June 18, 1935. W. D. DRYSDALE 2,005,578

COMPRESSING MACHINE

Filed Aug. 6, 1932 5 Sheets-Sheet 1

Fig. 1.

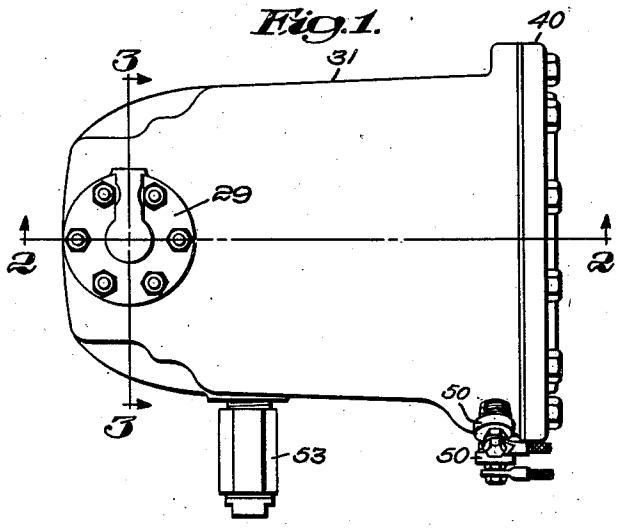
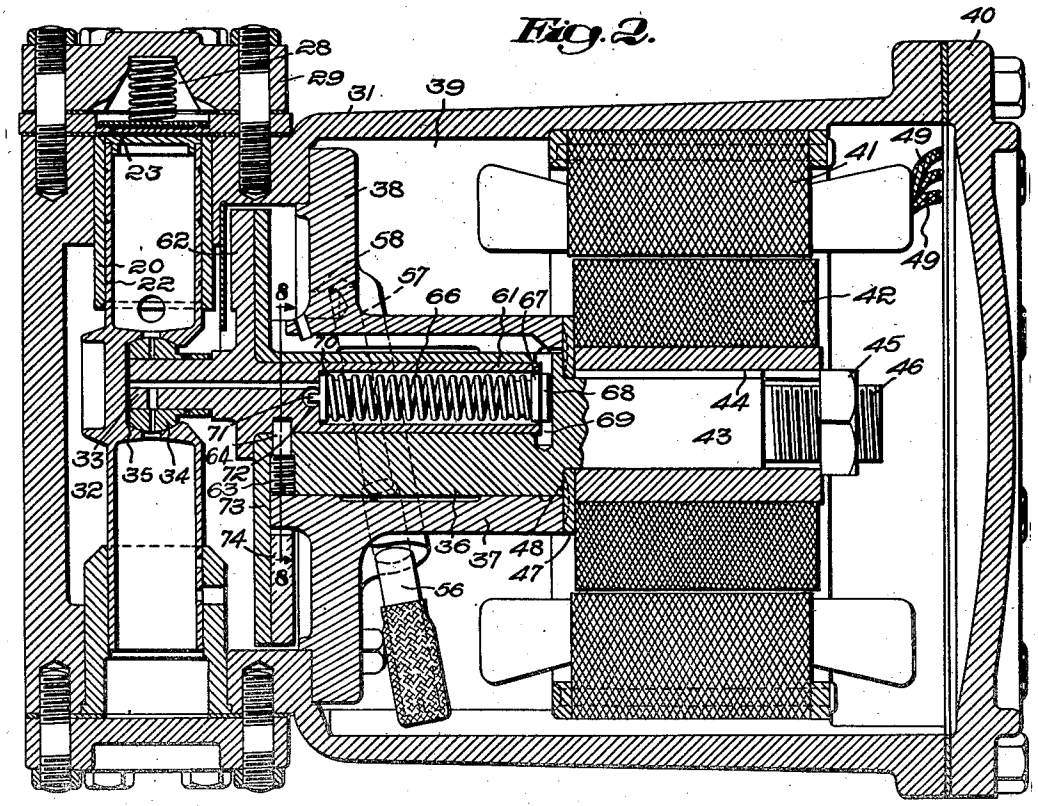



Fig. 2.




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COMPRESSING MACHINE

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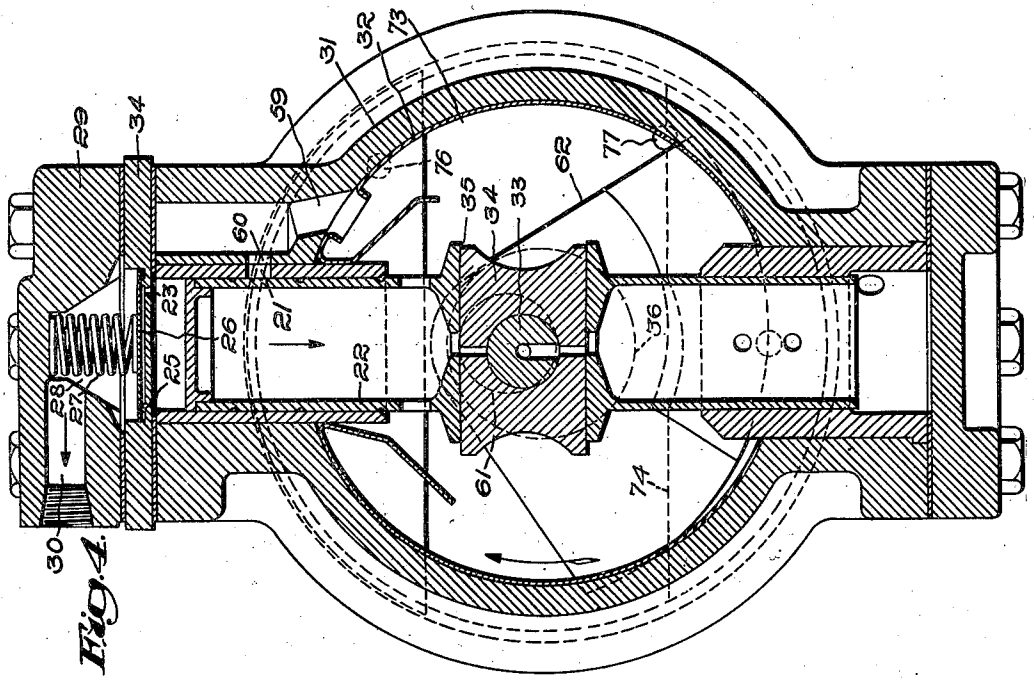



Fig. 4.

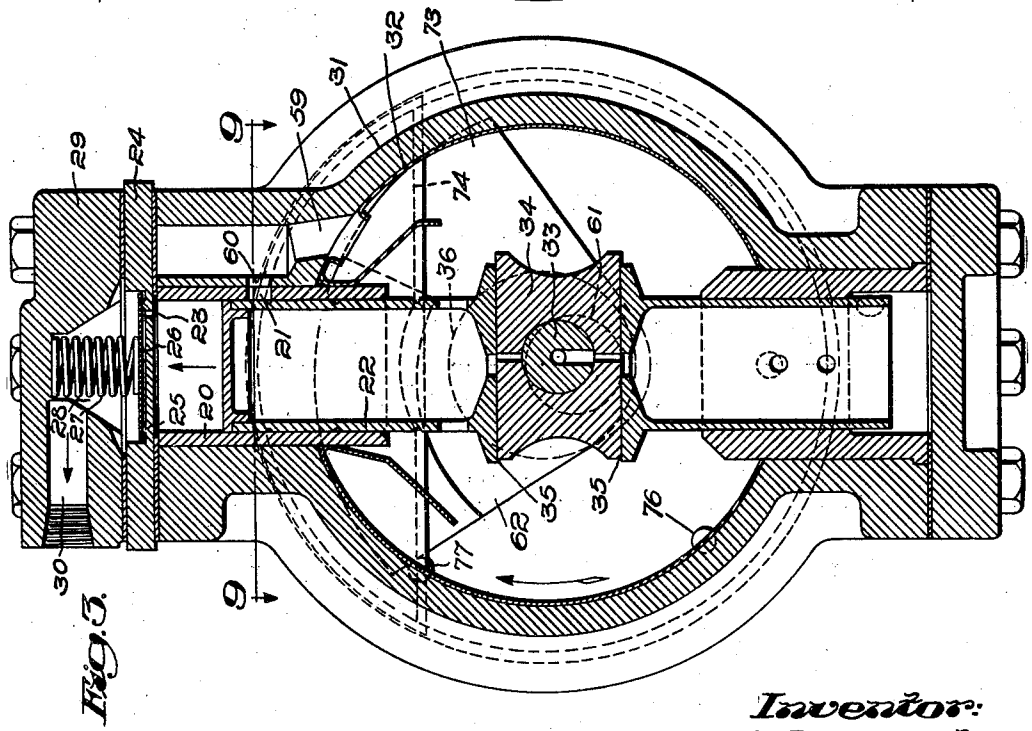



Fig. 5.

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COMPRESSING MACHINE

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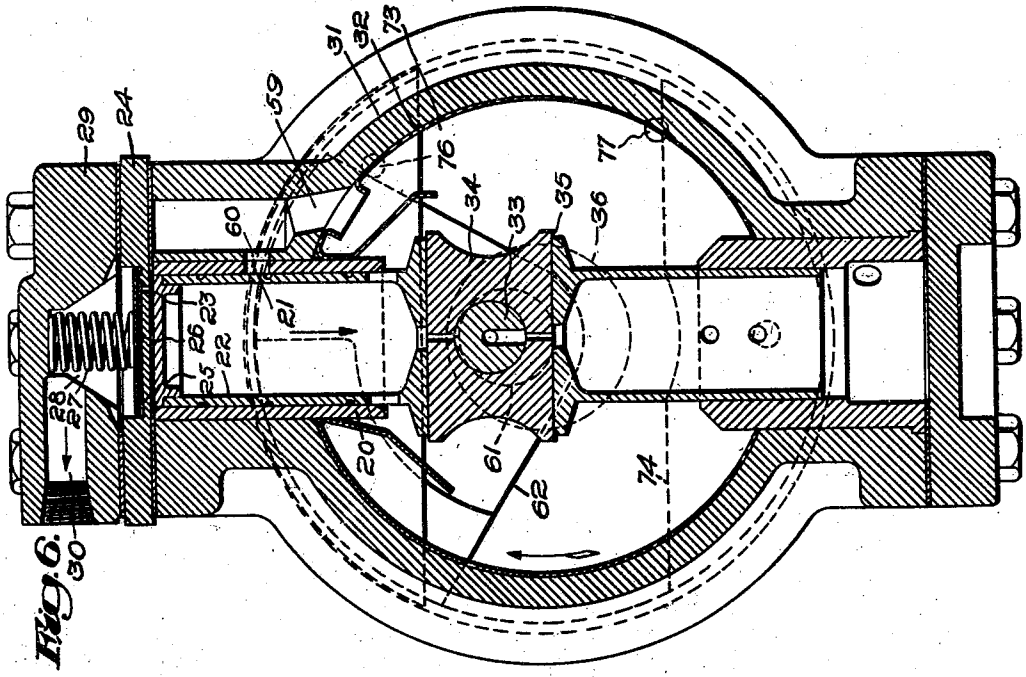



Fig. 6.

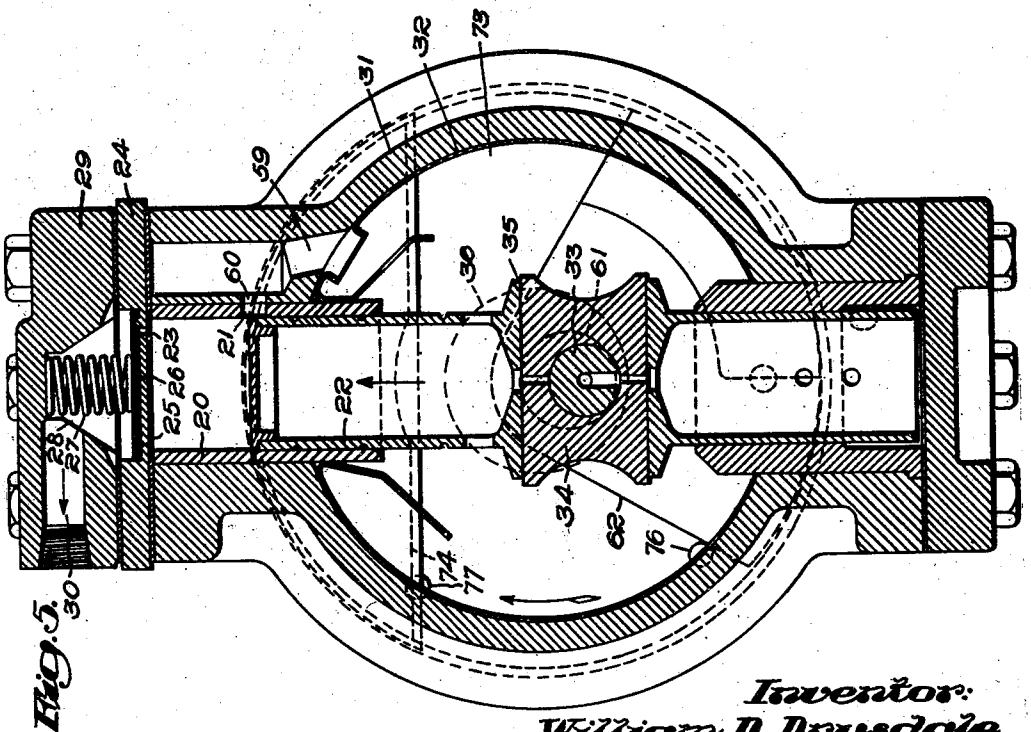



Fig. 5.

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COMPRESSING MACHINE

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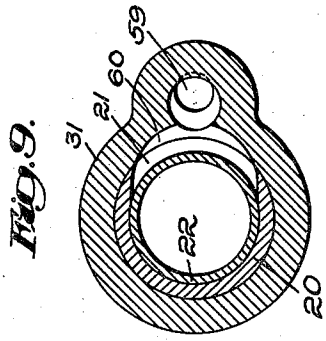



Fig. 9.

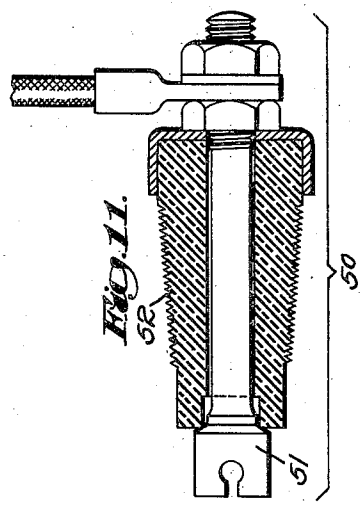



Fig. 11.

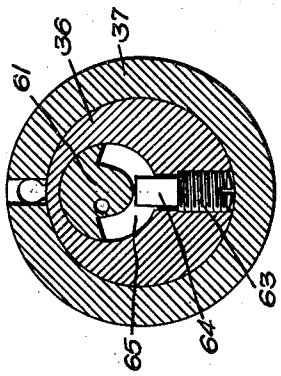



Fig. 8.

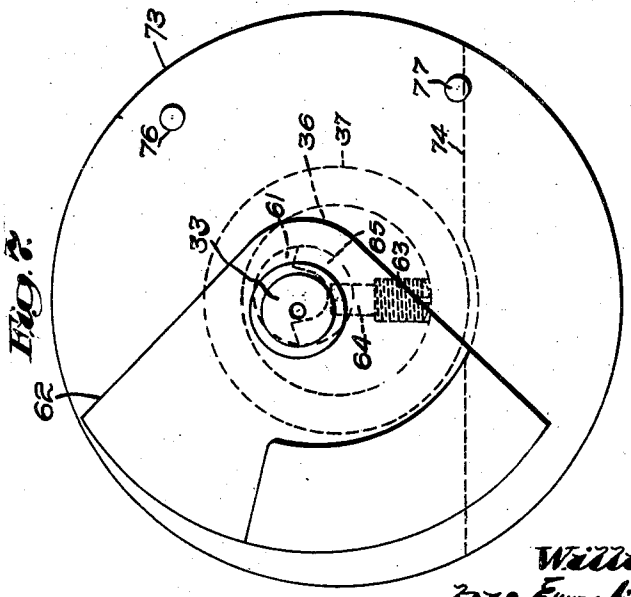



Fig. 7.

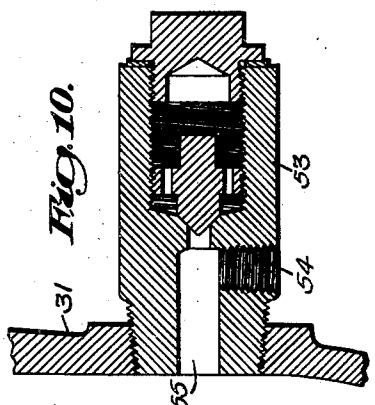



Fig. 10.

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June 18, 1935. W. D. DRYSDALE 2,005,578

COMPRESSING MACHINE

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Fig. 12.

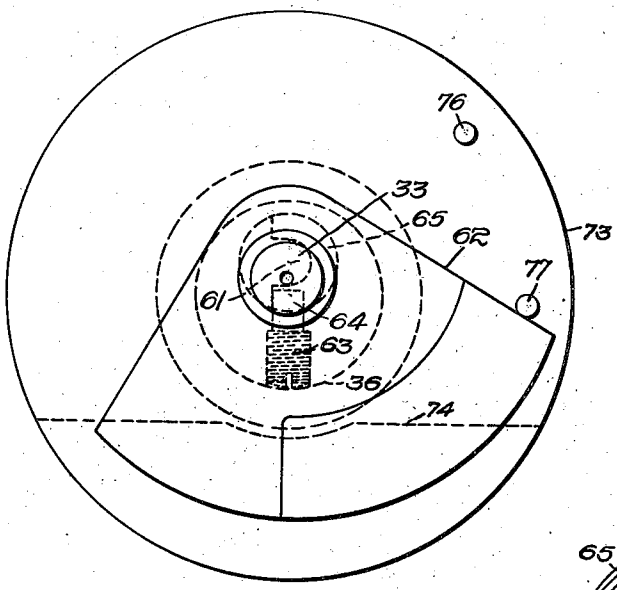



Fig. 14.

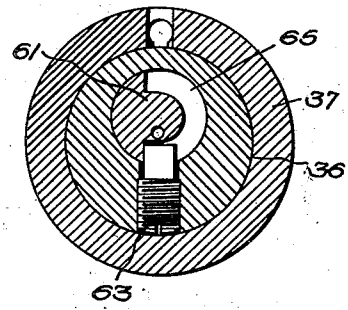



Fig. 15.

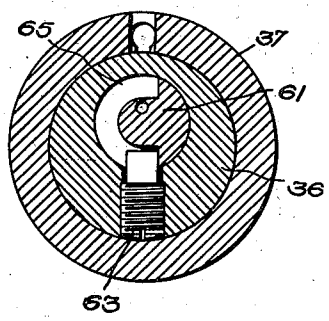



Fig. 13.

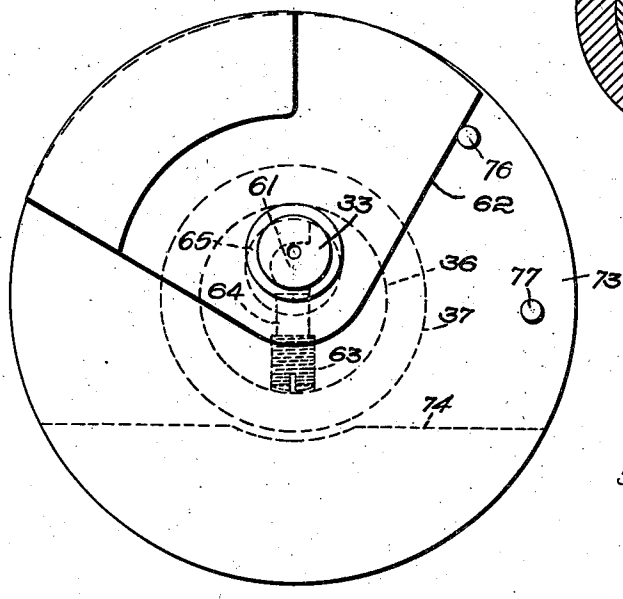
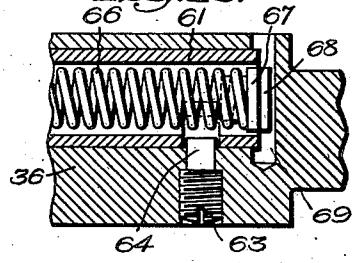



Fig. 16.




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Patented June 18, 1935 2,005,578

# UNITED STATES PATENT OFFICE

2,005,578

## COMPRESSING MACHINE

William D. Drysdale, Buffalo, N. Y., assignor to Walter J. Sugden, Boston, Mass.

Application August 6, 1932, Serial No. 627,736

19 Claims. (Cl. 230—20)

This invention relates to a compressing machine susceptible of general application, but particularly useful in connection with mechanical refrigerators, of the compressor, condenser, expander type, and more particularly to a machine comprising a compressor driven by an electric motor. This invention aims to provide a machine of this class with a direct driving mechanism without a reduction or other ratio between the driving and driven members, and having means which shall either partially or wholly avoid creating a load on the motor during the starting of the latter, thereby enabling a motor of low starting torque to be employed, without resort to the use of a belt drive, or other means of establishing a ratio permitting the motor shaft to operate at higher speeds than the apparatus it drives through the belt, or a capacitor motor, to allow the motor to take up the load of the compressor gradually. The invention also aims to provide a driving mechanism which shall cause the piston of the compressor to maintain the compressor intake closed when the compressor is at rest, thereby preventing the refrigerant from flowing into the compressor cylinder.

The invention will best be understood by reference to the following description, when taken in connection with the accompanying drawings of one specific embodiment thereof, while its scope will be pointed out more particularly in the appended claims.

In the drawings:

Fig. 1 is a plan of a motor-driven compressor embodying the invention;

Fig. 2 is a vertical, longitudinal section, on an enlarged scale, on line 2—2 of Fig. 1;

Figs. 3, 4, 5 and 6, are sectional views, on an enlarged scale, on line 3—3 of Fig. 1, illustrating the operation of the unloading mechanism;

Fig. 7 is an end elevation of the unloading mechanism in its neutral or initial position;

Fig. 8 is a sectional view on line 8—8 of Fig. 2;

Fig. 9 is a horizontal, sectional view on line 9—9 of Fig. 3;

Fig. 10 is a horizontal, sectional view illustrating the inlet for the refrigerant into the motor housing;

Fig. 11 is a sectional view illustrating one of the electric terminals for the motor;

Figs. 12 and 13 are end elevations of the unloading mechanism illustrating a slight modification, in which the load of the compressor is entirely removed from the motor for starting purposes;

Figs. 14 and 15 are sectional views corresponding with Figs. 12 and 13, respectively, and illustrating the means for predetermining the limits of movement of the oscillatory elements of the unloading mechanism; and

Fig. 16 is a sectional view similar to a portion of Fig. 2, showing a slight modification.

Referring to the drawings, and to the embodiment of the invention illustrated therein, and having reference at first more particularly to Fig. 3, there is shown a motor-driven compressor, the latter comprising a cylinder 20 having a lateral intake port 21, which is covered and uncovered by a piston 22. The charge drawn into the cylinder and compressed by the piston is discharged through openings 23 in a plate 24, having an annular seat 25 for an outlet valve 26, which, as shown, is a thin, steel, wafer-like disk, normally urged to its seat by a spring 27 within an outlet chamber 28 formed in a cylinder head 29, and communicating with an outlet passage 30, the latter in practice being connected with a condenser. In the present example, the cylinder 20 is in the nature of a sleeve or lining, fixedly mounted in a surrounding support, herein a housing 31, having a chamber 32 which encloses part of the driving mechanism.

The driving mechanism, as herein shown, comprises an element such as a crank-pin 33, having an orbital path, and suitably connected to the piston to reciprocate the latter, the connection shown being a shoe or cross-head 34, mounted to slide in a groove 35 extending transversely of the piston, though the invention is not limited to this form of driving connection, but might employ a connecting rod.

Turning now to Fig. 2, the crank-pin is driven by a rotatable element, herein a shaft 36, mounted to rotate in a bearing 37 presented by a plate 38, which constitutes a cover for the chamber 32. The plate 38 constitutes a partition between the chamber 32 and a motor chamber 39 also formed in the housing 31, and the other end of this motor chamber is closed and sealed by a cover-plate 40, thus providing a sealed housing for the entire mechanism.

The motor chamber 39 houses an electric motor comprising a stator 41 fixed in the housing, and a rotor 42 suitably secured to the shaft 36, as by providing the latter with a reduced portion 43, to which the rotor is secured, as by a key 44 and by a nut 45 threaded onto a further reduced portion 46. The nut urges the rotor, and a suitable thrust washer 47 toward a shoulder 48 presented by the body of the shaft, said washer resting against the adjacent end of the bearing 37.

The rotor is slightly offset axially with relation to the stator in a direction opposite to the bearing, thereby to utilize the magnetic flux to eliminate any tendency of the rotor to move endwise. The stator has three lead wires **49**, attached respectively to lead-in plugs **50**, one of which is shown in detail in Fig. 11, the same comprising a conductor **51** for attachment to the wire, and a tapered, threaded, insulating shell **52**, which is screwed into the housing **31**. The details of this plug have no necessary bearing upon the present invention, and therefore require no further description.

Referring now to Fig. 10, in the embodiment shown, the refrigerant to be compressed, instead of entering the chamber **32** directly, enters the motor chamber **39**, as by means of a plug **53** threaded into the housing, and provided with passages **54** and **55**, the former being connected as usual with an expander. The refrigerant, after entering the motor chamber **39**, enters the lower end of a conduit **56** (see Fig. 2), and passes thence through passages **57** and **58** in the plate **38** into the chamber **32**. From this chamber, the gas passes upwardly through a passage **59** in the housing **31** (see Fig. 3, and thence through a port **60** in registration with the lateral intake port **21** of the cylinder **20**. Thus, the refrigerant on its way to the cylinder, passes through the motor chamber, and cools the motor, as well as the shaft and its bearing.

The unloading mechanism will now be described, reference being had at first to Fig. 2. In general, the mechanism imparts to the piston a reciprocatory motion of variable amplitude, varying from a zone in which the piston covers and uncovers the lateral intake port and causes gas to be admitted through said port and discharged past the outlet valve to a zone within which the piston maintains said port closed. In the first zone, a full stroke is imparted to the piston, while in the second zone, the stroke is either reduced to one of small amplitude, or if desired may be reduced to zero. In the form shown in Figs. 2 to 8, inclusive, the stroke is reduced to one of small amplitude, while in the form shown in Figs. 12 to 15, inclusive, the stroke is reduced to zero. The amount of reduction of the stroke is determined by the amount of eccentricity of the oscillatory element now to be described.

Referring to Fig. 2, the crank-pin which has been referred to as an element having an orbital path is carried by an oscillatory element, herein a rockshaft **61**, having an axis of oscillation eccentric to the axis of rotation of the rotatable element, namely, the shaft **36**. When, therefore, the rockshaft **61** is turned about its axis, the radius of the orbit of the crank-pin is varied from a radius in which the piston is effective to cover and uncover the lateral intake port of the cylinder to a radius in which the piston is ineffective to uncover said port, and, furthermore, this change of radius changes the load of the compressor on the motor from full load, in which the piston is at full stroke, to a reduced load or no load at all, depending, as has been stated, upon the location of the axis of the rockshaft. This reduction, or total elimination of the load, enables the motor to start and to get up to speed partially or wholly free from load, and therefore a motor of low starting torque can be employed, with a direct drive, instead of using other expedients heretofore employed.

As herein shown, the eccentricity of the rockshaft **61** and corresponding eccentricity of the crank pin **33** are governed by a centrifugal governor which is responsive to variations in the speed of the motor. This is conveniently accomplished by mounting on the rockshaft a centrifugal weight **62** (best shown in Fig. 7), herein formed as an integral part of the rockshaft. Endwise movement of the rockshaft is prevented by suitable means, such as a screw **63** (see Fig. 8), having a reduced portion **64**, which is received in a segmental groove **65** in the rockshaft. If desired, the screw and the slot may be located near the inner end of the rockshaft, as shown in Fig. 16. The screw and slot, while employed primarily to prevent endwise movement of the rockshaft, also serve as one means to limit turning movement of the rockshaft. However, as they are near the axis, I prefer to employ other stops presently to be described, much farther from the axis, to limit turning movement of the rockshaft.

While the weight **62** might be relied upon without other aid to control the turning of the rockshaft, under the influence of variations in the speed of the motor, I prefer to employ a spring **66** (see Fig. 2) to assist the weight. This spring can be arranged to present a yielding resistance to the weight **62** in either direction,—that is to say, it may be utilized either to increase or to decrease the eccentricity of the crank-pin; but in the embodiment shown, the spring is arranged to have a neutral position in which it is not stressed, and in which position the stop screw **63** (see Fig. 8) is in the center of the segmental slot **65** when the machine is at rest, the intake port being closed. This is simply a matter of securing the ends of the spring in the desired relationship to the parts which they connect. As shown in Fig. 2, one end of the spring is wound about and secured to a plug **67**, having a tongue **68** which is received in a slot **69** in the shaft **36**, and the other end of the spring is wound about and secured to a similar plug **70**, having a tongue **71** received in a slot **72** in the rockshaft **61**. As herein shown, these slots are conveniently formed by making drilled holes, into which the tongues extend laterally.

In order that the rotating parts shall be in balance after the full speed of the motor is attained, I provide the rotatable shaft **36** with a fly-wheel **73**, having a weight **74**, which is opposite to the weight **62** when the latter is fully advanced. The counterweight **74** balances the weight **62**, as well as the rockshaft with its crank-pin. This ensures smooth running, without noticeable vibration, as the two weights under this condition constitute together a balanced fly-wheel. The fly-wheel **73** is provided with stops **76** and **77** (see Fig. 7), to be engaged by opposite edges of the weight **62** to limit turning movement of the rockshaft **61** in opposite directions.

The operation of the unloading mechanism will readily be understood from a comparison of Figs. 3 to 8, inclusive. Fig. 3 shows what may be termed the retarded position, in which the radius of the crank-pin is at minimum and the stroke of the piston is correspondingly at minimum. As hereinbefore stated, in the initial position of the crank-pin, when parts are at rest, the crank-pin may have a slight throw, as shown in Figs. 3 to 8, inclusive, or its axis may be coincident with the axis of the rotatable shaft **36**, in which it has no throw at all, as shown in the form illustrated in Figs. 12 to 15, inclusive. The form illustrated in Figs. 3 to 8, inclusive, is preferred, because of the small-

er radius through which the crank-pin and the rockshaft turn in advancing and retarding. This short radius gives the eccentric weight an increased leverage in throwing the crank-pin to its position of maximum throw, and in maintaining the piston at full stroke, and hence at maximum pumping efficiency. When the piston is in its maximum operating position, that is at the full stroke, the main shaft, rockshaft and crank-pin centers are preferably directly over each other in the order named. This provides a positive drive, so that the piston operates just as efficiently in this position as if no starting relief were provided. Furthermore, as hereinafter suggested, until this full stroke of the piston is reached, the piston may fall back and cushion any excess burden imposed by oil slugs in the compression chamber. When the rockshaft is in its neutral position and when the machine is at rest, the lateral intake port 21 is covered by the piston 22, and no refrigerant can enter the cylinder. When the port is closed, the refrigerant in the cylinder is simply compressed slightly, and then expanded, thus imposing no material load upon the motor. When the motor starts, there is only a slight load, or none at all, depending of course upon the amount of eccentricity of the rockshaft 61. With the first form, the stroke of the piston, when the motor starts to run, is shown by a comparison of Figs. 3 and 4, Fig. 3 showing the piston at the bottom of its stroke, and Fig. 4 showing the piston at the top of its stroke.

As the speed of the motor increases, the eccentricity of the crank-pin increases, until in the full running position shown in Figs. 5 and 6, the piston has its maximum stroke, Fig. 5 showing the piston at the bottom of its stroke with the port 21 uncovered by the piston, and Fig. 6 showing the piston at the top of its stroke with a slight clearance, amounting in practice to a few thousandths of an inch. During the increase of the piston stroke and before the full stroke is reached, if an oil slug should happen to be taken into the cylinder, no damage will result, because the resistance which is encountered will naturally cause a slight retardation in the position of the crank-pin, and a corresponding momentary shortening of the stroke of the piston.

It might be supposed that it would be more desirable to have the setting of the spring 66 such that the latter would tend to retain the crank-pin 33 in its fully retarded position,—that is, in the position in which the crank-pin has its shortest throw. Such setting of the spring has been found to produce satisfactory results, but it has been found more desirable to set the spring so that it tends to restore the crank-pin to its mid position. With the latter setting of the spring, the crank-pin is at mean position when the machine is at rest and the intake port is closed.

When the motor starts, the weight 62 will by its inertia lag behind the shaft 36, and will thus bring the crank-pin momentarily to its minimum throw, in opposition to the resistance of the spring. When, however, the shaft acquires sufficient speed, the centrifugal effect of the weight, due to its eccentric mounting, results in the weight being thrown outwardly with relation to the shaft. During the first half of this movement, the spring which is under stress assists the weight in moving outwardy with relation to the shaft.

As the speed of the shaft increases, the weight carries the rockshaft and the crank-pin past the neutral position of the spring, and thereafter the spring is stressed in the opposite direction, and yieldingly resists outward movement of the weight. When the weight, the rockshaft and the crank-pin reach their extreme outward position, the crank-pin has its greatest throw and the piston its greatest stroke.

When the current is cut off from the motor, and the speed of the shaft is reduced, the weight commences to lag behind the shaft, and is assisted by the spring during the first half of this backward movement with relation to the shaft. During this time, the throw of the crank-pin is reduced, the stroke of the piston is correspondingly decreased and the load on the motor is diminished, inasmuch as the piston has little or no work to do, depending of course upon whether the design shown in Figs. 3 to 8, inclusive, or that which is shown in Figs. 12 to 15, inclusive, is used. Moreover, it is to be noted that only a very slight shortening of the stroke of the piston is required to prevent the latter from uncovering the intake port. This means a definite and quick relief of compression stresses and consequent load on the motor.

Observation of the operation of the design illustrated in Figs. 3 to 8, inclusive, shows that sometimes when the motor stops, the crank-pin has returned to its position of minimum throw in opposition to the spring, while at other times, it returns only to the mid position in which the spring is neutral,—that is, not under stress. Observation has also shown that if the machine stops with the crank-pin at mid throw, when the motor starts again, the lag of the weight will bring the crank-pin momentarily to its minimum throw, and then as the speed of the motor increases, the crank-pin throw will be increased to maximum, as the motor speed approaches or reaches maximum.

Having thus described one embodiment of the invention, but without limiting myself thereto, what I claim and desire by Letters Patent to secure is:

1. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, and mechanism to impart to said piston a reciprocatory motion of variable amplitude varying from a zone within which said piston covers and uncovers said port and causes refrigerant to be admitted through said port and discharged past said outlet valve, to a zone within which said piston maintains said port closed.

2. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, means to reciprocate said piston, said means including an element having an orbital path, and means to change the path of said element to vary the stroke of said piston from a full stroke during which said piston covers and uncovers said port to a condition during which said piston maintains said port covered.

3. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, means to reciprocate said piston, said means including an element having an orbital path, and means to vary the radius of the orbit of said element from a radius in which said piston is effective to cover

and uncover said port to a radius in which said piston is ineffective to uncover said port.

4. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, an element having an orbital path to impart a reciprocatory motion to said piston, an oscillatory element which carries the first-mentioned element and moves it in its orbital path, and means to oscillate said oscillatory element to shift the first-mentioned element from a path in which the latter is effective to cause said piston to cover and uncover said port to a path in which the first-mentioned element is ineffective to cause said piston to uncover said port.

5. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, a rotatable element, an oscillatory element carried by said rotatable element and having an axis of oscillation eccentric to the axis of rotation of said rotatable element, an orbitally movable element carried by said oscillatory element in an orbital path during the rotation of said rotatable element, and means to cause said oscillatory element to oscillate about its axis to shift said orbitally movable element toward and from the axis of said rotatable element.

6. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, a rotatable element, an oscillatory element carried by said rotatable element and having an axis of oscillation eccentric to the axis of rotation of said rotatable element, an orbitally movable element carried by said oscillatory element in an orbital path during the rotation of said rotatable element, biasing means normally to retain said oscillatory element in an initial position adapted to yield to permit said oscillatory element to move about its axis, and means to cause said oscillatory element to move in opposition to said biasing means.

7. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, a rotatable element, an oscillatory element carried by said rotatable element and having an axis of oscillation eccentric to the axis of rotation of said rotatable element, an orbitally movable element carried by said oscillatory element in an orbital path during the rotation of said rotatable element, biasing means normally to retain said oscillatory element in an initial position and adapted to yield to permit said oscillatory element to move about its axis, and speed-responsive means to cause said oscillatory element to move in opposition to said biasing means.

8. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, a rotatable element, an oscillatory element carried by said rotatable element and having an axis of oscillation eccentric to the axis of rotation of said rotatable element, an orbitally movable element carried by said oscillatory element in an orbital path during the rotation of said rotatable element, means to limit the oscillatory movement of said oscillatory element, and speed-responsive means to cause said oscillatory element to oscillate in accordance with variations in the speed of rotation of said rotatable element.

9. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, a rotatable element, an oscillatory element carried by said rotatable element and having an axis of oscillation eccentric to the axis of rotation of said rotatable element, an orbitally movable element carried by said oscillatory element in an orbital path during the rotation of said rotatable element, means to limit the oscillatory movement of said oscillatory element, speed-responsive means to cause said oscillatory element to oscillate in accordance with variations in the speed of rotation of said rotatable element, and a spring which resists oscillatory movement of said oscillatory element and restores said oscillatory element to its initial position as the speed of rotation of said rotatable element is reduced.

10. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, a rotatable element, an oscillatory element carried by said rotatable element and having an axis of oscillation eccentric to the axis of rotation of said rotatable element, an orbitally movable element carried by said oscillatory element in an orbital path during the rotation of said rotatable element, means to predetermine limits of the oscillatory movement of said oscillatory element in opposite directions, speed-responsive means to cause said oscillatory element to oscillate in accordance with variations in the speed of rotation of said rotatable element, and a spring which resists oscillatory movement of said oscillatory element and tends to restore said oscillatory element to an initial position between said limits as the speed of rotation of said rotatable element is reduced.

11. In a refrigerant pump, the combination of a cylinder having a lateral intake port, an outlet valve, a piston working in said cylinder and adapted to cover and uncover said port, a rotatable element, an oscillatory element carried by said rotatable element and having an axis of oscillation eccentric to the axis of rotation of said rotatable element, an orbitally movable element carried by said oscillatory element in an orbital path during the rotation of said rotatable element, a weight carried by said oscillatory element to cause the latter to oscillate about its axis in response to variations in the speed of said rotatable element to shift said orbitally movable element toward and from the axis of said rotatable element, and a weight carried by said rotatable element to counterbalance the first-mentioned weight when said orbitally movable element is at its greatest distance from the axis of said rotatable element.

12. In a refrigerating machine, the combination of a compressor to compress the refrigerant, said compressor including a cylinder having a lateral intake port, a piston reciprocating in said cylinder and covering and uncovering said port, a motor to drive said compressor, and driving mechanism connecting said motor and said compressor, and comprising means responsive to the speed of said motor to vary the amplitude of the stroke of said piston from a zone in which the piston covers and uncovers said port to a zone in which said piston maintains said port closed.

13. In a refrigerating machine, the combination of a compressor to compress the refrigerant, a rotatable element to drive said compressor, and positive driving mechanism connecting said element to said compressor, said driving mechanism including a revoluble element which is revoluble about an axis other than its own, and means responsive to variations of the speed of said rotatable revoluble element to move said element toward the axis of said rotatable element when the speed of said rotatable element is reduced, and to move said revoluble element from the axis of said rotatable element when the speed of said rotatable element is increased.

14. In a refrigerating machine, the combination of a compressor to compress the refrigerant, a rotatable element to drive said compressor, and positive driving mechanism connecting said element to said compressor, said driving mechanism including a crank-pin which drives said compressor, and means responsive to variations of the speed of said rotatable element to move said crank-pin toward the axis of said rotatable element when the speed of said rotatable element is reduced, and to move said crank-pin from the axis of said rotatable element when the speed of said rotatable element is increased.

15. In a refrigerating machine, the combination of a compressor to compress the refrigerant, said compressor including a cylinder and a piston to reciprocate therein, a rotatable element to drive said piston, and driving mechanism between said element and said piston, said driving mechanism including stroke-changing means responsive to changes of the speed of said element to diminish the length of the stroke of said piston as the speed of said rotatable element diminishes, and to increase the length of said stroke as the speed of said rotatable element increases.

16. In a refrigerating machine, the combination of a compressor to compress the refrigerant, a shaft to operate said compressor, and driving mechanism connecting said shaft and said compressor, said mechanism including a crank-pin, and means responsive to the speed of said shaft to move said crank-pin toward the axis about which it revolves when the speed of said shaft diminishes, and to move said crank-pin from said axis as the speed of said shaft increases.

17. In a refrigerating machine, the combination of a compressor to compress the refrigerant, an electric motor, and driving mechanism at all times connecting said motor to said compressor, said mechanism including means to increase the mechanical advantage as the speed of said motor diminishes and to decrease the mechanical advantage as the speed of said motor increases, said means including a weight which tends to lag behind said motor when said motor starts, and to lag behind said motor when the speed of said motor diminishes.

18. In a refrigerating machine, the combination of a compressor to compress the refrigerant, an electric motor, and driving mechanism at all times connecting said motor to said compressor, said mechanism including means automatically to change the driving relationship between said motor and said compressor in accordance with differences between the power of said motor and the load of said compressor, said means including a weight which causes the effective load to be at minimum when the power of said motor is at minimum, and which causes the effective load to be at maximum when the power of said motor is at maximum.

19. In a refrigerating machine, the combination of a compressor to compress the refrigerant, an electric motor, and gearless speed-responsive mechanism at all times connecting said motor and said compressor to increase the mechanical advantage as the speed and torque of said motor diminish and to decrease the mechanical advantage as the speed and torque of said motor increase.

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