Dec. 22, 1931. F. I. SMITH 1,837,685

BLAST FURNACE CHARGING EQUIPMENT

Filed Feb. 27, 1931 2 Sheets-Sheet 1

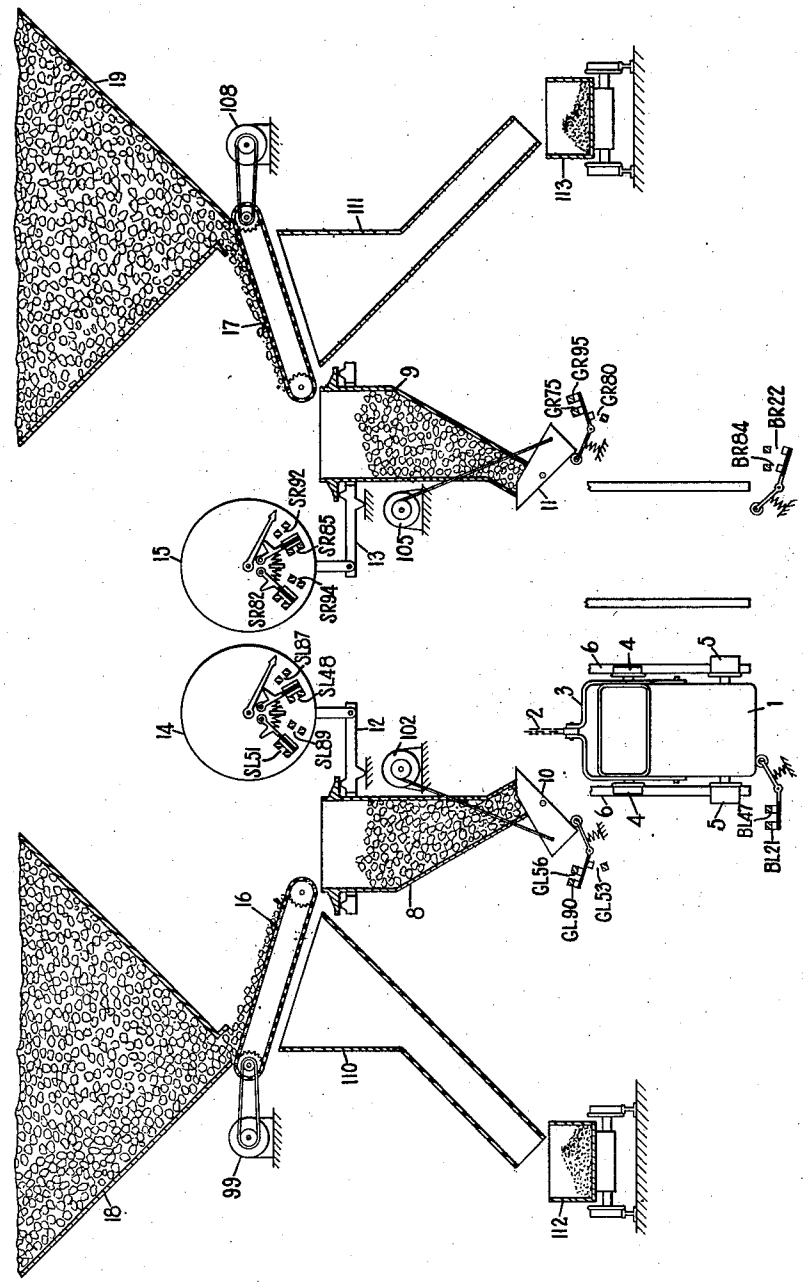

FIG. 1

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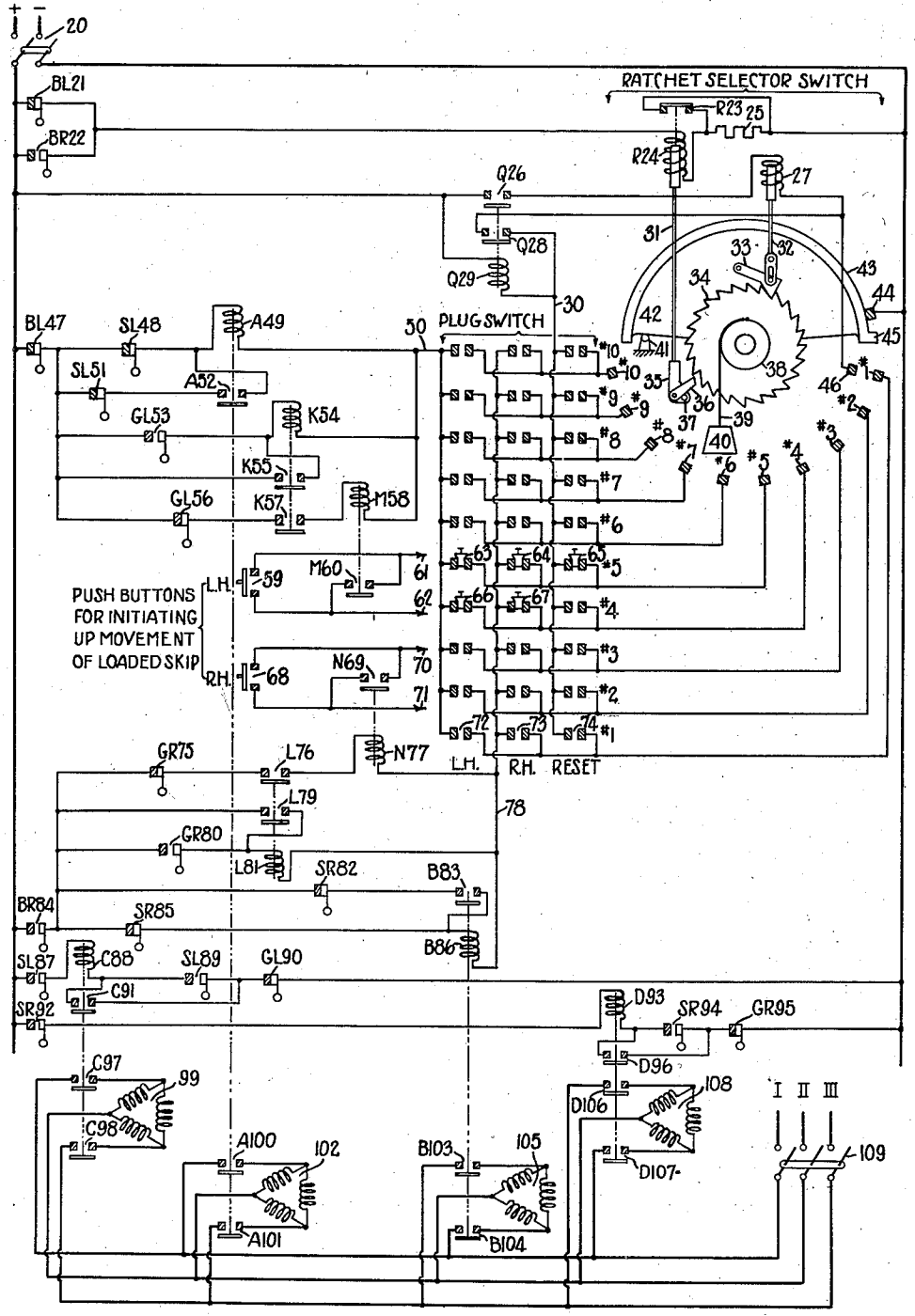

FIG. 2

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1,837,685

UNITED STATES PATENT OFFICE

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BLAST FURNACE CHARGING EQUIPMENT

Application filed February 27, 1931. Serial No. 518,773.

This invention relates to equipment for charging blast furnaces.

The primary object of this invention is to reduce the number of manual operations to be performed in charging blast furnaces, and to increase the amount of material that may be handled in a given length of time by a given sized blast furnace skip hoist. As a consequence, larger sized blast furnaces may be employed with a given sized skip hoist than is employed at present, and such larger blast furnaces may be charged with fewer manual operations.

The principal feature of the invention is the provision of equipment for handling a blast furnace ingredient entirely automatically, from the bin in which such ingredient is stored to the hopper at the top of the blast furnace.

Other features, ancillary thereto, will become apparent from the following description and appended claims.

The invention involves the removal of a predetermined amount of a blast furnace ingredient from the bin where such ingredient is stored, the loading of such measured amount of ingredient into the appropriate skip bucket or buckets of the blast furnace hoist at the proper time or times in the charging cycle, and the dispatch of such loaded skip bucket or buckets up to the dumping position at the top of the furnace, the accomplishment of all the operations above described being entirely automatic.

In the drawings:—

Figure 1 is a schematic diagram of the equipment that may be provided in accordance with this invention for automatically charging a blast furnace; and

Figure 2 is a simplified schematic diagram of the power and control circuits for the equipment illustrated in Figure 1.

Referring to Figure 1, there is there shown a skip bucket, designated as 1, of a blast furnace skip hoist of any suitable and well known construction. This bucket, illustrated as in the loading position, travels upon the tracks 6 by means of the front wheels 4 and rear wheels 5. A hoisting cable 2 is suitably attached to the skip bucket 1 as by means of the yoke 3. The raising and lowering of the skip bucket is effected through the medium of this hoisting cable 2, commonly by winding the same in a suitable manner upon a drum. The manner by which this drum may be driven, and the other details of the skip hoist, are believed to be sufficiently well understood that further description thereof is unnecessary.

In the illustrated embodiment of the invention the blast furnace skip hoist comprises two skip buckets, each operated from the same hoisting drum in such a manner that while one skip bucket is being raised, the other skip bucket is being lowered. As a consequence, when one of the skip buckets is in the loading position, as is the illustrated bucket 1, the other bucket is at the top of the hoistway dumping its contents into the hopper at the top of the blast furnace. The principles of this invention are, however, readily applicable to skip hoists of the single bucket type, but for conciseness the details of such application to single bucket skip hoists are not here described.

The material with which the blast furnace is to be automatically charged is shown in Figure 1 as stored in two separate bins 18 and 19, or a common bin having two separate discharge portions 18 and 19. Inasmuch as the equipment for withdrawing such material from the left-hand bin 18 and for loading the left-hand skip bucket 1 therewith, and also for initiating the movement of such left-hand skip, when loaded, upward to its dumping position at the top of the blast furnace, is similar to that for effecting the loading and starting of the right-hand skip bucket, only the equipment for the left-hand skip bucket is herein described.

Beneath the discharge opening of the left-hand bin 18 there is provided a chain-like screening device 16 operated by the motor 99. The design of the discharge opening of bin 18 and of the screening device 16 is such that the material within the bin 18 is removed therefrom only when motor 99 operates, that is, only when there is movement of the chains of the screening device 16. As the material is conveyed by the screening device

16, the fines drop down into the chute 110 and thence into the car 112. The remainder of the material passes off the end of the screening device into a weigh hopper 8. This weigh hopper 8 is provided with a gate 10 which is normally closed by reason of the weight of such gate. The weigh hopper 8 is suitably supported on a scale beam 12 to which scales 14 are appropriately connected. By this arrangement the material that is dumped into the weigh hopper from the screening device may be measured as to weight. It is to be understood that the illustrated showing of the means for supporting the weigh hopper and also the various illustrated constructional features of the scale beams and of the scale itself, are purely diagrammatic.

The gate 10 of the weigh hopper 8 is arranged to be opened upon energization of a torque motor 102. Upon deenergization of such motor, the gate 10 returns to its initial, (and illustrated) position. It is to be understood that this manner of operation of the gate is illustrative only, for many various methods of operating the gate by power may be used. One manner, for those who prefer hydraulic operators, is to have motor 102 operate a centrifugal pump. The opening of gate 10 is then effected by the movement of a piston resulting from displacement of the liquid in which the pump attached to motor 102 operates.

For effecting the automatic operation of the left-hand screening motor 99, the left-hand gate motor 102 and the left-hand skip bucket 1, and also the automatic operation of the right-hand screening motor 108, the right-hand gate motor 105 and the right-hand skip bucket, a number of mechanically operated switches are provided. These switches are mechanically actuated in accordance with the positions of various parts of the equipment illustrated. For the left-hand equipment, there is provided a bucket switch, comprising contacts BL 21 and BL 47, which is actuated when the left-hand skip bucket is in the loading position. There is another switch, termed a gate switch, which comprises contacts GL 56, GL 90 and GL 53, and which is actuated in accordance with the position of the left-hand weigh hopper gate 10. There is a third switch, referred to as a scale switch and illustrated as having two independently movable arms and comprising the series of contacts SL 51, SL 89, SL 48 and SL 87, which is actuated in accordance with the load in the weigh hopper 8. In the diagrammatic form in which the invention is illustrated in Figure 1, this series of contacts of the scale switch is shown as operated by the pointer of the left-hand scales 14. The two independently movable arms of this scale switch are so urged by small springs that both contacts SL 51 and contacts SL 87 are normally closed, and that the other two contacts SL 89 and SL 48 are normally open. Each arm, however, is movable against the action of its spring when the pointer of the scales engages with a projection on the corresponding arm. As a consequence, when the pointer of the scales 14 indicates that the weigh hopper 8 has been filled with the prescribed amount of material, the pointer causes the separation of contacts SL 87 and the engagement of contacts SL 48. Such is the position of the pointer and of the contacts SL 87 and SL 48 that is illustrated in Figure 1. When the weigh hopper is empty the pointer engages with the other movable arm to cause the separation of contacts SL 51 and the engagement of contacts SL 89.

For the right-hand equipment switches similar to those described above are provided. It is believed unnecessary to further describe them in detail at this point.

For convenience, and in order to afford a rapid understanding of the invention, the contacts of the mechanically operated switches set forth above are designated with prefixes in accordance with the following table:

BL—Bucket switch for left-hand skip bucket.

BR—Bucket switch for right-hand skip bucket.

GL—Gate switch for left-hand weigh hopper.

GR—Gate switch for right-hand weigh hopper.

SL—Scale switch for left-hand weigh hopper.

SR—Scale switch for right-hand weigh hopper.

Thus, contacts GL 53 are contacts adapted to be engaged when the gate of the left-hand weigh hopper 8 is open and contacts SR 94 are contacts adapted to be engaged when the right-hand weigh hopper is empty.

Reference may now be had to Figure 2 which illustrates diagrammatically an arrangement of various control and power circuits effectual to cause the operation of the equipment illustrated for automatically charging the blast furnace with the material contained in bins 18 and 19 in accordance with the principles of this invention. In this figure, the coils and contacts of the electromagnetic switches are separated in the interest of simplification of circuits. For convenience in understanding the diagram, however, each coil is associated with the contacts which it actuates by means of a dot-and-dash line. Also, to assist in the understanding of the invention the stationary contacts of all the switches, mechanical as well as electromagnetic, are illustrated in cross section.

The various electromagnetic switches employed in the control system chosen to illus-

trate the principle of the invention are designated as a whole as follows:

A—Left-hand gate motor switch.
B—Right-hand gate motor switch.
C—Left-hand screening motor switch.
D—Right-hand screening motor switch.
K—Auxiliary relay for left-hand skip.
L—Auxiliary relay for right-hand skip.
M—Push button relay for left-hand skip.
N—Push button relay for right-hand skip.
Q—Reset relay.
R—Ratchet operating coil.

Throughout the description which follows, these letters are applied as prefixes of the reference numerals for the parts of the above designated switches. Thus, for example, A 49 indicates that the coil referred to is the actuating coil of the left-hand gate motor switch, while L 79 indicates contacts of the auxiliary relay for the right-hand skip. In the case of the numerals employed in the control system, the lowest number (20) appears in the upper left-hand corner of Figure 2 with the succeeding numbers following in numerical sequence, from left to right, downwardly of the sheet of drawings. The arrangement of the numbers in this sequence facilitates the ready location of any element referred to in the description. Electromagnetic switches are shown in their deenergized positions.

In Figure 2 there is illustrated what is termed a "ratchet selector switch". This switch comprises a rachet operating coil R 24 which, upon energization, causes a ratchet 36 (secured to rod 31) to engage with a tooth of the ratchet wheel 34 and then to effect clockwise rotation of the ratchet wheel 34. This clockwise rotation of the ratchet wheel 34 is effected against the action of a weight 40. Weight 40 is suspended from one end of a flexible connection 39, such as a rope or chain, the other end of which rope or chain is secured to a drum 38 formed upon the ratchet wheel 34. The clockwise rotation of ratchet wheel 34 thus winds the flexible connection 39 around the drum 38, thereby raising the weight 40. The counterclockwise rotation of the ratchet wheel 34 is normally prevented by means of the pawl 33. The pawl 33, however, is adapted to be withdrawn from engagement with the ratchet wheel by an upward movement of the rod 32, which in turn occurs when the pawl magnet 27 is energized.

To the ratchet wheel 34 there is suitably secured, so as to rotate therewith, a rotating segment 42. Cooperating with one edge of segment 42 is the stop 41 by which is determined the ultimate counterclockwise rotation of the ratchet wheel and of the rotating segment. The rim of the rotary segment 42 is provided with an arcuate conducting portion 43. A brush 44 is provided which at all times engages with this conducting portion of the rotary segment. A brush 46 is provided which engages the conducting portion 43 of the rotary segment at all times except when the rotary segment is in its initial position against the stop 41. (This is the position in which the parts of the ratchet selector switch are illustrated in Figure 2). The conducting portion 43 of the rotary segment has formed at one end thereof an outwardly extending projection 45 as is shown in Figure 2. Along the path of travel of projection 45 there is located a series of brushes, indicated as #1, #2, #3, etc. to #10, inclusive. These numbered brushes are arranged so that, with the rotary segment in the initial position as illustrated, the first energization of the ratchet operating coil R 24 causes the engagement of projection 45 with brush #1; the next, or second energization of the ratchet operating coil causes the engagement of projection 45 with brush #2; and so on, each energization of the ratchet operating coil R 24 causing the projection 45 to engage with that numbered brush which corresponds to the number of times the ratchet operating coil has been energized.

In Figure 2 there is also illustrated what is termed a "plug switch". This switch comprises three vertical rows of open circuited contacts, the number of contacts in each row being equal to the number of the numbered brushes provided upon the ratchet selector switch. Thus, in the illustrated embodiment, there are ten contacts 72 in the vertical column indicated by "L. H.", ten contacts 73 in the vertical column indicated by "R. H." and ten contacts 74 in the vertical column indicated by "Reset". As a result, there is associated with each numbered brush of the ratchet selector switch a set of three contacts, each set comprising one of each of the contacts 72, 73 and 74. Plugs similar to those indicated at 63 may be inserted in any of the open circuited contacts so as to close the circuit therethrough. Such plugs are readily removable and interchangeable so that any combination may be obtained with the plug switch.

In Figure 2 there are also illustrated two push buttons, one, 59, arranged to complete a circuit between the wires 61 and 62, and the other, 68, arranged to complete a circuit between wires 70 and 71. Wires 61, 62, 70 and 71 lead to a suitable controlling equipment for the blast furnace skip hoist by which the raising and lowering of the skip buckets is controlled. The details of this controller for the skip hoist are not shown inasmuch as it is believed unnecessary for the understanding of this invention. It is believed sufficient to note that when the circuit between wires 61 and 62 is completed when the left-hand skip bucket is in the loading position, the left-hand skip bucket is caused

to start upwardly; while when the circuit between wires 70 and 71 is completed when the right-hand skip bucket is in the loading position, the right-hand skip bucket is caused to start upwardly.

The principal ingredients with which a blast furnace is charged are ore, limestone and coke. It is common practice in blast furnace operation to have each charge which is dumped into the blast furnace by the opening of the large bell thereof, to be composed of certain predetermined amounts of each of the three ingredients set forth above. Each of these ingredients is customarily hoisted to the top of the furnace in separate skip loads. In other words, each charge consists of a certain number of skip loads of ore, a certain number of skip loads of limestone and a certain number of skip loads of coke. The number of skip loads of the various ingredients which make up a charge is variable between wide limits depending upon the type of ore employed, the type of iron desired, and numerous other factors. In addition, the amount of any one ingredient carried by a skip bucket may differ from the amount of each of the other ingredients carried by such skip bucket.

As explained previously, this invention is applicable to the automatic charging of any of the ingredients with which a blast furnace is charged. In the following description, however, it is assumed that the equipment illustrated is employed for automatically charging coke into the blast furnace. It is further assumed that a charge is to comprise five skip loads, of which the first two loads are to be of ore, the third load is to be of limestone, and the last two loads are to be of coke. As a consequence of the fact that each charge is to comprise five skip loads, a plug 65 is inserted in the column of contacts 74 (designated the Reset column) in the plug switch at the fifth row from the bottom thereof. In view of the fact that the last two skip loads of a five skip charge are to be of coke, (the ingredient which the illustrated equipment is to automatically charge into the blast furnace), plugs 66 and 67 are inserted in the column of contacts 72 and 73, respectively, (designated the L. H. column and R. H. column, respectively) of the plug switch at the fourth row from the bottom thereof, and also, plugs 63 and 64 are inserted in the L. H. column of contacts (72) and in the R. H. column of contacts (73) respectively, of the plug switch at the fifth row from the bottom thereof. This is the arrangement of the plugs shown in Figure 2.

The various parts illustrated in the wiring diagram of Figure 2 are shown in the positions which they take when the equipment is in the position illustrated in Figure 1. It is to be noted, however, that all the power and control circuits are ineffective until knife switches 20 and 109 are closed. Assume that now these two knife switches are closed. The closure of knife switch 109 (in the power circuit which is illustratively taken as three phase alternating current) is of no effect as at this moment each of the four switches C, A, B and D is in its inoperative position, with the result that no one of the motors, 99, 102, 105 or 108 is connected to the power mains.

Upon the closure of knife switch 20 a circuit is immediately completed to energize the ratchet operating coil R 24. This circuit may be traced from the plus main, by way of contacts BL 21 of the bucket switch of the left-hand skip bucket, ratchet operating coil R 24, contacts R 23, to the minus main. The consequent operation of the ratchet 36 of the ratchet selector switch causes the clockwise rotation of rotary segment 42 so that conducting portion 43 engages with brush 46 and projection 45 engages with brush #1. After the ratchet selector switch has been so operated, contacts R 23 separate to insert cooling resistance 25 in circuit with the ratchet operating coil.

In view of the fact that the horizontal row of contacts in the plug switch corresponding to brush #1 of the ratchet selector switch, has no plug in either the L. H., R. H. or Reset column, the engagement of projection 45 with brush #1 is ineffective. The left-hand skip bucket is therefore at this time ready to be loaded with ore. The loading of ore (and also of limestone) into the skip buckets may be effected by any suitable means, and either manually or by equipment similar to that herein described. For convenience, and as an aid to the understanding of the illustrated automatic charging operations of coke, it is assumed that the loading of the ore (and also of the limestone) is effected manually.

After the left-hand skip bucket has been loaded with the proper amount of ore, the attendant presses push button 59, (designated L. H., inasmuch as it controls the left-hand skip bucket), so as to send that skip bucket up. As the left-hand skip bucket ascends from the loading position, the bucket switch for the left-hand skip bucket returns to its initial position, wherein both contacts BL 47 and BL 21 are separated. The separation of contacts BL 21 deenergizes the ratchet operating coil R 24, thereby permitting the ratchet to return to its initial position. This is facilitated by the fact that ratchet 36 is pivotally secured to the enlarged portion of the rod 31 so that the ratchet 36, when descending, may clear the teeth of the ratchet wheel 34. Inasmuch as the ratchet wheel is locked in the position to which it is moved by the ratchet wheel 36, this locking being effected by the pawl 33, the position of the rotary segment 42 when the ratchet returns to its initial position continues to be such that

projection 45 remains in engagement with brush #1.

The separation of contacts BL 47 which occurs at this departure of the left-hand skip bucket from the loading position, is of no effect at this time.

When the left-hand skip bucket reaches the top of the blast furnace and dumps its contents into the hopper thereat, the right-hand skip bucket arrives at the loading position. The bucket switch for the right-hand skip bucket thereupon operates to cause the engagement of contacts BR 22 and BR 84. The engagement of contacts BR 22 completes a circuit for the ratchet operating coil R 24 so that as a result the ratchet selector switch is operated another step. Projection 45, mounted upon the rotary segment thereof, thereupon engages with brush #2. Inasmuch, however, as the horizontal row of contacts in the plug switch corresponding to brush #2 of the ratchet selector switch has no plug in either the L. H., R. H., or Reset column, the engagement of projection 45 with brush #2 is ineffective. The engagement of contacts BR 84 is also ineffective at this time.

The right-hand skip bucket is thereupon loaded with ore and caused to ascend by the operation of the push button 68, (designated R. H., inasmuch as it controls the right-hand skip bucket). Upon the departure of the right-hand skip bucket, the bucket switch therefor returns to its initial position wherein contacts BR 84 and BR 22 are separated. The separation of contacts BR 22 deenergizes the ratchet operating coil R 24 so that, similarly as described above, the ratchet 36 thereupon returns to its initial position. The ratchet selector switch remains in its second-step position, however, due to the action of pawl 33.

For convenience, it may be noted at this juncture that each time that one of the skip buckets returns to the loading position the ratchet selector switch is caused to rotate another step.

Upon the return of the left-hand skip bucket to the loading position the ratchet selector switch is operated so that projection 45 engages with the brush #3. Similarly, as with the two preceding operations of the ratchet selector switch, the absence of a plug in any of the contacts in level 3 of the plug switch, associated with the brush #3 of the ratchet selector switch, results in the fact that the engagement of projection 45 with brush #3 is of no effect. At this time the limestone is loaded upon the left-hand skip bucket and at the completion thereof the bucket is caused to ascend by the operation of the push button 59.

The next two skip bucket loads are of coke, and in accordance with the illustrated embodiment of the invention, these two skip bucket loads of coke are withdrawn from the storage bins therefor and charged into the furnace automatically.

The arrival of the right-hand skip bucket at the loading position causes the operation of the bucket switch for that bucket with the result, as previously described, that contacts BR 84 and BR 22 engage. The engagement of contacts BR 22 causes the ratchet selector switch to again operate with the result that projection 45, mounted upon the rotary segment 42 thereof, engages with brush #4. There is thereupon completed a circuit for the right-hand gate motor switch B. This circuit may be traced from the plus main, by way of contacts BR 84 (which engaged at the same time as did contacts BR 22), contacts SR 85 of the scale switch for the right-hand weight hopper, actuating coil B 86 of the right-hand gate motor switch, conductor 78, plug 67 inserted in the R. H. column of contacts of the plug switch at the row thereof corresponding to brush #4, brush #4 of the ratchet selector switch, projection 45, arcuate conducting portion 43, brush 44, to the minus main. The consequent operation of the right-hand gate motor switch causes the engagement of contacts B 83, B 103 and B 104. The engagement of contacts B 83 completes a holding circuit for the actuating coil B 86 by establishing a circuit by-passing the contacts SR 85 of the scale switch for the right-hand weigh hopper. This by-pass circuit, it is to be noted, includes contacts SR 82 of the scale switch for the right-hand weigh hopper. The engagement of contacts B 103 and B 104 causes the operation of the right-hand gate motor 105 which, as a result of that operation, opens the right-hand weigh hopper gate 11 so that the contents of the right-hand weigh hopper 9—in this instance, coke—is discharged into the right hand skip bucket.

The opening of gate 11 causes the separation of contacts GR 75 and GR 95 and the engagement of contacts GR 80. The separation of contacts GR 75 and GR 95 is of no effect at this moment other than to render the circuits in which they are positioned ineffective until the gate recloses. The engagement of contacts GR 80 completes a circuit for the actuating coil L 81 of the auxiliary relay for the right-hand skip. This circuit may be traced from the plus main, by way of contacts BR 84, GR 80, actuating coil L 81, conductor 78, and out to the minus main as previously described. The consequent operation of the auxiliary relay L causes the engagement of contacts L 79 and L 76. The engagement of contacts L 79 completes a holding circuit for the auxiliary relay L around the contacts GR 80. The engagement of contacts L 76 is of no effect at this moment.

As the coke is discharged from the weigh

hopper 9, the pointer of the right hand scales 15 recedes from the position indicating full load in the weigh hopper. As a consequence of the recession of this pointer, contacts SR 85 separate and contacts SR 92 engage. The separation of contacts SR 85 is of no effect inasmuch as a circuit by-passing these contacts has been established by way of contacts SR 82 and B 83. The engagement of contacts SR 92 is of no effect at this moment.

When all the coke has been discharged from the weigh hopper 9, the pointer of the right-hand scales 15 assumes a position indicating that the weigh hopper is empty. The assumption of this position by the pointer causes the separation of contacts SR 82 and the engagement of contacts SR 94. The separation of contacts SR 82 opens the circuit for the actuating coil B 86 so that as a result the right-hand gate motor switch B returns to its initial position.

The gate 11, when the gate operating motor 105 is deenergized, as a result of the dropping out of the gate motor switch B, returns by its own weight to closed position. The return of gate 11 to its closed position causes the engagement of contacts GR 75 and GR 95 of the gate switch for the right-hand weigh hopper and also the separation of the contacts GR 80 of the same switch. The separation of the contacts GR 80 is of no effect as these contacts are by-passed by contacts L 79. The engagement of contacts GR 75 completes a circuit for the actuating coil N 77 of the push button relay for the right-hand skip bucket. This circuit may be traced from the plus main, by way of contacts BR 84, contacts GR 75, contacts L 76, actuating coil N 77, conductor 78, to the minus main as previously described. The consequent operation of the push button relay N causes the engagement of contacts N 69. The engagement of contacts N 69 completes a circuit between wires 70 and 71 to initiate the up movement of the right-hand skip bucket. The right-hand skip bucket thereupon starts upwardly to dump its load into the hopper at the top of the blast furnace. The departure of the right-hand skip bucket from the loading position causes the separation of contacts BR 22 and BR 84. The separation of contacts BR 22, as previously described, deenergizes the ratchet operating coil R 24. The separation of contacts BR 84 breaks the circuits for both the actuating coil L 81 of the auxiliary relay and the actuating coil N 77 of the push button relay, both for the right-hand skip bucket. As a consequence, these switches become deenergized and return to their initial positions.

When the gate 11 for the right-hand weigh hopper returns to its closed position it will be recalled that contacts GR 95 were caused to engage. The engagement of these contacts effects the energization of actuating coil D 93 of the right-hand screening motor switch. This circuit may be traced from the plus main, by way of contacts SR 92, actuating coil D 93, contacts SR 94, and contacts GR 95, to the minus main. (It will be recalled that when the weigh hopper 9 is empty, contacts SR 92 and contacts SR 94 are engaged.) The resulting operation of the screening motor switch D causes the engagement of contacts D 96, D 106 and D 107. The engagement of contacts D 96 establishes a by-pass circuit around contacts SR 94, the purpose of which will presently appear. The engagement of contacts D 106 and D 107 causes the operation of right-hand screening motor 108. As a result of the operation of this motor 108, coke is withdrawn from bin 19, screened, and loaded into the weigh hopper 9. The position of the pointer of the scales 15, it will be recalled, indicated the amount of coke which has been loaded into the weigh hopper 9. At the very beginning of the process of refilling the weigh hopper, the movement of the pointer of the scales 15 from the position indicating an empty hopper causes the separation of contacts SR 94 and the engagement of contacts SR 82. The engagement of contacts SR 82 is of no effect inasmuch as contacts B 83 are separated. The separation of contacts SR 94 is of no effect inasmuch as these contacts are by-passed by contacts D 96. The screening motor 108 therefore continues to operate and to effect refilling of the weigh hopper 9 until the weigh hopper has been filled with the predetermined amount. At that time, the pointer of the scales 15 causes the separation of contacts SR 92 and the engagement of contacts SR 85. The separation of contacts SR 92 breaks the circuit for the actuating coil D 93 of the right-hand screening motor switch D so that this switch returns to its initial position, and, by the resulting separation of contacts D 106 and D 107, stops the operation of screening motor 108. The engagement of contacts SR 85 is of no effect at this time, inasmuch as by the time the weigh hopper 9 is refilled to cause the engagement of these contacts, the right-hand skip has departed from its loading position, with the result that contacts BR 84 are separated. The engagement of contacts SR 85 therefore merely prepares the circuit for the next operation of the gate motor switch B.

As a result of this sequence of operation the equipment provided in accordance with this invention at the proper time automatically loaded a skip bucket with the proper amount of coke, automatically dispatched the skip bucket to the top of the blast furnace and automatically withdrew more coke from the storage bin, screened it, and meas-

ured out a proper amount for the next automatic loading of the skip bucket.

When the right-hand skip bucket reaches the top of the blast furnace and dumps its contents into the hopper thereat, the left-hand skip bucket arrives at the loading position. The resulting closure of the contacts BL 21 of the left-hand bucket switch causes the ratchet selector switch to rotate another step so that as a result projection 45, mounted upon the rotary segment 42 thereof, thereupon engages with brush #5. Inasmuch as the horizontal row of contacts of the plug switch corresponding to brush #5 of the ratchet selector switch has a plug 63 in the L. H. column, the arrival of the left-hand skip bucket at the loading position and the engagement of projection 45 with brush #5 completes a circuit for the left-hand gate motor switch A. This circuit may be traced from the plus main, by way of contacts BL 47 (which engaged at the same time as did contacts BL 21), contacts SL 48 of the scale switch for the left-hand weigh hopper, actuating coil A 49 of the left-hand gate motor switch, conductor 50, plug 63 inserted in the L. H. column of contacts of the plug switch at the row thereof corresponding to brush #5, brush #5 of the ratchet selector switch, projection 45, arcuate conducting portion 43, brush 44, to the minus main.

The operations which follow from this point until the loaded left-hand skip bucket is started upwardly are analogous to the operations described above for the right-hand skip bucket. For completeness, however, the operations for the left-hand skip bucket are described in the same manner as are the operations for the right-hand skip bucket.

The energization of the actuating coil A 49 of the left-hand gate motor switch causes the engagement of contacts A 52, A 100 and A 101. The engagement of contacts A 52 completes a holding circuit for the actuating coil A 49 by establishing a circuit by-passing the contacts SL 48 of the scale switch for the left-hand weigh hopper. This by-pass circuit, it is to be noted, includes contacts SL 51 of the scale switch for the left-hand weigh hopper. The engagement of contacts A 100 and A 101 causes the operation of the left-hand gate motor 102 which, as a result of that operation, opens the left-hand weigh hopper gate 10 so that the contents of the left-hand weigh hopper 8—in this instance, coke—is discharged into the left-hand skip bucket. The opening of gate 10 causes the separation of contacts GL 56 and GL 90 and the engagement of contacts GL 53. The separation of contacts GL 56 and GL 90 is of no effect at this moment other than to render the circuits in which they are positioned ineffective until the gate recloses. The engagement of contacts GL 53 completes a circuit for the actuating coil K 54 of the auxiliary relay for the left-hand skip. This circuit may be traced from the plus main, by way of contacts BL 47, GL 53, actuating coil K 54, conductor 50, and out to the minus main as previously described. The consequent operation of the auxiliary relay K causes the engagement of contacts K 55 and K 57. The engagement of contacts K 55 completes a holding circuit for the auxiliary relay K around the contacts GL 53. The engagement of contacts K 57 is of no effect at this moment.

As the coke is discharged from the weigh hopper 8 the pointer of the left-hand scales 14 recedes from the position indicating full load in the weigh hopper. As a consequence of the recession of this pointer, contacts SL 48 separate and contacts SL 87 engage. The separation of contacts SL 48 is of no effect inasmuch as a circuit by-passing these contacts has been established by way of contacts SL 51 and A 52. The engagement of contacts SL 87 is of no effect at this moment.

When all the coke has been discharged from the weigh hopper 8, the pointer of the left-hand scales 14 assumes a position indicating that the weigh hopper is empty. The assumption of this position by the pointer causes the separation of contacts SL 51 and engagement of contacts SL 89. The separation of contacts SL 51 opens the circuit for the actuating coil A 49 so that as a result the left-hand gate motor switch A returns to its initial position.

The gate 10, when the gate operating motor 102 is deenergized as a result of the dropping out of the gate motor switch A, returns by its own weight to closed position. The return of gate 10 to its closed position causes the engagement of contacts GL 56 and GL 90 of the gate switch for the left-hand weigh hopper and also the separation of the contacts GL 53 of the same switch. The separation of the contacts GL 53 is of no effect as these contacts are by-passed by contacts K 55. The engagement of contacts GL 56 completes a circuit for the actuating coil M 58 of the push button relay for the left-hand skip bucket. This circuit may be traced from the plus main, by way of contacts BL 47, contacts GL 56, contacts K 57, actuating coil M 58, conductor 50, to the minus main as previously described. The consequent operation of the push button relay M causes the engagement of contacts M 60. The engagement of contacts M 60 completes a circuit between wires 61 and 62 to initiate the up movement of the left-hand skip bucket. The left-hand skip bucket thereupon starts upwardly to dump its load into the hopper at the top of the blast furnace. The departure of the left-hand skip bucket from the loading position causes the separation of contacts BL 21 and BL 47. The separation of contacts BL 21, as previously described, deenergizes ratchet operating coil R 24. The

separation of contacts BL 47 breaks the circuits for both the actuating coil K 54 of the auxiliary relay and the actuating coil M 58 of the push button relay, both for the left-hand skip bucket. As a consequence, these switches become deenergized and return to their initial positions.

When the gate 10 for the left-hand weigh hopper returns to its closed position it will be recalled that contacts GL 90 were caused to engage. The engagement of these contacts effects the energization of actuating coil C 88 of the left-hand screening motor switch. This circuit may be traced from the plus main, by way of contacts SL 87, actuating coil C 88, contacts SL 89, and contacts GL 90, to the minus main. (It will be recalled that when the weigh hopper 8 is empty contacts SL 87 and contacts SL 89 are engaged.) The resulting operation of the screening motor switch C causes the engagement of contacts C 91, C 97 and C 98. The engagement of contacts C 91 establishes a by-pass circuit around contacts SL 89, the purpose of which will presently appear. The engagement of contacts C 97 and C 98 causes the operation of left-hand screening motor 99. As a result of the operation of this motor 99, coke is withdrawn from the bin 18, screened, and loaded into the weigh hopper 8. The position of the pointer of the scales 14, it will be recalled, indicated the amount of coke which has been loaded into the weigh hopper 8. At the very beginning of the process of refilling the weigh hopper, the movement of the pointer of the scales 14 from the position indicating an empty hopper causes the separation of contacts SL 89 and the engagement of contacts SL 51. The engagement of contacts SL 51 is of no effect inasmuch as contacts A 52 are separated. The separation of contacts SL 89 is of no effect inasmuch as these contacts are by-passed by contacts C 91. The screening motor 99 therefore continues to operate and to effect refilling of the weigh hopper 8 until the weigh hopper has been filled with the predetermined amount. At that time, the pointer of the scales 14 causes the separation of contacts SL 87 and the engagement of contacts SL 48. The separation of contacts SL 87 breaks the circuit for the actuating coil C 88 of the left-hand screening motor switch C so that this switch returns to its initial position, and, by the resulting separation of contacts C 97 and C 98, stops the operation of screening motor 99. The engagement of contacts SL 48 is of no effect at this time, inasmuch as by the time the weigh hopper 8 is refilled to cause the engagement of these contacts, the left-hand skip has departed from its loading position, with the result that contacts BL 47 are separated. The engagement of contacts SL 48 therefore merely prepares the circuit for the next operation of the gate motor switch A.

It is to be noted that when the ratchet selector switch was rotated so that projection 45, mounted on the rotary segment 42 thereof, engaged with brush #5, there was completed, at the same time the circuit by way of the plug 63 in the fifth row of the L. H. column of contacts of the plug switch was completed, a second circuit through the ratchet selector switch. This second circuit was completed by way of the plug 65 in the fifth row of the Reset column of contacts of the plug switch. This circuit, established as soon as projection 45 engaged with brush #5, may be traced from the plus main, by way of actuating coil Q 29 of the reset relay Q, conductor 30, plug 65, brush #5 of the ratchet selector switch, projection 45, arcuate conducting portion 43, brush 44, to the minus main.

The consequent operation of the reset relay Q causes the engagement of its contacts Q 26 and Q 28. The engagement of contacts Q 28 completes an auxiliary circuit for the actuating coil Q 29 from conductor 30, through the contacts Q 28, by way of brush 46, arcuate conducting portion 43, brush 44, to the minus main. The engagement of contacts Q 26 completes a circuit for the pawl magnet 27. This circuit may be traced from the plus main, by way of contacts Q 26, pawl magnet 27, brush 46, arcuate conducting portion 43, brush 44, to the minus main. The energization of the pawl magnet 27 effects withdrawal of the pawl 33 from engagement with the ratchet wheel 34. The ratchet selector switch remains in its position with projection 45 in engagement with brush #5, however, in spite of the fact that the locking pawl 33 has been withdrawn, in view of the fact that the ratchet operating coil R 24 is still energized and the ratchet still in engagement with the ratchet wheel 34. This condition—of the ratchet 36 maintaining the ratchet selector switch in the fifth or final position—continues so long as the ratchet operating coil R 24 is maintained energized, which is as long as the last skip bucket of the series constituting a charge remains in the loading position. In the situation which has been assumed when describing the operation of the system, this was the left-hand skip bucket. Thus, when the final skip bucket of a charge leaves the loading position, the contacts of the bucket switch for that bucket (in this instance, contacts BL 21) separate and break the circuit for the ratchet operating coil R 24. As a consequence, after the return of the ratchet operating mechanism 31, 35 and 36 to its initial position, the weight 40 causes counterclockwise rotation of the ratchet wheel 34, and of rotary segment 42, thereupon effecting restoration of the ratchet selector switch to its initial position. As the rotary segment 42 is rotated counterclockwise during this restoring operation, the actuating coil of the

reset switch Q, and also the pawl magnet 27, are maintained energized by means of the engagement of brush 46 with the continuous arcuate conducting portion 43 of the ratchet selector switch. Just before the rotary segment 42 reaches its initial position against the stop 41, the brush 46 disengages from this arcuate conducting portion 43 so that reset switch Q and the pawl thereupon return to their initial positions.

When the left-hand skip, which was automatically loaded with coke and started up the hoistway as described above, reaches the dumping position at the top of the blast furnace and the right-hand skip reaches the loading position, a full charge of the predetermined proportions—in this instance two skips of ore, one skip of limestone and two skips of coke—has been raised to the top of the blast furnace and charged therein. The charging cycle is thereupon completed.

It may be mentioned at this point that after the contents of each skip load is dumped into the hopper at the top of the blast furnace, such material is customarily, by equipment which forms no part of this invention, distributed (as by rotating the hopper and the small bell), and then, by opening the small bell, dumped upon the large bell. Also by equipment forming no part of this invention, it is customary, when a charge of the requisite number of skip loads has been dumped upon the large bell, to have the large bell operate and dump the whole charge into the furnace.

A full charge of the various ingredients, and in the proper proportions, having thus been taken from the storage bins and dumped into the blast furnace, the equipment is in condition to repeat such operation for another charge. It is believed unnecessary to describe in detail the operation of the illustrated equipment during the second or any subsequent charging cycles. It is believed sufficient to note that as an odd number of skip loads has been taken to constitute a full charge, the fourth and fifth skip loads are alternately in the sequence of left-hand skip and right-hand skip, respectively, and then in the sequence of right-hand skip and left-hand skip, respectively. Attention is directed to the fact, however, that the equipment of this invention automatically causes the operation of the equipment associated with whichever skip bucket is in the loading position, regardless of such changes in sequence.

In the equipment illustrated the number of skip loads which make up a charge may be varied from any number from 1 to 10, inclusive. It is to be noted that all that is necessary to effect a proper operation of such equipment for a charge of any number of skip loads is that plug 65 be inserted in the reset column of the contacts of the plug switch at the row from the bottom thereof corresponding to the total number of skip loads which is to make up a charge. It is also to be noted that any of the skips in the series constituting a charge may be automatically loaded and started by this equipment. This may be effected by inserting a plug in each of the two columns of contacts L. H. and R. H. of the plug switch at the row from the bottom thereof corresponding to the number of that skip in such series that is desired to be automatically loaded and started. Thus, when a charging cycle of five skip loads is employed, and it is desired that the last two skip loads be of coke, plugs 63, 64, 66 and 67 are inserted as shown in Fig. 2.

If it is desired to add an extra skip load of coke after a charging cycle has been completed, this may readily be effected by inserting a plug in each of the three lowermost contacts of the plug switch and withdrawing the same after the extra skip load has started upwardly. If the person who inserts the plugs in the plug switch knows which of the two skips is the skip that is to take such extra load, he may insert only two plugs, one in the L. H. or R. H. column for the skip in question, as the case may be, and the other in reset column.

If it is desired to add an extra skip load of material other than coke, after a charging cycle has been completed, this may be effected by dumping such material into the skip bucket then in the loading position and causing it to move upwardly by the operation of the proper push button. Before the extra skip load of material reaches the dumping position at the top of the furnace a plug should be inserted in the lowermost contact in the reset column of contacts of the plug switch so as to cause the resetting of the ratchet selector switch to its initial position, whereupon the plug should be withdrawn.

It is to be noted that the addition of such extra skip loads, either of coke or of material other than coke, when effected in the manner described above, does not disturb the sequences for any subsequent operations of the equipment. Accordingly, the invention is effective to automatically charge a blast furnace with a given ingredient under all of the conditions ordinarily encountered in blast furnace operation.

In the operation of the control circuits illustrated it will be recalled that when a hopper gate is returned to closed position, such return thereof initiates the starting of the loaded skip and commences the operation of the associated feeder for refilling the empty hopper. In normal practice, with the equipment illustrated employed for charging coke, the time required to refill an empty hopper is such that before the hopper is completely refilled the loaded skip has left its loading position. If the equipment employed, or the ingredient charged, is such

that the empty hopper may reach completely refilled condition before the loaded skip leaves the loading position (in other words, considering the left-hand equipment, that contacts SL 48 may engage before contacts BL 47 separate), provision may readily be made to insure against any possible difficulties that may arise from such quick refilling of the empty hopper. Such provision may be effected, for example, considering the left-hand equipment, by providing the bucket switch for the left-hand skip bucket with an additional set of contacts arranged to be engaged only when contacts BL 47 are separated, and by inserting this additional set of contacts in circuit between actuating coil C 88 and contacts SL 89. As a result of this provision, the refilling of the empty hopper is commenced after the loaded skip has left its loading position, so that it follows as a matter of course that the hopper reaches completely refilled condition after the loaded skip has departed.

Attention is directed to the fact that in the event it is desired not to screen the ingredient which is to be automatically charged into the blast furnace in accordance with this invention, there may be substituted for the screening devices illustrated in Figure 1 any suitable rotary gate or apron feeder, or any other type of equipment for withdrawing the ingredient from the storage bin. When coke is to be automatically charged into the blast furnace, however, it is preferred to employ such screening devices in the manner illustrated so that the amount of fines from such material is as small as practicable. It may be noted at this juncture that the coke fines, or breeze, obtained as a result of screening the coke, may, instead of being directed to the cars 112 and 113 for conveyance from the pits into which the breeze falls, be conveyed from such pits by suitable belt conveyors or elevators arranged to be operated at the same time that the screening devices are operated.

It is to be understood that this invention is not limited to the particular form of equipment or circuits illustrated. Such equipment and circuits are to be considered merely as schematic and illustrative of one manner of reducing applicant's invention to a concrete, operative system.

What is claimed is:

1. Blast furnace charging equipment comprising, in combination; a bin for storing an ingredient to be charged therein; a power driven feeder associated with said bin for effecting, upon operation thereof, withdrawal of said ingredient; a hopper into which said feeder discharges, said hopper being provided with a gate which, when in open position, permits the contents of said hopper to pass out therefrom; a power operator for said gate; a blast furnace skip hoist having the loading position for one skip thereof arranged so that the contents of said hopper, when said hopper gate is opened, discharges into said skip at said loading position thereof; mechanism effective to determine the weight of said ingredient in said hopper; means controlled by the presence of said skip at said loading position when said hopper is filled with the requisite amount of said ingredient, as determined by said mechanism, to effect the opening of said hopper gate by said power operator so as to discharge the contents of said hopper into said skip; and means controlled by said mechanism when said hopper is empty for effecting the closure of said hopper gate and for initiating the operation of said skip hoist to cause the hoisting of said skip from said loading position to its dumping position at the top of the blast furnace, and also for causing, after said hopper gate is moved to closed position, the operation of said power driven feeder until said hopper is refilled with the requisite amount of said ingredient.

2. Blast furnace charging apparatus for charging a predetermined number of skip loads of several primary ingredients in a predetermined sequence wherein equipment is provided for automatically conveying a primary ingredient from a storage bin, automatically loading the proper amount thereof at the proper time into a blast furnace skip bucket, and automatically initiating the operation of hoisting the loaded skip bucket up to dumping position at the top of the blast furnace, said equipment comprising; a power driven feeder associated with said bin for effecting, upon operation of said feeder, withdrawal of said ingredient; a hopper into which said feeder discharges, said hopper being provided with a gate which, when in open position, permits the contents of said hopper to pass out therefrom into a skip in the loading position of said skip hoist; a power operator for said gate; mechanism effective to determine the weight of said ingredient in said hopper; means responsive to the arrival of said skip at said loading position at such time when, by the charging sequence adopted, a skip load of such ingredient for which this equipment is provided is next, for effecting, in the event said hopper is filled with the requisite amount of said ingredient, the opening of said hopper gate by said power operator, so as to discharge the contents of said hopper into said skip; and means controlled by said mechanism when said hopper is empty for effecting the closure of said hopper gate and for initiating the operation of said skip hoist to cause the hoisting of said skip from said loading position to the dumping position at the top of the blast furnace, and also for causing, after said hopper gate is moved to closed position, the operation of said power driven feeder until

said hopper is refilled with the requisite amount of said ingredient.

3. Blast furnace charging apparatus for charging a predetermined number of skip loads of several primary ingredients in a predetermined sequence wherein equipment is provided for automatically conveying a primary ingredient from a storage bin, automatically loading the proper amount thereof at the proper time into a blast furnace skip bucket, and automatically initiating the operation of hoisting said skip bucket, when so loaded, up to dumping position at the top of the blast furnace, said equipment comprising; a power driven feeder associated with said bin for effecting, upon operation of said feeder, withdrawal of said ingredient; a hopper into which said feeder discharges, said hopper being provided with a gate which, when in open position, permits the contents of said hopper to pass out therefrom into said skip in its loading position; a power operator for said gate; mechanism effective to determine the weight of said ingredient in said hopper; switching means responsive to each arrival of said skip at said loading position for totalizing the number of said skip loads during each charging cycle, said switching means including means for altering the electrical condition of each of a plurality of independent circuits individually and successively in accordance with the total number of said skip loads registered by said switching means; means responsive to the alteration of the electrical condition of that circuit corresponding to each of said skip loads of said charging cycle for which said skip is, by said predetermined ratio, to be loaded with that ingredient for which this automatic equipment is provided, for effecting, in the event said hopper is filled with the requisite amount of said ingredient, the opening of said hopper gate by said power operator, so as to discharge the contents of said hopper into said skip; and means controlled by said mechanism when said hopper is empty for effecting the closure of said hopper gate and for initiating the operation of said skip hoist to cause the hoisting of said skip from said loading position to the dumping position at the top of the blast furnace, and also for causing, after said hopper gate is moved to closed position, the operation of said power driven feed until said hopper is refilled with the requisite amount of said ingredient.

4. Blast furnace charging equipment comprising, in combination; a bin for storing an ingredient to be charged into a blast furnace, said bin having a gravity discharge opening; a power driven feeder associated with said opening for effecting, upon operation thereof, withdrawal of said ingredient; a hopper into which said feeder discharges, said hopper being provided with a gate which, when in open position, permits the contents of said hopper to pass out therefrom; a power operator for said gate; a gate switch actuated in accordance with the position of said gate; a blast furnace skip hoist having the loading position for one skip thereof arranged so that the contents of said hopper, when said hopper gate is opened, discharges into said skip at said loading position thereof; mechanism effective to weigh said ingredient in said hopper, said mechanism including a scale switch actuated in accordance with the amount of said ingredient in said hopper; a bucket switch actuated in accordance with the position of said skip; a totalizing switch actuated in steps, progressively, one step each time said bucket switch is operated upon the arrival of said skip at its loading position, said totalizing switch being provided with enough steps to totalize any number of operations of said skip that reasonable practice dictates may be employed to constitute a blast furnace charge; a plurality of independent circuits, one for each of the steps provided for said totalizing switch; means cooperating with said totalizing switch for altering, when said totalizing switch is actuated to each of its steps, the electrical condition of that circuit corresponding to the step at which said totalizing switch is actuated; selecting means for rendering effective the electrical circuit, or circuits, corresponding to each of the operations of said skip during a charging cycle for which said skip is to be loaded with said ingredient; means responsive to the alteration of the electrical condition of each of said circuits rendered effective by said selecting means, for causing, in the event said scale switch is in the position indicating that said hopper is filled with the requisite amount of said ingredient, the operation of said power operator to effect the opening of said gate, and thereby to effect the discharge of the contents of said hopper into said skip; means responsive to said scale switch when in the position indicating that said hopper is empty, for causing said power operator to effect the closure of said gate; means responsive to said gate switch, upon the reclosure of said gate, for causing said skip to be hoisted from said loading position to its dumping position at the top of the blast furnace, and for causing the operation of said power driven feeder to effect refilling of said hopper; and means responsive to said scale switch, when in the position indicating that said hopper has been refilled with the requisite amount of said ingredient, for causing said power driven feeder to suspend operation.

5. In a blast furnace charging equipment; a blast furnace skip hoist; a measuring hopper having a gate controlling the discharge of the contents of said hopper into a skip of said hoist in its loading position; a power operator for said gate; means for preventing

the opening of said gate by said power operator at all times when said skip is away from said loading position; mechanism for totalizing the number of operations of said skip during each charge of a predetermined number of skip loads emptied into said furnace; means responsive to said totalizing mechanism for effecting loading of said skip from said hopper for only certain of its operations in each charging cycle, said means, when effective, causing said power operator to open said hopper gate when said skip, during said certain operations, is in said loading position, thereby resulting in the discharge of the contents of said hopper into said skip; and means, actuated as a result of the discharge of all the contents of said hopper, to automatically effect the starting of said skip.

6. In a blast furnace charging equipment; a blast furnace skip hoist; a weigh hopper having a gate which, when opened, permits the contents of said hopper to discharge into a skip bucket of said hoist in the loading position thereof, said weigh hopper being provided to effect the loading of said skip with a measured quantity, by weight, of that which is loaded therein; a power operator for said gate; means for preventing the opening of said gate by said power operator at all times when said skip is away from said loading position; additional means for preventing the opening of said gate by said power operator; mechanism for totalizing the number of operations of said skip during each charge of a predetermined number of skip loads emptied into said furnace; means responsive to said totalizing mechanism for rendering said additional preventing means ineffective for certain of the operations of said skip in each charging cycle, so that as a consequence said power operator may be operated to open said weigh hopper gate when said skip, during said certain operations, is in said loading position for thereby effecting the discharge of the contents of said weigh hopper into said skip; and means responsive to the return of said weigh hopper to empty condition for causing said power operator to effect the closure of said gate and for initiating, after said gate returns to closed position, the upward movement of said skip toward its dumping position at the top of the blast furnace.

7. In a blast furnace wherein each charge therefor normally comprises a predetermined total number of blast furnace skip loads resulting from one or more skip loads, in a predetermined ratio, of each of the several primary ingredients, equipment for automatically conveying a primary ingredient from bins in which it is stored, automatically loading the proper amount thereof at the proper time into the proper skip of a double-skip blast furnace skip hoist having a right hand and a left hand skip, and automatically initiating the operation of hoisting the loaded skip up to dumping position at the top of the blast furnace, said equipment comprising; two power driven feeders, one associated with each of said bins for effecting, upon operation of each feeder, withdrawal of said ingredient; a hopper for each feeder into which the feeder corresponding thereto discharges, each of said two hoppers being provided with a gate which, when in open position, effects the discharge of the contents of the associated hopper, the discharge from one hopper being into the left hand skip of the two skips such left hand skip is in the loading position, and the discharge from the other hopper being into the right hand skip of the two skips when such right hand skip is in the loading position; a power operator for each of said gates; mechanism effective to determine the weight of said ingredient in each of said hoppers; means responsive to the arrival of either skip at its loading position at such time when, by the charging sequence adopted, a skip load of such ingredient for which this equipment is provided in next in sequence, for effecting, in the event the hopper for such arriving skip is filled with the requisite amount of said ingredient, the opening of the gate for such hopper by its associated power operator, so as thereby to discharge the contents of such hopper into such skip; and means controlled by said mechanism for such hopper, when such hopper is empty, for effecting the closure of the gate for such hopper and for initiating the operation of said skip hoist to cause the hoisting of such loaded skip from the loading position thereof to the dumping position at the top of the blast furnace, and also for causing, after such hopper gate is moved to closed position, the operation of the power driven feeder for such hopper until such hopper is refilled with the requisite amount of said ingredient.

8. In a blast furnace wherein each charge therefor normally comprises a predetermined total number of blast furnace skip loads resulting from one or more skip loads, in a predetermined ratio, of each of the several primary ingredients, equipment for automatically conveying a primary ingredient from the bins in which it is stored, loading the proper amount thereof at the proper time into the proper skip or a double-skip blast furnace skip hoist, and initiating the operation of hoisting the loaded skip up to dumping position at the top of the blast furnace, said equipment comprising; two power driven feeders, one associated with each of two openings in said bins for effecting, upon operation of each feeder, withdrawal of said ingredient; a hopper for each feeder into which the feeder corresponding thereto discharges, each of said two hoppers being provided with a gate which, when

in open position, effects the discharge of the contents of the associated hopper, the discharge from one hopper being into one of the two skips when such one skip is in its loading position, and the discharge from the other hopper being into the other skip when such other skip is in its loading position; a power operator for each of said gates; weighing mechanism effective to determine the weight of said ingredient in each of said hoppers; switching means responsive to the arrival of each skip at its loading position for totalizing the number of skip loads during each charging cycle, said switching means including means for altering the electrical condition of each of a plurality of independent circuits individually and successively in accordance with the total number of skip loads registered by said switching means; means responsive to the alteration of the electrical condition of that circuit corresponding to each skip load of said charging cycle for which a skip is, by said predetermined ratio, to be loaded with that ingredient for which this automatic equipment is provided, for effecting, by the associated power operator, the opening of the hopper gate for that hopper corresponding to the skip then to be loaded with said ingredient, regardless of which of the two skips it may be, so as to discharge the contents of such hopper into such skip; and means controlled by said weighing mechanism for such hopper, when such hopper is empty, for effecting the closure of the gate for such hopper and for initiating the operation of said skip hoist to cause the hoisting of such loaded skip from the loading position thereof to the dumping position at the top of the blast furnace, and also for causing, after such hopper gate is moved to closed position, the operation of the power driven feeder for such hopper until such hopper is refilled with the requisite amount of said ingredient.

9. Blast furnace charging equipment comprising, in combination; a bin for storing coke to be charged into a blast furnace, said bin having two gravity discharge openings; two power driven screening devices, one associated with each of said openings in said bin for effecting, upon operation of each screening device, withdrawal of coke from said bin and for effecting the screening of the coke so withdrawn; a hopper for each screening device into which the coke screened thereby is discharged, each of said hoppers being provided with a gate which, when in open position, effects the discharge of the contents of the associated hopper; a power operator for each of said gates; two gate switches, one for each hopper gate, each gate switch being actuated in accordance with the position of its corresponding gate; a double-skip blast furnace hoist having the loading position for the two skips thereof arranged so that the contents of one of said hoppers, when the gate thereof is opened, discharges into one of said skips at its loading position, and so that the contents of the other of said hoppers, when the gate thereof is opened, discharges into the other of said skips at its loading position; mechanism effective to weigh the coke in each of said hoppers, said mechanism including a scale switch for each hopper, each scale switch being actuated in accordance with the amount of coke in the hopper corresponding thereto; two bucket switches, one for each skip, actuated in accordance with the position of their respective skips; a totalizing switch actuated in steps, progressively, one step each time either of said bucket switches is operated upon the arrival of the corresponding skip at its loading position, said totalizing switch being provided with enough steps to totalize any number of operations of said skips that reasonable practice dictates may be employed to constitute a blast furnace charge; a plurality of independent circuits, one for each of the steps provided for said totalizing switch, each of said circuits being closed successively, one at a time, by said totalizing switch as it is actuated step by step; selecting means for rendering effective any number of said circuits, in any desired combination to determine during which operations of said skips, said skips shall be loaded with coke; means, responsive to the closing of each of said circuits rendered effective by said selecting means, for causing the loading of the skip then in its loading position regardless of which of the two skips that may be, said means causing the loading of such skip by causing the power operator for the hopper gate corresponding to such skip then in its loading position to effect the opening of such gate, provided the scale switch for such hopper is in the position indicating that such hopper is filled with the requisite amount of coke; means responsive to the scale switch for such hopper, when the scale switch is in the position indicating that such hopper is empty, for causing such power operator to effect the closure of such gate; means responsive to the gate switch for such gate, upon the reclosure of such gate, for causing such skip to be hoisted from its loading position to its dumping position at the top of the blast furnace, and for causing the operation of the power driven screening device associated with such hopper to effect refilling of such hopper; and means responsive to the scale switch for such hopper, when the scale switch therefor is in the position indicating that such hopper has been refilled with the requisite amount of coke, for causing such power driven screening device to suspend operation.

10. In a blast furnace charging equip-

ment; a double-skip blast furnace hoist; two measuring hoppers, each having a gate controlling the discharge of the contents of its associated hopper, the one, into one of said skip buckets when in its loading position, and the other, into the other of said skip buckets when in its loading position; a power operator for each of said gates; means for preventing the opening of each gate by its power operator at all times when the skip corresponding thereto is away from its loading position; mechanism for totalizing the number of operations of said skips during each charge of a predetermined number of skip loads emptied into said furnace; means responsive to said totalizing mechanism for effecting loading of said skips from said hoppers for only certain of their operations in each charging cycle, said means, when effective to cause loading of a skip during an operation thereof, causing the power operator for the hopper gate associated with such skip to open such hopper gate when such skip, during such certain operation, is in its loading position, thereby resulting in the discharge of the contents of such hopper into such skip; and means, actuated as a result of the discharge of all the contents of such hopper, to automatically effect the starting of such skip.

11. In a blast furnace charging equipment; a double-skip blast furnace blast; a weigh hopper for each skip; a gate for each weigh hopper to control the discharge of its contents into the corresponding one of the two skips in the loading position thereof, said weigh hoppers being provided to effect the loading of said skips with a measured quantity, by weight, of that which is loaded therein; a power operator for each of said gates; means for preventing the opening of each of said gates by its corresponding power operator at all times when the skip corresponding thereto is away from its loading position; additional means for preventing the opening of each of said gates by its corresponding power operator; mechanism for totalizing the number of operations of said skips during each charge of a predetermined number of skip loads emptied into said furnace; means responsive to said totalizing mechanism for rendering said additional preventing means ineffective for certain of the operations of said skips in each charging cycle, so that as a consequence the power operator, for the weigh hopper gate corresponding to whichever skip is, during one of said certain operations, in its loading position, may be operated to open such weigh hopper gate and thereby effect the discharge of the contents of such weigh hopper into such skip; and means responsive to the return of such weigh hopper to empty condition for causing such power operator to effect the closure of such weigh hopper gate and for initiating the upward movement of such skip toward its dumping position at the top of the blast furnace.

In testimony whereof, I have signed my name to this specification.

FRANK I. SMITH.