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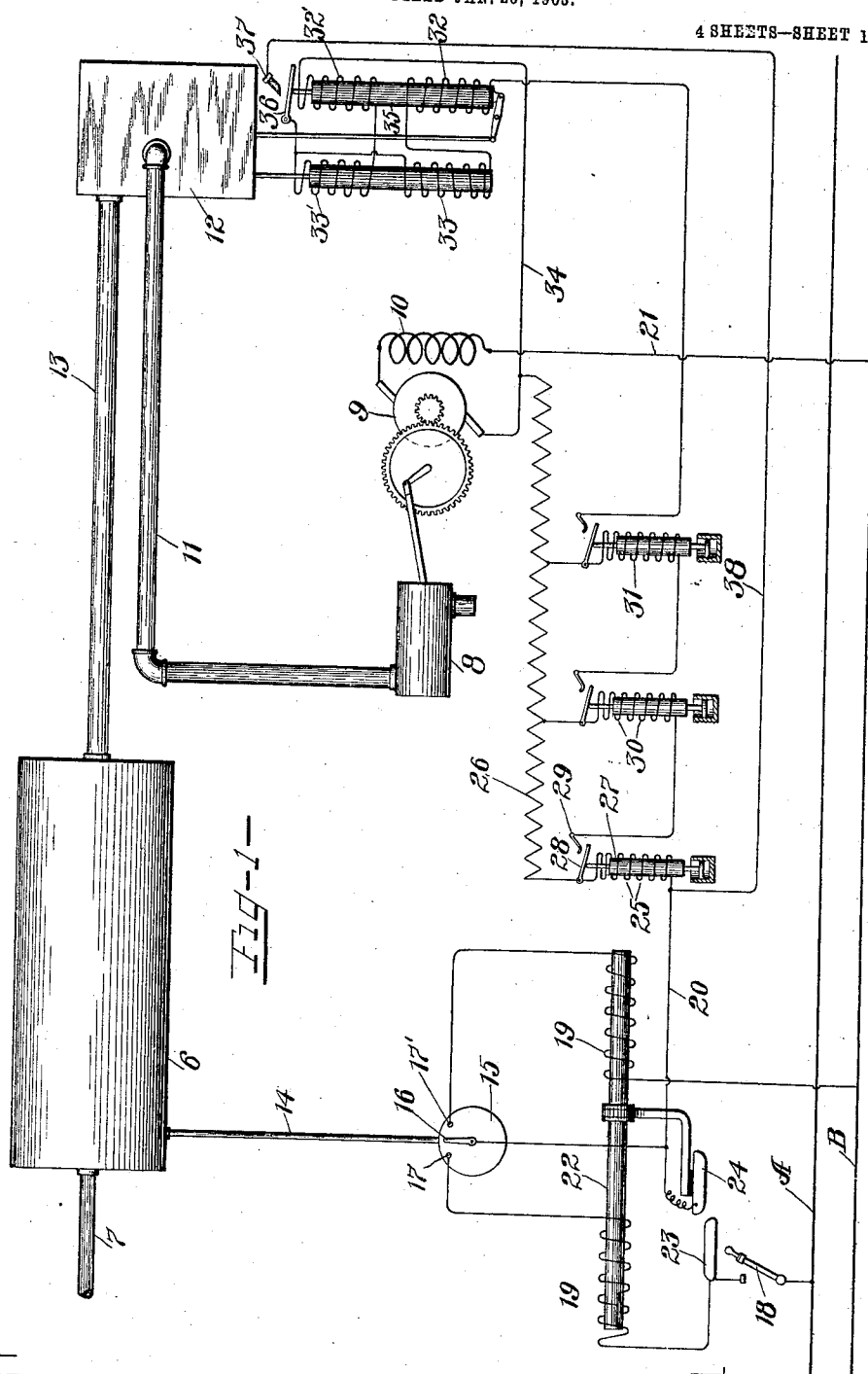
No. 858,467.

PATENTED JULY 2, 1907.

W. J. RICHARDS.
AUTOMATIC DEVICE FOR STARTING MOTORS.

APPLICATION FILED JAN. 23, 1903.

4 SHEETS—SHEET 1.



Witnesses

Charles F. Schmitt.
Lynn A. Williams

Inventor

WALTER J. RICHARDS

By Charles A. Brown

Attorney

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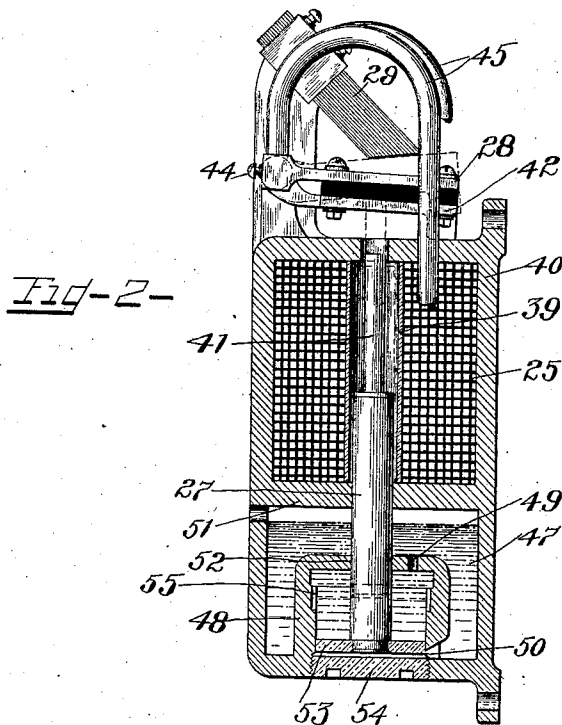
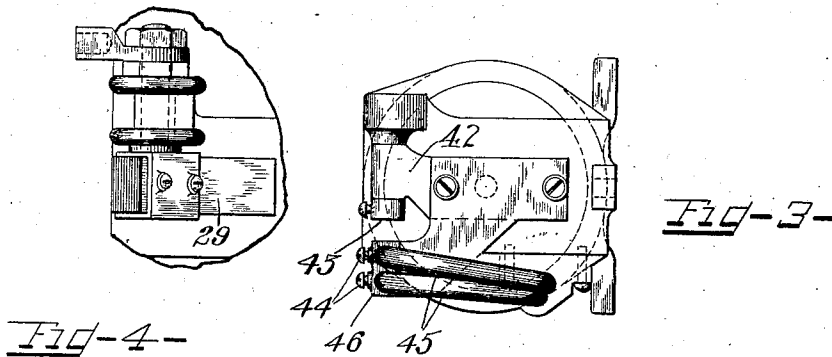
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4 SHEETS—SHEET 2.



Witnesses:

Seward W. Novander.

Symon A. Williams

By

Inventor

WALTER J. RICHARDS

Charles A. Brown

ATTORNEY

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4 SHEETS—SHEET 3.

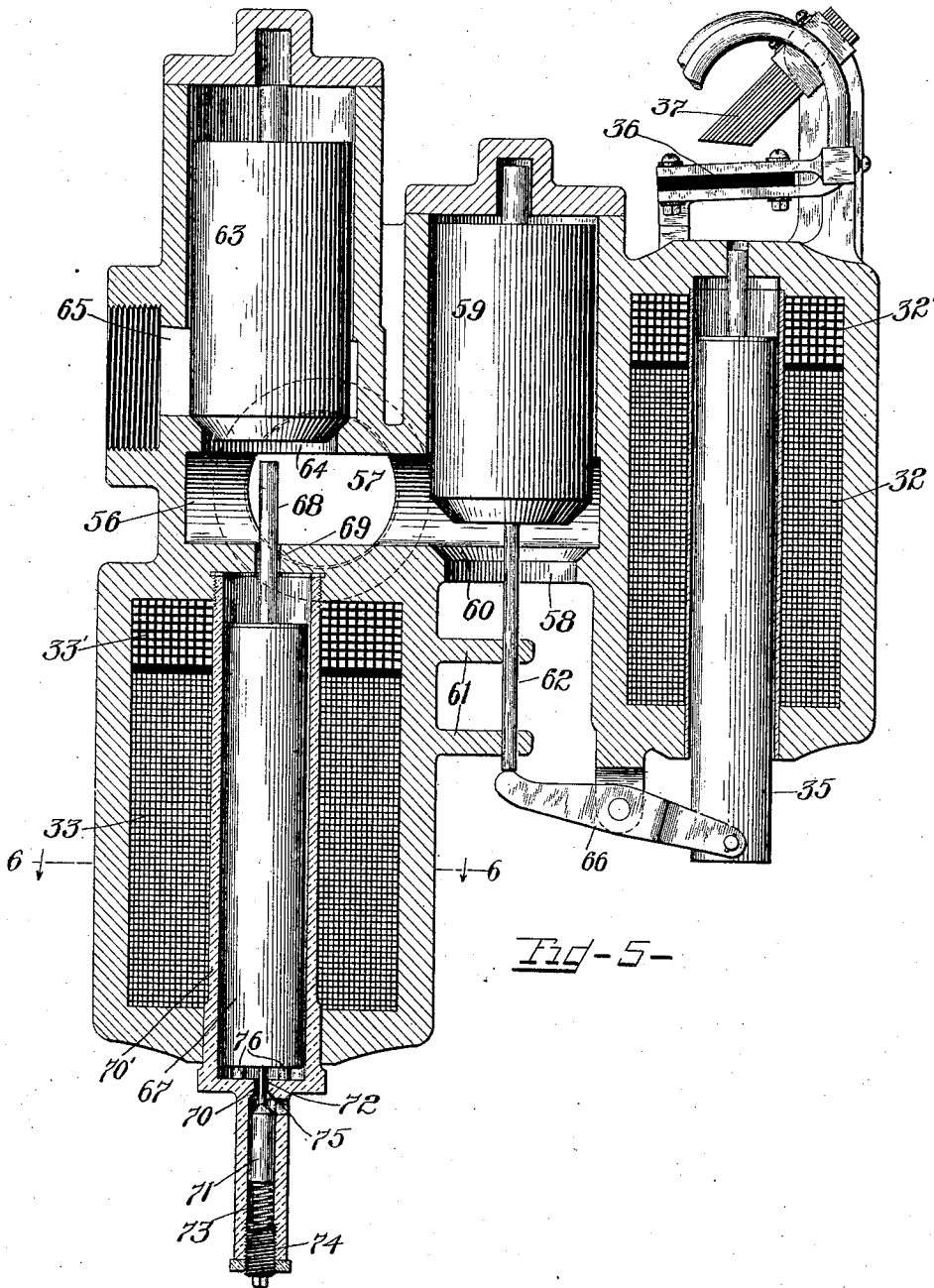


Fig. 5-

Witnesses:

Leonard W. Novander.

Lyman A. Williams

BY

INVENTOR

WALTER J. RICHARDS.

Charles A. Brown

ATTORNEY.

No. 858,467.

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4 SHEETS—SHEET 4.

Fig. 6.

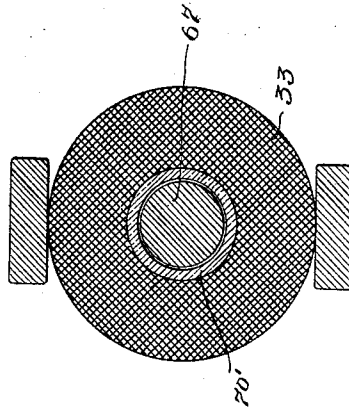
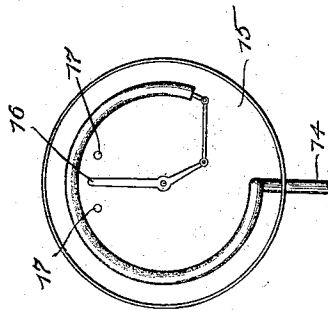


Fig. 7



Witnesses,

Leonard W. Novandy

Lynn A. Williams By

Inventor,

Walter J. Richards.

Charles A. Brown
Attorney

UNITED STATES PATENT OFFICE.

WALTER JOSEPH RICHARDS, OF MILWAUKEE, WISCONSIN.

AUTOMATIC DEVICE FOR STARTING MOTORS.

No. 858,467.

Specification of Letters Patent.

Patented July 2, 1907.

Application filed January 23, 1903. Serial No. 140,202.

To all whom it may concern:

Be it known that I, WALTER JOSEPH RICHARDS, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented a certain new and useful Improvement in Automatic Devices for Starting Motors, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

10 My invention relates to improvements in automatic mechanism for starting motors.

My invention is peculiarly applicable where an automatic device is desired for properly starting an electric motor.

15 It is well understood by those skilled in the art that it is desirable to start an electric motor with considerably less than the full load current and gradually bring the current up to its normal strength. It is also desirable to start the motor on a light load and increase the load upon the motor after the same has been brought up to its normal speed. Under many conditions of operation it is possible manually to control the current supplied to the motor and the load thereon; but under certain conditions it becomes desirable that an electric motor should be started and stopped by some automatic means controlled by some condition of the load upon the motor, or it may become desirable that a motor should be located at some point inaccessible to the attendant. In such cases it becomes desirable to provide automatic means whereby the motor may be started and the load upon the motor may be regulated as though by an attendant. Good illustrations of such conditions are that of a motor used to operate an air compressor, and that of a motor used to operate a hydraulic pump. In these cases the compressor or pump is frequently installed to supply a reservoir in which a certain pressure or level should be maintained, and upon which reservoir a variable demand is made.

20 In order to properly illustrate my invention, I shall describe its application in connection with an air compressor adapted to supply a compressed air reservoir, from which supply pipes may lead to various apparatus operated by compressed air. In such compressed air systems it is usually found desirable to maintain the pressure within the reservoir at or near a certain working pressure. Since the demand for compressed air is variable, the supply of air from the compressor to the reservoir cannot be made constant. It is customary to provide a switching device, or a load shifting device, such that upon the pressure in the reservoir reaching a given maximum, the supply of air from the compressor is automatically cut off, and upon the pressure in the reservoir falling to a certain minimum limit, the compressor is again automatically set in operation to supply air to the reservoir to bring up the pressure to

the given maximum. Thus the pressure within the reservoir is allowed to vary over a comparatively small range. One means of accomplishing this intermittent supply of air to the reservoir, is to provide the electric motor used in driving the compressor with a switching device whose position is controlled by the pressure within the reservoir. Thus upon the decrease to the lower limit of the air pressure, this switching mechanism is operated to close the motor circuit, thereupon setting the motor and compressor in operation whereby the air supply brings up the reservoir pressure to the maximum limit, whereupon the switching device is again actuated, this time, however, to cut off the supply of current to the motor, whereupon the operation of the compressor is stopped. Another common method of controlling the supply of air to the storage reservoir is to control the valving mechanism of the air compressor, whereby the operation of the same may go on continuously, but without operating the valving mechanism to cause any appreciable compression; that is to say, the load upon the compressor may be temporarily removed. In either of these cases the controlling mechanism may be pneumatically operated, or may be operated by electromagnetic means controlled by the pressure in the pneumatic system.

My invention is particularly adapted for use in connection with a system in which the motor is intermittently operated to drive a compressor connected with a reservoir. When using a properly designed series motor for such work as this, it is customary in some cases to throw the full voltage directly upon the motor by means of automatically controlled switching devices. This will frequently take a starting current of between two and three times the full load current. When compound or shunt wound motors are used, it is customary to employ rheostats, and as the motor increases its speed resistance is cut out of the motor circuit. Due to the nature of the work required of a motor connected with a compressor, in such a system as this, it is practically impossible to keep the starting current down to much less than twice the full load current. Thus it is seen that in the present state of the art, in starting such automatic motor-compressors, the starting current is from two to three times that of the full load current. This undue rush of starting current places an undue strain upon the motor compressor. The motor must be of very generous design in order to carry these sudden rushes of current, and there is the still greater objection that in plants where there is but little margin on the generator, and in those plants where the capacity of the generator is but a trifle larger than that of the motor-compressor, these sudden rushes of current throw the circuit breakers, and place a severe strain on the generator and the engine. Where the same generator is used for lighting purposes, as well as for supplying power to the motor-

compressor the regulation of the generator for lighting purposes is seriously interfered with.

My invention provides means whereby the supply of current to the motor is automatically controlled independent of the load upon the motor. Furthermore, my invention provides means whereby the load upon the compressor may be shifted and very greatly reduced, until the motor has been brought up to normal speed, whereupon the load upon the compressor may be gradually increased to full load conditions. In the present embodiment of my invention I have combined these two automatic means for regulating the current supplied to the motor, with automatic means controlled by the pressure in the reservoir, whereby the motor-compressor is intermittently set in operation to maintain the pressure within the reservoir. The automatic controlling switch for controlling the operation of the motor-compressor may be of a well known type, in which a Bourdon pressure gage U-tube is connected with a switch arm adapted to close electric circuits through electromagnetically operated switching devices. Thus upon the decrease of the reservoir pressure to the minimum limit the switch arm closes circuit through an electromagnet, adapted to actuate a switch and close the motor circuit, whereupon the compressor is operated to supply air to the reservoir. When the pressure has then been brought up to the maximum limit, the switch arm is actuated to close circuit through another electromagnet, whereupon the motor circuit is opened. When a direct current motor is used to operate the compressor, I find it desirable to provide in the motor circuit a suitable starting resistance, which may be automatically shunted by low resistance circuits controlled by slow acting electromagnetically operated switches.

It is well understood by those skilled in the art that the supply of current to an electric motor may be controlled either by electrical means in the motor circuit, or by variation in the mechanical load upon the motor or both. Thus the resistance and shunting mechanism referred to above, provide a means, independent of the load upon the motor, for varying and regulating the current supplied to the motor. I further provide means for regulating the current supplied to the motor, which consists preferably in an automatic device for shifting and varying the load upon the compressor itself. One embodiment of this feature of my invention consists in the provision, in the compressor discharge pipe, of an escape valve adapted to afford communication with the atmosphere, whereby the compressor is permitted to discharge against a negligible back pressure until the motor has brought the compressor up to full speed, when the escape valve may be automatically closed, thus permitting the compressor to discharge into the reservoir. I find it desirable to provide at least a small chamber between the escape valve and the compressor cylinder. Thus, upon the closure of the escape valve, the back pressure upon the compressor is gradually increased until equal to that in the reservoir itself, whereupon a check valve is forced open to permit the discharge of air from the compressor into the reservoir.

My invention will be best understood by reference to the accompanying drawings, in which—

Figure 1 is a diagrammatic illustration of the invention applied to a compressed air system; Fig. 2 is a cen-

tral longitudinal cross-sectional view, illustrating one of the slow acting electromagnetic switching devices employed; Fig. 3 is a plan view of the same, one of the switch contacts having been removed for clearness; Fig. 4 is a plan view of such switch contact; Fig. 5 is a central longitudinal cross-sectional view of electromagnetically controlled valving mechanism and switching means adapted to automatically control the load upon the compressor. Fig. 6 is a cross-sectional view taken on line 6—6 of Fig. 5; Fig. 7 is a detailed view showing the construction of the Bourdon pressure gage switch employed.

Like parts are indicated by similar characters of reference throughout the different figures.

I have illustrated a supply reservoir 6, from which leads the supply main 7. An air compressor is diagrammatically illustrated at 8, having gear connection with the motor armature 9. This motor, it will be seen, is of the series type, in which a part of the circuit is afforded by the series coil 10. In Fig. 1, the discharge pipe 11, from the compressor, is shown entering a casing 12, which incloses valving mechanism to be hereinafter more fully explained, and from which the pipe 13 leads to the reservoir 6. Connected with the reservoir by a small pipe 14, is the automatic controlling switch 15, the switch arm 16 of which is controlled by a Bourdon U-tube (not shown). Supposing the normal pressure in the reservoir should be one hundred pounds per square inch, the controlling switch 15 may be regulated so that when the pressure falls to ninety-five pounds, the switch arm 16 will make contact with the terminal 17. An electric circuit may then be traced as follows: From the positive main A, through the main switch 18, to the electromagnet coil 19, to the contact 17, to the switch arm 16, to the conductor 20, thence through the motor circuit and conductor 21, to the other main B. An oscillating iron core 22 will be attracted by the magnetization of the coil 19, whereupon it will be moved toward the left, thus closing a circuit between the sliding switch contacts 23 and 24. Circuit will then be closed as follows: from the main A, through the switch 18 and contacts 23 and 24, through the conductor 20, to the solenoid 25, to the resistance 26, to the motor armature 9, to the field coil 10, through the conductor 21, to the main B.

As will hereinafter be more fully explained, the energization of the coil 25 is adapted to slowly raise the core 27, thereby closing circuit between the switch arm 28 and the contact 29. Thus a path of comparatively low resistance is shunted around the first section of the resistance 26. The coil 30 of the second electromagnetic switching device becoming energized, closes the associated switch, thereby shunting the second section of the resistance 26 through the solenoid 31. Upon the energization of this coil 31, the third switch is closed, thus shunting the third section of the resistance 26, and establishing a circuit as follows: from the main A, through the switch 18, through switch contacts 23 and 24, conductor 20, solenoid 25, switch 28, contact 29, to solenoid 30, through its associated switch to solenoid 31, through its associated switch to the electromagnet coil 32, to coil 33, to coil 33', to coil 32, through conductor 34, to the motor armature 9, to the series coil 10, to the negative main B.

Since the coils on the electromagnetic devices employed are all of low resistance, it will be seen that upon the closure of the motor circuit by the automatic con-

trolling switch contacts 23 and 24, the resistance 26 is automatically shunted by a path of comparatively low resistance.

As will be hereinafter more fully explained, the energization of the coils 32 and 32' draws up the core 35, thus actuating the switch arm 36 to make contact with the terminal 37, thereby short circuiting the resistance 26 and the coils 25, 30 and 31, through the conductor 38, to contact 37, to switch arm 36, to coil 33', to coil 32', to conductor 34, to armature 9, to series field coil 10, to the main B.

In order to make the operation of my invention more clear, I shall describe one of the electromagnetic switching devices employed for automatically shunting sections of the resistance 26. One of these devices is illustrated in Figs. 2, 3 and 4. The electromagnet coil 25 is shown wound upon a brass tube 39 and inclosed in an iron casing 40. The core 27 is adapted to slide easily through this tube, and is provided with an upwardly extending brass rod 41, adapted, when the core is drawn up, due to the energization of the winding 25, to raise the switch-arm 28 to its alternate position, shown in dotted lines, where it makes connection with the spring contact 29. The switch-arm 28, which may desirably be of copper, is insulated from the pivoted iron tongue 42, upon which it is carried. This iron tongue may be pivoted at 43, and I find it desirable to carry the copper switch arm 28 off to the side and to a point opposite the axis of rotation of the switch arm, as best illustrated in Fig. 3. I provide the switch arm 28, with connecting screws at 44, where the conductors 45 may be attached. I thus provide a means of attachment for these conductors, which involves no hinge or moving joint, and which, on account of the comparatively small motion of the extension 46, permits the use of comparatively heavy conductors. These conductors are desirably bent into large loops, as shown, thereby permitting the turning of the switch arm upon its pivot. I find that the contact 29 may desirably be made of leaves of spring copper like a dynamo brush. The lower part of the casing 40 contains an oil chamber 47, into which there extends an oil cylinder 48, provided at its top and bottom with small openings 49 and 50, which lead into the chamber 47. The core 27 extends through a partition 51 and an opening 52 in the top of the cylinder 48, and is provided at its lower extremity with a brass piston 53, adapted to fit and reciprocate within the cylinder. A brass cap 54 may be screwed into the bottom of the cylinder, as shown, to prevent the escape of oil. Upon the energization of the solenoid 25, an attractive force will be exerted, tending to draw the core 27 up into the solenoid. The rapid movement of this core is prevented by the oil in the upper part of the cylinder 48, which it will be seen must be expelled through the opening 49, and returned through the opening 50 to the underside of the piston. Grooves 55 may be provided to afford a bypass connection around the piston when near the upper part of its stroke, thus allowing the upper part of the stroke to be more rapid than the lower part thereof. The switch 28 is, therefore, brought into contact with the contact 29 by this more rapid part of the upward stroke of the core 27. It will be seen that this device provides a means whereby the closure of an electric circuit through the coil 25 causes, after the elapse of a

short interval of time, depending upon the size of the openings 49 and 50, a closure of a circuit through the switch arm 28 and the contact 29. Each of the coils 25, 30 and 31 is associated with similar mechanism.

In Fig. 5, I have represented a preferred embodiment of the mechanism employed to regulate the load upon the compressor. A cast iron casing is provided with a chamber 56, into which the compressor discharge pipe 11 opens at 57. This chamber is provided with an opening at 58, leading to the atmosphere, and adapted to be closed by the puppet valve 59, when seated upon the valve seat 60. A pair of ears 61 serves to guide the valve stem 62, by which the valve may be raised from its seat, as shown in Fig. 5. The valve 63, when seated, closes an opening 64, leading from the chamber 56 to a passage 65, to which is connected the pipe 13, leading to the reservoir 6. As illustrated in the drawings, these valves are of considerable weight and tend to seat themselves and close the openings associated therewith. The normal position and condition of this load varying mechanism is shown in Fig. 5, the weight of the core 35 being sufficient to raise the valve 59 from its seat, through the agency of the lever 66 and the valve stem 62. An energization of the coils 32 and 32' raises the core 35 within the coils, thereby raising the switch arm 36 into contact with the brush contact 37, and allowing the valve 59 to seat, thus closing the opening from the chamber 56 to the atmosphere. It will be seen that pressure within the chamber 56 will tend to maintain the valve 59 seated. The back pressure from the reservoir 6, through the pipe 13, tends to maintain the valve 63 upon its seat. A sufficient pressure within the chamber 56, however, will unseat this valve, thereby affording a connection between the pipes 11 and 13. An energization of the coils 33 and 33' tends to raise the core 67, and while the upward force of this attraction is not sufficient to raise the valve 63 from its seat, still when the air pressure within the chamber 56 raises the valve, the core moves up and through the agency of the rod 68 serves to hold the valve in its upward position, thereby allowing a free connection between the chamber 56 and the pipe 13.

As illustrated in the drawing, the spool 70', upon which the coils 33 and 33' are wound, consists of a brass tube screwed into the wall of the chamber 56. The opening 69 in the wall of the chamber is somewhat larger than the rod 68, so that an air passage is formed around the rod into the spool of the electromagnet. The lower end of the brass spool is closed, except for a small opening 70, adapted to be closed by the relief pin valve 71. The pin valve is provided with an upwardly extending valve stem 72, by means of which the valve is depressed against the compression of the spring 73, when the core 67 is in its lowest position shown. An adjustable stop 74 provides a means for varying the compression of the spring 73. The core 67 is made slightly smaller in diameter than the bore of the tube 70', whereby air under pressure in the chamber 56 may leak through the opening 69, and around the sides of the core 67 to the opening 70, and with the core in the position shown, and the pin valve 71 correspondingly depressed, through the opening 75 into the atmosphere. The studs 76 are provided on the lower end of the core 67 to prevent the same coming down and closing the opening 70. When the core 67 is slightly raised, the spring 73 causes the closure of

the opening 70, by means of the relief valve 71, whereby the small opening from the chamber 56 to the atmosphere is closed.

The operation of this embodiment of my invention will now become apparent. A reduction in the pressure within the reservoir 6 having caused the operation of the controller switch mechanism to close the motor circuit, current flows through the coil 25 of the first automatic cut-out magnet, whose core is slowly moved upward, due to the energization of the solenoid and the restraining influence of the oil dash pot, above described. Upon the closure of the circuit through the switch arm 28 and the contact 29, the coil 30 of the second electromagnetic cut-out is energized, and upon the operation of its associated switch, the coil 31 of the third cut-out is energized. Thus the sections of the resistance 26 are gradually shunted by paths of comparatively low resistance. The last of the cut-out switches being closed, the circuit may be traced through the coils 32, 33, 33' and 32' to the motor armature 9. It will be seen that the resistance in the motor circuit has thus been gradually reduced and the motor been brought up to speed without an undue rush of current.

Immediately upon the energization of the coils 32 and 32', the core 35 is drawn up, closing circuit between the switch arm 36 and the contact 37, thus short circuiting the resistance 26, and the coils 25, 30 and 31, and the coils 32 and 33, thus leaving the coils 33' and 32', which are desirably made of very heavy wire, alone in the motor circuit.

It will be remembered, by referring more particularly to Fig. 5, that the upward movement of the core 35 permits the valve 59 to seat. Since the motor is directly connected with the compressor 8, it will be seen that as the motor-compressor comes up to speed the discharge pipe 11 remains open through the chamber 56 and the opening 58 to the atmosphere. This, of course, imposes practically no load upon the compressor, but after the motor-compressor has been brought up to speed, the energization of the coils 32 and 32' causes the closure of the opening 58, by the valve 59, while the energization of the coils 33 and 33' causes the core 67 to rise until the rod 68 strikes the lower side of the valve 63. This slight movement of the core 67 is sufficient to permit the closure of the relief valve 71, thereby preventing the escape of air from the chamber. The pressure in the chamber 56 is increased due to the operation of the compressor, until, when it becomes equal to that in the reservoir and the pipe 13, the valve 63 is lifted from its seat, whereupon the core 67 follows it up, due to the energization of the winding 33', and serves to hold the valve 63 in its upward position. The rod 68 prevents the movement up and down of the valve 63 with each stroke of the compressor piston, thereby preventing the wear upon the valve and the valve seat, which would otherwise ensue.

Since it requires considerable less attractive effort to merely maintain the cores in their upper positions than it does to move them into these positions, I find it sufficient to utilize only the coils 32' and 33' to retain the cores in their alternate positions, the coils 32 and 33 being cut out of circuit upon the closure of the switch 36. After the compressor has operated a sufficient length of time to bring up the pressure in the reservoir 6 to the maximum limit, the switch arm 16 closes circuit

through the contact 17' and the solenoid 19', whereupon the core 22 is moved to its alternate position, shown in Fig. 5, whereupon the circuit through the motor is broken, the compressor then coming to rest. The coils 32' and 33' will also be deenergized, releasing their cores 35 and 67. The core 35, however, cannot drop back into its normal position, on account of the air pressure within the chamber 56 upon the top of the valve 59, this pressure maintaining that valve firmly upon its seat 60. The core 67 being free to drop, allows the valve 63 to seat itself, thereby preventing the passage of air from the reservoir 6 through the pipe 13 to the chamber 56. The dropping of this core 67 also serves to cause the depression of the relief valve 71, thereby opening the small passage 70 to permit the slow escape of air under pressure from the chamber 56 and the pipe 11. The pressure in the chamber 56 thus becomes sufficiently reduced to permit the weight of the core 35 to raise the valve 59 from its seat, thereby opening the chamber 56 to atmospheric pressure. The mechanism is thus returned to its normal position, whereby the above cycle of operations may be again repeated.

It will thus be seen that I have provided a means whereby the starting current of a motor used to run a compressor may be controlled independently of the load until the motor is brought up to speed, when the load upon the motor may be gradually increased until the motor-compressor operates on normal full load current. I find it advisable to make the chamber 56 and the pipe 11 of considerable capacity, so that the load may not be too suddenly thrown upon the compressor. By making this chamber of considerable capacity, a short interval of time is required to increase the pressure therein from that of the atmosphere to that of the reservoir.

I find that there is particular advantage in providing the hollow air-tight spool for the coils 33 and 33', for the reason that by this means I may do away with an air-tight packed joint between the stem 68 and the wall of the casing through which it passes. Another feature which I find particularly serviceable is the provision of the oil chamber 47, which permits me to do away with a stuffing gland between the core 27 and the walls of the cylinder 48.

While I have herein shown and described one particular embodiment of my invention, it will be apparent to those skilled in the art that many modifications might be made therein, without departing from the spirit of my invention, and I do not, therefore, wish to limit myself to the precise disclosure herein set forth; but

Having described my invention I claim as new and desire to secure by Letters Patent:

1. In combination, a fluid pump, motor means for intermittently driving said pump, a pressure system supplied by said pump, a normally open escape valve in the discharge pipe from said pump, a second valve between said escape valve and said pressure system, means for closing said second valve before the opening of the escape valve, means for restricting the supply of energy to said motor means, means for automatically closing said escape valve upon the removal of the restriction in the supply of energy to said motor means, and means for maintaining the closure of said escape valve while said second valve is open, substantially as described.

2. In combination, a fluid pump, motor means for intermittently driving said pump, a pressure system supplied by said pump, a chamber in the discharge pipe from said

21. In combination, a fluid pump, motor means for in-

27. In combination, an air compressor, motor means for intermittently driving said compressor, a pneumatic pressure system supplied by said compressor, a chamber in the discharge pipe from said compressor, a normally open es-

cape valve in said chamber, a check valve between said chamber and said pressure system, means for automatically closing said check valve when the supply of energy to said motor means is shut off, means for restricting the supply of energy to said motor means at starting, means for automatically closing said escape valve upon the removal of the restriction in the supply of energy to said motor means whereby the load upon the compressor is gradually increased, a relief valve for relieving the pressure in said chamber after the closure of said second valve, and means for automatically holding said second valve open when the said compressor is discharging into said pressure system, substantially as described.

28. In combination, a fluid pump, a pressure system supplied thereby, an electric motor for intermittently driving said pump, an automatic rheostat for restricting the starting current supplied to said motor independent of the load on said motor, and automatic means acting independently of the pressure in said system to increase the load on said motor upon the removal of the restriction in the supply of current by said automatic rheostat.

29. In combination, an air compressor, a pressure system supplied thereby, an electric motor for intermittently driving said compressor, an automatic rheostat for restricting the starting current supplied to said motor independent of the load on said motor, and automatic electromagnetic means acting independently of the pressure in said system for gradually increasing the load on said compressor upon the removal of the restriction in the current supplied to said motor, substantially as described.

30. In combination, a fluid pump, a pressure system supplied thereby, an electric motor for intermittently driving said pump, an automatic rheostat for restricting the starting current supplied to said motor independent of the load on said motor, and automatic electromagnetic means acting independently of the pressure in said system and adapted to be included in the motor circuit for gradually increasing the load on said pump upon the removal of the restriction in the supply of current to said motor.

31. In combination, a pneumatic pump, a pressure system supplied thereby, an electric motor for driving said pump, means controlled by the pressure in said system to intermittently close the motor circuit, an automatic rheostat for restricting the starting current supplied to said motor independently of the load on said motor, and automatic means acting independently of the pressure in said system for increasing the load on the pump upon the removal of the restriction in the supply of energy to said motor.

32. In combination, a fluid pump, a pressure system supplied thereby, an electric motor for driving said pump, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in said system to a minimum limit and to open said motor circuit upon an increase in said pressure to a maximum limit, an automatic rheostat for restricting the starting current supplied to said motor independent of the load on said motor, and automatic electromagnetic means acting independently of the pressure in said system for increasing the load on said pump upon the removal of the restriction in the supply of energy to said motor.

33. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said air compressor, means controlled by the pressure in said system to intermittently close the motor circuit, means for restricting the supply of current to said motor at starting, a normally open escape valve in the discharge pipe from said compressor, a check valve in the discharge pipe between said escape valve and said pressure system, electromagnetic means for automatically closing said escape valve upon the removal of the restriction in the supply of energy to said motor, and electromagnetic means for automatically maintaining said check valve in an open condition while said compressor is discharging into said pressure system, substantially as described.

34. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said air compressor, means controlled by the pressure in said system to intermittently close the motor circuit, means for restricting the supply of current to said

motor at starting, a normally open escape valve in the discharge pipe from said compressor, a check valve in the discharge pipe between said escape valve and said pressure system, electromagnetic means for automatically closing said escape valve upon the removal of the restriction in the supply of energy to said motor, electromagnetic means for automatically maintaining said check valve in an open condition while said compressor is discharging into said pressure system, and means for maintaining the closure of said escape valve when said check valve is open, substantially as described.

35. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said air compressor, means controlled by the pressure in said system to intermittently close the motor circuit, means for restricting the supply of current to said motor at starting, an escape valve in the discharge pipe from said compressor, a check valve in the discharge pipe between said pump valve and said pressure system, electromagnetic means for automatically closing said escape valve upon the removal of the restriction in the supply of energy to said motor, and electromagnetic means for automatically maintaining said check valve in an open condition while said compressor is discharging into said pressure system, substantially as described.

36. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said air compressor, means controlled by the pressure in said system to intermittently close the motor circuit, means for restricting the supply of current to said motor at starting, an escape valve in the discharge pipe from said compressor, a check valve in the discharge pipe between said escape valve and said pressure system, electromagnetic means for automatically closing said escape valve upon the removal of the restriction in the supply of energy to said motor, electromagnetic means for automatically maintaining said check valve in an open condition while said compressor is discharging into said pressure system, and means for maintaining the closure of said escape valve when said check valve is open, substantially as described.

37. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in said system to a minimum limit and to open said circuit upon an increase in said pressure to a maximum limit, means for restricting the supply of current to said motor at starting independent of the load on said motor, a chamber in the discharge pipe from said compressor, an escape valve in said chamber, a check valve between said chamber and said pressure system, electromagnetic means for automatically preventing said check valve from seating when said compressor is discharging into said pressure system, said means being adapted to permit the closure of said check valve when the supply of current to said motor is shut off, and electromagnetic means for automatically closing said escape valve upon the removal of the restriction in the supply of current to said motor, whereby the load upon the compressor is gradually increased, substantially as described.

38. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in said system to a minimum limit and to open said circuit upon an increase in the pressure to a maximum limit, a chamber in the discharge pipe from said compressor, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, electromagnetic means for automatically preventing the seating of said check valve when said compressor is discharging into said pressure system, said electromagnetic means being adapted to permit the closure of said check valve when said motor circuit is open, means for restricting the supply of current to said motor at starting, electromagnetic means for closing said escape valve upon the removal of the restriction in the supply of current to said motor, whereby the load upon the com-

pressor is gradually increased, and a relief valve for relieving the pressure in said chamber after the closure of said check valve, substantially as described.

39. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in said system to a minimum limit and to open said circuit upon an increase in the pressure to a maximum limit, a chamber in the discharge pipe from said compressor, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, electromagnetic means for automatically preventing the seating of said check valve when said compressor is discharging into said pressure system, said electromagnetic means being adapted to permit the closure of said check valve when said motor circuit is open, means for restricting the supply of current to said motor at starting, electromagnetic means for closing said escape valve upon the removal of the restriction in the supply of current to said motor, whereby the load upon the compressor is gradually increased, a relief valve for relieving the pressure in said chamber after the closure of said check valve, and means for maintaining said escape valve in a closed condition when said check valve is open, substantially as described.

40. In combination, an air compressor, an electric motor for driving said compressor, a pneumatic pressure system supplied thereby, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in the system to a minimum limit and to open the motor circuit upon an increase in said pressure to a maximum limit, a resistance in the motor circuit, a path of high conductivity including a normally open switch connected in shunt of said resistance, electromagnetic means included in said circuit adapted upon energization to close said switch, a normally open escape valve in the discharge pipe from said compressor, and means for automatically closing said escape valve when said resistance has been cut out of circuit, substantially as described.

41. In combination, an air compressor, an electric motor for driving said compressor, a pneumatic pressure system supplied by said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in the system to a minimum limit and to open the motor circuit upon an increase in said pressure to a maximum limit, a resistance in the motor circuit, a path of high conductivity including a normally open switch connected in shunt of said resistance, slow-acting electromagnetic mechanism included in said circuit, adapted upon energization to close said switch, a normally open escape valve in the discharge pipe from said compressor, and electromagnetic means for automatically closing said escape valve when said resistance has been shunted, substantially as described.

42. In combination, an air compressor, an electric motor for driving said air compressor, a pneumatic pressure system supplied by said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in the system to a minimum limit and to open the motor circuit upon an increase in said pressure to a maximum limit, resistance in the motor circuit, a path of high conductivity including a normally open switch connected in shunt of said resistance, electromagnetic mechanism included in said circuit adapted upon energization to close said switch, a dash pot adapted to control and retard the motion of said electromagnetic mechanism, a normally open escape valve in the discharge pipe from said compressor, a second valve in the discharge pipe between said escape valve and said pressure system, and electromagnetic means for automatically closing said escape valve when said motor operates at substantially full speed, substantially as described.

43. In combination, an air compressor, an electric motor for driving said compressor, a pneumatic pressure system supplied by said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in the system to a minimum limit and to open the motor circuit upon an increase in said pressure to a maximum limit, a resistance in the motor

circuit, paths of high conductivity, each including a normally open switch connected in shunt of sections of said resistance, electromagnetic means included in said circuit adapted upon energization to close the switch in one of said paths, a chamber in the discharge pipe from said compressor, a second valve between said chamber and said pressure system, a normally open escape valve in said chamber, and electromagnetic means for automatically closing said escape valve when said motor operates at substantially full speed, substantially as described.

44. In combination, an air compressor, an electric motor for driving said compressor, a pneumatic pressure system supplied by said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in said system to a minimum limit and to open the motor circuit upon an increase in said pressure to a maximum limit, a resistance in the motor circuit, paths of high conductivity, each including a normally open switch connected in shunt of sections of said resistance, electromagnetic means included in said circuit adapted upon energization to close the switch in one of said paths, electromagnetic means included in circuit in each of said paths of high conductivity and adapted upon energization to close the switch in another of said paths, a chamber in the discharge pipe from said compressor, a normally open escape valve in said chamber, a second valve between said chamber and said pressure system, electromagnetic means for automatically closing said second valve when said compressor comes to rest, and electromagnetic means for automatically closing said escape valve when said motor operates at substantially full speed, substantially as described.

45. In combination, an air compressor, an electric motor for driving said compressor, a pneumatic system supplied by said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in pressure in said system to a minimum limit and to open the motor circuit upon an increase in said pressure to a maximum limit, a resistance included in the motor circuit, paths of high conductivity, each including a normally open switch connected in shunt of sections of said resistance, slow-acting electromagnetic mechanism included in circuit in each of said paths of high conductivity adapted upon energization to close the switch in the next succeeding path, electromagnetic means serially included in circuit with said resistance adapted upon energization to close the first of said switches, whereby the electromagnetic mechanism may serve to automatically cut out the succeeding sections of said resistance, a chamber in the discharge pipe from said compressor, a normally open escape valve in said chamber, a second valve between said chamber and said pressure system, means for automatically closing said second valve when said compressor comes to rest, means for automatically closing said escape valve when said resistance has been cut out of circuit, whereby the load upon the compressor is gradually increased, a relief valve for relieving the pressure in said chamber after the closure of said second valve, and means for automatically holding said second valve open when the compressor is discharging into said pressure system, substantially as described.

46. In combination, a fluid pump, motor means for intermittently driving said pump, a pressure system supplied by said pump, a chamber in the discharge pipe from said pump, a check valve between said chamber and said pressure system, an escape valve in said chamber, and automatic electromagnetic means for closing said escape valve a short period after the application of energy to said driving means, the intervening length of time being adapted to permit said motor means to attain substantially its full speed, substantially as described.

47. In combination, a fluid pump, means for intermittently driving said pump, a pressure system supplied by said pump, a chamber in the discharge pipe from said pump, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, means for preventing said check valve from seating when said pump is discharging into said pressure system, said means being adapted to permit the closure of said check valve when said pump comes to rest, means for automatically closing said escape valve a short period after

the application of energy to said driving means, the intervening length of time being adapted to permit said driving means to attain substantially its full speed, means for maintaining said escape valve in a closed condition when said check valve is open, and a relief valve for relieving the pressure in said chamber after the closure of said check valve, thereby permitting said escape valve to open, substantially as described.

48. In combination, a fluid pump, means for intermittently driving said pump, a pressure system supplied by said pump, a chamber in the discharge pipe from said pump, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, means for preventing said check valve from seating when said pump is discharging into said pressure system, said means being adapted to permit the closure of said check valve when said pump comes to rest, means for automatically closing said escape valve a short period after the application of energy to said driving means, the intervening length of time being adapted to permit said driving means to attain substantially its full speed and a relief valve for relieving the pressure in said chamber after the closure of said check valve, thereby permitting said escape valve to open, substantially as described.

49. In combination, an air compressor, motor means for intermittently driving said compressor, a pneumatic pressure system supplied by said compressor, means controlled by the pressure in said system for intermittently supplying energy to said motor means, a chamber in the discharge pipe from said compressor, a check valve between said chamber and said pressure system, an escape valve in said chamber, and means independent of the speed of the motor means for automatically closing said escape valve a short period after the application of energy to said driving means, the intervening length of time being adapted normally to permit said driving means to attain substantially its full speed.

50. In combination, a fluid pump, motor means for intermittently driving said pump, a pressure system supplied by said pump, means controlled by the pressure in said system for controlling the supply of energy to said motor means, a normally open escape valve in the discharge pipe from said pump, a check valve between said escape valve and said pressure system, automatic means independent of the flow of fluid for preventing the closure of said check valve when said pump is discharging into said pressure system, said means being adapted to permit the closure of said check valve when said compressor comes to rest, and means for automatically closing said escape valve a short period after the application of energy to said motor means, the intervening length of time being adapted to permit the said motor means to attain substantially its full speed.

51. In combination, a fluid pump, motor means for intermittently driving said pump, a pressure system supplied by said pump, means controlled by the pressure in said system for controlling the supply of energy to said motor means, a normally open escape valve in the discharge pipe from said pump, a check valve between said escape valve and said pressure system, automatic means for holding said check valve open when said pump is discharging into said pressure system, said means being adapted to permit the closure of said check valve when said compressor comes to rest, means for automatically closing said escape valve a short period after the application of energy to said motor means, the intervening length of time being adapted to permit the said motor means to attain substantially its full speed, and means for preventing the opening of said escape valve when said check valve is open, substantially as described.

52. In combination, a fluid pump, motor means for intermittently driving said pump, a pressure system supplied by said pump, means controlled by the pressure in said system for controlling the supply of energy to said motor means, a normally open escape valve in the discharge pipe from said pump, a check valve between said escape valve and said pressure system, automatic means for holding said check valve open when said pump is discharging into said pressure system, said means being adapted to permit the closure of said check valve when said compressor comes to rest, means for automatically

closing said escape valve a short period after the application of energy to said motor means, the intervening length of time being adapted to permit the said motor means to attain substantially its full speed, means for preventing the opening of said escape valve when said check valve is open, and a relief valve in said chamber, substantially as described.

53. In combination, an air compressor, an electric motor for intermittently driving said compressor, a pressure system supplied by said compressor, an escape valve in the discharge pipe from said compressor, a second valve in the discharge pipe between said escape valve and said pressure system, and electromagnetic means for automatically closing said escape valve a short period after the closure of the motor circuit, substantially as described.

54. In combination, an air compressor, an electric motor for intermittently driving said compressor, a pressure system supplied by said compressor, a chamber in the discharge pipe from said compressor, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, electromagnetic means for maintaining said check valve in an open condition when said compressor is discharging into said pressure system, and for permitting the closure of said check valve when said compressor comes to rest, and electromagnetic means for automatically closing said escape valve a short period after the closure of the motor circuit, whereby the load upon the compressor is gradually increased, substantially as described.

55. In combination, an air compressor, an electric motor for intermittently driving said compressor, an automatic rheostat for restricting the starting current supplied to said motor, independent of the load on said motor, and automatic electromagnetic means for gradually increasing the load on said compressor, said means being adapted to remain inoperative during the initial supply of current to said motor, substantially as described.

56. In combination, an air compressor, an electric motor for driving said compressor, a pneumatic pressure system supplied by said compressor, means controlled by the pressure in said system to close the motor circuit upon a decrease in the pressure in said system to a minimum limit, and to open the motor circuit upon an increase in said pressure to a maximum limit, a resistance in the motor circuit, paths of high conductivity, each including a normally open switch connected in shunt of sections of said resistance, electromagnetic means included in said circuit adapted upon energization to close the switch in one of said paths, electromagnetic means included in circuit in each of said paths of high conductivity and adapted upon energization to close the switch in another of said paths, a chamber in the discharge pipe from said compressor, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, electromagnetic means adapted to maintain said check valve in an open condition when said compressor is discharging into said pressure system, and to permit the closure of said check valve when said compressor comes to rest, and electromagnetic means for automatically closing said escape valve a short period after the closure of the motor circuit, substantially as described.

57. In combination, a fluid pump, a pressure system supplied thereby, motor means for intermittently driving said pump, a check valve in the discharge pipe from said pump, and automatic means independent of the flow of fluid through said check valve for maintaining said valve in an open condition when said pump is discharging into said pressure system.

58. In combination, an air compressor, a pressure system supplied thereby, an electric motor for intermittently driving said compressor, a check valve in the discharge pipe from said compressor, and automatic electromagnetic means for preventing said check valve from seating when said compressor is discharging into said pressure system, substantially as described.

59. In combination, a fluid pump, a pressure system supplied thereby, motor means for intermittently driving said pump, a check valve in the discharge pipe from said pump, automatic means independent of the flow of fluid through said check valve for maintaining said valve in an open condition when said pump is discharging into said pressure

system, and means adapted to permit the closure of said valve when said compressor comes to rest.

60. In combination, a fluid pump, a pressure system supplied thereby, motor means for intermittently driving said pump, an escape valve in the discharge pipe from said pump, a check valve in the discharge pipe between said escape valve and said pressure system, automatic means independent of the flow of fluid through said check valve for preventing the closure of said check valve when said pump is discharging into said pressure system and for permitting the closure of said check valve when said compressor comes to rest, and means for causing the closure of said escape valve after the lapse of a short interval after the initial movement of said compressor in starting.

61. In combination, a fluid pump and pressure system supplied thereby, motor means for intermittently driving said pump, the control of said motor means being effected by the pressure in said system, a chamber in the discharge pipe from said pump, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, electromagnetic means for allowing the closure of said escape valve after the initial movement of said pump in starting, and automatic means for preventing the closure of said check valve when said pump is discharging into said pressure system.

62. In combination, a fluid pump, a pressure system supplied thereby, motor means for intermittently driving said pump, the control of said motor means being effected by the pressure in said system, a chamber in the discharge pipe from said pump, a normally open escape valve in said chamber, a check valve between said chamber and said pressure system, electromagnetic means for allowing the closure of said escape valve after the initial movement of said pump in starting, and electromagnetic means for preventing the closure of said check valve when said pump is discharging into said pressure system and for permitting the closure of said check valve when said pump comes to rest.

63. In combination, a chamber for fluid under pressure, a weighted check valve controlling an opening in said chamber and opened by an excess of pressure in said chamber, an electromagnet, an armature for said electromagnet contained in said chamber, and means whereby the energization of said electromagnet causes an actuation of said armature to prevent the closure of said check valve.

64. In combination, a chamber for fluid under pressure, a check valve in a wall of said chamber, said check valve permitting the escape of fluid from said chamber when the excess of the pressure has reached a predetermined maximum limit, an electromagnet, an armature for said electromagnet contained in said chamber, a source of electric current, an electric circuit connecting said source of current and said electromagnet, and means whereby the energization of said electromagnet causes an actuation of said armature to prevent the closure of said check valve.

65. In combination, a chamber for fluid under pressure, two valves for said chamber, the first valve being normally closed and the second valve being normally held open, and electromagnetic mechanism associated with each valve, energization of the respective electromagnetic mechanisms causing said first valve to be opened and said second valve to be allowed to close.

66. In combination, a chamber for fluid under pressure, a check valve in a wall of said chamber, said check valve being arranged to permit the flow of fluid from said chamber but to prevent the flow of fluid into said chamber, an electromagnet, armature mechanism for said electromagnet contained in said chamber, a normally open relief valve opening into said chamber, a second electromagnet, armature mechanism for said second electromagnet, and means whereby the energization of said electromagnets causes actuation of said armature mechanisms to prevent the closure of said check valve and to permit the closure of said relief valve.

67. In combination, a chamber having an aperture therein, a weighted check valve in said aperture opening away from said chamber, an electromagnet, armature mechanism associated with said electromagnet, a relief valve in said chamber, a second electromagnet, armature mechanism for said second electromagnet, means whereby

the energization of said electromagnets causes actuation of said armature mechanisms to respectively prevent the closure of said check valve and to permit the closure of said relief valve, and means whereby the de-energization of said second electromagnet causes an actuation of its armature mechanism to open said relief valve.

68. In combination, a chamber having an aperture therein, an electromagnetically controlled check valve in said aperture, a relief valve associated with said chamber, detent means for normally preventing closure of said relief valve, means whereby an energization of the electromagnet associated with said check valve prevents the closure thereof, and additional electromagnetic means for actuating said detent means to allow closure of said relief valve.

69. In combination, a chamber for fluid under pressure, two valves for said chamber, electromagnets associated with said valves, armature mechanism for each electromagnet, one of the armature mechanisms being normally mechanically arranged to allow closure of the first valve, the other armature mechanism being normally arranged to prevent closure of the second valve, and means upon energization of said electromagnets for causing actuation of said armature mechanisms to respectively prevent closure of the first valve and to allow closure of the second valve.

70. In combination, a chamber, an electromagnetically controlled check valve tending to permit the flow of fluid from said chamber but to prevent the flow of fluid into said chamber, a source of electric current, an electric circuit connecting said source of current with the electromagnet associated with said check valve, and means whereby the energization of said electromagnet serves to maintain said check valve in an open condition, the electrical constants of said source of current, circuit and electromagnet being so adjusted that the normal energization of said electromagnet is insufficient to cause said check valve to open when subjected to less pressure from within said chamber than from without.

71. In combination, a chamber for fluid under pressure, an electromagnetically controlled check valve tending to permit the flow of fluid from said chamber but to prevent the flow of fluid into said chamber, a normally open relief valve in said chamber, means whereby the energization of the electromagnet associated with said check valve tends to open the check valve, and automatic means for at the same time allowing closure of said relief valve.

72. In combination, a chamber for fluid under pressure, two valves for said chamber, electromagnetic mechanism associated with each valve, deenergization of respective electromagnetic mechanism allowing the first of said valves to close and preventing the second of said valves from closing, and means upon energization of said electromagnetic mechanism for causing opening of said first valve, and closing of said second valve.

73. In combination, a chamber, an electromagnetically controlled check valve tending to permit the flow of fluid from said chamber but to prevent the flow of fluid into said chamber, a source of electric current, an electric circuit connecting said source of current with the electromagnet associated with said check valve, means whereby the energization of said electromagnet prevents said check valve from seating, the electrical constants of said source of current, circuit and electromagnet being so adjusted that the normal energization of said electromagnet is insufficient to open said check valve when subjected to less pressure from within said chamber than from without, a normally open relief valve in said chamber, and electromagnetic means adapted upon energization to allow opening of said relief valve.

74. In combination, a chamber for fluid under pressure, a check valve tending to permit the flow of fluid from said chamber but to prevent the flow of fluid into said chamber, an electromagnet, armature mechanism for said electromagnet located in said chamber, a source of electric current, an electric circuit connecting said source of current with said electromagnet, means whereby the energization of said electromagnet causes an actuation of said armature mechanism to prevent the closure of said check valve, the electrical constants of said source of current, circuit and electromagnet being so adjusted that the nor-

mal energization of said electromagnet is insufficient to cause said check valve to open when subjected to less pressure from within said chamber than from without, a relief valve in said chamber, a second electromagnet, and mechanism associated with said second electromagnet and said relief valve, said mechanism upon deenergization of said second electromagnet preventing the closure of said relief valve and upon energization of said second electromagnet allowing closure of said relief valve.

75. In combination, a fluid pressure system, a fluid pump for supplying fluid under pressure to said system, a chamber interposed in the connection between said pump and said system, a normally closed check valve for checking the flow of fluid from said system, an electromagnet, and armature mechanism for said electromagnet normally disconnected from said valve and located in said chamber, said armature mechanism serving to engage said valve to prevent the closure thereof upon the energization of said electromagnet.

76. In combination, a fluid pressure system, a fluid pump for supplying fluid under pressure to said system, a normally closed check valve interposed between said pump and said system, an electromagnet, armature mechanism for said electromagnet normally disconnected from said valve and subjected at all points to the pressure of the discharge from said pump, and means whereby the energization of said electromagnet causes engagement of said armature mechanism with said valve to prevent the closure thereof.

77. In combination, a fluid pressure system, a fluid pump for supplying fluid under pressure to said system, a check valve interposed between said pump and said system, an electromagnet, armature mechanism associated with said electromagnet and subjected at all points to the pressure of the discharge from said pump, a relief valve between said pump and said check valve, a second electromagnet, armature mechanism for said second electromagnet normally mechanically associated with said relief valve to prevent closure thereof, means whereby the energization of said first electromagnet causes an actuation of its armature mechanism to prevent the closure of said check valve, means whereby the energization of the second electromagnet causes actuation of its armature mechanism to permit the closure of said relief valve.

78. In combination, a fluid pressure system, a fluid pump for supplying fluid under pressure to such system, a chamber interposed in the connection between said pump

and said system, a check valve arranged to check the flow of fluid from said system into said chamber, an electromagnet, armature mechanism located in said chamber, means whereby the energization of said electromagnet causes an actuation of said armature mechanism to prevent the seating of said check valve, a relief valve associated with said chamber, a second electromagnet, armature mechanism for said second electromagnet, means whereby the energization of said second electromagnet causes actuation of its armature mechanism to allow closure of said relief valve, and means whereby upon reduction of pressure in said chamber the de-energization of said electromagnet causes the opening of said relief valve by said armature mechanism.

79. In combination, an air compressor, a pneumatic pressure system supplied thereby, an electric motor for driving said air compressor, means controlled by the pressure in said system to intermittently close the motor circuit, means for restricting the supply of current to said motor at starting, a normally open escape valve in the discharge pipe from said compressor, a check valve in the discharge pipe between said escape valve and said pressure system, and electromagnetic means for automatically closing said escape valve upon the removal of the restriction in the supply of energy to said motor.

80. In combination, a fluid pump, an electric motor for intermittently driving said pump, a pressure system supplied by said pump, a chamber in the discharge pipe from said pump, a normally open escape valve in said chamber, a second valve between said chamber and said pressure system, electromagnetic means for automatically maintaining said second valve in open condition when said compressor is discharging into said pressure system, and for permitting the closure of said second valve when said pump comes to rest, electromagnetic means for automatically closing said escape valve after the lapse of a suitable interval after the closure of the motor circuit whereby the load upon the pump is gradually increased, and a relief valve for relieving the pressure in said chamber after the closure of said second valve.

In witness whereof, I have hereunto subscribed my name this 6th day of December A. D., 1902.

WALTER JOSEPH RICHARDS.

Witnesses:

EMMA DRAEGER,
THEO. MUELLER.