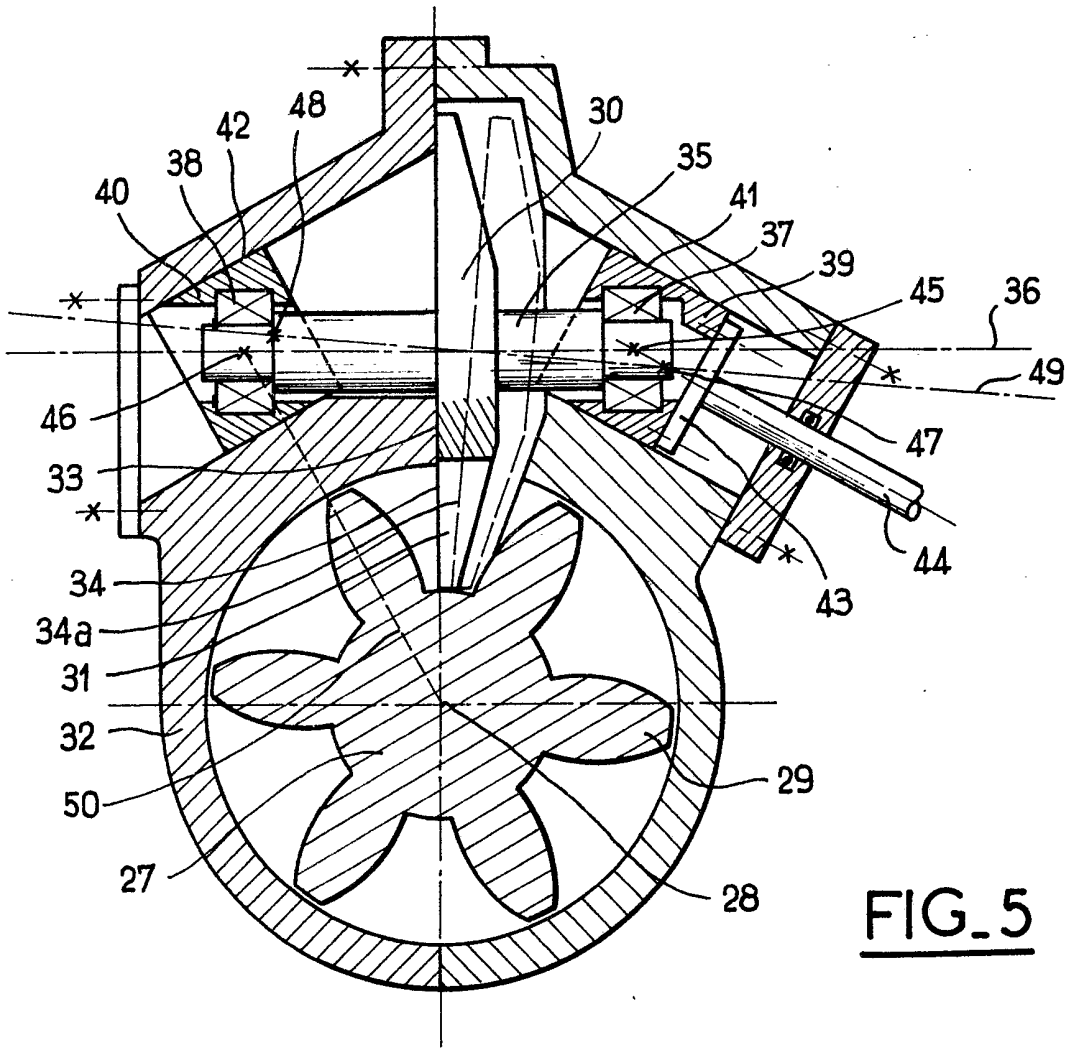


FIG. 5

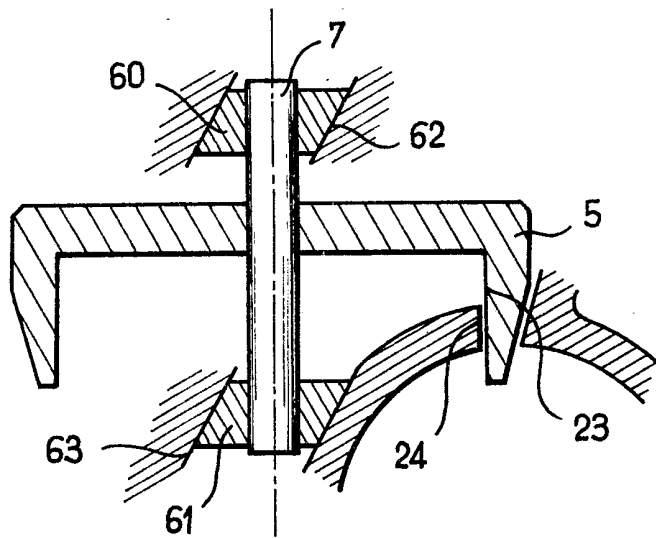


FIG. 6

SPECIFICATION

A method for regulating the delivery of screw compressors and a device for the application of said method

5 This invention relates to a method for regulating the delivery of screw compressors and is also concerned with a device for the practical application of said method.

10 It is a known practice to regulate screw compressors and especially single-screw compressors of the type described, for example, in French patents No. 1,331,998 and No. 1,586,832, either by throttling the flow at the intake or by varying the swept volume. Design solutions having been described in particular in French patent Applications No. 74 27132, No. 75 01187, No. 76 25431.

15 The disadvantage of these solutions, however, lies in the fact that they either prove costly when it is necessary; for example, to make provision within the casing for two continuous-motion slides as described in French patent Application No. 76 25431, or have low efficiency when the design is simple, as is the case with the method of regulation by throttling the intake, particularly at low deliveries.

20 The aim of the present invention is to provide a method of regulation which makes it possible to retain high efficiency while employing flexible and economical equipment.

30 In accordance with the invention, the method is intended to regulate the delivery of compressors and expansion machines of the type constituted by a screw provided with a plurality of threads, at least one pinion provided with teeth in cooperating relation with said threads, a casing which surrounds said screw at least to a partial extent and is provided with a passage for the teeth of said pinion, at least one low-pressure port and at least one high-pressure port provided within the casing. The invention is distinguished by the fact that, in order to stop the flow produced by a pinion, the pinion is displaced from its work position in a direction substantially parallel to the axis of rotation of said pinion.

45 By displacing the pinion from its work position, there is in fact created a leakage flow which is higher as the clearance is greater, thus resulting in a corresponding reduction of the discharge flow rate in the case of a compressor. By displacing the pinion to a sufficient extent, compression can be completely stopped in the case of a compressor or expansion can be completely stopped in the case of an expansion unit; provision must accordingly be made for auxiliary stopping means in the high-pressure duct (such as a non-return valve, for example, in the case of a compressor) in order to stop the flow of fluid between the high-pressure side and the low-pressure side.

60 The practical application of this method is particularly straightforward as will become apparent from the following description. The method has the further advantage, however, of eliminating the greater part of the passive losses

65 which are usually associated with other regulating devices.

70 In the case of compressors to which reference will essentially be made, the power consumption is sufficiently low in this case to be dissipated by the casing and this makes it possible to stop any injection of oil into the compressor for cooling purposes. In conventional devices, it is necessary to maintain oil injection and consequently to leave the exhaust port of the compressor at high pressure, which in turn results in substantial power losses.

75 By applying the method in accordance with the invention, it has been found that power consumptions at zero delivery were less than 20% of the power at full load, which is beyond the bounds of feasibility in the majority of known designs employed in conventional practice.

80 Another feature which is adopted in preferred alternative designs lies in the fact that single-screw compressors are mostly constituted by a screw in cooperating relation with two pinions, thus forming two compressors in parallel which are intended to produce partial deliveries by initiating upward displacement of only one of the two pinions.

90 If the two half-compressors have the same swept volume, it is possible to produce a transition from 100% delivery to 50% delivery by lifting one pinion and then to 0% delivery by lifting the second pinion.

95 On the contrary, if the two half-compressors are so designed as to have different swept volumes having a value in one case which is twice the value of the other, for example, it is possible by effecting alternate upward displacement of the pinions to produce partial deliveries of 66 and 33%, for example. Finally, this mode of regulation by upward displacement of the pinion can be combined with known regulating devices. Thus, by combining the use of upward pinion displacement with the mode of regulation which consists in throttling the intake, this mode of operation is employed within the range of 100 to 50% in which it remains relatively efficient from a power consumption standpoint, whereupon the pinion is lifted so as to suppress the throttling action, this action being again employed over the range of 50 to 0% with a single pinion in the work position.

100 Provision can also be made for a known regulating device of the type described for example in U.S. patent No. 3,108,739 or in French patent Application No. 76 25431 by placing said device in only one of the two half-compressors and employing the device throughout the range of 100 to 50% with both pinions disposed in meshing engagement, then within the range of 50 to 0% by initiating upward displacement of the pinion of the half-compressor which is not provided with the device.

115 A more complete understanding of the present invention will be gained from the accompanying drawings which are given by way of example and not in any limiting sense, and in which:

120 —Fig. 1 is a sectional view of a pinion having

cylindrical teeth in accordance with the arrangements disclosed in French patent No. 1,586,832 and showing a pinion-displacement device;

5 —Fig. 2 is a sectional view taken along line II—II of Fig. 1;

—Fig. 3 is a diagrammatic sectional view of a screw along the contact surface between screw and pinion;

10 —Fig. 4 is a view in elevation showing a screw in cooperating relation with two substantially symmetrical pinions similar to those in section in Fig. 1;

15 —Fig. 5 is a sectional view of a pinion having flat teeth in accordance with French patent No. 1,331,998 and shows a device for producing relative displacement of the pinion;

20 —Fig. 6 is a diagrammatic sectional view of a device which is similar to that of Fig. 1 and shows another mode of displacement of the pinion.

Referring now to Fig. 1, a compressor in accordance with French patent No. 1,486,832 is constituted by a screw 1 provided with threads 2 and rotatably mounted within a casing 3, said screw being disposed in meshing engagement with a pinion constituted in accordance with the teachings of French patent No. 2,148,677 by a plastic pinion 4 placed within a metallic support 5 and maintained in position by means of a circlip 6, the two parts being secured angularly by means of a stud (not shown).

30 The pinion 5 is mounted to rotate freely on a shaft 7 by means of bearings 8 and 9. The shaft 7 does not rotate but is capable of sliding freely within two bores: the bore 10 is formed in a cap 11 which is fixed on the casing 3 by means of screws and the bore 12 is formed within the casing 3.

40 In the normal operating position or in other words in the compression position, a spring 13 maintains the nut 14 applied against the cap 11 by means of a washer 15.

45 In the sectional view shown in Fig. 2 and taken along line II—II of Fig. 1, it is apparent that the shaft 7 is provided with two milled flat portions which pass through a cut-out portion of the spring and prevent rotation of the shaft.

50 Fig. 3 shows in full lines a cross-section of the screw 1 along the surface of cooperation with the flanks of the teeth and the position of the teeth of the pinion 4 when the nut 14 is applied against the washer 15. The threads are then completely closed-off by the teeth and compression accordingly takes place.

55 It can be readily understood that the casing is provided with at least one low-pressure port for the suction and at least one high-pressure port for the discharge, the arrangement of these latter having already been disclosed in the patents cited earlier. Sain ports have therefore not been illustrated or described since this would make no useful contribution to the present invention.

60 A piston 16 (shown in Fig. 1) provided with a piston-rod 17 on which is fixed an adjusting nut 18 is slidably mounted within a plug 19; an

admission of compressed fluid is provided by means of a pipe 20.

70 When compressed fluid such as air, for example, is passed through the pipe 20, this causes displacement of the piston 16 which in turn initiates displacement of the shaft 7 and compresses the spring 13 until the nut 18 comes into abutment with the plug 19. The pinion and pinion-teeth then take up a position shown in dashed lines in Fig. 3, thus freeing clearance spaces 21 and 22 of substantial volume through which the compressed gas escapes.

75 It will be noted that, in the arrangement given by way of example, the face 23 is the tooth face which is exposed to the high pressure and that said face is disposed on a cylinder, with the result that it always remains in contact with the surface 24 having a cylindrical external contour which is disposed on the casing.

80 This distinctive feature is not essential, however, and provision could be made for a different type of surface 23 such as, for example, a cone which would then move away from the corresponding surface of the casing at the moment of upward displacement. One example will in any case be presented with reference to Fig. 5 in which the tooth surface exposed to the pressure lies on a plane.

85 It is possible to vary the clearances 21 and 22 by displacing the shaft 7 to a greater or lesser extent; this can be obtained, for example, by applying a pressure of more or less high value through the pipe 20.

90 The leakage flow through the clearance spaces 21 and 22 consequently varies and in turn produces a variation in the delivery of the compressor.

95 This possibility of continuous variation in delivery can readily be applied in practice but offers a very low degree of efficiency. For this reason it is preferable to operate on the all-or-none principle or in other words to leave the pinion in the work position or to effect a positive upward displacement of the pinion over an appreciable distance as shown in Fig. 3, with the result that compression no longer takes place.

100 It is in fact an easy matter to carry out displacements which free sufficient sections to ensure that the rate of gas flow through these sections decreases to values below 30 or 40 meters per second.

105 It will be assumed by way of example that the screw of a typical compressor has a diameter of 125 millimeters and cooperates with two cylindrical pinions which have a diameter of approximately 160 millimeters and rotate at 3000 rpm, that the pinion teeth penetrate within the screw to a depth of approximately 40 millimeters and that the compressor sweeps approximately 1600 liters at 3000 rpm. Thus, even when heavy gases are employed such as halogenated cold-producing gases, a pinion lift of 5 millimeters ensures velocities of this order which practically eliminate any pressure rise within the threads and therefore any significant

compression energy consumption.

In order to prevent communication between the high pressure and the low pressure, it accordingly proves necessary to close-off one of the pipes
5 which connects them through the compressor, for example by placing a non-return valve on the discharge side of the compressor.

Similarly, if the compressor is provided with an injection of auxiliary liquid and is constituted by
10 one screw and a single pinion or, in the case of a screw with two pinions, if both pinions are lifted simultaneously, it proves necessary to cut-off the injection of liquid during upward displacement of the pinion.

One remarkable and noteworthy result in this connection is that the power dissipated in the upwardly displaced position of the pinion is of such low value that the compressor can continue to rotate without thereby entailing any need to
20 cool this latter by continued injection of liquid.

In a compressor of the type under consideration in which an air pressure of 7 bar is developed and in which provision is made for two symmetrical pinions, the power in the upwardly displaced position of the pinions is less than 20% of the power at full load and is established in the vicinity of 10%.

The corresponding heat can be removed through the casing, this being achieved if
30 necessary by providing the casing with suitable ventilating means and cooling fins.

It is desirable, however, to maintain within the casing a certain quantity of liquid for ensuring heat distribution and lubrication of contacts. This
35 quantity can be obtained by delaying interruption of the injection with respect to upward displacement of the pinions by means of a timing system or, more simply, by providing an enclosure between the shut-off valve and the compressor.

Since the liquid is usually charged with bubbles of gas under pressure and has a tendency to expand when stationary, the greater part of the volume contained in the enclosure is again present within the compressor.

In the final analysis, the result of the method in accordance with the present invention is very remarkable since it is usually necessary to maintain the injection in screw-type compressors even when these latter rotate with zero delivery in
45 order to ensure removal of heat by the liquid supplied. In order to recover this liquid, however, it accordingly proves necessary to maintain an open connection between the discharge side of the compressor and the pressurized reservoir, thus
50 resulting in a high work output of the compressor and consequently in low power efficiencies.

This arrangement is particularly advantageous in compressors for air brakes and in fact makes it possible to dispense with the radiator which is
60 usually provided for dissipating the heat produced by the compression.

In fact, since the periods of operation of the compressor at full load or at partial load are short, the thermal inertia of the injection liquid such as
65 oil for example is sufficient to prevent an excessive

increase in this temperature. Said increase is also dissipated by radiation or convection from the oil storage reservoir during the long periods in which the compressor rotates without injection.

This cooling action would not take place if an oil injection were to be continuously maintained.

All the disadvantages mentioned in the foregoing are removed by means of the present invention.

It is even possible to obtain still more remarkable results when the present invention is employed in compressors or expansion machines so designed that the screw cooperates with two more or less symmetrical pinions as shown
75 diagrammatically in Fig. 4. A compressor of this type is in fact constituted by two half-compressors or expansion machines which operate in parallel and are similar to the unit shown in Fig. 1, the pinion 4b is shown in the upwardly displaced position. The arrows 25, 26a and 26b show the directions of rotation of the screw and of the pinions 4a and 4b when the device is employed as a compressor. Since each pinion 4a and 4b is provided with a device of the type described with
80 reference to Fig. 1, it is accordingly possible in the first place to initiate upward displacement of the pinion 4a, which has the effect of reducing the delivery to a value corresponding substantially to one-half the normal delivery, then to initiate
85 upward displacement of the pinion 4b, which accordingly reduces the delivery to zero. A step-by-step regulation is thus achieved with delivery values of 100%, 50%, 0%.

It will be noted that, if the compressor is provided with one injection of liquid per pinion, the injection corresponding to the pinion 4a can be cut-off when this latter is lifted although this is not essential since the injected liquid is restored to high pressure by the pinion 4b. On the other hand,
100 it is necessary to stop any injection when the pinion 4b is also lifted.

This method can also be employed in order to obtain a three-level regulation by making arrangements to ensure that the volumes swept by each pinion around the screw are swept in a non-symmetrical manner or by reducing that portion of casing which cooperates with the thread crests in one of the two half-compressors which constitute this single-screw compressor.

For example, if the swept volumes are equal to 2 in the case of the pinion 4a and to 1 in the case of the pinion 4b, the delivery is substantially equal to 3 when the two pinions are engaged within the screw, to 2 if the pinion 4b is upwardly displaced while leaving the pinion 4a in position, to 1 if the pinion 4a is upwardly displaced while again engaging the pinion 4b, and to 0 when both pinions are upwardly displaced.

The possibility of regulation at three levels is thus provided as a result of alternate upward displacement and results in the following values of delivery: 100, 66, 33 and 0%.

It is even possible to combine this method of upward pinion displacement with conventional
130 regulating devices.

By way of example, the method can be used in conjunction with a regulation of delivery by throttling the flow at the intake, which is the conventional method employed in air compressors.

Though particularly simple, this method nevertheless entails high power consumption when employed alone as is especially the case with deliveries below 50%.

As long as the necessary delivery remains higher than 50%, the method accordingly consists in obtaining this latter by throttling of the intake. But when the delivery falls below 50%, the method then consists in opening the throttle or constriction, in producing upward displacement of one of the pinions and in adjusting the throttle to the desired value of delivery. This results in a very appreciable improvement in efficiencies below 50%. A value other than 50% can clearly be adopted as a value for determining upward displacement if the volumes swept by each pinion are not equal.

A further possibility lies in the use of the present invention in conjunction with the regulating devices of the type described in French patent Application No. 76 02173 or No. 76 25431. In accordance with the design principle of these devices, the delivery of the compressor is varied by displacing a segment of the casing in such a manner as to retard the point of closure of the threads and therefore the swept volume. It is possible in this case to provide regulation only on one half-compressor such as the half-compressor corresponding to the pinion 4a, for example, to produce a variation in delivery by varying said auxiliary means within the range of 100 to 55—60% (since these types of regulating device do not permit variation in one half-compressor throughout the entire range), then to initiate upward displacement of the pinion 4b by returning the regulating device to its initial position and thus producing a delivery of approximately 50% of the maximum value, then to perform the regulation within the range of 50% to 5—10%.

Instead of displacing a portion of the casing in a progressive and continuous manner, a simplified solution consists in placing within the casing at least one movable check-valve which forms a hole in the casing in contact with the thread crests and through which the gas escapes when it is displaced from its seating, thus having the effect of reducing the volume trapped within the threads and returning said gas to the suction side through suitable ducts. Valves of this type are described in U.S. patents No. 3,151,806 and No. 3,108,739 applied to twin-screw compressors.

In the present invention, it is only necessary to place one of the check-valves mentioned above within the zone of the casing which cooperates with the pinion 4a, for example. Thus the volume swept by the corresponding half-compressor falls to a value of one-half, for example, when the valve is lifted. By combining the lifting of the valve with the upward displacement of the pinion 4b, 100%, 75%, 50% and 25% deliveries are accordingly

obtained in a simple manner.

This number of operational steps usually proves sufficient to meet the majority of requirements in the regulation of cold-producing compressors while maintaining high thermodynamic efficiency in any one position.

There is shown in Fig. 1 an arrangement in which the pinion is in the compression position in the inoperative state. But, by reversing the action of the spring 13, by displacing the admission of compressed gas to the other face of the piston 16 and by rigidly fixing said piston to the shaft 7, it would be possible to carry out the operation in reverse. In other words, the pinion would be in the upwardly displaced position in the inoperative state and would be brought to the compression position only by admitting a pressure through the pipe 20.

If this modified arrangement is applied to the pinion 4b while retaining the arrangement of Fig. 1 in the case of the pinion 4a, this makes it possible to initiate the operation of a single-screw compressor in which only the half-compressor corresponding to the pinion 4a discharges under pressure and solely when the pressure is established so as to control the action of the other half-compressor corresponding to the pinion 4b by means of the pressure already developed in order to bring the compressor to full delivery. This makes it possible to reduce the current intensity at the time of start-up of the electric drive motor.

As can readily be understood, the upward displacement of the pinion can be controlled by mechanical, electric, hydraulic or other means without thereby modifying the scope of the invention.

A rather remarkable and noteworthy fact is that it has been possible to obtain the above-mentioned results in industrial service without any wear of the pinion and of the screw.

In fact, the slope along a tooth flank varies along the entire length of said flank in order to be paired with the slope of the screw threads which also varies according to the depth.

It is therefore apparent that, by displacing the pinion backwards over a distance which is not negligible (since it represents, in the numerical example given earlier, a displacement of more than 10% of the full height of tooth engaged within the thread), pinion-tooth flank zones are put into contact with screw-thread flank zones having slopes which are no longer paired and this should therefore result in wear.

It has been found, however, that in the case of combinations such as a screw formed of cast-iron and a pinion formed of plastics containing carbon or glass fibers and fillers which improve the sliding coefficient such as Teflon, the compressor could be operated without any appreciable wear in spite of upward displacements of the piston which can be of the order of 3 or 4 per minute.

There is shown in Fig. 5 another example of a device for carrying out the method in accordance with the invention in the case of single-screw compressors or expansion machines so designed

that each pinion-tooth face which is exposed to the pressure lies on a plane as described, for example, in French patent No. 1,331,998.

5 A screw 27 having an axis of rotation 28 and provided with threads 29 is adapted to cooperate with a pinion 30 provided with teeth such as the teeth 31 which are disposed in meshing engagement with the threads of the screw.

10 Said screw rotates within a casing 32, a lip 33 of which comes in the vicinity of the high-pressure face 34 of the teeth; this face is usually flat but could be conical or more generally a surface of revolution but not cylindrical without thereby modifying the invention.

15 During normal operation, the clearance between the lip 33 and the face 34 is as small as possible in order to limit leakages to the maximum extent and is in practice of the order of a few hundredths of a millimeter.

20 The pinion 30 is rigidly fixed to a shaft 35 rotatably mounted about an axis 36 in bearings 37 and 38 which permit of slight directional displacement and preferably consist of spherical bearings. These bearings are in turn rigidly fixed to sleeves 39 and 40 which are capable of sliding within bores 41 and 42 formed in the casing. The sleeve 39 is attached to a member 43 which is rigidly fixed to an operating rod 44.

30 The range of travel of said operating rod is limited by means of devices (not shown) in order to ensure that the end positions occupied by the pinion are the position shown in full lines and the position shown in chain-dotted lines in the figure.

35 The centers of the spherical bearings then take up the position 45 in the case of the bearing 37 and the position 46 in the case of the bearing 38 when the pinion is in the normal position shown in full lines and the positions 47, 48 when the pinion is in the upwardly displaced position shown in chain-dotted lines. In the upwardly displaced position, the axis 36 accordingly takes up the position 49.

45 The direction of the axis of the bore as designated by the reference 42 is chosen so as to be substantially perpendicular to the plane bisecting the planes such as 50 which pass through the axis 28 of the screw 27 and the bearing center in the end positions thereof, namely the positions 46 and 48.

50 In addition, by so arranging the bearings that these latter are located at a substantially equal distance from the axis of the screw, it is ensured that the envelope of the axis 36 in the displacement produced by the action of the operating rod 44 is substantially a circular arc centered on the axis of rotation 28 and therefore that, even if the displacement of the sleeves 39 and 40 is a linear displacement by virtue of its simplicity of design, the displacement of the pinion proper is very close to a movement of rotation about the axis 28.

65 The operation of the device and its use are the same as in the case of the cylindrical pinions described with reference to Figs. 1 to 5, except that the space through which the gas escapes is

no longer located between the teeth and the threads but within the clearance provided between the face 34 when this latter is in the position shown at 34a and the lip 33. But all the arrangements described in the foregoing and especially the combinations which make use of two pinions in cooperating relation with the same screw apply in an identical manner to the case of the flat pinions of Fig. 5.

70 The scope of the present invention would not be affected if, instead of employing the device described in Fig. 5, the axis of the pinion had been disposed on a device which is capable of rotating about the axis 28 or if, instead of employing screws having a cylindrical external profile as described in Figs. 1 to 5, the screws employed had different profiles such as conical or flat profiles, for example, as described in the patents cited earlier.

80 It is also worthy of note that, in the two examples of devices hereinabove described, the displacements of the pinion are carried out strictly in the direction of the axis since, even in the case of Fig. 5 which is close to a movement of rotation, differential displacement at each point takes place in a direction parallel to the axis of the pinion.

90 However, it would be possible to depart from this direction to a certain extent thereby modifying the invention.

95 In the case of Fig. 1, sliding motion of the shaft within its bearings could be replaced by a sliding displacement as shown diagrammatically in Fig. 6 in which the shaft 7 would be rigidly fixed to sleeves 60 and 61 slidably mounted in bores 62 and 63. The direction of the axes of said bores which are not necessarily parallel is inclined with respect to the direction of the shaft 7 and such that, when the teeth of the pinion are moved away from the groove between the threads, the high-pressure face 23 is also moved away from the lip 24. The result thereby achieved is to combine the two types of clearance described with reference to Figs. 1 and 5, namely the screw-pinion clearance and the pinion-casing clearance 4.

100 Similarly, in the case of fig. 5, steps can be taken to ensure that the displacement of the pinion does not take place strictly along its axis. As a result of operating clearances, it is possible in the first place to ensure that the displacement of the pinion is not strictly a movement of rotation about the axis 28 and is therefore not continuously tangent to the direction of the axis 36 when this latter is at right angles to the axis 28 as shown in Fig. 5. Moreover, it is possible to construct flat-pinion single-screw compressors of the type shown in Fig. 5 but in which the axis of the pinion is not at right angles to the axis of the screw while being located transversely with respect to this latter. In this case, in order to maintain correct meshing engagement between the screw and the pinion during displacement of this latter, it would be found necessary to maintain a movement of rotation about the axis of the screw and therefore to carry out a displacement in a direction which no longer coincides with the axis of the pinion.

However, both in the case of Fig. 6 and in the case of a pinion having flat teeth and an axis which is not at right angles to the axis of rotation, the difference between the direction of displacement and the direction of the axis of the pinion cannot be much greater than about ten degrees without giving rise to interferences between the pinion teeth and the screw threads, such interferences being the cause of leakages and therefore of impaired performance of the compressor or of the expansion machine during operation at full load. Thus, even if the two directions are not strictly parallel, they remain substantially so.

It can finally be noted that, in the case of Fig. 1, the pinion rotates about a stationary shaft but it would have been equally possible to provide a shaft in rigidly fixed relation to the pinion which rotates in bearings and is actuated as in the case of Fig. 5.

CLAIMS

1. A method for regulating the delivery of compressors of the type constituted by a screw provided with a plurality of threads, at least one pinion provided with teeth in cooperating relation with the said threads, a casing which surrounds the said screw at least to a partial extent and is provided with a passage for the teeth of the said pinions, at least one low-pressure port and at least one high-pressure port provided within the casing, characterized in that, in order to stop the flow produced by a pinion, the pinion is displaced from its work position in a direction substantially parallel to the axis of rotation of the said pinion.

2. A device for carrying out a method in accordance with claim 1 in which that surface of the pinion teeth which is exposed to the pressure is disposed substantially on a cylinder, characterized in that the pinion is rotatably mounted on a stationary shaft slidably fitted within bores which are substantially concentric with the cylinder aforesaid.

3. A device for carrying out a method in accordance with claim 1 in which that surface of the pinion teeth which is exposed to the pressure is substantially a plane, characterized in that the pinion is maintained in a device which rotates about the axis of rotation of the screw.

4. A device in accordance with claim 3, characterized in that the shaft which supports the said pinion is mounted in bearings which permit of slight directional displacement and are in turn rigidly fixed to sleeves slidably mounted within bores having an axis substantially perpendicular

55 to the plane which passes through the axis of the screw and the centre of the bearing, and that the centres of the bearings are located substantially at the same distance from the axis of the said screw.

60 5. A method in accordance with claim 1 in which the said compressor or expansion machine has two pinions disposed in substantially symmetrical relation on each side of the screw, characterized in that only one pinion is displaced from the work position thereof in order to produce partial delivery.

65 6. A method in accordance with claim 5 in which the volumes swept by each pinion are different, characterized in that the two pinions are displaced from the work positions thereof in alternate sequence in order to obtain different partial deliveries.

70 7. A method in accordance with claim 5 in which the said compressor or expansion machine is provided with devices for producing a variation in delivery by throttling of the flow, characterized in that the said means are employed alone in respect of deliveries of higher value than one-half the maximum delivery and in conjunction with displacement of the pinion in respect of deliveries lower than one-half the maximum delivery.

75 8. A method in accordance with claim 5 in which the said compressor or expansion machine is provided with known means for producing a variation in delivery which are placed within the casing, characterized in that the said means are disposed only on the half-compressor in which the pinion remains in the work position below one-half the maximum delivery and that the said means are employed alone in respect of values higher than one-half the maximum delivery and in conjunction with the displacement of the pinion which cooperates with the other half-compressor in respect of deliveries below one-half the maximum delivery.

85 9. A method for regulating the delivery of screw compressors, substantially as hereinbefore described.

90 10. A device for regulating the delivery of screw compressors, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

95 11. A method for regulating the delivery of compressors wherein in order to stop the flow produced by a pinion, the pinion is displaced from its work position in a direction substantially parallel to the axis of rotation of the said pinion.

100 12. Any novel feature or combination of features described herein.