

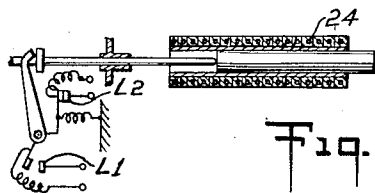
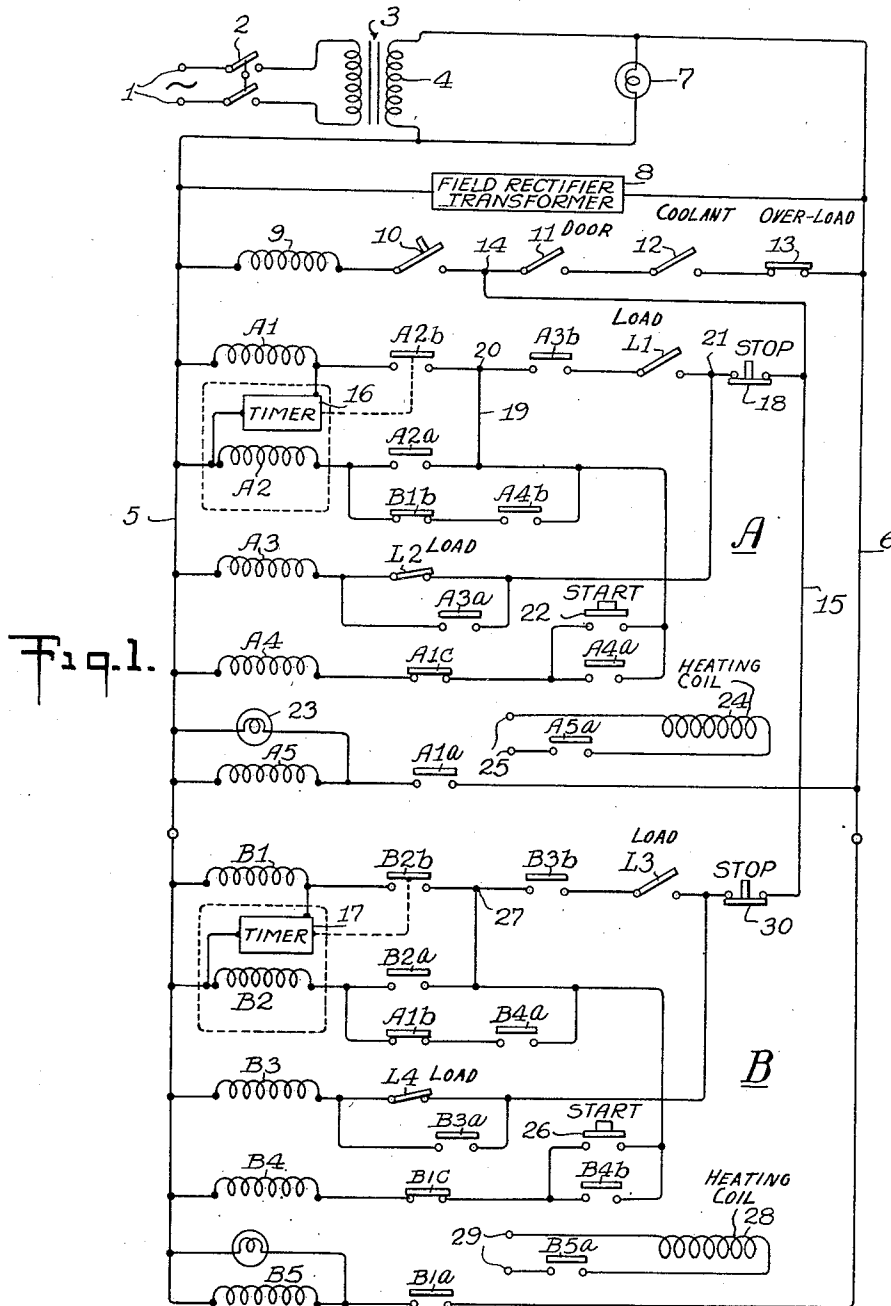
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MULTIPLE FURNACE CONTROL

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MULTIPLE FURNACE CONTROL

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This invention relates to control apparatus for power units with particular application to induction heating furnaces.

In the operation of several power units such as induction furnaces from the same power source, it is desirable frequently that the power be applied to each unit separately so that too great a load may not be placed on the power source. If connection to the source is made manually from unit to unit the time loss over the period of operation of the equipment may be considerable, resulting in a substantial reduction in output. Also, in operating a bank of power units such as induction furnaces, not only is it desirable that the shifting of power from furnace to furnace be immediate and automatic, but it is also important that means be provided to prevent operation of any one unit while the other is in operation.

Among the objects of the invention, therefore, is to provide a control apparatus which will insure automatic and immediate power connection to the individual power units consecutively.

Another important object is to provide control means which will prevent operation of any one of the units if at the same time another of the units is in operation.

An object also is to provide apparatus as above indicated which will not prevent individual use of any one unit to the exclusion of the other units.

Other objects of the invention will become apparent on consideration of the following description and the related drawing pertaining to a preferred modification of the invention in which Figure 1 is a circuit diagram of the apparatus; and Figure 2 is a detail illustrating operation of the load switches.

Referring to the drawing, Figure 1 is a wiring diagram of the control circuit applicable to a plurality of power units such as induction furnaces.

In my co-pending application Serial No. 384,503 filed March 21, 1941, now Patent No. 2,408,350, issued September 24, 1946, I have described the structural features and electrical circuit of an induction furnace suitable for miscellaneous bar heating. This furnace equipment is adequate for single unit operation but under conditions of multiple unit operations where the power is derived from a single source or where the heating coils are assembled in a single casing with connections to a common bus bar system, there is lack of provision for operation of each of the separate heating units consecutively and with immediate and automatic transfer of power from one unit to the

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other after heating operation is respectively completed in the heating coils.

The circuit of Figure 1 illustrates one mode which may be preferred of securing this desirable transfer from one unit to the other.

The numeral 1 indicates the source of power for the heating equipment illustrated and is desirably alternating current at commercial frequency. From this source through the manual switch 2 and transformer 3 current is supplied to the main control switch of furnace coils A and B through a series of relay coils and switches which are in general parallel in both of the furnace circuits. As will become apparent, the relays applicable to the A furnace are indicated by the letter A with subscript numerals with relay contact switches corresponding and the relays and contact switches of the B furnace by the letter B with appropriate subscript numerals.

From the transformer secondary 4 of the transformer 3 a current is passed to the main conductors 5 and 6 for supplying power to the various relays and other equipment. An indicating lamp 7 is connected across the secondary 4 to indicate application of power to the main circuits 5 and 6. Connected across the mains also is the field rectifier and transformer unit 8 for supplying a rectified current to the high frequency generator field of the heating circuit. The field transformer contactor relay coil 9 is connected in series with a manual switch 10 and with the door or other structure switch 11, coolant pressure switch 12 and over-load contact switch 13 between the mains 5 and 6. At the point 14 between manual switch 10 and door switch 11 a conductor 15 leads to the intermediate contactor relay coils A1 and B1. Connected also between the conductors 5 and 15 are the relays A2, A3, and A4 and the corresponding relays B2, B3, and B4. The A2—B2 relays constitute the clutch coils for the timers 16 and 17 respectively. The coils A3 and B3 form the anti-reset coils for the A and B sections. Coils A4 and B4 form the contactor pilot relays for sections A and B. Coils A5 and B5 connected across conductors 5 and 6 constitute the main contactor relays for energizing of the relay switches in the heating circuits of furnaces A and B.

Following the individual branch circuit of the relays more specifically, A1 connects between conductors 5 and 15 through the normally open contact switch A2b, normally open contact switch A3b, load switch L1 and normally closed manual stop switch 18. The load switch L1 is operatively related to the heating coil of the A furnace so that when the load is placed in the coil the switch

will be closed. Figure 2 illustrates diagrammatically the action of the load switches L1 and L2 by a push-out rod in engagement with the work-piece. When the workpiece is completely inside the heating coil 24, L1 switch closes and L2 switch opens. Switches L3 and L4 are similarly operated.

The branch circuit including the clutch coil A2 includes the normally open relay contact A2a, this contact switch being shunted by the normally closed relay switch B1b in series with the normally open contact switch A4b, further connection being made to the conductor 15 through the conductor 19 to the point 20 between switches A2b, A3b in the A1 circuit.

The A3 branch circuit includes the normally closed load switch L2 bypassed by the normally open contact switch A3a from which connection is made to the point 21 between load switch L1 and stop switch 18 in the A1 circuit. L2 switch is open when a load is in the A furnace.

The A4 branch circuit in addition to the relay A4 includes the normally closed relay contact switch A1c, and the normally open starting switch 22 with the normally open relay switch A4a in parallel therewith, the circuit continuing to conductor 19 and the point 20 in the A1 branch circuit.

The A5 branch circuit includes the normally open switch A1a from which connection is made directly to the main conductor 6. The relay A5 is bypassed by the indicating lamp 23. Also the end of coil A1 between the coil and contact switch A2b is connected to the end of coil A2 at conductor 5 through a timer mechanism indicated by the term Timer. The heating circuit of furnace A is indicated by the heating coil 24 there being the main contact switch A5a in series therewith, with appropriate connections to the high frequency terminals 25.

The relay load and manual switches in the B furnace circuit are identical as to number and nature of switches. The B1 coil branch includes normally open relay switches B2b and B3b as well as load switch L3 normally open and the normally closed manual stop switch 30.

The B2 branch circuit includes the normally open relay switch B2a and the shunted circuit including normally closed relay switch A1b and normally open relay switch B4a.

The B3 branch circuit includes the normally closed load switch L4 and the shunted normally open relay switch B3a.

The branch circuit B4 includes the normally closed relay switch B1c, and normally open starting switch 26 and normally open relay switch B4b connected in parallel, the circuit continuing to point 27 in the B1 circuit.

The B5 branch circuit includes the normally open relay switch B1a. The B furnace circuit comprises the heating coil 28 this coil having connections to the power terminals 29 through the normally open contactor switch B5a.

In describing the operation of the circuit it should be kept in mind that relay switches are identified with the operating relay coil by the first two indicia. For example, relay switch A1b is operated by relay A1 and is one of several contact switches operated by this relay designated A1a, A1b and A1c. Similarly, relay A4b is operated by relay A4 and is one of two relay switches operated by this coil.

In operation, the coolant is supplied to the various conductors and tubing of which the unit is constructed bringing about closure of the pressure switch 12. The switch 11 in the coil 9 circuit

will be closed through proper positioning of doors and other enclosures. The over-load switch 13 is in its normally closed position. The main switch 2 is then closed, placing the transformer voltage between the conductors 5 and 6, conditioning the A4 and B4 circuits for energization on closure of the appropriate manual starting switches 22 or 26, and energizing relay coils A3 and B3 through the normally closed load switches L2 and L4. Energization of coils A3 and B3 brings about closure of the lock and relay switches A3a and B3a and A1 and B1 circuit switches A3b and B3b. Assuming that there is no load in the B furnace, a load is now placed in A furnace bringing about closure of the L1 load switch in the A1 circuit and opening of L2 load switch in the A3 circuit. Since A3a is locked in by the active coil A3 the opening of the L2 switch does not disturb the closure of the A3b switch in the A1 circuit. Manual starting switch 22 is now closed causing A4 relay coil to become energized, A4a switch closing and locking in the circuit around the starting switch. Also open switch A4b in the A2 circuit is closed bringing about energization of the timer clutch coil A2 which locks itself in through closure of switch A2a. Switch A2b in the A1 circuit is also closed by coil A2 thus energizing the coil A1 and the timer 16 and bringing about the initiation of the timing cycle. A1 closes switch A1a in the A5 circuit, energizing coil A5 which in turn closes the main contactor switch A5a in the load circuit of coil 24. A1 also opens the normally closed switch A1c in the A4 circuit to prevent closure of a circuit through the starting switch 22 and consequently switch A4a opens. Switch A1b in the B2 branch of the B furnace also opens thus preventing any possibility of a circuit being established through the timer coil B2 to initiate a heating or power cycle in the B furnace.

The various switch actions mentioned above take place after the closure of the A starting switch 22 and with the energization of the timer coil A1 a static condition exists while the timer carries through its timing period. At the end of the timer period the timer mechanism acts to release contact switch A2b thus de-energizing coil A1 and releasing switches A1a in the main circuit A5, A1b in the B2 circuit of the B furnace and A1c in the A4 circuit. Opening of A1a opens the main contactor switch A5a in the power circuit of the A furnace; release of switch A1b closes the same making possible energization of the B furnace; and release of A1c closes the switch to permit completion of a starting circuit when desired. The completion of the timing cycle however does not release switch A2a which remains closed and consequently the timer is not reset by the termination of the timer period. To reset the timer it is necessary that clutch coil A2 be de-energized and this can be accomplished only by removal of the load from the heating coil of the A furnace to open the L1 switch or through the actuation of the manual stop switch 18 or the over-load switch 13, the pressure switch 12, the door or miscellaneous switches indicated by the numeral 11, or by a break down in power supplied the main conductors. Consequently after a given load is heated through a timing cycle it cannot be reheated merely by pressing the manual starting switch 22, but the load must first be removed.

As above-noted de-energization of the intermediate contactor relay coil A1 permits closure of switch A1b in the B2 circuit of the B furnace. While this switch is open it is impossible to heat a charge in the B furnace since it is impossible to

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close this circuit through the clutch coil B2 of the timer. However the B furnace may be loaded and the starter switch 26 in the B4 circuit closed to condition the B circuit for immediate actuation on closure of switch A1b in the B2 circuit. The procedure is to place the load in the B furnace immediately after the normal heating cycle has begun in the A furnace. This closes load switch L3 in the B1 circuit and as soon as switch B3b adjoining the load switch is closed voltage is placed on the B4a switch pending closure of the A1b switch. Also voltage is placed on the starting switch 26 so that when this switch is closed coil B4 is energized closing B4b switch and B4a in the B2 circuit. The B circuit is now in condition to start the heating cycle in the B furnace as soon as switch A1b, which is held open by the A1 coil, is closed and this occurs on the completion of the heating cycle in the A circuit. Immediately thereafter B2 is energized closing B2a and B2b switches, energizing B1 coil, closing B1a switch in the main contactor circuit B5, and thus closing the power switch B5a in the B furnace. At the same time coil B2 releases the timer mechanism and the timer cycle is completed. Also switch B1b in the A2 circuit is opened preventing a heat cycle in the A furnace. During the heat cycle in the B furnace the A furnace is again loaded and the manual starting switch 22 closed so as to condition the A circuit for immediate energization for a new heating cycle as soon as the load is removed from the B furnace. This alternate loading and heating is continued as desired.

It thus appears from the above description that two furnaces A and B supplied from the same power source may be kept continuously in sequential operation automatically and without any appreciable time interval between the completion of the heating cycle in the one furnace and the energization of the heating cycle in the other furnace. It also appears from this description that if the operator fails to remove the load from one furnace another furnace can be operated after the completion of the heating cycle in the loaded furnace. Also it is evident that the circuit does not prevent continued operation of one only of the furnaces provided there is no load in the other furnace. In the event that the pressure in the cooling circuit drops to a point causing opening of switch 12 or over-load switch 13 opens, the entire circuit will be de-energized but on resumption of current through the switches a new heating cycle will not develop in the furnace in which the cycle was interrupted unless the load is first removed from the furnace. This is definite notice to the operator that the load has been partially heated only and will not stand a new complete cycle of heat. In this connection use may be made of manual switches 18 and 30 to break the heating circuit at the proper time for securing full heat treatment of the prior partially heated load.

The showing made is diagrammatic and it is apparent that modification may be made to suit special conditions met with in practice. The invention therefore is not intended to be limited except by the scope of the following claims.

What is claimed is:

1. In power equipment, a first power unit, a second power unit, means for supplying power to said units, control means for initiating a power cycle in the first unit, and means controlled by the first unit control means for conditioning said second unit for initiation of a power cycle therein

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only after cessation of power flow in the first unit.

2. In power equipment, a first power unit adapted to receive a load, a second power unit adapted to receive a load, means for initiation and completion of a power cycle in each of said units, and means for preventing initiation of a power cycle in both of said units succeeding an interrupted power cycle in one of said units without removal of the load from both of said units.

3. In power equipment, a first induction heating coil adapted to receive a load, a second induction heating coil adapted to receive a load, a common source of power for said coils, timer means for timing a heating cycle separately in each coil, load control means for preventing a heat cycle in either coil without a load in the coil, and control means for preventing a heat cycle in either coil while a heat cycle is progressing in the other coil.

4. In power equipment, a first induction heating coil adapted to receive a load, a second induction heating coil adapted to receive a load, a common source of power for said coils, timer means for timing a heating cycle separately in each coil, load control means for preventing a heat cycle in a coil without a load in that coil, control means for preventing a heat cycle in either coil while a heat cycle is progressing in the other coil, and means for preventing a renewed cycle in either one of said coils after an interrupted cycle in that coil, without first removing and replacing the load in that coil.

5. In power equipment, a first power unit, a second power unit, means for supplying power to said units from a common source, control means for initiating a power cycle in the first unit, control means for initiating a power cycle in the second unit, and means actuated by the first unit control means for conditioning said second unit for initiation of a power cycle therein only after cessation of power flow in the first unit.

6. In power equipment, a first power unit adapted to receive a load, a second power unit adapted to receive a load, means for initiation and completion of a power cycle in each of said units, means for preventing initiation of a power cycle in either of said units succeeding a power cycle in that unit, without removal of the load from that unit, and additional means for preventing initiation of a power cycle in either unit while the other unit is passing through a power cycle.

7. In power equipment, a first power unit adapted to receive a load, a second power unit adapted to receive a load, means for initiation and completion of a power cycle alternately in each of said units, and means for preventing initiation of power cycles in alternate sequence in said units succeeding a power cycle in one of said units without removal of the load from both of said units.

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