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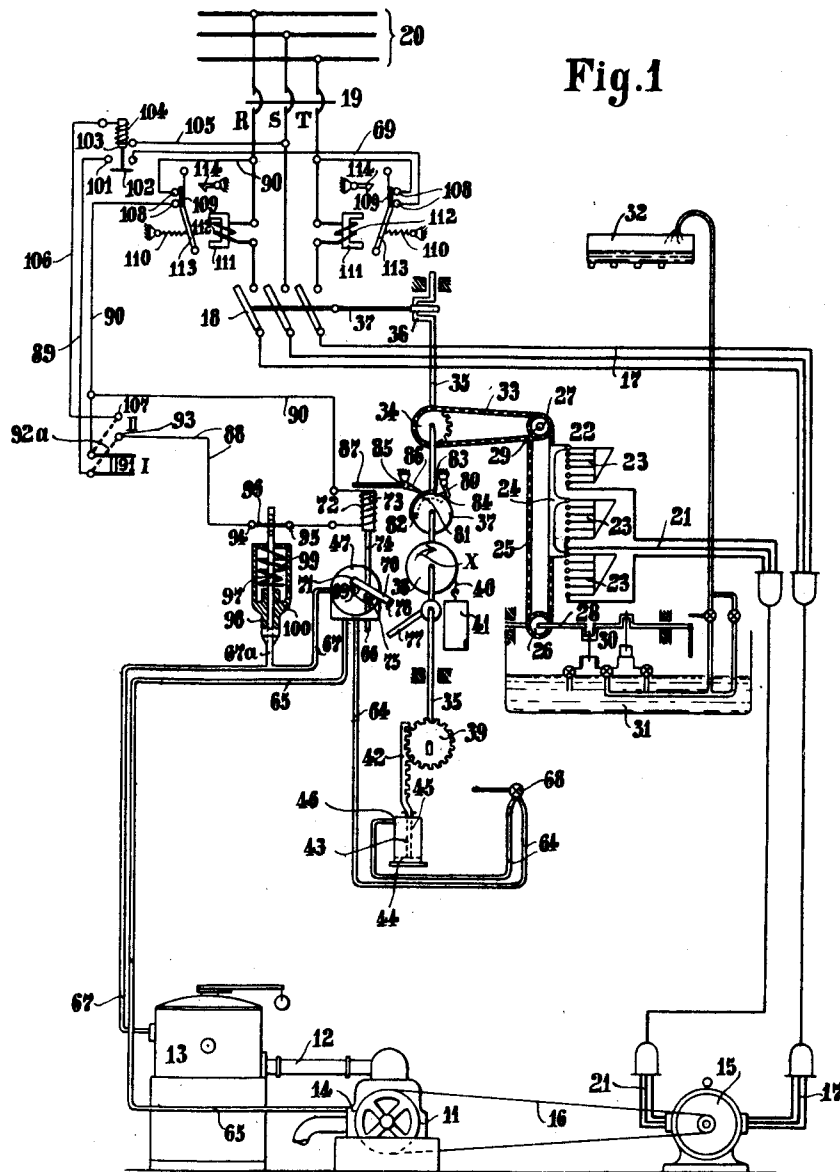
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AUTOMATIC CONTROLLING APPARATUS FOR PUMPS, COMPRESSORS, AND THE LIKE

Filed March 29, 1926

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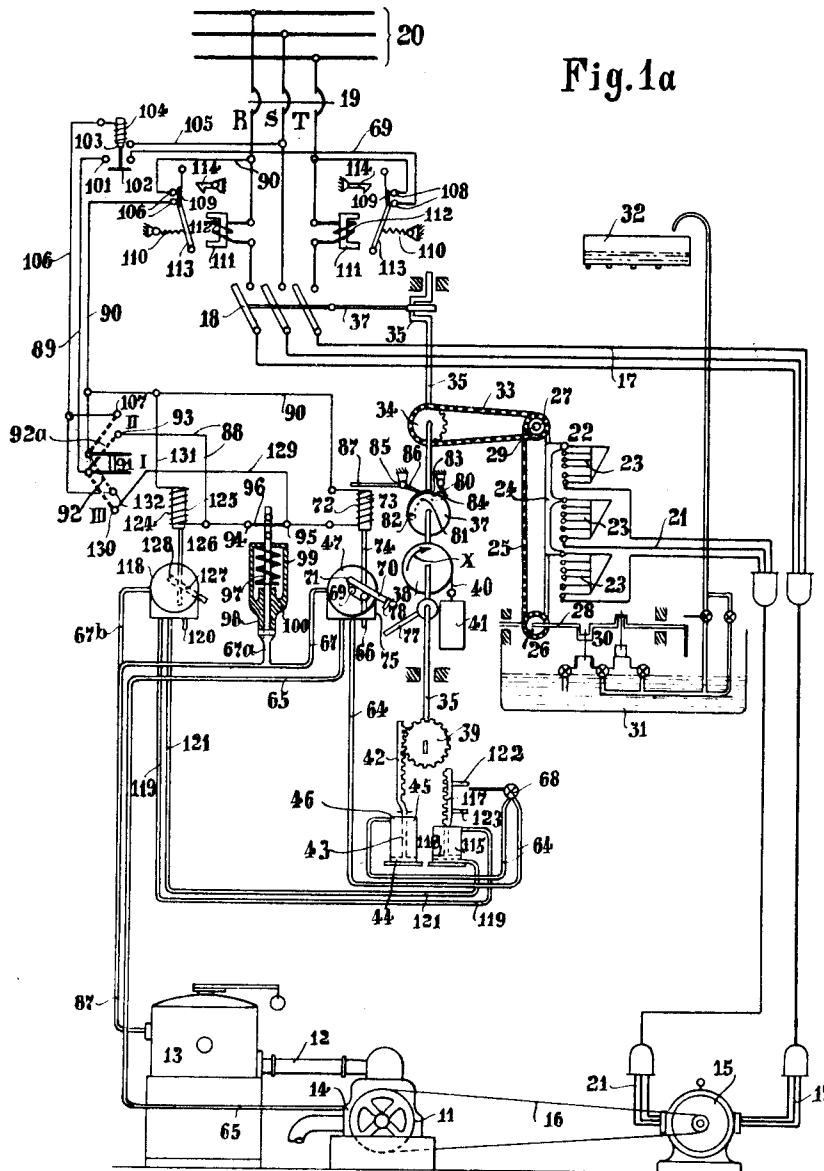
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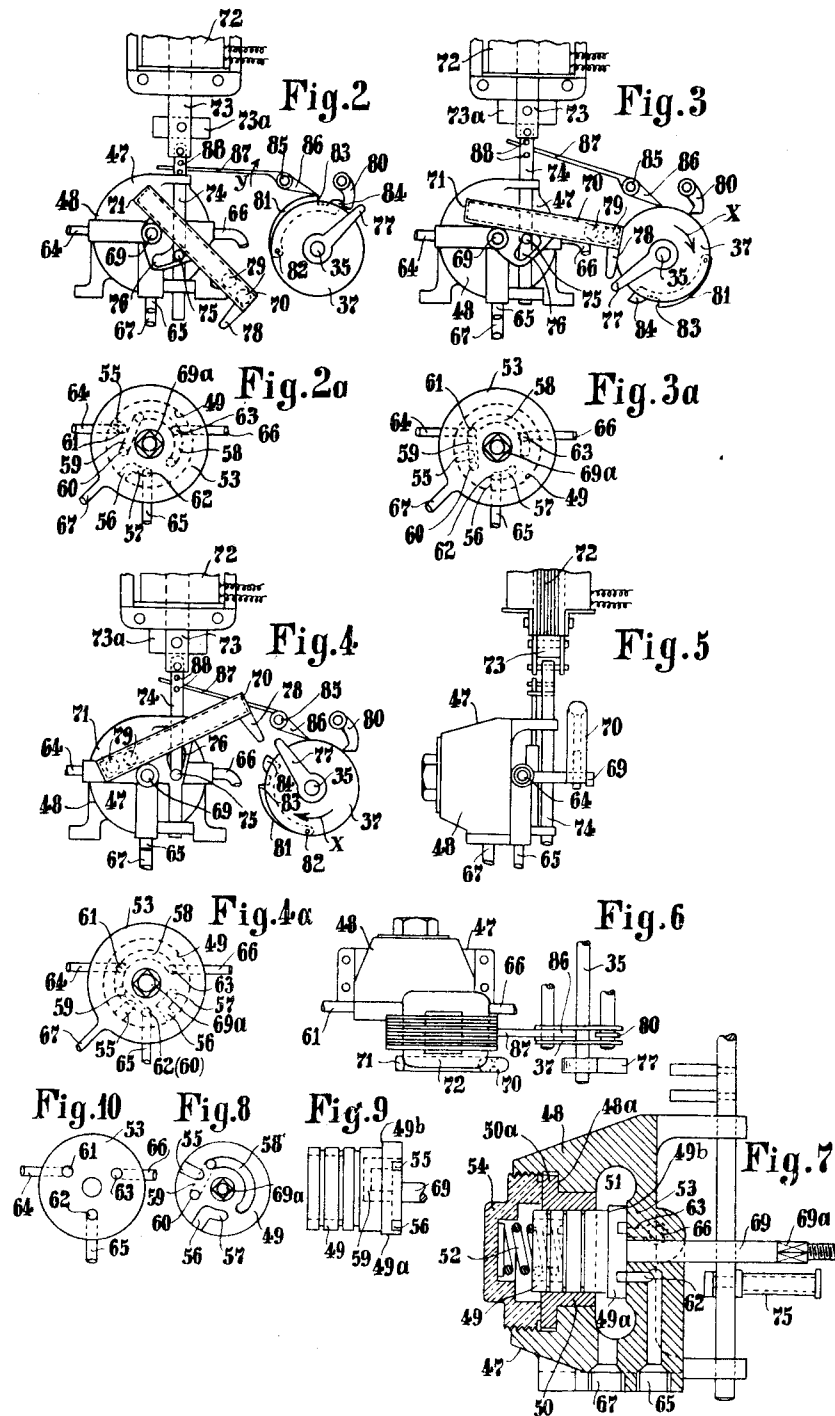
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE.

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AUTOMATIC CONTROLLING APPARATUS FOR PUMPS, COMPRESSORS, AND THE LIKE.

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The subject matter of the present invention is an automatic controlling apparatus for pumps, compressors and the like which is particularly intended to start up the pump or the compressor when the pressure in the conduit or in a receiver supplied by the pump or the compressor falls below a predetermined value and on the other hand to bring the pump or the compressor to a standstill again when a maximum pressure has been reached. The starting apparatus comprises a starting switch, of a type known per se, which is moved in the direction for starting the driving motor of the pump or the compressor by means of a weight and in the opposite direction, by the pressure medium through the agency of a piston which is fitted in a so-called regulating cylinder. The apparatus comprises further a device, which is also known per se, for unloading the pump or compressor. In the controlling apparatus in accordance with the invention the pressure medium cylinder for moving the starting switch and the device for unloading the pump are controlled by means of a valve which in one end position, namely, its position of rest, subjects at least the regulating cylinder for the starting switch and in some cases also a fluid pressure actuating unloading valve to pressure. In its middle position on the other hand the valve relieves the regulating cylinder from pressure and subjects the unloading valve to pressure and, finally, in its other end position, namely in its operating position, it relieves not only the regulating cylinder for the starting switch but also the unloading valve from pressure. The adjustment of this valve is effected in accordance with the invention partly by an electro-magnet which is connected in shunt with the circuit of the motor and is itself controlled by means of a switch actuated by the pressure medium, and partly by the actuating weight of the starting switch, in such a manner that the movement of the valve from its position of rest to its middle position is effected by the armature of the electro-magnet being attracted, and the movement from the middle position to the operating position, after the starting procedure has been completed, is on the contrary effected by the actuating weight of the starting switch, while the return movement of the valve into its position of rest is effected by the fall of the armature. Finally, even if mechanical disturbances occur within the starting switch, starting up of the motor under load is avoided with certainty, since the unloading of the pump or the compressor can not take place until the starter has made connection with the last contact of the series of contacts over which it travels, that is when the starting up of the motor is completed. The new controlling apparatus is distinguishable from the known apparatus serving the same purpose by its exact and reliable operation in addition to its greater simplicity. It possesses the further advantage that the driving motor for the pump or the like is always switched over so as to run at full speed when the compressor is unloaded not only when everything is in order but also if any electrical disturbances occur so that the re-starting of the driving motor only when the pump or the compressor is unloaded is ensured. If, for instance, owing to failure of the voltage or in consequence of automatic disconnection by an overload relay, current ceases to flow in the electromagnet the falling armature of the electromagnet returns the controlling valve into its original position, the consequence of which is that the starting switch is also returned into its original position by the pressure medium admitted to its regulating cylinder. Furthermore, there is an avoidance, when the voltage is again applied, of the starting switch being set in the position for full speed and the pump or compressor being subjected to full load, so that damage to the installation is prevented. The new apparatus can also be so constructed that, when a predetermined pressure is reached in the receiver supplied by the pump or the compressor, instead of both of these latter-named agents being brought completely to a standstill, only a reduction in the output of the pump is effected. In this case the starting switch is regulated, in correspondence with the pressure in the receiver, in such a manner that when the maximum pressure is attained it reduces the speed of the driving motor and when the pressure falls the motor is again driven at full speed. A constructional embodiment of the new controlling apparatus is illustrated, by way of example, in the accompanying drawings, in which

Fig. 1 is a diagrammatic view of the complete installation in a constructional example as adapted for the purpose of bringing the pump or the compressor alternately to a complete standstill and again to full speed.

Fig. 1^a is a similar view of the apparatus as modified for reducing the output of the pump or compressor when the maximum pressure is reached.

Figs. 2-10 are detail views of the controlling valve for the regulating cylinder. Of these,

Figs. 2, 3, 4 show the valve in plan from the front in three different positions, while Figs. 2^a, 3^a, 4^a show the corresponding positions of the rotary piston of the valve.

Fig. 5 is a side view and,

Fig. 6 a plan of the valve from the top.

Fig. 7 shows the valve, on a somewhat larger scale, partly in vertical section through its axis and partly in side elevation.

Fig. 8 is a plan of the front face of the rotary piston of the valve containing the controlling passages.

Fig. 9 a side view of this piston, and,

Fig. 10 a plan of the front wall of the casing of the valve which is also provided with controlling openings.

Referring to Fig. 1 of the drawings 11 is a compressor, the pressure side of which is connected by means of the pipe 12 with a receiver 13 which is to be supplied by the compressor. The compressor is provided at 14 with a fluid pressure actuated unloading valve (not shown) of a type well known in the art which is so arranged that when the valve is loaded by compressed air the compressor unloaded, while when the load on the valve is diminished the compressor operates and delivers the compressed air to the receiver 13. The compressor 11 is driven by means of an endless belt 16 from an electric motor 15 which, in the example illustrated, is a three-phase motor. The stator windings of the motor 15 are connected to the mains 20 by means of the conductors 17 through an automatic opening and closing switch 18, which is controlled in a manner to be hereinafter described, and through a circuit-breaking switch 19. A starting switch 22, of a type known per se, which is connected by means of the leads 21 to the winding of the rotor serves the purpose of starting the motor. The starting switch possesses three groups of starting resistances 23 and a bridge 24 which is movable over their contacts. The bridge 24 is fitted on an endless chain 25 which runs on two chain wheels 26, 27 which are fitted on the shafts 28 and 29. The shaft 28 is in connection with an oil brake which is so arranged that the movement of the bridge 24 for disconnecting the resistances 23 is retarded, while a retardation of the movement for inserting the resistances in series in the circuit does not

take place. The brake consists, in the example illustrated, of several pumps 30, which are driven by the shaft 28 which is formed as a crank shaft, and pump lubricating oil from a low-lying storage container 31 to an elevated container 32 from which the oil is conducted to those parts of the machine which require to be lubricated. A detail description of this device is unnecessary since it forms no part of the invention.

The shaft 29 is connected by means of a second chain drive, which consists of a chain wheel, behind the wheel 27 and not visible in the drawing, fitted on the shaft 29, the endless chain 33 and the wheel 34, with a driving shaft 35 for the starting switch 22. The shaft 35 also serves the purpose of moving the previously mentioned opening and closing switch 18, which is connected with the shaft 35 in such a manner that it is closed by the rotation of the latter in the direction of the arrow α before the bridge 24 of the starting switch 22 begins to cut out the resistances while, in the opposite direction of rotation of the shaft 35, the switch 18 is again opened after the starting switch 22 has been moved back into its original position in which the whole of the resistances 23 are connected in the circuit. In the drawing it has been assumed for the sake of simplicity that the shaft 35 is connected with the switch 18 by means of a crank 36, which runs loose for a portion of its pathway, and a connecting rod 37, but other suitable means for the purpose may be employed.

The shaft 35, carries, in addition to the chain wheel 34 and the crank 36 or other device for the movement of the starting switch 22 and the switch 18, a locking disc 37, of which a more detailed description is hereinafter given, a rope pulley 38 and a toothed wheel 39. Round the pulley 38 is wound a rope or other flexible tension member 40 of which one end is fixed to the pulley 38, while the other end carries a weight 41 which tends to rotate the shaft 35 in the direction of the arrow α , that is, to rotate it in such a manner that the switch 18 is closed and the bridge 24 of the starter 22 is moved in the direction for disconnecting the resistances 23, that is to say it is moved downwards. With the toothed wheel 39 on the other hand there meshes a rack 42 which is fixed to the piston rod 43 of a piston 44 fitted in a cylinder 45. The upper end of the cylinder 45 possesses an inlet and outlet 46 for the compressed air. When compressed air is admitted to the cylinder 45 the piston 44 moves downwards whereby the shaft 35 is rotated in opposite direction to that indicated by the arrow α , so that the bridge 24, through the agency of the chains 33 and 25, is moved in such a way as to cause resistances 23 to be connected in series in

the circuit. When the piston 44 has reached its lower end position it is retained in this position by the pressure medium.

The inlet and outlet 46 of the cylinder 45 is controlled by a valve 47 which also serves the purpose of controlling the admission of pressure medium to the unloading valve 14 of the compressor 11. The valve 47, which has been illustrated separately in Figs. 2-10, possesses a casing 48 and a rotary valve 49 fitted therein. The valve 49 is, for a portion of its length, tightly journaled in a stuffing box 50 of the casing 48 while its end 49^a is surrounded by an annular space 51 in the casing. The front face of the end 49^a of the valve which lies in the annular space 51 is also pressed by means of a spring 52 acting against the other end of the valve, tightly against the front face 53 of the casing 48. The spring 52 is supported with its outer end against a cap 54 which is screwed into the casing 48 and which simultaneously serves the purpose of securing the stuffing box 50 and pressing a flange 50^a with which it is provided tightly against the surface 48^a of the casing which may be provided with packing. The front surface of the rotary valve 49 which faces the wall 53 of the casing contains a number of controlling channels. There are in this surface two approximately radial grooves 55 and 56 of limited length the outer ends of which open into the annular space 51 of the casing. Of these the groove 56 is connected at its inner end with a short arc-shaped groove 57 concentric to the axis of rotation of the valve 49. There is provided also an approximately semi-circular groove 58, which is also concentric to the axis of the rotation of the valve, of which one end is connected by means of a passage 59 passing round the groove 55 with an opening 60. Three openings 61, 62 and 63 provided in the front wall 53 of the casing and arranged at about 120° apart coact with the above-mentioned controlling channels and openings in the front surface of the valve. Of these openings the opening 62 is connected by a pipe 65 with the unloading valve 14 of the compressor 11, the opening 61 is connected by a pipe 64 with the pressure medium inlet and outlet 46 of the regulating cylinder 45 for the starting switch 22, while the opening 63 leads to the atmosphere through an exhaust 66. In the pipe 64 there is interposed a shut-off cock 68 which is however usually open and can therefore be neglected in the description of that part of the starting device which is, with respect to the operation of the apparatus as shown in Fig. 1, being dealt with. Finally the annular space 51 of the casing 48 is connected by means of a pipe 67 with the receiver 13, so that the annular space 51 and the grooves 55 and 56 connected with it are supplied with compressed air.

In order to relieve the valve 49 from the axial pressure which is exerted upon it by the pressure medium present in the grooves 55, 56 the shape of the valve inside the annular space 51 is made such that the end 49^a containing the controlling channels is of somewhat larger diameter than the remaining portion of the valve. In this way there is formed a small shoulder 49^b which is also subject to the pressure of the pressure medium in the annular space 51 but in the opposite direction to that of the pressure on the end surfaces of the grooves 55, 56, so that the two axial pressures neutralise one another. In practice the area of the annular surface at the shoulder 49^b may be such that the valve 49 will be pressed tightly against the front wall 53 of the casing 48 by the pressure acting on the shoulder, in which case the spring 52 only serves the purpose of pressing the valve 49 against the front wall 53 when compressed air is not present.

The controlling channels in the valve 49 and the openings in the front wall 53 of the casing are so arranged with respect to one another that three different connections are produced in the three different positions of the valve 49. Namely, in the end position illustrated in Figs. 1, 2 and 2^a which is the position of rest, the annular space 51 of the casing 48 is connected by means of the grooves 55, 56 and 57 with the openings 61, 62, so that the pressure medium coming from the receiver 13 through the pipe 67 flows along the pipes 65 and 64 to the unloading valve 14 of the compressor 11 and into the cylinder 45 of the starting switch 22. In the middle position illustrated in Figs. 3 and 3^a, on the contrary, the pipe 64 leading to the cylinder 45 is connected through the opening 61, the groove 58 and the exhaust 66 with the atmosphere, while the unloading valve 14, owing to the arc-shaped groove 57 being connected to the groove 56, remains connected with the collector 13. In the end position, as illustrated in Figs. 4, 4^a (the so-called operating position) on the contrary, in addition to the cylinder 45, the unloading valve 14 is also connected with the atmosphere, namely by means of the openings 62, 60, the passage 59, the groove 58 and the exhaust 66 and is thus relieved from pressure.

The end 49^a of the valve 49 is provided with a shaft 69 which passes out through the front wall 53 of the casing and has a quadrangular outer end 69^a. On the quadrangular end 69^a of the shaft there is fixed a double-armed lever 70, 71 which serves the purpose of rotating the valve 49. The double-armed lever 70, 71 is of a hollow construction, that is to say it consists of a tube, in which two balls 79, which serve as loading weights, are arranged. These balls, when the lever is inclined, can run from

one arm of the lever into the other and thereby displace the centre of gravity of the lever alternately from one side of the axis of rotation to the other. The balls or weights 79 serve the purpose of assisting the rotation of the lever 70, 71 and the valve 49 in the one or the other direction and partly also of completing the movements which have been initiated by other means. The regulation of the valve 49 is effected in part electrically and in part by mechanical means. For the purposes of the electrical adjustment there is arranged a magnet coil 72 the armature 73 of which is connected by means of a rod 74 with the valve lever 70, 71 in such a manner that it has a certain amount of free movement. The loose coupling consists in this case of a pivot 75 provided on the rod 74 and a slot 76 which runs at an angle to the lever arm 70 and is made in a downward extension of the arm 70, in which slot the pivot 75 of the rod 74 engages. If, in the position of rest of the valve 47 illustrated in Figs. 2, 2^a, the armature 73 of the magnet is attracted the rod 74, after a short free movement, then carries the lever 70, 71 with it and thereby rotates the valve 49 into the middle position illustrated in Figs. 3, 3^a. The movement of the armature 73 when attracted by the magnet is limited by means of a stop 73^a provided on the armature. The mechanical adjustment consists on the other hand of an arm 77 fitted on the shaft 35 of the driving mechanism of the starter 22, which arm, when the shaft 35 is rotated in the direction of the arrow *x*, knocks against a projection 78 provided on the arm 70 of the lever 70, 71 and therefore turns the lever further in the same direction in which it was previously rotated by the armature 73. The arm 77, however, does not effect the whole of the rotation of the valve into the end position illustrated in Figs. 4, 4^a, on the contrary, it only rotates the lever until it takes up an inclined position such that the balls 79 which were originally in the lever arm 70 can run into the arm 71 the result of which is that the centre of gravity of the lever 70, 71 is displaced to the arm 71 and the lever is now rotated by the action of gravity completely into the end position illustrated in Figs. 4, 4^a. In addition to moving the valve 49 out of the position of rest of Figs. 2 and 2^a into the middle position of Figs. 3, 3^a the electro-magnet 72, 73 also serves the purpose of returning the valve from the end position of Figs. 4, 4^a into the position of rest. For as soon as current ceases to flow in the magnet-coil 72 its armature 73 falls down again, the rod 74, again after a certain free movement, carries the lever 70, 71 with it and thus rotates the valve 49 in the opposite direction to that in which it was previously rotated. In this case as soon as the lever 70, 71 takes

up approximately the inclined position illustrated in Figs. 3, 3^a the balls 79 roll back again into the lever arm 70 and the remainder of the rotary movement of the valve into the position of rest, which cannot be effected by the armature 73 owing to its initial free movement, is brought about by the weight of the balls.

The electro-magnet 72, 73 finally serves the purpose also of controlling a locking device. This consists of a disc 37 which, as previously mentioned, is fitted on the shaft 35 of the operating mechanism of the starting switch 22. a catch 80 pivoted about a fixed point and a lever 81 pivoted on the disc 37. The lever 81 is bent to the shape of an arc of a circle and one end is revoluble about a pivot 82 fixed to the disc 37. The free end of the lever carries two projections 83, 84 which lie one behind the other when seen in the direction of rotation of the disc 37 and are for the purpose of coacting with the catch 80. The lever 81 is always rotated outwardly by means of a spring which is fixed to the disc 37 and is not illustrated in the drawing into a position such that not only the projections 83, 84 but also a part of the lever itself projects beyond the edge of the disc. In the position of the shaft 35 and the disc 37 illustrated in Figs. 1, 2, 2^a the projection 84 of the lever 81 abuts against the catch 80, whereby the shaft 35 and therefore the whole operating mechanism of the starting switch 22 and the switch 18 are prevented from rotating in the direction of the arrow *x*. The release of the locking device is effected by means of the electro-magnet 72, 73 through the agency of a double-armed lever 86, 87 which is revoluble about a pivot 85 which is fixed in position. One arm 86 of this lever serves the purpose of rotating the locking lever 81 inwardly relatively to the disc 37 while its other arm 87 is so placed relative to the armature 73 that it extends between two transverse studs 88 provided on its rod 74. When the armature 73 falls the releasing lever 86, 87 takes up a position such that the lever 81 can be held by its spring in the locking position in which the projection 84 engages with the catch 80 (Figs. 1 and 2). If however the armature 73 is attracted it then rotates the lever 86, 87 in the direction of the arrow *y* (Fig. 2) whereby the locking lever 81 is rotated inwardly relatively to the disc 37, so that the projection 84 is released from the catch 80 and the shaft 35 of the starting mechanism can be rotated in the direction of the arrow *x*.

The magnet-coil 72 which is constructed as a voltage coil is connected in shunt with the motor circuit, and is connected by the leads 88, 89, 90 in front of the automatic switch 18 to the two phases R and T of the main supply to the motor 16. In the aux-

iliary circuit of the magnet-coil there is inserted, on the one hand, a hand-operated switch 91 whereby the auxiliary circuit can be opened and closed at will. In the position I of this switch 91 indicated by full lines in Fig. 1 of the drawings the auxiliary circuit is opened, while in position II illustrated by dotted lines it is closed through the switch blade 92 and the contact 93. The auxiliary circuit of the magnet contains on the other hand an automatic opening and closing switch which consists of two contacts 94, 95 and a bridge-piece 96. The operation of this automatic switch is dependent upon the pressure in the receiver 13. To this end the bridge-piece 96 is fixed at the outer end of a plunger 97 which is guided in a cylinder 98 and is insulated from the plunger. This cylinder 98 is connected by a branch 67^a to the pipe 67 and by the latter to the receiver 13, in such a manner that the pressure medium conducted to the lower side of the plunger 97 tends to open the switch 96. The movement of the switch in the opposite direction on the other hand is effected by a spring 99 which is located in a casing 100 which is formed on the cylinder 98. One end of the spring 99 is fixed to the plunger 97 while the other end is supported against the cover of the casing 100 which is suitably adjustable for the purpose of regulating the tension of the spring. The tension of the spring 99 is so adjusted that the pressure acting on the plunger 97 holds the switch 96 in the open position if and so long as the pressure of the compressed air in the collector 13 does not fall below a predetermined value, for example, 4 atmospheres. As soon, however, as the pressure falls below this value, for example below 4 atmospheres, the plunger 97 is moved downwards by the spring 99 against the action of the air pressure in the cylinder 98 and the switch 94, 95, 96 is thereby closing. When this happens current flows through the magnet-coil 72 and the armature 73 is attracted with the result that the valve 49 is operated and thereby starts the compressor 11 in a manner to be hereinafter described in greater detail.

The magnet-coil 72 connected to the two phases R, T of the supply mains forms also a no-voltage coil which watches whether the voltage is maintained in these two phases. If the voltage fails the armature 73 cannot be lifted upwards and it is therefore impossible for the valve 47 to be set in a position in which it starts up the compressor 11. If the armature 73 has already been attracted upwards then, when current ceases to flow through the coil 72, it falls downwards and rotates the valve 47 back into its position of rest. In order further to keep a watch on the third phase S, an automatic switch-consisting of the contacts 101 and the

bridge 102 is also arranged in the auxiliary circuit of the magnet coil. The bridge 102 of this switch is fitted on the armature 103 of a voltage coil 104. This coil 104 is connected by the leads 105, 106 and 89 to the phases S and T of the supply mains. Its circuit can also be opened and closed by the hand-operated switch 91, as follows. When the circuit of the magnet-coil 72 is closed the circuit of the coil 104 is closed through the second switch blade 92^a and the contact 107 while, on opening the circuit of the magnet 72 the circuit of the relay 104 is also opened. Owing to the arrangement of the no-voltage relay the result is obtained that when there is a failure of voltage in the phase S only the controlling magnet 72 of the valve 47 is without current since the auxiliary circuit of this magnet is broken by the switch 101, 102.

Finally, in order to automatically disconnect the magnet-coil 72 if the current should become greater than is permissible owing to a short circuit or similar reasons, two further circuit breaking switches 108, 109 are arranged in the auxiliary circuit of the coil 72. These switches are usually held closed by means of a spring 110, they can however be opened by two magnets 111. The coils 112 of these two magnets 111 are directly connected to the two phases R and T of the leads to the motor and they are constructed in such a manner that, if a short circuit or similar rush of current takes place, they attract the armatures 113 which carry the contact bridges 109 and thereby break the auxiliary circuit of the magnet 72. The switches 108, 109 are held in the open position by two catches 114 which must be released by hand when the switch is to be opened again after the short circuit or other disturbances which caused an unpermissible increase in the strength of the current, has been put right.

The method of operation of the hereinbefore described apparatus is as follows.

Let it be assumed that the receiver 13 has been partly filled but that the pressure is not sufficient to hold the switch 96 in the open position against the action of the spring 99, so that this switch is closed. If now the hand-operated switch 91 is moved into the position II, that is, is closed, then, on the one hand, the circuit of the magnet coil 72 is partially connected up through the switch blade 92^a and the contact 93, and on the other hand the circuit of the voltage relay 104 is closed through the switch blade 92^a and the contact 107. The armature 103 of the relay 104 is therefore attracted and closes the circuit of the controlling magnet 72 across the switch 101, 102. The magnet 72 is thereby excited and attracts its armature 73. The attracted armature 73 effects, on the one hand, through the agency of the

lever 86, 87 the elevation of releasing lever 86, 87 and the disengagement of the locking lever 81 on the disc 37 whereby the shaft 35 is set free to rotate in the direction of the arrow α , and, on the other hand, it carries with it through the agency of the rod 74 the adjusting lever 70, 71 of the valve 49 of which is therefore moved into the middle position illustrated in Figs. 3 and 3^a. In this position of the valve 49 the pipe 65 leading to the unloading valve 14 of the compressor 11 is connected through the opening 62 and the grooves 57, 56 with the annular space 51 of the casing 48, which is itself in connection through the pipe 67 with the receiver 13, so that the valve 14 is placed under pressure and unloads the compressor 11. On the other hand the pipe 64 leading to the regulating cylinder 45 of the starting switch is connected by way of the opening 61, the groove 58 and the exhaust 66 with the atmosphere, that is to say, it is relieved from pressure. The shaft 35 is consequently rotated by the weight 41 in the direction of the arrow α and raises the piston 44 in so doing. As this takes place the switch 18 is first closed whereupon the bridge 24, moving downwards, gradually cuts out the resistances 23 until the motor 15 and the compressor 11 which is driven by it and is at this time unloaded are making their full number of revolutions. As soon as the starting switch 22 reaches its end position the arm 77 carried by the shaft 35 engages the projection 78 on the adjusting lever 70, 71 of the valve 49 and thereby effects the rotation of the valve 49 into the position illustrated in Figs. 4, 4^a, which rotation, after the lever 70, 71 has been inclined to a certain angle, is completed by the weight of the balls 79 which run out of the arm 70 of the lever into the arm 71. In the end position of the valve 49 illustrated in Figs. 4, 4^a not only does the regulating cylinder 45 of the starting switch 22 remain connected with the atmosphere but the pipe 65 leading to the unloading device 14 of the compressor 11 is now also connected to the atmosphere by way of the openings 62, 60, the passage 59, the groove 58 and the exhaust 66. That is to say the valve 14 is now also released from pressure so that it loads the compressor 11. The compressor which has been meanwhile driven at full speed therefore now compresses air into the receiver 13 which is thus again charged. When, owing to the receiver being completely charged, the pressure in it reaches a predetermined maximum value the load on the plunger 97 has been increased to such an extent that the plunger can be displaced against the action of the spring 99 by means of the pressure medium introduced into the cylinder 98. The switch 96 is thus opened and breaks the circuit of the magnet-coil 72 which therefore allows the armature 73 to fall down. The falling armature on the one hand returns the releasing lever 86, 87 of the locking device to locking position and, on the other hand, through the agency of the rod 74 it carries the adjusting lever 70, 71 of the valve with it and thereby initiates the return of the lever into its original position or position of rest as illustrated in Figs. 1, 2, 2^a. This movement is again completed by the weight of the balls 79 since, after the lever 70, 71 has been inclined to a certain angle, they run into the arm 70 and thereby load the piston of the valve in such a way as to rotate it backwards. Owing to the rotation of the valve 49 into its original position the pipe 65 leading to the unloading valve 14 is first connected by way of controlling passages and channels 62, 57, 56 with the annular space 51 and thereby places the unloading valve under pressure, that is to say the compressor 11 is again unloaded and the pipe 64 is finally connected with the annular space 51 by way of the passage 61 and the groove 55, so that compressed air again flows into the regulating cylinder 45. The compressed air moves the piston 44 into its lower end position whereby the shaft 35 is rotated in the opposite direction to that indicated by the arrow α by means of the rack and pinion mechanism 42, 39. When this takes place the starting resistances 23 are first again connected in series in the circuit and then, owing to the opening of the switch 18, the motor 15 is disconnected from the mains 20. When this has occurred the shaft 35 is again held fast in the position illustrated in Fig. 1 owing to the catch 80 coacting with the projection 84 on the lever 81 of the locking disc 37. The motor 15 and compressor 11 are now unloaded. The starting device now remains at rest as long as the pressure in the receiver 13 does not fall below a predetermined limiting value. If, owing to the withdrawal of compressed air, the pressure in the receiver 13 falls below the predetermined value the switch 96 in the circuit of the magnet coil 72 is again closed by the spring 99 and the above-described action is repeated. The compressor, as will now be clear, is always unloaded and develops full speed before it is loaded and, conversely, on again disconnecting the driving motor the compressor is again unloaded and comes to a stop. The same action however, also takes place when current ceases to flow in the motor owing to failure of the voltage or if a short circuit or similar electrical disturbances occur. Assume for example, that the compressor has been started in the manner previously described and is now running fully loaded. If now the voltage in one or all of the phases fails or a short circuit occurs the magnet-coil 72 either becomes im-

mediately currentless or its circuit is broken either by the switch 101, 102 of the no-voltage relay 104 or by the switch 108, 109 of the overload relay, the consequence of which is that the armature 73 falls. Therefore the locking device for the shaft 35 fitted on the disc 37 is released in the manner previously described and the valve 49 is simultaneously returned to its original position or position of rest, so that the valve 14 on the one hand and the regulating cylinder 45 on the other hand are again subjected to pressure. The motor 15 is therefore disconnected by the starting switch 22 and the switch 18 and the compressor 11 unloaded, after which the shaft 35 is finally held fast in the disconnected position. The result is the same if the circuit of the magnet-coil is purposely broken by hand by means of the switch 91. Thus, in all cases the starting switch is returned to its original position of rest, and locked in this position, so that on the return of the voltage or on re-connecting the magnet circuit the driving motor 15 is started properly while the compressor 11 is unloaded. If the disconnection of the driving motor has been due to failure of the voltage the starting procedure takes place entirely automatically when the voltage returns and no special switching by hand is necessary. The new device therefore gives the greatest possible security in operation and requires very little attention and faulty operation of the apparatus, for example starting up the compressor under full load, is quite out of the question even if electrical disturbances have occurred.

The new controlling apparatus can, according to the invention, also be so constructed that, when a maximum pressure is attained in the receiver 13, the driving motor 15 and the compressor 11 are not brought absolutely to a standstill but run at a lower speed and therefore produce a smaller output. In this case the above described installation is augmented by the devices illustrated in Fig. 1^a. These are, firstly, in addition to the regulating cylinder 45, a second pressure medium cylinder 115 for the return of the starting switch 22. In this cylinder 115 there is again fitted a piston 116 the piston rod 117 of which is formed as a rack. The rack 117, the object of which also is to coact with the pinion 39, is however somewhat shorter than the rack 42 so that, on the one hand, in the lower end position of the piston 116 it does not mesh with the pinion 39 and, on the other hand, it can only partially rotate the shaft 35, namely about an angle in the opposite direction to that indicated by the arrow α such that the starter 22 can be returned from the full speed position to the position in which a portion of the resistances 23 corresponding to the desired reduced speed is inserted in the circuit, while

the opening and closing switch 18 on the contrary remains connected. The second regulating cylinder 115 is controlled by a valve 118. This valve is for the most part arranged similarly to the valve 49 but is however constructed as a simple reversing valve, namely, in such a manner that in its position of rest it connects the upper end of the regulating cylinder 115 by way of pipe 119 with an exhaust 120 leading to the atmosphere, and the lower end of the cylinder by way of a pipe 121 with a branch 67^b of the pipe 67 leading to the collector 13. In its other end position the valve 118 effects the reversed connections, that is to say the pressure medium then flows by way of the pipe 119 above the piston 116 in the cylinder 115 while the space below the piston 116 is connected by way of the pipe 121 with the atmosphere. The piston 116 of the cylinder 115, in addition to rotating the shaft 35, also serves the purpose of adjusting the previously mentioned shut-off cock 68 which is arranged in the pressure piping 64 of the regulating cylinder 45. To this end two lateral stops 122, 123 are fitted on the rack 117, of which the upper 122 opens the cock 68 when the piston 116 moves downwards while the other closes the cock 68 when the piston moves in the reverse direction.

The reversing valve 118 is regulated exclusively by electricity, and for this purpose there is provided a magnet-coil 124 the armature 125 of which is connected by means of a rod 126 with a double-armed lever 127, 128 fitted on the shaft of the rotary piston of the valve 118 in such a manner that, when the armature 125 is attracted, the valve 118 is rotated out of the position of rest illustrated in the drawing into the opposite end position, and, when the armature 125 falls, is again rotated into the position of rest. This rotation is only initiated by the armature 125 and is completed on the contrary by a weight which runs alternately from one arm of the valve lever 127, 128 to the other arm. This weight may consist, as in the valve 49, of balls guided in the hollow lever.

In the position II of the hand switch, that is to say, when the starter 22 is controlled by the valve 49 and the regulating cylinder 45, the magnet-coil 124 is, on the one hand, connected by means of the conductor 88, the contact 93, the switch blade 92^a and the conductor 89 and on the other hand by a conductor 131 and the conductor 90 in parallel with the magnet-coil 72 and the switch 94, 96 to the two phases R and T. The coil 124 therefore in this case always has the voltage applied to it, the consequence of which is that the armature 125 is attracted and the valve 118 is so adjusted that the piston 116 is held fast in its lower end position by the pressure medium introduced into the

top of the cylinder 115, so that the rack 117 remains inoperative and the cock 68 is open. If, however, the hand-switch 91, which is constructed as a reversing switch, is rotated
 5 into the position III the magnet-coil 124 is then placed under the control of the pressure switch 94, 96, while the circuit of the magnet-coil 72 is in parallel to the switch 96. In the position III of the hand-switch the
 10 circuit of the coil 124 is as follows. The current flows from the conductor 90 along the conductor 131 to the upper end of the coil and from the lower end of the coil across the switch 94, 96 through a conductor 129, the
 15 contact 130 and the switch blade 92 to the conductor 89. The magnet coil 72 on the other hand is connected firstly through the conductor 90, and secondly through the conductor 129, the contact 130, the switch blade
 20 92, and the conductor 89, independently of the switch 94, 96, to the phases R and T. In the position III of the hand switch 91 the circuit of the voltage relay 104 is closed since the switch-blade 92^a connects to an
 25 auxiliary contact 132 which is connected with the conductor 106.

The method of operation of the augmented apparatus is as follows.

Assuming in the first place that, when the
 30 hand-switch has been placed in the position II, the motor 15 is started and runs at full speed while the compressor 11 is unloaded and is then loaded in the manner which has been hereinbefore described in detail. When
 35 this starting procedure has been completed the hand-switch 91 is placed in the position III, that is to say the circuit of the coil 124 is closed through the switch 94, 96 and the circuit of the coil 72 on the contrary is closed
 40 independently of this switch. Since the coil 72 now has the voltage always applied to it, the valve 49 remains in the operating position of Figs. 4, 4^a in which the regulating cylinder 45 and the unloading valve 14
 45 of the compressor 11 are relieved from pressure, so that the switching of the starting switch 22 can be now effected by the second regulating cylinder 115. If now the pressure in the receiver 13 reaches the maximum
 50 value at which the switch 94, 96 opens, the magnet-coil 124 is then without current and the falling armature 125 rotates the valve 118 from the position in which the upper side of the piston 116 is subjected to pressure
 55 into its other end position. The space above the piston 116 is therefore connected with the atmosphere while compressed air enters from the bottom into the cylinder 115 and drives the piston 116 upwards. The
 60 shaft 35 is thereby rotated in the direction opposite to that indicated by the arrow x , owing to the rack 117 meshing with the pinion 39 after a short inoperative movement, and the bridge 24 of the switch 22 is returned
 65 to the required position for a reduced speed,

that is a portion of the resistances 23 is connected in series with the winding of the rotor 15 and the compressor 11 runs at a reduced speed. If the quantity of pressure
 70 medium withdrawn from the collector 13 is greater than that delivered by the compressor when running at the reduced speed the switch 94, 96 will be again closed, after a certain interval of time, by the spring 99. The armature 125 then being attracted re-
 75 verses the valve 118 so that the space under the piston 116 is again connected with the atmosphere and compressed air on the other hand enters the space above the piston 116. The shaft 35 is consequently rotated in the
 80 direction of the arrow x partly by the rack 117 and partly by the weight 41, whereby the resistances 23 are entirely disconnected so that the motor 15 and the compressor 11 again run at full speed.
 85

Also when employing the apparatus as a revolution or output regulator, care is taken to ensure that if electrical disturbances occur the switch 22 is always returned to its
 90 original position, that is to say the resistances 23 are connected in series. If, for instance, current ceases to flow in the magnet-coils 72, 124 when the driving motor 15 is connected so that it is running at full
 95 speed, then both the valves 49 and 118 are returned to the position of rest by the falling armatures 73 and 125, the consequence of which is that the switch 22 and the switch 18 are returned to the position of
 100 disconnection by the piston 44 of the regulating cylinder 45 and are held fast in this position by the locking device on the disc 37. If an electrical disturbance occurs when the motor and compressor are connected so as to run at a low speed, that is
 105 when the piston 116 of the cylinder 115 is in its upper end position, then only the catch on the disc 37 comes into action and, owing to the coaction of the projection 83 of the lever 81 with the catch 80, holds the
 110 shaft 35 and the switch 22 fast, the resistances 23 having been connected in series, while the switch 18 remains open. In the upper end position of the piston 116 the cock 68 inserted in the pressure pipe 64 of
 115 the cylinder 45 is closed by the stop 123 on the rack 117, so that the pressure medium cannot flow into the cylinder 45. This closing of the cock 68 is necessary to prevent damage to the rack and pinion mechanisms
 120 42, 39, 117 and the cylinder 115, which might otherwise occur if the cylinder 45, of which the piston 44 has a longer stroke than the piston 116 of the cylinder 115, were subjected to pressure in the upper end
 125 position of the piston 116. If the apparatus has been closed down or shut off from air pressure when the starting switch 22 is inserted but the switch 18 is open then, when the magnet-coils 72 and 124 are re-excited, 130

re-starting takes place since pressure medium is admitted above the piston 116 into the cylinder 115 and the space below the piston 116 is, on the other hand, connected with the atmosphere, while the piston 44 in the cylinder 45 is free from load. In the lower end position of the piston 116 the cock 68 is again opened so that the cylinder 45, the regulating valve 49 of which has again moved into its operating end position, as shown in Figs. 4 4*, when starting occurred, is again ready to effect disconnection should any electrical disturbances occur.

Obviously, many alterations of the embodiment illustrated are possible without departing from the spirit of the invention. In particular, the devices which have only been illustrated more or less diagrammatically in Figs. 1 and 1* could in practice be constructed in any suitable known manner. The new controlling apparatus is not limited to employment with three-phase current, it could, of course also be employed with a pump or compressor driven by a direct or alternating current motor. In this case the special no-voltage relay 104 as well as one of the overload relays are unnecessary.

I claim:—

1. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a switch for controlling the supply of current to the motor circuit, a compressor loading and unloading device, and fluid pressure responsive electro-mechanical means including a control valve for shifting the switch to motor starting and stopping positions and simultaneously governing the compressor loading and unloading device for compressor loading and unloading actions.

2. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a switch controlling said circuit for motor starting and stopping actions, a device mechanically operated in one direction and fluid pressure operated in the reverse direction for shifting the valve respectively in starting and stopping directions, a loading and unloading device, locking means for normally holding the switch actuating device from operation, a control valve movable in one direction to place the loading and unloading device in unloading condition and the fluid pressure actuating means of the switch operating device in condition to permit said switch operating device to be operated in one direction by its mechanical means, and said valve being movable in a reverse direction to place the loading and unloading device in loading condition and to cause actuation of the fluid pressure op-

erated means of the switch operating device to return said device to normal position for a current cut out action of the switch, fluid pressure responsive electrical means for moving the control valve in the first-named direction, and means actuated by the fluid pressure operating means of the switch actuating device and with the latter for moving the control valve in the second-named direction.

3. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a main circuit, a motor circuit, a compressor loading and unloading device, a primary switch controlling the main circuit, a starting switch controlling the motor circuit, and fluid pressure responsive combined electrical and mechanical means, including a control valve, for placing the loading and unloading device in unloading and loading conditions and simultaneously actuating said switches for current supplying and cut out actions.

4. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a main circuit, a primary switch in the main circuit, a starting switch in the motor circuit, a compressor loading and unloading device, fluid pressure responsive combined electrical and mechanical means, including a control valve, for placing the loading and unloading device in unloading and loading conditions and simultaneously actuating said switches for current supplying and cut out actions, said means operating to move the starting switch on its current feed motion after the primary switch has been closed and to move the starting switch back to initial position prior to the opening of said primary switch.

5. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a resistance starting switch in said motor circuit, a compressor loading and unloading device, a switch actuating device, mechanical means for moving said switch actuating device in one direction, fluid pressure operated means for moving the switch actuating device in the reverse direction, a control valve movable in one direction to place the loading and unloading device in unloading condition and to place the fluid pressure actuating means for the switch actuating device in condition to permit said device to be operated by said mechanical means, fluid pressure responsive electrical means for moving the control valve in the first-named direction, and means operable by the switch actuating device for moving the control valve in the second-named direction.

6. In an automatic controlling apparatus

for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a compressor loading and unloading device, a resistance switch in the motor circuit, a switch actuating device movable in reverse directions to actuate the switch for current supplying and cut off actions; mechanical means for moving the switch actuating device in one direction, fluid pressure operating means for moving the switch actuating device in the opposite direction, locking means for holding the switch actuating device from motion under the action of its mechanical actuating means, a control valve movable in one direction to place the loading and unloading device in unloading condition and to place the fluid pressure actuating means of the switch actuating device in condition to permit operation thereof by said mechanical means, and said valve being movable in the reverse direction by the switch actuating device in the direction of motion imparted by its fluid pressure actuating means for supplying fluid pressure to said fluid pressure actuating means and placing the loading and unloading device in loading condition, and a fluid pressure responsive electrical device for moving the control valve in the first-named direction and releasing the locking means.

7. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a resistance switch controlling said circuit, a loading and unloading device for the compressor, a rotary switch actuating device movable in one direction for switch motor starting actions and in the reverse direction for switch motor stopping actions, mechanical means for rotating said switch actuating device in the first-named direction, fluid pressure actuated means for rotating said switch actuating device in the second-named direction, a control valve movable in one direction to place the loading and unloading device in unloading condition and to place the fluid pressure actuating means of the switch actuating device in condition to permit actuation of said device by its mechanical means, and said valve being movable in the reverse direction to place the loading and unloading device in loading condition and to supply fluid pressure to the fluid pressure actuating means of the switch actuating device for switch actuating operation by said means, a locking means for holding the switch actuating device against actuation by its mechanical means, fluid pressure responsive electrical means for releasing said actuating device and moving the control valve in the first-named direction, and means operable by and movable with the switch actuating device on its actuation by its fluid

pressure means for moving the control valve in the second-named direction.

8. In an automatic controlling apparatus for fluid pressure supply systems; the combination of a compressor and an electric motor for driving the same, a motor circuit, a resistance starting switch in said circuit, a loading and unloading device for the compressor, a switch actuating device movable in one direction by mechanical means to actuate the switch in one direction and movable in the reverse direction by fluid pressure operating means for actuating the switch in the opposite direction, a control valve movable in one direction by the switch actuating device for supplying fluid pressure to said fluid pressure actuating means and placing the loading and unloading device in loading condition and said valve being movable in a reverse direction to place the loading and unloading device in unloading condition and said fluid pressure operating means in condition to permit actuation of the valve actuating device by its mechanical means, and fluid pressure responsive electrical means for moving the control valve in the second-named direction.

9. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a resistance starting and stopping switch in said circuit, an auxiliary circuit containing a control switch, an electro-magnet in said auxiliary circuit, a switch actuating device movable in opposite directions for current supply and cut out movements of the switch, mechanical means for actuating said switch actuating device in one direction, fluid pressure operated means for actuating said switch actuating device in the reverse direction, a compressor loading and unloading device, a locking means for holding the switch actuating device from movement in one direction, a control valve movable in reverse directions for governing the loading and unloading device and the pressure actuating means of the switch actuating device, means operated by the energization of the electro-magnet for releasing the locking means and moving said valve in one direction, and means actuated by the valve actuating device for moving said control valve in the opposite direction.

10. In an automatic controlling apparatus for fluid pressure supply systems, the combination of a compressor and an electric motor for driving the same, a motor circuit, a resistance starting and stopping switch in said circuit, a switch actuating device movable in opposite directions to move the switch in opposite directions, a loading and unloading device for the compressor, mechanical means for moving the switch actuating device in one direction, fluid pressure

operated means for moving the switch actuating device in the opposite direction, a control valve movable in one direction to place the loading and unloading device in unloading conditions and to place the fluid pressure actuating means of the switch actuating device in condition to permit actuation of said switch actuating device by its mechanical means, and said valve being movable in the reverse direction to supply fluid pressure to said fluid pressure actuating means and to place the loading and unloading device in loading condition, locking means for holding the switch actuating device from action by its mechanical means, a fluid pressure responsive means including an electro-magnet for releasing said locking means and moving the control valve in the first-named direction, and means operative by the valve actuating device on the motion of the same by its mechanical means to shift said valve in the second-named direction.

11. An automatic controlling apparatus in accordance with claim 1 in which the electromechanical means operates the valve and the motor circuit switch and comprises a controlling circuit, an electromagnet in said circuit, a valve actuating lever, a weight normally held from movement and released for movement by the energization of the magnet and operative on its working motion to close the motor circuit switch and to shift the valve actuating lever for valve operating motion in one direction for a portion of its travel in such direction, an armature controlled by the magnet and operative to shift the valve actuating lever for valve operating motion in the opposite direction for a portion of its travel in such direction, gravity means for completing the travel of the valve actuating lever in either direction when initiated in one direction or the other by the weight and the armature, and valve controlled means for returning the weight to normal position and the switch to motor circuit opening position.

12. In an automatic controlling apparatus in accordance with claim 1, in which the electromechanical means includes mechanism for operating the switch and valve, a control circuit, a control magnet in said circuit, an armature actuated by said magnet and operative to throw said mechanism into action, a pressure actuated switch for opening and closing said circuit, an overload relay for opening and closing said circuit, and a no-voltage relay for opening and closing said circuit.

13. An automatic controlling apparatus in accordance with claim 1, in which the electromechanical means includes a control circuit, a control magnet in said circuit, a mechanism for operating the valve and the motor circuit switch, a locking device for holding said mechanism from movement, and

an armature actuated by the magnet when the latter is energized to release the locking device.

14. An automatic controlling apparatus in accordance with claim 1, in which a starting switch is employed in conjunction with the motor circuit switch and in which the electromechanical means includes a control circuit, mechanism for operating the valve and the switches, and electromechanical means in said circuit for starting said mechanism into action when the control circuit is closed, the said motor circuit and starting switches connected with the operating mechanism in such manner that said motor circuit switch will be closed before the starting switch is set into operation for a motor starting action and will be opened upon the completion of the opening movement of the starting switch.

15. An automatic controlling apparatus in accordance with claim 1, in which the control valve comprises a casing having a front wall provided with controlling channels, and a rotary valve body having an end portion fluid pressed tightly against said front wall of the casing and provided with controlling channels coacting with said channels in the front wall of the casing.

16. An automatic controlling apparatus in accordance with claim 1, in which the control valve comprises a casing having an end wall provided with controlling channels, and a rotary body having controlling channels at one end, the casing being provided with a pressure receiving space surrounding the channeled end of the body and into which space some of the controlling channels of the body open, the said rotary body being so shaped as to provide a shoulder adapted to be acted upon by the fluid pressure so as to press the channeled end of the body against the channeled front wall of the casing.

17. An automatic controlling apparatus in accordance with claim 1, in which the control valve comprises a casing having a ported end wall, a rotary body enclosed in said casing and having a coacting ported end, and a spring for pressing the ported end of the valve body against the ported end wall of the casing.

18. An automatic controlling apparatus in accordance with claim 1, in which the electromechanical means operates the control valve and includes a double-armed lever fixed on the shaft of the control valve, means for shifting said lever to a part way inclined position in either of its directions of movement, and a weight mounted to roll from one arm of the lever to the other when the position of the lever is inclined to complete its movement.

19. An automatic controlling apparatus in accordance with claim 1, in which the motor circuit switch is a variable speed switch and

the electromechanical means operates a control valve and switch and comprises a mechanical device movable in one direction and to adjust the switch for a current supplying action and movable in the reverse direction for adjusting the switch for a current cut-out action, a control circuit, an electromagnet in said circuit, an armature actuated by the magnet for shifting the valve in the opposite direction and for setting the mechanical device into operation to shift the valve in the first-named direction and adjust the switch for current supplying action, a fluid pressure device for retracting the mechanical device to shift the switch to cut-out position, a second fluid pressure device for retracting the mechanical device to adjust the switch to a low speed current feed position, a second valve for controlling the supply of fluid pressure to render the first-named fluid pressure device inoperative when the second-named fluid pressure device is in action, a second electromagnet, an armature influenced thereby for adjusting the second-named valve, a switch for throwing said second-named electromagnet into and out of the control circuit and maintaining the first-named electromagnet permanently energized when the second-named electromagnet is connected in the circuit, and a fluid pressure

operated switch for opening and closing the control circuit.

20. An automatic controlling apparatus in accordance with claim 1, in which the motor circuit switch is a speed regulating switch and in which the electromechanical means includes control devices for respectively shifting the switch between full speed and cut-out positions and adjusting the switch between full speed and low speed positions, and means for throwing either of said control devices into and out of action at will.

21. An automatic controlling apparatus in accordance with claim 1, in which the motor circuit switch is a speed regulating switch and in which the electromechanical means operates the valve and switch for adjusting the valve to govern the action of the compressor up to a predetermined pressure limit and then adjusting the switch to cut-out position, a second electromechanical means for controlling the valve and adjusting the switch for maintaining the compressor in action after such predetermined pressure is reached, at low speed, and means for rendering the apparatus operative by either of said electromechanical means at will.

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