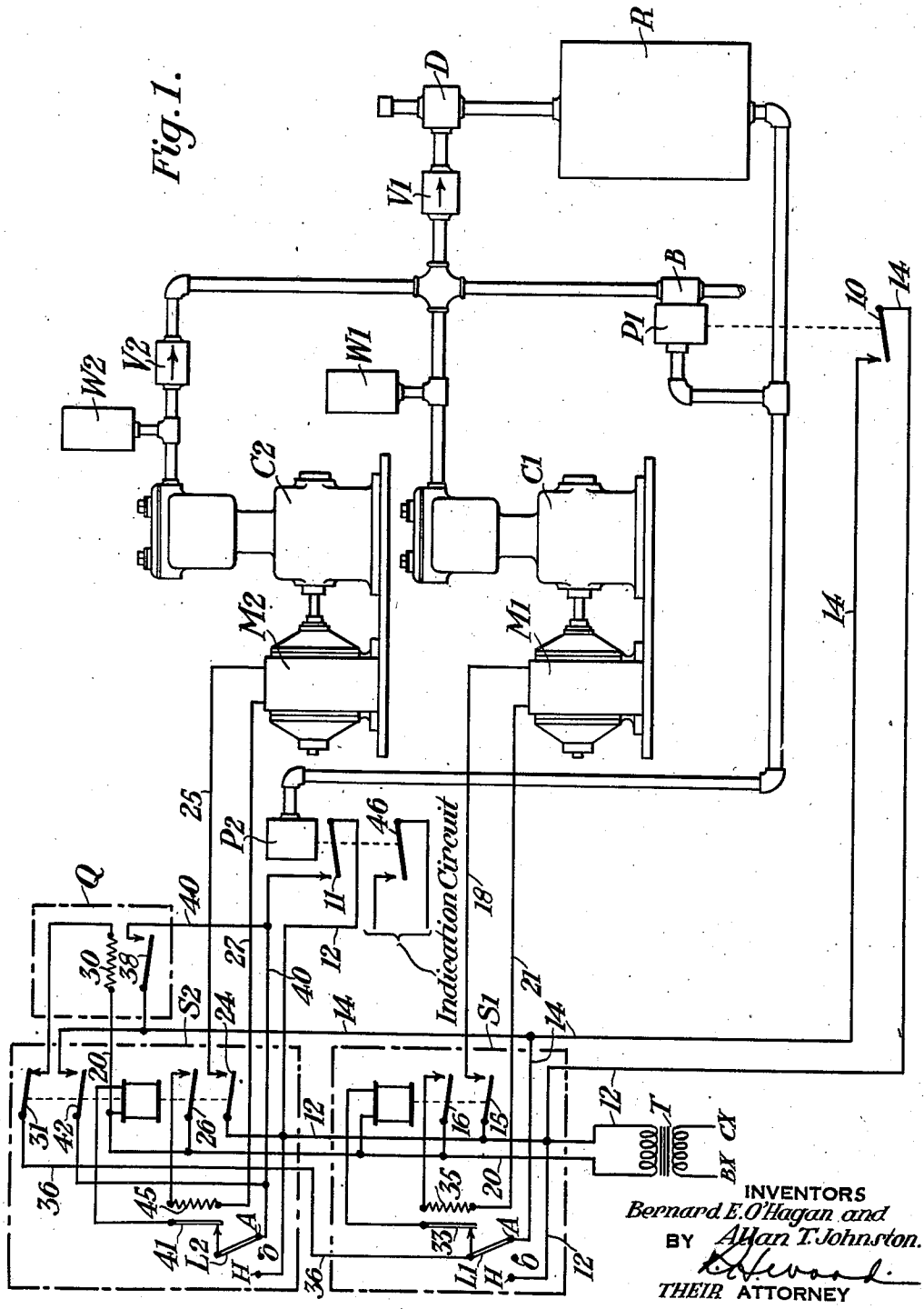
March 2, 1943. B. E. O'HAGAN ET AL 2,312,728

COMPRESSOR CONTROL SYSTEM

Filed July 12, 1941 2 Sheets-Sheet 1

Fig. 1.



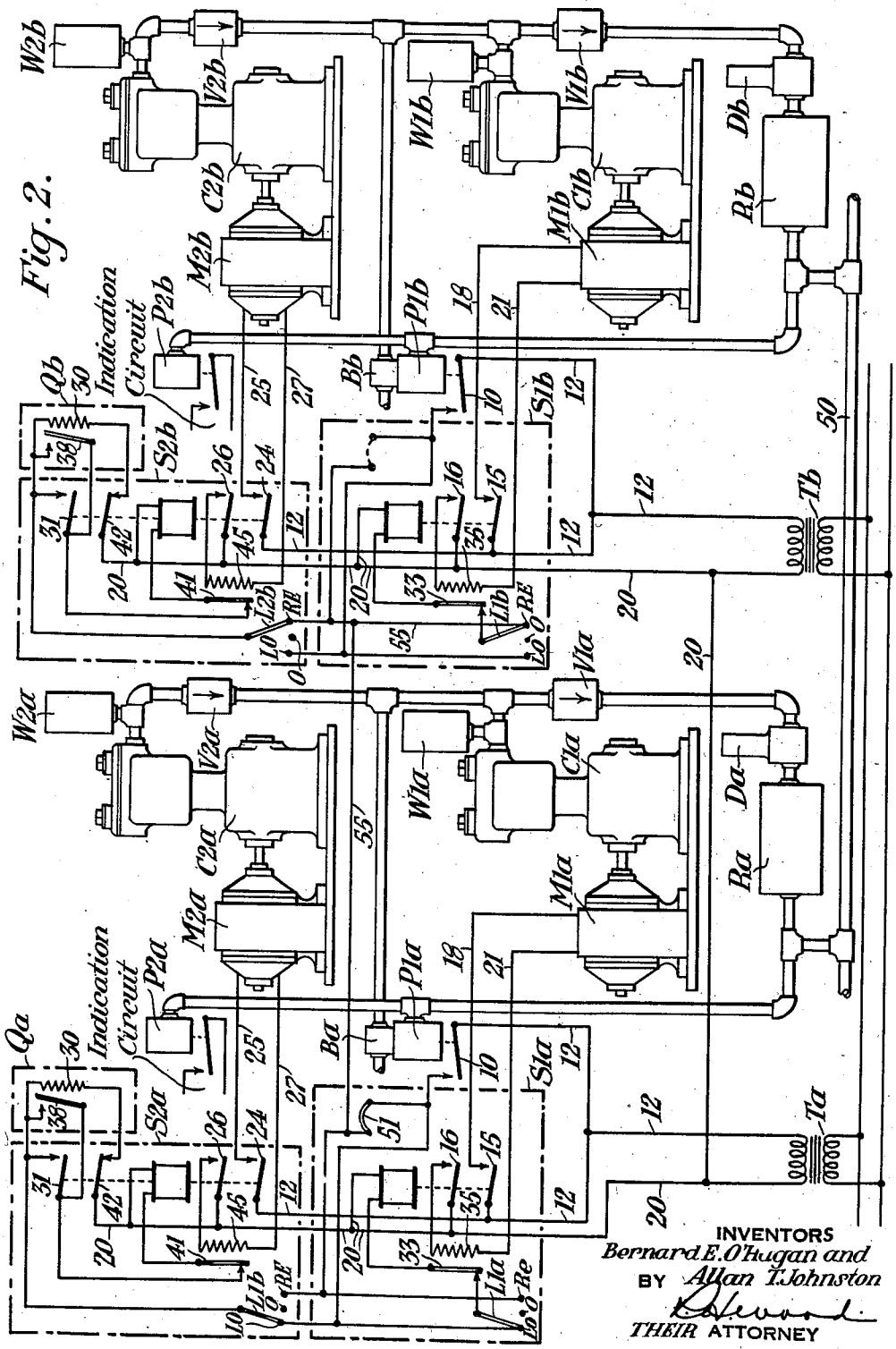
INVENTORS
Bernard E. O'Hagan and
Allan T. Johnston.
BY
THEIR ATTORNEY

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Fig. 2.



INVENTORS
Bernard E. O'Hagan and
BY Allan T. Johnston
THEIR ATTORNEY

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UNITED STATES PATENT OFFICE

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COMPRESSOR CONTROL SYSTEM

Bernard E. O'Hagan, Swissvale, and Allan T. Johnston, Mount Lebanon, Pa., assignors to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application July 12, 1941, Serial No. 402,178

7 Claims. (Cl. 230—18)

Our invention relates to improved means for controlling a plurality of air compressors.

In some situations, as for example in interlocking plants where pneumatic switches are employed, several air compressors are provided to supply the compressed air to operate the switches. These compressors are driven by electric motors which are supplied with current over the same transmission line while they supply compressed air to the same or connected reservoirs. These compressors are controlled by pressure switches so that they are placed in operation when the pressure in the reservoir drops to a predetermined value, and are continued in operation until the pressure in the reservoirs is increased to a higher predetermined value.

It is desirable in situations of this kind that on a reduction in the pressure in the reservoir that all of the air compressors driven by motors supplied with energy through the same transformer do not attempt to start up simultaneously as this might place such a heavy load on the transformer that the voltage of the current supplied through the transformer would drop so much that the motors would be unable to start the compressors.

It is desirable also that the compressors be unloaded when they are started, that is, that they be not required to compress air against the pressure in the reservoir during the period in which the compressors are being started.

It is an object of our invention to provide improved means for controlling a plurality of air compressors so that there is a time interval between the start of operation of the compressors.

A further object of the invention is to provide a system of the type described and incorporating means to maintain each of the compressors unloaded during the starting period of the compressor.

Another object of the invention is to provide a system of the type described and which employs standard commercial apparatus insofar as possible.

Other objects of the invention and features of novelty will be apparent from the following description taken in connection with the accompanying drawings.

We shall describe two forms of compressor control systems embodying our invention, and shall then point out the novel features thereof in claims.

In the drawings, Fig. 1 is a diagram showing the compressor control system provided by our invention applied to two compressors and

Fig. 2 is a diagram showing the compressor control system of our invention applied to two compressor units each having two compressors.

Similar reference characters refer to similar parts in each of the two views.

Referring to Fig. 1 of the drawings, there is shown therein a compressor control system embodying our invention. The equipment shown in Fig. 1 includes compressors C1 and C2 which are driven by alternating current motors M1 and M2, respectively. The compressors C1 and C2 may be of any construction well known in the art and are of a type which do not incorporate unloading means. The motors M1 and M2 may be any appropriate type of alternating current motors.

The compressors C1 and C2 supply fluid under pressure or compressed air to a reservoir R from which air may be drawn for any desired purpose, as for example to operate the track switches in an interlocking plant on a railroad.

The compressor C1 is connected to the reservoir R through a supply pipe and a check valve V1 which permits air to be supplied from the compressor to the reservoir and prevents flow of air from the reservoir to the compressor. The compressor C2 is connected to the reservoir R through a check valve V2, the supply pipe, and also through the check valve V1 so that air may be supplied from the compressor C2 through the check valves V2 and V1 to the reservoir R, but is prevented from flowing from the reservoir to the compressor. The check valve V2 also prevents air compressed by the compressor C1 reaching the compressor C2.

An unloading volume W1 is connected to the supply pipe intermediate the compressor C1 and the check valve V1, while a similar unloading volume W2 is connected intermediate the compressor C2 and the valve V2.

Pressure operated switches P1 and P2 are provided and are connected with the reservoir R by a suitable pipe. These switches may be of any appropriate construction well known in the art and their design is not a part of our invention. These switches include contacts which are governed in accordance with the pressure in the reservoir. These contacts are closed when the air in the reservoir is at atmospheric pressure and remain closed until the pressure in the reservoir is increased to a predetermined value when they become opened. These contacts when open remain open until the pressure in the reservoir

drops to a value somewhat less than that which caused them to open. The pressure operated switches also include means by which the pressures at which their contacts close and open may be adjustably varied as desired, and it is contemplated that the switches P1 and P2 in this system will be adjusted to operate at different pressures. The switch P1 may be adjusted so that its contacts open when the reservoir pressure is 70 pounds and to close when it is 55 pounds to the square inch. The switch P2 may be adjusted so that its contacts open when the reservoir pressure is 60 pounds and to close when the pressure falls to 45 pounds.

The pressure switch P1 has incorporated therein an unloading valve device B which controls connection from the supply pipe and thereby from the compressors C1 and C2 to the atmosphere. The valve B is connected to the supply pipe intermediate the compressor C1 and the check valve V1, and intermediate the check valves V2 and V1 so that when the valve B is open the compressors C1 and C2 and the unloading volumes W1 and W2 are vented to the atmosphere, while the check valve V1 prevents escape of air from the reservoir R through the valve B.

The valve B is controlled by the pressure switch P1 so as to be open when the contacts of the pressure switch are open, and to be closed when the switch contacts are closed.

A safety valve D is provided and operates in the usual manner to release fluid from the reservoir R if the pressure therein exceeds a predetermined pressure.

The current for operating the motors M1 and M2 is supplied through a transformer T from a suitable source of alternating current the terminals of which are designated BX and CX. This energy may be supplied over a transmission line, not shown.

The supply of energy from the transformer T to the motors M1 and M2 is controlled by magnetic switches indicated generally by the reference characters S1 and S2, while a thermal time delay switch Q is employed to provide a time interval between the supply of energy to the motors M1 and M2. In addition, the magnetic switches S1 and S2 each incorporate a thermal overload device to protect the motor controlled by the switch in the event of an overload.

The switches S1 and S2 are provided with manually operable control levers designated L1 and L2, respectively. Each of these levers has an intermediate or "off" position designated O, in which it interrupts the circuit of the winding of the associated switch to thereby prevent operation of the motor governed by that switch. Each control lever also has an automatic position A in which the circuit of the winding of the associated switch is controlled by the pressure switches in the manner hereinafter explained in detail. In addition, each of the control levers has a hand position H in which a circuit independent of the pressure switches is established to energize the winding of the associated switch and thereby cause operation of the associated compressor regardless of the pressure in the reservoir R.

The equipment is shown in Fig. 1 of the drawings in the condition which it assumes when the pressure in the reservoir R is above 55 pounds to the square inch so that contact 10 of pressure switch P1 and contact 11 of pressure switch P2 are open. The equipment is also shown with the control levers L1 and L2 in their automatic positions.

As contact 10 of switch P1 is open, it interrupts connection from supply wire 12, leading from one terminal of the secondary winding of transformer T, to wire 14 from which energy is supplied to the windings of the switches S1 and S2. Accordingly, the contacts of the switches S1 and S2 are released and contact 15 of switch S1 interrupts connection from supply wire 12 to wire 18 leading to the motor M1, while contact 16 of switch S1 interrupts connection from supply wire 20 leading from the other terminal of the transformer secondary winding to wire 21 leading to the motor M1.

Similarly, contact 24 of switch S2 interrupts connection from supply wire 12 to wire 25 leading to motor M2 and contact 26 interrupts connection from supply wire 20 to wire 27 leading to motor M2.

Accordingly, the motors M1 and M2 are not operating, while energy is not supplied to the heating element 30 of thermal relay Q even though contact 31 of switch S2 is closed, since contact 10 of pressure switch P1 is open.

In addition, at this time the unloading valve B is open so that the unloading volumes W1 and W2 and the pipes connected therewith are open to the atmosphere.

When the pressure in the reservoir R drops below 55 pounds, the contact 10 of pressure switch P1 closes, while the unloading valve B also closes. When contact 10 of switch P1 is closed, energy is supplied from transformer T to the winding of switch S1 over the circuit which is traced from one terminal of the transformer secondary winding over supply wire 12, contact 10 of switch P1, wire 14, control lever L1, and contact 33 of the thermal overload device incorporated in switch S1 to one terminal of the winding of switch S1, while the other terminal of this winding is connected to supply wire 20 and thus to the other terminal of the secondary winding of transformer T.

On energization of the winding of switch S1 its contacts 15 and 16 pick up and establish connection from the supply wires 12 and 20 to wires 18 and 21 leading to motor M1 so that this motor operates and drives compressor C1. The compressor C1 will start readily as the unloading volume W1 is at atmospheric pressure so there is no air pressure to oppose operation of the compressor. As the compressor is operated, the pressure of the air in the volume W1, the supply pipe, and the connected pipes builds up, and when it exceeds the pressure in the reservoir R, air flows through the check valve V1 to the reservoir. The check valve V2 prevents air supplied from compressor C1 at this time from reaching volume W2 and compressor C2 so that the compressor C2 is maintained unloaded. The volume W1 is proportioned so that the pressure therein does not build up appreciably until the compressor has been operated several revolutions and reaches a substantial speed so that the motor M1 will be able to continue to drive the compressor after it is subjected to load.

On closing of contact 10 of pressure switch P1 energy is supplied to the heating element of thermal relay Q over the circuit which is traced from one terminal of the secondary winding of transformer T through supply wire 12, contact 10 of switch P1, wire 14, control lever L1, wire 36, and contact 31 of switch S2 to one terminal of the heating element 30 of relay Q, while the

other terminal of the element 30 is connected to supply wire 20 and thus to the other terminal of the transformer secondary winding. On the supply of energy to the element 30 is heats up, and after the expiration of a time interval long enough for the compressor C1 to have substantially reached its full speed the element 30 is hot enough to cause contact 38 of device Q to close.

Contact 38 of device Q when closed establishes a pick-up circuit for the winding of switch S2. This circuit is traced from transformer T through wire 12, contact 10 of switch P1, wire 14, contact 38 of device Q, wire 40, control lever L2, and contact 41 of the thermal overload device incorporated in switch S2 to one terminal of the winding of switch S2, while the other terminal of this winding is connected by wire 20 to the transformer T. Energy, therefore, is supplied to the winding of switch S2 and the contacts of this switch pick up and its contact 42 establishes connection from wire 14 to wire 40 to maintain the winding of switch S2 energized after opening of contact 38 of device Q. On picking up of the contacts of switch S2 its contact 31 interrupts the circuit traced above for supplying energy to the heating element 30 of device Q so that this element cools and its contact 38 opens.

In addition, on picking up of the contacts of switch S2 its contacts 24 and 26 establish connection from supply wires 12 and 20 to wires 25 and 27 leading to motor M2 so that the motor M2 operates and drives compressor C2. As pointed out above, the compressor C2 is unloaded at this time so that it will start readily.

When the pressure in the reservoir R increases to 70 pounds, the contact 10 of switch P1 opens and interrupts connection from wire 12 to wire 14 and thereby cuts off the supply of energy to the windings of switches S1 and S2 so that the contacts of these switches release and interrupt the circuits of the compressor motors M1 and M2. In addition, on release of switch S2 its contact 42 interrupts the holding circuit for the switch winding, while its contact 31 closes to permit energy to be supplied to the heating element 30 of device Q. At this time the unloading valve B associated with pressure switch P1 also is opened so that the air under pressure in the unloading volumes W1 and W2 and in the supply pipe may escape to the atmosphere.

The control system provided by our invention is arranged so that if either motor is obstructed or overloaded, the thermal overload device incorporated in the switch associated with that motor will interrupt the circuit of the switch winding so that the switch contacts will release and interrupt the supply of energy to the motor.

If, for example, motor M1 is overloaded and draws unusually heavy current for an excessive period, the thermal element 35, which is connected in series with the motor M1 will be heated to an abnormal degree with the result that contact 33 will open and interrupt the circuit of the winding of switch S1 and contacts 15 and 16 of the switch will release and interrupt the supply of energy to the motor and to the element 35. After a time interval the element 35 will cool sufficiently for the contact 33 to close and reestablish the circuit of the switch winding so that the switch contacts will close and energy will again be supplied to the motor. If the motor now operates freely, it will continue to operate until stopped by operation of the pressure switch P1 or by manipulation of the control lever L1. If, however, the overload condition remains, the thermal element 35 will again be heated and contact 33 will again interrupt the circuit of the switch winding so that the switch contacts will again release and interrupt the switch motor circuit. This cycle will be repeated indefinitely until the motor starts and runs, or until operation of the motor is prevented by the pressure switch P1 or the control lever L1.

In like manner the motor M2 is protected by the thermal overload device in the switch S2. This device has a heating element 45 which is connected in series with the motor circuit and on occurrence of an overload this element heats up and causes contact 41 to open. Contact 41 is included in both the pick-up and stick circuits for the switch winding so that when this contact is open, the switch winding is deenergized and the switch contacts release and interrupt the switch motor circuit. In addition, on realese of the switch contacts contact 31 establishes the circuit to permit energy to be supplied to the heating element of the device Q. If control lever L1 is in its automatic position and contact 10 of pressure switch P1 is closed, energy will be supplied to thermal element 30 and contact 38 of device Q will close and establish the pick-up circuit for the winding of switch S2 so that the contacts of this switch pick up and reestablish the circuit of the motor M2, and also establish the holding circuit for the switch winding and interrupt the circuit of the heating element 30 of device Q.

If the motor M2 starts and operates properly, it will continue to run until stopped by pressure switch P1 or control lever L2, but if the overload condition still exists, thermal element 45 will again be overheated and contact 41 will interrupt the circuit of the switch winding, and this cycle will be repeated indefinitely until stopped by switch P1 or control lever L1 or L2.

The system provided by this invention is arranged so that if desired either compressor may be started and run at any time regardless of the pressure in the reservoir R.

If it is desired to operate compressor C1, the control lever L1 is moved to its position H to thereby establish a circuit independent of the pressure switch P1 for energizing the winding of switch S1. This circuit is traced from supply wire 12 through control lever L1, and contact 33 of the overload device to one terminal of the switch winding, while the other terminal of this winding is connected to supply wire 20. The switch contacts 15 and 16 therefore close and establish the circuit of the motor M1 and this motor will operate as long as control lever L1 remains in its position H, or until the overload device operates to interrupt the circuit of the switch winding. At this time the safety valve D serves to prevent an increase in the pressure in the reservoir R beyond a safe value.

It will be seen that the thermal element 35 is included in the motor circuit and that contact 33 is included in the circuit of the switch winding so that the full overload protection is provided for the motor M1.

When control lever L1 is in position H, energy is supplied to the heating element 30 of device Q over the circuit which is traced from supply wire 12 through control lever L1, wire 36, and contact 31 of switch S2 to one terminal of element 30, while the other terminal of this element is

connected to supply wire 20. The element 30 thereupon heats up so that contact 38 closes. However, closure of contact 38 will not establish the pick-up circuit for the winding of switch S2 unless contact 10 of pressure switch P1 is closed and if at the same time control lever L2 is in its automatic position. If at the time the control lever L1 is moved to its position H the control lever L2 is moved to its "off" position O, the pick-up circuit for switch S2 will not be established and this switch will remain released so that compressor C2 will not be operated. This arrangement permits a serviceman to operate only the compressor C1 if desired so that he can inspect it and determine its condition. This arrangement is also such that if the control lever L2 is left in the automatic position when lever L1 is moved to its position H, the switch S2 will not be energized until after the expiration of the time delay period determined by thermal switch Q. This prevents starting of the compressors C1 and C2 at the same time and prevents overloading of the transformer.

The compressor C2 may also be operated whenever desired without regard to the condition of pressure switch P2. When control lever L2 is moved to its hand position H, a circuit is established to energize the winding of switch S2. This circuit is traced from supply wire 12 through control lever L2, and contact 41 of the overload protective means to one terminal of the winding of switch S2, the other terminal of which is connected to supply wire 20. The contacts of switch S2, therefore, close and establish the circuit of the motor M2 so that compressor C2 operates. The heating element 45 of the overload protection means is included in the motor circuit, while contact 41 of this means is included in the circuit of the winding of switch S2 so that the motor M2 is provided with full overload protection.

When the control lever L2 is in its position H, no circuit is established to supply energy to the winding of switch S1 and this switch remains released.

The pressure switch P2 controls a pick-up circuit for the winding of switch S2 so that the compressor C2 will be operated if for any reason the compressor is not placed in operation by switch P1, and the pressure in the reservoir R drops to 45 pounds to the square inch.

When the pressure in the reservoir drops to 45 pounds, contact 11 of switch P2 closes and establishes a pick-up circuit for switch S2, assuming that lever L2 is in its automatic position. This circuit is traced from supply wire 12 through contact 11 of switch P2, wire 40, control lever L2, and contact 41 of the overload means to one terminal of the winding of switch S2, while the other terminal of this winding is connected to supply wire 20. Accordingly, the contacts of switch S2 close and establish the circuit of motor M2 so that the compressor C2 operates and supplies air to the reservoir R.

At this time the motor is provided with full overload protection, while it will be seen that on closing of the contact 11 of pressure switch P2 the pick-up circuit for switch S2 is complete without waiting for operation of the thermal time delay device Q. The compressor C2 is, therefore, placed in operation without delay on closing of the contact 11 of switch P2. This is desirable as the pressure in the reservoir is at an abnormally low value and should be increased without delay.

The pressure switch P2 may be provided with a contact 46 which may control an indication circuit to provide an indication at a remote point in the event that the pressure in the reservoir falls to the value effective to close the contacts of pressure switch P2.

The system shown in Fig. 1 is intended for use where there are two compressors. In some situations two compressors are inadequate and one or more units each having two compressors are provided to give additional capacity. These other units are located at other points in the interlocking installation and the reservoirs of the various units are connected together so that any unit may supply air throughout the entire installation.

In such a situation it is desirable that the same pressure switch control all of the compressors so that they will all operate the same amount and the wear on them will be evenly distributed. Accordingly, the equipment at one location is arranged so that it controls not only the compressors at that location but also those at the other locations.

While all of the compressors are controlled by a single pressure switch, it is desired that the compressors at each location do not start simultaneously as this would overload the transformer through which energy is supplied to the motors for the compressors at that location. Accordingly, the control apparatus for the compressors at each location should be arranged so that there is a time interval between the time of starting of the compressors at that location. The compressors at different locations are supplied through different transformers so there is no need to provide for a delay in the starting of the compressors at different locations.

Equipment of this type is supplied in complete units which include a case in which are mounted the compressors, motors, pressure switches, magnetic switches, etc., all wired up and ready to operate. For manufacturing reasons it is desirable that the units for all locations, both controlling and controlled, be substantially the same so that the same equipment may be employed for either type of location.

In Fig. 2 of the drawings the control system provided by our invention is shown applied to two units of the type described. One of these units is the controlling unit, and the other is the controlled unit. In the drawings the controlling unit is shown at the left and the controlled unit at the right. Although only one controlled unit is shown it should be understood that two or more such units may be employed if desired.

The equipment at each of the locations is similar to that at the other locations, and is similar also to the equipment shown in Fig. 1. At each location there are two compressors which are connected through check valves to a reservoir, as explained in connection with Fig. 1, while the reservoirs at the various locations are connected by a pipe 50 from which air may be supplied to the switches or other air consuming devices. The electric current for the motors for driving the compressors is supplied over a transmission line, while a transformer is provided at each location for supplying energy from the high voltage transmission line to the motors.

To identify the equipment at the different locations, the reference characters for the equipment at the controlling station, that is the equipment at the left-hand side of the drawings, are followed by the suffix *a*, while the reference characters for the equipment at the controlled or subsidiary location, that is the equipment at the right-hand

end of the drawings, are followed by the suffix *b*.

The control levers L1 and L2 at the various stations serve to condition the equipment at that location for local or remote control or to prevent operation of the equipment altogether. Each lever has a local position LO in which it conditions the equipment at that location to be controlled by the pressure switch at that location, and a remote position RE in which the equipment at that station is controlled by the pressure switch at another station. Each control lever also has an "off" position O in which it maintains the compressors at that location idle.

In addition, each unit is provided with a connector 51 which may be connected between the local contacts LO and the remote contacts RE of the control levers. This connection is installed in the unit which is to serve as the controlling unit, but is removed from the units which are to serve as subsidiary or controlled units.

The pressure switches P1*a* and P2*a* at the control location are adjusted to operate at the same pressures as the switches in the system shown in Fig. 1. Thus the switch P1 opens when the reservoir pressure reaches 70 pounds and remains open until the pressure falls to 55 pounds whereupon it closes and remains closed until the pressure is built up to 70 pounds. The switch P2*a* opens at 60 pounds and closes at 45 pounds. The pressure switch P1*b* at the subsidiary location is adjusted to operate at slightly different pressures than the switch P1*a* at the control location. Thus the switch P1*b* opens at 63 pounds or slightly before P1*a* while it closes at 57 pounds or slightly before P1*a*. The pressure switch P2*b* may be adjusted to operate at the same pressures as switch P2*a*.

If there are subsidiary locations other than that shown, the switches corresponding to P1*b* are adjusted to operate at the same pressures as switch P1*b*, that is, before P1*a* operates.

The equipment is shown in the condition it assumes when the pressure in the reservoirs R*a* and R*b* exceeds 55 pounds. At this time, the contacts of the pressure switches are open, while the unloading valve devices B*a* and B*b* are open and connect the unloading volumes to atmosphere. In addition at this time, the contacts of the switches S1*a*, S2*a*, S1*b*, and S2*b* are released and interrupt the circuits of the compressor motors so that neither of the compressors is operating.

When the pressure in the air in the reservoirs R*a* and R*b* falls to 57 pounds, switch P1*b* closes and closes the associated unloading valve B*b* to thereby cut off communication from unloading volumes W1*b* and W2*b* to the atmosphere. At this time, contact 10 of switch P1*b* is closed, but it has no effect as control levers L1*b* and L2*b* are in their remote positions.

When the pressure of the air in the reservoirs R*a* and R*b* drops to 55 pounds, switch P1*a* closes and closes the associated unloading valve B*a*. At this time, contact 10 of switch P1*a* closes and establishes the circuit of the winding of switch S1*a*, and also establishes the circuit to supply energy to the heating element 30 of time element device Q*a*. In addition, on picking up of contact 10 of switch P1*a*, energy is supplied to the winding of switch S1*b* and to the heating element 30 of time element device Q*b*.

The circuit for supplying energy to the winding of switch S1*a* is traced from one terminal of the secondary winding of transformer T*a* through supply wire 12, contact 10 of switch P1*a*, control lever L1*a*, contact 33 of the overload device, and winding of switch S1*a* to supply wire 20 leading to the other terminal of the transformer. Accordingly, the contacts 15 and 16 close and establish the circuit to supply energy to the motor M1*a* so that this motor operates and drives compressor C1*a*. The compressor C1*a* is unloaded at this time as volume W1*a* has been connected to the atmosphere so the compressor will start readily.

The circuit for supplying energy to the heating element 30 of device Q*a* is traced from supply wire 12, contact 10 of switch P1*a*, control lever L1*b*, heating element 30, and contact 42 of switch S2*a* to supply wire 20. Accordingly, the element 30 heats up, and causes contact 38 to close, to establish a pick-up circuit for the winding of switch S2*a*, while on picking up of the contacts of this switch contact 42 interrupts the circuit of heating element 30 and contact 31 establishes the holding circuit for the winding of switch S2*a*. The pick-up and holding circuits for switch S2*a* include the contact 41 of the overload protective device so that the motor M2*a* is fully protected. As a result of picking up of the contacts of switch S2*a*, the circuit of the motor M2*a* is complete and this motor drives compressor C2*a*. The compressor C2*a* is unloaded when it is started as volume W2*a* is at atmospheric pressure.

At the time contact 10 of switch P1*a* closes, energy is supplied to the winding of switch S1*b* over the circuit which is traced from control wire 12 through contact 10 of switch P1*a*, jumper 51, control wire 55, control lever L1*b*, contact 33 of the overload device in switch S1*b*, and winding of switch S1*b* to supply wire 20 which is common to both locations. Accordingly, the winding of switch S1*b* is energized and the contacts 15 and 16 of this switch close and establish the circuit to energize motor M1*b* from transformer T*b* so that motor M1*b* drives compressor C1*b*. This compressor is unloaded as volume W1*b* is at atmospheric pressure, while on operation of the compressor the pressure in this volume builds up promptly as unloading valve B*b* is closed since switch P1*b* is assumed to be adjusted to close at a slightly higher pressure than switch P1*a*.

On closing of contact 10 of switch P1*a*, energy is also supplied over the control wires to heating element 30 of device Q*b*. The circuit for supplying energy to the element 30 is traced from supply wire 12 over contact 10 of switch P1*a*, jumper 51, control wire 55, control lever L2*b*, element 30, and contact 42 of switch S2*b* to common supply wire 20. Element 30 thereupon heats up and causes contact 38 to close and establish a pick-up circuit for supplying energy over the control wires 55 and 20 to the winding of switch S2*b*, while on picking up of the contacts of this switch, contact 42 interrupts the circuit of element 30, and contact 31 establishes the holding circuit to maintain switch S2*b* energized by current supplied over the control wires. In addition, on picking up of the contacts of switch S2*b*; its contacts 24 and 26 establish the circuit for supplying energy from the transformer T*b* to the motor M2*b*, and this motor drives compressor C2*b*. The compressor C2*b* is unloaded at this time as volume W2*b* is at atmospheric pressure so that the compressor starts readily.

From the foregoing, it will be seen that on closing of pressure switch P1*a*, energy is supplied to the switches S1*a* and S1*b* so that compressors C1*a* and C1*b* start at once, while energy is also supplied to the heating elements 30 of time delay

devices Q*a* and Q*b* so that after a period, these devices establish the circuits of the switches S2*a* and S2*b* and thereby cause the compressors C2*a* and C2*b* to operate.

While the compressors C1*a* and C1*b* start simultaneously, this is not objectionable as the motors for driving them are supplied from different transformers and there is no danger of overloading the transformers. Similarly, the compressors C2*a* and C2*b* start at about the same time, but these are also supplied from different transformers. The transformers T*a* and T*b* are both supplied from the same transmission line, but the capacity of this line is such that it is not affected materially by the load represented by two compressors starting at the same time.

Each of the motors is provided with complete overload protection as the contact of the overload device associated with the switch governing that motor is included in the circuit of the winding of that switch. Accordingly, if any motor is overloaded, the circuit of the switch controlling that motor will be interrupted and the switch will interrupt the supply of energy to the motor.

The overload protection for each motor is independent of that for the other motors and cutting off of the supply of energy to one motor will not affect the others. The supply of energy over the control wires 20 and 55 is entirely independent of the switches at the control location so that release of either of these switches does not affect the switches at the controlled or subsidiary location. Accordingly, if any motor is overloaded, its circuit will be interrupted, but the other motors will continue to operate in the normal manner.

When the pressure of the air in the reservoirs R*a* and R*b* increases to 68 pounds, switch P1*b* opens and opens unloading valve B*b*. This valve has a relatively small port so that air escapes through it slowly. Accordingly, as compressors C1*b* or C2*b* continue to operate most of the air compressed by them will be supplied to reservoir R*b* and only a limited amount will escape through the unloading valve B*b* to the atmosphere.

It is desired that valve B*b* open while the compressors C1*b* and C2*b* are still operating to insure that the compressors will be unloaded when they cease to operate.

When the pressure in the reservoirs R*a* and R*b* increases to 70 pounds, the contact 10 of pressure switch P1*a* opens, while unloading valve B*a* opens. Opening of contact 10 of switch P1*a* cuts off the supply of energy to the windings of switches S1*a*, S1*b*, S2*a* and S2*b* so that the contacts of these switches release and cut off the supply of energy to the motors so that they cease to operate.

As a result of opening of unloading valve B*a*, the air in the unloading volumes W1*a* and W2*a* escapes to the atmosphere, while on cessation of operation of the compressors C1*b* and C2*b*, the air in the volumes W1*b* and W2*b* escapes to atmosphere through the unloading valve B*b*. Because of the restricted size of the port in this valve, some time is required for these volumes to reduce to atmospheric pressure, but they have ample time to do so before the compressors operate again.

In this modification of the invention, the pressure switches P2*a* and P2*b* serve only to control indication circuits to provide an indication if the pressure in the reservoirs falls substantially below that to which the switch P1*a* is intended to respond.

If it is desired to change the units so that the unit at the right becomes the controlling unit and that at the left becomes the controlled or subsidiary unit, the jumper 51 is removed from the left unit and is installed in the right unit. In addition, the pressure switches P1*a* and P1*b* are readjusted so that switch P1*a* opens at a lower pressure than switch P1*b*, and closes at a higher pressure than that switch. A restriction or choke should also be installed in the unloading valve B*a*, while the control levers L1*b* and L2*b* should be moved to their local positions LO, and the control levers L1*a* and L2*a* should be moved to their remote positions RE.

With the apparatus arranged as described above on a drop in the pressure in the reservoirs R*a* and R*b*, switch P1*a* will close and close unloading valve B*a*. Closure of contact 10 of pressure switch P1*a* does not have any effect as jumper 51 has been removed at this location and as control levers L1*a* and L1*b* are in their remote positions.

When the pressure in the reservoirs R*a* and R*b* drops further, pressure switch P1*b* closes and closes unloading valve B*b*. Closing of contact 10 of switch P1*b* establishes a circuit to supply energy to the switch S1*b* and to heating element 30 of device Q*b* as the control levers L1*b* and L2*b* are in their local positions LO, while it also establishes a circuit to supply energy over the control wires 20 and 55 to the switch S1*a* and to element 30 of device Q*a*. As a result, the compressors C1*b* and C1*a* start at once, while the compressors C2*b* and C2*a* start after a time interval. When the pressure builds up so that switch P1*b* opens, operation of the compressors is discontinued as explained above.

It will be seen, therefore, that the modification shown in Fig. 2 is arranged so that either unit may serve as either the controlling unit or as a controlled or subsidiary unit. Furthermore, little change in the adjustment of the equipment is required, while no change is required in the equipment itself to change a unit from a controlling to a subsidiary unit. This enables all of the units to be constructed alike and then employed wherever desired.

Although we have herein shown and described only two forms of compressor control systems embodying our invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. In combination, a reservoir, a first and a second compressor for supplying fluid to said reservoir, a first motor for driving the first compressor and a second motor for driving the second compressor, a first magnetic switch effective when energized to establish a circuit to supply energy to the first motor, a second magnetic switch effective when energized to establish a circuit to supply energy to the second motor, a time delay device effective when supplied with energy to establish after a predetermined time interval a circuit over which energy may be supplied to the second magnetic switch, a pressure switch responsive to the pressure of the fluid in said reservoir, said switch being effective on a predetermined decrease in said pressure to supply energy to the winding of said first magnetic switch, to said time delay device and to establish the circuit controlled by said time delay device for supplying energy to the winding of said second magnetic switch, a control member govern-

ing the circuit of the winding of said first magnetic switch, said control member having a first position in which it permits the circuit governed by the pressure switch for supplying energy to the first magnetic switch to be established, a second position in which it interrupts the circuit of said winding, a third position in which it establishes a circuit independent of sad pressure switch for supplying energy to said winding, a second control member governing the circuit of the winding of the second magnetic switch, said second control member having a first position in which it permits the circuits governed by the time delay device, the second magnetic switch and the pressure switch for supplying energy to said winding to be established, a second position in which it interrupts the circuit of said winding, and a third position in which it establishes a circuit independent of said pressure switch and of said time delay device for supplying energy to said winding.

2. In combination, a reservoir, a first compressor for supplying fluid to a supply pipe from which fluid may be supplied through a first check valve to the reservoir, a second compressor for supplying fluid through a second check valve to said supply pipe, a first motor for driving the first compressor, a second motor for driving the second compressor, a first magnetic switch effective when energized to establish a circuit to supply energy to the first motor, a second magnetic switch effective when energized to establish a circuit to supply energy to the second motor, a time delay device effective when supplied with energy to establish after a predetermined time interval a circuit over which energy may be supplied to the second magnetic switch, a pressure switch responsive to the pressure of the fluid in said reservoir, said switch having a contact which is closed on a predetermined decrease in the pressure in said reservoir and is effective when closed to establish a circuit to supply energy to the winding of the first magnetic switch, to said time delay device and to the circuit controlled by said time delay device for supplying energy to the winding of said second magnetic switch, said pressure switch contact being opened on a predetermined increase in the pressure in said reservoir, and an unloading valve device controlling communication between said supply pipe and the atmosphere, said valve device being governed by the pressure switch so as to be open when the switch contact is open and to be closed when the switch contact is closed.

3. In combination, a reservoir, a first and a second compressor for supplying fluid to said reservoir, a first motor for driving the first compressor, a second motor for driving the second compressor, a first magnetic switch effective when energized to establish a circuit to supply energy to the first motor, a second magnetic switch effective when energized to establish a circuit to supply energy to the second motor, a time delay device effective when supplied with energy to establish after a predetermined time interval a circuit over which energy may be supplied to the second magnetic switch, a first pressure switch responsive to the pressure of the fluid in said reservoir, said switch being effective on a reduction in the pressure in the reservoir to one predetermined pressure to establish a circuit to supply energy to the winding of said first magnetic switch, to said time delay device, and to the circuit controlled by said time delay device for supplying energy to the winding of said second magnetic switch, and a second pressure switch effective on a reduction in the pressure in said reservoir to a value less than said one predetermined pressure to establish a circuit independent of said first pressure switch and of said time delay device for supplying energy to the winding of the second magnetic switch.

4. In combination, a reservoir, a first compressor for supplying fluid to a supply pipe from which fluid may be supplied through a first check valve to the reservoir, a second compressor for supplying fluid through a second check valve to said supply pipe, a first motor for driving the first compressor, a second motor for driving the second compressor, a first magnetic switch effective when energized to establish a circuit to supply energy to the first motor, a second magnetic switch effective when energized to establish a circuit to supply energy to the second motor, a time delay device effective when supplied with energy to establish after a predetermined time interval a circuit over which energy may be supplied to the second magnetic switch, a first pressure switch responsive to the pressure of the fluid in said reservoir, said switch having a contact which is closed on a decrease in the pressure in the reservoir to one predetermined pressure and is effective when closed to establish a circuit to supply energy to the winding of the first magnetic switch, to said time delay device, and to the circuit controlled by said time delay device for supplying energy to the winding of said second magnetic switch, said pressure switch contact being opened on a predetermined increase in the pressure in said reservoir, an unloading valve device controlling communication between said supply pipe and the atmosphere, said valve device being governed by the pressure switch so as to be open when the switch contact is open and to be closed when the switch contact is closed, and a second pressure switch effective on a reduction in the pressure in the reservoir to a pressure lower than said one predetermined pressure to establish a circuit independent of said first pressure switch and of said time delay device for supplying energy to the winding of said second magnetic switch.

5. In combination, a reservoir, a plurality of compressor units each having a first and a second compressor supplying fluid to said reservoir, each unit having a first motor for driving the first compressor and a second motor for driving the second compressor, each unit having associated therewith a transformer from which energy may be supplied to the motors of such unit, each unit having a first magnetic switch effective when energized to establish a circuit to supply energy from the transformer for such unit to the first motor of such unit, each unit having a second magnetic switch effective when energized to establish a circuit to supply energy from the transformer for such unit to the second motor of such unit, each unit having a time delay device effective when supplied with energy to establish after a predetermined time interval a circuit over which energy may be supplied to the winding of the second switch of such unit, and a pressure switch responsive to the pressure of the fluid in said reservoir, said switch being effective on a predetermined decrease in the pressure in said reservoir to supply energy to the winding of the first magnetic switch of each unit, to the time delay device of each unit, and to the circuits controlled by the time delay devices for supplying

energy to the windings of the second magnetic switches of each unit.

6. In combination, a reservoir, a first and a second compressor unit each having a first compressor supplying fluid to a supply pipe from which fluid may flow through a check valve to the reservoir and a second compressor supplying fluid through a check valve to the supply pipe for such unit, each unit having a first motor for driving the first compressor and a second motor for driving the second compressor, each unit having associated therewith a transformer from which energy may be supplied to the motors of such unit, each unit having a first magnetic switch effective when energized to establish a circuit to supply energy from the transformer for such unit to the first motor of such unit, each unit having a second magnetic switch effective when energized to establish a circuit to supply energy from the transformer for such unit to the second motor of such unit, each unit having a time delay device effective when supplied with energy to establish after a predetermined time interval a circuit over which energy may be supplied to the winding of the second switch of such unit, each unit having a pressure switch responsive to the pressure of the fluid in said reservoir, the pressure switch associated with the first unit being effective on a decrease in the pressure in said reservoir to one predetermined value to supply energy to the winding of the first magnetic switch of each unit, to the time delay device of each unit, and to the circuits controlled by the time delay devices for supplying energy to the windings of the second magnetic switches of each unit, the pressure switch associated with said first unit being effective on an increase in the pressure in said reservoir to a second predetermined value to interrupt the supply of energy to the windings of the switches and to the time delay devices of each unit, each unit having an unloading valve governed by the pressure switch for such unit and controlling communication from the supply pipe of such unit to the atmosphere, the valve for the first unit being open when the switch interrupts the circuits controlled thereby and being closed when the switch establishes the circuits controlled thereby, the valve and pressure switch for the second unit being arranged and adjusted so that on a decrease in the pressure in the reservoir the valve for the second unit closes before the valve for the first unit closes and so that on an increase in the pressure in the reservoir the valve for the second unit opens before the valve for the first unit opens.

7. In combination, a reservoir, a first and a second compressor unit each having a first and a second compressor supplying fluid to said reservoir, each unit having a first motor for driving the first compressor and a second motor for driving the second compressor, each unit having a transformer associated therewith, each unit having a first magnetic switch effective when energized to establish a circuit to supply energy from the associated transformer to the first motor and a second magnetic switch effective when energized to establish a circuit to supply energy from the transformer to the second motor, each unit having a first control lever governing the circuit of the winding of the associated first magnetic switch and a second control lever governing the circuit of the winding of the associated second magnetic switch, each lever having a local position in which it connects one terminal of the winding of the controlled switch to a local contact, a remote position in which it connects the terminal of said winding to a remote contact, and an off position in which it interrupts the circuit of the switch winding, each unit having a pressure switch responsive to the pressure of the fluid in said reservoir, each pressure switch having a contact which is opened when the pressure in the reservoir increases to a predetermined value and is closed when the pressure in the reservoir decreases to a predetermined value, the pressure switch contact of each unit when closed establishing connection from one terminal of a source to the local contact of that unit, each unit having a time delay device effective when supplied with energy to establish after a predetermined time interval a circuit over which energy may be supplied to the winding of the associated second switch, and a control wire extending between the remote contacts of said units, each unit being adapted to have a removable connection installed between its local and remote contacts, the first unit having such a contact installed, whereby when the control levers of the first unit are in their local positions and the control levers of the second unit are in their remote positions and the contact of the pressure switch for said first unit is closed energy is supplied to the winding of the first switch of the first unit, to the time delay device of such unit, and to the circuit governed by said time delay device for supplying energy to the winding of the second switch of said first unit, and whereby energy is supplied over said control wires to the winding of the first switch of the second unit, to the time delay device of the second unit and to the circuit governed by said time delay device for supplying energy to the winding of the second switch of said second unit.

BERNARD E. O'HAGAN.
ALLAN T. JOHNSTON.