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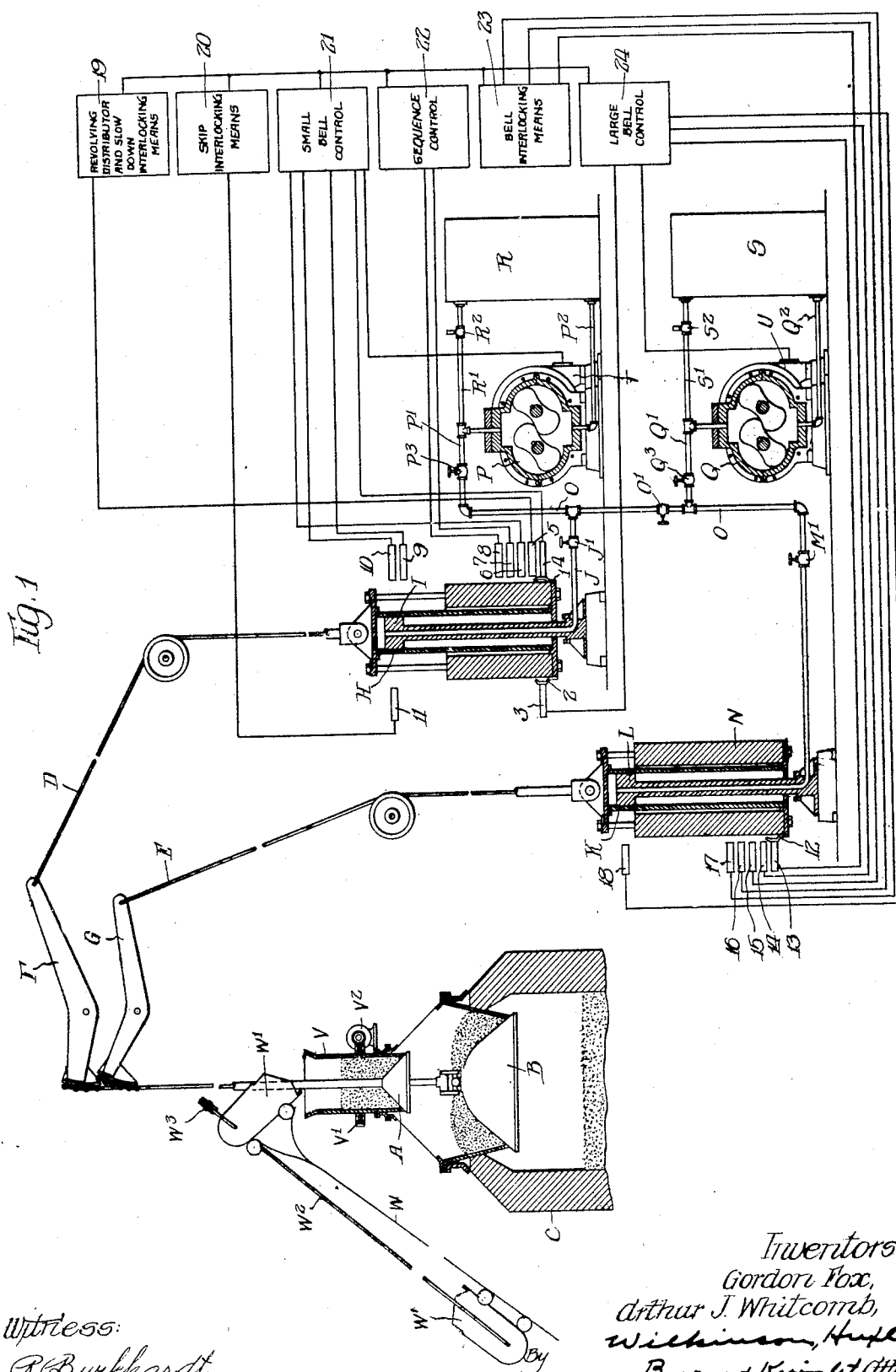
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1,937,951

BLAST FURNACE CHARGING SYSTEM

Filed July 13, 1927

3 Sheets-Sheet 1



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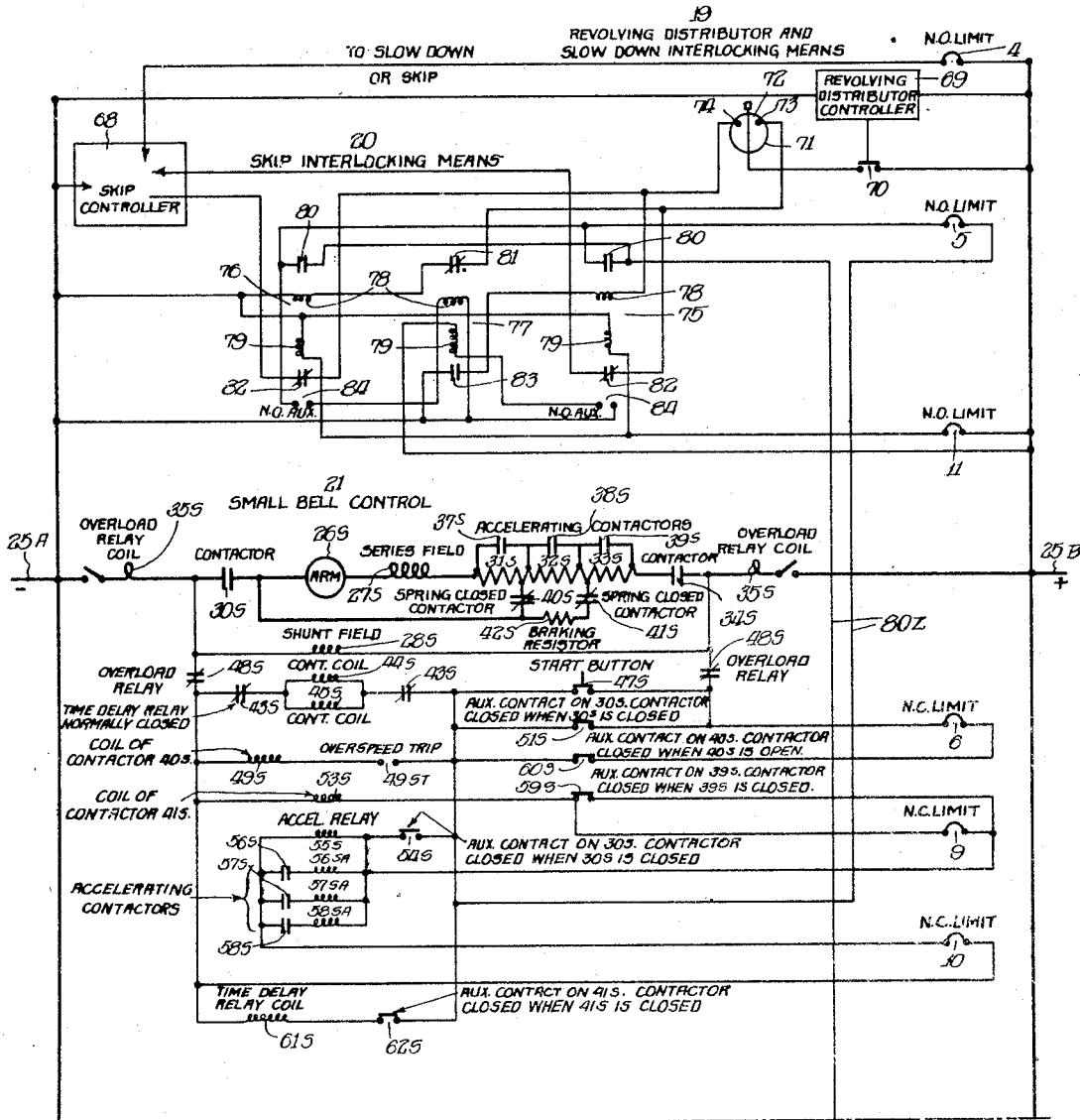
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3 Sheets-Sheet 2

Fig. 2
PART A



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UNITED STATES PATENT OFFICE

1,937,951

BLAST FURNACE CHARGING SYSTEM

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Application July 13, 1927. Serial No. 205,400

21 Claims. (Cl. 214—37)

The present invention relates to blast furnace charging systems.

More particularly the present invention relates to a control system for charging a blast furnace or the like in which the various instrumentalities employed in charging said blast furnace or the like are controlled to operate in a predetermined sequence. It is common practice to provide a blast furnace with two charging bells, commonly termed the large bell and the small bell; or equivalent means may be used instead of one or the other or both of said bells. It is also common practice to provide a skip or a pair of skips for lifting material to the top of the blast furnace, which skip or skips are dumped at the upper region of travel. It is also common practice to provide a distributing device for distributing the material dumped from the skip or skips. It is also common practice to charge material upon the small bell or its equivalent, and to dump each charge before the large bell is opened to allow said material to fall into the furnace. In order to avoid losses, the large bell should be closed when the small bell is open, and, conversely, the small bell should be closed when the large bell is open. The present invention contemplates the utilization of means for interrelating the actions of the elements referred to, and contemplates a control system to that end.

An object of the present invention is to provide an improved blast furnace charging system involving such instrumentalities as have been mentioned above, or their equivalents, which system will have interlocking means whereby part or all of the following advantages may be had: to prevent operation of the skip or skips and the small bell while the distributing means is in motion; to prevent either of the skips from dumping upon the open small bell; to cause the small bell to open automatically at the time either of the skips is started on its upward trip by the operator; to prevent the next succeeding trip of a skip unless the small bell has been fully opened to dump the previous charge; to cause the small bell to open, to remain open for a set interval, and to close, which operation is dependent upon the operation of the skip or skips; to cause a predetermined sequence for the purpose of causing the large bell to open after a predetermined variable number of dumps of the small bell in one portion of a charging round and causing the large bell to open after a predetermined variable number of dumps of the small bell in another portion of the charging round, which predetermined number of dumps in one of said portions

of a round may be different from the number in said other portion of said round; to allow the number of dumps of the small bell before the large bell operates to be readily varied at the will of the operator; to interlock the operation of the large and small bells whereby the small bell is prevented from operating (after the sequence control has started the large bell control to function) unless and until the large bell has completed its operation; to prevent the small bell from operating in the event that the large bell does not function completely and to stop the skip mechanism and to prevent the dumping of a further charge upon the small bell in the event that the large bell does not function completely; and to cause the large bell to function to open and close in response to a predetermined number of operations of the small bell, which predetermined number may be readily varied at the will of the operator.

A further object of the present invention is to provide a blast furnace charging system which is well adapted to meet the needs of commercial operation and which will enable an operator to charge a blast furnace in a minimum of time.

A further object is to provide a blast furnace charging system utilizing instrumentalities which are relatively inexpensive and which occupy a minimum of space, which will not only cut down the labor incident to charging, but which will enable the operator in a minimum of time to provide a desired distribution of the various materials within the blast furnace.

Further objects will appear as the description proceeds.

Referring to the drawings—

Figure 1 is a view, which is more or less diagrammatic, illustrating a blast furnace charging system embodying the principles of the present invention; and

Figure 2 is a wiring diagram illustrating diagrammatically the electric control system involved in the layout shown in Figure 1, said Figure 2, for purposes of clarity, being shown on two sheets and being divided into two parts, *a* and *b*, respectively.

A description of the present invention may be prefaced by a statement of the preferred cycle of operation.

Cycle of operation

A preferred cycle of operation is as follows. The system of control embodied in the present invention provides for automatic dumping of the small and large bells of a blast furnace ac-

cording to a specified round that may be varied as desired. As shown in the accompanying drawings, provision is made for as many as seven dumps of the small bell for each two dumps of the large bell. It will be understood, of course, that if a larger number of dumps of the small bell is desired, this result can be attained by adding more sequence relays. For the purpose of this explanation it may be assumed that the selector switches have been arranged so that a round will consist of three dumps of the small bell followed by a dump of the large bell, after which two more dumps are made by the small bell followed by a dump of the large bell. This round may be considered typical and is used for the purpose of explanation. The possibility of predetermining the number of dumps of the small bell prior to the dumping of the large bell has decided advantages in commercial operation, inasmuch as it allows the charging of a predetermined mixture with a minimum number of trips of the skip hoist. The proportions of coke, ore and stone will, of course, vary under varying conditions. Under certain conditions it may be considered best to charge a load of coke, a mixed load of ore and stone and another load of coke upon the large bell before dumping, after which another load of mixed ore and stone and a load of coke will be deposited upon the large bell, followed by the dumping of the large bell. Under other conditions it may be preferred to have four dumps of the small bell, followed by the dumping of the large bell, after which it is desired to have three dumps of the small bell followed by a dumping of the large bell. A typical round under the conditions just mentioned may be two loads of ore and two loads of coke, followed by the dumping of the large bell, and one load of ore, one load of stone and one load of coke, followed by the dumping of the large bell. These examples are, of course, not to be considered in a limiting sense in any respect, but are cited merely in explanation of the advantage of allowing ready selectability of the sequence of action of the large and small bells.

A description of the sequence of operation for a round is as follows. The scale car operator will throw the skip master switch so as to send up the proper skip, that is—the skip which is at the lower level at that particular time. If the revolving distributor means cooperating with the small bell is motionless, the "revolving distributor and slow-down interlocking means" will permit the skip control to function and the skip will be sent on its way to the top of the furnace. If said revolving distributor is in motion, the skip is automatically held at the bottom of its incline until such time as the distributor has stopped, whereupon the skip then goes up the incline automatically.

At the same time that the skip starts upwardly the "skip interlocking means" is caused to function, which in turn starts the small bell control and causes the small bell to open and close in a predetermined cycle, which preferably includes a period of dwell to permit the load upon said small bell to completely drop away from said small bell. The small bell in normal operation opens and closes in less time than it takes the skip to go to the top of the incline. Hence, when the skip arrives at the dumping point, the small bell is closed and its hopper is empty, ready to receive the charge from the skip. Slow-down means are provided near the upper limit of travel of each skip, and according to the present invention

provision is made for stopping the skip at the slow-down point should the small bell not be closed at the time at which the skip arrives at this point. However, according to the present invention, as soon as the small bell is closed, the skip is automatically carried to the upper limit of its travel and automatically dumped.

Should the small bell fail to dump at any time, provision is made through the "skip interlocking means" for preventing the skip mechanism from starting until such time as the small bell is made to dump, whereupon the skip mechanism automatically resumes its cycle. Hence, the small bell is forced to dump for each load the skip mechanism delivers to it, and the interlocking is such as to prevent the possibility of the small bell receiving two or more loads before dumping. Provision is also made for insuring that the large bell is closed before the small bell can open.

As has been stated above, the small bell is caused to dump after each dump of a skipload of material upon said small bell. Each dumping of the small bell initiates the functioning of the "sequence control". When a predetermined number of skiploads (which predetermined number may be varied at the will of the operator) have been sent up, the "sequence control" actuates the large bell control to cause the large bell to dump.

Provision is also made so that the large bell cannot dump until the small bell is closed. By means of the bell interlocking, provision is made for preventing the small bell from operating until such time as the large bell has dumped. Hence, when the predetermined number of dumps of the small bell have been made, the large bell must dump, or else the small bell is prevented from dumping. If the small bell does not dump, the skip mechanism cannot start. Consequently, the operations of the skip, the small bell and the large bell are not only sequenced, but also are interlocked, so that if one of said instrumentalities does not function properly, operation of the system is stopped. After the dumping of the large bell as above described, more skiploads are sent up, which according to the example above taken are two skiploads. After each of said two skiploads is dumped upon said small bell, said small bell opens to deposit the material upon the large bell. The sequence control then functions to cause the large bell to dump. These operations are also interlocked in the same manner as described for the operations in the first part of a round. These operations complete the desired round described at the beginning of the cycle of operation. The sequence control means, skip interlocking means and bell interlocking means automatically reset themselves for the beginning of the next round, during which the described cycle is repeated.

Description of instrumentalities

Referring now to Figure 1, a system is disclosed wherein counterweighted hydraulic cylinders are connected directly with cables leading to bell levers connected with the large and small bells of the blast furnace. It is the function of each hydraulic cylinder to hoist its corresponding counterweight, thereby permitting the corresponding bell to open by gravity. It is a further function of the hydraulic cylinder to provide a retarding motion during the lowering of the counterweight, whereby to govern the speed of closure of the corresponding bell. In connection with each hydraulic cylinder it is proposed to use a rotary

hydraulic pump, of which there are several types available in commercial use. The particular types of hydraulic pumps contemplated are such that they can be used interchangeably for pumping fluid under pressure or as hydraulic motors to convert hydraulic pressure to rotary motion. The pump referred to is connected to a dynamo-electric machine which operates as a motor or as a generator, depending upon whether said dynamo-electric machine is called upon to perform motor or generator functions. Not only does the hydraulic system function to translate straight line movement to rotary movement, and conversely, but it also functions to translate from high speed motion of the motor with a small torque to a low speed motion of the hydraulic cylinder with large force, or, conversely, from a low speed motion of the hydraulic cylinder with a large force to a relatively high speed motion of the motor with generator functions. The provision of the hydraulic cylinders with their reversible pumps and dynamo-electric machines is not claimed specifically in this application, these instrumentalities forming the subject matter of another application filed by one of the present applicants. It will be understood, of course, that the instrumentalities between the bells and their corresponding dynamo-electric machines may be chosen as preferred, though the hydraulic means illustrated are considered at the present time to be preferable. The cycle of operation of the hoisting mechanism for each bell is accomplished by means not claimed specifically in the present application, said means forming the subject matter of other applications filed by one of the present applicants. It may be briefly stated, however, in explanation of the present invention that in order to open either of the bells the corresponding electric motor is started, driving the hydraulic pump referred to and causing a flow of liquid into the corresponding cylinder, raising the counterweight and allowing the corresponding bell to open. When the bell has opened the desired amount, the motor can be made to slow down and substantially stop, as for example by introducing suitable resistors in series and in shunt with the motor armature. After a predetermined period, or upon the happening of a certain event, the electrical circuits can be changed to allow the counterweight to lower. In so doing, the counterweight will force fluid out of the cylinder and through the rotary pump into a storage reservoir. In so doing, the pump will drive the motor in the reverse direction as a generator. By the provision of suitable braking circuits, which braking circuits will be referred to hereinafter, the retarding effect of the motor may be regulated to thereby govern the speed at which the counterweight is lowered.

Referring to the drawings, the letter A represents one bell and the letter B indicates a second and larger bell, which cooperate with one another in the charging of the blast furnace C. The two bells A and B may be arranged concentrically in a manner which is common in practice, the bell A being controlled by a cable D, while the larger bell B is controlled by the cable E, levers F and G being connected to said cables D and E, respectively, said levers F and G being connected to the bells A and B, respectively. The cable D is connected to the hydraulic cylinder H, which is adapted to have a reciprocating movement along a vertical axis, the inner wall of said cylinder H having fluid-tight sliding engagement with the fluid supply member I, the interior of

which is connected by means of the pipe J to rotary fluid pumps and liquid reservoirs, to be referred to hereinafter, the pipe J being provided with the valve J1. The cable E is connected to the cylinder K, which is adapted to have a reciprocating movement along a vertical axis, the inner wall of said cylinder K having sliding fluid-tight engagement with the fluid supply member L, the interior of which is connected by means of the pipe M to the two rotary pumps and fluid reservoirs above referred to, the pipe M being provided with the valve M1. Each of the cylinders H and K is provided with a counterweight N, which may be chosen of a size suitable for the bell with which it cooperates.

As noted from Figure 1 of the drawings, the pipes J and M are connected to the common pipe O, which common pipe is connected to the corresponding sides of the rotary pumps P and Q through the pipes P1 and Q1. The pipe O is provided with the valve O1 between the pipes J and Q1. The other sides of said rotary pumps P and Q are connected to the oil reservoirs R and S through the pipes P2 and Q2. Pipes P1 and Q1 are provided with the valves P3 and Q3, respectively. The pipes P1 and Q1 are connected to the upper regions of the reservoirs R and S through the relief pipes R1 and S1, respectively, which relief pipes R1 and S1 are provided with the relief valves R2 and S2. Connected to drive the rotary pump P is the dynamo-electric machine T, and similarly connected to drive the rotary pump Q is the dynamo-electric machine U.

Cooperatively associated with the small bell A is the rotary distributor indicated by the letter V, which rotary distributor may take any preferred form, several forms being available in the open market. Said distributor V may be provided with the annular gear V1, which may be driven by the motor V2. The details of the means for driving the distributor V form no part of the present invention except that, as referred to above, the skip mechanism is prevented from operating unless the distributor is motionless. The electric interlock whereby this feature is had will be described hereinafter. The letter W indicates an incline provided with a pair of skips W1—W1, which skips are connected to the two ends of a cable W2 which runs over a sheave W3 disposed at a region above the blast furnace C. The incline W is provided with any preferred abutment means, several forms of which are available in the market, for dumping each skip W1 when it reaches the upper limit of its travel.

A number of limit switches are contemplated in the present invention, which limit switches may be operated in response to travel of the cylinders H and K. The connections and functions of said limit switches will be referred to presently.

Referring to the cylinder H, the framework of said cylinder is provided with a switch operating member 1 and a second switch operating member 2. Said operating member 2 at the lower limit of travel of the cylinder H is adapted to control a switch indicated by the numeral 3, which is normally open, but, being operated by the member 2, is closed only at the bottom of the stroke of the small bell cylinder H. The operating member 1 at the bottom of the stroke of the small bell cylinder H is adapted to operate the switches 4 and 5, both of which switches are normally open. Said switches 4 and 5, being engaged by the member 1 at the bottom of the stroke of the cylinder H, are closed only at the bottom of the stroke of the small bell cylinder. Located above the

switches 4 and 5 is the switch 6, which is normally closed. When engaged by the member 1, said switch 6 is opened, this opening occurring at the slow-down point of the small bell. Above the switch 6 is the switch 7, which is normally open, but when engaged by the member 1 closes momentarily on the up and down stroke of the small bell cylinder H. Above the switch 7 is the switch 8, which is normally open, but when engaged by the member 1 closes momentarily on the up and down strokes of the small bell cylinder. Located at the top of the range of travel of the cylinder H are the switches 9 and 10 adapted to be operated by the member 1 when the small bell A is at full open position. Also located in position to be engaged by the member 1 at the top of the range of movement of the small bell cylinder H (that is, the full open position of the small bell A) is the switch 11, which is normally open and is therefore closed only at the top of the stroke of the small bell cylinder H.

The large bell cylinder K is provided with the switch operating member 12, which at the bottom of the stroke of said large bell cylinder K is adapted to operate the switches 13 and 14, which switches 13 and 14 are normally open and therefore closed only when the large bell cylinder K is at the bottom of its stroke, that is—when the large bell is closed. Above the switches 13 and 14 is the switch 15, which is normally closed and which is opened by the member 12 at the slow-down point of the large bell cylinder K. Above the switch 15 are the switches 16 and 17, both of which are normally open and which are closed momentarily at the slow-down point of the large bell cylinder K by reason of the momentary engagement of the member 12 with said switches 16 and 17. Located in position to be engaged by the member 12 at the top of the movement of the large bell cylinder K is the switch 18, which is normally closed and opens only at the top of the stroke of the large bell cylinder K, which is to say that said switch 18 is open only when the large bell is at full open position. The switches above referred to are connected to the control panels 19, 20, 21, 22, 23 and 24, the connections being referred to more in detail hereinafter.

Control means for the individual bells

The two sides of an electric circuit are indicated by the numerals 25A and 25B. Connected across the leads 25A and 25B is a circuit including the dynamo-electric machine T (which drives the small bell operating cylinder) and various switches and resistors. The armature of said dynamo-electric machine is indicated by the numeral 26S. The series field winding thereof is indicated by the numeral 27S and the shunt field winding thereof is indicated by the numeral 28S. The circuit referred to across the mains 25A and 25B includes the contactor 30S, the armature 26S, the series field winding 27S, the sections 31S, 32S and 33S of an accelerating resistance, and the contactor 34S. Also connected in the circuit referred to is the overload relay coil 35S. The sections 31S, 32S and 33S of the accelerating resistance are adapted to be shunted out of circuit, for which purpose accelerating contactors 37S, 38S and 39S are provided. Connected in parallel across the circuit of the armature 26S, series field winding 27S and section 31S of the accelerating resistance is a shunting circuit controlled by the normally closed contactor 40S. The normally closed spring contactor 41S is provided for connecting the braking resistors 42S across the cir-

cuit including armature 26S, series field winding 27S and sections 31S and 32S of the accelerating resistance. Connected across the mains 25A and 25B is a circuit including the normally closed time delay relay 43S, the operating coils 44S and 45S (which coils are in parallel with each other) and the normally open start button 47S. The normally closed overload relays 48S—48S may be provided in the circuit immediately above described, which overload relays are responsive to energization of the overload relay coil 35S. Connected in parallel relationship with the time delay relay 43S and the coils 44S and 45S is the operating coil 49S for the contactor 40S and the overspeed trip 49ST. If for any reason the speed of the motor T in operating the pump P should become too great, the overspeed trip 49ST will be opened, thereby closing contactor 40S, closing a dynamic braking circuit upon the armature series field and resistor 31S to slow down the motor speed. Arranged in parallel relationship with the start button 47S is the circuit including the slow-down limit switch 6, which is biased to closed position, and the auxiliary switch 60S, which is closed when contactor 40S is open. Also connected in parallel relationship with the start button 47S is the auxiliary contact 51S, which moves in unison with the contactor 30S. Said auxiliary contactor 51S is in closed position when contactor 30S is in closed position. The start button 47S will be used ordinarily only for emergency purposes when it is desired to operate the small bell independently of the sequence control to be referred to hereinafter. Operation of said start button 47S connects the operating coil 49S across the mains 25A and 25B.

Connected in parallel relationship with the circuit of the coil 49S and the trip 49ST is a circuit including the operating coil 53S, the normally closed limit switch 9 and the auxiliary switch 54S, which switch 54S is closed when contactor 30S is closed. Connected across the circuit of the operating coil 53S, the normally closed limit switch 9 and the auxiliary switch 54S is a circuit which includes the normally closed limit switch 10 and the parallel circuit which includes the operating coil 55S of the accelerating relay which embodies the switches 56S, 57S and 58S, which switches control the coils 56SA, 57SA and 58SA, respectively, which coils in turn control the contactors 37S, 38S and 39S, respectively. In parallel with the limit switch 9 is the auxiliary contact 59S, which contact is an auxiliary contactor on the contactor 39S and is closed when contactor 39S is closed.

Across the circuit including the operating coil 49S and the overspeed trip 49ST is a circuit including the operating coil 61S for the time delay relay 43S and the auxiliary contact 62S, which auxiliary contact 62S is closed when the normally closed contactor 41S is closed.

The operating circuit for the small bell control may conveniently be located upon the panel indicated in Figure 1 by the numeral 21.

The control system for operating the large bell is similar in a number of respects to the system for controlling the small bell, and like parts are indicated by like numerals, the numerals which refer to the large bell being provided with the suffix L instead of the suffix S.

A description of the motor circuit cooperating with the large bell including the shunt field thereof will be clear from the description above applying to the small bell, with the exception that in the large bell control the contactor 41L is a back

contactor upon the contactor 30L and is closed when contactor 30L is open, and, conversely, is open when contactor 30L is closed.

Connected across the mains 25A and 25B is a circuit which includes the normally closed limit switch 18, the up relay coil 63 and the normally open start button 47L. The start button 47L is provided for emergency purposes and is in parallel circuit with the switch 140 of relay 64, which will be referred to hereinafter, said switch 140 having in series therewith the limit switches 3 and 13. Mounted to move in response to energization of the up relay coil 63 is the auxiliary contact 65, which is normally open but which is closed when the up relay coil 63 is energized. Said auxiliary contact 65 is in parallel with the start button 47L and with the circuit above referred to, which includes the switch 140 of the relay 64 and limit switches 3 and 13. Also mounted to operate in response to the up relay coil 63 is the up relay switch 66, which is normally open and which is connected across the mains 25A and 25B in a circuit which includes the normally closed limit switch 18, contactor coils 44L and 45L (in parallel), the auxiliary contact 60L of contactor 40L and said up relay switch 66. Said contactor 60L is normally open and is closed when contactor 40L is closed. Also connected to operate in response to the up relay switch 66 is the auxiliary contact 67, which is normally open and closes when up relay switch 66 closes. Said up relay auxiliary contact 67 is connected across the mains 25A and 25B in a circuit which includes the operating coil 49L of contactor 40L, the over-speed trip 49LT and said auxiliary contact 67. Shunted across the auxiliary contact 67 is the normally closed limit switch 15. Also connected in circuit across the mains 25A and 25B is a circuit including the coil 55L of the accelerating relay embodying the switches 56L, 57L and 58L. Said circuit includes the normally closed limit switch 18, the operating coil 55L of the accelerating relay and the auxiliary contactor 54L. Said auxiliary contactor is mounted on contactor 44S of small bell control and is closed when contactor 44S is closed. When said coil 55L is energized, switches 56L, 57L and 58L are closed in succession, energizing coils 56LA, 57LA and 58LA in succession to cause the closure of the accelerating contactors 37L, 38L and 39L to short-circuit the starting resistors 31L, 32L and 33L.

Revolving distributor and slow-down interlocking means

It is one of the features of the present invention that neither skip shall be allowed to pass the slow-down point on its travel to the top of the furnace unless the small bell is in closed position. It is another feature of the present invention that the skip may not be operated unless the revolving distributor is motionless. The controls for producing these results may form part of panel 19. Connected across the mains 25A and 25B is a circuit which includes the skip controller 68 and the normally open limit switch 4. The skip controller may be of any of the well known commercial forms and will have the function of starting the skip when switch member 4 is closed, which is to say—when the small bell is at or near closed position; or, expressed in other language, when the cylinder H is at or near its lowermost position. Other connections, to be referred to hereinafter, are made to the skip controller, interlocking said skip controller with the other mechanism of the system. The numeral 69 indi-

cates the control means for the revolving distributor V. Said control means forms no part of the present invention and is shown as connected in circuit across the mains 25A and 25B. A mechanical connection is provided between the control means 69 and a normally closed contactor 70, to be referred to hereinafter. Said contactor 70 is in closed position only when the control means 69 and consequently the distributor V are not operating; the idea being that said distributor V will revolve through a portion of a revolution after each dumping of the skip to deliver successive loads of material to spaced portions of the large bell to provide uniform charging of the furnace.

Skip interlocking means

The present invention contemplates a system in which the operator may by moving a simple switch to either of three selectable positions cause the system to be stopped, to operate the skip hoisting mechanism for raising one of the skips or to operate the skip hoisting mechanism to hoist the other of said skips. Inasmuch as it is usual practice to connect the two skips by means of a cable, as shown in Figure 1, the switching mechanism referred to will have the function of controlling the direction of rotation of a motor for driving the cable which operates said skips. The switching mechanism referred to is indicated by the numeral 71 and will be termed a "master switch". Said switch 71 includes the relatively movable switch member 72 adapted to selectively engage the relatively stationary contacts 73 and 74. The means for interlocking the skips and the bells includes three relays 75, 76 and 77, of which relays 75 and 76 may be identical and of which relay 77 may be similar in many respects to relays 75 and 76. Each of said relays 75, 76 and 77 includes an operating coil 78 and a trip coil 79. Each of said relays 75, 76 and 77 is a latched relay which is latched in position when closed but which moves to unlatched position when its corresponding trip coil 79 is energized. Relays 75 and 76 include the normally open contactors 80—80 and the relay 77 includes the normally closed contactor 81. Said relays 75 and 76 also include the normally closed contactors 82—82, and the relay 77 includes the normally open contactor 83. Contactors 75 and 76 also include the normally open auxiliary contactors 84—84.

It will be noted that each of the relatively stationary contacts 73 and 74 is connected through one of the normally closed contactors 82 to the skip controller 68, whereby the skip controller may be energized to start the driving motor of the skip mechanism in either the forward or reverse direction, as desired, to raise either of the two skips. Engagement of the movable contact member 72 with either contact 73 or contact 74 closes a shunt circuit across the start button 47S in the following manner. If contact 73 is engaged, circuit is completed from main 25B, through contactor 70, contactor 81 of relay 77 and operating coil 78 of the relay 76, to the main 25A. Similarly, if contact 74 is engaged, circuit is completed through the operating coil 78 of the relay 75, through the contactor 83 of relay 77 to main 25A. Closure of the contactor 80 on either relay 75 or 76 completes an interlocking circuit 80Z, which is in shunt with the start button 47S as follows: From left-hand side of start button 47S, through the normally open limit switch 5, through contactor 80 of either relay 75 or 76, 150

through the sequence control 22, to be referred to hereinafter, and through the bell interlocking means 23 to be referred to hereinafter, through the normally open limit switch 14, to the main 25B, which is connected to the right-hand side of the start button 47S. Operation of the master switch 71 will therefore accomplish the starting of the motor T for driving the small bell B. When the small bell reaches or approaches full open position, which corresponds to a raised position of the corresponding bell cylinder H, the normally open limit switch 11 will be closed, energizing the two trip coils 79—79 of the relays 75 and 76, resulting in the unlatching of the relay 75 or 76, depending upon which one has been moved to latched position, thereby opening the corresponding contactor 80. By reason of relay 77 it is rendered certain that once the operator has made a choice as to whether he shall raise one skip or the other he cannot cause damage by throwing the master switch 72 to the other of the selectable positions. This advantage accrues from the fact that the relays 75 and 76 are provided with switches controlling locking means, which switches are indicated by the numerals 84—84. It will be noted from the drawings that the normally open auxiliary contactor 84 of relay 75 controls the trip coil 79 of relay 77 and the normally open contactor 84 of relay 76 controls the operating coil of relay 77. The normally open auxiliary contactor 84 of relay 75 is adapted to connect the trip coil 79 of relay 77 directly across the mains 25A and 25B. The normally open contactor 84 of relay 76 connects the operating coil 78 of relay 77 in circuit from the main 25A through circuit 80Z, above referred to, which may be traced as follows: Through the operating coil 78 of relay 77, auxiliary contactor 84 of relay 76, through the contactor 80 (now closed) of either relay 75 or relay 76, through the sequence control 22 to be referred to hereinafter and the bell interlocking means 23 to be referred to hereinafter, and through the normally open limit switch 14 to the main 25B. If the operator has engaged contact 72 of the master switch 71 with the stationary contact 73 of said master switch, he will, as above described, start the corresponding skip on its upward travel and will complete a circuit across the start button 47S, as above described. While the corresponding skip is being raised, the small bell will be dumped and will return to its closed position ready to receive a load from the upgoing skip. The action of the operator in closing contact 72 upon contact 73 has resulted in the closure of contactor 80 of relay 76, which is latched in closed position and is not unlatched and allowed to open until the normally open limit switch 11 has been closed, which closure occurs when the bell is at or near its full open position. When the contactor 80 of the relay 76 is closed, the auxiliary contactor 84 is also closed, which has energized the operating coil 78 of relay 77, which opens the contactor 81, deenergizing the operating coil 78 of said relay 76. Under these circumstances the operator cannot cause a second operation of the small bell except by moving the movable contact 72 of master switch 71 into engagement with the opposite stationary contact 74, inasmuch as circuit from contact 73 is open at the contactor 81. He may, however, complete circuit through the contact 74, energizing the operating coil 78 of relay 75 through the contactor 83, which is now closed, to the main 25A. This

interlocking mechanism renders it certain, therefore, that the small bell cannot be opened except in response to reversals of the skip driving mechanism. Conversely, after the operator has engaged contactor 74 and has caused the operation of the small bell, he cannot cause the next succeeding operation of the small bell except by throwing the contact 72 into engagement with the contactor 73.

Bell interlocking means

It is a feature of the present invention that when the time comes for the large bell to operate it must complete its operation; otherwise the remainder of the equipment is prevented from operating. This feature is accomplished by means which will now be described. The bell interlocking means includes the relays 90, 91 and 92. All of said relays 90, 91 and 92 are latch relays, remaining closed after having been moved to closed position until said latches are tripped open by means presently to be described. Each of said relays includes an operating coil 93 and a trip coil 94. Relays 90 and 91 include the normally closed switches 95 and 96, respectively, and the relay 92 includes the normally open switch 97. The relay 90 is provided with the normally open auxiliary contact 98 and the normally closed auxiliary contact 99. Relay 91 is provided with the normally closed auxiliary contact 100 and the normally open auxiliary contact 101. Relay 92 is provided with the normally closed auxiliary contacts 102 and 103.

Referring to the interlocking circuit 80Z across the start button 47S of the small bell, which interlocking circuit is above referred to, circuit may be traced from the left side of the start button 47S, through normally open limit switch 5, through contactor 80 of either relay 75 or 76, through the sequence control in a manner to be hereinafter more fully referred to, through the normally closed switch 96 of the bell interlocking means 23 and normally open limit switch 14, to the main 25B which is connected to the right-hand side of the start button 47S. Bridged across the normally closed switch 96 of the relay 91 is a circuit which includes in series the normally closed switch 95 and the normally open switch 97 of relays 90 and 92, respectively. Connected across the mains 25A and 25B is a circuit which may be traced from main 25A, through the three trip coils 94 in parallel, through the auxiliary contact 98, through the normally open limit switch 16 and through the normally closed auxiliary contact 104 on contactor 34L of the large bell control to the main 25B. Also connected across the mains 25A and 25B is a circuit including the normally open auxiliary switch 101 of relay 91, the operating coil 93 of relay 92, the normally open limit switch 17 and through the normally closed auxiliary contact 105 on contactor 34L of the large bell control. Connected across the mains 25A and 25B is another circuit which may be traced from the main 25A through the first dump bus (to be described hereinafter) of the sequence control 22, through the operating coil 93 of relay 91, the normally closed auxiliary contact 102, to the main 25B. The operating coil 93 of relay 90 is connected in a circuit from the main 25A, through the second dump bus (to be referred to hereinafter) of the sequence control 22, to the main 25B. The normally closed auxiliary contacts 99, 100 and 103 are connected in series in a circuit across the mains 25A and 25B, which circuit is included in the sequence control

22 to be described hereinafter. Said circuit is an interlocking circuit which insures that the bell interlocking relays 90, 91 and 92 must be at their normal positions for the beginning of a round before the remainder of the equipment is permitted to resume its cycle of operation.

Sequence control

The function of the sequence control is to enable the operator to predetermine the number of dumps of the small bell before the dumping of the large bell, and to predetermine the ratio between the numbers of dumps of the small bell before and after a dump of the large bell.

The numeral 106 indicates the first dump bus and the numeral 107 indicates the second dump bus. The numeral 108 indicates the first of a series of relays. Thirteen relays are indicated in the sequence control 22, which relays bear the numerals 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119 and 120. Said relays 108-120 may be identical, each being a latched relay which will remain closed when moved to closed position but which will move to open position when tripped. Each of said relays 108-120, inclusive, includes the normally open switch 121, the operating coil 122, the trip coil 123 and the normally closed auxiliary switch 124. The operating coil 122 of the relay 108 is connected across the mains 25A and 25B, through the normally open limit switch 8 and the normally closed auxiliary contact 125 on contactor 34S of the small bell, to the main 25B. Said auxiliary contact 125 on the contactor 34S is closed when contactor 34S is opened, and, conversely, is open when contactor 34S is closed. Said coil 122 of relay 108 controls the closing of the normally open switch 121 of said relay 108. When said switch 121 is closed, the operating coil 122 of relay 109 is connected across the mains 25A and 25B, through the normally open limit switch 7 and the auxiliary contact 125. Said operating coil 122 of relay 109 controls the normally open switch 121 of said relay 109. When said switch 121 of relay 109 is closed, it closes circuit of the operating coil 122 of the next relay, which is 110, connecting same in circuit from main 25A, through the switch 121 of relay 108, through the operating coil 122 of relay 110, through the switch 121 of relay 109, normally open limit switch 8 and auxiliary contact 125 to the main 25B. In like manner, the closure of each relay 108-120, inclusive, causes the energization of the operating coil of the next succeeding relay (of those relays which are connected to the first and second dump buses, through the selector switches to be referred to hereinafter) in the order in which said relays have been indicated in Figure 2 of the drawings.

Seven selector switches have been indicated in Figure 2, which bear the numerals 126, 127, 128, 129, 130, 131 and 132. Said switches 126 to 131, inclusive, are shown as single pole double throw switches, though in practice the first of said switches (126) will rarely be thrown to connect to the second dump bus. Switch 132 is a single pole single throw switch, the movable blade of which is adapted to engage the second dump bus 107. The movable blade of the switch 126 is connected to a point between the switches 121 of relays 108 and 110. Similarly, the movable blade of switch 127 is connected to a point between the switches 121 of relays 110 and 112. The movable blades of switches 128, 129, 130, 131 and 132 have similar relationship with relays 112-114, 114-116, 116-118 and 118-120, re-

spectively. The blades of switches 126 to 131, inclusive, may be selectably engaged with either the first dump bus 106 or the second dump bus 107. The movable blade of each of the selector switches 126 to 132, inclusive, is connected through a corresponding signal light 133 to indicate at all times to the operator just what part of the round is being accomplished at any particular instant; or, expressed in other language, which skipload in order is being handled by the small bell. This will be understood from the fact that for each dump of the small bell a corresponding relay 108, 110, 112, 114, 116 or 120 is operated to close its switch 121, whereby to connect the corresponding signal light 133 in circuit across the mains 25A and 25B.

The first dump bus 106 may be connected to the main 25A through any one of the selector switches 126 to 131, inclusive, and through one or more of the switches 121 of relays 108, 110, 112, 114, 116 or 118. Said first dump bus is connected through the normally closed switch 135 of latched relay 134 and through the operating coil 139 of the large bell relay 64 to the main 25B. The relay 134 includes the normally closed switch 135, the operating coil 136, the trip coil 137 and the auxiliary switch 138, which is closed when switch 135 is closed and open when switch 135 is open. The relay 64 includes the operating coil 139 and the normally open switch 140. Closure of the switch 140 bridges the start button 47L of the large bell. The large bell control 24 is thus caused to function to cause the opening of the large bell B. Reference may now be had to the up relay 66 of the large bell control. As described above, the bridging of the start button 47L closes the up relay 66 of the large bell control, causing the upward movement of the large bell cylinder K, which results in the opening of the large bell. Moreover, closure of the up relay 66 closes a circuit from the main 25A through those relays 108-110, 112-114, 116-118 which have been closed, through the first dump bus, through the operating coil 136 of the relay 134, through the up relay 66, to the main 25B. Energization of said coil 136 results in the opening of switch 135 of relay 134, interrupting the circuit of the operating coil 139 of the large bell relay 64. The numeral 141 indicates a relay including the switch 142 and the operating coil 143, which relay 141 may be termed "second dump bus transfer relay". The operating coil 143 is connected across the mains 25A and 25B through one or more of the switches 121 of those relays 108, 110, 112, 114, 116, 118 and 120 which are closed, and through the selector switch 126 to 132, which has been engaged with the second dump bus 107. Energization of the operating coil 143 closes switch 142, connecting the second dump bus through the relays immediately above referred to, through operating coil 139 of large bell relay 64 to the main 25B. Energization of coil 139 results in the closure of switch 140, bridging the start button 47L of the large bell and inaugurating the functions of the large bell in a manner which will be understood from the description above in connection with the energization of the first dump bus 106.

The numeral 144 indicates a return relay having the normally open switch 145, the operating coil 146, the trip coil 147 and the normally closed auxiliary switch 148, which closes when the switch 145 opens. Circuit is completed through the operating coil 146 from the second dump bus, which is now energized, through said operating coil 146, 150

through the up relay 66, to the main 25B. Energization of the coil 146 closes the switch 145. Inasmuch as the relay 144 is a latched relay, said relay will remain closed until tripped open. Circuit is now complete through the trip coils 123 of relays 108 to 120, inclusive, and also through the trip coil 137 of relay 134, resulting in restoring all of said relays to normal position, which closes the auxiliary contacts 124 of said relays 108 to 120, inclusive, and auxiliary contact 138 of relay 134. Auxiliary contacts 99, 100 and 103 in the bell interlocking means 23 are closed when the large bell closes at the end of a round, so that circuit is completed from the main 25A, through certain of the auxiliary contacts 124, through auxiliary contacts 100, 103 and 99, through the remainder of the auxiliary contacts 124, through auxiliary contact 138 and trip coil 147, through the switch 145, which is now closed, to the main 25B. Energization of the trip coil 147 restores the relay 144 to its normal position, closing the normally closed auxiliary contact 148 and closing the interlocking circuit 80Z between the skip interlocking means, sequence control and bell interlocking means.

The numeral 149 indicates a normally open emergency switch which may be operated to connect the operating coil 143 of the second dump bus transfer relay 141 directly across the mains 25A and 25B, thereby permitting emergency operation of the large bell.

Statement of function

The function of the above described instrumentalities will be described with reference to six parts, which are so interrelated as to cause the successive operations of the charging equipment to be performed according to a definite schedule. The six parts referred to are as follows:

- I. Revolving distributor and slow-down interlocking means.
- II. Skip interlocking means.
- III. Small bell control.
- IV. Sequence control.
- V. Bell interlocking means.
- VI. Large bell control.

A brief statement of the functions of the six parts above enumerated is as follows:

I. The auxiliary contactor 70 of the revolving distributor interlocking means 19 is provided to prevent operation of the skip mechanism and of the small bell A while the revolving distributor is in motion. The slow-down interlock 4 is provided to stop the skip at slow-down in case the small bell has not fully closed when either of the skips reaches the slow-down point, approaching the dumping position.

II. The skip interlocking means 20 is provided to automatically cause the small bell A to open at the time either skip is started up by the operator. This control also prevents the next skip from going up unless the small bell has been fully opened in dumping the previous charge. This prevents loading more than one skipload on the small bell.

III. The small bell control 21 causes the small bell A to open, hold open for a set interval, and close. This operation is initiated by the skip master switch 71 and is dependent upon the skip interlocking means 20 as described in paragraph II above.

IV. The sequence control 22 is provided for the purpose of causing the large bell B to open after a set number of dumps of small bell A. The num-

ber of dumps of small bell A before the large bell B operates can be varied at the will of the operator by means of selector switches 126-132, inclusive. Combinations may be made such as to give—say two dumps of small bell A, followed by dumping of large bell B, then say three dumps of small bell A before large bell B dumps again, after which the cycle is repeated. The number of dumps of the small bell before each dump of the large bell may be varied in combinations similar to the above at the will of the operator.

V. The bell interlocking means 23 is for interlocking the operation of the large and small bells. This interlocking means prevents the small bell from operating (after the sequence control 22 has started the large bell control to function) unless and until the large bell has completed its operation. If the large bell does not function completely, the small bell is prevented from dumping additional charge upon the large bell, and the ascending skip in turn is stopped at slow-down and prevented from dumping further charge upon the small bell.

VI. The large bell control 24 causes the operating mechanism for the large bell to function so as to open and close the large bell at the intervals set by the sequence control 22.

Cycle of operation

The normal cycle of operation is as follows:

This system of control provides for automatic dumping of small and large bells, according to a specified round that may be varied as desired. As shown in Figure 2, provision is made for as many as seven dumps of the small bell for each two dumps of the large bell. More dumps than seven per round can be obtained by adding more sequence relays. For the purpose of this explanation it may be assumed that the selector switches (126-132) have been arranged so that a round will consist of four dumps of the small bell followed by a dump of the large bell, after which two more dumps are made by the small bell followed by a dump of the large bell. This round may be considered typical and is used for the purpose of explanation. A description of the sequence of operation for a round follows:

The operator throws the skip master switch 71 so as to send up the proper skip, that is—the skip which is at the bottom of the incline. If the revolving distributor V has ceased to revolve, the revolving distributor and slow-down interlocking means 19 will permit the skip controller 68 to function and send the skip up the incline. If the distributor V has not stopped revolving, the skip is automatically held at the bottom of the incline until such time as said distributor V has stopped, whereupon the skip then goes up the incline without further attention on the part of the operator.

At the same time that the skip starts, the skip interlocking means 20 is caused to function, which in turn starts the small bell control 21 and thereby causes the small bell A to open and close.

The small bell A opens and closes in less time than it takes a skip to go from the bottom to the top of the incline. Hence, when a skip arrives at the dumping point, the small bell A is in closed position and its hopper is empty, ready to receive the charge from said skip. Provision is made to bring to a complete stop the ascending skip at the slow-down point should the small bell not be closed at the time at which said skip arrives at this point. After such an

event said skip automatically dumps as soon as the small bell is closed.

Should the small bell fail to dump at any time, provision is made through the skip interlocking means 20 for preventing the skip mechanism from starting until such time as the small bell is made to dump, whereupon the skip mechanism automatically resumes its cycle. Hence, the small bell is forced to dump for each load the skips deliver to it, and the interlocking is such as to prevent the possibility of the small bell receiving two or more loads before dumping.

Provision is also made to insure that the large bell be closed before the small bell can open.

As has been stated, the small bell is caused to dump for each strip of the skips. Each time the small bell A dumps, the sequence control 22 is caused to function. When the predetermined number of skiploads have been sent up to require the dumping of the large bell, the sequence control 22 actuates the large bell control 24 to cause the large bell B to dump.

Provision is made so that the large bell B cannot dump until the small bell A is closed. By means of the bell interlocking means 23, provision is made for preventing the small bell A from operating until such time as the large bell has dumped. Hence, when the specified number of dumps of small bell A have been made, large bell B must dump, or else the small bell is prevented from dumping. If the small bell does not dump, the skip mechanism cannot start. Consequently it can be seen that the operations of the skip mechanism, small bell and large bell are not only sequenced but also are interlocked so that if they do not follow the prescribed sequence the operation is stopped.

So far the description of the round has included four operations of the skip mechanism, four dumps of small bell A and one dump of large bell B. The cycle is continued and two more skips are sent up, each of which is followed by a dump of the small bell A. The sequence control 22 then functions to cause the large bell B to dump. These operations are also interlocked in the same manner as was described for the operations in the first part of the round.

These operations complete the assumed round described at the beginning of this section. The sequence control 22, skip interlocking means 20 and bell interlocking means 23 automatically reset themselves for the beginning of the next round for which the cycle is repeated.

Mode of operation

A mode of operation is substantially as follows:

I. Revolving distributor and slow-down interlocking means

1. The operator has loaded a skip and desires to send it to top of the furnace C. He throws the master switch 71 either to 73 or 74, depending on which skip is at the bottom of the incline. Assume that the operator throws the master switch to 73.

2. If or when the revolving top V has stopped revolving, a circuit will be completed from 25B through auxiliary contact 70, contactor of revolving distributor control 69 to movable blade 72 of skip master switch 71, through 73 of skip master switch 71, through normally closed switch 82 of relay 75 of skip interlocking means 20, through skip controller 68 to main 25A, thereby starting the skip mechanism.

3. If for any reason the small bell A should

be open when the ascending skip reaches slow-down, normally open limit switch 4 will be open, thereby stopping the skip. This normally open limit switch 4 is closed only when the small bell A is closed, and only under that condition does it permit the ascending skip to pass through its slow-down range and dump without interruption. This prevents the skip from dumping upon an open small bell.

II. Skip interlocking means

1. By the action described in paragraph 1 of Section I under Mode of operation, a circuit is also completed from 73 through the normally closed switch 81 of relay 77, through the closing coil 78 of relay 76 to 25A, thereby closing switch 80 of relay 76 and latching it closed.

2. Closure of switch 80 of relay 76 starts the small bell, as will be described in paragraph 1 of Section III hereinbelow. Closure of switch 80 of relay 76 also results in opening of normally closed switch 82 of relay 76. This interrupts circuit from contact 74 of skip master switch 71 to skip controller 68, thereby preventing the sending up of a successive skip until the small bell A has dumped.

3. Closure of switch 80 on relay 76 also closes the normally open auxiliary switch 84 thereon, which completes a circuit from 25A through the operating coil 78 of relay 77, through the auxiliary switch 84 of relay 76, through the switch 80 of the relay 76, and through the interlocking circuit 80Z which passes through the skip interlocking means 20, bell interlocking means 23 and sequence control 22 (which will be explained in paragraph 14 of Section IV hereinbelow), through limit switch 14 to 25B. This opens normally closed switch 81 of relay 77 and latches it open, and thereby interrupts the circuit to the operating coil 78 of relay 76 (described in paragraph 1 of this section). Switch 80 of relay 76 remains closed, however, for it is a latched relay. The action just described on relay 77 also closes its normally open switch 83, thereby setting the circuit for the next dump of small bell A, as described in paragraph 8 of this section, and also prevents reclosing of switch 80 of relay 76 after it is tripped open as in the next succeeding paragraph.

4. At the top of stroke of the small bell operating cylinder H normally open limit switch 11 closes, which action closes a circuit from 25B, through limit switch 11, through trip coil 79 of relay 76 to 25A, thereby tripping switch 80 of relay 76 open and preventing a second start being made by small bell A when it returns to closed position.

5. Opening of switch 80 of relay 76 opens the normally open auxiliary switch 84 on it, thereby interrupting circuit to operating coil 78 of relay 77 (described in paragraph 3 of this section). The normally closed switch 81 of relay 77 remains open, however, for this is a latched relay.

6. Since normally closed switch 81 of relay 77 is open, it is impossible to close switch 80 of relay 76 to actuate small bell A a successive time from side 73 of skip master switch 71. For this reason, a skip may be started and stopped as many times as is desired on its way up the incline without causing more than one dump of the small bell.

7. A second skipload is sent up by throwing the master switch 71 to 74. This completes a circuit (provided the revolving distributor V has stopped revolving) from 25B, through auxiliary switch 70

on revolving distributor controller 69, through 72 and 74 of skip master switch 71, through normally closed switch 82 of relay 76, to skip controller 68 and to main 25A, thereby starting the skip mechanism.

8. A circuit is also completed from 74 through operating coil 78 of relay 75, through normally open switch 83 of relay 77 (closed in paragraph 3 of this section) to main 25A. This closes switch 80 of relay 75 and latches it closed, thereby completing circuit to start small bell A (described in paragraph 1 of Section III under Mode of operation).

9. Closure of switch 80 of relay 75 also results in opening of normally closed switch 82 of relay 75. This interrupts circuit from contact 73 of skip master switch 71 to the skip controller 68, thereby preventing the sending up of a successive skip until the small bell A has dumped.

10. Closure of switch 80 of relay 75 also closes normally open auxiliary switch 84 on it, completing circuit from 25A through auxiliary switch 84, through trip coil 79 of relay 77 to main 25B. This trips open the switch 83 of relay 77, thereby interrupting circuit to operating coil 78 of relay 75 (mentioned in paragraph 8 of this section). Switch 80 of relay 75 remains closed, however, for it is a latched relay. Tripping of relay 77 closes its normally closed switch 81, thereby setting circuit for operating coil 78 of relay 76 for the next operation of the skip and small bell. As can now be seen, the purpose of relay 77 is to alternately open and close switches in series with the operating coils 78 of relays 75 and 76, thereby causing operation of the small bell only once for each complete ascent of a skip.

11. When small bell operating cylinder H reaches the top of its stroke, normally open limit switch 11 closes, which action closes a circuit from main 25A, through trip coil 79 of relay 75, through limit switch 11 to main 25B, thereby tripping switch 80 of relay 75 open.

12. This cycle is repeated for each successive complete trip of a skip.

III. Small bell control

1. The small bell control is energized from 25B through the interlocking circuit Z referred to above and more fully described in paragraph 14 of Section IV hereof, through switch 80 of relay 75 or 76, as the case may be, (described in paragraphs 1 and 8 of Section II), through normally open limit switch 5 (closed when small bell is closed), through normally closed time delay relay contacts 43S, through operating coils 44S and 45S of contactors 30S and 34S, respectively, to main 25A.

2. This causes contactors 30S and 34S to close, which completes a circuit from 25A, through contactor 30S, through motor armature 26S, through series field winding 27S, through accelerating resistance 31S, 32S and 33S, through contactor 34S, through operating coils 35S of overload relays 48S to main 25B. Armature of motor T now starts to revolve.

3. The closing coil 49S of contactor 40S is energized simultaneously with the closing coils 44S and 45S of contactors 30S and 34S, respectively. The circuit is as described in paragraph 1 of this section, except that from limit switch 5 it passes through overspeed trip contacts 49ST, through coil 49S of contactor 40S to 25A. This causes normally closed contactor 40S to open simultaneously with closure of contactors 30S and 35S. Opening of contactor 40S removes shunt

across armature and series field of the small bell hoist motor T.

4. Closure of contactor 30S closes auxiliary contact 51S on it, which forms a sustaining circuit to 25B (thereby by-passing the circuit to 25B, through limit switch 5 and switch 80 of relay 75 or 76, as described in paragraph 1 of this section).

5. Closure of contactor 30S also closes auxiliary contact 54S on it, which completes a circuit from 25A through operating coil 53S of contactor 41S, through normally closed limit switch 9, through auxiliary contact 54S, through auxiliary contact 51S to 25B. This causes normally closed contactor 41S to open, thereby removing dynamic circuit from motor.

6. Closure of auxiliary contact 54S also completes circuit from 25A to normally closed limit switch 10, through accelerating relay coil 55S, through auxiliary contact 54S, through auxiliary contact 51S to 25B. This causes the relay switches 56S, 57S and 58S to close successively at definite intervals to function.

7. Closure of switches 56S, 57S and 58S successively energizes coils 56SA, 57SA and 58SA of accelerating contactors 37S, 38S and 39S, respectively, thereby successively cutting out steps of the accelerating resistance and putting the motor T directly across the line.

8. Closure of contactor 39S closes an auxiliary contact 59S on it, which shorts out limit switch 9. This causes no action at this time.

9. When small ball operating cylinder H reaches the top of its stroke, it opens up the normally closed limit switches 10 and 9.

10. Opening limit switch 10 opens the circuit through the accelerating relay coil 55S and coils of contactors 37S, 38S and 39S, (described in paragraph 6 of this section). This causes these three contactors to open and thereby inserts the accelerating resistance 31S, 32S and 33S in the circuit of motor T, thereby slowing up the motor.

11. When contactor 39S opens, auxiliary contact 59S on it is opened, which removes the short across limit switch 9, and since limit switch 9 is open (see paragraph 9 of this section), the circuit through coil 53S of contactor 41S (see paragraph 5 of this section) is opened. This causes normally closed contactor 41S to close, placing a shunt around the armature and series field of the small bell motor T. As can now be seen, the operation mentioned in paragraph 8 of this section is for the purpose of necessitating the opening of contactor 39S before the closing of contactor 41S; otherwise there would be a low resistance path from 25A to 25B through the main circuits of the small bell control.

12. The motor is now operating with resistance in series and in shunt with itself and at a greatly reduced speed, which is just sufficient to hold small bell cylinder H at top of stroke; or said motor may be stalled, but developing sufficient torque to hold the cylinder H at the top of its stroke.

13. Closing of contactor 41S (paragraph 11 of this section) closes auxiliary contact 62S on it. This completes circuit from 25A, through coil 61S of time delay relay 43S, through normally closed auxiliary contact 62S, on contactor 41S, through auxiliary contact 51S to 25B.

14. After an interval of a predetermined time (depending upon the setting of time delay relay 43S), the time delay relay contacts open the circuit through the operating coils 44S and 45S of contactors 30S and 34S (described in para-

graph 1 of this section). This opens contactors 30S and 34S, thereby disconnecting the motor armature and series field from the line.

15. However, contactor 41S still remains closed, forming a dynamic braking circuit through armature 26S and series field 27S, through part of accelerating resistance 31S and 32S, through braking resistance 42S, and back to armature 26S. The shunt field 28S of the motor is connected permanently across the line. The counterweight N on cylinder H causes the backflow of oil through the pump P, reversing said pump and driving the dynamo-electric machine T reversely. The dynamic circuit just described restricts the speed of the motor during this movement.

16. As the bell cylinder H approaches the bottom of its stroke, the slow-down point is reached, at which point the normally closed limit switch 6 is opened, thereby opening the circuit to the coil 49S of contactor 40S (described in paragraph 3 of this section). This causes the normally closed contactor 40S to close, thereby decreasing the resistance in the dynamic circuit described in paragraph 15 of this section, which results in greatly decreasing the motor speed, permitting the bell A to seat gently at the end of its stroke.

17. This completes the operation of the small bell.

18. Overspeed trip 49ST operates only if the motor T tends to overspeed. Operation of trip 49ST interrupts the circuit described in paragraph 16 of this section, applying slow-down dynamic circuit to motor T, permitting the small bell A to seat at moderate speed without slam.

IV. Sequence control

1. On each up trip of the small bell cylinder H, the latter closes two limit switches, 8 and 7. However, normally closed auxiliary contact 125 located on contactor 34S of small bell is in series with the supply from 25B to these limit switches. Since contactor 34S is closed on the up stroke of the small bell cylinder H (see paragraphs 1 and 14 of Section III), auxiliary contact 125 is open, thereby rendering ineffective the closure of limit switches 8 and 7 on the up stroke of cylinder H. On the down stroke contact is made on 125, 8 and 7, which affects the sequence control. Hence, it can be seen that for every down stroke of the small bell operating cylinder (up stroke of small bell), these limit switches will close, giving an impulse to the sequence control, as explained hereafter.

2. Limit switch 8 closes momentarily first, thereby completing a circuit from 25B, through auxiliary contact 125, through limit switch 8, through closing coil 122 of relay 108 of sequence control to 25A. This closes switch 121 of relay 108 (and latches it closed) and completes circuit from 25A through switch 121 to selector switch 126. If the selector switch were thrown to first dump bus 106, this would now energize said first dump bus.

3. Limit switch 7 closes momentarily, immediately after limit switch 8 closes, thereby completing a circuit from 25B through auxiliary contact 125, through limit switch 7, through coil 122 of latched relay 109, through switch 121 of relay 108 to 25A, thereby closing and latching closed the switch 121 of relay 109.

4. This action connects coil 122 of next sequence relay 110 to the same circuit as coil 122 of relay 108 (described in paragraph 2 of this section), so that on the next down stroke of

small bell cylinder H, switch 122 of relay 110 will be closed and latched closed.

5. Likewise, closure of switch 122 of relay 110 connects 25A to second selector switch 127, and also connects 25A through switches 122 of relays 108 and 110 to operating coil 122 of relay 111, so that on the next down stroke of small bell cylinder H, closure of limit switch 7 will now close and latch the switch 121 of relay 111 just as it closed switch 121 of relay 109, as described in paragraph 3 of this section.

6. Hence, on each down stroke of the small bell cylinder H, two relays are closed, the first of which connects 25A to a selector switch and the second of which sets the circuit for connecting to the proper sequence relay on the next down stroke of the small bell cylinder.

7. By throwing the proper selector switches so as to connect to the first dump and second dump buses, main 25A will be connected to each bus after the desired number of sequence relays 106 and 107, respectively, have been actuated. For the moment, assume that the fourth selector switch, 129, is thrown to the first dump bus 106 and that the sixth selector switch, 131, is thrown to the second dump bus 107. Then after four skips have been dumped on the small bell A and the small bell opened and closed four times, the switches 121 of the first four sequence relays 108, 110, 112 and 114 will have been latched closed, thereby connecting 25A to the first dump bus 106, which in turn energizes the bell interlocking means 23 and also the large bell control 24 to cause the large bell to dump (as later described in detail). After sending up two more skips and having caused the small bell to dump two more times, the switches 121 of the next two sequence relays, 118 and 120, will have been closed, thereby connecting 25A to the second dump bus 107, which in turn energizes the bell interlocking means 23 and also the large bell control 24 (as described later) to cause the large bell to dump a second time. The sequence relays are then tripped open as described in paragraph 10 of this section, and a new round is started. Thus it is seen that it is not necessary to use all of the relays in order to complete a round. The first relay that is connected to the second dump bus renders effective the instrumentalities which carry a round to its conclusion. Any combination of dumps can be made within the limits of the apparatus. If more than seven dumps per round are desired, two relays of the type indicated by the numerals 108—120 will be provided for each extra dump of the small bell.

8. Assume that the first dump bus 106 has been connected to main 25A by means of the desired number of sequence relays and the proper selector switch, then the circuit through the sequence control 22 is as follows: from the first dump bus 106, through the normally closed switch 135 of the first dump bus transfer relay 134, through the coil 139 of the large bell relay 64 to main 25B. This closes the switch 140 of large bell relay 64 and in turn energizes the large bell control 24 as described in paragraph 1 of Section V.

9. As soon as the large bell control 24 starts to function, a circuit is completed from first dump bus 106 through coil 136 of first dump bus transfer relay 134 through contacts of up relay 66 of large bell control to main 25B. This latches open the switch 135 of first dump bus transfer relay 134 and interrupts circuit to coil 139 of large bell relay 64 described in paragraph 8 of this section. Thus it is seen that the first dump bus transfer

relay 134 permits energizing the large bell relay only once for a round from the first dump bus. The next energization of the large bell relay 64 must be from the second dump bus 107, as described below.

10. Assume now that the second dump bus 107 has been energized through the closing of the proper sequence relays. The circuit will then be established from the second dump bus 107 through the coil 143 of the second dump bus transfer relay 141 to 25B. This closes switch 142 of the second dump bus transfer relay 141, which in turn completes the circuit from second dump bus 107 through coil 139 of large bell relay 64 to 25B. This causes the switch 140 of large bell relay 64 to close and thereby energize the large bell control 24.

11. As soon as the up relay 66 closes on large bell control 24 (described in paragraph 1 of Section VI), it completes circuit from second dump bus 107, through coil 146 of return relay 144, through up relay 66 to 25B. This closes, and latches closed, switch 145 of return relay 144, which energizes trip coils 123 of all latched relays of the series 108-120 inclusive and trip coil 137 of first dump bus transfer relay 134. Circuit is from 25A through trip coils 123 in parallel and 137, through switch 145 of return relay 144 to main 25B.

12. As each latched relay opens, it closes a normally closed auxiliary switch thereon, which auxiliary switches bear the numerals 124 and 138. These auxiliary switches, together with auxiliary switches 99, 100 and 103 on relays 90, 91 and 92, respectively, of bell interlocking means 23 (later discussed) are all in series. When all of these auxiliary switches are closed, circuit is completed from 25A through all these auxiliary switches in series, through trip coil 147 of return relay 144, through return relay switch 145, to 25B. This opens the switch 145 of return relay 144 and thereby places sequence control in the same condition it was in at the beginning of the round. Cycle may now be repeated.

13. Closing switch 145 of return relay 144 as described in paragraph 11 of this section opens normally closed auxiliary switch 148 on return relay 144, thereby opening interlocking circuit Z from bell interlocking means 23 (later discussed) to small bell control 21. This prevents operation of small bell until after the sequence control 22 and the bell interlocking means 23 have been returned to operating condition found at beginning of round.

14. Tripping of switch 145 of return relay 144 as described in paragraph 12 of this section closes auxiliary switch 148 on it, thereby completing interlocking circuit Z mentioned in paragraph 13 of this section. This circuit is from 25B through limit switch 14 and certain of the switches 95, 96 and 97 of bell interlocking relays 90, 91 and 92 (as described in paragraphs 1 and 2 of Section V), through auxiliary switch 148 on return relay 144, through switch 80 on either relay 75 or 76 of skip interlocking means 20 (as described in paragraphs 1 and 8 of Section II), through limit switch 5 to small bell control 21.

V. Bell interlocking means

1. When the first dump bus 106 is energized as described in paragraph 7 of Section IV, a circuit is completed from 25A through first dump bus

106, through operating coil 93 of normally closed relay 91, through normally closed auxiliary switch 102 on relay 92, to 25B. This latches switch 96 of relay 91 open, thereby opening interlocking circuit Z to small bell control 21 (described in paragraph 14 of Section IV) and preventing the small bell from further operation.

2. At slow-down point of large bell (as described in paragraph 11 of Section VI), normally open limit switch 17 closes momentarily, completing a circuit from 25B through normally closed auxiliary switch 105 on contactor 34L of large bell control, through limit switch 17, through coil 93 of relay 92, through auxiliary switch 101 (closed when switch 96 of relay 91 is open) to main 25A. This closes, and latches closed, switch 97 of relay 92, and since switch 95 of relay 90 is normally closed, a bridge through switches 97 and 95 of relays 92 and 90 is placed across open switch 96 of relay 91, thereby completing interlocking circuit Z described in paragraph 14 of Section IV. This action permits small bell to be operated as soon as large bell has closed. The reason for the normally closed auxiliary switch 105 in series with limit switch 17 is to make said limit switch 17 ineffective on the up stroke of the large bell cylinder K. This auxiliary switch 105 is opened by contactor 34L on up stroke of large bell cylinder K. Hence, circuit is not reset for small bell operation until large bell cylinder has very nearly completed its operation. Small bell cannot start, however, until large bell is completely closed and limit switch 5 is closed, as described in paragraph 1 of Section III.

3. Closure of switch 97 of relay 92 also opens normally closed auxiliary switch 102 on it, thereby interrupting circuit to coil 93 of relay 91. Switch 96 of relay 91 remains open, however, for it is a latched relay.

4. As soon as the second dump bus 107 is energized, a circuit is completed from the second dump bus, through the coil 93 of relay 90 to 25B, thereby opening, and latching open, switch 95 of relay 90, which opens the interlocking circuit Z described in paragraph 14 of Section IV and presents small bell from operating.

5. Near the bottom of the down stroke of the large bell, limit switch 16 momentarily closes, thereby completing a circuit from 25A through the trip coils 94 of relays 91, 92 and 90 in parallel, through normally open auxiliary switch 98 on relay 90, through limit switch 16, through normally closed auxiliary switch 104 on contactor 34L of large bell control (auxiliary switch 104 closed when contactor 34L is open), to main 25B. This causes switches 96 and 95 of relays 91 and 90 to close and switch 97 of relay 92 to open, thus placing them back to normal operating position for the beginning of a round.

6. Closure of switches 96 and 95 of relays 91 and 90 and opening of switch 97 of relay 92 closes the normally closed auxiliary switches 100, 99 and 103 on them. These switches 100, 99 and 103 are in series with the circuit to the trip coil 147 on return relay 144 as described in paragraph 12 of Section IV. When these auxiliary switches 100, 99 and 103 close, the circuit is completed through auxiliary switches 124 on relays 108-120 and auxiliary switch 138 of relay 134 to trip coil 147 of return relay 144, thereby opening switch 145 of return relay 144. This act closes auxiliary switch 148 on return relay 144, 250

which completes interlocking circuit Z as described in paragraph 14 of Section IV.

VI. Large bell control

1. When sequence control 22 closes switch 140 of large bell relay 64 as described in paragraphs 8 and 10 of Section IV, a circuit is completed from main 25B, through switch 140 of large bell relay 64, through normally open limit switch 3, through normally open limit switch 13, through coil 63 of up relay 66 of large bell control 24, through normally closed limit switch 18 to 25A. This causes up relay 66 to close. Limit switch 3 is closed only when the small bell is closed, hence it prevents operation of large bell unless small bell is closed. Limit switch 13 is closed only when large bell is closed, hence when large bell starts to open, the limit switch 13 is opened, thereby energizing momentarily the up relay coil 63, thereby closing up relay 66 and starting the large bell control 24.

2. Closure of up relay 66 closes auxiliary switch 65 thereon, which completes circuit from main 25A, through limit switch 18, through up relay coil 63, through auxiliary switch 65 on up relay 66, to main 25B. This is a holding circuit to keep up relay 66 closed after being closed by push button 47L or by large bell relay 64.

3. Closure of up relay 66 closes auxiliary switch 67 thereon, which completes circuit from 25A through coil 49L of contactor 40L, through overspeed trip 49LT, through auxiliary switch 67 to 25B, thereby causing normally closed contactor 40L to open. Opening this contactor opens the low resistance dynamic circuit used at slow-down of large bell cylinder.

4. Opening of contactor 40L closes auxiliary switch 60L thereon, which completes circuit from 25A, through limit switch 18, through coils 44L and 45L of contactors 30L and 34L in parallel, through auxiliary switch 60L on contactor 40L, through up relay 66 to 25B.

5. Closure of contactor 30L opens back contactor 41L, which is spring closed, thereby removing dynamic circuit used in closing large bell B.

6. Closure of contactors 30L and 34L applies power to motor U. Circuit is from 25A through contactor 30L, through armature 26L, through series field 27L, through accelerating resistance 31L, 32L and 33L, through contactor 34L, to main 25B. This causes motor U to operate to open large bell B.

7. Closure of contactor 30L closes an auxiliary switch 54L thereon, which completes circuit from 25A through limit switch 18, through accelerating relay 55L, through auxiliary switch 54L on contactor 30L, to main 25B. This causes accelerating relay to function and close switches 56L, 57L and 58L successively at definite intervals, thereby completing circuits through coils 56LA, 57LA and 58LA of contactors 37L, 38L and 39L, which cut out successive steps of accelerating resistance 31L, 32L and 33L until motor U is across line.

8. At top of stroke of large bell cylinder K, normally closed limit switch 18 is opened. This opens circuit to up relay coil 63, as well as accelerating relay coil 55L, as described in paragraphs 1 and 7 of this section.

9. Opening the up relay 66 causes the following:

(9a) Opens normally open auxiliary switch 67 on up relay 66 which is shunted around slow-down limit switch 15, thereby making slow-down

limit switch 15 effective on down stroke of large bell cylinder K.

(9b) Opens contactors 30L and 34L and accelerating relay switches 56L, 57L and 58L, thereby breaking circuit to coils 56LA, 57LA and 58LA and causing contactors 37L, 38L and 39L to open, thereby disconnecting line from motor U.

(9c) Prevents contactors 30L, 34L, 37L, 38L and 39L from again closing when limit switch 18 closes as bell cylinder K lowers out of its uppermost position.

10. Opening contactor 30L automatically closes contactor 41L, thereby applying dynamic braking circuit to motor U. This circuit is from armature 26L, through series field 27L, through accelerating resistance 31L and 32L, through contactor 41L, through braking resistor 42L, to armature 26L.

11. Bell cylinder K descends until slow-down point is reached, whereupon slow-down limit switch 15 opens, interrupting circuit from 25A, through coil 49L of contactor 40L, through overspeed trip 49LT, through limit switch 15 to main 25B, thereby closing contactor 40L and applying low resistance dynamic braking circuit to motor U, slowing down speed of same to permit a gentle stop.

12. Overspeed trip 49LT operates only if motor U tends to overspeed. Operation of trip 49LT interrupts the circuit described in paragraph 11 of this section, applying slow-down dynamic circuit to motor, permitting the bell to seat at moderate speed without slam.

The mode of operation above outlined is given for illustration and should not be considered in a limiting sense. Many modifications of the present invention will occur to those skilled in the art. It is intended to cover all such modifications that fall within the scope of the appended claims.

What is claimed is—

1. In combination, a first motor, control means therefor, a second motor, control means therefor, a plurality of successively operable relays responsive to successive operations of said first motor, and switches for simultaneously connecting said relays in a plurality of predetermined sets in successively operable circuits to said second motor control means to cause operation thereof.

2. In combination, a first motor, control means therefor, a second motor, control means therefor, sequence means for connecting said second motor control means in circuit across a source of E. M. F., said sequence means including a plurality of successively operable relays, means for simultaneously connecting said relays in a plurality of predetermined sets, said sequence means also including a relay for said second motor, and means for actuating said last mentioned relay when the last of said first mentioned relays in each set is actuated, said relay for said second motor being connected to operate said second motor control.

3. In combination, a first motor, control means therefor, a second motor, control means therefor, sequence means for connecting said second motor control means in circuit across a source of E. M. F., said sequence means including a plurality of successively operable relays, means for simultaneously connecting said relays in a plurality of predetermined sets, said sequence means also including a relay for said second motor, means for actuating said last mentioned relay when the last of said first mentioned relays

in each set is actuated, said relay for said second motor being connected to operate said second motor control, and switch means for predetermining the number of said first mentioned relays in each of said sets.

4. In combination, a first motor, control means therefor, a second motor, control means therefor, a plurality of sequence relays, switches for simultaneously connecting said relays in a plurality of predetermined sets, means interconnecting said relays to cause said relays to be successively operated in response to successive operations of said first motor, a relay for said second motor responsive to the operation of the last relay in the first set of said sequence relays, the relay for said second motor being responsive also to the operation of the last relay of the second set of said sequence relays.

5. In combination, a first motor, control means therefor, a second motor, control means therefor, a plurality of sequence relays, switches for simultaneously connecting said relays in a plurality of predetermined sets, means interconnecting said relays to cause said relays to be successively operated in response to successive operations of said first motor, a relay for said second motor responsive to the operation of the last relay in the first set of said sequence relays, the relay for said second motor being responsive also to the operation of the last relay of the second set of said sequence relays, and switches for predetermining the number of relays in each of said sets.

6. In combination, a first member to be operated, weight means for holding said first member in a predetermined position, motive means for raising said first weight means to permit said first member to descend, a second member to be operated, weight means for holding said second member in a predetermined position, motive means for lifting said second weight means to permit said second member to descend, first and second control means for controlling said first and second motive means respectively, each of said control means being operative to set up a predetermined cycle of movement of its corresponding member to be operated, interlocking means between said control means whereby neither of said motive means may operate when the other of said motive means is in operation, a plurality of relays for predetermining the number of operations of said first motive means prior to operation of said second motive means, and means for simultaneously connecting said relays in a predetermined plurality of sets for varying the ratio of the number of operations of said first motive means before and after an operation of said second motive means regardless of the total number of said operations of said first motive means before and after an operation of said second motive means.

7. In a control system, in combination, skip motive means which motive means is reversible in a motive sense, bell motive means, and interlocking means between said two motive means for preventing reversal of said skip motive means except after successive complete operations of opening and closing movements of said bell motive means.

8. In a system of control, in combination, a first motive means, control means therefor for inaugurating successive operations of said motive means, a plurality of successively operable relays responsive to successive operations of said first mentioned motive means, selector switches for simul-

taneously selectably grouping said relays in a plurality of sets, a second motive means, and means including said selector switches for energizing said second motive means in response to the last relay in each of said sets.

9. In a system of control, in combination, a first motive means, control means therefor for inaugurating successive operations of said motive means, a plurality of successively operable relays responsive to successive operations of said first mentioned motive means, selector switches for simultaneously selectably grouping said relays in a plurality of sets, a second motive means, means including said selector switches for energizing said second motive means in response to the last relay in each of said sets, and interlocking means for preventing the energization of said second motive means except in response to successive operations of said sets of relays.

10. In a system of control, in combination, a first motive means, control means therefor for inaugurating successive operations of said motive means, a plurality of successively operable relays responsive to successive operations of said first mentioned motive means, selector switches for simultaneously selectably grouping said relays in a plurality of sets, a second motive means, means including said selector switches for energizing said second motive means in response to the last relay in each of said sets, and interlocking means between said first and second motive means for preventing operation of said first motive means while said second motive means is operative.

11. In a system of control, in combination, a first motive means, control means therefor for inaugurating successive operations of said motive means, a plurality of successively operable relays responsive to successive operations of said first mentioned motive means, selector switches for simultaneously selectably grouping said relays in a plurality of sets, a second motive means, means including said selector switches for energizing said second motive means in response to the last relay in each of said sets, interlocking means for preventing the energization of said second motive means except in response to successive operations of said sets of relays, and interlocking means cooperating with said first and second motive means for preventing operation of said first motive means while said second motive means is operative.

12. In a blast furnace charging system, in combination, charging bell motive means, skip motive means, distributor motive means, and interlocking means cooperating with said motive means for causing simultaneous operation of said skip motive means and said bell motive means and for preventing operation of said skip motive means and said bell motive means while said distributor motive means is operative.

13. In a blast furnace charging system, skip motive means, bell motive means, and interlocking means for initiating substantially simultaneous starting of said skip motive means and said bell motive means and for stopping operation of said skip motive means when at a predetermined position unless said bell motive means is in a predetermined position.

14. In a blast furnace charging system, in combination, bell motive means, skip motive means, and interlocking means for initiating substantially simultaneous starting of said bell motive means and said skip motive means and for preventing the completion of a cycle of operation of said skip motive means unless said bell motive

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means has completed its next preceding cycle of operation.

15. In a blast furnace charging system, in combination, large bell operating means, small bell operating means, and sequence control means simultaneously connecting said relays in a plurality of sets for predetermining a fractional ratio of the number of operations of said small bell operating means before and after an operation of said large bell operating means in a charging round regardless of the total number of operations of said small bell operating means before and after an operation of said large bell operating means.

16. In a blast furnace charging system, large bell motive means, small bell motive means, skip motive means, and interlocking means responsive to the functions of said large bell motive means to cause substantial simultaneous starting of said small bell motive means and said skip motive means and to prevent operation of said skip motive means in the event that said large bell motive means does not function.

17. In a blast furnace charging system, in combination, small bell motive means, large bell motive means, control means for said motive means for automatically causing said motive means to operate in a predetermined sequence in a charging round of said system, said control means including a plurality of relays responsive to operation of said small bell motive means, said large bell motive means being responsive to said relays, and selector switches for simultaneously connecting said relays in a plurality of predetermined sets for predetermining a fractional ratio between the number of said relays that shall be operative before and after an operation of said large bell motive means in a charging round regardless of the total number of said relays that shall be operative before and after an operation of said large bell motive means.

18. In a blast furnace charging system, in combination, large bell motive means, small bell motive means, skip motive means, distributor motive means, interlocking means for preventing operation of said skip motive means except when said distributor motive means is inoperative, interlocking means between said skip motive means and said small bell motive means to prevent operation of said skip motive means except when said small bell motive means is in a predetermined position, interlocking means between said small bell motive means and said large bell motive means to prevent operation of either of said motive means except when the other of said motive means is in a predetermined position, and se-

quence control means cooperatively associated with said small bell motive means and said large bell motive means, said sequence control means including selector switches for selectably varying the number of operations of said small bell motive means before and after an operation of said large bell motive means regardless of the total number of operations of said small bell motive means before and after an operation of said large bell motive means.

19. In a blast furnace charging system, in combination, reversible skip motive means, bell motive means, and interlocking means cooperating with said bell motive means and said skip motive means for causing simultaneous operation of said two motive means and for preventing reversal of said skip motive means until after an operation of said bell motive means.

20. In a blast furnace charging system, in combination, large bell motive means, small bell motive means, control means for controlling said motive means to cause same to operate according to predetermined cycles, and sequence control means including a plurality of relays and switches for simultaneously connecting said relays in a plurality of predetermined sets for predetermining a fractional ratio of the number of cycles of operation of said small bell motive means before and after a cycle of operation of said large bell motive means regardless of the total number of said cycles of operation of said small bell motive means before and after a cycle of operation of said large bell motive means.

21. In a blast furnace charging system, in combination, large bell motive means, small bell motive means, control means for controlling said motive means to cause same to operate according to predetermined cycles, sequence control means including a plurality of relays and switches for simultaneously connecting said relays in a plurality of predetermined sets for predetermining a fractional ratio of the number of cycles of operation of said small bell motive means before and after a cycle of operation of said large bell motive means regardless of the total number of said cycles of operation of said small bell motive means before and after a cycle of operation of said large bell motive means, and interlocking means for preventing an operation of said small bell motive means after said sequence control means has energized said large bell motive means until said large bell motive means has completed its cycle of operation.

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