

Dec. 5, 1939.

E. M. PAULLIN, JR

2,181,978

VARIABLE CAPACITY COMPRESSOR

Filed March 11, 1938

8 Sheets-Sheet 1

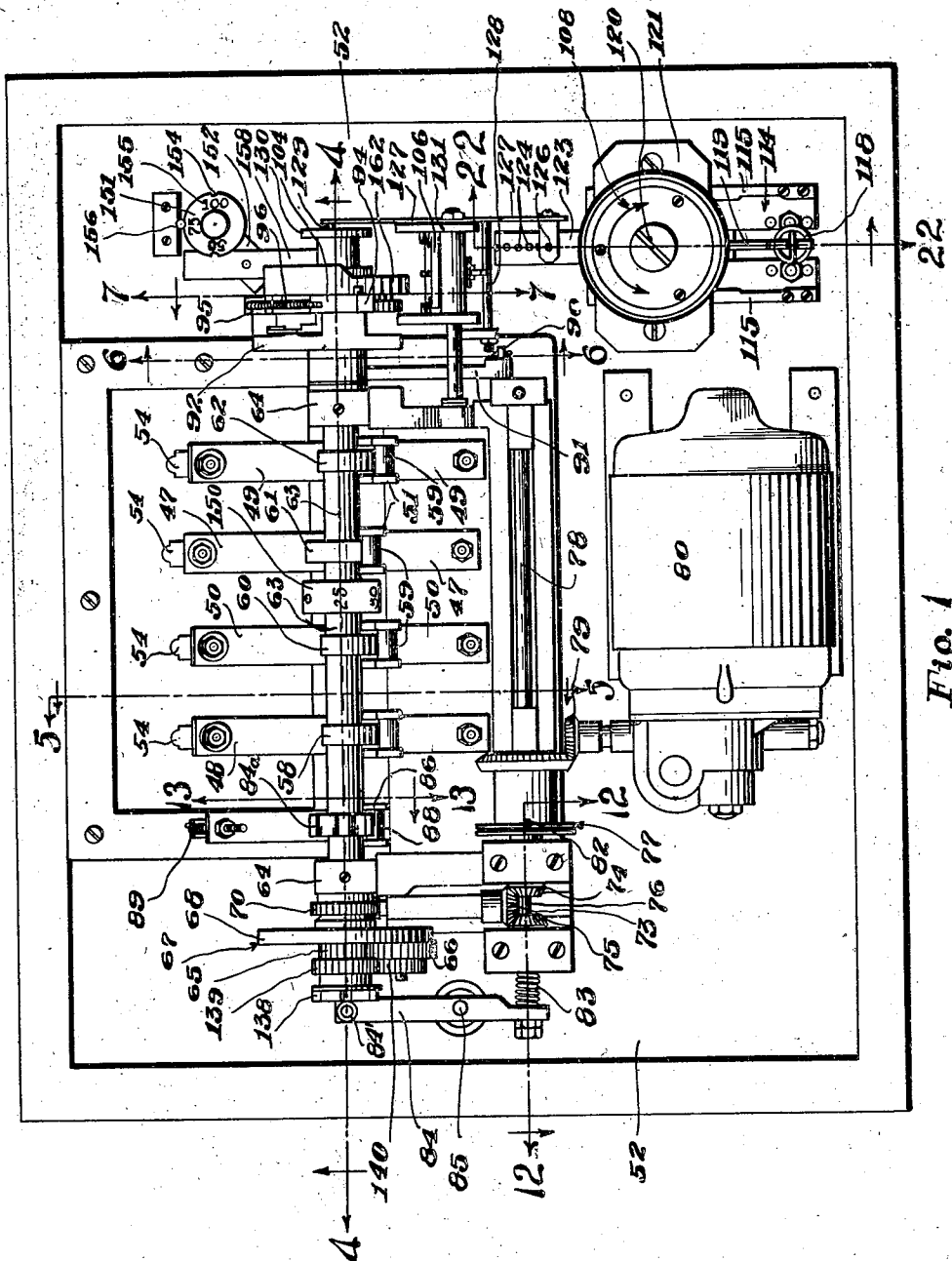


Fig. 1

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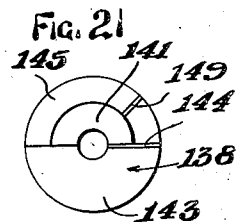
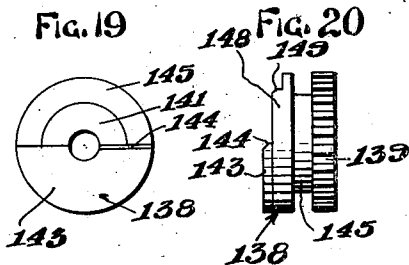
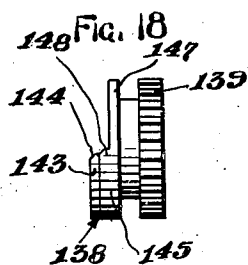
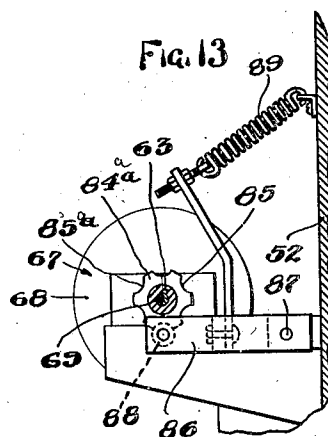
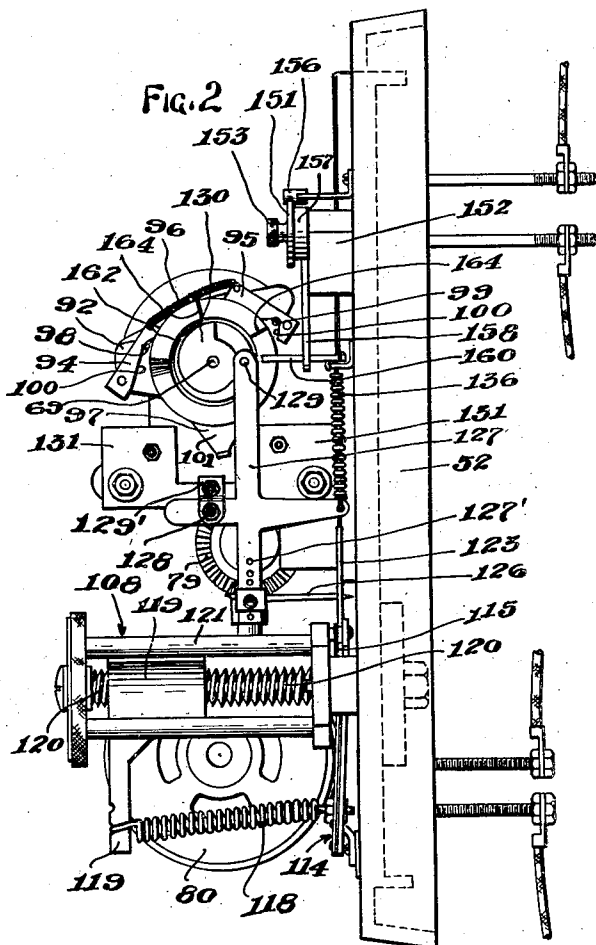
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8 Sheets-Sheet 2



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VARIABLE CAPACITY COMPRESSOR

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Fig. 3

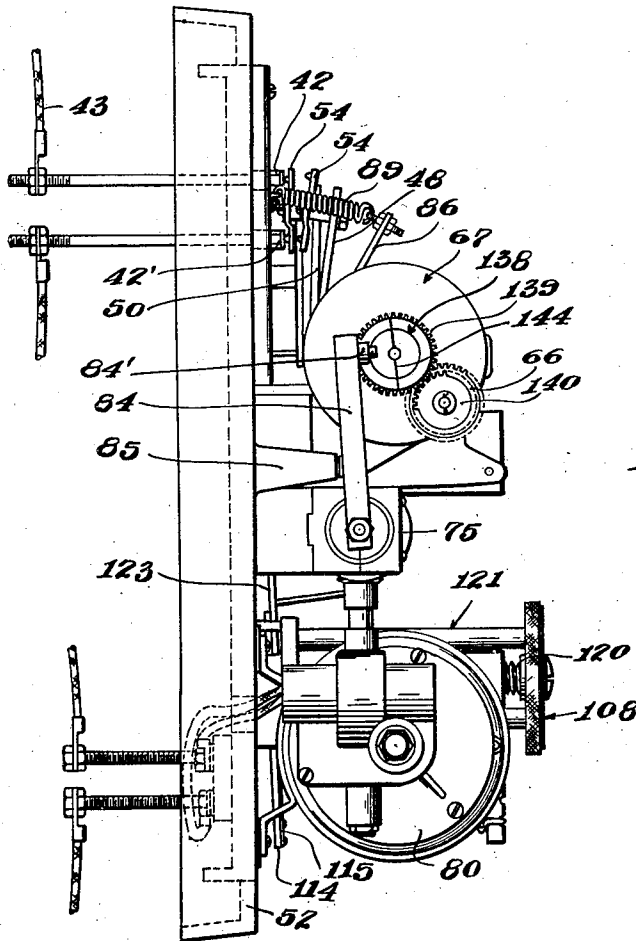


Fig. 14

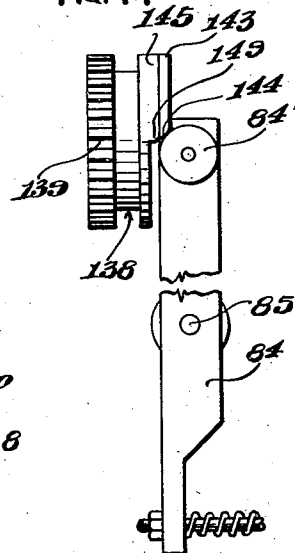
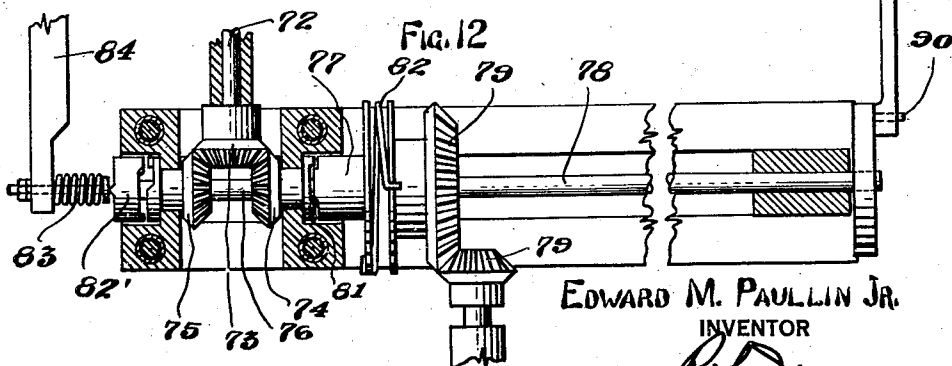


Fig. 12



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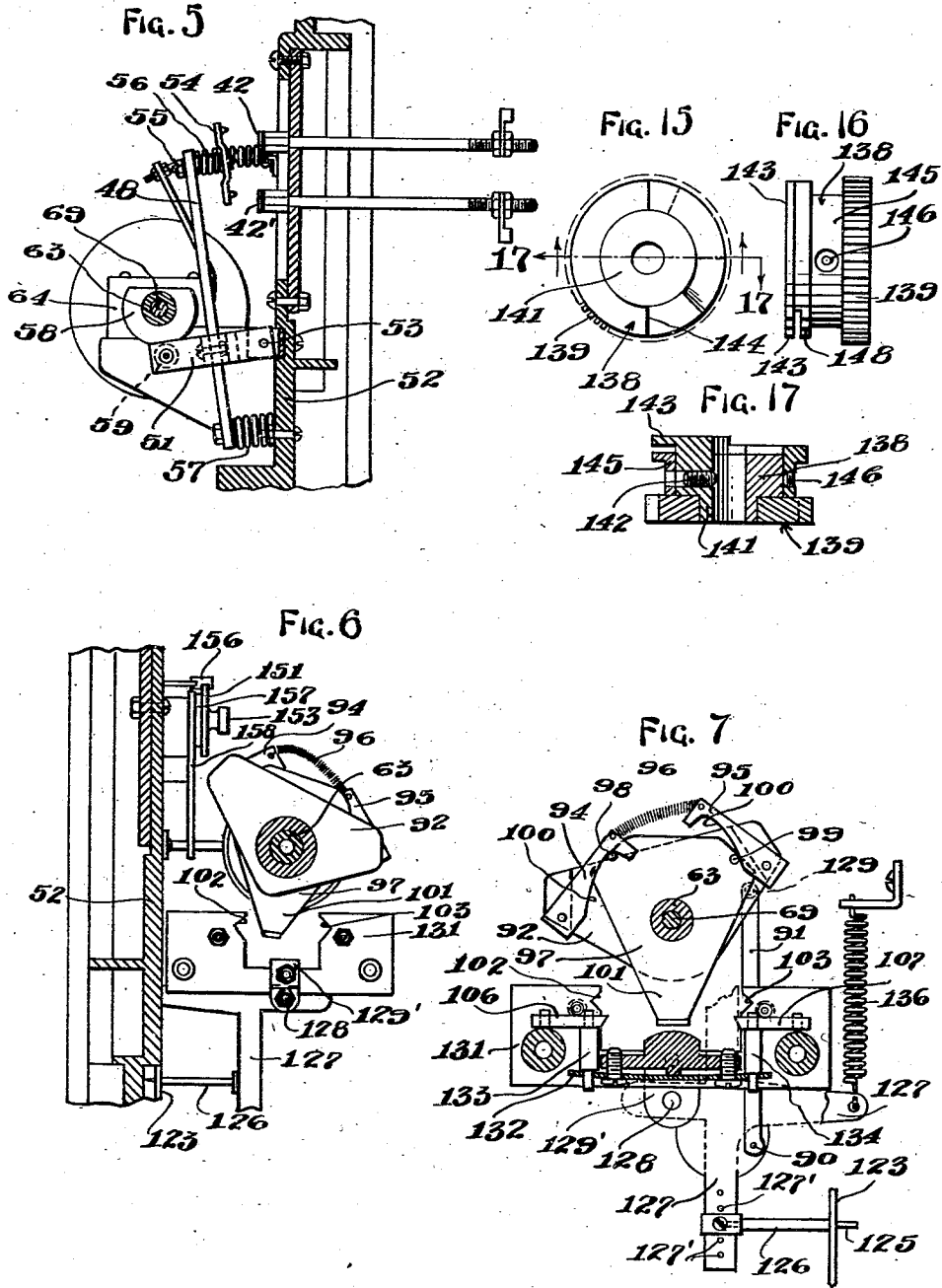
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VARIABLE CAPACITY COMPRESSOR

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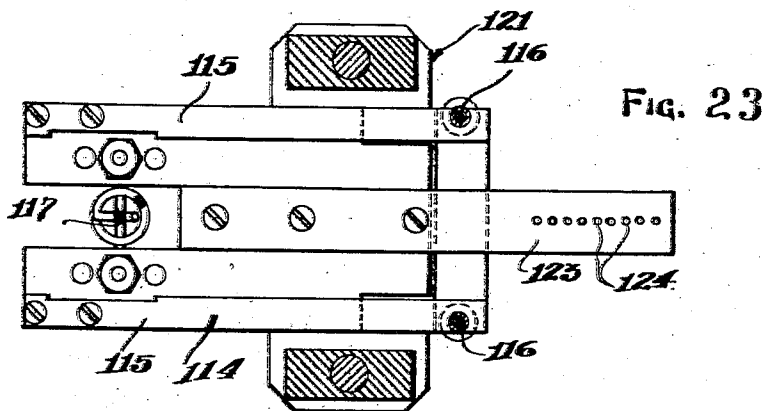
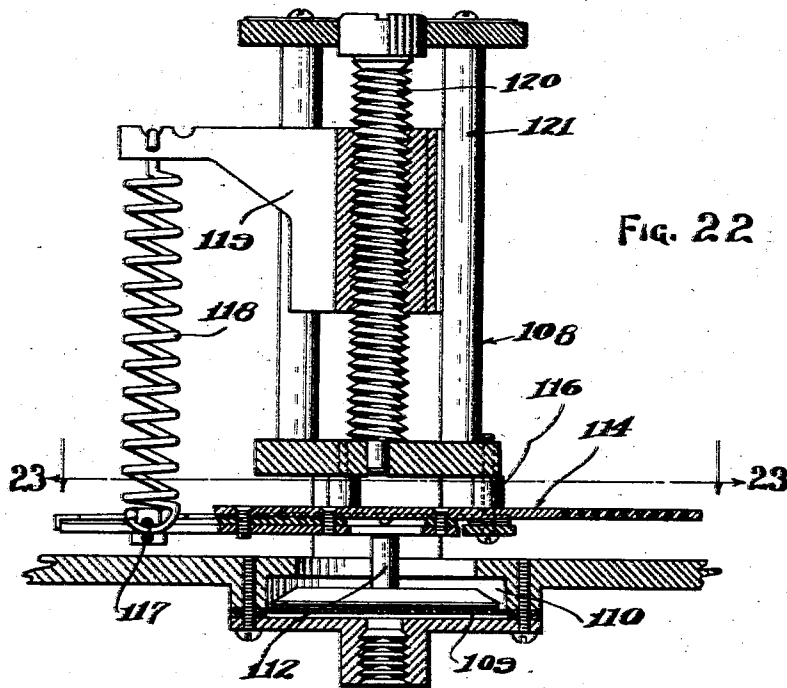
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VARIABLE CAPACITY COMPRESSOR

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VARIABLE CAPACITY COMPRESSOR

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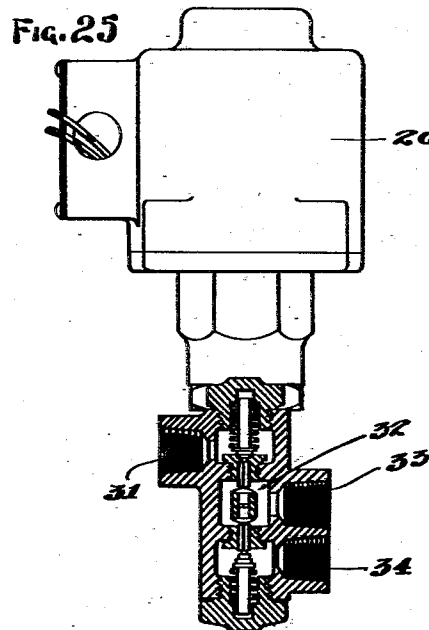
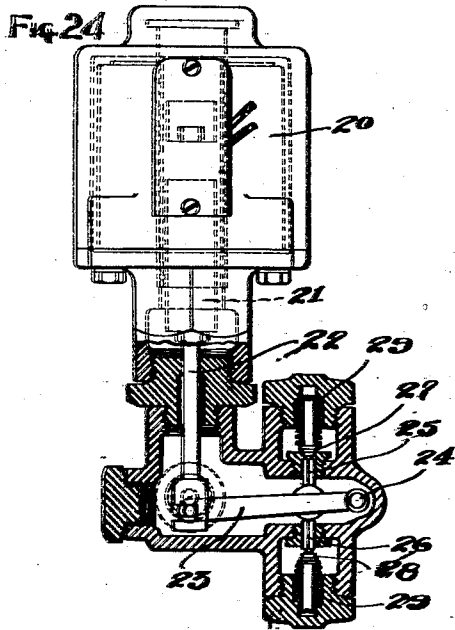


Fig. 26

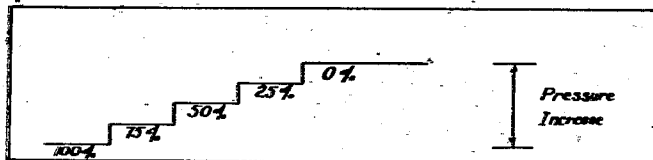
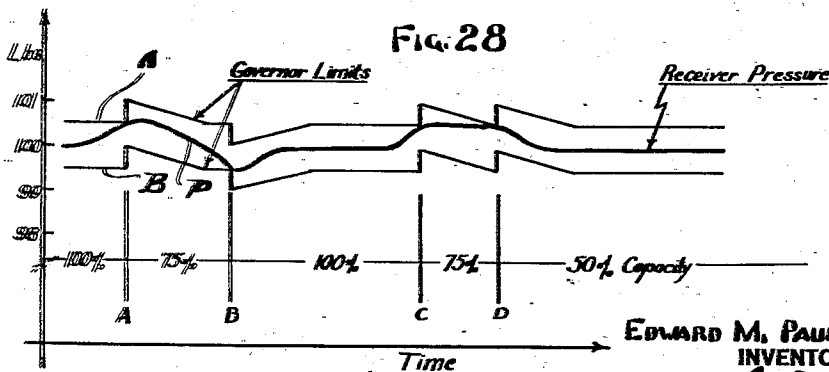
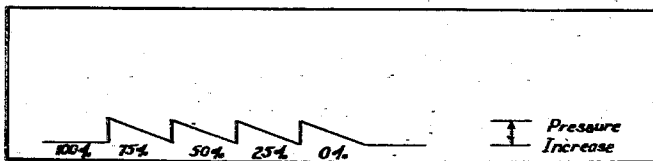


Fig. 27



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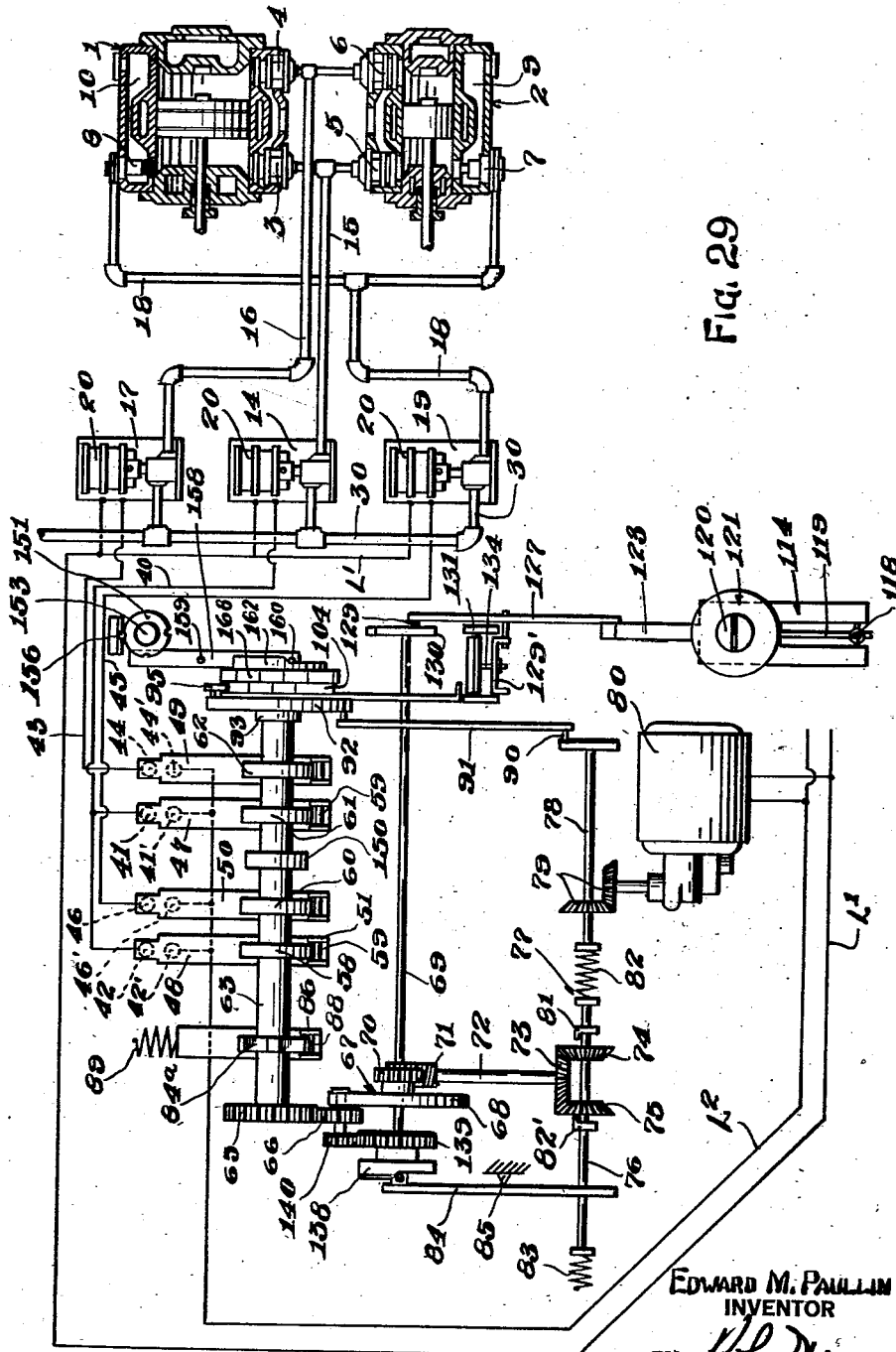


Fig. 29

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UNITED STATES PATENT OFFICE

2,181,978

VARIABLE CAPACITY COMPRESSOR

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Application March 11, 1938, Serial No. 195,277

33 Claims. (Cl. 230-4)

This invention relates to variable capacity air or gas compressors, and more particularly to a governing mechanism for controlling the loading and unloading of a compressor in predetermined percentages of its capacity, such loading and unloading being automatically controlled by pressure of fluid compressed, either before or after compression in accordance with the load demands upon the compressor, thereby maintaining practically constant the suction or the reservoir pressure.

More particularly the present invention is an improvement of the variable capacity compressor and governing mechanism disclosed in my co-pending application Serial Number 740,869, filed August 22, 1934.

An object of the present invention is to provide a variable capacity control governor or instrument which embodies means, the action of which makes it possible to operate the compressor at fractional percentages of its capacity at exactly the same pressures as those at which it would operate at full load and capacity.

Heretofore, in variable capacity compressors and their control mechanisms, the above operation has not been possible, since in approved types on the market, with the compressor operating at full capacity a decrease in load demand is reflected in an increased receiver pressure. If the increased pressure is sufficient to cause the governor or control instrument to operate, the compressor drops to 75% capacity operation and continues to operate at the higher pressure unless the pressure in the reservoir system due to the decreased compressor capacity tends to fall off. If a further increase in pressure is had, the governor or control mechanism will again operate to reduce the output capacity of the compressor to 50%. Likewise the pressures pyramid until finally the compressor is completely unloaded at a pressure which is considerably above the normal 100% capacity pressure, actually four times the pressure differential per step of fractional unloading of the compressor.

With the present invention, the re-positioning means will, within a predetermined time, always re-position the step control operating means to its original position, thereby permitting operation of the compressor at partial capacity within the same pressure limits as at full load or capacity.

Another object of the invention is to provide in combination with an air or gas compressor, an instrument or governor which will hold an average pressure on a system by varying compressor capacity and re-position the governor limits after

each successive step in the loading or unloading of the compressor.

In some systems or compressor installations where the receiver system is particularly large or the rate of variance of compressor capacity, that is, the lag of each step of variance of compressor capacity, is particularly small, there may be sufficient time lag or delay between the change in capacity of the compressor and the pressure in the receiving system so that the restoring of the pressure limits in the governor mechanism would cause successive operations thereof that were not actually in accordance with capacity demands. This would mean that the instrument or governor would be operating or swinging through two or three steps of capacity varying operation when only one step would be required to accommodate or compensate for the pressure change or the increase or decrease in the demand for air or gas in the system.

Therefore it is an object of the present invention to provide, in a variable capacity compressor and its control, means which controls the restoration feature of the bias return of the instrument or governor which will delay the action of the re-setting or bias return for one step, two steps, any desired number of steps or even for the entire range of the instrument or governor, thereby providing a simulation of the action of governor mechanisms in present use in which pressures are allowed to pyramid, or in other words, if one-half pound variances is required for the first step, an additional one-half pound will be required for the second step, etc., through the entire range of loading and unloading of the compressor, without requiring such pyramiding of pressures.

By delaying the re-setting or bias return of the instrument or governor the limits between steps of operation of the governor and consequently the fractional unloading or loading of the compressor are reduced, thereby narrowing the differential and holding the pressure output more nearly at demand, than would be provided if such delay of the resetting or bias return were not provided. For example, if one-half pound pressure variance would cause the instrument or governor to change the capacity of the compressor one step or one predetermined fractional portion of its capacity, and there was a delay in the reaction of this change in the reservoir system and the present elements of the instrument were returned to their original position by the return action, that same half-pound pressure variance would cause the instrument or governor to move

through another step of operation. Such action is prevented by the present invention.

Other objects of the present invention are to provide in a variable capacity compressor and its control instrument or governor, a mechanism which is positive in operation, provides automatic initial unloading of the compressor, embodies a compressor capacity indicator whereby the percentage of full capacity at which the compressor is operating may be readily ascertained at all times, embodies a demand limiter or capacity selector whereby the mechanism may be set to cause operation of the compressor at any predetermined percentage of its full capacity, beyond which set percentage of capacity the compressor will not go; a mechanism which is responsive to time as well as pressure variances; embodies adjustable differential means whereby the differential in pressures required to load or unload the compressor in steps may be varied as desired, and one which readily lends itself to control from a remote point.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a variable capacity compressor embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a plan view of the improved governor mechanism for a variable capacity compressor.

Figure 2 is an end elevation of the governor.

Figure 3 is an end elevation of the governor showing the end opposite to the one shown in Figure 2.

Figure 4 is a longitudinal section through a part of the governor taken on the line 4—4 of Figure 1.

Figure 5 is a detailed section of a part of the governor taken on the line 5—5 of Figure 1 and showing the contact making and breaking mechanism in elevation.

Figure 6 is a detailed section on the line 6—6 of Figure 1 showing part of the resetting mechanism.

Figure 7 is a section on the line 7—7 of Figure 1 showing a part of the operating mechanism for the contact making and breaking cams.

Figure 8 is a detailed side elevation of the demand limiter mechanism.

Figure 9 is a detail in plan of the limiter mechanism.

Figure 10 is a detailed plan view of the demand limiter cam.

Figure 11 is a diagrammatic lay-out of the demand limiter cam.

Figure 12 is a detailed section taken on the line 12—12 of Figure 1 and showing the power connecting mechanism.

Figure 13 is a detailed section on line 13—13 of Figure 1 showing the step-by-step cam.

Figure 14 is a detailed view of the resetting cam and lever.

Figure 15 is a front elevation of the resetting cam.

Figure 16 is an edge view of the resetting cam. Figure 17 is a section through the resetting cam.

Figure 18 is an edge view of the resetting cam showing it in one adjusted position.

Figure 19 is a front elevation of the resetting

cam showing it in the adjusted position illustrated in Figure 18.

Figure 20 is an edge elevation of the resetting cam showing it in a different adjustment from that shown in Figures 18 and 19.

Figure 21 is a front elevation of the resetting cam in the adjusted position shown in Figure 20.

Figure 22 is a vertical section through the pressure operated mechanism and taken on the line 22—22 of Figure 1.

Figure 23 is a horizontal section through the pressure operated mechanism and taken on the line 23—23 of Figure 22.

Figure 24 is a detailed view partly in section of a solenoid operated valve employed in the variable capacity compressor, control.

Figure 25 is a view partly in section and partly in elevation of the solenoid valve and taken at right angles to the view shown in Figure 24.

Figures 26, 27 and 28 are a series of graphs illustrating the phases of operation of the variable capacity compressor. Figure 26 shows a curve or graph of the loading or unloading of the present approved type of variable capacity compressor, while Figures 27 and 28 show that of a variable capacity compressor constructed in accordance with the present invention.

Figure 29 is a diagrammatic view illustrating the variable capacity compressor and governor arrangement.

Referring more particularly to the drawings, and with particular reference to the diagrammatic Figure 29, a multi-cylinder compressor is shown comprising a low pressure cylinder 1 and a high pressure cylinder 2. These compressor cylinders are loaded and unloaded in predetermined fractional percentages of their capacity by the various control valves 3, 4, 5, 6, 7 and 8. While, in the drawings, the loading and unloading of the compressor cylinders is illustrated as being provided through the medium of holding open suction valves which are indicated as the control valves 3, 4, 5 and 6 and by opening the clearance pockets 9 and 10 through the medium of the control valves 7 and 8 respectively, it is to be understood that the improved control or governor mechanism forming the present invention may be employed in connection with any approved type of control or unloading valves and with any approved system of unloading such as the one illustrated in Figure 29 of the drawings, or other approved types employing only unloader control valves or various combinations of unloader or control valves as shown, for instance, in Patents Nos. 1,636,439; 1,704,343; 1,579,781; 1,579,782; 1,764,646, and others.

In Fig. 29 of the drawings the various control valves of the cylinders 1 and 2 are shown connected in pairs as, for instance, the control valves 3 and 5 are connected to each other and to the solenoid operated distributor valve structure 14 through a pipe 15. The valves 4 and 6 are connected together and through the pipe 16 to the solenoid operated distributor valve 17, while the valves 7 and 8 are connected through the pipe 18 with the solenoid operated distributor valve 19, thus the valves will operate in pairs to simultaneously load and unload both the low pressure cylinder 1 and the high pressure cylinder 2 in the same predetermined percentage of capacity of the cylinders.

The solenoid operated valves 14, 17 and 19 are all similar in construction and may be of any approved type of solenoid operated valve applicable for performing the work. One such con-

struction of solenoid operated valve is shown in detail in Figures 24 and 25 of the drawings.

Each of the distributor valve structures comprises a solenoid 20, the core 21 of which is connected by means of a rod 22 to the pivoted valve operated lever 23. The valve operating lever is pivotally supported as shown at 24 and contacts the valve operating pins 25 and 26 which in turn engage the valves 27 and 28 respectively for unseating the valves. The valves 27 and 28 are seated by springs 29 when the pressure of the lever 23 is relieved therefrom.

When the solenoid 20 is de-energized, the dropping of the core 21 will move the lever 23 into the position shown in Figure 24 of the drawings at which time the pressure fluid valve 27 will be seated, cutting off the flow of pressure fluid as vented from the control valves which are connected to the respective solenoid operated valve, and the valve 28 will be unseated.

Pressure fluid from any suitable source, preferably either the suction line of the compressor system or from the receiver into which the fluid compressed is delivered, is delivered to the solenoid operated valve structure through a pipe 30 and enters the valve structure through the port 34. When the valve 28 is open or unseated the pressure fluid will flow through the solenoid operated valve structure into the chamber 32 therein, outwardly through the port 33 into any one of the pipes 15, 16, or 18, to which the respective valve is connected, for supplying pressure fluid to operate the control valves which are connected to the solenoid operated valve for unloading the compressor cylinders in the fractional percentages of their capacities as provided by the respective control valves. For example, when the solenoid 20 of the valve structure 14 is de-energized through the medium of the governor mechanism, as will be hereinafter fully described, pressure fluid passes from the pipe 30 through the solenoid operated valve structure and pipe 15 to the control valves 3 and 5, operating these control valves and rendering the crank ends of the cylinders 1 and 2 non-compressing, thus unloading the crank ends and causing the compressor to operate at 50 per cent of its capacity.

When the solenoid 20 is energized, the core 21 thereof will rise, allowing the spring 29 to seat the valve 28 and cut off the delivery of operating pressure fluid to the valves 3 and 5, or such other of the control valves as are connected to the solenoid de-energized. When the core 21 rises it will open the valve 27 and will connect the control valves through the port 33, chamber 32, to the exhaust or bleed-off port 31, allowing the pressure fluid to bleed from the control valves and the control valves to seat, thereby loading the compressor in the proportion of its capacity, as controlled by the respective affected control valves. The port 31 may either open to atmosphere, or it may be connected to the suction line of the compressor system if it is so desired, this depending upon the type of fluid being compressed.

The specific construction of the control valves 3, 4, 5, 6, 7 and 8 will not be described in the present application since they are relatively well known and their specific construction is illustrated and described in the prior patents hereinabove mentioned, and it is to be understood that the present invention is not limited to any particular type of control valve, but any of the many types of compressor loading and unloading control valves now in use may be employed in the

present invention without departing from the spirit of the invention.

The present invention comprises a novel arrangement of various mechanisms, both pressure and electrically operated, for controlling the energizing of the solenoids 20 of the various distributor valves, for timing the period of energization of such solenoids, and for operating the control mechanism in such manner as to make it highly sensitive to variations or differentials in either receiver or suction pressure, and to the demand on the compressor, so that the loading and the unloading steps of the compressor may be effected with much narrower or reduced differentials than has been possible with the use of approved types of compressor governor mechanisms.

For instance, in the various approved types of compressor unloading control governors and systems heretofore in use, a differential or variance of approximately two pounds is required to effect successive steps of loading or unloading the compressor cylinders and these variances build up or pyramid, whereas in the present variable capacity compressor and control governor therefor the effecting of such successive steps of loading or unloading on a differential or variance of approximately one-half pound or even less in the pressure of fluid compressed will be permitted, and in lieu of such variances pyramided to require the successive steps, the present mechanism will effect the successive steps on successive differentials of equal degree.

One end of the circuit of each of the solenoid valves 14, 17 and 19 is connected with the line L—1 of the main current supply and the other ends of the coils of the solenoids are connected through suitable wires with contact points on the governor mechanism. For instance, the solenoid 20 of the valve 14 is connected by means of wire 40 to the contacts 41 and 42. The solenoid 20 of the valve 17 is connected through the wire 43 with the governor carried contact 44, while the solenoid 20 of the valve structure 19 is connected through the wire 45 with the contact 46 of the governor mechanism. Electrical circuits are completed through the solenoids by contact levers 47, 48, 49 and 50, which bridge or connect the contacts 41 and 41', 42 and 42', 44 and 44', and 46 and 46'. The contacts 41', 42', 44' and 46' are connected to the line L—2 of the main electrical current supply.

The specific construction and mounting of the circuit closing contact levers is illustrated in Figure 5 of the drawings, wherein the contact lever 48 and its cooperating mechanisms are illustrated. The specific construction of the contact levers will be described in connection with the lever 48, but it is to be understood that all of the levers are similarly constructed and mounted. The lever 48 is carried by an arm 51, which is pivotally supported on the supporting base 52 of the governor mechanism as shown at 53. For the purpose of insuring proper contact, a contact bar 54 is connected to the lever 48 by a bolt 55 on which the bar 54 is slidably mounted. The bar 54 is urged into contact making position by a spring 56, and the contact lever 48 is also urged into contact making position by means of a spring 57 which engages the end of the lever 48 opposite of its connection with the pivoted arm 52 from the end which carries the contact bar 54.

The lever 48 is moved out of contact making position by means of a cam 58 which engages a cam roller 59 carried by the outer free end of the pivoted arm 51. Cams 60, 61, and 62 are provided for operating the contact levers 50, 47, and 49

respectively, and they are similar to the cam 58. The cams 58, 60, 61 and 62 are carried by a shaft 63, which is shown in the drawings, with the exception of the diagrammatic Figure 29, as a hollow shaft which receives therein a second shaft, hereinafter referred to specifically. The making of the shaft 63 hollow and the extending the second shaft therethrough is merely an expedient to consolidate the governor mechanism and render it more compact, so that this shaft 63 need not be a hollow shaft in so far as the spirit of the present invention is concerned.

The hollow shaft 63 is rotatably supported in suitable bearings 64, carried by the supporting base 52 of the governor mechanism and it has a gear 65 mounted thereon which meshes with the pinion 66 of the differential gear mechanism 67. The pinion 66 is carried by the disk 68 of the differential gear mechanism, which disk is rotatably mounted on the shaft 63. In the drawings, with the exception of the diagrammatic Figure 29, a shaft 69 is shown as extending through the hollow shaft 63 for the purpose of compactness in the construction of the governor, but if expedient this shaft 69 may be placed in any suitable position, in proper relation to the shaft 63. The disk 68 has a gear 70 thereon which meshes with a worm 71. This worm 71 is carried by a shaft 72 which has a bevel gear 73 thereon. The beveled gear 73 is adapted to mesh with either one of the bevel gears 74 or 75, which are carried by the shaft 76. The shaft 76 is connected by an expansive spring clutch 77 with the shaft 78. The shaft 78 is connected by suitable gearing 79 with the operating motor 80 of the governor mechanism in such manner that the shaft 78 will rotate continuously during the operation of the motor 80.

The bevel gears 74 and 75 are rotatably mounted on the shaft 76 and they are always in mesh with the gear 73. The bevel gears 74 and 75 are rotatably connected to the shaft 76 by means of clutches 81 and 82'. Either the gear 74 or 75 is rotated with the shaft 76 depending upon the direction of movement of the shaft 76 against the spring 82 of the clutch 77 or the spring 83 which engages the opposite end of the shaft. The shaft 76 is either held in neutral position as shown in Figure 29 of the drawings, at which time the disk 68 is stationary, or it is forced to the right, thereby connecting the gear 75 with the shaft 76, or forced to the left, thereby connecting the gear 74 to the shaft through the medium of the pin 81. The movement of the shaft 76 is caused by movement of the lever 84 which is pivoted on a suitable fulcrum 85.

The shaft 63 is rotated, in either direction, for rotating the cams 58, 60, 61 and 62, depending upon which of the gears 74 or 75 are rotatably connected to the shaft 76. The rotation of the cams 58, 60, 61 and 62 in one direction causes the cams to depress the respective contact levers for opening the circuits, while the rotation of the shaft in a reverse direction releases the contact levers from the restraint of the cams and permits the springs 57 to act to close the circuit through the respective contacts. The cams 58, 60, 61 and 62 are set on the shaft 63 at different angles so as to provide the proper sequence of operation of the various contact levers to provide proper sequence control of the loading and unloading of the compressor. A stop cam 84^a is mounted on the shaft 63 and has a plurality of arcuate indentations or serrations 85^a in its circumference. A pivoted arm 86 is pivotally supported from the supporting base 52, as shown at 87 in Figure 13 of the draw-

ings, and it has a roller 88 on its outer free end which engages in any one of the notches or serrations 85 to provide a stop to prevent hunting movement of the governor mechanism. The pivoted arm 86 is urged into stop relationship with the stop cam 84^a by a spring 89, which is connected to the pivoted arm 86. The spring 89 is tensioned to cause the roller 88 to be urged against the perimeter of the cam 84^a with sufficient strength to provide a brake or stop to prevent over-run of the shaft 63, the tension of the spring 89, however, being such that upon the starting of operation of the governor mechanism and rotation of the shaft 63 the shaft will be permitted to move at least one step, or sufficient distance to provide one step in the unloading of the compressor.

The shaft 78 has a crank pin 90 thereon which is connected to a kick rod 91. The kicking rod 91 is connected to a yoke 92. The yoke 92 oscillates back and forth, pivoting or rocking on a bearing 93 on the shaft 63. The yoke 92 has two dogs 94 and 95 pivotally mounted thereon, connected by a spring 96 at their free ends and normally held in a neutral position by a leaf 97, which is rockably mounted on the shaft 63. The leaf 97 carries two pins 98 and 99 which engage the cam surfaces 100 of the dogs 94 and 95 respectively, and hold the two dogs out of operative position. The leaf 97 has an extension 101 thereon which swings through a given arc, being repositioned at the end of each stroke by engagement with suitable stops 106 and 107, which are moved into and out of stopping position as will be hereinafter described. Notches 102 and 103 are provided in the carrier member 131 to permit normal swinging movement of the leaf 97 through its complete path. The leaf 97 is mounted in relation to the yoke 92 to provide sufficient friction to move the leaf with the rocking of the yoke but to permit limited movement of the leaf independently of the yoke if the extension 101 of the leaf engages the stops or other means stop or limit its movement. If the extension 101 is not allowed to travel through its entire stroke the leaf 97 will stop but the yoke 92 will continue its movement, thereby allowing either the pin 98 or 99, depending upon which direction the yoke is moving when restriction is applied to the leaf 97, to be displaced with respect to the dogs 94 and 95. If the pins are displaced a dog will then drop, for example, into the position shown at the left hand side of Figure 7 of the drawings, and on the return stroke of the yoke 92 the dog, which has dropped, will engage the ratchet wheel 104. The ratchet wheel 104 is keyed to or rigidly carried by the cam shaft 63, so that the movement of the yoke 92, with the dog 94 or the dog 95 engaging the ratchet 104 will crank or turn the shaft 63 a definite number of degrees, thereby changing the positions of the cams 58, 60, 61 and 62.

The restriction or stopping of the leaf 97 is caused by the movement into its path of one or the other of the stops 106 or 107, movement of which is controlled by the pressure operated mechanism 108.

The pressure operated mechanism 108 includes a diaphragm 109, which extends across the interior of a suitable housing 110, which is connected through its inlet 111 to the source of pressure, variations in which are to be employed for controlling loading and unloading of the compressor. That is, the diaphragm 109 may be acted upon either by receiver pressure or by the

pressure of suction of the compressor structure.

The diaphragm 109 has a pin 112 carried thereby which projects out of the casing 110 and engages the plate structure 114. The plate structure 114 has a pair of flat springs 115 connected thereto which are in turn connected to posts 116. A pin 117 is carried by the plate structure 114 near the end opposite to the end at which the posts 116 are located. A spring 118 is connected to the pin 117 so that the plate structure 114 is yieldably suspended by the action of the springs 115 and 118 for rocking movement under action of the diaphragm 109 through the medium of the pin 112. The tension of the spring 118 and consequently the adjustment of the pressure operated device for operation by different degrees of pressure is provided by the adjustment of the spring carrying collar 119 along its screw-threaded supporting column 120. The column 120 is rotatably supported by the supporting structure 121, which also serves to prevent rotation of the spring carrying collar 119.

An arm 123 is rigidly attached to the plate structure 114 and projects laterally therefrom. The arm 123 has a plurality of spaced openings 124 in its outer projecting end, any one of which is adapted to receive the reduced end 125 of the connecting arm 126 (see Figure 7). The arm 126 is adjustably mounted on the lower end of the cross member or lever 127. The cross lever 127 is pivoted on the rod 128 of the rocking bracket 129'. The upper or forward end of the cross lever 127 has a pin 129 carried thereby which engages the periphery of the cam 130 mounted on the shaft 69. The bracket 129' is pivotally carried by the structure 131 and it has a plate 132 carried thereby. The plate 132 carries pins 133 and 134 disposed on opposite sides of its pivot which engage and actuate the pawls 106 and 107 respectively. The pawls 106 and 107 are rockably supported by the member 131 and they are moved by rocking movement of the cross lever 127 upon variances in the pressure of fluid delivered against the diaphragm 109, to control movement of the leaf 97, pawls 94 and 95, and consequently the positioning of the cams 58, 60, 61 and 62. The cross lever 127 is held with the pin 129 engaging the periphery of the cam 130 by the spring 136.

The shaft 69 has a resetting or elevation cam 138 on its end opposite to the cam 130. The cam 138, which controls the resetting of the governor mechanism, is shown in detail in Figures 15 to 21 inclusive of the drawings, and in association with the lever 84 in Figure 14 of the drawings.

The shaft 69 is connected to the shaft 76 through the differential gearing structure 67, as clearly shown in the diagrammatic Figure 29; that is, the shaft 69 has a gear 139 mounted thereon which meshes with a pinion 140 carried by the disk 68.

The cam 138 is an adjustable cam, adjustable to vary the time of operation of the lever 84 and consequently vary the time of resetting of the mechanism actuated by the pressure operated device 108 and consequently vary the time interval between the operation of the mechanisms controlling the various steps of unloading of the compressor, or in other words, it is adjustable to vary the time of the resetting or biasing of the governor mechanism.

The cam 138 includes the hub 141 which is rigidly connected to the gear 139, and is pinned on the shaft 69 by a set screw shown at 142, so as to permit adjustment of the position of the cam on the shaft. The hub portion 141 of the cam

has a segmental flange 143 on its outer end, which is off-set laterally from the end face of the hub 141 of the cam and provides an angled shoulder 144, which forms a step for operating the lever 84. The cam 138 also includes the adjustable ring 145 which is rotatably mounted on the hub 141 of the cam. The ring 145 is held in adjusted positions by means of a suitable set screw shown at 146. The ring 145 has an annular flange 147 formed thereon which flange has a laterally off-set portion 148 encompassing substantially half its area. The laterally off-set portion 148 forms a shoulder 149 which is tapered similar to the taper of the shoulder 143 and provides an abutment or shoulder over which the end of the lever 84 rides for rocking the lever. By adjusting the position of the shoulder 149 on the adjustable ring of the cam in positions as shown in Figures 18 to 21 inclusive, it will be apparent that the time of operation of the lever 84 during the rotation of the shaft 69 may be varied: either advanced or delayed, depending upon the time delay desired in the resetting or biasing of the governor control mechanism.

The lower end of the cross-lever 127 is provided with a plurality of spaced openings 127' which permit of various adjustments in the connection between the bar 126 and the lever. The series of openings 127' and 124 permit a relatively wide range of adjustment between the connection of the lever 127 and the movable arm 123 for regulating the scope of movement of the cross lever 127 as necessary or desired.

The lever 84 has a cam roller 84' thereon for engagement with the cam 138.

The shaft 63 has a visible indicator 150 mounted thereon and rotatable therewith which shows the percentage of capacity at which the compressor is operating.

The varying of the time for restoring or resetting action is accomplished by the shifting of the sections of the cam 138. By shifting the sections of the cam 138 the time at which the shoulders 144 and 148 engage the lever 84 for rocking it is varied so that the shifting or engagement of the sections of the clutch 82' is varied. The rotation of the cam 130 depends upon the connection of the gear 75 with the motor and consequently by varying the time of coupling the gear 75 to the motor shaft 78 and the resultant operation of the shaft 72 the time required for restoring or resetting the mechanism may be varied.

The present variable capacity compressor control mechanism embodies means in the form of a demand limiter which is manually set to regulate or determine the maximum out-put of the compressor. That is, if the existing conditions are such that it is desirable to confine the maximum out-put of the compressor to 50 per cent, or perhaps 75 per cent of its maximum capacity, then the demand limiter structure may be set so that when the governor has once unloaded the compressor below the degree indicated by the setting of the demand limiter, the governor mechanism will operate to further unload the compressor and will continue to function in the usual manner, except that it will never reload above the setting of the demand limiter.

The demand limiter structure includes a dial 151, which is rotatably supported by a suitable supporting structure 152 and has a finger knob 153 thereon to facilitate its adjustment. The dial 151 has a series of notches 154 cut in its periphery which have suitable indicia 155 associated

therewith to indicate percentages of capacity of the compressor. The notches receive a spring mounted pin or button 156 which acts as a stop to hold the dial 151 in adjusted position. The dial 151 has a cam 157 attached thereto, the perimeter of which engages one end of a lever 158. The lever 158 is pivotally mounted intermediate its ends as shown at 159, and carries a pin 160 at its end opposite to the end which engages the cam 157. The pin 160 is held in engagement with the lateral stepped face 161 of a cam 162 by means of a spring 163. The cam 162 has a plurality of steps or shoulders 164 formed on its face which are engaged by the pin 160. The shoulders 164 correspond to the indicated percentages of capacity 155 on the dial 151.

The cam 162 is rotatably mounted on the shaft 63 for limited rotary movement relative thereto, by means of a spring coupler structure 167, which is of approved construction. The cam 162 has a second cam 168 formed integrally therewith which is of the same diameter as the ratchet or star wheel 104, and abuts the cam 104. The cam 104 has a series of notches 169 in its perimeter as well as having shoulders 170 formed thereon. The notches 169 and shoulders 170 are engaged by the pawls 94 and 95 for turning the shaft 63 and positioning the cams 58, 60, 61 and 62 to control the degree of unloading and loading of the compressor and to cause rotation of the shaft 63 and the consequent setting of the cams either the pawl 94 or 95 must engage in one of the notches 169 or against one of the shoulders 170. In the lay-out Figure 11 the projected peripheral spaces 171 of the ratchet or star wheel 104 are indicated with the various degrees of capacity of the compressor. The cam 168 has a pair of peripherally extended portions 172 and 173 formed thereon, the outer surfaces of which align with the outer surfaces of the peripheral extensions 171 of the ratchet or star wheel 104.

The spring coupling 167 is such that it will connect the cams 162 and 168 to the shaft 63 for rotation therewith until an obstruction is presented to arrest rotation of the cams 162 and 168, such as the contact of the pin 160 with one of the shoulders 164, at which time movement of both the cams 162 and 168 with the shaft 63 will be arrested. The point or position of these cams upon the arresting of their movement relative to the shaft 63 is determined by the positioning of the pin 160 through the adjustment of the lever 158 by the cam 157. The positioning of the cam 157 is controlled by the manual rotation of the dial 151, so that if the dial 151 is rotated to position where the notch 154 represented by the indicia 75 receives the spring stop 156, this means that the maximum loading of the compressor at such time will be 75 per cent of the capacity of the compressor, and the lever 158 will be adjusted so that the pin 160 will engage the corresponding step or shoulder 164 to arrest rotation of the cams 162 and 168 with the shaft 63 when the peripheral extension 172 on the periphery of the cam 168 is in position to prevent the dogs 94 or 95 from engaging either the shoulder 170 or the notch 169 in the ratchet or star wheel 104 to rotate the shaft 63 for adjusting the position of the cams 58, 60, 61 or 62 to permit loading of the compressor to 100 per cent of its capacity, and thus the maximum operating capacity of the compressor at such adjustment will be limited to 75 per cent and when the output demand is less than this 75 per cent capacity or when the pressure reaches a predetermined de-

gree corresponding thereto, the compressor will start to unload. The indicator disk 150 on the shaft 63 is always visible and thus it may be readily determined at just what capacity the compressor is operating.

The variable capacity compressor and control system hereinabove described is primarily a system or instrument which holds an average pressure on a system by varying compressor capacity and repositioning the governor limits after each successive step. However there may be instances or particular applications where the compressor receiver system is particularly large, and the rate of variance of the compressor capacity is particularly small, there may be sufficient lag between the change of the compressing rate and the pressure in the system so that the restoring of the pressure limits in the governor would cause successive operations thereof that were not in accordance with the capacity demand, resulting in unnecessary step operations of the governor. By adjustment of the cam 138, the restoration or resetting action of the governor mechanism may be delayed one step, two steps, or for the entire range of the governor, which results in operation of the present mechanism in simulation of the action of compressor governors of approved types now in use, as shown by Figure 26 of the drawings. That is, the pressure differences required for each step operation of the governor are allowed to pyramid, so that if one-half pound pressure change is required for the first step operation of the governor, an additional one-half pound will be required for the second step operation, etc. through the entire range of the governor.

Ordinarily, in the operation of the present governor, if one-half pound in pressure variance will cause the governor to change the output capacity of the compressor one step, and the cam 130 and the co-operating parts are restored to their original position or reset, then the same one-half pound pressure variance will cause a successive step operation of the governor mechanism. Thus the pressure differential is narrowed. This action is shown in Figure 27 of the drawings.

Referring to Figure 28 of the drawings, A and B represent the governor limits or points at which the step operations of the governor takes place, and P represents the receiver or suction pressure, or in other words, the pressure source, variation of which effects unloading and loading of the compressor cylinders 1 and 2.

If the compressor cylinders 1 and 2 are operating at 100 per cent of capacity and the controlled pressure rises so that it reaches the limit represented by the line A, the pressure operated mechanism 114 will move the arm 123 and operate the cross lever 127. The operation of the cross lever 127 will rock the rocker bracket 129 and move the stop pawl 107 into the path of the extension 101 on the leaf 97, arresting movement of the leaf 97 while the yoke 92 continues its stroke. The arresting of movement of the leaf 97 will cause the pawl 94 to drop and engage one of the shoulders 170 on the ratchet or star wheel 104 and rotate the shaft 63 by movement of the yoke 92. This movement of the shaft 63 will cause depression of the circuit closing contact lever 50, de-energizing the solenoid 20 of the valve 19 and resulting in operation of the control valves 7 and 8 and the consequent reduction of output capacity of the compressor cylinders 1 and 2, 25 per cent, permitting operation of the com-

pressor cylinders at 75 per cent of the maximum out-put capacity of the cylinders.

As the governor takes this first step, the cam 130 will reposition the cross lever 127 leveling off the rocker bracket 129', moving the stop pawl 107 out of the path of the extension 101 of the leaf 97, repositioning these parts for an additional step or operation. At this point the differential gearing 67 returns the cam 130 to its original position, although should the pressure in the control source not change in the interval, the cross lever will again be operated and cause a second step operation of the governor with the resultant change in the out-put capacity of the compressor cylinders 1 and 2.

If, however, the pressure is dropping, the diaphragm 109 will allow the cross lever 127 to return to its original position so that by the time the cam 130 has returned to its original position, the leaf 97 will be permitted uninterrupted movement through its arc and no governor action will be set up.

Should the pressure in the source decrease sufficiently so that it reaches the lower limit indicated by the line B, the same action is set up, except that the direction of movement of the cross lever 127 is reversed, and the stop pawl 106 is brought into position to arrest movement of the leaf 97, causing the pawl 95 to engage the ratchet or star wheel 104 and operate the shaft 63 in a reverse direction, to make the circuit through the solenoid 20 of the valve structure 19, allow the pressure operating fluid to bleed from control valves 7 and 8 through the port 31 of the valve structure 19, with the resultant loading of the compressor cylinders.

The above same operations are repeated regardless of the percentage of out-put capacity at which the compressor cylinders are operating.

The shaft 69 is geared to the shaft 63 through the differential gearing 67 so that as the shaft 63 is operated by either of the pawls 94 or 95 the shaft 69 will be correspondingly rotated, which rotation will move the cam 138, causing the roller 84' to move from the neutral position on the cam 138, and rock the lever 84. The rocking of the lever 84 will move the shaft 76, and cause either the clutch 81 or 82' to engage its respective gear 74 or 75, depending upon whether the pressure in the control source is increasing or decreasing. The connecting of one of the gears 74 or 75 with the shaft 76 will start the operation of the differential gear mechanism which will slowly change the relative positions of the shafts 63 and 69. The shaft 63 however is held against rotation, under the small amount of power transmitted through the differential gearing by the locking cam 84^a and pivoted arm 86, so that the gearing must move the shaft 69, which movement restores the cam 130 to its original position.

From the foregoing it will be apparent that the unloading is effected by successively de-energizing solenoids in control of pressure fluid means for operating the unloading means. Energizing of the solenoids is controlled by switch levers 47-50 which are operated by cams 58 to 62 on shaft 63.

The motor 80 operates continuously and oscillates yoke 92 by means of rod 91. When the receiver pressure rises above that desired pressure fluid acts against diaphragm 109. This diaphragm acts through pin 112, plates 114, 123 to rock 127 counter clockwise (Fig. 7) to move stop 107 into the path of the leaf 101. The yoke 92 may then move relative to the leaf 101 so that

the pawl 94 drops down as shown in Fig. 7 and engages the periphery of the ratchet wheel 104 and turns the shaft 63 to cause one of the cams 58 to 62 on the shaft 63 to operate one of the solenoids. Rotation of shaft 63 operates through gears 65, 66, 140 and 139 to turn shaft 69 and cam 130 to turn lever 127 clockwise towards its original position and move 107 away from the leaf 101, so that the spring 96 again may raise the pawl 94 from ratchet wheel 104 to center the leaf 101 with the yoke 92.

Rotation of the shaft 69 causes the cam 138 to move the lever 84 and release spring 83 so that spring 82 moves clutch 81 into engagement with gear 74. During this time shaft 63 is held against rotation by engagement of roller 88 in recess 85^a of cam 84^a (Fig. 13). Motor 80 rotates gear 73 and shaft 69 in the opposite direction to return the cam 130 to its original position.

The time needed to reposition the several parts is varied by adjusting hub 141 on shaft 69 and ring 145 on hub 141 (Figs. 15-21).

The indicator 151 on shaft 63 shows at what percentage of its full capacity the pump is operating.

The pressure at which the unloading is effected is adjusted by sleeve 119 and screw 120.

The maximum is adjusted by turning 153. This aligns projections 172, 173 on cam 168 opposite recesses in the ratchet wheel 104 to prevent pawls 94 and 95 from dropping into ratchet spaces at the capacity above that for which 153 is set.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor in fractional parts of its full capacity, means for controlling operation of said control valves, pressure responsive means for operating said valve control means, means for automatically re-setting said valve control means after each operation whereby the compressor will operate at the same discharge pressure irrespective of the percentage of its full capacity at which it is operating, and a manually operable demand limiter embodying a plurality of stops brought selectively into or out of stopping relation with said control valve controlling means for regulating the maximum percentage of capacity at which the compressor can operate.

2. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor in fractional parts of its full capacity, means for controlling operation of said control valves, pressure responsive means for operating said valve control means, means for automatically re-setting said valve control means after each operation whereby the compressor will operate at the same discharge pressure irrespective of the percentage of its full capacity at which it is operating, adjustable means for momentarily delaying the return of the valve control operating means to allow the change effected by operation of the control valves to become effective in the receiver system of the compressor before a successive operation of the control valve operating means is permitted, and a demand limiting device embodying a plurality of stops brought selectively into or out of stopping

relation with said control valve controlling means for regulating the maximum percentage of capacity at which the compressor can operate.

3. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor in fractional parts of its full capacity, means for controlling operation of said control valves, pressure responsive means for operating said valve control means, means for automatically re-setting said valve control means after each operation whereby the compressor will operate at the same discharge pressure irrespective of the percentage of its full capacity at which it is operating, means for momentarily delaying the return of the valve control operating means to allow the change effected by operation of the control valves to become effective in the receiver system of the compressor before a successive operation of the control valve operating means is permitted, said delay means including a cam comprising relatively adjustable sections adjustable to regulate the time interval of the delay.
4. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said control valves, said electrically operated means comprising means responsive to deviation from a predetermined pressure for controlling operation of the electrically operated means, means for varying the setting of said responsive means, means for re-positioning said control valve operating means after each operation, and means controlling connection of said repositioning means and said electrically operated means for momentarily delaying the repositioning of said control valve operating means to allow the change effected by operation of the control valves to become effective in the receiver system of the compressor before a successive operation of the control valve operating means is provided.
5. The combination with a variable capacity air or gas compressor, of control valves on the compressor for controlling the loading and unloading of the compressor, solenoid operated distributor valves for controlling admission of operating pressure fluid to said control valves, solenoids for operating said distributor valves, means responsive to deviation from a predetermined pressure value for controlling energizing of said solenoids, means for varying the setting of said responsive means, means for restoring said responsive means to its original setting, and means controlling connection of said repositioning means and said electrically operated means for momentarily delaying the restoring of said responsive means to allow the change effected by operation of the control valves to become effective in the receiver system of the compressor before a successive operation of the control valves is permitted.
6. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of the control valves, means responsive to deviation from a predetermined pressure for controlling operation of said electrically operated means, means for varying the setting of said responsive means through a series of predetermined positions, means for restoring the responsive means to its original set-

ting, and means controlling connection of said repositioning means and said electrically operated means for momentarily delaying the return of the responsive means to its original setting.

7. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, means operated by said prime mover for rotating said step by step cam, said prime mover operated means being normally out of cam moving engagement with the step by step cam, and pressure operated means for moving said prime mover operated means into cam rotating engagement with said step by step cam.

8. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, means operated by said prime mover for rotating said step by step cam, said prime mover operated means being normally out of cam moving engagement with the step by step cam, pressure operated means for moving said prime mover operated means into cam rotating engagement with said step by step cam, and means for re-positioning said pressure operated means after each operation thereof.

9. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, means operated by said prime mover for rotating said step by step cam, said prime mover operated means being normally out of cam moving engagement with the step by step cam, pressure operated means for moving said prime mover operated means into cam rotating engagement with said step by step cam, means for repositioning said pressure operated means after each operation thereof, and means for delaying the re-positioning of said pressure operated means.

10. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, means operated by said prime mover for rotating said step by step cam, said prime mover operated means being normally out of cam moving engagement with the step by step cam, pressure operated means for moving said prime mover operated means into cam rotating engagement with said step by step cam, and a demand limiter including means for rendering certain steps of the step by step cam inactive for regulating the max-

imum percentage of the full capacity at which the compressor can operate.

11. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, a rocking yoke operated by said prime mover, pawls on said yoke for rotating engagement with said step by step cam, and pressure operated means for moving said pawls into cam rotating engagement with said step by step cam.

12. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, a rocking yoke operated by said prime mover, pawls on said yoke for rotating engagement with said step by step cam, and pressure operated means for moving said pawls into cam rotating engagement with said step by step cam, said pawls arranged one to rotate the cam in one direction and the other to reverse the direction of rotation of said cam, said pressure operated means acting under pressure differences to control the direction of rotation of the step by step cam.

13. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, means controlling operation of said control valves including a step by step cam, means for rotating said cam in steps, and a demand limiter including means for rendering certain of the step operations of said cam inactive.

14. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, means operated by said prime mover for rotating said step by step cam, said prime mover operated means being normally out of cam moving engagement with the step by step cam, pressure operated means for moving said prime mover operated means into cam rotating engagement with said step by step cam, and a ratchet cam and pawl operated with said contact moving cams for preventing overrun movement of the contact operating cams.

15. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, a rocking yoke operated by said prime mover, pawls on said yoke for rotating engagement with said step by step cam, pressure operated means for moving said pawls into cam rotating engage-

ment with said step by step cam, a ratchet cam and pawl associated with said contact moving cams for preventing overrun movement of the contact operating cams, and means for re-positioning said pressure operated means after each operation thereof.

16. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, a rocking yoke operated by said prime mover, pawls on said yoke for rotating engagement with said step by step cam, pressure operated means for moving said pawls into cam rotating engagement with said step by step cam, a ratchet cam and pawl associated with said contact moving cams for preventing overrun movement of the contact operating cams, means for re-positioning said pressure operated means after each operation thereof, and means for delaying the re-positioning of said pressure operated means.

17. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, a rocking yoke operated by said prime mover, pawls on said yoke for rotating engagement with said step by step cam, pressure operated means for moving said pawls into cam rotating engagement with said step by step cam, said pawls arranged one to rotate the cam in one direction and the other to reverse the direction of rotation of said cam, said pressure operated means acting under pressure differences to control the direction of rotation of the step by step cam, and a ratchet and pawl associated with said contact moving cams for preventing overrun movement of the contact operating cams.

18. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, means operated by said prime mover for rotating said step by step cam, said prime mover operated means being normally out of cam moving engagement with the step by step cam, pressure operated means for moving said prime mover operated means into cam rotating engagement with said step by step cam, pressure responsive means for operating said pressure operated means, adjustable means for regulating said pressure responsive means to vary the degree of differential pressure demand required to operate the pressure operated means, a re-positioning cam for re-positioning said pressure operated means after each operation thereof.

19. The combination with a variable capacity air or gas compressor, of control valves on said compressor for controlling the loading and unloading of the compressor, means for controlling

operation of said control valves including movable electric-circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, means operated by said prime mover for rotating said step by step cam, said prime mover operated means being normally out of cam moving engagement with the step by step cam, pressure operated means for moving said prime mover operated means into cam rotating engagement with said step by step cam, pressure responsive means for operating said pressure operated means, adjustable means for regulating said pressure responsive means to vary the degree of differential pressure demand required to operate the pressure operated means, a re-positioning cam for re-positioning said pressure operated means after each operation thereof, said re-positioning cam being adjustable whereby the time interval of re-positioning may be varied.

20. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, a step by step cam for controlling operation of said valves, means for operating said step by step cam normally out of operative connection with the cam, pressure operated means for operatively connecting said cam operating means and cam, means for repositioning said pressure operated means after each operation thereof, and means for delaying the repositioning of said pressure operated means.

21. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, a step by step cam for controlling operation of said valves, means for operating said step by step cam normally out of operative connection with the cam, pressure operated means for operatively connecting said cam operating means and cam, means for repositioning said pressure operated means after each operation thereof, and means for delaying the repositioning of said pressure operated means, said delaying means including a cam having relatively adjustable sections adjustable for regulating the time interval of the delay.

22. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, a step by step cam for controlling operation of said valves, means for operating said step by step cam normally out of operative connection with the cam, pressure operated means for operatively connecting said cam operating means and cam, means for repositioning said pressure operated means after each operation thereof, means for delaying the repositioning of said pressure operated means, and a demand limiter including means for rendering certain steps of the step by step cam inactive for regulating the maximum percentage of the full capacity at which the compressor can operate.

23. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, means for controlling operation of said control valves including movable electric circuit closing contacts, cams for moving said contacts into and out of circuit closing position, a prime mover, a step by step cam for rotating said contact moving cams, a rocking yoke operated by said prime mover, pawls on said yoke for rotating engagement with said step by step cam, pressure

operated means for moving said pawls into cam rotating engagement with the step by step cam, and stop means associated with said contact moving cams for definitely stopping movement of the cams after each contact has been moved into or out of circuit closing position.

24. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, a step by step cam for controlling operation of said valves, means for operating said step by step cam normally out of operative connection with the cam, pressure operated means for operatively connecting said cam operating means and cam, means for repositioning said pressure operated means after each operation thereof, means for delaying the repositioning of said pressure operated means, and means for stopping movement of said step by step cam after each step operation thereof.

25. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, means controlling operation of said control valves including a step by step cam, means for rotating said cam in steps, and a star cam associated with said step by step cam for preventing overrun of movement of the step by step cam upon each step operation thereof.

26. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said valves, cams for controlling the energizing of said electrically operated means, a continuously operating electric motor, pressure actuated means for operatively connecting said motor and cams to operate the cams by the motor, means actuated by said motor for resetting said motor and cam connecting means, and means actuated by said motor for delaying the resetting of said connecting means.

27. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said valves, cams for controlling the energizing of said electrically operated means, a continuously operating electric motor, pressure actuated means for operatively connecting said motor and cams to operate the cams by the motor, means actuated by said motor for resetting said motor and cam connecting means, means actuated by said motor for delaying the resetting of said connecting means, and means associated with said cam to prevent overrun of the cams upon each operation thereof.

28. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said valves, cams for controlling the energizing of said electrically operated means, a continuously operating electric motor, pressure actuated means for operatively connecting said motor and cams to operate the cams by the motor, means actuated by said motor for resetting said motor and cam connecting means, a star cam operable with said cams, and means co-acting with said star cam to prevent overrun operation of said cams.

29. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for con-

trolling operation of said valves, cams for controlling the energizing of said electrically operated means, a continuously operating electric motor, pressure actuated means for operatively
 5 connecting said motor and cams to operate the cams by the motor, means actuated by said motor for resetting said motor and cam connecting means, and means actuated by said motor for delaying the resetting of said connecting means,
 10 said delay means including a cam comprising relatively adjustable sections adjustable to regulate the time interval of the delay.

30. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said valves, cams for controlling the energizing of said electrically operated means, a continuously operating electric
 20 motor, pressure actuated means for operatively connecting said motor and cams to operate the cams by the motor, and a demand limiting device embodying a plurality of stops brought selectively into or out of stopping relating with said
 25 cams to regulate the movement of the cams and the maximum capacity at which the compressor can operate.

31. The combination with a variable capacity air or gas compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said valves, cams for controlling the energizing of said electrically operated means, a continuously operating electric
 30 motor, pressure actuated means for operatively connecting said motor and cams to operate the cams by the motor, and a manually set demand limiting device embodying a plurality of stops

brought selectively into or out of active relation with said motor and cam connecting means for controlling the connection between the motor and cams for regulating the maximum capacity at which the compressor can operate.

32. The combination with a variable capacity compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said valves, cams controlling energizing of said electrically operated means, a shaft carrying said
 10 cams, a continuously operating motor, an operating yoke connected to said motor and operated thereby, means normally holding said yoke out of operating connection with said shaft, pressure operated means for moving said holding
 15 means to permit operative connection of the yoke and shaft, means actuated by said motor for resetting said pressure operated means, and adjustable means actuated by said motor for delaying the resetting of said pressure operated
 20 means.

33. The combination with a variable capacity compressor, of control valves for controlling the loading and unloading of the compressor, electrically operated means for controlling operation of said valves, cams controlling energizing of said electrically operated means, a shaft carrying said
 25 cams, a continuously operating motor, an operating yoke connected to said motor and operated thereby, means normally holding said yoke out of operating connection with said shaft, pressure operated means for moving said holding means to permit operative connection of the yoke and shaft, and a star cam carried by said shaft to
 30 prevent overrun of the cams upon each operation thereof.

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