March 10, 1964 G. E. C. RANDELL ETAL 3,124,736

AUTOMATIC CONTROLS FOR POSITIONING A MACHINE

Filed July 20, 1959

4 Sheets-Sheet 1

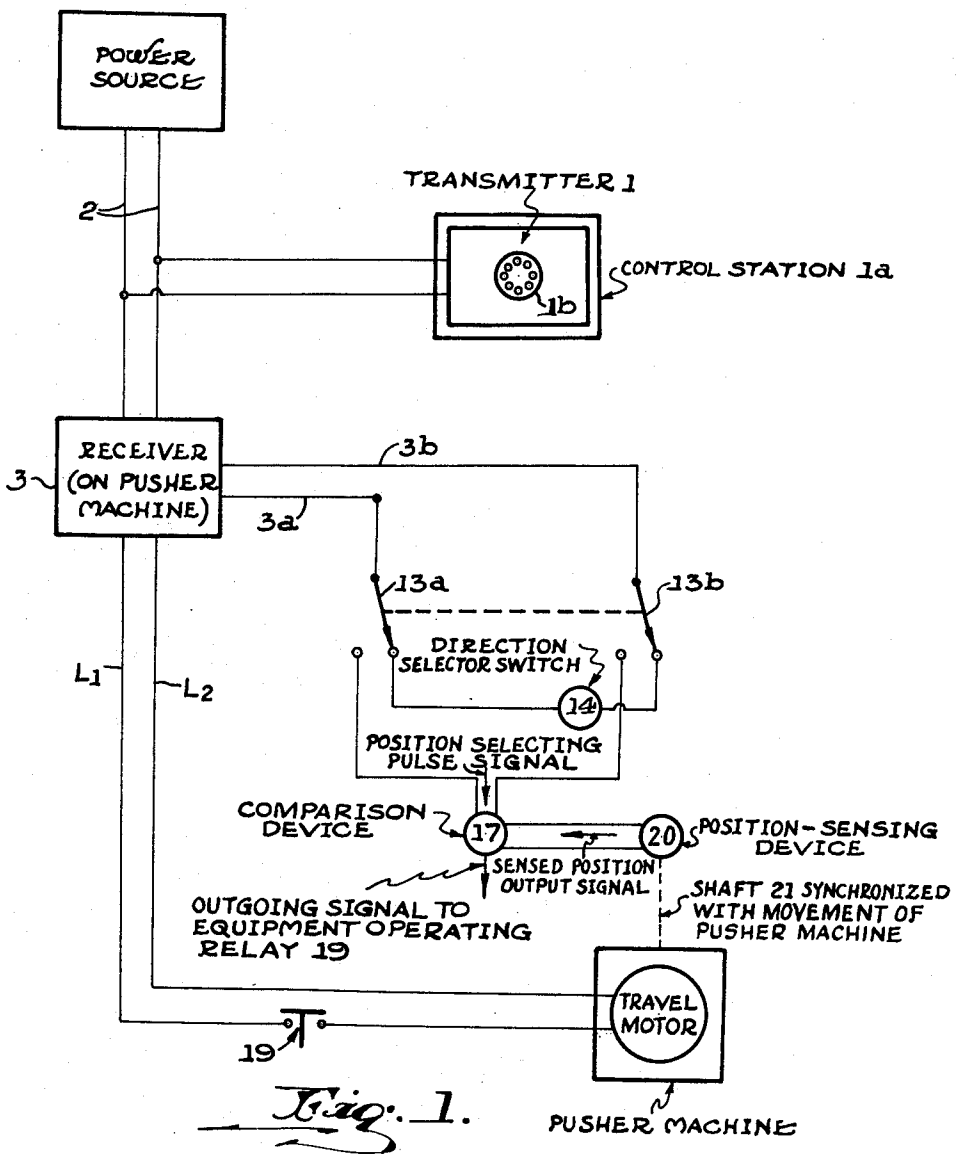


Fig. 1.

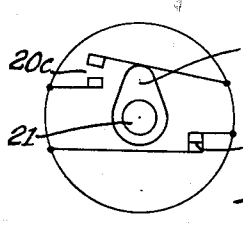


Fig. 3B

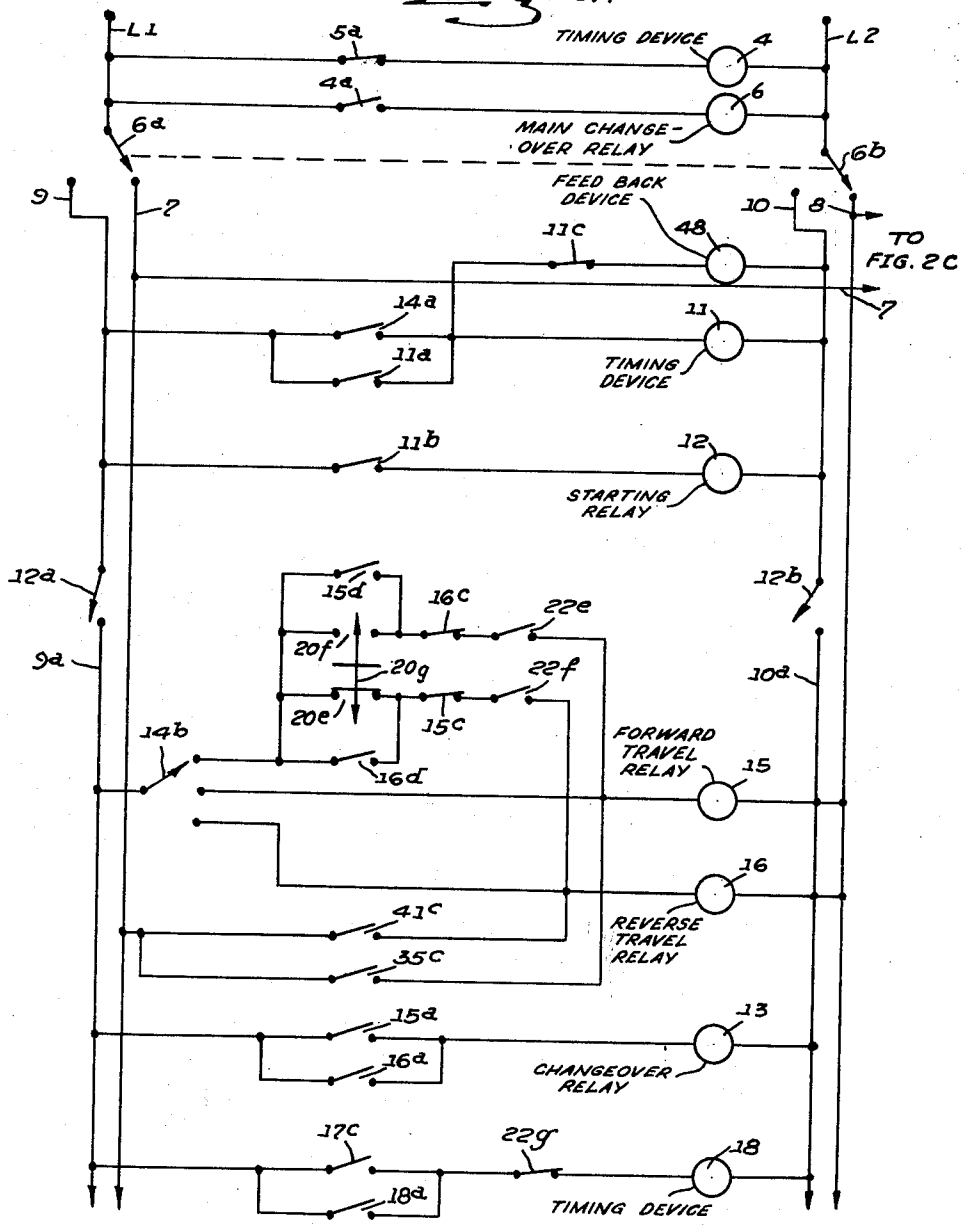
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Fig. 2A



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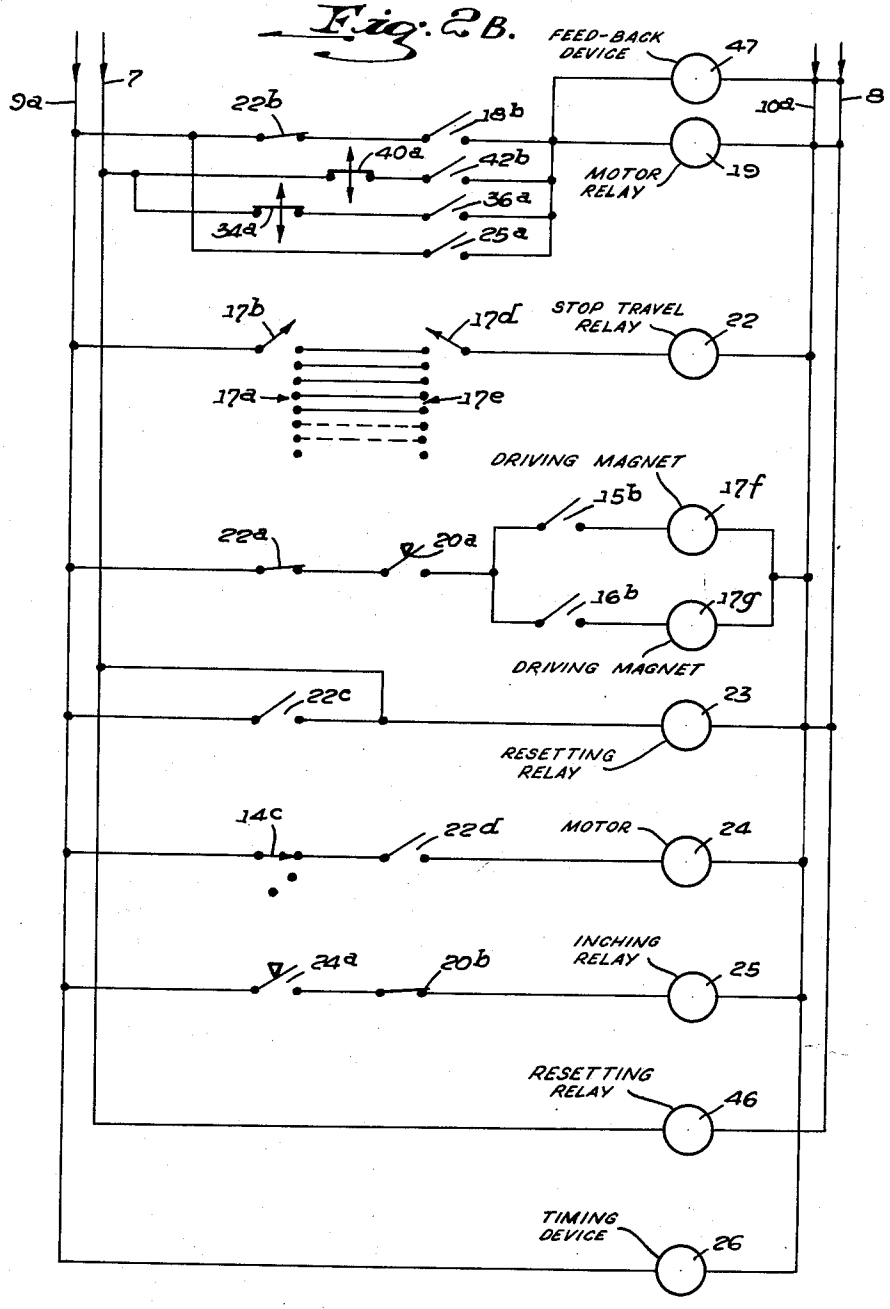
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AUTOMATIC CONTROLS FOR POSITIONING A MACHINE

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Fig. 2B.



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AUTOMATIC CONTROLS FOR POSITIONING A MACHINE

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Fig. 2C.

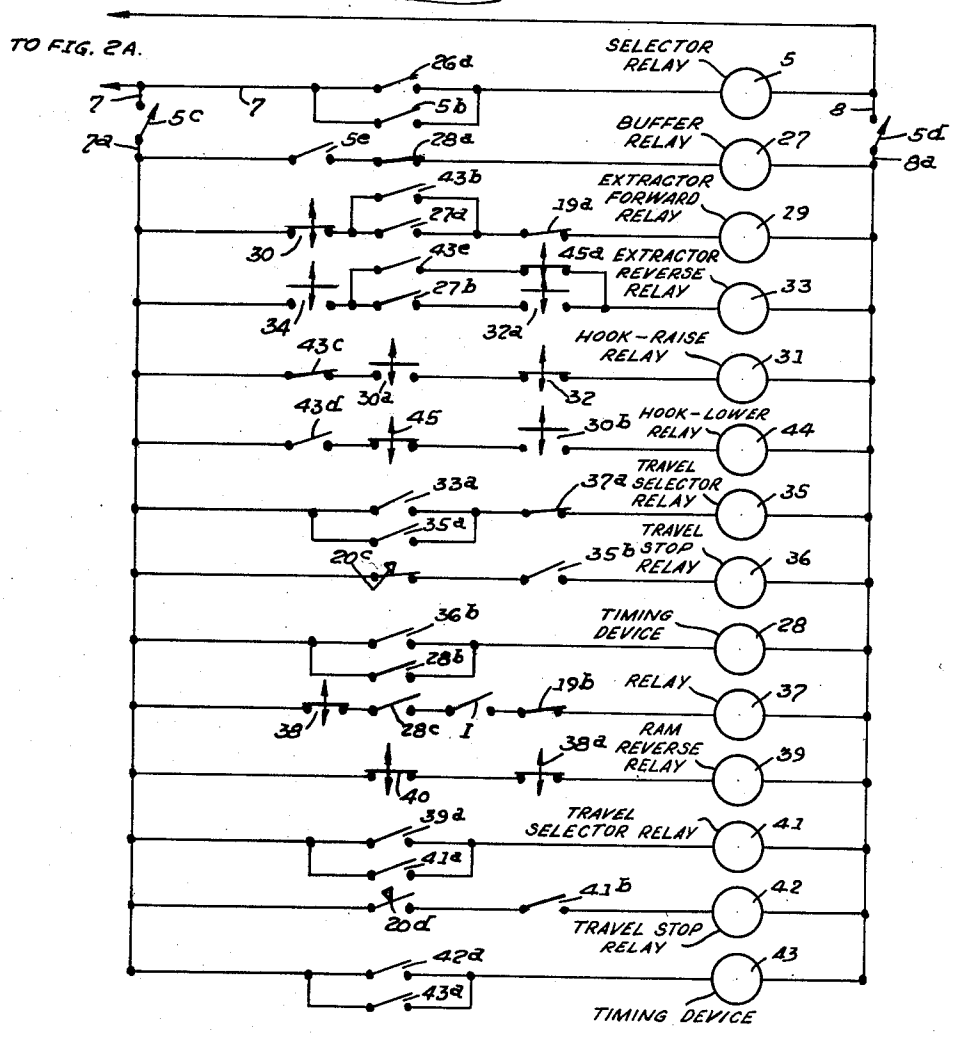
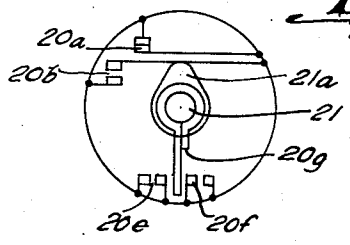


Fig. 3A



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AUTOMATIC CONTROLS FOR POSITIONING A MACHINE

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4 Claims. (Cl. 318—162)

This invention concerns the operation of coal carbonizing installations, that is, installations comprising carbonizing means such as horizontal coke ovens, or continuous or static vertical retorts or intermittent vertical chambers, and their ancillary equipment such as coal blending and handling, plant, coke quenching or cooling plant, coke handling plant, by-product recovery plant and handling plant, gas-purification plant, treatment and storage plant, and other equipment necessary for the proper operation of the carbonizing means.

In the operation of coal carbonizing installations a variety of different operations have to be carried out, certain operations or groups of operations having to be performed simultaneously or in a predetermined sequence. In many instances, rigid adherence to a program is required if one or more operations, e.g. a group of operations, are to be performed effectively and with safety, and in such cases supervision by responsible personnel, often aided by "interlocks" of a mechanical, fluid-pressure, electrical electromechanical nature to prevent dangerous departures from the program, is required. In general, however, responsibility for the successful performance of specific operations or groups of operations is divided amongst several persons, coordination of the overall pattern of operations being a matter of cooperation between such persons.

An object of the present invention is to provide, in a coal cabonizing installation, a supervisory and/or control system by which supervision and/or control of one or more operations or groups of operations, and/or proper coordination of two or more operations or groups of operations, may be aided or ensured.

In coal carbonizing installations, most of the operations which are or can be performed by mechanical means are susceptible to electrical control in that the mechanical means are or may be electrically operated or are carried by electrically or driven machines, using a common source of electrical power. Thus, a coal carbonizing installation equipped with a supervisory and/or control system in accordance with the present invention comprises a control station including a transmitter adapted to inject a high-frequency, e.g. radio-frequency signal into the electrical power supply mains for a machine or means to be supervised or controlled, such machine or means being equipped with a receiver associated with the power supply thereof and adapted to respond to such signal to provide a supervisory or controlling function.

Thus in the simplest case, the transmitter may merely inject a single high-frequency signal into the power supply mains of a single machine in the installation, this signal being carried by the mains to the machine and there causing a receiver to respond to the signal by producing either an indication to an operator of the machine that a certain operation is to be performed, or a controlling function directly to cause such operation to be performed. In the latter case, the performance of the operation concerned may be caused by an operator at the control station setting the transmitter into operation, or by automatic equipment at the control station setting the transmitter into operation at appropriate times (in the case of an operation that has to be performed at known intervals)

or in response to a signal indicating the completion of a preceding operation in a sequence of operations.

The charging and discharging of static vertical retorts and intermittent vertical chambers is an example of a group of operations that has to be carried out sequentially at known intervals and is susceptible to supervision and/or control by a system in accordance with the invention. In such a case the transmitter could be arranged to inject a plurality of distinguishable signals (e.g. of different frequencies and/or coded) into the power supply mains for the machines by which the operations are performed, receivers on these machines responding to the appropriate signals to supervise and/or control the performance of the several operations. In this instance, the injection of the different signals by the transmitter could be caused, in the appropriate combinations and/or sequence, by a programming device set in operation at appropriate intervals by suitable timing means.

The charging and discharging of horizontal coke ovens in a battery is an instance of two groups of operations that are carried out sequentially at known intervals, the operations involved in discharging an oven falling in one group of operations that have to be performed in a specified order and with close coordination between three or more machines, to be followed by recharging of the discharged oven by a sequence of operations constituting a second group. Supervision and/or control of all these operations could be achieved, by a system in accordance with the invention, from a control station transmitter operated manually or by a programming device.

In cases, such as the above, in which a sequence of operations or groups of operations has to be performed, it is often the case that the performance of one operation or group of operations must await the completion of a preceding operation or group; in such circumstances, the system may be elaborated by the provision of feedback transmitters on appropriate machines to return a signal to the control station upon completion of an operation or group of operations, the reception of this signal being employed directly, or through human intervention, to cause the control station transmitting to inject the signal for performance of the next operation or group of operations. Alternatively, a programming device which allows for any operation or group of variable length, a time not less than the maximum expected under adverse conditions, could be used.

Operations or groups of operations which have to be performed at variable intervals may be supervised and/or controlled by a system in accordance with the invention. In such cases, injection of a signal by the transmitter may be initiated by human agency although in many cases such an operation or group of operations has to be performed in response to certain conditions arising in the installation and the transmission of a signal, indicative of the presence of those conditions, to the control station may be utilized to trigger the transmitter at the latter to inject the desired signal for performance of the operation or group of operations. Whilst signals to the control station could be transmitted in any convenient manner, use of power supply lines as high-frequency signal conductors in the manner in which they are used for conducting signals from the transmitter to the receiver of the basic system is preferred as a means of avoiding special signalling cables and the complexity of having two or more different signalling systems in operation between the control station and different points of the installation.

It will be appreciated that the basic system of this invention is capable of elaboration to provide complete coordination of substantially all the operations performed in the operation of a carbonizing installation, the system being either supervisory in function, i.e. providing indi-

cations to appropriate personnel as to the operations to be carried out at any particular time, or controlling in function, providing for the control of the operations from a control station. The system can, if desired, provide a supervisory function for certain operations (such as those which are unsuitable for performance by mechanical means either because of their nature or on economic grounds) and a controlling function for other operations.

In either case, the control station may be automatic, the transmitter being controlled by one or more programming devices incorporating timing means or means responsive to condition-indicative signals as required by the nature of the operations to be supervised or controlled. Alternatively, the control station may only be semi-automatic, a human operator initiating the injection of certain combinations and/or sequences of signals by setting programming devices into operation as required by conditions known or signalled to the operator. Especially in cases where only a few individual operations are to be supervised and/or controlled the control station transmitter could be entirely manually controlled by a human operator, as mentioned above in connection with the simple cases first discussed.

It is to be understood that where convenient or desirable, a system in accordance with this invention may be employed in combination with known "interlock" arrangements to provide addition safety in the performance of operations or groups of operations of an inherently dangerous nature; additionally or alternatively, especially when the control station is not fully automatic, interlocking arrangements may be provided at the control station to prevent the injection of signals in combinations and/or sequences which could give rise to operations being performed at inopportune moments or under inherently dangerous conditions for their performance.

In the case of a carbonizing installation embodying a horizontal coke oven battery, some of the operations concerned with the latter which are particularly suscetpible to supervision and/or control by a system in accordance with the invention are:

(*a*) Movement of the charging car to the coal bunker, and filling the charging car from the bunker, using interlocks, if desired, to ensure correct positioning of the car;

(*b*) Movement of the charging car into position for recharging an oven after discharge thereof, using appropriate means for ensuring correct positioning of the car;

(*c*) Removal and replacement of the charging hole lids, e.g. by the means described in the specification of our copending British application No. 43943/58 and charging of an oven from the charging car;

(*d*) Movement of the pusher machine and of the coke-guide machine to an oven to be discharged, and operation of the door handling equipment before and after discharge, alignment of machines with the same oven being ensured, if desired, by an appropriate interlock arrangement, e.g. that described in the specification of British Patent No. 214,502;

(*e*) Movement of coke car into position and coordination of its movement with that of the pusher ram, using an interlock, if desired, to cause arrest of pusher ram in the event of failure of the coke car drive, and/or to cause arrest of the coke car in the event of stoppage of the ram movement;

(*f*) Operation of the quenching or coke cooling plant to ensure correct quenching or cooling of the coke;

(*g*) Operation of ascension pipe valves during charging and discharging of an oven;

(*h*) Operation of the heating system reversing valves at appropriate intervals.

In the case of a carbonizing installation embodying vertical retorts or carbonizing chambers, operations equivalent to the above-listed operations in connection with a horizontal coke oven battery may be supervised and/or controlled by means of a system in accordance with the present invention. In either type of installation, the operation of the coal blending plant, the coal handling plant, the coke handling plant, the by-products plant and the gas purification, treatment and storage plant are all susceptible to supervision and/or control by the system of the invention.

In operations involving movement of a machine selectively to one of several positions, e.g. movements of coke-oven battery operating machines, charging cars and coke cars, supervision and/or control of position may be achieved in any convenient manner; thus positioning-sensing devices and devices for comparing sensed position with required position may be employed for indicating position error or to exert a controlling influence to eliminate position error. Specifically, feed-back transmitters may be employed to repeat sensed position back to the control station for comparison with required position at the latter, or the signals from the control station may be significant of required position, the receiver being adapted to pass required-position information to a comparison device which operates to arrest the movement concerned when the sensed position coincides with the required position. Fine adjustment of position, when required, may be achieved by appropriate means, for instance 'inching" devices actuated by the interruption of a light or other electromagnetic radiation beam resulting from position error.

Further, when rigorous coordination of two or more operations performed simultaneously by independently driven items of equipment is required, appropriate interlocking arrangements may be employed and such arrangements may include transmitters associated with the items of equipment performing the operations to provide for the transmission of coordinating signals, over the power supply mains, to receivers on the items of equipment and responsive to such signals to indicate proper coordination or to exert a controlling function ensuring such coordination.

The control of the pusher machine and the door-handling mechanism carried by such machine by means of a system in accordance with the present invention will be described as a typical example of the use of a control system in accordance with the invention in a carbonizing installation embodying a horizontal coke oven battery. In the accompanying drawings:

FIGURE 1 is a diagrammatic representation of a transmitter located at a control station and a receiver mounted on the pusher machine, the transmitter and receiver being interconnected by the power supply lines to the pusher machine;

FIGURE 2A illustrates part of the control circuit associated with the receiver of FIGURE 1;

FIGURE 2B shows a further part of the control circuit and represents a continuation of the lower part of FIGURE 2A;

FIGURE 2C shows the remainder of the control circuit; and

FIGURES 3A and 3B are semi-diagrammatic representations of a position-sensing device.

Referring to FIGURE 1 of the drawings, this illustrates in diagrammatic form a transmitter **1** which is located at a control station **1***a* at some convenient location in the carbonizing installation and in this instance is adapted for manual operation by control station personnel to superimpose on the normal A.C. power supply to the pusher machine a high-frequency signal which is carried by power supply lines **2** to the pusher machine and there picked up by a receiver **3** and applied to lines **3***a*, **3***b*.

In this particular arrangement, the signals transmitted are simple pulses, a train of such pulses being used to carry position information to the pusher machine for the purpose of adjusting a comparison device which compares the required position of the machine with its actual position and causes the machine to travel along its track alongside the battery to align the door-handling mechanism on the machine with the door of a particular oven of the

battery. Thus conveniently the transmitter is equipped with means such as a telephone dial switch 1*b* by means of which the control station personnel can "dial" the number of an oven which is to be discharged by means of the pusher machine.

In this particular arrangement, high-frequency signals are used only to transmit position (and direction of travel) information to the pusher machine; initiation of the operation of the pusher machine when positioned relatively to an oven to be discharged is brought about by momentary disconnection of the power supply to the lines 2, whilst arrest of its operation and resetting of the control system components on the machine is also effected by switching of the main power supply to the machine. It will, however, be understood that such additional functions could, if desired, be controlled by high-frequency signals using, for example, different frequencies for different control functions. However, since it is usual for the various machines of a carbonizing installation to be separately supplied with power through suitable lines from independent circuit-breakers at a central power station in the installation, interruption of the power supply to the pusher machine for signalling purposes as aforesaid will not disturb the operation of the other machines or equipment of the installation since their power supplies will not be affected: accordingly, control of certain functions by power supply switching is simple and assists in reducing the number of different frequencies to be employed in a more elaborate system controlling several machines or other equipment in a carbonizing installation.

The receiver 3 cooperates with a control circuit shown diagrammatically in FIGURES 2A, 2B and 2C. Leads L1, L2 of the control circuit are energized from the main power supply lines 2, suitable converting equipment being incorporated in the event that the control circuit is to work at other than main supply voltage, or with D.C. It will be understood that since the control circuit is ultimately supplied from lines 2 its leads L1 and L2 will be sensitive to interruptions in the main supply over lines 2.

In the circuit diagram of FIGURES 2A to 2C, all components are shown de-energized, i.e. relay break contacts are shown closed and relay make contacts are shown open.

Referring to FIGURE 2A, it will be noted that the leads L1, L2 are shunted by a first timing device 4 in series with break contacts 5*a* of a selector relay 5 (FIGURE 2C). The timing device 4 has a set of make contacts 4*a* in series with a main changeover relay 6 across the leads L1, L2. The changeover relay 6 has transfer contacts 6*a*, 6*b* connected to leads L1, L2 respectively and in the released condition of the relay 6 these contacts connect said leads to lines 7 and 8 respectively whilst in the operated condition of the relay 6 said contacts connect leads L1, L2 to lines 9 and 10 respectively. Thus application of power to lines 2 will energize the leads L1, L2 and also energize the timing device 4. After an interval (of five seconds in the arrangement shown) contacts 4*a* will close and changeover relay 6 will transfer the control circuit power from lines 7 and 8 to lines 9 and 10.

The control circuit components associated with lines 7, 8 and lines 9, 10 and with the extensions of these pairs of lines comprises a number of relays, timing devices, limit switches, motor-driven contacts and a comparison device associated with a position-sensing device and these components will be described in the course of a description of the operations which follow the application of power to lines 2 and subsequent operation of the main changeover relay 6 as described above. Where the form of components, such as relays, is not described it is to be understood that they are electromagnetically operated devices of form appropriate to the control circuit power supply and, subject to this, of a form well understood in the art.

It will be noted that the two components connected across lines 9 and 10, namely a second timing device 11 and a starting relay 12, are both open-circuited by open make contacts in series therewith so that neither of these components is energized following operation of the changeover relay 6. Accordingly device 11 and relay 12 remain for the moment in their de-energized condition and, in particular, make contacts 12*a* and 12*b* of the starting relay 12 remain open so that the extensions 9*a* and 10*a* of lines 9 and 10 remain de-energized and the various components connected to such extensions also remain de-energized.

Following operation of the changeover relay 6 as described above, the control circuit is set up to receive position information significant of the oven to be discharged by the operation of the pusher machine. As mentioned hereinabove this position information is transmitted to the receiver 3 by means of high-frequency pulses applied to the power lines 2 by the actuation of a dial switch associated with the transmitter 1.

The ovens in the battery are numbered consecutively from one end of the battery and since there will usually be between 10 and 99 ovens in the battery, two trains of up to ten pulses will be sufficient to identify any one oven in the battery, one train of pulses representing a particular group of ten ovens and the second train of pulses representing the particular oven in a selected group of ten.

Prior to transmitting the trains of pulses significant of the position of an oven to be discharged, the present position of the pusher machine is noted and the direction in which it is to travel to approach an oven to be discharged is determined and a "direction signal" is transmitted to the receiver 3. Such "direction signal" consists of a single high-frequency pulse if the machine is to move forwards (i.e. towards a higher-numbered oven) and two such pulses if the machine is to move in reverse (towards a lower-numbered oven).

Any "direction" pulse received is applied by the receiver 3 over lines 3*a*, 3*b* to transfer contacts 13*a*, 13*b* of a second changeover relay 13 (FIGURE 2A) and since this is in its released condition such pulse(s) is applied to a "direction selector" switch 14 (FIGURE 1). This has a set of make contacts 14*a*, which close for each pulse applied to switch 14, in the circuit of the second timing device 11, thereby causing energization of the latter which locks over a set of its own make contacts 11*a* shunting contacts 14*a*, whilst for each "direction" pulse a wiper 14*b* of switch 14 is indexed one step from its "home" or "zero" position shown in FIGURE 2A. In the event that one "direction" pulse is received, a forward travel relay 15 (FIGURE 2A) is connected between line 9*a* and lines 8 and 10, whilst in the event that two "direction" pulses are received, a reverse travel relay 16 is connected between line 9*a* and lines 8 and 10.

After an interval (of five seconds in the arrangement shown) from the operation of timing device 11, make contacts 11*b* of the timing device 11 close and complete the circuit of the starting relay 12. Contacts 12*a* and 12*b* of the latter thus close and apply power to extension lines 9*a* and 10*a* and the selected travel relay 15 or 16 operates. The travel relays 15 and 16 have make contacts 15*a* and 16*a* wired in parallel in the circuit of the second changeover relay 13 so that upon operation of starting relay 12 and subsequent operation of a travel relay, relay 13 is operated and transfer contacts 13*a* and 13*b* (FIGURE 1) connect the line, 3*a*, 3*b* of receiver 3 to the "required position" input of a comparison device 17 (FIGURES 1 and 2B).

The comparison device 17 conveniently comprises a selector switch such as used in automatic telephone exchanges, having a number of banks of contacts 17*a* and a wiper 17*b* which may be stepped from one bank to the next and thereafter indexed to a selected contact 17*a* in a selected bank.

The two trains of pulses significant of the position of the oven to be discharged are applied to the device 17,

the pulses of the first train stepping the wiper 17*b* of the device to the level of the bank of contacts significant of the group of ten ovens containing the desired oven and the pulses of the second train causing the wiper 17*b* to be indexed into engagement with a contact 17*a* in such bank significant of the oven to be discharged.

The device 17 also has a set of make contacts 17*c* which are closed on receipt of the first pulse by the device 17 and complete the circuit of a third timing device 18 which operates and locks over a set of its own make contacts 18*a* shunting contacts 17*c*.

The third timing device 18 has a set of make contacts 18*b* which close about ten seconds after the device is energized and complete the circuit of a motor relay 19 (FIGURE 2B) which when operated completes the power supply to the travel motor of the pusher machine. The operated travel relay 15 or 16 determines the direction of travel of the pusher machine.

The pusher machine accordingly commences to travel in the required direction towards the oven to be discharged.

The pusher machine is equipped with a position-sensing device 20 shown diagrammatically in FIGURES 3A and 3B and which has a driving shaft 21 which rotates in synchronism with the movement of the pusher machine. Preferably the driving shaft 21 is rotated by a pinion engaging a rack extending along the track of the pusher machine so that rotation of the shaft 21 in exact synchronism with the machine is assured.

The shaft 21 is coupled to cams 21*a*, 21*b*, cam 21*a* making one complete rotation for movement of the pusher machine by a distance equal to the centreline separation of two adjacent ovens whilst the cam 21*b* makes two revolutions for movement of the machine by a distance equal to the separation of the pusher ram and door extractor on the machine. The cams actuate four sets of contacts 20*a*, 20*b*, 20*c* and 20*d* whilst the direction of rotation of shaft 21, and hence the direction of movement of the pusher machine, is sensed by two sets of contacts 20*e* and 20*f* which are both normally open but which cooperate with a striker 20*g* frictionally driven by the shaft 21 so that contacts 20*e* are closed when the pusher machine moves forward whilst contacts 20*f* are closed when the pusher machine moves in reverse.

Contacts 20*a* control the "sensed position" input of the comparison device 17 which includes a seeker 17*d* in the form of a wiper arm movable over a bank of contacts 17*e* connected in order to the contacts 17*a* swept by wiper 17*b* of the device 17. The direction of movement of the seeker 17*d* is determined by the operated travel relay 15 or 16, these relays having make contacts 15*b* and 16*b* controlling forward and reverse driving magnets 17*f* and 17*g*, respectively, in a circuit including the contacts 20*a*.

Accordingly, as the pusher machine moves towards the desired oven the seeker 17*d* approaches the contact 17*e* connected to the contact 17*a* engaged by wiper 17*b* of the device. When the seeker 17*d* engages such contact 17*e* a "stop travel" relay 22 is energized and break contacts 22*a* of the latter open to prevent further pulses being applied to the relevant driving magnet 17*f* or 17*g* of the seeker 17*d*.

The relay 22 also has break contacts 22*b* in series with said make contacts 18*b* controlling the motor relay 19 so that upon operation of relay 22, relay 19 is released and the travel motor of the pusher machine switched off.

Since the momentum of the pusher machine will carry it past the desired oven before it comes to rest, means are provided for "inching" the pusher machine into exact position for the door extractor of the door-handling mechanism on the machine to cooperate with the door of the desired oven.

Thus it will be noted in FIGURE 2B that the stop travel relay 22 has two further sets of make contacts, 22*c* and 22*d* respectively. The contacts 22*c* control a resetting relay 23 for the direction selector switch 14, closure of contacts 22*c* and consequent operation of relay 23 causing the direction selector switch 14 to be reset to its "zero" position. In its "zero" position a second wiper 14*c* of the switch 14 and the closed make contacts 22*d* of relay 22 complete the circuit for a motor 24 which, by means of a cam, cyclically opens and closes a set of contacts 24*a* in the circuit of an "inching" relay 25. This circuit includes the contacts 20*b* of the position-sensing device 20 and the arrangement is such that as long as the pusher machine is out of its proper position contacts 20*b* are closed and the "inching" relay 25 is repeatedly operated by the cyclic closing of contacts 24*a*.

It will be noted from FIGURE 2A that the stop travel relay 22 has further make contacts 22*e* and 22*f* in circuit respectively with the travel relays 15 and 16 and a contact engaged by the wiper 14*b* of switch 14 in the "zero" position of the latter. The circuit for relay 15 including contacts 22*e* includes break contacts 16*c* of relay 16 and contacts 20*f* of device 20, contacts 20*f* being shunted by make contacts 15*d* of relay 15; the circuit for relay 16 including contacts 22*f* includes break contacts 15*c* of relay 15 and contacts 20*e* of device 20, contacts 20*e* being shunted by make contacts 16*d* of relay 16. Accordingly, upon operation of stop relay 22 and subsequent resetting of switch 14 to "zero" by resetting relay 23 one or other of relays 15 and 16 is operated in accordance with the closure of one or other of contacts 20*e* and 20*f* of the position-sensing device 20 and the arrangement is such that the appropriate relay 15 or 16 will be operated and lock over its own make contacts 15*d* or 16*d* to set up the circuit of the travel motor of the pusher machine to cause return of the latter towards the desired oven which it overshot following operation of the stop travel relay 22.

It will be further noted that the stop travel relay 22 has break contacts 22*g* (FIGURE 2A) in series with the third timing device 18 so that this is de-energized upon operation of relay 22 cutting off motor relay 19 and thereby power to the pusher machine.

The "inching" relay 25 has a set of make contacts 25*a* in a circuit shunting contacts 22*b* and 18*b* in the circuit of motor relay 19 and accordingly relay 19 will operate in sympathy with relay 25 and the travel motor of the pusher machine will be "pulsed" by the above-described cyclic operation of relay 25 to cause the desired return movement of the pusher machine. When the pusher machine is exactly in position for extratcion of the door of the desired oven, contacts 20*b* will open and prevent further operation of relay 25.

It will be noted that a fourth timing device 26 is wired across extension lines 9*a* and 10*a*. This timing device which is energized upon closure of starting relay contacts 12*a*, 12*b* as above described, has make contacts 26*a* in the operating circuit of the aforesaid selector switch 5 and the arrangement is such that contacts 26*a* open approximately five seconds following deenergization of device 26.

To initiate the performance of the series of operations required of the pusher machine when this has been properly positioned with respect to an oven to be discharged, as described above, the power supply lines 2 are momentarily de-energized by the control station personnel. This momentary de-energization of lines 2 also de-energizes leads L1, L2 and accordingly causes release of the main changeover relay 6 with the result that transfer contacts 6*a* and 6*b* connect leads L1, L2 to lines 7 and 8 respectively.

Provided that power is restored to lines 2, and hence to leads L1, L2 and lines 7 and 8, prior to opening of contacts 26*a* of timing device 26, the selector switch 5 will be operated and lock over its own make contacts 5*b* shunting contacts 26*a*. Make contacts 5*c* and 5*d* of switch 5 close when the latter is operated to apply power to extension lines 7*a* and 8*a* of lines 7 and 8 respectively.

It will be noted that the operation of switch 5 and opening of its break contacts 5*a* interrupts the circuit for the first timing device 4 and so prevents the subsequent operation of changeover relay 6 as previously described.

As a result of the application of power to lines 7*a* and 8*a* a "buffer" relay 27 operates, the circuit of this relay including make contacts 5*e* of switch 5 and break contacts 28*a* of a fifth timing device 28.

Operation of buffer relay 27 closes make contacts 27*a* thereof to complete the circuit of an "extractor forward" relay 29 which when operated causes advance of the door extractor. The circuit for relay 29 includes break contacts 19*a* of motor relay 19, so that relay 29 cannot operate if the pusher machine travel motor is energized, and a limit switch 30 which opens when the door extractor reaches its forward limit position.

Thus upon operation of relay 27 the door extractor is advanced until it is in position to engage the oven door.

The limit switch 30 has a set of contacts 30*a*, which are closed when the extractor reaches its forward limit position, in the circuit of a "hook raise" relay 31 which when operated causes the door extractor hooks to be raised to engage the oven door. The circuit of relay 31 includes a limit switch 32 which opens when the hooks have reached their fully raised position thereby to deenergize relay 31 when the hooks have been fully engaged with the door.

The limit switch 32 has a set of contacts 32*a* which are closed when the hooks reach their fully raised position and these contacts 32*a* in series with make contacts 27*b* of buffer relay 27 complete the circuit of an "extractor reverse" relay 33 which when operated causes retraction of the door extractor to extract the door from the oven. The circuit of relay 33 includes a limit switch 34 which opens when the door extractor is in its fully retracted position and thereby causes release of relay 33.

The relay 33 has a set of make contacts 33*a* in circuit with a "second travel" selector relay 35 (FIGURE 2C) which thus operates in synchronism with the operation of relay 33 and locks over a set of its own make contacts 35*a*. Make contacts 35*b* of relay 35, in series with contacts 20*c* of the position-sensing device 20, control a "second travel stop" relay 36.

Relay 35 has further make contacts 35*c* in circuit with the forward travel relay 15 so that this relay is operated when relay 35 operates as described above.

Whilst the pusher machine is in position for door extraction, the contacts 20*c* of the device 20 are closed and hence relay 36 operates in synchronism with relay 35. Operation of relay 36 closes make contacts 36*a* thereof in a circuit for the motor relay 19, such circuit including contacts 34*a* of the limit switch 34, which contacts are closed when the door extractor reaches its fully retracted position. Thus motor relay 19 is operated when the door extractor has completed its forward and reverse cycle to extract an oven door as described above.

Accordingly, on completion of the door extractor cycle the pusher machine moves forwardly (toward the higher numbered ovens) to bring the pusher ram into alignment with the oven from which the door has just been extracted. When the pusher machine reaches this position, contacts 20*c* open causing release of relay 36 and consequent release of relay 19.

It will be noted that the "second travel stop" relay 36 has a set of make contacts 36*b* in circuit with the said fifth timing device 28 which is thus energized in synchronism with the operation of relays 35 and 36 and locks over a set of its own make contacts 28*b*. Energization of this device 28 opens contacts 28*a* in the circuit of buffer relay 27 and causes the latter to release. Moreover a set of make contacts 28*c* of device 28 close after approximately 25 seconds and complete part of a "ram forward" circuit including a relay 37. This circuit includes break contacts 19*b* of the motor relay 19, a limit switch 38 which opens upon full advance of the ram and interlock contacts I which are only closed when all is ready for advance of the ram. These contacts I may be controlled by any suitable interlocking system for ensuring correct relative positioning of the operating machines of the battery and readiness to receive discharged coke at the coke side of the battery, prior to coke discharge.

Assuming that the pusher machine has by then come to rest so that contacts 19*b* are closed and contacts I have also closed, closure of contacts 28*c* will result in operation of relay 37 and consequent advance of the pusher ram to discharge coke from the oven. Operation of relay 37 opens break contacts 37*a* thereof in circuit of relay 35 and causes release of the latter.

When the ram reaches its forward limit, switch 38 opens, whilst contacts 38*a* of switch 38 close to complete the circuit of a "ram reverse" relay 39 which causes retraction of the ram, the circuit of relay 39 including a limit switch 40 which opens when the ram has fully retracted.

The "ram reverse" relay 39 has make contacts 39*a* controlling a "third travel" selector relay 41 which thus operates immediately upon operation of relay 39 and locks over a set of its own make contacts 41*a*. The relay 41 also has make contacts 41*b* in series with the contacts 20*d* of the position-sensing device 20 controlling a "third travel stop" relay 42. Accordingly when relay 41 operates, relay 42 also operates since at this time contacts 20*d* are closed.

Relay 42 has a set of make contacts 42*a* in the circuit of a sixth timing device 43 which thus operates and locks over a set of its own make contacts 43*b*.

Make contacts 41*c* of relay 41 are in circuit with the "reverse travel" relay 16 and cause operation of the latter immediately upon operation of the relay 41 thereby setting up the circuit for the travel motor of the pusher machine to move the latter in reverse.

Make contacts 42*b* of relay 42 in series with contacts 40*a* of limit switch 40 are in circuit with the motor relay 19 and accordingly relay 19 is operated when the pushed ram has completed its advance and retraction cycle.

Thus upon completion of the ram advance and retraction cycle, the pusher machine travel motor is energized and the pusher machine travels in reverse to realign the door extractor with the oven which has just been discharged. When the pusher machine reaches such position the contacts 20*d* of the device 20 open and thereby cause release of relay 42 and deenergization of motor relay 19 at contacts 42*b*.

By this time, make contacts 43*b* of the timing device 43 in a circuit shunting contacts 27*a* of relay 27 in the circuit of relay 29 will have closed since these contacts 43*b* close approximately 25 seconds following the energization of device 43. Accordingly, relay 29 is energized upon release of the motor relay 19 and closure of its break contacts 19*a* which are in series with contacts 43*b*. As above explained, energization of relay 29 causes advance of the door extractor until this reaches its forward limit position when limit switch 30 opens to deenergize relay 29.

When the door extractor reaches its forward limit position, contacts 30*a* of limit switch 30 close in the circuit of relay 31 but this relay is not operated since at this time break contacts 43*c*, of device 43, in the circuit for such relay are open. However, contacts 30*b* of limit switch 30, which close simultaneously with contacts 30*a* at the forward limit position of the door extractor, are in series with a "hook lower" relay 44 and with make contacts 43*d* of device 43 (which at this time are closed) so that relay 44 is operated. Operation of this relay causes lowering of the extractor hooks, the circuit of relay 44 being broken by a limit switch 45 when the hooks reach their lower limit position.

Contacts 45*a* of limit switch 45 close when the hooks reach their lower limit position and these contacts in series with closed make contacts 43*e* of device 43 com-

plete the circuit of the relay 33. As explained above, this causes retraction of the door extractor, the circuit of relay 33 being opened by limit switch 34 when the extractor reaches its fully retracted position. Upon full retraction of the door extractor, the cycle of operations required of the pusher machine during the discharge of an oven is completed.

It will be apparent that before a further cycle of operations of the machine can be initiated, the machine must be moved to the correct position with respect to the next oven to be discharged and this involves resetting of the components of the control circuit to the condition obtaining at the commencement of the foregoing description.

As has already been described, the direction selector switch 14 is reset to its "zero" position upon operation of relay 23, so that deenergization of leads L1, L2 to cause release of all operated relays and other energized devices may be effected by switching off the power supply to lines 2; accordingly it is merely necessary to provide for resetting the wiper 17*b* of the comparison device 17 to its starting position, ready for re-adjustment upon receipt of a second set of "required position" significant pulse trains.

This resetting of the wiper 17*b* of device 17 is achieved during the above described cycle of operations immediately following release of the main changeover relay 6 to transfer control circuit power from lines 9 and 10 to lines 7 and 8, that is, upon restoration of power to the lines 2 following correct positioning of the pusher machine.

Thus it will be noted that a resetting relay 46 is wired across lines 7 and 8 so as to be energized when power is applied to these lines and this relay 46 has make contacts (not shown) controlling suitable resetting mechanism for the wiper 17*b* of device 17.

It will be noted that the relay 46 is also energized at the commencement of the above-described cycle of operations, i.e. when power is applied to lines 2 (and hence to leads L1 and L2) prior to operation of the first timing device 4. Accordingly the wiper 17*b* will be reset to its starting position even if a cycle of operations is deliberately interrupted at any point by switching off the power supply to the pusher machine over lines 2. Thus in the event that an incorrect "required position" signal was sent to the pusher machine, deenergization of lines 2 for a period longer than the period required for opening of contacts 26*a* of timing device 26 would automatically bring about resetting of wiper 17*b*, ready for adjustment in accordance with another set of "required position" pulse trains, upon restoration of the power supply to lines 2.

It will have been noted that following the transmission of "position significant" pulses to the receiver, a certain period must elapse to permit the pusher machine to reach the signalled position prior to initiation of the cycle of operations which follows the aforesaid momentary interruption of the power supply to lines 2. Whilst in certain instances the movement of the pusher machine might be visible to control station personnel, in many instances it will not be so visible and in order that the control station personnel may be aware of the readiness of the pusher machine for its cycle of operations to be initiated at the selected oven, the control circuit includes a feed-back device 47 (FIGURE 2B) which provides a signal during movement of the pusher machine.

It will be noted that the device 47 is wired in parallel with the motor relay 19 so as to be energized simultaneously with the latter. The device 47 may take any convenient form and may for instance comprise a visual signalling device such as a lamp or an audible signalling device such as a bell or hooter, or it may comprise a transmitter associated with the power lines 2 and adapted to send a high-frequency signal of suitable form back to the control station to be picked-up there by a suitable receiver.

Also it will be understood that an interval must elapse between the receipt of a "direction" pulse by the receiver 3 and setting up of the control circuit to accept "position significant" pulse trains. To prevent premature sending of "position significant" pulse trains, the timing device 11 is shunted by a feed-back device 48 in series with break contacts 11*c* which open shortly after closing of the contacts 11*b* of the device 11. Accordingly, the device 48 will be energized during the interval which elapses between the receipt of a "direction" pulse and the readiness of the control circuit to receive "position significant" pulses. The device 48 may take any of the forms discussed above in connection with the feed-back device 47.

The above described control system provides for remote control of the movement and operation of the pusher machine of a horizontal coke-oven battery. It will, of course, be readily understood that the movement and operation of the coke-guide machine could be controlled from a remote control station by means of a fundamentally similar system whilst the movement of the coke car could be similarly controlled as could also the movement of the charging car on the top of the battery.

In the case of the coke-guide machine, the "direction" pulses and the "position significant" pulses applied to the power lines 2 for the pusher machine as described above may simultaneously be applied to the power lines to the coke-guide machine since the latter, of course, has to be positioned adjacent to the same oven as the pusher machine for every discharge operation. Consequently, "direction" and "position significant" signals of the same frequency could be injected into the central power supply for the installation to bring about the required movements of the pusher machine and the coke-guide machine.

In the case of other machines and equipment, such as the charging car, position and control signals would preferably be of a different frequency from those used for the pusher machine and coke-guide machine to avoid the risk of signals for one machine affecting another.

Although the above described arrangement provides control of the basic movements and operations performed by the pusher machine of a horizontal coke-oven battery, it is to be understood that if such machine were equipped with other mechanisms to perform further functions, such mechanisms could be controlled directly from the control station by suitable signals sent over the power lines 2, or such functions could be brought about in the required sequence by arrangements similar to those for producing sequential movements and operations of the door extractor, door hooks and pusher ram as described above.

For example, at the termination of the cycle of the arrangement described above, closing of contacts of limit switch 34 could initiate movement of the machine to align a leveller bar with the replaced oven door, followed by appropriate strokes of the leveller to level the charge introduced into the open following replacement of its doors; in this instance it would be necessary to provide a suitable interlock to coordinate leveller movement with the completion of charging.

Moreover, if the pusher machine were equipped with mechanism for cleaning the sealing surfaces of the door and/or door frame of an oven being discharged, such mechanism could be arranged to function as and when required in the whole cycle of operation of the pusher machine.

The high-frequency signals injected into the power lines 2 may have any suitable frequency, frequencies of the order of 100 kcs. being at present preferred.

We claim:

1. A system for controlling a machine in the conduct of certain mechanical procedures in connection with the operation of a coke-oven battery comprising a control station, means for carrying electric power from a power source through said control station to said machine, transmitting means in said control station for superimposing high-frequency positional-significant signals on said power

carrying means, means on said machine responsive to the high-frequency signals from said transmitting means for controlling the operation of said machine, said control means comprising first means connected to said power carrying means for automatically selecting a position to which said machine is to be moved in response to the high-frequency signals, second means connected to said power carrying means for connecting said power carrying means to said machine in response to the high-frequency signals whereby power is supplied thereto, third means mounted on said machine and actuated by movement of said machine for automatically sensing the position of said machine, fourth means connected to said first means and to said third means for impressing on said first means the position sensed by said third means and fifth means connected between said power carrying means and said second means for deactivating said second means in response to coincidence between the sensed position of the machine and the position selected therefor.

2. A control system substantially as described in claim 1 wherein the first means comprises an automatic selector switch having a first set of banks of contacts and a wiper which may be stepped from one bank of contacts to another and said fourth means comprises a wiper arm, a second set of banks of contacts connected in order to said first set of contacts, a forward and a reverse driving magnet.

3. A system for controlling a machine in the conduct of certain mechanical procedures in connection with the operation of a horizontal coke-oven battery comprising a control station, means for carrying electric power from a power source through said control station to said machine, transmitting means in said control station for superimposing high-frequency positional-significant signals on said power carrying means, means on said machine responsive to the high-frequency signals from said transmitting means for controlling the operation of said machine, said control means comprising first means connected to said power carrying means for automatically selecting a position to which said machine is to be moved in response to the high-frequency signals, second means connected to said power carrying means for connecting said power carrying means to said machine in response to the high-frequency signals whereby power is supplied thereto, third means mounted on said machine and actuated by movement of said machine for automatically sensing the position of said machine, fourth means connected to said first means and to said third means for impressing on said first means the position sensed by said third means, fifth means connected between said power carrying means and said second means for deactivating said second means in response to coincidence between the sensed position of the machine and the position selected therefor and sixth means connected between said third means and said power carrying means for inching said machine into the selected position.

4. A system for controlling a machine in the conduct of certain mechanical procedures in connection with the operation of a horizontal coke-oven battery comprising a control station, means for carrying electric power from a power source through said control station to said machine, transmitting means in said control station for superimposing high-frequency positional-significant signals on said power carrying means, means on said machine responsive to the high-frequency signals from said transmitting means for controlling the operation of said machine, said control means comprising first means connected to said power carrying means for automatically selecting a position to which said machine is to be moved in response to the high-frequency signals, second means connected to said power carrying means for connecting said power carrying means to said machine in response to the high-frequency signals whereby power is supplied thereto, third means mounted on said machine and actuated by movement of said machine for automatically sensing the position of said machine, fourth means connected to said first means and to said third means for impressing on said first means the position sensed by said third means, fifth means connected between said power carrying means and said second means for deactivating said second means in response to coincidence between the sensed position of the machine and the position selected therefor, sixth means connected between said third means and said power carrying means for inching said machine into the selected position and seventh means for signaling back to the control staiton of the completion of the operation.

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