No. 858,468. PATENTED JULY 2, 1907.

W. J. RICHARDS.

CONTROLLING APPARATUS.

APPLICATION FILED APR. 11, 1904.

4 SHEETS—SHEET 1.

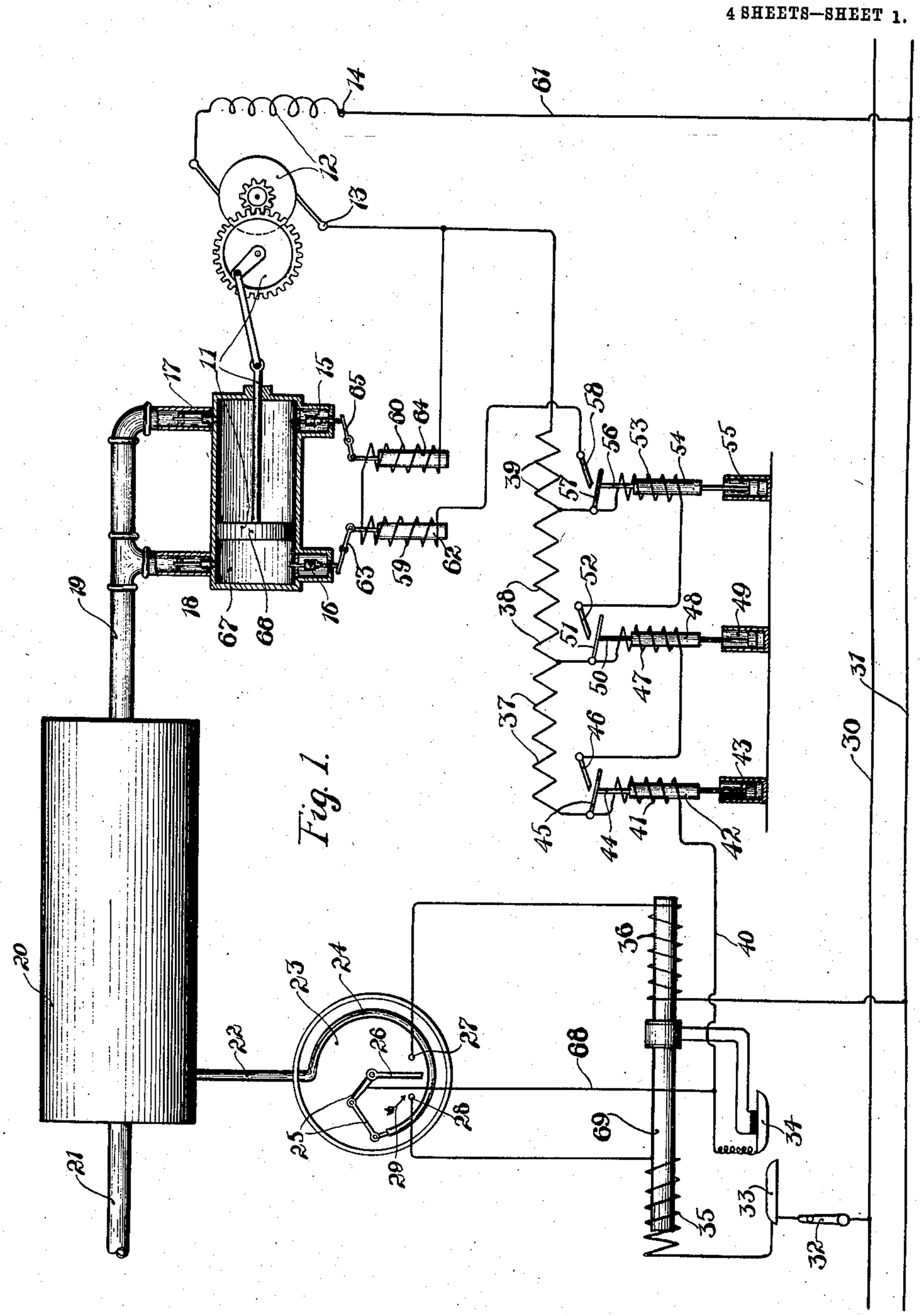

Fig. 1.

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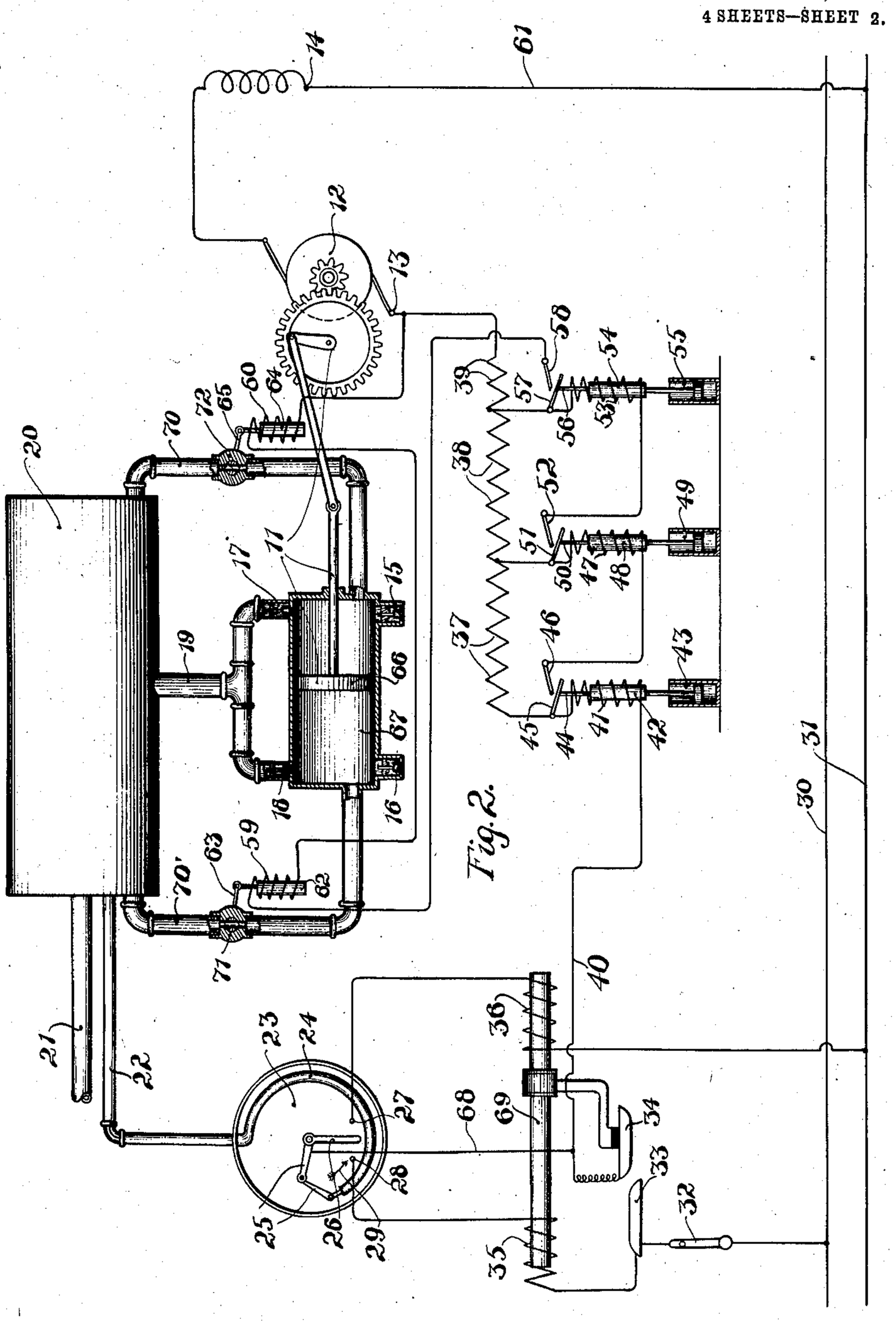
4 SHEETS—SHEET 2.



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4 SHEETS—SHEET 3.

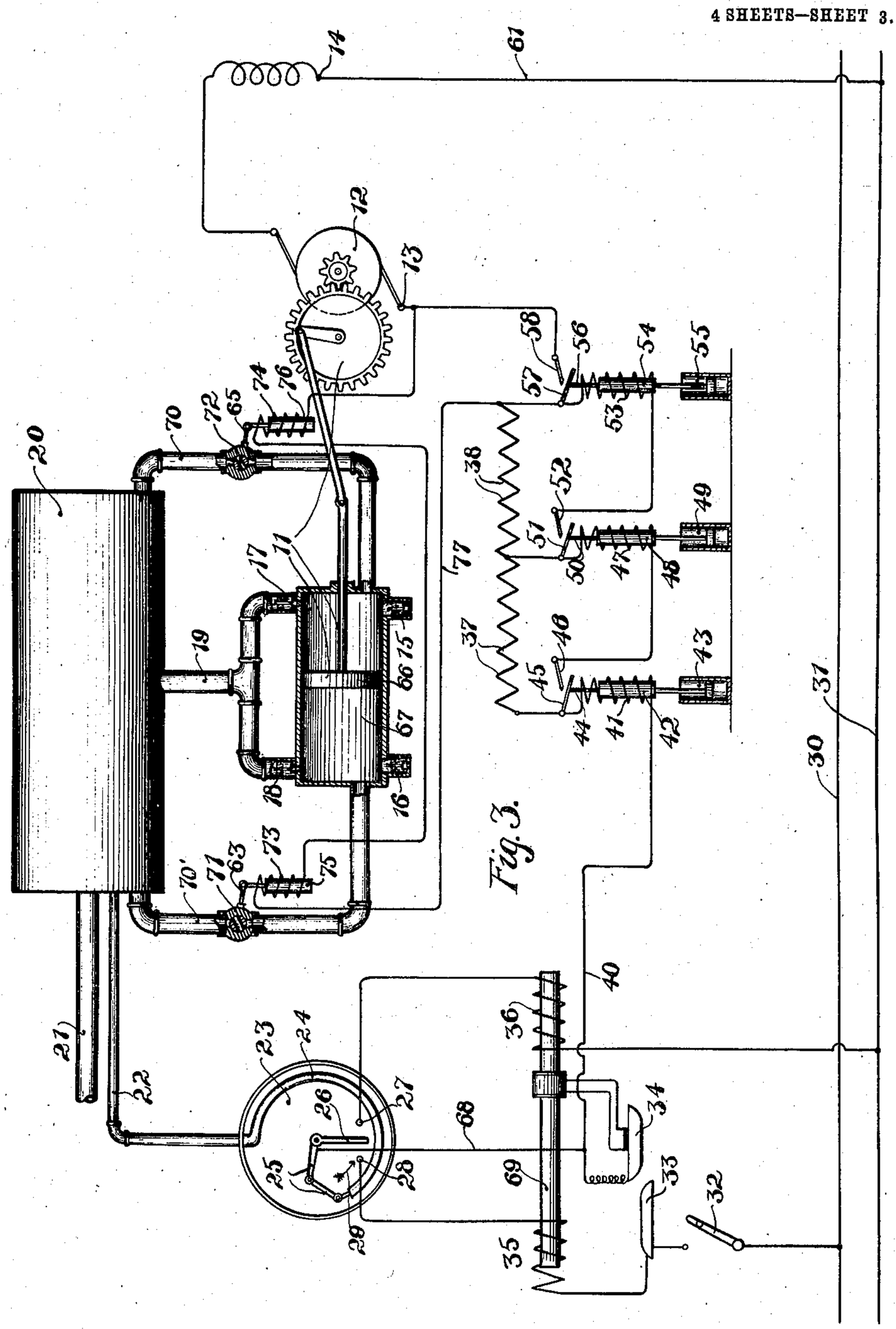

Fig. 3.

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4 SHEETS—SHEET 4.

Fig. 5.

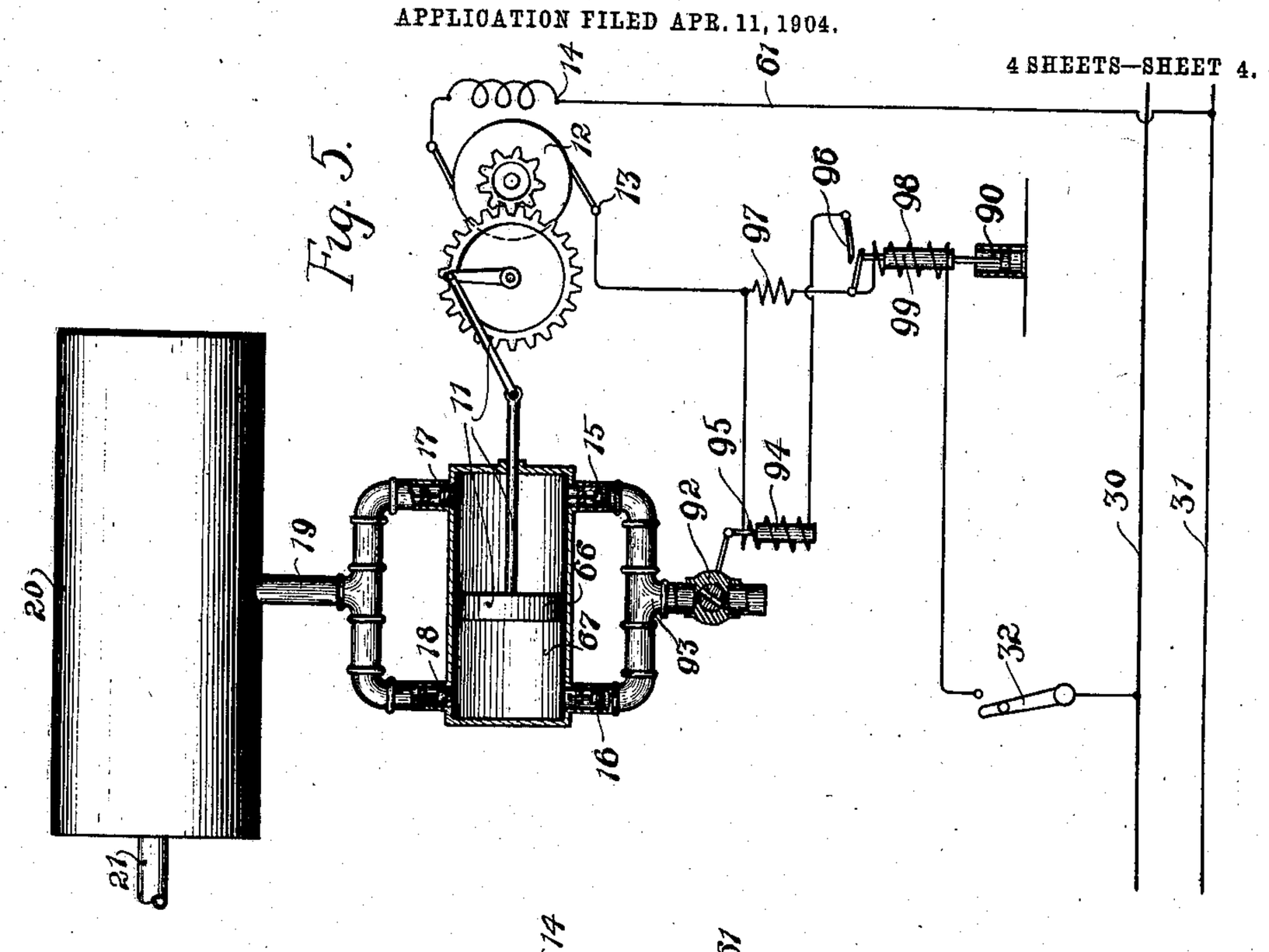
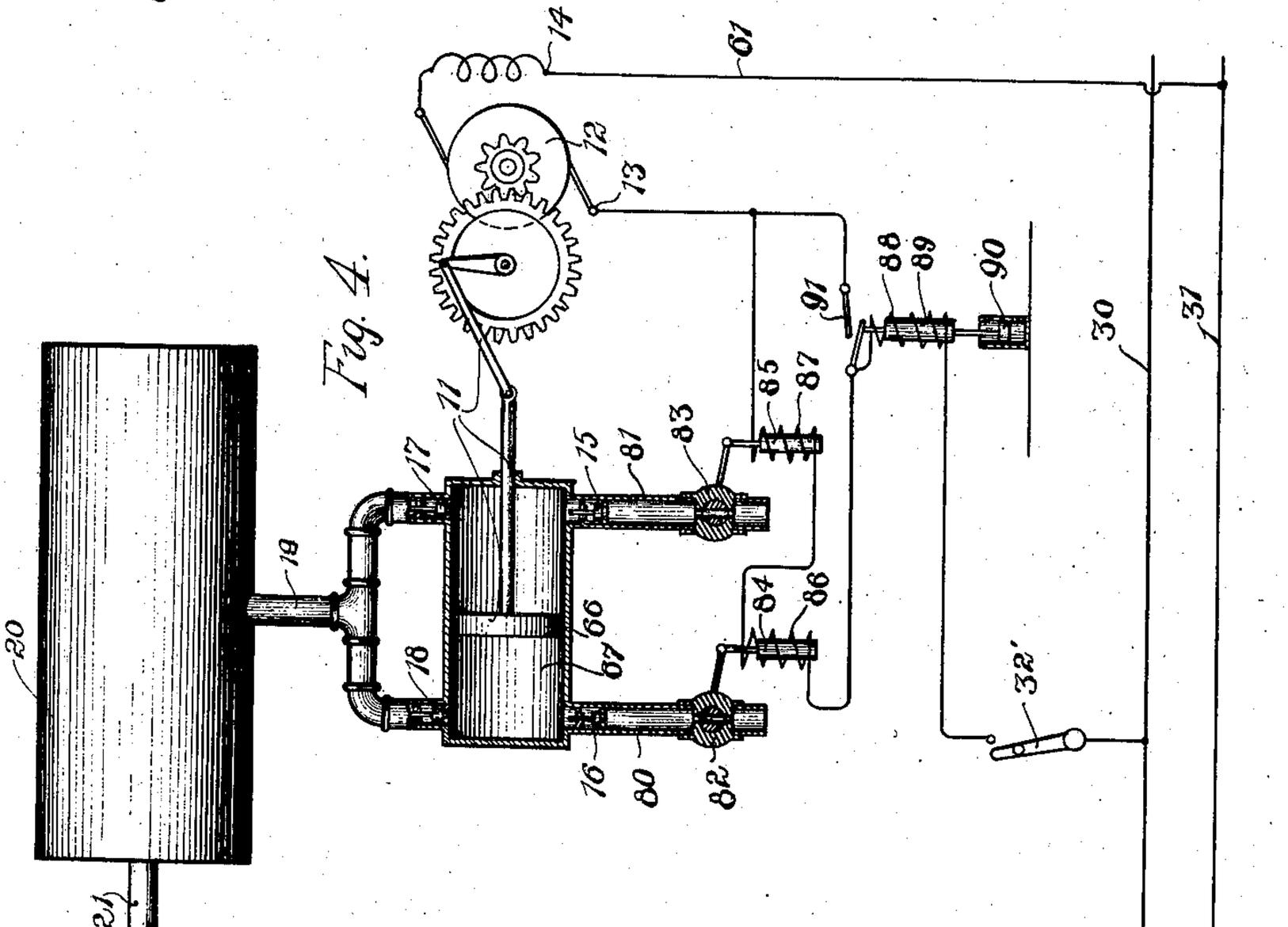


Fig. 4.



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UNITED STATES PATENT OFFICE.

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CONTROLLING APPARATUS.

No. 858,468. Specification of Letters Patent. Patented July 2, 1907.

Application filed April 11, 1904. Serial No. 202,567.

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 Controlling Apparatus, 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.

My invention relates to means for automatically regulating the operation of fluid pumps, and is particularly well adapted for use in conjunction with air compressors when operated by means of electric motors.

One of the particular purposes of my invention is to so regulate the load upon the motor means employed to drive the pump or compressor that when starting the motor may obtain substantially its full speed before being subjected to the full normal load of the compressor or pump.

One of the well-known uses of the air compressor is that of supplying a pressure system with air to be maintained so near as possible at uniform pressure. In conjunction with such pressure systems, means have been provided for causing the operation of the compressor when the pressure in the system drops to a minimum limit, and causing cessation of the operation of the compressor when the pressure in the system attains to the maximum limit. In this way an intermittent operation of the compressor and its motor means is required. When an electric motor is employed to drive the compressor, it is found desirable to control the motor circuit by means of the pressure in the pressure system. If the compressor is permanently connected with the motor, the closure of the motor circuit will cause an unduly great quantity of current to flow through the motor, unless means are provided for decreasing the load upon the motor at starting.

My invention relates to such means as will so regulate the load and supply of current to a motor as to prevent an injurious flow of current at starting. Where such a combination as I have above described is employed, it is frequently found desirable to provide an automatic rheostat for restricting the supply of current to the motor at starting. Whether or not such an automatic rheostat is employed, it is desirable that means be provided for relieving temporarily the load upon the motor at starting.

My present invention is closely allied with that described and claimed in my co-pending application, Serial No. 164,085, filed, July 2, 1903.

In the preferred embodiment of my present invention, means are provided for normally maintaining the valves of an air compressor in an open or inoperative condition. The automatic rheostat is employed for independently limiting the supply of current to the motor at starting; this rheostat serving, upon the closure of the motor circuit, gradually to cut out the resistance normally included in the circuit. There is in conjunction with this automatic rheostat a switching device, which is actuated at about the time the resistance is cut out of the motor circuit, to put the valves of the compressor in an operative condition. When the compressor valves are inoperative, there is, of course, only a very slight or nominal load upon the motor, but when the valves are released for operation by means of the actuation of the switching device referred to, the load upon the motor is increased to its normal operating condition.

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

Figure 1 illustrates the preferred embodiment of my invention, and in which Figs. 2 and 3 represent certain modifications thereof. Figs. 4 and 5 diagrammatically represent modifications in which no automatic controller and no automatic rheostat are shown.

All of the figures represent the devices employed in diagrammatical or symbolical form.

In all of the figures the features common to all are designated by similar characters of reference.

Referring more particularly to Fig. 1, I have illustrated the air compressor at 11; this compressor being mechanically connected or geared with a series electric motor 12, to the terminals 13 and 14 of which a suitable supply of electric current is furnished.

The suction valves of the compressor are represented diagrammatically at 15 and 16, and the discharge valves are located at the points 17 and 18. The discharge pipe 19 leads from the discharge valves of the compressor cylinder to an air reservoir 20, to which the pressure system is connected by means of the pipe 21. The reservoir is connected by means of the pipe 22 with the circuit controlling device 23. This latter consists essentially of a bent pipe 24, similar to that of a Bourdon pressure gage. This bent pipe is connected through suitable links and lever mechanism with a switch-arm 26, which may make connection with the contact 27, or with the contact 28. An increase in the pressure on the reservoir 20, causes a movement of the switch-arm in the direction shown by the arrow 29, while a decrease in the pressure causes a movement in the reverse direction.

The electric current for the motor is supplied from the mains 30 and 31, these mains being connected with a suitable source of current not shown. A manually operated switch 32 serves to connect main 30 with the contact shoe 33. The current is supplied through the automatic rheostat (to be hereinafter more fully described,) to the motor 12, when the contact shoe 34 makes connection with shoe 33. The shoe 33 is connected through a helix or solenoid 35 with the controller contact 28; contact 27 is connected through the solenoid 36 with the main 31.

The automatic rheostat referred to comprises the seri-

ally connected resistances 37, 38 and 39, together with switch mechanism for controlling the operation of these resistances and their functions.

A conductor 40, leads from the contact shoe 34 through a solenoid 41 to the outer terminal of the resistance 37. A core 42 is adapted to move within the solenoid and is connected at its lower end with a dash-pot 43; this dash-pot serving to retard the motion of the core 42. The stem 44 extending upwardly from the core controls the movement of the switch-arm 45, which makes connection with the contact 46. The contact is connected through a second solenoid 47 with the common terminal of the resistances 37 and 38. A core 48 is adapted for movement within the solenoid 47, and is connected at its lower end with the dash-pot 49, and at its upper end by means of the stem 50 with the switch-arm 51; this switch-arm making connection, when in its upper position, with the contact 52. This latter contact is in turn connected with a third solenoid 53, which actuates the core 54, this core being retarded in its motion by the dash-pot 55, and serving, through the stem 56 to actuate the switch 57, which makes electrical connection with the contact 58. The contact 58 is connected through the solenoids 59 and 60 with the terminal 13 of the electric motor; the other terminal being connected through conductor 61 with the main 31 already mentioned. The solenoid 59 controls the movement of the core 62; the energization of the solenoid serving to elevate the core and the de-energization of the solenoid permitting the core to drop to its normal position shown in the figure. Normally, the weight of the core is such as to raise the suction valve 16 from its seat by means of the connection afforded by the pivoted lever 63; in the same way the solenoid 60 controls the position of the suction valve 15 by means of the core 64 and the lever 65. The suction valves 15 and 16 are normally raised from their seats as shown, and the energization of the solenoids 59 and 60 permits the valves to seat themselves; whereupon they are operated by the suction caused by the movement of piston 66 within the cylinder 67.

The operation of this embodiment of my invention may be described as follows: Assuming that the pressure in the reservoir 20 has fallen to the minimum limit, the switch-arm 26 will be brought into connection with the contact 28, thereupon causing the passage of current through the solenoid 35; the circuit being traced as follows: from the main 30 through the switch 32, solenoid 35, contact 28, switch-arm 26, conductors 68 and 40, solenoid 41, the resistances 37, 38 and 39 to terminal 13 of the motor, and from terminal 14 of the motor through the conductor 61 to the main 31. The slight current passing through this circuit is insufficient to cause the operation of the motor 12, but is of sufficient strength to cause an energization of the solenoid 35 such that its core 69 will be drawn to the left, thereby causing an electric connection between the contact shoes 33 and 34—it being noted that the shoe 34 is mechanically connected with the core 69. Upon connection of these contact shoes, the following circuit may be traced: from the main 30 to the switch 32, contact shoes 33 and 34, conductor 40, solenoid 41, the resistances 37, 38 and 39, and thence through the motor to the main 31. The current passing through this circuit is limited by the serial inclusion of the resistances, but is of sufficient strength to start the motor. The operation of the motor sets in motion the compressor 11, but as the suction valves 15 and 16 are held open, due to the weight of the cores 62 and 64, the compressor places no appreciable load upon the motor, the air being alternately admitted and exhausted through the suction valve at either end of the compressor cylinder. The current passing through the circuit last traced is sufficient to cause the energization of the solenoid 41, whereupon its core 42 is attracted into its upper position, thereby causing an electrical connection between the switch 45 and its contact 46. It will be noted that the connection of these parts serves to short-circuit or shunt the section 37 of the resistances through the solenoid 47. The consequent energization of this solenoid causes the attraction of its core 48, whereupon the second section 38 of the resistances is short-circuited, and the solenoid 53 brought into the motor circuit. The consequent energization of this latter solenoid in turn causes the attraction of its core 54 to close a connection between the switch-arm 57 and its contact 58. The resistance 39 is sufficient to divert part of the motor current from the switch 57 through the solenoids 59 and 60, thereby causing their energization and the upward attraction of their cores 62 and 64. It will be noted that until the resistances 37 and 38 have been shunted out of the circuit and until the third solenoid 53 has been energized to cause the actuation of its switching mechanism, the solenoids 59 and 60 remain in their normally deënergized condition, thereby maintaining the suction valves of the compressor in their open condition. The resistances 37 and 38 may be replaced by any desired number of sections, some or all of them associated with electro-magnetic controlling mechanism such as described in connection with the sections shown. As the resistances are cut out of the circuit, the speed of the motor increases, so that when the solenoids 59 and 60 become energized and raise their cores, the motor is operated at substantially its full normal speed. Upon removing the influence of the weighted cores from the suction valves, the latter are placed in an operative condition, so that the reciprocations of the piston 66 raise and lower the suction valves from their seats and cause compression of air in either end of the cylinder, whereupon the discharge valves are operated and the compressed air is delivered into the pressure system. The delivery of this air into the reservoir causes an increase in the pressure, and the switch-arm 26 is moved in the direction indicated by the arrow 29. When the pressure reaches its maximum limit, connection is made with the contact 27, thereby closing a circuit, which may be traced as follows: from the main 30 through the switch 32, contact shoes 33 and 34, conductor 68, switch-arm 26, contact 27, solenoid 36, and back to the main 31. The energization of this solenoid causes an attraction of the core 69 moving it toward the right and breaking the motor circuit closed by the contact shoes 33 and 34. Upon the interruption of the motor circuit, the solenoids 41, 47, 53 59 and 60 are all deenergized, thereby permitting their respective cores to drop into their normal positions as shown in the drawing. In this embodiment of my invention the air compressor is normally in such condition, due to the fact that the suction valves are raised from their seats, that its operation requires the expenditure of only a negligible amount of energy—in other words, the operation

of the compressor under normal conditions places practically no load upon the driving motor. It is only after the motor circuit has been closed and after the lapse of some time succeeding the initial closure of the motor circuit that the compressor valves are put in commission. It will be noted that as the suction valves are normally open there can be no accumulation of air in either end of the compressor cylinder due to any slight leakage which might occur in the discharge valves. If there is such leakage from the pressure system back into the compressor cylinder when the machine is not in operation, the air will be exhausted at once into the atmosphere through the open suction valves, thereby insuring the presence of not more than atmospheric pressure in the compressor cylinder at the time the motor circuit is closed.

It may be noted that the force which may be exerted by the weighted levers, that is, by the cores, 62 and 64, in the above described construction, is small as compared with that which may be exerted upon the valves by the compressed air within the cylinder. It may be desirable, therefore, to call attention to the fact that the valves are lifted primarily by the suction due to the movement of the piston within its cylinder. The office of the cores of the electro-magnets or solenoids is essentially that of holding the suction valves up and away from the position at which the compressed air can affect their operation; that is to say, if the suction valve is close to its seat, the compression of air within the cylinder will cause it to seat itself notwithstanding the slight opposing force of the weighted lever. When the circuit for the driving motor is open, the solenoids 59 and 60 are, of course, immediately deënergized. This would naturally permit the cores to drop into their normal positions, causing the suction valves to raise from their seats; but at the time of stopping the air in either one or both ends of the cylinder is likely to be under a considerable degree of compression, and the force due to the compressed air within the cylinder would be quite sufficient to maintain the suction valves upon their seats notwithstanding the slight upward force, due to the weight of the cores from which the magnetic influence will have been drawn. This defective mode of operation is prevented, however, by the momentum of the moving parts of the compressor which causes the compressor piston to make one or more strokes after the interruption of the motor circuit, and consequent deënergization of the solenoids 59 and 60. Such additional strokes of the compressor piston serve to raise the suction valves from their seats, due to the force of external air pressure, thus permitting the cores to drop into their lower positions, as shown in Fig. 1. In the position shown the suction valves are so far raised from their seats that the succeeding reverse stroke of the piston cannot cause the slight compression of air within the cylinder to reseat the suction valve against the opposing force of the weighted lever.

In Fig. 2, I have illustrated a modification in which both the discharge and suction valves of the compressor are free to operate independently of any outside electromagnetic or mechanical control; all of the valves being quite free to operate solely in accordance with the difference of air pressure upon the opposite sides of the valves. In this embodiment of my invention, the pipes 70 and 70′ lead from either end of the cylinder to the reservoir 20. The solenoids 59 and 60 of Fig. 2 are connected in circuit in the same way as are solenoids 59 and 60 of Fig. 1. The cores 62 and 64 in these solenoids, however, serve respectively to control the valves 71 and 72. These latter valves are connected, one in each of the equalizing pipes 70 and 70′, and are normally open as shown. Upon the energization of the solenoids 59 and 60 at a time when the resistances have been cut out of the motor circuit and the motor thereby brought to substantially full speed, the cores are upwardly attracted to close the valves; the valves being retained in their closed condition until the motor circuit is again broken, as already described in connection with the disclosure of Fig. 1. It will be apprehended that under normal conditions the equalizing pipes 70 and 70′ serve to equalize the pressure on the two sides of the piston 66 of the compressor. When, therefore, the circuit is first closed through the motor and the piston of the compressor set in motion, there will be practically no load placed upon the motor, due to the fact that the pressure on both sides of the piston is the same. Only after the motor has attained substantially its full speed, on account of the removal of the restriction in the supply of energy to the motor, the valves 71 and 72 are closed, thereby causing an increased pressure in the air in one end of the compressor cylinder and a corresponding tendency to produce a vacuum in the other end of the compressor cylinder, whereupon the discharge and suction valves will be set in operation to deliver air under pressure into the reservoir and pressure system. In other respects, the operation of the apparatus shown in Fig. 2 is similar to that described in connection with the arrangement shown in Fig. 1.

In Fig. 3, I have shown a somewhat different arrangement, in which the valves 71 and 72 in the equalizing pipes 70 and 70′ are normally in a closed condition; as shown, the energization of the associated solenoids 73 and 74 serving to raise their cores, 75 and 76, to open equalizing valves, 71 and 72. In many respects the arrangement here shown is similar to those already described, but I shall trace certain of the circuits and the currents caused to flow therethrough: Upon the decrease of the pressure in the pressure system, the contact shoes 33 and 34 are brought into engagement as already described, whereupon a circuit may be traced from the main 30 through the switch 32, which will have been closed by hand, and thence through the contact shoes 33 and 34 and the conductor 40 to the solenoid 41, and thence through the resistances 37 and 38 to the conductor 77, which leads to the solenoids 73 and 74, and thence to the motor terminal 13. Thus, upon the closure of the motor circuit and during the initial and restricted supply of energy thereto, the solenoids 73 and 74 will have been energized to cause the upward attraction of their cores, thereby maintaining the equalizing valves 71 and 72 in their open condition. These valves being open, the compressor requires practically no power to operate it, and the load upon the motor is decreased to such a degree that its effect is negligible. The slow-acting electro-magnetic mechanism forming a part of the automatic rheostat, operates, as already described, to gradually cut the resistances out of the motor circuit, and as the last solenoid 53 becomes energized causing the upward attraction of its core 54, the switch 57 is brought into connection with the contact

58, whereupon the solenoids 73 and 74 are shunted or short-circuited to cause their de-energization. Upon the de-energization of these coils, their cores drop back into their normal condition as shown, thereby closing the equalizing valves and permitting the operation of the suction and discharge valves of the compressor as under usual conditions.

The modification last described differs from those shown in Figs. 1 and 2 in that, under normal condition of rest, the compressor is in its operative condition so far as the suction and discharge valves are concerned; whereas in the other embodiment of the invention, the compressor is normally in an inoperative condition. In the embodiment of the invention illustrated in Fig. 3, the operation of the compressor valves is immediately prevented upon the closure of the motor circuit by means of the accompanying opening of the equalizing valves due to the concurrent energization of their controlling solenoids 73 and 74.

In Fig. 4 I have illustrated a modification of my invention in which the electro-magnetic control is somewhat similar to that shown in Fig. 3, but in which the mechanical arrangement is different. In this modification a separate valve or valves are placed in the suction pipe of the compressor. These valves, in the modification shown in Fig. 4, are normally open but are automatically closed during a suitable period immediately following the closure of the motor circuit, whereupon they are again opened to permit the operation of the compressor.

In the modification shown in Fig. 4 I have not illustrated an automatically governed switch for the motor circuit, but have shown merely a hand switch 32′. The motor, compressor and the system into which the compressor discharges, are substantially like those shown in the other figures and need not be more specifically described. Leading to each of the suction valves, 15 and 16, of the compressor, there is what may be called a suction pipe, 80 or 81. The pipe 80 is provided with a normally open cock 82, pipe 81 being provided with a similar cock 83. The cocks are respectively controlled, to a certain extent, by the cores 84 and 85, which are adapted to be actuated by their associated solenoids, 86 and 87. These solenoids are normally included in the motor circuit as shown. There is also included in the circuit a controlling solenoid 88, whose core 89, is mechanically associated with the dash-pot 90, or other suitable restraining mechanism. A stem extending from the upper end of the core serves to close the switch contacts, 91, upon the energization of the solenoids 88.

The operation of this arrangement is as follows: The switch 32 being closed current is caused to flow from the main 30, through the switch 32′, solenoid 88, and normally (the switch 91 being open) through the solenoids 86 and 87 to the motor and thence to the other main 31. The energization of the solenoids 86 and 87 causes an immediate attraction of their cores, which are raised to their upper position, thereby closing cocks 82 and 83, which are normally in an open condition as shown. These cocks in the suction pipes being closed, it is impossible for air to be admitted to the compressor cylinder at either end. The air previously admitted to the compressor cylinder is, of course, compressed, but as this requires comparatively little power, the motor is started under practically a no load condition. After the lapse of a suitable period of time,—determined to a certain extent by the adjustment of the dash-pot 90, or other retarding mechanism, the switch contacts 91 are closed, thereby short-circuiting the solenoids 86 and 87; whereupon, they are de-energized to permit their cores 84 and 85 to drop to the normal position shown, thereupon opening the cocks 82 and 83 to admit air under atmospheric pressure of the lower side of the suction valves 15 and 16. The rapidity with which the slow-acting mechanism is actuated to close the contacts 91 is regulated in such a way that the motor will have attained substantially its full speed before the opening of the auxiliary cocks 82 and 83 in the suction pipes of the compressor. After these cocks are opened the load is thrown upon the compressor, but at that time the motor had attained sufficient speed to take care of its full normal load.

In Fig. 5 I have shown a similar mechanical arrangement associated with the electro-magnetic scheme of the modification shown in Fig. 1. In this Fig. 5 I have shown also a single cock 92 in a single suction pipe 93 which leads to both of the suction valves 15 and 16. The cock 92 of Fig. 5 is normally closed as shown, the opening of this cock being effected by the mechanically connected core 94 of the solenoid 95. The circuit through the solenoid 95 is controlled by the switch contacts 96, normally open, as shown. I have illustrated a resistance 97 for causing current to flow through the solenoid 95, upon the closure of the switch 96. The operation of the modification here shown is as follows: The closure of the switch 32′ causes current to flow through the solenoid 98, and thence through the resistance 97, to the motor which is started while the closed cock 92 prevents the admission of air to either end of the compressor cylinder. The retarding mechanism associated with the core 99 prevents its immediate attraction, due to the energization of the coil 98, and a suitable interval is thus caused to elapse subsequent to the initial closure of the motor circuit, and before the switch contacts 96 are closed. After a brief interval, however these contacts are closed, whereupon current from the solenoid 98 divides and passes partly through the resistance 97, and partly through the coil 95 to the motor. The energization of coil 95 causes an upward attraction of its core 94, to open the cock 92, the cock being maintained in this open condition during the subsequent operation of the compressor and motor under normal full load conditions. Upon opening the motor circuit the coils 95 and 98 are de-energized, permitting their armatures to drop back into the normal positions shown, the former causing the closure of the cock 92, and the latter causing the switch 96 to be opened, whereupon the subsequent closure of the switch 32′ will cause a repetition of the operations already described.

I have not attempted to show in these drawings the actual mechanical design or construction of the various parts, as these matters lie within the skill of the ordinary engineer or mechanic. I have represented, however, in a diagrammatical way, certain embodiments of my invention, which indicate the spirit and scope thereof.

Without, therefore, wishing to limit myself to the

precise constructions herein set forth, I claim as new and desire to secure by Letters Patent:—

1. In combination, a fluid pump having check valves normally maintained in an open condition, motor means for driving said pump, and means automatically actuated after the initial supply of energy to the motor means to permit the closure of said valves.

2. In combination, a fluid pump having inlet valves normally maintained in an open condition, a motor for driving said pump, and automatic means actuated after the initial supply of energy to the motor to permit the closure of said valves.

3. In combination, an air compressor having suction valves normally maintained in an open condition, an electric motor for driving said pump, and electromagnetic means automatically actuated after the initial supply of current to said motor to permit the closure of said suction valves.

4. In combination, an air compressor having check valves normally maintained in an open condition, an electric motor for driving said pump, means for restricting the supply of current to said motor at starting, and means automatically actuated after the removal of the restriction in the supply of current to permit the closure of said valves.

5. In combination, a fluid pump having valves normally maintained in an open condition, a pressure system supplied thereby, a motor for driving said pump, means governed by the pressure in said pressure system to control the supply of energy to said motor, and means automatically actuated after the initial supply of energy to said motor to permit the closure of said valves.

6. In combination, a fluid pump having suction valves normally maintained in an open condition, an electric motor for driving said pump, and means for permitting the closure of said valves upon the lapse of a suitable interval after the closure of the motor circuit.

7. In combination, an air compressor having valves normally maintained in an inoperative condition, a pressure system supplied thereby, a motor for driving said compressor, means governed by the pressure in said system to control the supply of energy to said motor, and means electromagnetically actuated upon the lapse of a suitable interval after the initial supply of energy to said motor to render said valves operative.

8. In combination, a fluid pump having suction valves normally maintained in an inoperative condition, motor means for driving said pump, and means electromagnetically actuated upon the lapse of a suitable interval after the initial supply of energy to said motor to render said valves operative.

9. In combination, an electric motor, a fluid pump driven thereby, a pressure system supplied by said pump, switching means controlled by the pressure in said system to govern the circuit for said motor, means in the path of the valves of said pump serving normally to prevent the actuation of the valves, and electromagnetic mechanism for automatically removing said preventive means from the path of the valves upon the lapse of a suitable interval after the closure of the motor circuit.

10. In combination, an electric motor, a fluid pump driven thereby, switching means for controlling the circuit through said motor, and means serving to hold the valves of the pump off their seats until after closure of the motor circuit.

11. In combination, an electric motor, a fluid pump driven thereby, a pressure system supplied by said pump, switching 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 the pressure in said system to a maximum limit, restricting means serving normally to maintain the valves of said pump in an inoperative condition, and electromagnetic means for removing said restricting means upon the lapse of a suitable interval after the closure of the motor circuit to render said valves operative.

12. In combination, a fluid pump having check valves normally maintained in an open condition, an electric motor for driving said pump, a pressure system supplied by said pump, switching 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 the pressure in said system to a maximum limit, and means electromagnetically actuated after the lapse of a suitable interval after the closure of the motor circuit to permit the closure of said valves.

13. In combination, an air compressor having check valves normally maintained in an inoperative condition, an electric motor for driving said compressor, a pressure system supplied by said compressor, switching means governed by the pressure in said system to control the motor circuit, means for restricting the supply of current to said motor at starting, and electromagnetic means for rendering said valves operative upon the removal of the restriction in the supply of current to said motor.

14. In combination, an electric motor, a fluid pump driven thereby, said pump having valves normally maintained in an inoperative condition, a pressure system supplied by said pump, switching means governed by the pressure in said system to control the motor circuit, means for restricting the supply of current to said motor at starting, and electromagnetic means automatically actuated to permit the operation of said valves upon the removal of the restriction in the supply of current to said motor.

15. In combination, a fluid pump having suction valves normally maintained in an open condition, an electric motor for driving said pump, a pressure system supplied by said pump, switching means controlled by the pressure in said system to control the circuit through said motor, means for restricting the supply of current to said motor at starting, and means for automatically permitting the operation of said valves and for removing the restriction of the supply of current to said motor after the lapse of a suitable interval after the closure of the motor circuit.

16. In combination, a fluid pump, an electric motor for driving said pump, switching means for controlling the supply of current to said motor, means serving normally to prevent the operation of the pump valves, and electromagnetic mechanism associated with said pump valves adapted to incapacitate said preventive means after the initial supply of current to said motor.

17. In combination, an air compressor, an electric motor for driving said compressor, a pressure system supplied by said compressor, means governed by the pressure in said system to close the motor circuit upon a decrease in the pressure to a minimum limit and to open the motor circuit upon an increase in the pressure to a maximum limit, means serving normally to prevent the operation of the pump valves, and electromagnetic mechanism associated with said pump valves adapted to incapacitate said preventive means after the initial supply of current to said motor.

18. In combination, an air compressor, an electric motor for driving said compressor, a pressure system supplied by said compressor, means governed by the pressure in said system to control the motor circuit, and electromagnetically controlled means for maintaining an opening in each end of the compressor cylinder until said compressor has been started.

19. In combination, a fluid pump, an electric motor for driving said pump, switching means for controlling the motor circuit, a valve communicating with each end of the compressor cylinder, means for maintaining said valves in an open condition during the initial supply of current to said motor at starting, and electromagnetic means actuated after the lapse of a suitable period subsequent to the closure of the motor circuit, to permit the closure of said valves.

20. In combination, a fluid pump, an electric motor for driving said pump, switching means for controlling the motor circuit, a valve communicating with each end of the compressor cylinder, and electromagnetically controlled means for maintaining said valves in an open condition until the lapse of a suitable period after the closure of the motor circuit.

21. In combination, a fluid pump, an electric motor for driving said pump, a pressure system supplied by said pump, switching means governed by the pressure in said system for controlling the motor circuit, a valve communicating with each end of the compressor cylinder, means for

simultaneously maintaining said valves in an open condition during a certain period subsequent to the closure of the motor circuit, and electromagnetic means actuated after the lapse of a suitable period subsequent to the closure of the motor circuit, to permit the closure of said valves.

22. In combination, an electric motor, a fluid pump driven thereby, switching means controlling the circuit through said motor, a resistance normally included in the motor circuit, automatic means for gradually cutting said resistance out of the motor circuit, upon the closure of said circuit, means serving normally to prevent the operation of the valves of the compressor, electro-magnetic mechanism serving when energized to permit the operation of said valves, and means for causing the energization of said electro-magnetic mechanism after said resistance has been cut out of the motor circuit.

23. In combination, an electric motor, an air compressor driven thereby, a pneumatic pressure system supplied by said compressor, switching mechanism governed by the pressure in said system to cause the closure of the circuit through said motor upon a decrease of the pressure in said system to a minimum limit, and to cause a break in the circuit through said motor upon an increase in the pressure in said system to a maximum limit, a slow acting automatic rheostat in the motor circuit, adapted gradually to short circuit resistances normally included in the motor circuit after the closure of the motor circuit, means serving normally to prevent the operation of the valves of said compressor, electro-magnetic mechanism serving, when energized, to permit the operation of said valves, and a slow acting electromagnetic switching device serving to close circuit through said electromagnetic mechanism after the lapse of a suitable interval subsequent to the closure of the motor circuit.

24. In combination, an electric motor, an air compressor driven thereby, a pneumatic pressure system supplied by said compressor, switching mechanism governed by the pressure in said system to cause the closure of the circuit of said motor upon the decrease in the pressure of said system to the minimum limit and to cause a break in the motor circuit upon an increase in the pressure in said system to a maximum limit, a slow acting automatic rheostat in the motor circuit adapted gradually to short circuit resistances normally included in the motor circuit, after the closure of the motor circuit, means serving normally to maintain an opening in each end of the compressor cylinder, and electro-magnetic mechanism energized after said resistances have been cut out of the motor circuit, to cause the closure of the openings in the ends of the compressor cylinder.

25. In combination, a fluid pump, an electric motor for driving said pump, switching means for controlling the circuit through said motor, a normally open valve communicating with each end of the pump cylinder, electro-magnetic mechanism serving, when energized, to close said valves, an automatic rheostat in the motor circuit, and a slow acting electro-magnetic switching device serving, when actuated, to cause the energization of said electro-magnetic mechanism.

26. In combination, a fluid pump, an electric motor for driving said pump, switching means for controlling the circuit through said motor, a normally open valve communicating with each end of the pump cylinder, electro-magnetic mechanism serving, when energized, to close said valves, and a slow acting electro-magnetic switching device serving, when actuated, to cause the energization of said electro-magnetic mechanism.

27. In combination, a fluid pump having discharge valves, an electric motor for driving said pump, mechanism serving normally to prevent actuation of said valves, and electromagnetic means for controlling said mechanism after the lapse of a suitable period subsequent to the closure of the motor circuit to allow actuation of said valves.

28. In combination, a fluid pump having discharge valves, an electric motor for driving said pump, a pressure system supplied by said pump, means governed by the pressure in said system to control the motor circuit, means serving normally to prevent the operation of said valves, and a slow acting electromagnetic device included in the motor circuit serving after the lapse of a suitable interval subsequent to the closure of the motor circuit to control said means to allow actuation of said valves.

29. In combination, an electric motor, a fluid pump driven thereby, switching means for controlling the circuit through said motor, means normally effective to prevent actuation of the valves of said pump, and automatic electromagnetic mechanism adapted to render ineffective said normally effective means after the lapse of a suitable interval subsequent to the closure of the motor circuit, whereby said valves become operative.

30. In combination, a fluid pump having valves, a motor for driving said pump, and electromagnetic mechanism serving to prevent the operation of said valves during the lapse of a suitable period subsequent to the initial supply of energy to said motor.

31. In combination, a reciprocating pump, motor means for driving said pump, means for controlling the supply of energy to said motor means, a normally open valve communicating with one end of the pump cylinder, and slow acting electromagnetic mechanism set in operation upon the initial supply of energy to said motor means, said slow acting mechanism serving to permit the closure of said valve after the lapse of a suitable interval subsequent to the initial supply of energy to said motor means.

32. In combination, a reciprocating pump, motor means for driving said pump, means for controlling the supply of energy to said motor means, normally open valves communicating with the ends of the pump cylinder, electromagnetic mechanism set in operation upon the initial supply of energy to said motor means to cause the closure of said valves, and a retarding device associated with said automatic mechanism.

33. In combination, a reciprocating pump, motor means for driving said pump, means for controlling the supply of energy to said motor means, an open valve communicating with the end of the pump cylinder, electromagnetic mechanism adapted to be set in operation when the motor is started to permit said valve to close, and a retarding device associated with said mechanism.

34. In combination, an air compressor, an electric motor for driving said compressor, a switch for controlling the motor circuit, means for maintaining the suction valves of said compressor normally open, and slow acting mechanism set in operation upon the closure of the motor circuit to permit subsequently the closure of said suction valve.

35. In combination, a pump, an electric motor for driving said pump, a switch for controlling the motor circuit, an open valve communicating with one end of the pump cylinder, and slow acting solenoid mechanism energized by current in the motor circuit to permit the closure of said valves.

36. In combination, an air compressor, an electric motor for driving said compressor, a switch for controlling the motor circuit, a normally open valve communicating with either end of the compressor cylinder, electro magnetic mechanism serving, when energized, to permit the closure of said valves, a switch serving when closed to cause the energization of said electro-magnetic mechanism, and a slow acting device automatically actuated to cause the closure of said switch after the lapse of a suitable interval succeeding the closure of the motor circuit.

37. In combination, an electric motor having a switch for controlling its circuit, an air compressor driven thereby, said compressor having a suction valve in an open condition, electro-magnetic means adapted, upon energization, to permit the closure of said suction valve, a switching device and slow acting electro-magnetic mechanism set in operation upon the closure of the motor circuit, and serving after an appreciable length of time to actuate said switching device to cause the energization of said electromagnetic means for permitting the closure of said suction valve.

38. In combination, an electric motor, having a switch for controlling its circuit, an air compressor driven thereby, said compressor having suction valves normally maintained in an open condition, electro-magnetic means adapted upon energization to permit the closure of said suction valves, an electric switching device, electro-magnetic mechanism in the motor circuit serving, when actuated, to operate said switching device to cause the energization of

said electro-magnetic means, thereby permitting the closure of said suction valves, and a retarding device associated with said electro-magnetic mechanism whereby the actuation of said switching device is prevented until the lapse of a suitable interval after the initial closure of the motor circuit.

39. In combination, an electric motor, a fluid pump driven thereby, switching means for controlling the circuit through said motor, normally incapacitating means adapted to cause inoperativeness of the valves of said pump, and electromagnetic means adapted to remove said incapacitating means to render the valves operative.

40. In combination, a pump, an electric motor for driving said pump, normally incapacitating means for rendering the pump valves inoperative, and solenoid mechanism serving to render said valves operative when said motor has reached normal speed.

41. In combination, a fluid pump, a motor for driving said pump, means for preventing the operation of valves of said pump, said means being operative when said pump is in a state of rest, and electromagnetic mechanism serving to render said means inoperative after said motor has been started.

42. In combination, a pump, means for driving said pump, means serving normally to maintain an opening to permit the access of atmospheric pressure to a chamber of said pump, and electromagnetic mechanism serving to close said opening after said pump has been started.

43. In combination, a fluid pump, an electric motor driving said pump, switching means for controlling the circuit through said motor, and electromagnetically controlled means serving to hold the valves of the pump off their seats until after the closure of the motor circuit.

44. In combination, an electric motor, a fluid pump driven thereby, a pressure system supplied by said pump, a suction valve for said pump, an electrical circuit controlled by the pressure in said system, and electromagnetic means in said circuit associated with said suction valve, said electromagnetic means being actuated after the motor has reached normal speed to cause actuation of said suction valve to allow said pump to be operative to force fluid into said system, said magnetic means being also mechanically associated with said suction valve to render said valve inoperative before said motor has reached normal speed.

45. In combination, an electric motor, a fluid pump driven thereby, a pressure system supplied by said pump, suction valves for said pump, and mechanism electromagnetically and mechanically associated with said suction valves, the mechanical connection of said mechanism causing said valves to be rendered inoperative while the motor is starting, and the electromagnetic connection of said mechanism causing said valves to become operative after the motor has reached normal speed.

46. In combination, a fluid pump, an electric motor driving said pump, a pressure system controlled by said pump, an electric circuit controlled by the pressure in the system, and mechanism mechanically and electromagnetically associated with the pump valves, the mechanical connection of said mechanism causing inoperativeness of the valves while the motor is starting, and electromagnetic connection of said mechanism controlling said mechanical connection to cause the valves to become operative after the motor has reached a suitable speed.

47. In combination, a fluid pump, an electric motor driving said pump, a pressure system supplied by said pump, suction valves for said pump, an electric circuit controlled by the pressure in the system, preventative means associated with said suction valves for preventing the operation of said valves during the starting period of said motor, and electrical means adapted for inclusion in said circuit for releasing said preventative means to allow operation of said valves when the motor has reached suitable speed.

48. In combination, a fluid pump, an electric motor driving said pump, a pressure system supplied by said pump, suction valves for said pump, a circuit for said motor including a resistance for limiting the speed of said motor at starting, mechanism mechanically and electromagnetically associated with said valves, the mechanical connection serving to render the valves inoperative in the starting period of the motor and the electromagnetic connection of said mechanism being rendered effective after said resistance has been removed from the motor circuit to cause said valves to become operative.

49. In combination, a fluid pump, a pressure system supplied by said pump, an electric motor driving said pump, means for controlling the supply of energy to said pump, normally inoperative valves for said pump and electromagnetic means for automatically allowing operation of the normally inoperative valves after the motor has reached a suitable speed.

50. In combination, an air compressor having valves normally maintained in an inoperative position, a pressure system supplied thereby, a motor for driving said compressor, means directly governed by the pressure in said system to control the supply of energy to said motor, and means electrically actuated upon the lapse of a suitable interval after the initial supply of energy to said motor to render said valves operative.

51. In combination, an air compressor having valves normally maintained in an inoperative condition, a pressure system supplied thereby, a motor driving said compressor, means positively connected with the pressure in said system to control the supply of energy to said motor, and means electrically actuated upon the lapse of a suitable interval after the initial supply of current to said motor to render said valves operative.

52. In combination, an air compressor having valves normally maintained in an inoperative position, a reservoir supplied by said compressor, a motor driving said compressor, means connected directly with said reservoir and directly governed by the pressure in said reservoir to control the supply of energy to said motor, and means electrically actuated for rendering said valves operative.

53. In combination, an air compressor having valves normally maintained in an inoperative condition, a pressure system supplied thereby, a motor driving said compressor, switch actuating means directly connected with said pressure system and governed by the pressure therein to control the supply of energy to said motor, and means electrically actuated upon the lapse of a suitable interval after the initial supply of energy to said motor to render said valves operative.

In witness whereof I hereunto subscribe my name this 17th day of March A. D., 1904.

WALTER JOSEPH RICHARDS.

Witnesses:

VICTOR H. GREISSER,

W. L. WATERS.