Oct. 19, 1937. F. I. SMITH 2,096,567

BLAST FURNACE CHARGING MECHANISM

Filed Oct. 15, 1935 4 Sheets-Sheet 1

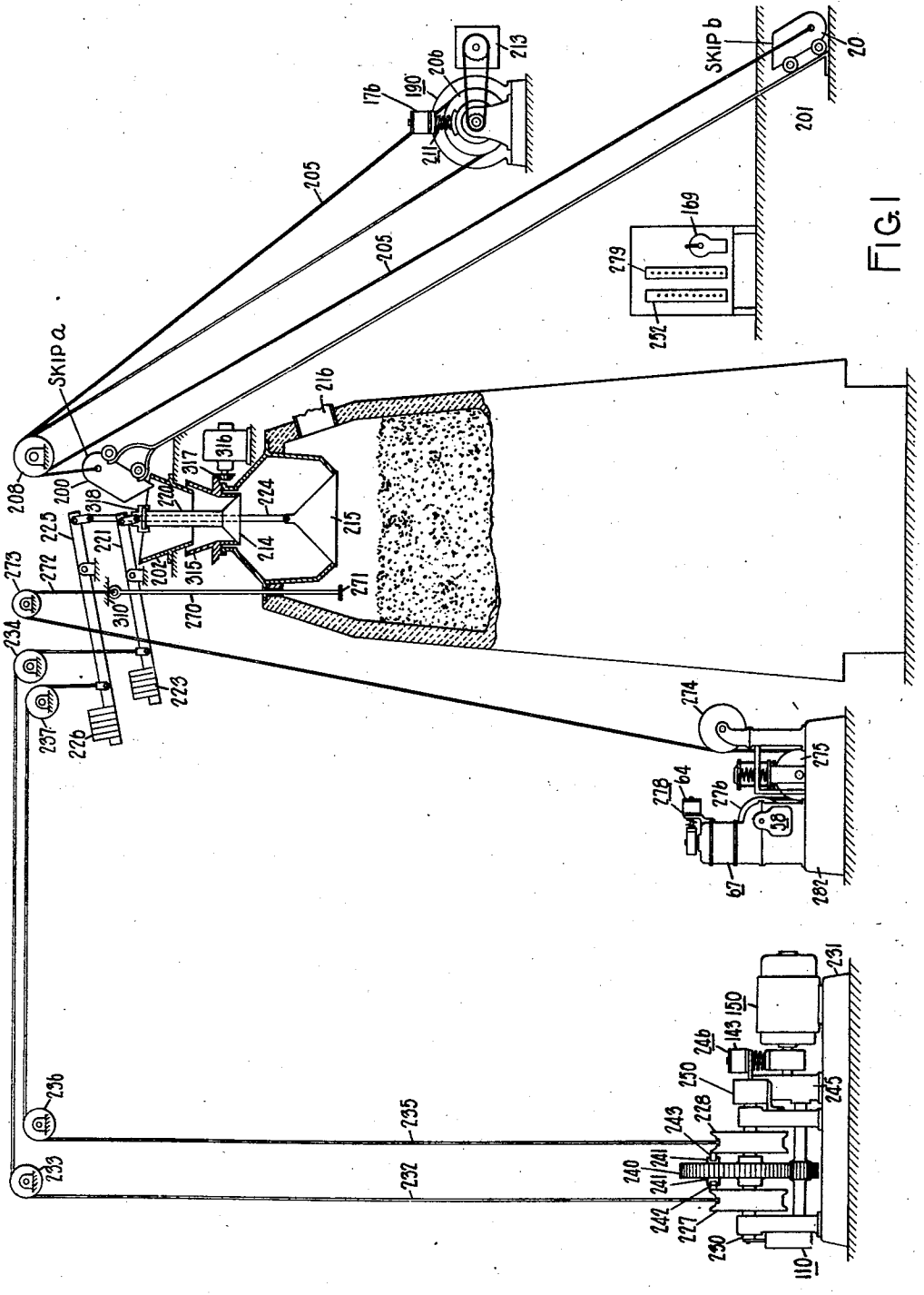


FIG. 1

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BLAST FURNACE CHARGING MECHANISM

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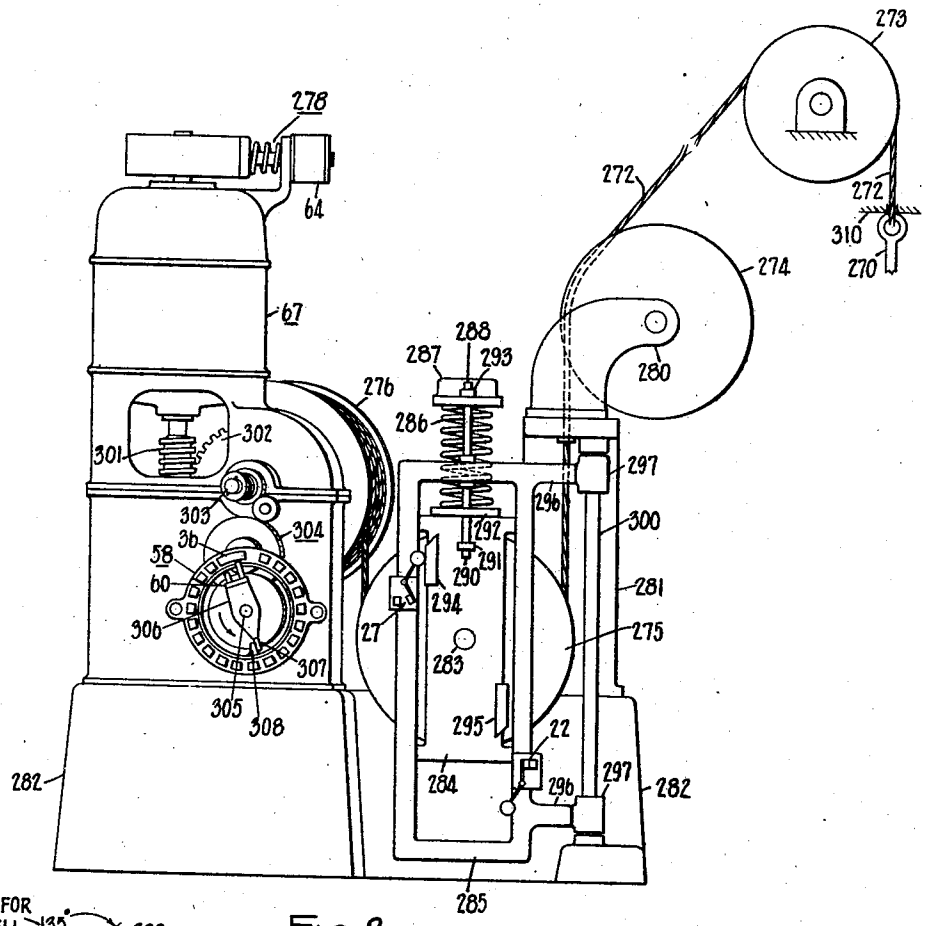


FIG. 2

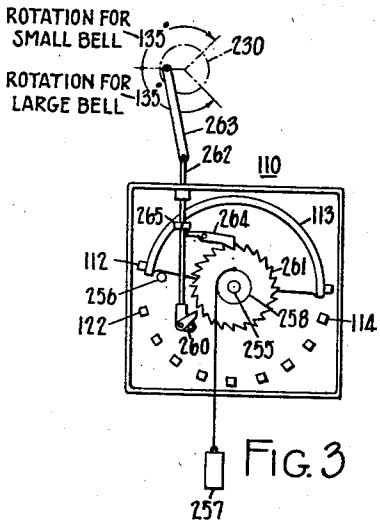


FIG. 3

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BLAST FURNACE CHARGING MECHANISM

Filed Oct. 15, 1935 4 Sheets-Sheet 3

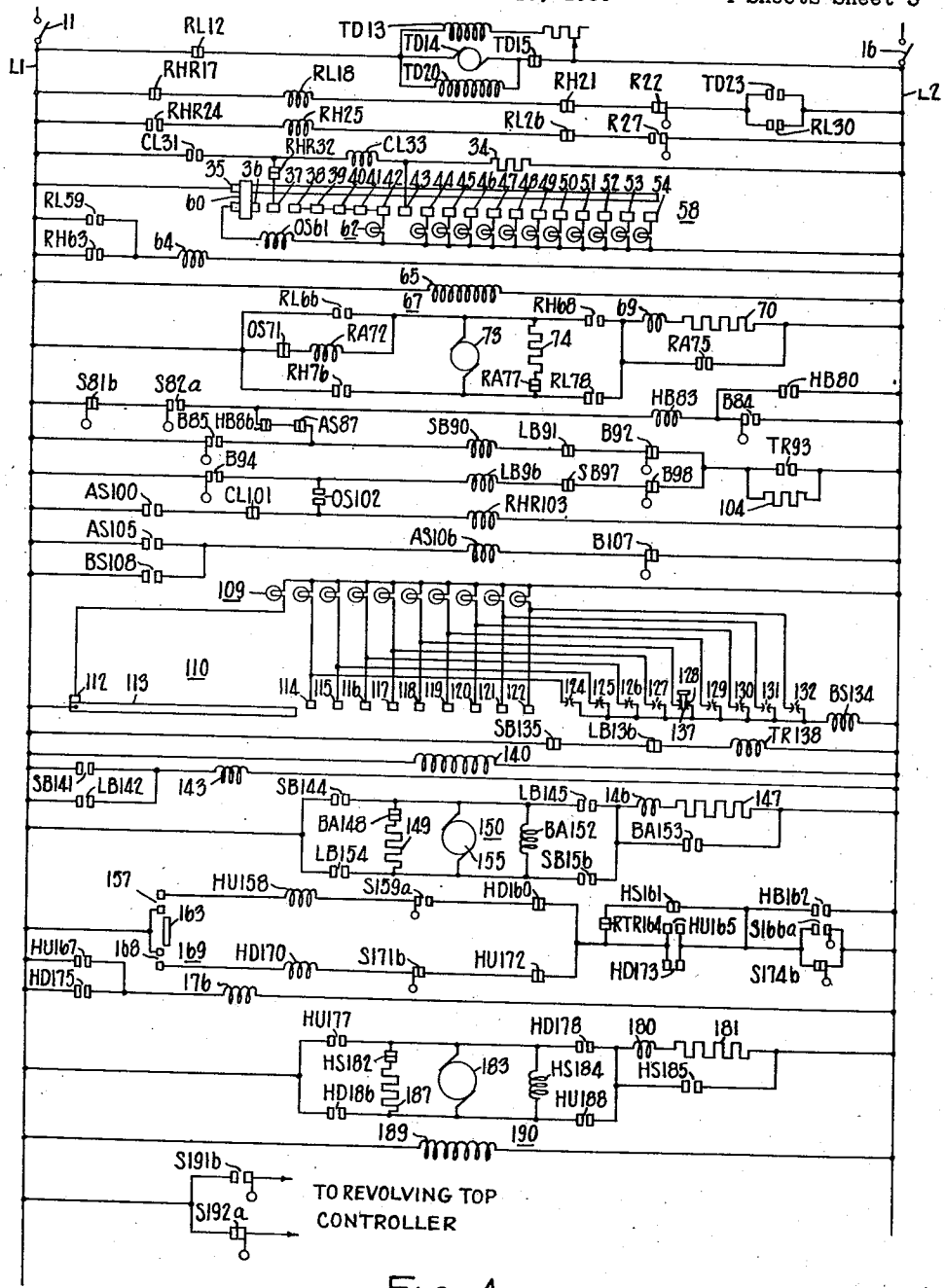


FIG. 4

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BLAST FURNACE CHARGING MECHANISM

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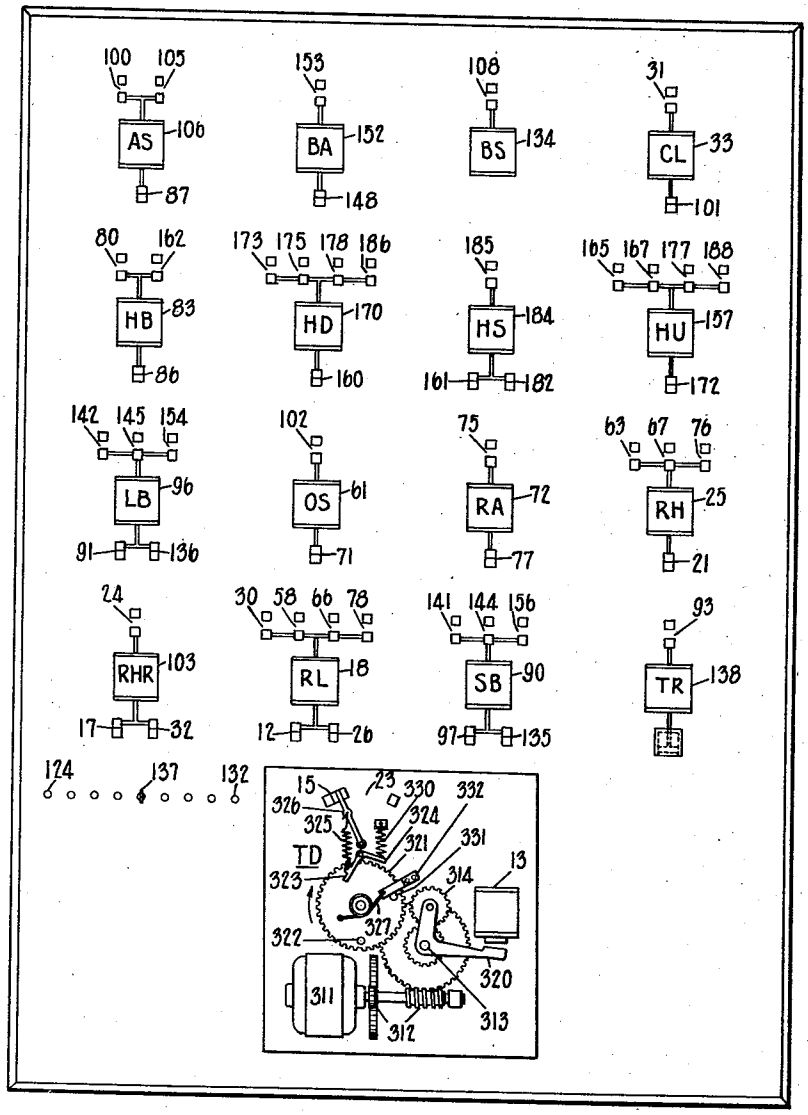


FIG. 5

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Patented Oct. 19, 1937

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UNITED STATES PATENT OFFICE

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BLAST FURNACE CHARGING MECHANISM

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Application October 15, 1935, Serial No. 45,031

5 Claims. (Cl. 214—36)

The invention relates to the control of the charging of blast furnaces.

In a typical blast furnace installation, the stock for the furnace is loaded into a skip bucket at a loading point. The skip is then hoisted to the top of the furnace where the stock is dumped onto a small bell. The small bell is then operated to dump the stock onto a large bell and then reclosed. Another load is then brought up from the loading point and dumped onto the small bell which thereupon dumps the stock onto the large bell and recloses. This cycle of operation is repeated until a certain number of loads have been dumped onto the large bell whereupon, after reclosure of the small bell, the large bell dumps the charge into the furnace.

It is desirable to maintain the level of the stock in the furnace, that is the stock line, at a certain average height. The object of the invention is to automatically control the height of the stock in the furnace.

It may happen that, as the time arrives for dumping the large bell, the stock line is such, due for example to the furnace not being drawn or the charge becoming stuck, that to dump the large bell would overfill the furnace. This would be highly objectionable, not only from the standpoint of operation, but it might prevent all the new stock dropping into the furnace and thus prevent the closing of the large bell.

It is a specific object of the present invention to automatically control the charging of a blast furnace in accordance with the stock line so that the furnace will not be overfilled.

One feature of the invention is to stop operation of the charging mechanism when, as the time arrives to dump the large bell, the stock line of the furnace is above a certain point.

Another feature resides in automatically resuming operation of the charging mechanism when the stock line drops to a certain point.

Other features and advantages of the invention will become apparent from the following description and appended claims.

In the drawings:—

Figure 1 is a simplified schematic representation of a blast furnace installation embodying the invention;

Figure 2 is a view of stock line recorder mechanism employed in the installation;

Figure 3 is a diagrammatic representation of commutating mechanism associated with the bell operating mechanism;

Figure 4 is a simplified wiring diagram of certain of the power and control circuits of the control system for the blast furnace charging mechanism; and

Figure 5 is a diagrammatic representation of a control panel, showing particularly the relationship of the coils and contacts of the various electromagnetic switches employed in the control system of Figure 4.

For a general understanding of the invention reference may be had to Figure 1, wherein various parts of a blast furnace installation are indicated by reference characters. The stock for the furnace is carried in a skip bucket **200** from a loading pit **201** to a hopper **202** at the top of the furnace. Two skips are illustrated, these skips running on separate tracks from the loading pit to the hopper. Each of the tracks is arranged at the top to automatically dump the skip as it arrives at the hopper.

The skip buckets are raised and lowered by skip hoisting mechanism. This mechanism comprises roping **205** connected to one of the skips and passing around a drum **206** which is driven by a motor **190**, and similar roping connected to the other skip and passing around drum **206**. The roping is arranged on the drum so that one skip is raised from the loading pit to the hopper as the other is returned to the pit. One end of the roping for one skip is connected to the skip and extends therefrom upwardly to an idler sheave **208** and thence downwardly around hoisting drum **206**. The roping for the other skip is similarly arranged but is wound oppositely on the drum. An electromechanical brake **211** having a release coil **176** is provided for stopping the hoisting motor.

The hoisting motor and brake are controlled through a master control switch **169** arranged at the loading platform for manual operation by an operator. Mechanically operated switching mechanism **213** actuated in accordance with the positions of the skips is illustrated as driven by the skip hoisting motor. This switching mechanism and the master control switch act through electromagnetic switches to control the operation of the skips.

Upon a load of stock being dumped into hopper **202**, it falls onto the small bell **214**. The small bell is opened to dump the load onto the large bell **215** as the emptied skip starts on its return to the loading pit. As each skip load is dumped onto the small bell, the cycle of operation is repeated, dumping the load onto the large bell. When a specified number of loads have been dumped onto the large bell, the large bell is opened, dumping the charge into the furnace.

When the small bell is opened and dumps a

load, it is returned to closed position before receiving another load. Also, the large bell is not opened until the small bell has been closed, and the large bell is returned to closed position before the small bell is opened. This seals the furnace, an outlet for the gases at the top of the furnace being provided by pipe 216, which carries the hot gases to the heaters and other parts in the installation.

The bells are operated by the bell hoisting mechanism. Small bell 214 is connected by hollow rod 220 to one end of lever 221. At its opposite end lever 221 carries a counterweight 223 of sufficient mass to counterbalance the weight of the bell and the rod plus the weight of the load of material resting on the bell, and to provide sufficient force to maintain a sealing pressure between the bell and its seat. Large bell 215 is connected to a lever 225 by a rod 224 which extends through hollow rod 220. Lever 225 is likewise provided with a counterweight 226 which counterbalances the weight of the bell and rod as well as the weight of material resting on the bell and provides sufficient sealing pressure between the bell and its seat.

In the hoisting machine for the bells, drums 227 and 228 are loosely mounted upon a shaft 230 supported by bearing pedestals mounted on base 231. Hoisting cable 232 for small bell 214 has its lower end secured to drum 227, passes over stationary pulleys 233 and 234 and is connected to the weighted end of lever 221. Hoisting cable 235 for large bell 215 has its lower end secured to drum 228, passes over stationary pulleys 236 and 237 and is connected to the weighted end of lever 225. Rotation of drum 227 from the neutral position shown causes cable 232 to move the weighted end of lever 221 upwardly, thereby opening small bell 214, and rotation of drum 228 from this neutral position causes cable 235 to move the weighted end of lever 225 upwardly, thereby opening large bell 215.

A driving gear 240 is keyed to shaft 230. A lug 241 is provided on each side of the gear. A lug 242 is arranged on drum 227 in the path of movement of the lug on the left side of gear 240 so as to be engaged thereby when the gear is rotated to move from neutral in a counterclockwise direction as viewed from the left hand end of the bell hoisting machine. Continued movement of the gear after the engagement of the lugs causes drum 227 to rotate therewith, thereby opening the small bell. To close the small bell, the direction of rotation of gear 240 is reversed to allow drum 227 to return to neutral under the influence of weight 223. A similar lug 243 is arranged on drum 228 in the path of movement of the other lug 241 so as to be engaged thereby when gear 240 is rotated from neutral in the opposite direction. Continued rotative movement of the gear after lug 243 is engaged causes rotation of drum 228 to open large bell 215. In closing bell 215, the direction of rotation of gear 240 is reversed to allow drum 228 to return to neutral under the influence of weight 226.

Driving gear 240 is driven through a train of gears 245 by motor 150 mounted on base 231. An electromechanical brake 246 having a release coil 143 is provided for bringing the rotating members rapidly to rest when the motor is deenergized. The operation of the motor and brake is controlled by switching mechanism 250 actuated in accordance with the positions of the bells, by certain of the switches actuated in accordance with the positions of the skips and by switching mechanism actuated by the stock line recorder mechanism, these various switching mechanisms acting through the intermediary of electromagnetic switches. Switching mechanism 250 is illustrated as driven from shaft 230.

Commutating mechanism 110 is also driven from shaft 230, this mechanism acting to control the operation of the bell indicator 252 and to control the sequence of operation of the bells. The bell indicator comprises a column of lamps 109 arranged at the loading platform for observation by the operator to indicate which of the bells is in operation and, in the case of the small bell, the number of times it has been operated since the opening of the large bell.

Referring to Figure 3, commutating mechanism 110 comprises a series of stationary contacts 112 and 114–122 inclusive arranged in the arc of a circle and a contact segment 113 for engaging and bridging these stationary contacts. This segment is arranged on a shaft 255 for rotation therewith. The segment is biased into position against a stop 256 with segment 113 in engagement with stationary contact 112 by a weight 257. This weight is connected to a pulley 258 on shaft 255. The segment is moved clockwise against the force of its biasing weight by means of a ratchet 260 and ratchet wheel 261. The ratchet wheel is secured to shaft 255 while the ratchet is connected by a rod 262 to a link 263. This link in turn is actuated by a crank motion from shaft 230 as diagrammatically illustrated. With shaft 230 in neutral position, the crank arm extends horizontally from the center of the shaft.

Upon clockwise rotation of the shaft to open the small bell, the motion imparted to link 263 lifts rod 262. This causes the ratchet to engage the ratchet wheel and move the wheel an amount sufficient to rotate segment 113 into engagement with the next stationary contact. From the position in which the segment is shown, the first step of movement causes segment 113 to engage stationary contact 114 and to disengage stationary contact 112. As the small bell is returned to closed position, pawl 264 cooperates with the ratchet wheel 261 to retain the segment in the position to which it is moved. The next operation of the small bell moves the segment in a like manner another step into engagement with an additional stationary contact. This cycle is repeated as each operation of the small bell takes place.

When a certain number of small bell operations have taken place, circuits are set up to cause operation of the large bell. Upon counterclockwise rotation of shaft 230 from neutral to open the large bell, the ratchet is moved away from the ratchet wheel by the crank action and a collar 265 on rod 262 engages and releases pawl 264, permitting weight 257 to return the segment to the position shown against stop 256. This resets the commutating mechanism for another cycle of operation. The ratchet 260 does not engage the ratchet wheel upon return of shaft 230 to neutral to close the large bell. After the closing of the large bell, the small bell is again operated, starting another cycle of operation.

The stock line recorder comprises a rod 270 extending downwardly into the furnace at the top thereof. At the bottom end this rod is provided with a plate 271 for resting on the stock. The stock line recorder mechanism acts to permit the rod to follow the stock, the upper end of the rod being suspended by a rope 272 which passes over idler pulley 273, downwardly over idler

pulley 274, around a tensioning sheave 275, and thence upwardly and around a drum 276. The drum 276 is driven by the motor 67 which is provided with an electromechanical brake 278 having a release coil 64. Commutating mechanism 58 is driven by motor 67 in accordance with the movement of rod 270. This mechanism controls a stock line indicator 279. This indicator comprises a series of lamps 62 arranged in a vertical column at the loading platform for observation by the operator.

Reference may be had to Figure 2, which illustrates a stock line recorder machine. Idler pulley 274 is rotatably mounted on an arm 280 supported on a pedestal 281 on base 282. Tensioning sheave 275 is rotatably mounted on a shaft 283 carried by an elongated frame 284. This tensioning frame 284 is guided for vertical movement within another frame 285. Frame 284 is biased for downward movement by its own weight and the weight of sheave 275. For a portion of this downward movement this force is augmented by that of a spring 286 arranged between a plate 292 and a spring seat 287 secured by oppositely disposed studs 288 to frame 285. Additional oppositely disposed studs 290 depend from frame 285 and each is provided at its lower end with a nut 291 for cooperating with plate 292 to form a stop for limiting the expansion of the spring. A nut 293 on each of studs 288 serves to adjust the compression of the spring.

Frame 284 carries cams 294 and 295. Cam 294 is for operating limit switch 27 while cam 295 is for operating limit switch 22, these limit switches being mounted on frame 285. These switches act through electromagnetic switching mechanism to control the operation of motor 67 and brake 278.

Frame 285 is provided with arms 296 having bearing lugs 297 formed on the ends thereof. A pivot shaft 300 extends through apertures provided in these lugs from the base to the top of pedestal 281. This arrangement permits the bracket to swing as rope 272 is wound on drum 276 or unwound therefrom.

Motor 67 for driving drum 276 is vertically mounted. On the lower end of its shaft the motor is provided with a worm 301 which acts through worm wheel 302 to drive the drum shaft 303. The drum shaft acts through a train of gears 304 to drive an operating shaft 305 for commutating mechanism 58. This commutating mechanism comprises a plurality of stationary contacts 36–54 inclusive arranged in a circle. The first of these contacts 36 is somewhat elongated. A contact ring 35 is arranged in a circle concentric with that of the stationary contacts and a bridge 60, comprising a pair of electrically connected brushes, acts to bridge the contact ring with individual stationary contacts. This bridge is arranged on an arm 306 mounted on shaft 305 for rotation thereby. On the other end of arm 306 is a stop 307 which cooperates with a stationary lug 308 to bring the bridge to rest upon clockwise rotative movement with the brushes bridging the contact ring and stationary contact 36.

In operation, assume that the rod 270 has been lifted against a stop 310. With the rod in this position, frame 284 is held against the force of spring 286 in position where cam 294 opens switch 27. Upon energization of motor 67 to pay out rope 272, the tensioning frame is lowered before movement of rod 270 takes place. This is because the weight of sheave 275 and frame 284 plus the force exerted by spring 286 is more than twice the weight of rod 270. As the tensioning frame moves downwardly, spring 286 expands and a position is reached where plate 292 engages nuts 291 on studs 290, thereby relieving rod 270 from the effect of the force of spring 286. The weight of frame 284 and sheave 275 is less than twice the weight of rod 270 so that as the rope continues to be paid out the rod is lowered into the furnace. When plate 271 engages the top of the stock in the furnace, the rod comes to a stop and further paying out of rope 272 permits the tensioning frame 284 to continue its downward movement until cam 295 engages and opens switch 22. This causes motor 67 to be deenergized and the brake applied to bring the mechanism to a stop.

This mechanism permits the rod to continue to follow the stock, preferably at intervals as will be explained later. When the time arrives to open the large bell, motor 67 is energized to take up on rope 272. This results first in raising the tensioning frame until a point is reached where the top of the frame engages plate 292 where the force of spring 286 is added to the weight of the tensioning frame and sheave. This increases the downward force exerted on rope 272 at sheave 275 sufficiently to cause rod 270 to be lifted until it is brought to rest by engagement with stop 310. Thereafter, the tensioning frame is raised against the force of spring 286 until cam 294 opens switch 27, which effects the deenergization of motor 67 and the application of the brake to bring the mechanism to a stop.

The invention is applicable to installations provided with a revolving top. A revolving top has been illustrated in Figure 1. It comprises a hopper 315 for the small bell, arranged for rotation in steps by a motor 316 through gearing 317. A swivel connection 318 between hollow rod 220 and lever 221 is provided to permit rotative movement of the small bell. The purpose of the revolving top is to effect a certain disposition of the various materials of the stock within the furnace.

When the stock in the furnace is within a certain distance of the large bell, the furnace is considered full. This distance varies from six to eight feet in present day installations, depending upon the area of the furnace at the stock line. The invention involves controlling the operation of the charging mechanism so that no new stock is admitted to the furnace when the furnace is full as the time arrives for dumping the large bell. As soon as the stock in the furnace settles to a point where the furnace is no longer considered full, the large bell is dumped and the operation of the charging mechanism is resumed.

In carrying out the invention, the stock line recorder is utilized to control the operation of the large bell. If, as the time arrives to open the large bell, the line of the stock in the furnace is such that the rod is at or above a certain point in the furnace, the operation of the large bell is prevented. In the preferred arrangement, another load may be dumped upon the small bell but, unless in the meantime the rod has been permitted to drop below this point, further operation of the bells, the skip hoist and also of the revolving top, if provided, is prevented. When the stock line in the furnace falls below the predetermined point, the stock line recorder mechanism acts automatically to raise rod 270 up against the stop and to cause the opening of the large bell. Upon reclosing of the large bell, the

small bell is dumped and the charging mechanism continues its cycle of operation.

Reference may now be had to Figure 4, which shows certain of the control and power circuits for the units of a blast furnace installation embodying the invention. The control and power circuits of the various units are illustrated as combined in a single wiring diagram. Not all of the circuits are shown, the circuits being simplified for convenience of description. However, enough of the circuits for the various units are shown to attain an understanding of the principles of the invention.

No attempt is made in Figure 4 to show the coils and contacts of the various electromagnetic switches and devices in their associated positions, a straight wiring diagram being employed. The separation of the coils and contacts of the switches enables the circuits to be arranged in an across the line form, rendering them comparatively simple.

The numerals employed in designating the various elements of the wiring diagram are arranged in sequence, the lowest number, in this case 11, appearing in the upper left hand corner and the succeeding numbers following in numerical sequence from left to right downwardly on the sheet of drawings. The arrangement of numerals in this sequence facilitates location of any element referred to in the description.

The electromagnetic switches have been designated as follows:

AS—Auxiliary sequence switch
BA—Bell accelerating switch
BS—Bell sequence switch
CL—Charge limiting switch
HB—Hoist bell interlock switch
HD, HU—Hoist direction switches
HS—Hoist speed switch
LB—Large bell switch
OS—Large bell operating switch
RA—Rod accelerating switch
RH—Rod hoisting switch
RHR—Rod hoisting relay
RL—Rod lowering switch
SB—Small bell switch
TR—Time relay

Throughout the description which follows, these letters, in addition to reference numerals, will be applied to parts of the above designated switches. For example, contacts RL112 indicate that these contacts are on the rod lowering switch, while operating coil RHR103 indicates that the coil operates the rod hoisting relay. The relationship of the coils and contacts of the above switches may be seen from Figure 5, where the switches are arranged in alphabetical order. It is to be understood that the exact arrangement of the switches is determined by the requirements of the particular installation.

The switches of the switching mechanisms of the various units will be termed limit switches. In accordance with the type of wiring diagram employed, the individual limit switches of each unit are shown separated. In order to differentiate between the limit switches of the various units, those operated by the skip hoist mechanism are designated generally by the letter S, those operated by the bell operating mechanism are designated generally by the letter B and those operated by the stock line recorder mechanism are designated generally by the letter R.

Commutating mechanism 110, in addition to controlling the bell indicator, controls the circuits to a series of jacks 124 to 132 inclusive. A plug 137 is provided for insertion in any one of the jacks to control the number of small bell operations. The jacks are arranged on the control panel shown in Figure 5.

The blast furnace control units are illustrated as arranged for direct current power supply. The power supply lines are designated L1 and L2. 11 and 16 are blades of a double pole knife switch for connecting the system to the power supply. It will be assumed that this switch has been closed.

The motor 67 of the stock line recorder mechanism has its armature designated 73, series field winding 69 and its separately excited field winding 65. A series resistance 70 and by-pass resistance 74 are illustrated for controlling the current flowing in armature 73 of the motor. The motor 150 of the bell operating mechanism has its armature designated 155, series field winding 146 and its shunt field winding 140. A series resistance 147 and by-pass resistance 149 are illustrated for controlling the current flowing in armature 155 of the motor. The motor 190 of the skip hoist mechanism has its armature designated 183, series field winding 180 and its separately excited field winding 189. A series resistance 181 and by-pass 187 are illustrated for controlling the current flowing in armature 183 of the motor.

Master control switch 169 comprises a bridging contact segment 163 operated in one direction to bridge contacts 157 and in the other direction to bridge contacts 168. Contacts 157 control the circuit for coil HU158 of one hoist direction switch while contacts 168 control the circuit for coil HD170 of the other hoist direction switch. These coils are also subject to limit switches.

The skip limit switches may be regarded as arranged in sets, each of those functioning for one of the skips, which will be termed skip "*a*", having the letter "*a*" appended to its designation and each of those functioning for the other skip, which will be termed skip "*b*", having the letter "*b*" appended to its designation. The limit switches of set "*a*" are S82*a*, S159*a* and S166*a*, while those of set "*b*" are S91*b*, S171*b* and S174*b*. Additional limit switches S192 and S191*b* may be provided for controlling the revolving top which will be referred to later. The bell limit switches are designated B84, B85, B92, B94, B98 and B107, while those of the stock line recorder mechanism are designated R22 and R27.

It will be assumed that skip "*b*" is in the pit below the loading platform and that skip "*a*" is in dumping position at the top of the furnace. Under such conditions limit switches S81*b*, S171*b* and S174*b* are closed and limit switches S82*a*, S159*a* and S166*a* are open. Switch S159*a* being open prevents the energization of coil HU158 of hoist direction switch HU. However, as limit switch S171*b* is closed, the hoisting of skip "*b*" may be started, when ready, by moving master control switch 169 into position where segment 163 bridges contacts 168. This completes a circuit for coil HD170 of hoist direction switch HD. This circuit may be traced from supply line L1, through contacts 168, coil HD170, limit switch S171*b*, interlock contacts HU172, contacts RTR164 of the revolving top relay, assuming a revolving top is provided, contacts HS161 of the hoist speed switch and limit switch S174*b*, to line L2. Hoist direction switch HD, upon operation, separates its interlock contacts HD160 in the cir-

cuit for coil HU158 and engages contacts HD173 to by-pass contacts RTR164 and HS161. It also engages contacts HD186 and HD178 to complete a circuit for the armature 183 of the skip hoist motor which is from line L1, through contacts HD186, armature 183, contacts HD178, series field winding 180 and resistance 181 to line L2. Contacts HD175 are also engaged, completing a circuit for release coil 176 of the skip hoist electromechanical brake.

The brake being released and the skip hoist motor being energized, its separately excited field winding 189 being directly connected across lines L1 and L2, the skip operating mechanism starts in a direction to hoist skip "b" and to return skip "a" to the loading pit. As the counter E. M. F. of armature 183 builds up, coil HS184 of the hoist speed switch is energized sufficiently to engage its contacts HS185 and separate its contacts HS182 and HS161. Contacts HS161 are in the initial energizing circuit for the coils of the direction switches, these contacts serving to prevent the sudden reversal of the direction of rotation of the skip operating motor. These contacts are now by-passed by contacts HD173, maintaining coil HD170 energized. Contacts HS182 disconnect by-pass resistance 187 from across armature 183, while contacts HS185 short-circuit resistance 181 and series field winding 180. This brings the skip hoist motor up to full speed.

As skip "b" leaves the pit, limit switch S159*a* closes and thereafter limit switch S174*b* opens. It will be assumed that contacts HB162 of the hoist bell interlock switch are engaged before the opening of limit switch S174*b* takes place. This being the case, the circuit for coil HD170 is maintained through contacts HB162 and HD173.

As skip "b" nears its dumping position, limit switch S166*a* closes and as it reaches this position limit switch S171*b* opens. The opening of limit switch S171*b* breaks the circuit for coil HD170 which separates its contacts HD186 and HD178 to disconnect the skip hoist motor from the supply lines and also separates its contacts HD175 to de-energize brake release coil 176 of the skip hoist electromechanical brake. The brake is applied to bring the skip hoisting mechanism to a stop with skip "b" in its dumping position and skip "a" in its loading position, being assisted by the by-pass resistance 187 reconnected across the motor armature by the dropping out of hoist speed switch HS to engage contacts HS182. It will be understood that the control system may be arranged to cause the by-pass resistance to be connected across the armature before the final stopping operation and that resistance 181 may be controlled in several steps to control acceleration and to provide a gradual slow down before the skip is finally brought to a stop. When the skip is brought to a stop, the operator returns the master control switch to neutral.

After skip "b" has dumped and skip "a" has been loaded, the operator throws the master control switch into its other operative position bridging contacts 157 by segment 163 and completing a circuit for coil HU158 of hoist direction switch HU through limit switches S159*a* and S166*a*. Hoist direction switch HU engages contacts HU177 and HU188 to establish a circuit for the skip hoist motor for rotation in the opposite direction. At the same time it engages contacts HU167 to energize brake release coil 176. Thus skip "a" is started in the up direction and skip "b" is started on its return to the loading station.

As skip "a" reaches its dumping position, it is brought to a stop by the opening of limit switch S159*a*. Skip "b", which has been returned to its loading position, is loaded as skip "a" is being dumped. Skip "b" is started in the up direction by movement of control switch segment 163 in a position to bridge contacts 168, as previously described. No further description of raising and lowering the skips is necessary as it is simply a repetition of that already described.

Both bells are closed while a skip is being dumped. With the bells closed, bell limit switches B84, B85 and B94 are open and bell limit switches B92, B98 and B107 are closed. Skip limit switch S82*a* is opened as skip "a" arrives within about ten feet of its dumping position. Similarly limit switch S81*b* is opened as skip "b" arrives within about ten feet of its dumping position. Thus either limit switch S81*b* or limit switch S82*a* is open when the skip is being dumped.

Assume that skip "a" is being dumped. As the skip is returned to the loading pit and reaches a point say ten feet away from the dumping position, limit switch S82*a* closes. Thus, as limit switch S81*b* is already closed, this completes a circuit for operating coil SB90 of the small bell switch. This circuit is from line L1, through skip limit switches S81*b* and S82*a*, contacts HB86 of the hoist bell interlock switch and contacts AS87 of the auxiliary sequence switch, coil SB90, interlock contacts LB91 of the large bell switch, bell limit switch B92 and contacts TR93 of the time relay to line L2, operating coil TR138 of the time relay being energized at this time, through contacts SB135 of the small bell switch and contacts LB136 of the large bell switch

Small bell switch SB, upon operation, separates contacts SB97 and SB135 and engages contacts SB141, SB144 and SB156. Contacts SB97 are interlock contacts in the circuit for coil LB96 of the large bell switch. Contacts SB135 break the circuit for coil TR138 of the time relay which separates its contacts TR93, the circuit for coil SB90 being thereafter maintained through resistance 104. Contacts SB144 and SB156 complete a circuit for armature 155 of the bell operating motor through resistance 147. Contacts SB141 complete a circuit for release coil 143 of the bell operating mechanism electromechanical brake.

The brake being released and the bell operating motor being energized, its separately excited field winding 140 being connected directly across lines L1 and L2, the bell operating mechanism starts in operation, the direction of rotation of the motor being such as to permit the opening of the small bell. Bell accelerating switch BA has its operating coil BA152 connected across armature 155. This switch operates upon the counter E. M. F. of the motor reaching a certain value to separate contacts BA148 and engage contacts BA153. The separation of contacts BA148 disconnects by-pass resistance 149 from across armature 155 while the engagement of contacts BA153 short-circuits series resistance 147 and series field winding 146. This brings the bell operating motor up to full speed.

As the bell operating mechanism starts in operation in a direction for lowering the small bell, its limit switches B85 and B94 close. Limit switch B85 establishes a circuit by-passing skip limit switches S81*b* and S82*a* and contacts HB86 and AS87 in the circuit for coil SB90. The purpose of limit switch B94 will be explained later. After the closing of limit switch B85, limit switch B84 closes, which completes a circuit for op-

erating coil HB83 of the hoist bell interlock switch through skip limit switches S81b and S82a. This switch, upon operation, separates contacts HB86 and engages contacts HB80 and HB162. Contacts HB80 establish a self-holding circuit for the switch subject to skip limit switches S81b and S82a. Contacts HB162 establish a circuit by-passing skip limit switches S166a and S174b. The separation of contacts HB86 breaks the initial energizing circuit for coil SB90 of the small bell switch, this switch being maintained energized, however, through bell limit switch B85.

As the small bell is lowered it dumps the stock thereon onto the large bell. As it reaches its full lowered position, bell limit switch B92 opens, breaking the circuit for coil SB90 of the small bell switch. The small bell switch, upon dropping out, reengages contacts SB97 and SB135 and separates contacts SB141, SB144 and SB156. The separation of contacts SB141 deenergizes brake release coil 143 while the separation of contacts SB144 and SB156 disconnects bell operating motor armature 155 and series field winding 146 from lines L1 and L2. The hoisting motor being deenergized and the brake being applied, the bell operating mechanism is brought to a stop, the brake being aided by by-pass resistance 149 which is reconnected across motor armature 155 by the reengagement of contacts BA148 as the armature voltage drops to a certain value. It is to be understood that the control system may be arranged to cause the by-pass to be reconnected across the motor armature before the final stopping operation and that resistance 147 and series field winding 146 may be controlled in steps to control acceleration and retardation of the bell operating motor.

The reengagement of contacts SB97 completes a circuit for operating coil LB96 of the large bell switch from line L1 through bell limit switch B94 and the coil LB96, contacts SB97, bell limit switch B98 and resistance 104 to line L2. Owing to resistance 104, the voltage applied to coil LB96 is insufficient to cause the large bell switch to operate. However, the reengagement of contacts SB135 completes a circuit for coil TR138 of the time relay which, upon expiration of its time interval, engages contacts TR93 to short-circuit resistance 104. Upon the short-circuiting of resistance 104, sufficient voltage is applied to coil LB96 to operate the large bell switch for returning the small bell to closed position. Thus the small bell is maintained open for a sufficient time to insure that all the stock thereon is dumped.

The large bell switch, upon operation, separates contacts LB91 and LB136 and engages contacts LB142, LB145 and LB154. Contacts LB91 serve as an electrical interlock for coil SB90 of the small bell switch. Contacts LB136 break the circuit for coil TR138 of the time relay. Contacts LB145 and LB154 establish a circuit for armature 155 of the bell operating motor for reverse rotative movement. The engagement of contacts LB142 completes a circuit for brake release coil 143. Thus the bell operating mechanism electromechanical brake being released and its motor being energized, the bell operating mechanism operates in the reverse direction permitting the biasing weight for the small bell to return the small bell to closed position.

As the small bell reaches closed position, bell limit switch B94 opens, breaking the circuit for coil LB96 of the large bell switch. The large bell switch, upon dropping out, reengages contacts LB91 and LB136 and separates contacts LB142, LB145 and LB154. Contacts LB91 prepare a circuit for another operation of small bell switch SB and contacts LB136 reestablish a circuit for coil TR138 of the time relay. Contacts LB154 and LB145 break the circuit for the bell operating motor. Contacts LB142 break the circuit for brake release coil 143. Thus, the bell operating motor being deenergized and the brake being applied, the bell operating mechanism is brought to a stop.

The above described operation of the bell operating mechanism is repeated for the next load dumped onto the small bell by a skip. Under the assumed conditions of operation, skip "b" is the next to dump its load. Thus, skip limit switch S81b is opened as the skip nears its dumping position. The opening of this switch breaks the circuit for coil HB83 of the hoist bell interlock switch which drops out to reengage its contacts HB86 and to separate contacts HB80 and HB162. The reengagement of contacts HB86 further prepares the circuit for reenergization of coil SB90 of the small bell switch. Upon operation of the skip operating mechanism to return skip "b" to the skip loading position and after say ten feet of downward movement of the skip, skip limit switch S81b closes completing the circuit for coil SB90 of the small bell switch. Thus the cycle of operation of opening the small bell to dump the stock onto the large bell and returning the small bell to closed position as above described is repeated.

These operations are repeated until a predetermined number of loads have been dumped from the small bell onto the large bell. The number of loads is selected by inserting plug 137 in a corresponding one of the jacks. Assume that it is desired to have five loads dumped onto the large bell before the above cycle of operations is interrupted. For this operation, plug 137 is inserted in the fifth jack 128.

As previously explained, each successive operation of the small bell causes an operation of the bell commutating mechanism 110. Upon the dumping of the first load onto the large bell, segment 113 of the commutator device moves off stationary contact 112 and into engagement with stationary contact 114. This causes lamp 109 connected to contact 112 to go out and the lamp connected to contact 114 to be illuminated. This indicates that the mechanism is on the first small bell operation. Upon the second small bell operation, segment 113 moves into engagement with contact 115, lighting lamp 109 connected to that contact. In this way the successive lamps are lighted indicating the number of operations of the small bell.

Upon the fifth operation, segment 113 moves into engagement with stationary contact 118, not only lighting the lamp connected thereto but also completing a circuit through jack 128 and plug 137 for coil BS134 of the bell sequence switch. This switch, upon operation, engages contacts BS108 completing a circuit for coil AS106 of the auxiliary sequence switch. Switch AS operates to separate contacts AS87 and to engage contacts AS100 and AS105. Contacts AS105 establish a self-holding circuit. Contacts AS87 are interlock contacts and serve to prevent the energization of coil SB90 of the small bell switch during this portion of the cycle of operation. Assuming charge limiting switch CL to be deenergized, the engagement of contacts AS100 completes a

circuit for coil RHR103 of the rod hoisting relay through contacts CL101.

The rod hoisting relay, as will be explained later, causes the rod of the stock line recorder to be raised from the stock line in the furnace until it is brought to a stop by abutment 310 (see Figure 1), as previously described. As the rod is lifted, bridging contact 60 of the stock line recorder commutating device 58 is moved back into position where it bridges contact 36 with segment 35. This completes a circuit for coil OS61 of the large bell operating switch. This switch separates contacts OS71 and engages contacts OS102. The purpose of contacts OS71 will be explained later. Contacts OS102 complete a circuit through contacts AS100 and CL101 by-passing bell limit switch B94 in the circuit for coil LB96 of the large bell switch. Inasmuch as switch BS is energized during the opening of the small bell, this by-pass circuit is established at the time the small bell is reclosed and switch B94 opens. Thus the large bell switch is maintained operated. This maintains the brake released and the motor energized, continuing the rotation of the bell operating mechanism past neutral position and effecting the opening of the large bell to dump the stock accumulated thereon into the furnace.

As the large bell starts to open, limit switches B85 and B94 close and as the bell reaches full open position, limit switches B98 and B107 open. The opening of switch B107 breaks the circuit for coil AS106 of the auxiliary sequence switch, which drops out to reengage contacts AS87 and to separate contacts AS100 and AS105. The reengagement of contacts LB91 of the large bell switch completes a circuit for coil SB90 of the small bell switch through bell limit switches B85 and B92 and resistance 104. The reengagement of contacts LB136 reestablishes a circuit for coil TR138 of the time relay which, upon expiration of it time interval, engages contacts TR93 to short-circuit resistance 104, causing the small bell switch to operate. This switch effects the release of the brake and establishes circuits for the bell operating motor to effect the return of the large bell to closed position. As the large bell reaches closed position, bell limit switch B85 opens, deenergizing the small bell switch. This causes the bell operating mechanism to be brought to a stop.

During the operation of the large bell, segment 113 of the bell commutating device is returned to the starting position where it engages contact 112 to reestablish a circuit for the lamp 109 connected to this contact. This indicates that a large bell operation is being performed and the next operation will be an operation of the small bell. This cycle of operation as above described is repeated upon the dumping of another skip load onto the small bell and the return of the skip toward the loading pit, the large bell being dumped again after the selected number of loads have been dumped thereon from the small bell.

Coil RHR103 of the rod hoisting relay is maintained energized after the separation of contacts AS100, as a result of the opening of bell limit switch B107 as the large bell reaches fully open condition, through bell limit switch B94 and contacts OS102. Thus this relay is maintained energized until switch B94 opens as the large bell reaches closed position. When this occurs, relay RHR drops out to reengage contacts RHR17 and RHR32 and to separate contacts RHR24. Contacts RHR24 are in the circuit for coil RH25 of the rod hoisting switch, preventing the establishment of a circuit for this coil, while contacts RHR17 are in the circuit for coil RL18 of the rod lowering switch. Operating coil RL18 of the rod lowering switch is further controlled by means of a timing device, designated generally by reference letters TD. A timing device suitable for this purpose is illustrated in Figure 5.

Referring to Figure 5, this timing device comprises a motor 311 which operates through reduction gearing 312 to drive a shaft 313. An idler gear 314 is supported by one arm of a bell crank lever 320 freely mounted on shaft 313. The idler gear is driven by the reduction gearing and is adapted to be thrown into mesh with another gear 321 by lever 320. The other arm of lever 320 constitutes the armature of a clutch magnet, the coil of which is designated 13. When this magnet is energized, lever 320 is swung counterclockwise to mesh idler gear 314 with gear 321. When motor 311 is in operation and the clutch magnet is energized, meshing gear 314 with gear 321, gear 321 is rotated in a clockwise direction. Upon the engagement of a pin 322 on gear 321 with arm 323 of bell crank lever 324, lever 324 is swung gradually counterclockwise about its pivot. This lever is connected by a spring 325 to a contact lever 326. When the lower end of the spring is moved beyond the center line through the pivot for contact lever 326, the contact lever is thrown clockwise about its pivot with a snap action. This disengages a contact carried by the lever from a cooperating stationary contact and moves another contact carried by the lever into engagement with another stationary contact. These cooperating contacts are designated 15 and 23. Upon the separation of contacts 15 the timing motor is deenergized as will be shown later. If the clutch magnet is maintained energized the contacts will be retained in this position with contacts 15 separated and contacts 23 in engagement. Upon deenergization of the clutch magnet, lever 320 drops, disengaging idler gear 314 from gear 321 and a torsion spring 327 associated with gear 321 returns the gear in a counterclockwise direction to the position from which it started. As this movement takes place, pin 322 moves away from lever 324, which is swung back about its pivot by a spring 330. As spring 325 passes the center line through the pivot for contact lever 326, the contact lever is snapped back into the position illustrated, separating contacts 23 and reengaging contacts 15. As gear 321 arrives at its former position, it is brought to rest by the engagement of a pin 331 carried thereby with a stop 332. The time interval provided by the timing device is from the time the motor and clutch are energized until the engagement of contacts 23 takes place. This time interval may be varied by varying the circumferential position of pin 322 on gear 321.

Referring back to Figure 4, contacts RL12 of the rod lowering switch are in engagement during the raising of the rod and while the large bell is being opened and closed. If the time interval for which the timing device is set expires before the large bell is closed, contacts TD23, upon engagement, are maintained so for the separation of contacts TD15, although breaking the circuit for armature TD14 and field winding TD20 of the timing device motor, does not deenergize clutch magnet coil TD13. Under such conditions, the engagement of contacts RHR17 completes the circuit for coil RL18 of the rod lowering switch. Otherwise, this circuit is com-

pleted upon the engagement of contacts TD23 of the timing device as the time interval expires. This circuit is through contacts RHR17, coil RL18, contacts RH21, stock line recorder limit switch R22 and contacts TD23.

Switch RL, upon operation, separates contacts RL12 and RL26 and engages contacts RL30, RL59, RL66 and RL78. Contacts RL26 are arranged in the circuit for coil RH25 of the rod hoisting switch. These contacts serve as an electrical interlock. Contacts RL30 by-pass contacts TD23 of the timing device, thereby establishing a self-holding circuit. Contacts RL12 break the circuit for the timing device motor armature TD14 and field winding TD20 and for clutch magnet coil TD13. This causes the separation of contacts TD23 and the reengagement of contacts TD15. Contacts RL66 and RL78 complete a circuit for armature 73 and series field winding 69 of the stock line recorder motor through resistance 70. The engagement of contacts RL59 completes a circuit for brake release coil 64 of the stock line recorder mechanism. The separately excited field winding 65 of the recorder motor is connected across lines L1 and L2. Thus, upon the brake being released, the stock line recorder mechanism starts in operation, the direction of rotation of the motor being such as to lower the rod into the furnace. The initial operation of the stock line recorder effects the reengagement of limit switch R27. When plate 292 engages nuts 291 (Figure 2), the rod starts to lower into the furnace.

The lowering of the rod takes place at a slow speed owing to the fact that contacts RL66 prevent the energization of coil RA72 of the rod accelerating switch and contacts RA75 remain separated. Thus, series field winding 69 and resistance 70 remain connected in series with the motor armature 73 and the by-pass resistance 74 remains connected across the motor armature.

When the rod has been lowered into position where the plate on the lower end thereof strikes the stock in the furnace, the recorder mechanism acts as previously described to open limit switch R22. This breaks the circuit for coil RL18 of the rod lowering switch. Switch RL drops out to reengage contacts RL12 and RL26 to separate contacts RL30, RL59, RL66 and RL78. Contacts RL26 are in the circuit for coil RH25 of the rod hoisting switch, the circuit for this coil being open at contacts RHR24. The separation of contacts RL66 and RL78 breaks the circuit for the operating motor of the recorder mechanism and as contacts RL59 break the circuit for the brake release coil 64, the stock line recorder mechanism is brought to a stop with the rod in its lowered position.

During the lowering of the rod, bridging contact 60 of commutator device 58 moves into position successively bridging the stationary contacts with feed contact 35. Upon the disengagement of contact 60 from stationary contact 36, the circuit for coil OS61 of the large bell operating switch is broken. This switch thereupon drops out to separate contacts OS102 in the circuit for causing operation of large bell switch LB to effect the opening of the large bell and reengages contacts OS71 in the circuit for coil RA72 of the rod accelerating switch. Upon the engagement of contact 60 with stationary contact 37 a circuit is completed through contacts RHR32 of the rod hoisting relay for operating coil CL33 of the charge limiting switch. Switch CL, upon operation, separates contacts CL101 in the circuit for coils LB96 and RHR103 and engages contacts CL31 to establish a self-holding circuit. Upon the engagement of contact 60 with contact 38, a circuit is completed for the first of the series of lamps 62 of the stock line indicator.

The reengagement of contacts RL12 reestablishes the circuit for the timing device which starts in operation. Upon the expiration of the time interval for which this device is set, say one minute, it reengages contacts TD23 to reestablish the circuit for coil RL18 of the rod lowering switch. This switch operates as before to permit the plate on the lower end of the rod to drop to the point to which the charge in the furnace has settled. The above cycle of operation is repeated at the specified time intervals.

Assume that before bell sequence switch BS is operated bridging contact 60 is moved into engagement with contact 43. This establishes a short-circuit for coil CL33 of the charge limiting switch, causing the charge limiting switch to drop out to reengage contacts CL101. Thus, upon the operation of auxiliary sequence switch AS to engage contacts AS100, as a result of the operation of bell sequence switch BS to engage contacts BS108, a circuit is established for coil RHR103 of the rod hoisting relay. This relay operates as previously described to separate contacts RHR17 and RHR32 and to engage contacts RHR24. Contacts RHR24 establish a circuit for coil RH25 of the rod hoisting switch through contacts RL26 and limit switch R27. Contacts RHR17 prevent the energization of coil RL18 of the rod lowering switch. The rod hoisting switch, upon operation, separates contacts RH21 and engages contacts RH63, RH68 and RH76. Contacts RH21 are in the circuit for coil RL18 and serve as an electrical interlock. Contacts RH68 and RH76 complete a circuit for armature 73 and series field winding 69 of the stock line recorder operating motor through series resistance 70 in a direction for operating the motor to lift the rod, the brake being released as a result of the engagement of contacts RH63 to establish a circuit for brake release coil 64. Inasmuch as the circuit for coil RHR103 is established during the opening of the small bell, the hoisting of the rod starts during this portion of the cycle of operation. In addition, coil RA72 of the rod accelerating switch is energized during the hoisting of the rod. This causes contacts RA77 to be separated, disconnecting by-pass resistance 74 from across armature 73 and contacts RA75 to be engaged, short-circuiting resistance 70 and series field winding 69. Thus the rod is lifted at full speed so as not to delay the opening of the large bell upon return of the small bell to closed position.

The bridging contact 60 is returned to its former position as the rod is raised in the furnace. Upon the engagement of this contact with stationary contacts 37, a circuit is not completed for coil CL33, owing to the fact that contacts RHR32 are separated. The engagement of bridging contact 60 with contact 36, however, establishes a circuit for coil OS61 of the large bell operating switch which operates, as previously described, to engage contacts OS102 in a circuit for causing the opening of the large bell and to separate contacts OS71. The separation of contacts OS71 breaks the circuit for coil RA72 of the rod accelerating switch which separates contacts RA75 and engages contacts RA77. The separation of contacts RA75 reinserts resistance 70 and series field winding 69 in series with motor armature

73 while the engagement of contacts RA77 connects resistance 74 across the motor armature. This causes the motor to slow down. The rod is thereafter brought to a stop by stop 310 and thereafter the motor is brought to a stop by the opening of limit switch R27 to deenergize coil RH25 of the rod hoisting relay.

So long as the stock in the furnace has settled to or below a point causing the dropping out of charge limiting switch CL as the time arrives for opening the large bell, the above described cycle of operation will be continued. However, if the stock line is above such point at this time, the mechanism operates automatically to prevent the opening of the large bell until the stock has settled to or below this point.

Assume that at the time that bell sequence switch BS is energized in preparation for effecting the opening of the large bell, the stock line in the furnace is at such a height as to prevent bridging contact 60 of commutating device 58 engaging contact 43 to drop out charge limiting switch CL. Under such conditions, the operation of auxiliary sequence switch AS to engage contacts AS100 does not establish a circuit for coil RHR103 of the rod hoisting relay, owing to the fact that contacts CL101 are separated. Thus, the hoisting of the rod of the stock line recorder does not take place. However, the operation of the bell operating mechanism to effect the dumping of the stock from the small bell onto the large bell and the return of the small bell to closed position, is completed. In addition, the loaded skip which is being hoisted to the top of the furnace may be dumped onto the small bell after it has closed. As the emptied skip starts down the incline and effects the closing of its limit switch (S81*b* or S82*a*), a circuit is not established for coil SB90 of the small bell switch, owing to the fact that contacts AS87 are separated. Thus, not only is the opening of the large bell prevented when the furnace is full but also further operation of the small bell is prevented after it completes the dumping of the last load of stock onto the large bell.

Since further operation of the bell operating mechanism is prevented when the furnace is full as the time arrives to dump the large bell, bell limit switch B84 is not closed and coil HB83 of the hoist bell interlock switch is not energized. Thus, contacts HB162 remain separated, which brings the skip operating mechanism to a stop. For an understanding of this operation, assume that skip "*a*" is the one which dumped the last load onto the small bell. Thus, upon the reclosure of skip limit switch S82*a* as skip "*a*" starts down the incline, a circuit is not established for coil HB83 owing to bell limit switch B84 being open. Contacts HB162 therefore remain separated so that the opening of skip limit switch S174*b*, which occurs after the closing of limit switch S82*a*, breaks the circuit for coil HD170 of hoist direction switch HD (switch HD being the hoist direction switch which was operated under the assumed conditions). This causes the skip operating mechanism to be brought to a stop with the skips in the positions to which they have been moved. Thus the entire charging operation is suspended. The stock line recorder, however, continues to function, permitting the lowering of the rod at successive intervals to follow the stock in the furnace.

When the stock in the furnace settles to a point permitting the operation of commutating device 58 to effect the bridging of contact 43 and contact 35, coil CL33 of the charge limiting switch is short-circuited, causing the reengagement of contacts CL101. This causes the operation of the rod hoisting relay RHR to cause the hoisting of the rod. As the rod reaches its uppermost position, switch OS is operated to engage contacts OS102, establishing a circuit for coil LB96 of the large bell switch. This causes the bell operating mechanism to open the large bell, dumping the material thereon into the furnace. As the large bell reaches open position, bell limit switch B107 opens to deenergize coil AS106 of the auxiliary sequence switch, which engages contacts AS87. Thus, a circuit is established by-passing bell limit switch B85, thereby continuing operation of the bell operating mechanism through neutral to open the small bell as the large bell is returned to closed position. As the small bell opens, bell limit switch B84 closes after reclosure of bell limit switch B85. The closing of switch B84 operates hoist bell interlock switch HB, which engages contacts HB162 and, the operator maintaining the master control switch in operated condition, this starts the skip hoisting mechanism in operation from the point at which it was brought to a stop. Thus, as soon as the stock line in the furnace falls to a point where the furnace is no longer considered full, the charging mechanism is automatically restarted in operation from the point it left off.

The lamps 62 of the stock line indicator indicate the height of the stock in the furnace. The first of the lamps shows when the furnace is full while those connected to contacts beyond contact 43 show that the furnace is not full and to what point below the full line the stock has settled.

It has previously been pointed out that the invention is applicable to a blast furnace installation having a revolving top. Circuits for interlocking the revolving top controller with the other control mechanism have been illustrated in Figure 4. The revolving top controller may be of the type shown in the patent to Mortensen, No. 1,790,942, dated February 3, 1931, and the circuits have been illustrated for application to such type of control. Skip limit switches S191*b* and S192*a* act to control the operation of the revolving top, these limit switches corresponding to limit switches 13 and 14 of the revolving top control system shown in the Mortensen patent. With this arrangement, when the furnace is full as the time arrives for opening the large bell, skip limit switches S191*b* and S192*a* prevent further operation of the revolving top controller. Skip limit switch S192*a* is closed as skip "*a*" reaches its dumping position, while skip limit switch S191*b* is closed as skip "*b*" reaches its dumping postion. At other times these limit switches are open. Thus, as the skip hoist mechanism is brought to a stop upon a certain distance of skip travel after a load is dumped on the small bell under conditions where operation of the large bell is prevented because the furnace is full, the operation of the revolving top is also prevented. Contacts RTR164 are contacts on a revolving top relay, the operating coil of which may be connected in parallel with coil 10*a* of the control system of the Mortensen patent. With this arrangement, contacts RTR164 remain separated until the cycle of operation of the revolving top has been completed and the revolving top motor has been brought to a stop. This prevents the starting of the skip hoist during re-

volving top operation, which in turn prevents operation of the bell operating mechanism.

Thus it is seen that, when the furnace is full as the time arrives to dump the large bell, not only is further operation of the bells prevented and the skip hoist brought to a stop, but, in an installation provided with a revolving top, further operation of the revolving top is prevented. It will also be seen that as soon as the stock line in the furnace drops to a point where the furnace is no longer considered full, the operation of the charging mechanism is automatically resumed.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:—

1. In combination; a blast furnace having a small bell and a large bell at the top thereof, the large bell being arranged below the small bell; mechanism for operating said bells; control means for causing said bell operating mechanism to operate the small bell a predetermined number of times to one operation of the large bell; a rod extending downwardly into the furnace at the top thereof; hoisting mechanism for said rod; means for controlling the operation of said rod hoisting mechanism to cause the bottom of the rod to follow the stock as it sinks in the furnace between operations of the large bell; means operable upon the last of the said predetermined number of operations of the small bell, under conditions where the top of the stock in the furnace beneath the rod is below a certain level, to cause operation of said rod hoisting mechanism to lift the rod, said means being ineffective to cause operation of said rod hoisting mechanism to lift the rod when the top of the stock beneath the rod is above said predetermined level; and means controlled by the lifting of said rod and operable as the rod in being lifted reaches a predetermined height in the furnace to cause operation of said bell operating mechanism to operate the large bell.

2. In combination; a blast furnace having a small bell and a large bell at the top thereof, the large bell being arranged below the small bell to receive stock from the small bell; mechanism for dumping successive loads of stock onto the small bell; mechanism for operating said bells; means for causing said bell operating mechanism to open the small bell to dump stock therefrom onto the large bell and thereupon to close the small bell; means for causing said bell operating mechanism to open the large bell after a predetermined number of operations of the small bell and to reclose the large bell after the stock has been dumped therefrom into the furnace; a rod extending downwardly into the furnace at the top thereof; hoisting mechanism for said rod; means for controlling the operation of said rod hoisting mechanism to cause the bottom of the rod to follow the stock in the furnace during said predetermined number of operations of the small bell, said means being responsive to the last of said predetermined number of operations of the small bell to cause said rod hoisting mechanism to lift the rod; means actuated in accordance with the position of said rod operable, when the top of the stock in the furnace beneath the rod as the time arrives to lift the rod is above a certain point, to prevent operation of said rod hoisting mechanism to lift the rod and to prevent further operation of said bell operating mechanism upon the return of the small bell to closed position after said last of said predetermined number of operations thereof; and means responsive to the stopping of said bell operating mechanism to stop operation of said mechanism for dumping stock onto the small bell.

3. In combination; a blast furnace having a small bell and a large bell at the top thereof, the large bell being arranged below the small bell to receive stock from the small bell; mechanism for operating said bells; means for causing said bell operating mechanism to open the small bell to dump stock therefrom onto the large bell and to reclose the small bell; means for causing said bell operating mechanism to open the large bell after a predetermined number of operations of the small bell to dump stock thereon and to reclose the large bell after the stock has been dumped therefrom into the furnace; a rod extending downwardly into the furnace at the top thereof; hoisting mechanism for said rod; means for controlling the operation of said rod hoisting mechanism to cause the rod to follow the stock in the furnace between operations of the large bell, said means being responsive to the last of said predetermined number of operations of the small bell to cause said rod hoisting mechanism to lift the rod; and means actuated in accordance with the position of said rod operable, when the bottom of the rod is at or above a predetermined point in the furnace, to prevent operation of said rod hoisting mechanism to lift the rod and to prevent operation of said bell operating mechanism as the time arrives for operating the large bell to open the large bell and also the small bell upon its return to closed position after said last of said predetermined number of operations of the small bell, said last named means thereafter acting upon the bottom of the rod dropping below said predetermined point to cause said rod hoisting mechanism to operate the large bell and to resume operation of the small bell after the large bell is returned to closed position.

4. In combination; a blast furnace having a small bell and a large bell at the top thereof, the large bell being arranged below the small bell to receive stock from the small bell; mechanism for dumping successive loads of stock onto the small bell; mechanism for operating said bells; means for causing said bell operating mechanism to open the small bell after a load has been dumped thereon and to reclose the small bell after the stock has been dumped therefrom onto the large bell; means for causing said bell operating mechanism to open the large bell after a predetermined number of loads have been dumped thereon by the small bell and to reclose the large bell after the stock accumulated thereon has been dumped into the furnace; a rod extending downwardly into the furnace at the top thereof; hoisting mechanism for said rod; means for controlling the operation of said rod hoisting mechanism to cause the rod to follow the stock in the furnace and to lift the rod prior to the opening of the large bell; and means actuated in accordance with the position of said rod for controlling the operation of said rod hoisting mechanism, said bell operating mechanism and said mechanism for dumping stock onto the small bell, said last named means acting, when the bottom of the rod is at or above a predetermined point in the furnace as the time arrives for operating the large bell, to prevent operation of said rod hoisting mechanism to

lift the rod, to prevent operation of said bell operating mechanism to dump either bell and to stop operation of said mechanism for dumping stock onto the small bell, said last named means thereafter acting upon the bottom of the rod dropping below said predetermined point to cause said rod hoisting mechanism to lift the rod, to cause said bell operating mechanism to dump the large bell and to resume dumping of the small bell after the large bell is returned to closed position and to cause said mechanism for dumping stock onto said small bell to resume operation.

5. In combination; a blast furnace having a small bell and a large bell at the top thereof, the large bell being arranged below the small bell to receive stock from the small bell; mechanism for dumping successive loads of stock onto the small bell; mechanism for operating said bells; means for causing said bell operating mechanism to open the small bell after a load has been dumped thereon and to reclose the small bell after the stock has been dumped therefrom onto the large bell; means for causing said bell operating mechanism to open the large bell after a predetermined number of loads have been dumped thereon by the small bell and to reclose the large bell after the stock accumulated thereon has been dumped into the furnace; a rod extending downwardly into the furnace at the top thereof; hoisting mechanism for said rod; means for controlling the operation of said rod hoisting mechanism to cause the rod to follow the stock in the furnace, said means being responsive to the opening of the small bell to dump the last of said predetermined number of loads onto the large bell to cause said rod hoisting mechanism to lift the rod; and means actuated in accordance with the position of said rod operable, when the bottom of the rod is at or above a predetermined point in the furnace, to prevent operation of said rod hoisting mechanism to lift the rod, to prevent operation of said bell operating mechanism as the time arrives for operating the large bell to open the large bell and also the small bell upon its return to closed position after dumping said last of said predetermined number of loads onto the large bell and to stop operation of said mechanism for dumping stock onto the small bell after dumping another load onto the small bell after the small bell has dumped said last load onto the large bell, said last named means thereafter acting upon the bottom of the rod dropping below said predetermined point to cause said rod hoisting mechanism to lift the rod, to cause said bell operating mechanism to dump the large bell and to resume dumping of the small bell after the large bell is returned to closed position and to cause said mechanism for dumping stock onto said small bell to resume operation.

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