May 31, 1960 F. LÜCK 2,938,663

ROTARY COMPRESSORS

Filed Oct. 25, 1955 4 Sheets-Sheet 1

Fig. 1

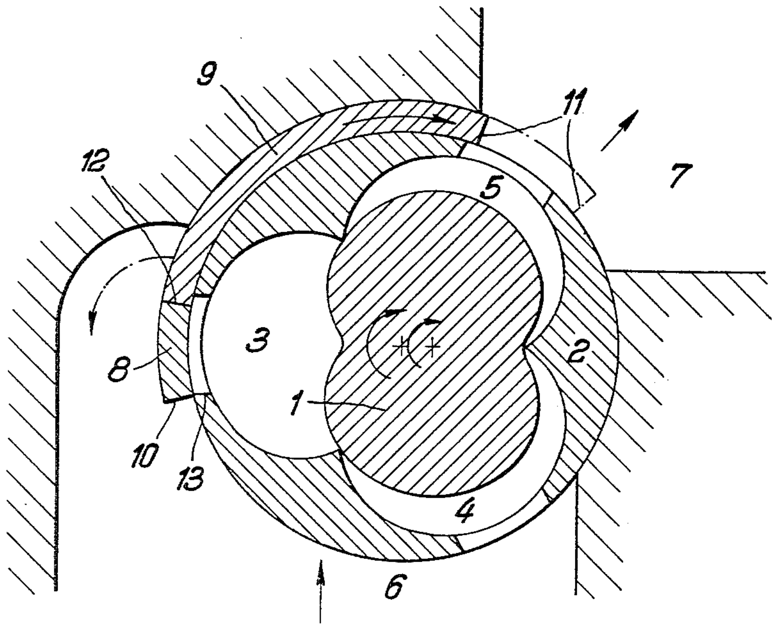
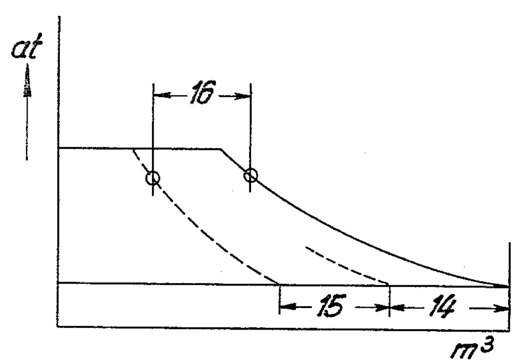


Fig. 2



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ROTARY COMPRESSORS

Filed Oct. 25, 1955 4 Sheets-Sheet 2

Fig. 3

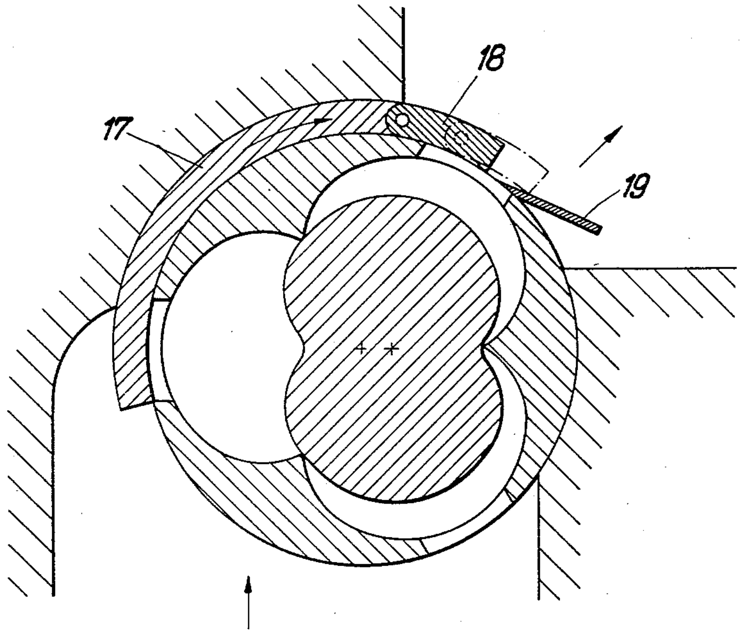
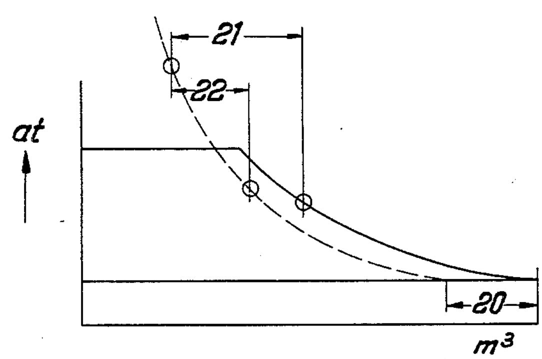


Fig. 4



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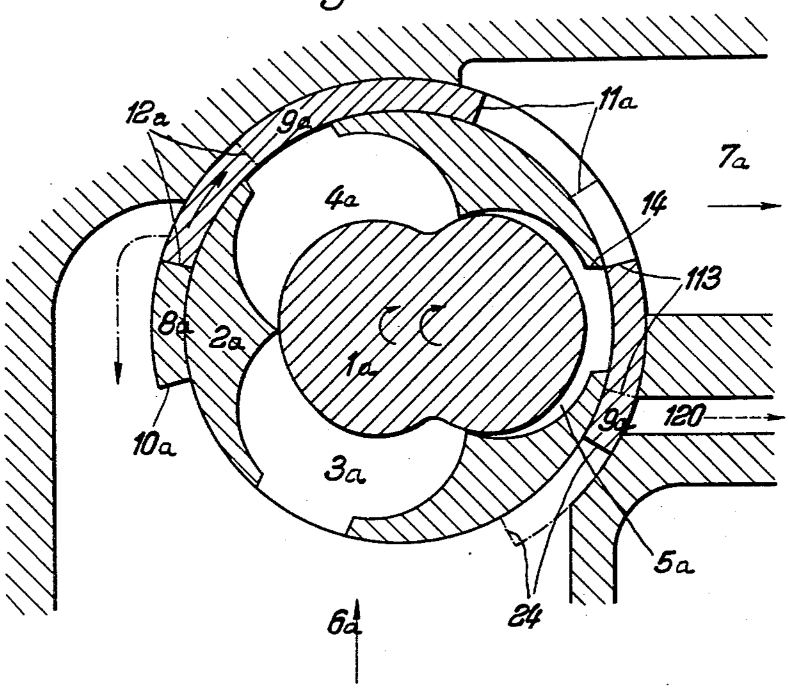
ROTARY COMPRESSORS

Filed Oct. 25, 1955 4 Sheets-Sheet 3

Fig. 5



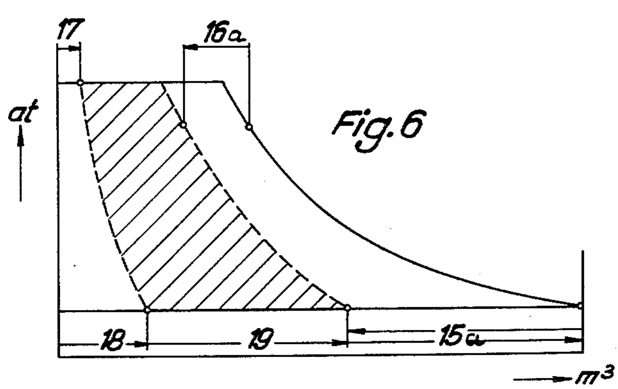
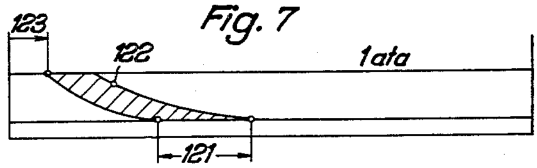


Fig. 7



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May 31, 1960 F. LÜCK 2,938,663

ROTARY COMPRESSORS

Filed Oct. 25, 1955 4 Sheets-Sheet 4

Fig. 8

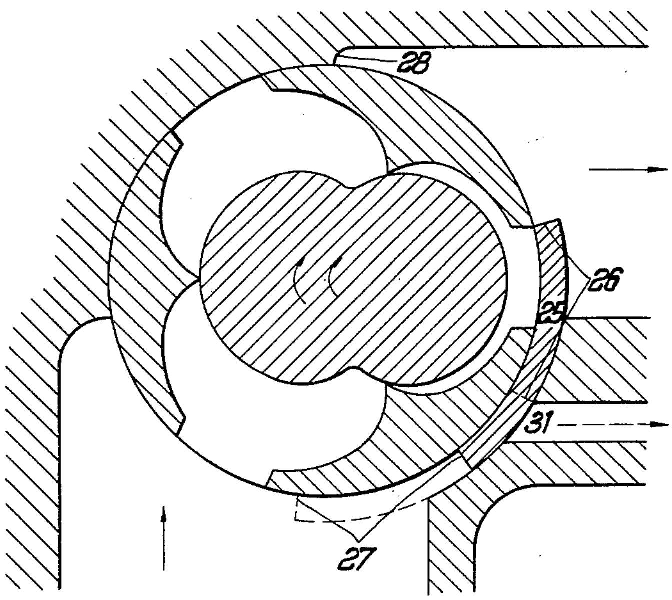


Fig. 9

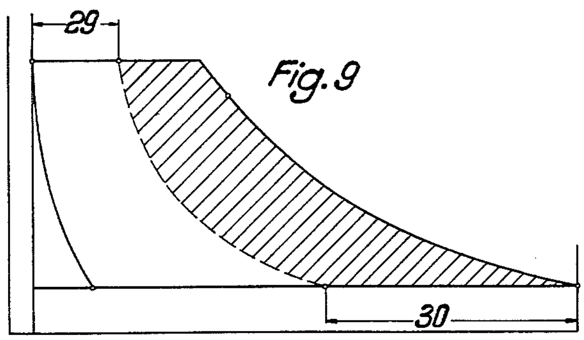
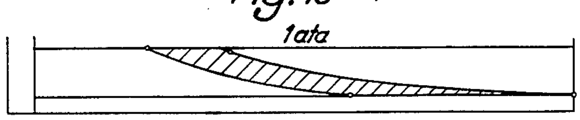


Fig. 10



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ROTARY COMPRESSORS

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4 Claims. (Cl. 230—138)

This invention relates to rotary compressors and is concerned more particularly with means for the regulation of output of rotary compressors which have no separate inlet and outlet elements but wherein the inlet and outlet is regulated automatically by means of openings provided in the rotary bodies and in the casing or in a stationary hollow axle.

In constructions of this type known in prior art the regulating edges do not change so that the transmitted amount of gas does not change also. Therefore, in order to regulate the transmitted amount of gas without steps, it is necessary to use a movable steering device which holds the inlet channel open during the compression stroke for a shorter or longer time period.

In the event an excessive amount of gas has been sucked in this excess is transmitted during this time back into the suction conduit, with the result that the counter-pressure in the cylinder is reached at a later time period. If the outflow edge were to remain unchanged at the same location then gas would flow back from the pressure conduit into the cylinder and would have to be withdrawn for a second time. In case of a substantial gas flow this would result in substantial losses in energy and excessive knocking. Therefore it was found necessary to provide for a shifting of the steering edge for the outflow.

It is apparent from each compressor diagram that the required distances for such adjustment are quite different for inflow and outflow steering edges. Therefore, it is not easily possible to regulate a rotory compressor at the inflow and outflow sides by means of a common steering slide.

An object of the present invention is to eliminate the above drawbacks of prior art constructions and to provide better regulation.

Another object is to provide a separate device by means of which the inlet and the outlet of a rotary compressor can be effectively regulated by a special construction.

In accomplishing the objects of the present invention it was found desirable to provide a single steering device for adjusting the steering edges controlling the inlet and the outlet openings provided in the rotor of the compressor on the one hand and on the other hand in the casing or the immovable hollow axis thereof. According to the invention two rotors located one within the other are provided, and the inflow and outflow take place by means of openings which are provided in one of the rotors and also in the casing or the immovable hollow axis.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings showing, by way of example, preferred embodiments of the inventive idea.

In the drawings:

Figure 1 is a diagrammatic section through a compressor constructed in accordance with the principles of the present invention.

Figure 2 is a compressor diagram.

Figure 3 is a diagrammatic section through a somewhat different compressor.

Figure 4 is another compressor diagram.

Figure 5 is a diagrammatic section through yet another compressor.

Figures 6 and 7 are working diagrams thereof.

Figure 8 is a section through still another compressor, and Figures 9 and 10 are working diagrams thereof.

The compressor shown in Figure 1 has rotors **1** and **2** which rotate about different axes in the same direction but with different speeds. The two rotors **1** and **2** and the enclosing parts defining three separate cylindrical spaces, namely, a suction chamber **3**, a suction chamber **4** and a compression chamber **5**. In the illustrated position of the two rotors the suction chamber **3** has the largest obtainable suction volume. If at that time the chamber **3** is already closed with respect to the suction tube **6**, then as the rotors continue their movement gas will be compressed in the chamber **3** and finally will flow into the pressure tube **7**.

The casing of the machine includes an immovable piece **8** of curved form which has a lower edge **10** steering the inflow of the gas. The machine is also provided with a steering slide **9** having a right-hand edge **11** (looking in the direction of Figure 1), which steers the outflow of the gas.

The slide **9** may be shifted clockwise in the direction of the arrow illustrated in Figure 1 until its edge **11** assumes the position shown by broken lines. At that time the opposite edge **12** of the slide **9** will form with the member **8** a slot connecting the suction chamber **3** with the suction pipe **6**.

When the rotors are further rotating the chamber **3** will continue to become smaller and a part of the sucked in gas will flow again into the suction space **6**; this will continue until the steering edge **13** of the rotor **2** has passed the edge **12** of the slide **9**. Thereafter the gas remaining in the chamber **3** will be compressed and removed. Due to the movement of the slide **9** its steering edge **11** has moved beyond the position shown in full lines in Figure 1 so that the gas is removed at a later time period.

The operation of the compressor constructed in accordance with the principles of the present invention is indicated upon the compressor diagram shown in Figure 2 illustrating relative changes in volume as a function of relative changes in pressure. On that diagram the line **14** represents the diminution of the suction volume when after a slight movement of the slide **9** there is a narrow slit between the member **8** and the slide **9**, and whereby during further turning of the rotor gas flows through this slit from the suction chamber **3** to the suction tube **6**. Then the edge **12** of the slide **9** takes over the functions of the edge **10** of the member **8**. When the slide **9** is moved further, the edge **12** will separate the suction chamber **3** from the suction tube **6** at a later time period and then an amount of gas corresponding to the line **15** can flow additionally back to the suction tube **6**. Thus, the total amount of gas returned to the suction conduit is equal to the sum of the distances **14** and **15**. The distance **16** represents the change in the beginning of the outflow caused by the fact that due to the angular shifting of the slide **9**, the edge **11** which causes the beginning of the outflow is moved to the same angular etxent as the edge **12**.

Since the changes in the volume of the cylindrical chambers do not take place linearly depending upon angular movements, the lengths **15** and **16** are not equal to each other. Since the relationship is a sine function, as in the case of every crank drive, without the member **8** the line **16** would be many times longer than the line **15**; however the line **16** must be considerably shorter in view of the amount to be compressed. The correct ratio is provided in this case by the member **8**, i.e. the addition of the line **14** to the line **15**. Furthermore, the point of opening of the outlet does not have to lie precisely at the end of the compression line. In the case of quickly rotating compressors this point may be so arranged that at the time counter-pressure is reached the outlet is already partly open. Therefore the length of the member **8** will be made so that the outlet steering point for all possible partial loads will always lie at a suitable but not always exactly the same distance in front of the end of the compression line.

Figure 3 shows another possibility of properly adjusting in relation to each other the edge providing further end of the inflow and the edge providing the end of the outflow; it illustrates a compressor which, in view of the above stated considerations, has a slide **17** provided with a swingable steering member **18** which is connected with the slide **17** by a pivot extending parallel to the axis of the compressor.

The member **18** may be made of elastic material.

In the course of movement of the slide **17** the member **18** may be guided by a rail **19** or the like, so that it will be raised at any desired time, and so that the extent to which it is raised will always increase with the increasing path of movement of the slide **17**. The guide rail **19** is connected to the casing of the compressor in any suitable manner (not shown). Consequently, the operative outflow-regulating edge will be constituted not by the right-hand end of the member **18** but by the left-hand end (looking in the direction of Figure 3).

The steering effect resulting from this change is shown in the compressor diagram of Figure 4. In this diagram the length **20** represents the change in volume of the cylindrical suction chamber which corresponds to the angular shifting of the actuating slide. The length **21** represents the corresponding change in volume upon the pressure side which would take place if the swingable steering piece **18** were not available. Thus the outlet would open then so late that super-pressure would exist in the cylinder chamber and consequently a substantial amount of energy would be lost. The swingable member **18** when raised moves the point of opening of the outflow back to the extent of stretch **22**, so that excessive pressure is avoided.

To avoid baffling losses the regulation by means of the swingable member **18** is usable only for small regulating ranges, or in combination with a regulation of the sucked in masses by again removing the gas through the use of the immovable piece **8** shown in Figure 1. In that case it is possible to extend the regulation range to the smallest partial loads.

In order to provide for even smaller partial loads, and in order to relieve the slide from one-sided tangential pressure upon the edge directed toward the pressure conduit, the present invention provides a construction wherein a cylindrically curved steering slide which is circumferentially reciprocated between rotary and immovable parts of the compressor is additionally provided with a steering edge used for the closing of the gas removing step.

According to a further development of this invention it is also possible to eliminate that part of the slide which provides for the end of the inflow and the beginning of the outflow procedure, whereby the regulation takes place only by those edges of the slide which provides for the termination of the outflow and the beginning of the inflow or intake.

Furthermore, in accordance with the present invention a no-load channel is provided in the casing and is connected with the intake conduit or with atmospheric air. This channel is opened by that edge of the slide which produces the closing of the outflow when the slide is adjusted to a position corresponding to that of the smallest partial load.

Regulating devices of this type and their operating

diagrams are illustrated diagrammatically in two embodiments in Figures 5 to 10 of the drawings.

The rotary compressor shown in Figure 5 has two rotors **1***a* and **2***a* which rotate about different axes and with different speeds but in the same direction. These two rotors form three separate operating chambers **3***a*, **4***a* and **5***a*. In the position shown in Figure 5 the chamber **3***a* is increasing in size and it sucks in the gas from the intake conduit **6***a*. The chamber **4***a* compresses the gas which is located therein while the chamber **5***a* after the outflow of the gas into the pressure conduit **7***a* has attained its smallest volume. The rotors are partly enclosed by an immovable regulating member **8***a*, having a front edge **10***a* which causes the end of the intake in the illustrated full-load regulating position. A slide **9***a* has operative edges **11***a* and **12***a* and also an additional edge **113**. When the slide **9** is rotated the edge **12***a* takes over the regulation instead of the edge **10***a* in such manner that a part of the sucked in gas can flow back to the intake conduit **6***a*. In the diagram shown in Figure 6 the returning amount of gas is indicated by the line **15***a*.

The beginning of the outflow is determined by the edge **11***a*. The further the slide **9***a* is moved in the direction of rotation of the compressor, the later will begin the outflow as is apparent from the line **16***a* of the diagram shown in Figure 6.

The additional operating edge **113** produces the end of the outflow. In the illustrated full-load position the edge **113** is about to cut off the chamber **5***a* from the outflow conduit **7***a*. If the slide **9***a* is shifted in the direction of rotation of the compressor, the edge **113** will move further downwardly (looking in the direction of Figure 5); then the chamber **5***a* which begins to increase in size remains connected with the pressure conduit **7***a* and can be filled with compressed gas until the edge **14***a* of the rotor **2***a* slides past the edge **113**. This procedure of filling the operating space with the gas is indicated by the line **17** in the diagram of Figure 6. The gas located in the chamber **5***a* and in the clearance space will now expand while giving up power, to the volume indicated by the length **18** in Figure 6. The length **19** represents the amount of gas actually sucked in and transmitted by the compressor.

The additional steering edge **113** makes it possible to cause a return flow of a part of the gas from the compression conduit to the intake conduit, and this makes it possible to provide for small partial loads. Furthermore, since pressure prevailing in the compression conduit is exerted upon the steering edge **11***a*, as well as the steering edge **113**, the slide **9***a* will be tangentially discharged of load.

The machine includes a no-load channel **120** which is connected with the intake channel **6** or with atmospheric air and which is opened by the steering edge **113** of the slide **9***a*, which causes the end of the outflow procedure. Due to the provision of the no-load channel **120**, and when the slide **9***a* is set to a position corresponding to the smallest partial load, it is possible to increase the regulation of the partial load range to a no-load regulation.

If now the slide **9***a* is further shifted in the direction of the rotation, beyond the position shown by broken lines in Figure 5, then the channel **120** will be opened by the edge **113** so that a direct connection is provided by the channel **120** between the compression conduit **7***a* and atmospheric air or the intake conduit **6***a*. Counter-pressure drops then to atmospheric pressure or to the suction pressure of the machine.

The regulating valve (not shown) is provided in the suction or intake conduit close to the inlet opening into the machine. This valve is closed when the slide reaches the no-load position. By means of this valve the machine can run empty with the smallest possible consumption of energy.

Figure 7 illustrates a no-load diagram, the size of which depends essentially upon sealing conditions prevailing in the compression chamber. In this diagram, as well as in the ones earlier described, the change in volume is illusrtated as a function of the change in pressure. The line designated at "**1** *ata*" represents the line of atmospheric pressure. When the slide **9***a* is in the no-load position and the regulating valve in the suction tube is closed, the operating pressure of the machine is below the atmospheric line, as indicated in Fig. 7. The length **121** corresponds to the amount of gas which must be compressed continuously at a substantially reduced intake pressure, and which results from lack of complete sealing. The point **122** upon the compression curve characterizes the steering position reached by the edge **11***a* and the length **123** corresponds to the amount of gas flowing back from the compression conduit **7***a* into the working chamber **5***a* until the chamber is cut off by the steering edge **113**. Then the amount of gas enclosed in the working chamber **5***a* can expand while giving up power until the steering edge **24** establishes the connection between the chamber **5***a* and the intake conduit **6***a*.

The additional regulation of the transmitted amount of gas by the steering edge **113** can be increased to such an extent that regulation by steering edge **12***a* becomes superfluous. Then the construction of the regulating device is considerably simplified.

Figure 8 illustrates a construction wherein the movable slide **25** has two steering edges **26** and **27**. The edge **26** terminates the gas outflow while the edge **27** regulates the beginning of the take-in. The edge **28** which determines the beginning of the outflow is formed by the immovable casing.

Figure 9 illustrates a full-load diagram which occurs in the illustrated position of the slide. If the slide **25** is shifted downwardly into the position shown by broken lines in Figure 8, gas can flow back from the compression conduit into the working space which begins to increase again. This procedure is indicated in the diagram of Figure 9 by the line **29**. When the working space is closed off by the edge **26** the gas expands giving up power until the steering edge **27** provides for a connection to the intake conduit. Line **30** remaining upon the intake line of the diagram shown in Figure 9, indicates the actual sucked-in partial load amount.

This regulating device can be also amplified through the addition of a no-load device. Figure 8 shows a channel **31** which again provides for a connection between the compression conduit and the atmospheric air or the intake conduit.

A valve (not shown) is used to close the intake or suction conduit by hand or automatically. When the valve is closed a no-load diagram is produced which may have the form shown in Figure 10.

It is apparent that various changes may be made in the described regulating devices. These devices, particularly the device shown in Figure 8, may be used for the regulating of admission in expansion machines. All such and other variations and modifications are to be included within the scope of the present invention.

What is claimed is:

1. In a rotary compressor, a stationary casing having substantially opposed concentric inner surfaces forming cylindrical sections, said casing having formed therein inlet and outlet openings between said surfaces, an outer hollow rotor located between said surfaces and between said inlet and outlet openings and having outer cylindrical surfaces which are concentrical with said inner surfaces of the casing, an inner rotor eccentrically mounted within said outer rotor and having curved outer surfaces, said outer rotor having inwardly projecting portions engaging said outer surfaces of the inner rotor and slidable relatively thereto when said rotors are rotated in the same direction at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor enclosing a plurality of working chambers which expand and contract when said rotors are rotated at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor being so shaped that said chambers expand as they move past said inlet opening and contract as they move toward and past said outlet opening, said outer rotor having openings communicating with said chambers and adapted to communicate with said inlet and outlet openings during the rotation of said outer rotor, a circumferentially movable steering slide having concentrical outer and inner surfaces concentrical with and engaging one of said inner surfaces of the casing and the outer surfaces of said outer rotor, respectively, said slide being located on the side wherein said chambers attain their largest expansion volume and having two opposed edges, one of said edges being located adjacent said inlet opening for determining the end of the suction period of said working chambers, the other one of said edges being located adjacent said outlet opening for determining the beginning of the outflow period of said working chambers, and an immovable member having concentrical outer and inner surfaces constituting continuations of said inner surfaces of the casing and the outer surfaces of said outer rotor, respectively, said immovable member having an edge located adjacent said one edge of said slide and an opposite edge, the two edges of said member being located in said inlet opening, said one edge of said immovable member being adapted to be engaged by said one edge of said slide, whereby the flow from a working chamber to the inlet opening may be varied.

2. In a rotary compressor, a stationary casing having substantially opposed concentric inner surfaces forming cylindrical sections, said casing having formed therein inlet and outlet openings between said surfaces, an outer hollow rotor located between said surfaces and between said inlet and outlet openings and having outer cylindrical surfaces which are concentrical with said inner surfaces of the casing, an inner rotor eccentrically mounted within said outer rotor and having curved outer surfaces, said outer rotor having inwardly projecting portions engaging said outer surfaces of the inner rotor and slidable relatively thereto when said rotors are rotated in the same direction at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor enclosing a plurality of working chambers which expand and contract when said rotors are rotated at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor being so shaped that said chambers expand as they move past said inlet opening and contract as they move toward and past said outlet opening, said outer rotor having openings communicating with said chambers and adapted to communicate with said inlet and outlet openings during the rotation of said outer rotor, a circumferentially movable steering slide having concentrical outer and inner surfaces concentrical with and engaging one of said inner surfaces of the casing and the outer surface of said outer rotor, respectively, said slide being located on the side wherein said chambers attain their largest expansion volume and having two opposed edges, one of said edges being located adjacent said inlet opening for determining the end of the suction period of said working chambers, the other one of said edges being located adjacent said outlet opening, a curved steering member connected to said other edge of said slide for swinging movement about an axis parallel to the axis of rotation of said outer rotor, said steering member having an outer edge located in said outflow opening for determining the beginning of the outflow period of said working chambers, and a guide rail connected to said casing and located in the path of movement of said steering member, said guide rail being substantially narrower than said outflow opening in a plane perpendicular to the outflow of the fluid through the outflow opening and being adapted to be engaged by said steering member and raising said steering member relatively to said slide

when said slide is moved in the direction of rotation of said outer rotor.

3. A rotary compressor, a stationary casing having substantially opposed concentric inner surfaces forming cylindrical sections, said casing having formed therein inlet and outlet openings between said surfaces, an outer hollow rotor located between said surfaces and between said inlet and outlet openings and having outer cylindrical surfaces which are concentrical with said inner surfaces of the casing, an inner rotor eccentrically mounted within said outer rotor and having curved outer surfaces, said outer rotor having inwardly projecting portions engaging said outer surfaces of the inner rotor and slidable relatively thereto when said rotors are rotated in the same direction at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor enclosing a plurality of working chambers which expand and contract when said rotors are rotated at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor being so shaped that said chambers expand as they move past said inlet opening and contract as they move toward and past said outlet opening, said outer rotor having openings communicating with said chambers and adapted to communicate with said inlet and outlet openings during the rotation of said outer rotor, a circumferentially movable steering slide having concentrical outer and inner surfaces concentrical with and engaging one of said inner surfaces of the casing and the outer surfaces of said outer rotor, respectively, said slide being located on the side wherein said chambers attain their largest expansion volume and having two opposed edges, one of said edges being located adjacent said inlet opening for determining the end of the suction period of said working chambers, the other one of said edges being located adjacent said outlet opening for determining the beginning of the outflow period of said working chambers, an additional slide member movable with said slide and constituting a continuation thereof, said additional slide member having concentrical outer and inner surfaces concentrical with and engaging the other one of said inner surfaces of the casing and the outer surfaces of said outer rotor, respectively, said additional slide member being located on the side wherein said chambers attain their smallest contraction volume and having two opposed edges, one of the last-mentioned edges being located adjacent said outlet opening for determining the end of the outflow period of said working chambers, the other one of the last-mentioned edges being located adjacent said inlet opening for determining the beginning of the suction period of said working chambers, and an immovable member having concentrical outer and inner surfaces constituting continuations of said inner surfaces of the casing and the outer surfaces of said outer rotor, respectively, said immovable member having an edge located adjacent said one edge of said slide and an opposite edge, the two edges of said member being located in said inlet opening, said one edge of said immovable member being adapted to be engaged by said one edge of said slide, whereby the beginning of the compression period of said working chambers is determined selectively depending upon the position of said slide by said opposite edge of the immovable member or by said one edge of said slide, said casing having a no-load channel formed therein and communicating with said other one of the inner surfaces of said casing on the side wherein said working chambers attain their smallest contraction volume and a point of low pressure, said no-load channel being opened by said slide at no load and being closed by said slide during load operations.

4. In a rotary compressor, a stationary casing having substantially opposed concentric inner surfaces forming cylindrical sections, said casing having formed therein inlet and outlet openings between said surfaces, an outer hollow rotor located between said surfaces and between said inlet and outlet openings and having outer cylindrical surfaces which are concentrical with said inner surfaces of the casing, an inner rotor eccentrically mounted within said outer rotor and having curved outer surfaces, said outer rotor having inwardly projecting portions engaging said outer surfaces of the inner rotor and slidable relatively thereto when said rotors are rotated in the same direction at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor enclosing a plurality of working chambers which expand and contract when said rotors are rotated at different speeds, said outer surfaces of the inner rotor and said inwardly projecting portions of the outer rotor being so shaped that said chambers expand as they move past said inlet opening and contract as they move toward and past said outlet opening, said outer rotor having openings communicating with said chambers and adapted to communicate with said inlet and outlet openings during the rotation of said outer rotor, said casing having an edge defining one end of said outflow opening, whereby the sliding of said outer rotor relatively to said edge determines the beginning of the outflow period of said working chambers, and a slide member having concentrical outer and inner surfaces concentrical with and engaging one of said inner surfaces of the casing and the outer surfaces of said outer rotor, said slide member being located on the side wherein said chambers attain their smallest contraction volume and having two opposed edges, one of the last-mentioned edges being located adjacent said outlet opening for determining the end of the outflow period of said working chambers, the other one of the last-mentioned edges being located adjacent said inlet opening for determining the beginning of the suction period of said working chambers, said casing having a no-load channel formed therein and communicating with said one inner surface of said casing on the side wherein said working chambers attain their smallest contraction volume and a point of low pressure, said no-load channel being opened by said slide at no load and being closed by said slide during load operations.

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