

Sept. 8, 1959

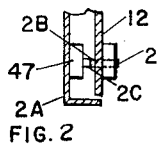
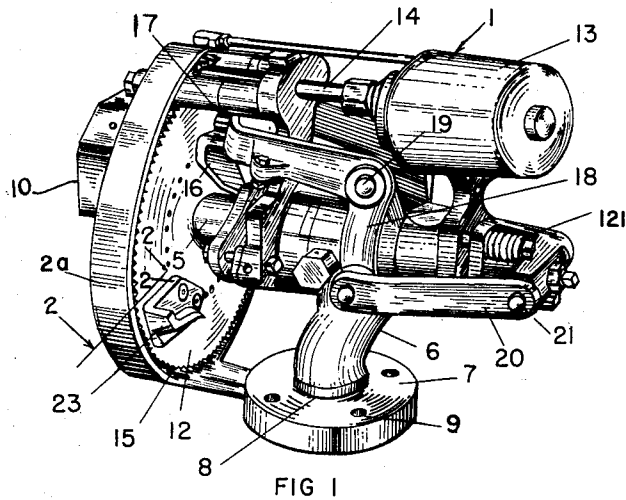
H. P. BEARER, JR

2,902,707

PROGRAM CONTROL FOR SOOT BLOWER

Filed June 1, 1954

4 Sheets-Sheet 1

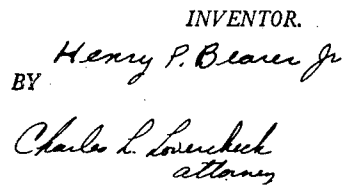


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4 Sheets-Sheet 2



Sept. 8, 1959

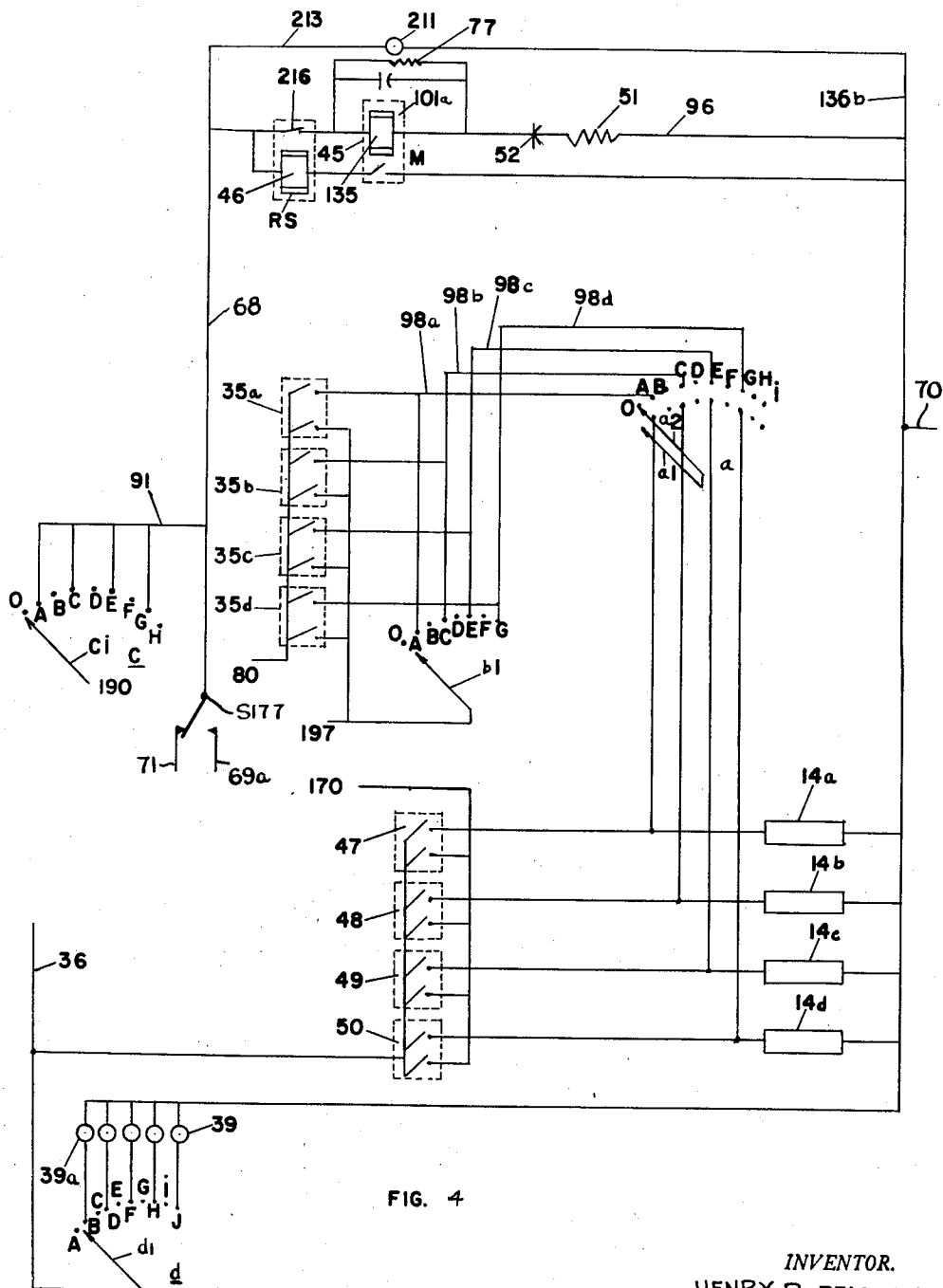
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PROGRAM CONTROL FOR SOOT BLOWER

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4 Sheets-Sheet 3



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PROGRAM CONTROL FOR SOOT BLOWER

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4 Sheets-Sheet 4

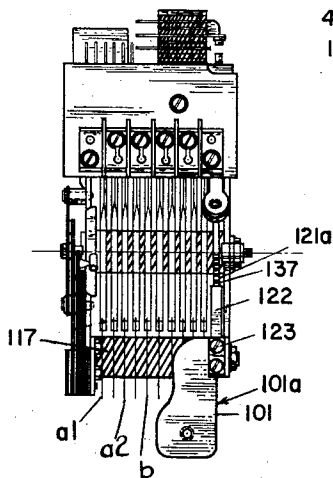


FIG 7

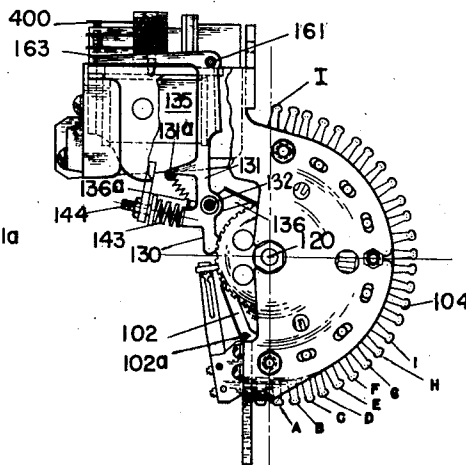


FIG 5

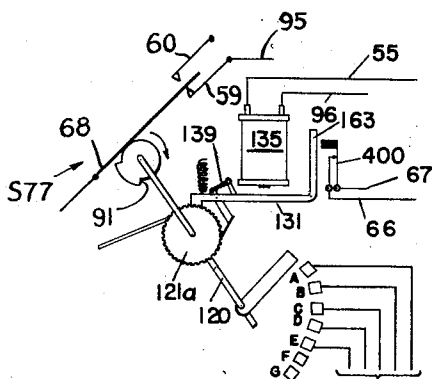


FIG 6

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PROGRAM CONTROL FOR SOOT BLOWERS

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Application June 1, 1954, Serial No. 433,668

8 Claims. (Cl. 15—316)

This invention relates to control equipment and more particularly to controls for controlling the sequence of operation of a plurality of conventional machines, especially soot blowers.

The soot blowers which are in common use in connection with large steam generating boilers usually comprise a tube having radially disposed jets directing steam or compressed air onto boiler tubes. The tubes of the blower are moved into position between the tubes of the boiler and air or steam from the jets blows the deposits of soot or foreign material from the boiler tubes, thereby obtaining a better heat transfer characteristic. It has been the practice to operate each individual soot blower manually. A skilled operator is needed to individually actuate each blower and, usually, no means is provided to warn the operator when the blowers are not functioning properly and to make sure that all blowers in a system have operated and that some of them have not been overlooked by the operator.

In overcoming disadvantages in prior soot blowers and in carrying out the present invention, I provide an electrical circuit with a relay commonly known as a stepping switch which controls electrical power from a common source to one soot blower or to a group of soot blowers in sequence. The control I provide can also be switched so that each individual soot blower can be actuated individually by the operator of the control or the control may be connected to operate various groups of soot blowers in sequence.

The controller has, as its main function, the automatic selection of a predetermined sequence for operation and control of electric driven or air driven soot blower units. With its various components, it is possible to set up a sequence by which a series of soot blowers are operated. It is also possible to insert all or any number of soot blowers into the sequence or manually start any unit individually from the panel without running through a sequence.

When under sequence control, the controller automatically steps from one soot blower unit, at the completion of its cycle, to the next unit in the series. This means that the overall time duration of a complete sequence has been reduced and that this time is now directly dependent upon the cumulative time of each soot blower unit.

This control system handling multiples of twenty-five units requires small front panel space per unit. A choice is available for the switch required per unit which is mounted on the front panel. It can be either a toggle or keying switch.

The standard mounting for the program lights whether they are locking or non-locking will be a rear illuminated, numeral engraved, lamicoid plastic sheet. The lights can be mounted as a unit behind a single sheet or separately mounted above each switch. These lights may also be mounted behind a plastic sheet, the face of which has a reproduced cross sectional view of the boiler. The

lights are mounted to denote the location of the soot blowers on the boiler.

The selector switches are shown as toggle switches and are mounted on the panel front, there being one per machine. Three control functions are provided for each machine unit. As illustrated, this allows the unit to be inserted into the sequence or taken out of the sequence (off) and also provides a means for manually starting the unit.

When the selector switches are in the "in sequence" position, the controller, when started, will pick up the impulses from these switches and send them to the control center, energizing the motor contactor or solenoid valve to supply power air to the air motor on air driven blowers, thus starting the soot blower unit. The controller allows only one machine to operate at a time and, at the completion of the operating cycle, the control then starts the next machine which has its selector switch in the sequence position. Any unit which has its selector switch in the "off" position is automatically bypassed.

At the same time the controller energizes the motor contactor or solenoid valve for a particular unit, it also energizes the program light for the corresponding unit. This light may be energized directly from the controller, at which time it illuminates the program number for the machine which is operating and only while that machine is operating. This light may also be energized indirectly through a relay which is energized from the controller, at which time it illuminates the program number for the machine which is operating and remains energized, giving an illuminated record of the machines operated until the relays are de-energized by a "clear" switch.

For manual control where it is not desired to run through a sequence, the machine which is chosen to be operated individually is started by merely depressing the selector switch lever to the manual position and holding it for several seconds until the machine starts. Upon releasing the lever, the lever will return to the center "off" position. After the selector switch has been released, the machine selected will move to close its limit switch 47, 48, 49, or 50 (Fig. 3) to lock in the machine control and cause the machine to operate through its cycle. The manual circuit bypasses the sequence controller and energizes the motor contactor or solenoid valve directly.

The stepping switch is a high speed heavy duty, single motion magnet driven stepping device with a positive non-overthrow stepping feature. It will operate in response to remote control pulses or by self-interruptions through interrupter contact springs actuated by the armature. The switch has wipers formed with wiping tips at both ends, one hundred eighty degrees apart, which are rotated in one direction only over a semi-circular bank of contacts.

The contact bank in actual use preferably has twenty-six points with ten levels, giving a total of two hundred sixty contacts, ten of which are shown for each stage. The ten wipers, one per each level, are non-bridging. The switch is also provided with one set of off normal contact springs, with a break and make combination, actuated by an arm on the wiper assembly on the twenty-sixth step required for homing or stopping the stepping switch on the number one contact.

The main sub-assemblies of the rotary switch are: (1) bank assembly; (2) wiper assembly; and (3) driving mechanism.

In addition to the twenty-five bank contacts partially shown as A, B, C, D, E, F, and G (Fig. 3) in each level, there is also the wiper brush spring which mounts as a twenty-sixth contact and makes electrical connection

between an associated set of wipers and the external circuit to which the wiper set is connected. This wiper brush spring extends inward toward the wiper bearing and is so positioned and tensioned that it makes frictional contact with the associated set of wipers. It is necessary from a circuit standpoint to have the wiper rest on a contact in the twenty-sixth step. Therefore, an extra contact is added to all ten levels which appears as the twenty-seventh bank contact in all levels and is the last contact of each stage shown in Fig. 3. There are twenty-six steps to each half revolution.

The wiper assembly is made up of the shaft tub bearing assembly, ratchet wheel, wipers, insulators, and position indicator wheel.

Each wiper pair is made up of two wiper springs with wiping tips at one end only. The split tips of the two springs act as twin contact springs, thus insuring double contact on each side of a back contact. These ten wipers are alternately spaced one hundred eighty degrees apart. Thus, five wipers rotate over alternate levels on the first twenty-six steps and the other five wipers rotate over the other five alternate levels for the next twenty-six steps.

The driving assembly consists of the driving magnet coil, a combined armature and stop, a driving spring, and a pawl and pawl spring. The driving coil is a direct current coil with a small rectifier attachment. The rectifier attachment consists of a selenium type rectifier, together with an associated resistor and electrolytic condenser. A resistor is also wired in parallel with the switch coil to provide spark suppression.

The pawl spring is a small coiled spring pretensioned to the proper value to cause the pawl to ride over the ratchet teeth and drop into the intervening troughs. The driving spring design is one of the major factors for the high stepping speed of this switch. This spring design obtains a maximum transfer of energy from the driving magnet into the driving spring.

It is, accordingly, an object of my invention to provide a controller for soot blowers and other machines to be controlled in sequence wherein the controller is simple in construction, economical to manufacture, and simple and efficient to use.

Another object of my invention is to provide a controlling device for controlling soot blowers and other machines wherein the machines are controlled in sequence.

Another object of the invention is to provide a controlling device for machines wherein the machines can be controlled individually or they may be selectively controlled in sequence.

It is another object of the invention to provide a controller for machines wherein the various components may be operated in a predetermined sequence.

A further object of the invention is to provide a control circuit wherein a plurality of soot blowers is operated in a predetermined sequence and wherein any individual soot blower or machine or plurality of soot blowers or machines may be removed from the sequence of operation and any individual soot blower or other machine may be operated manually without operating all the other blowers or machines in the sequence.

A further object of the invention is to provide a control for controlling soot blowers and similar electrical and air operated machines in sequence wherein a plurality of similar control circuits can be connected in series to increase the number of machines which can be operated in sequence.

With the above and other objects in view, the present invention consists of the combination and arrangement of parts hereinafter more fully described, illustrated in the accompanying drawings and more particularly pointed out in the appended claims, it being understood that changes may be made in the form, size, proportions, and minor details of construction without departing from

the spirit or sacrificing any of the advantages of the invention.

In the drawings:

Fig. 1 discloses a soot blower of the type commonly used in connection with steam boilers;

Fig. 2 is a cross sectional view taken on line 2—2 of Fig. 1;

Fig. 3 is a detailed schematic wiring diagram showing how soot blowers are connected through my novel sequence control to accomplish their purposes;

Fig. 4 shows an additional circuit which may be used with the circuit shown in Fig. 3 as disclosed herein;

Fig. 5 is a view of the stepping switch used in my novel circuit;

Fig. 6 is a schematic view of the operating mechanism of the stepping relay shown in Fig. 5; and

Fig. 7 is another view of the stepping relay switch.

Now with more specific reference to the drawings, by way of illustration, I show a soot blower 1 (Fig. 1) which is of the general character of one type of soot blower which is commonly used in connection with fuel fired steam boilers and shown for purposes of illustration of how a soot blower or other machine may be connected in my novel circuit. The blower unit is made up of the support 6 which may have the flange 7 attached thereto at 8 and has holes 9 through which bolts may be disposed to bolt the blower 1 to a corresponding flange of a supply pipe for a blowing medium; for example, a steam or air supply pipe.

The blower tube 5 extends through the plate 10 into the furnace. The tube 5 is connected to the gear 12 (shown in Fig. 1) and the gear 12 and the tube attached thereto are rotated by the motor 13 which has a pinion on the end of the shaft 14. The pinion engages the teeth 15 of the gear 12 to rotate the gear and the tube attached thereto.

Cam 23 is attached to the gear 12 and is adapted to strike the follower 17 to turn on the blowing medium; for example, steam or air, and cause it to flow through the tube 5 when the tube 5 is rotated to the proper position. The cam 23 lowers the follower 17 to rotate the bell crank 18 around the pivot 19 and, thereby, puts a compressive force on the link 20 which is connected to a valve actuating mechanism at 21 to open a valve against the force of spring 121 to turn on the steam which will flow through tube 5.

The cam 16 is likewise attached to the gear 12 which raises the follower 17, rotating the bell crank 18 to shut off the blowing medium when the blower tube 5 is rotated to its proper position at the end of its cycle.

The motor 13 is connected to a source of electrical power through the controller 14a (shown in Fig. 3) and may be supplied power from a power source by means of the wires 24. Other soot blowers are connected to controllers 14b, 14c, and 14d. The machine unit could be connected directly to the wire 26a rather than through the controller 14a and, likewise, the other machines connected through controllers 14b, 14c, and 14d.

The stepping switch is shown in Figs. 5, 6, and 7. The switch has a main body member or frame 101 which carries the contact bank assembly 102a and brushes 102. The fixed terminals 104 to which the wires leading to the control equipment are attached are supported on frame 101. The various banks a, b, c, and d of terminals A, B, C, and D are separated by means of insulating members 117 which separate the rows of contacts from each other. In the preferred type of switch, there are twenty-five contacts, five of which are shown on each stage a, b, c, and d, in Figs. 3 and 5 and numbered A, B, C, and D on each stage a, b, c, and d, respectively. The letter a in Figs. 3 and 7 indicates two rows of contacts, contacts A, C, E, and G in one row being connected to wires 82a, 82b, 82c, and 82d, respectively, through respective wires 98a, 98b, 98c, and 98d, and corresponding contacts in the adjacent row being connected to wires 26a, 26b, 26c, and 26d, respectively. The wiper

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arms *a1* and *a2* corresponding to the two rows of contacts designated *a* are connected together as shown in Fig. 3 so that they, in effect, form switches with their contacts as they pass thereover. The shaft 120 is attached to the wiper assembly ratchet wheel 121*a* which is held against reversing by the spring urged detent 122 attached to the frame 101 by means of screws 123. Lever 163 is rigidly attached to armature 131. The magnet driving motor M is made up of the fixed solenoid 135 having the armature 131 pivoted to the frame 101 at 161. The armature 131 has the pawl 136 pivoted thereto at 132 and urged into engagement with the teeth 137 of the ratchet wheel 121*a* by means of the coil spring 139 which is attached to the other end of the pawl 136 at 136*a* and to armature 131 at 131*a*. The lever 163 operates the interrupter contacts 400 upon each movement of the armature 131 and lever 163 to close a circuit through solenoid 46 of relay RS (Fig. 3). When the solenoid 46 of relay RS is thus energized by power flowing through contacts 400, the solenoid 46 will open contact 216, interrupting current to solenoid 135 and allowing the driving spring 143 to drive the ratchet wheel 121*a* ahead one notch. The adjustment of the force of the pawl 136 can be changed by means of the drive spring set screw 144 which controls the tension on the driving spring 143. When power is applied to the solenoid 135, it attracts the armature 131 attached to the lever 163 to swing the armature 131 about pivot 161 to cause the pawl 136 to slide back over the ratchet wheel 121*a*, thus cocking the ratchet wheel 121*a*. When power is interrupted to the solenoid 135 by actuation of contact 216 through solenoid 46, the driving spring 143 forces the pawl 136 to rotate the wheel 121*a* and the shaft 120 with the brushes 102 attached thereto one notch and the brushes advance one position. At the end of movement of the lever 163, solenoid 46 will be de-energized; contact 216 will close, energizing solenoid 135 and sliding pawl 136 back over ratchet wheel 121*a* for another stroke. In this manner, for each cycle of lever 163, the brushes 102 of alternate stages, *a*, *c*, and *e* engage one contact on alternate stages *a*, *c*, and *e* for the first one hundred eighty degree rotation of the stepping switch and, therefore, the individual machine connected to the terminal connected by the respective brush is actuated.

Switches 47, 48, 49, and 50 (Fig. 3) are limit switches, one mounted on each blower. Each switch 47, 48, 49, and 50 closes its contacts 47*a* to 47*b* and 47*c* to 47*d* as soon as the blower on which it is mounted is driven off its home position by its motor 13.

In the wiring diagram shown in Fig. 3, I show the novel circuit for my control. The wires 36 and 136*b* represent the two sides of a power line, preferably 110 volts A.C. The stepping relay 101*a* is connected across the power line by having the wire 96 connected to the resistor 51 and a rectifier 52 to the terminal 53 of the solenoid 135 of the motor magnet M of the stepping relay 101*a*. The solenoid 135 of the motor magnet M has the resistor 77 and the condenser 54 connected in parallel therewith. The wire 55 is connected to the other side of the solenoid 135 of the motor magnet M and to the normally closed contact 216 on the relay RS which is in turn connected to the push button 57 through wire 58 and to the terminal 59 of the off normal spring contact S77. The terminal 60 on the contact S77 is connected to the normally closed contact 216 on relay RS. The terminal 60 is also connected through the wire 61 and wire 63 to terminal 64 on relay RS. The other side of solenoid 46 on relay RS is connected through wire 65 to terminal 66 on the normally open interrupter contact of stepping switch 101*a* and thence through wire 67 to the other side of the line 136*b*. The interrupter contact 400 on the stepping relay 101*a* is closed when the solenoid 135 of the motor magnet M is energized and, likewise, the contact 216 on relay RS

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is opened when the solenoid 46 of relay RS is energized. The off normal contact S77 is connected through wire 68 to the wire 69 which is also connected to position I on bank *a* of the stepping switch. The circuit shown in Fig. 3 may be used to control a circuit in series with the circuit shown when a large number of machines are to be controlled. The additional circuit will be as shown in Fig. 4 wherein the parts corresponding to the parts shown in Fig. 3 have identical numbers. The terminals 69*a*, 71, 190, 80, 70, 197, 36, and 170 on the circuit shown in Fig. 3 will be connected to the terminals having the same numerals in Fig. 4. When wiper arm *a1*—*a2* moves to the I position, it will connect the wires 69*a* (Fig. 3) to the wires 71 (Fig. 4). This will have the same effect as pressing the start button in Fig. 3 and will cause the stepping switch 101*a* in Fig. 4 to advance its wiper arms one position and will close off normal switch S177, connecting wire 68 on the circuit of Fig. 4 to the wire 71 thereon. From thence on, the relays CRA and RIN will operate the circuit shown in Fig. 4 as they did the circuit shown in Fig. 3. The additional circuit will not have to include relays corresponding to relays RIN and CRA since the contact 88 on relay RIN will complete the circuit to the stepping switch. Since the relays RIN and CRA in the circuit shown will be in the same relative position in the additional circuit when brushes *a1* and *a2* complete a circuit from wire 69 to wire 71 and the off normal contact S177 of the additional circuit closes to connect the circuit through wire 69, it will be seen that the relays RIN and CRA can be deleted in the additional circuit. With the additional circuit corresponding to the circuit shown in Fig. 4 connected as shown to control an additional number of machines, power will be supplied to the additional circuit through wire 69 through wire 71 when the brush on the stepping switch shown in Fig. 8 has moved to its position I and then the machines are controlled by the stepping switches shown in Fig. 4 in the same manner that power is supplied to the circuit shown in Fig. 3 through the wires 136*b* and 36.

The terminals 92*a*, 92*b*, 92*c*, and 92*d* are connected through their respective wires to terminals A, C, E, and G on the bank *a* of the stepping switch 101*a*. Terminals A, C, E, and G are selectively connected by brushes *a1* and *a2* through wires 99*a*, 99*b*, 99*c*, 99*d*, 26*a*, 26*b*, 26*c*, and 26*d* to the respective operating mechanisms 14*a*, 14*b*, 14*c*, and 14*d* which represent the operating contactors on various machines which are to be operated. The motors of the machines to be operated could be connected directly to the respective terminals 13*a*, 13*b*, 13*c*, and 13*d* without going through the contactors 14*a* through 14*d*, if so desired. The terminals 13*a*, 13*b*, 13*c*, and 13*d* could be connected to the terminals of the solenoids of solenoid operated air valves for air operated machines. The control disclosed also has utility in operation of many other types of machines for other purposes where a sequence or program control is required. Banks *a*, *b*, *c*, and *d* comprise first, second, third, and fourth banks of contacts, respectively. CRA, RIN, and RS comprise first relays, second relays, and third relays as referred to in the claims herein. This convention is adhered to except in claim 8 wherein bank *c* is referred to as a second bank.

The wires 82*a*, 82*b*, 82*c*, and 82*d* are also connected to the terminals A, C, E, and G of the bank *b* on the stepping switch 101*a* through wires 62*a* through 62*d* whereby the brush *b1* rotates with the rotating mechanism on the stepping switch to connect the points A, C, E, and G to the solenoid 83 and through wire 86 to the other side of the line 136*b*. Wire 84 is also connected to one side of the solenoid 83 of the relay CRA and to one side of the solenoid 87 of the relay RIN. The normally open contact 88 on the relay RIN connects through the wire 89 to the common terminal 90 on the bank *c* of the stepping relay 101*a*. The wire 91 is

connected to the terminals A, C, E, and G of stage *c* of the stepping relay 101*a*. It will be seen that when the selector switches 35*a*, 35*b*, 35*c*, and 35*d* are moved to the S or sequence position so that they connect wire 80 to terminals 92*a*, 92*b*, 92*c*, and 92*d*, wires 82*a* through 82*d* to terminals A, C, E, and G on bank *a* of the stepping switch 101*a*, the circuit will be set for sequence control. When any of the selector switches 35*a* through 35*d* are in the position, with switch terminals 250*a* through 250*d* connected to wires 93*a* through 93*d*, respectively, current will flow from the wire 36 through the normally closed contact 78 through the reset terminal 79 through the selector switches which are in the manual position through the wires 93*a* to 93*d* which are connected to a closed selector switch through wires 26*a* through 26*d* directly to the control members 14*a* through 14*d* whereby the control members will be operated to start the machine connected thereto.

The indicating lights 39*a* through 39*d* are connected through their respective wires to terminals A, C, E, and G of the bank *d* of the stepping switch 101*a* whereby they are lighted when the stepping switch 101*a* rotates through these various positions and the lights indicate the respective position to which the stepping switch is moved and, therefore, indicate which one of the control members 14*a* through 14*d* is energized.

With brushes *a*1, *a*2, *b*1, *c*1, and *d*1 in the O position, the stepping relay 101*a* is started by closing push button 57. This completes the circuit from wire 36 through the normally closed contact 78, contact 76, stop button 75, wire 37, wire 68, contact S77, wire 95, push button 57, and normally closed interrupting contact 216 to solenoid 135 through rectifier 52, resistor 51, and line 96 to the other side of the line 136*b*. The solenoid 135 being energized, it closes its armature 163 and draws back its lever 131 which in turn closes interrupter contact 400, completing the circuit to solenoid 46 of relay RS and energizing it. Relay RS is connected in parallel with solenoid 135 in order to provide a time delay in the action of the stepping relay to allow the mechanical parts of the system to function at the time intervals between the steps of the stepping relay. The normally closed contact 216 on relay RS then opens, breaking the circuit to solenoid 135 of the motor magnet M, de-energizing the solenoid 135, and allowing spring 143 to move the armature 163 to the open position, causing the pawl 136 to rotate the ratchet wheel 121*a* one notch, thus stepping the unit one step and moving brushes *a*1, *a*2, *b*1, *c*1, and *d*1 to the A position. At this time, off normal contact S77 is closed by a cam 91 actuated on wheel 121*a* by the movement of the rotor of switch 101*a* on which it is attached, breaking the circuit to wire 95 through wire 212 and to indicating light 211. Light 211 will extinguish, signifying the unit is in operation. A circuit will be closed from control power wire 36 to relay solenoid 46. Simultaneously with this first step of the stepping switch 101*a*, brushes *a*1, *a*2, *b*1, *c*1, and *d*1 all rotate one step to position A. At this same time, if selector switch 35*a* is in the sequence position, that is, with terminals 92*a* in engagement with contact 250*a*, the circuit is completed from wire 36 through closed contact 78 and closed contact 79 through wire 80 through terminal 92*a* to wire 82*a* to the first bank *a*. The circuit is also completed from wire 82*a* through wire 62*a* to terminal A on bank *b* through brush *b*1 through wire 97 to solenoid 83 and wires 85 and 86 to the other side of the line 136*b*, energizing solenoid 83. Solenoid 83, upon being energized, breaks its normally closed contact 76 between wire 36 and the solenoid 135, stopping the stepping switch 101*a*. Solenoid 87 of relay RIN is energized to close contact 88 thereon at a time when brush *c*1 on bank *c* is in one of the positions A, C, E, or G and when one of the limit switches 47, 48, 49, or 50 is closed.

If the selector switch 35*a* had been in the manual posi-

tion with contact 250*a* connected to wire 93*a*, power would have flowed from wire 36 through contact 78, contact 79, wire 80, contact 250*a*, wire 93*a*, and wire 26*a* to controller 14*a*, energizing it. It is held energized by limit switch 47 until the machine completes its operation. Therefore, by snapping any switch 35*a*–35*d* to the manual position *m*, the corresponding soot blower will be operated individually through one cycle.

Further, if any of the switches 35*a* through 35*d*, for instance, 35*b*, is in the off position and the other switches are in the automatic position and the control is set for sequence operation, no power could flow to controller 14*b* from wire 80. When the stepping switch moves the brush *b*1 to the C position, since no power could flow from wire 36 through wire 80 through contact C of stage *b*, solenoid 83 of relay CRA would not be energized to open its contact 76, interrupting the flow of power to the solenoid 135 of the stepping switch 101*a*. Therefore, the relay CRA operated through terminal 92*d* would not operate. Therefore, the stepping switch would continue to step until brush *b*1 rested on one of the contacts A, C, E, or G which connected to a switch 35*a* through 35*d* which was closed to the sequence position. That is, power to the stepping switch would not have been interrupted by contact 76 on relay CRA and the stepping switch would continue to step until brush *b*1 engaged a contact A, C, E, or G thereon connected to a switch 35*a* through 35*d* which was closed to the sequence position.

Switches 47, 48, 49, and 50 are limit switches, one on each machine, mounted inside housing 2A and actuated by screw 2 which extends through the gear 12 at 2B, this screw being one of those holding cam 16 in place on gear 12, and engages actuating member 2C when the gear 12 starts rotating to a predetermined position. Each limit switch is actuated when the respective machine on which it is mounted is started. When the machine to which power is applied by the control starts its operation, then the machine screw 2 rides off of limit switch 47 or 48 or 49 or 50 and the limit switch closes, locking the circuit closed from wire 36 to wires 26*a*, 26*b*, 26*c*, or 26*d* to controller 14*a* or 14*b* or 14*c* or 14*d* and also completing the circuit from wire 36 to solenoid 87 of relay RIN. The respective limit switch which is closed by a machine will keep the machine operating until it has completed its cycle and the screw on cam 16 on gear 12 opens the limit switch on the machine. The solenoid of relay RIN is energized through the switch 47 or 48 or 49 or 50 which is closed by a machine through wire 170. Relay RIN, when energized, closes its normally open contact 88 connecting wire 36 therethrough to brush *c*1, through its bank contact and wire 91, through wire 37, closed contact 60 of contact S77, and contact 216 to solenoid 135 of motor magnet M which again energizes relay RS, opening contact 216 and allowing driving spring 143 to step the switch one step to bring brushes *a*1, *a*2, *b*1, *c*1, and *d*1 to their B position. In stepping the switch to the B position, contact is broken through the brushes *a*1, *a*2, *b*1, and *c*1 and to the elements connected which means that the soot blower energized is held energized only by the limit switch. With the brush *b*1 in position B, relay CRA will be de-energized and it will open. Brush *c*1 will also be in an open position. When the stepping relay moves brush *b*1 to any of the closed positions A, C, E, or G, brush *d*1 completes a circuit from wire 36, through wire 232, through the bank contact A, C, E, or G to wire 86, and to program indicating lights 39*a*, 39*b*, 39*c*, or 39*d*. This program light indicates that a particular machine is operating. The machine being operated, for example, by contactor 14*a*, completes its cycle and the limit switch rides upon its cam 2B on gear 12, opening the circuits to contactor 14*a*, dropping it out of the circuit. At the same time, it also breaks the circuit to the solenoid of relay RIN.

As soon as relay RIN opens, it closes its contact 78,

completing the circuit between wire 36, through contact 76, stop button 77, through terminal 60 on off normal spring contact S77, through closed contact 216, and to the solenoid 135, energizing motor magnet M which draws back the pawl 136, closing interrupter contact 400. The solenoid 46 of relay RS is energized which in turn opens normally closed contact 216. This de-energizes solenoid 135, allowing driving spring 143 to step the stepping switch 101a over to the third step to start another machine.

If one of the selector switches 35a through 35d for a particular unit is not in the automatic position, the circuit from wire 36 through wire 80 to the bank contacts A or C or E or G on bank b will remain open depending upon which selector switch is not in the automatic position. The circuit thus is open from wiper b1 to the solenoid 83 of relay CRA. The stepping relay 101a will continue to step until brush b1 again reaches a bank contact A or C or E or G on bank b which is connected through one of the selector switches 35a to 35d to wire 80. This will complete the circuit through brush b1 and wire 97 to the solenoid 83 of relay CRA, energizing it, which in turn opens its normally closed contact 76, breaking the circuit between wire 36 and contact 60 to the solenoid 135, stopping the stepping switch 101a.

The stepping switch 101a will continue to step as long as the normally closed contact 78 of relay RIN and contact 76 of relay CRA are closed, completing a circuit between wire 36 and off normal contact S77. When a selector switch is put in the sequence position, the stepping switch 101a through brush b1 will complete a circuit to solenoid 83 of relay CRA opening its contact 76, thus stopping the stepping switch. Contacts 201 and 79 are preferably operated by a push button which allows the operator to re-position the stepping switch 101a from any place in its cycle back to the home position by breaking the circuit between wire 36 through wire 80 to selector switches 35a to 35d. Simultaneously, it closes the circuit through wire 37, contact S77, and normally closed contact 216 to solenoid 135, automatically stepping the stepping switch 101a back to the home position where the switch allows contact S77 to open, breaking the circuit to the stepping switch 101a.

The numbers of the stepping switch positions A, B, C, D, E, F, G, H, and I may be increased to any practical number, depending upon the size of the stepping relay. The number of machines which can be controlled by the system may be increased by providing other stepping relays in series such as that connected to the wires 70 and 71 as explained above.

In the foregoing specification, I have set forth the invention in its preferred practical forms but I am aware that the structure shown is capable of modification within a range of equivalents without departing from the invention which is to be understood is broadly novel as is commensurate with the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In combination, a sequence circuit and a plurality of soot blowers for blowing foreign material from heat transfer surfaces of a steam boiler comprising a source of electrical power, a stepping switch having a motor, a first and a second relay, said stepping switch having a first bank and a second bank of contacts and wiper contact arms for each bank movable in unison by said motor, said first bank comprising spaced switches, one side of some of said switches being each connected to one of said soot blowers, the other side of said switches being connected through a normally closed contact on said second relay to said power source, said first relay having a motor connected to said wiper arm on said second bank, the side of said switches on said first bank connected to said normally closed contact being connected to corresponding contacts on said second bank, said first relay

having a normally closed contact connected between said normally closed contact on said second relay and said stepping switch motor, said soot blowers each having a limit switch thereon, said second relay having a motor, said limit switches connecting said second relay motor to said power source to open said normally closed contact thereon each time a soot blower is initially connected through a switch on said first bank to said power source, means connecting said soot blowers to said power source after they have been initially connected thereto for maintaining the connection of said soot blower to said power source, and means connected in parallel with said relay contacts to connect said stepping switch motor to said power source to cause said stepping switch motor to move said wiper arms temporarily to advanced open contact positions after a soot blower has started.

2. The combination recited in claim 1 wherein said means connected in parallel with said relay contacts to connect said stepping switch motor to said power source when said first relay contact is open comprises a third bank of contacts on said stepping switch, a wiper for said third bank of contacts, some of said contacts on said third bank being connected to said stepping switch motor, said wiper arm on said third bank being connected to said power source through a normally open contact on said second relay.

3. The combination recited in claim 2 wherein said means for maintaining each said soot blower connection to said power source comprises a second limit switch on each side soot blower connecting said soot blower to said source of power through its entire cycle after said soot blower has been started by connection thereof to said source of power through said first bank of switches and said second relay normally closed contact.

4. The combination recited in claim 3 wherein each said switch on said first bank of contacts is connected to said normally closed contact on said second relay by means of a double throw switch whereby each said soot blower can be selectively and individually connected to said power source.

5. The combination recited in claim 4 wherein a third relay is provided, said third relay having a solenoid connected in series with a normally open contact on said stepping switch and a normally closed contact in series with said stepping switch motor whereby said stepping switch motor is deactivated when said third relay is actuated and vice versa, thus introducing a time delay in the action of said stepping switch motor.

6. The combination recited in claim 1 wherein an additional bank of contacts is provided on said stepping switch, said additional bank of contacts having a wiper contact arm on said stepping switch driven by said stepping switch motor and connected to said power source, spaced contacts in said additional bank being connected to indicating lights for respective blowers, said wiper contact arm engaging successive ones of said spaced contacts during the blowing cycles of their corresponding blowers.

7. The combination recited in claim 1 wherein a reset switch is provided having normally open contacts connecting said power supply to said stepping switch motor, said reset switch being operable to complete a circuit to said stepping switch motor to supply power thereto to drive said stepping switch motor to a neutral position.

8. In combination, a sequence control and a plurality of soot blowers for blowing foreign material from the heat transfer surfaces of a steam boiler comprising a source of electrical power, a stepping switch having a first, and a second bank of contacts, said stepping switch having a motor thereon, a wiper contact arm on said stepping switch driven by said motor, a relay having a normally open and a normally closed contact and a solenoid thereon, said first bank of contacts comprising spaced switches, one side of some of said switches being each connected to one of said soot blowers, the other side of

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said switches being connected through said normally closed contact on said relay to said source of power, said stepping switch motor being connected to said source of power through said normally closed contact on said relay, and limit switches on each said soot blower, each said limit switch closing when the soot blower on which it is supported is energized and opening when the soot blower returns to normal position, one said limit switch on each said soot blower connecting said relay solenoid to said source of power, the other said limit switch connecting the soot blower on which it is mounted to said source of power, the normally open contact on said relay being connected in series between said power source and a wiper arm on said second bank of contacts, some of said contacts on said second bank being connected to said stepping switch motor and other said contacts being uncon-

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nected whereby said stepping switch will be moved to advanced open contact position and de-energized while any said soot blower is blowing.

References Cited in the file of this patent

UNITED STATES PATENTS

2,396,422	Hines	Mar. 12, 1946
2,579,983	Thornton	Dec. 25, 1951

FOREIGN PATENTS

491,915	Great Britain	Sept. 8, 1938
529,306	Great Britain	Nov. 19, 1940
529,598	Great Britain	Nov. 25, 1940
597,779	Great Britain	Feb. 3, 1948
651,553	Great Britain	Apr. 4, 1951
669,388	Great Britain	Apr. 2, 1952