May 10, 1932. R. A. HAWKINS ET AL 1,857,592

FURNACE FEEDING APPARATUS

Filed July 31, 1930 7 Sheets-Sheet 1

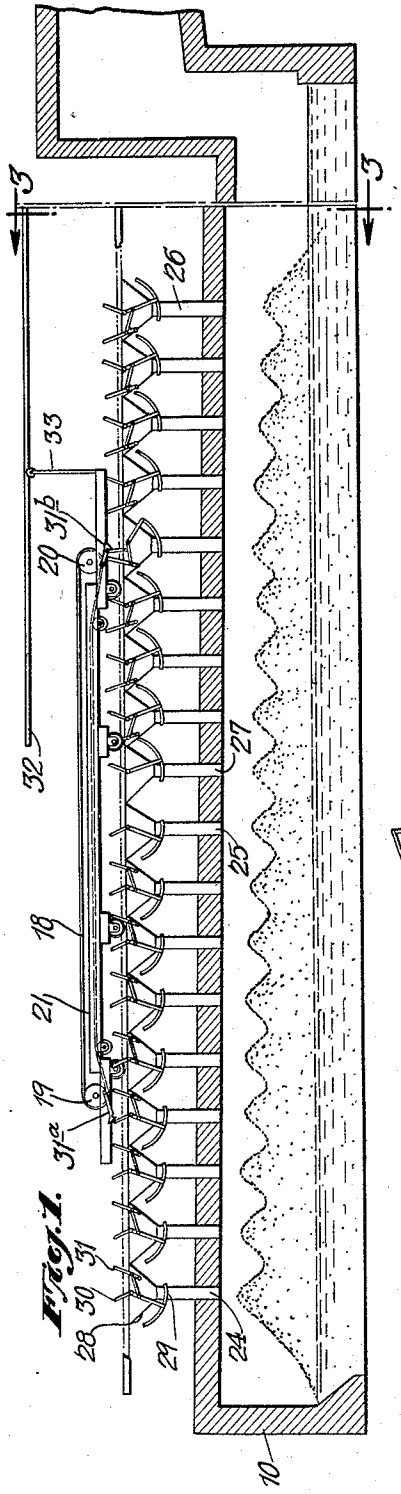

Fig. 1.

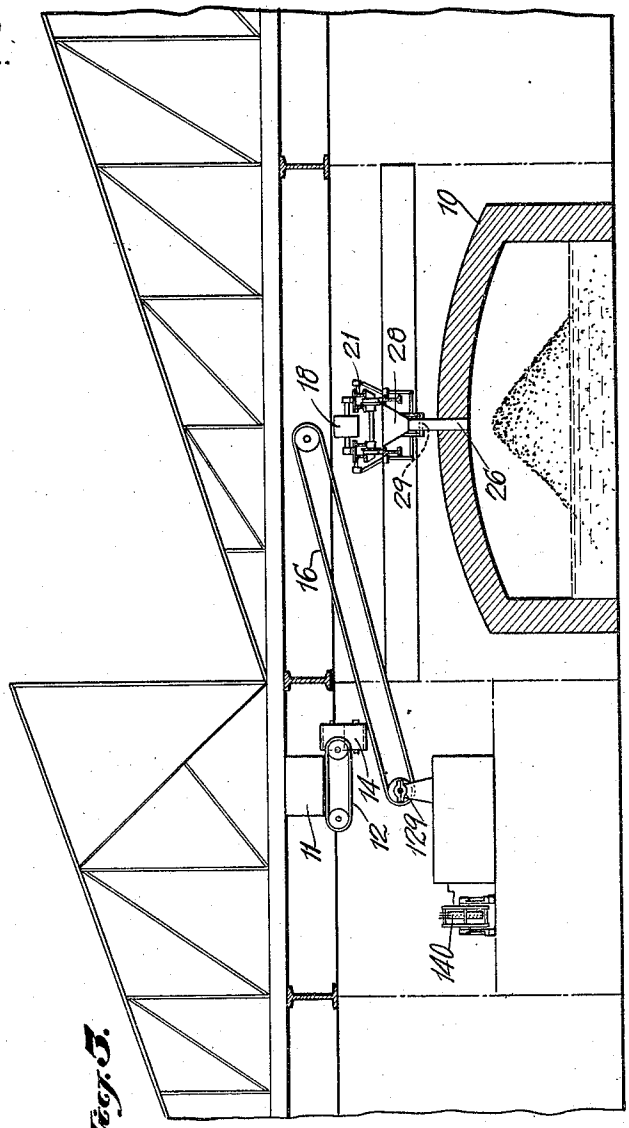

Fig. 3.

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FURNACE FEEDING APPARATUS

Filed July 31, 1930 7 Sheets-Sheet 2

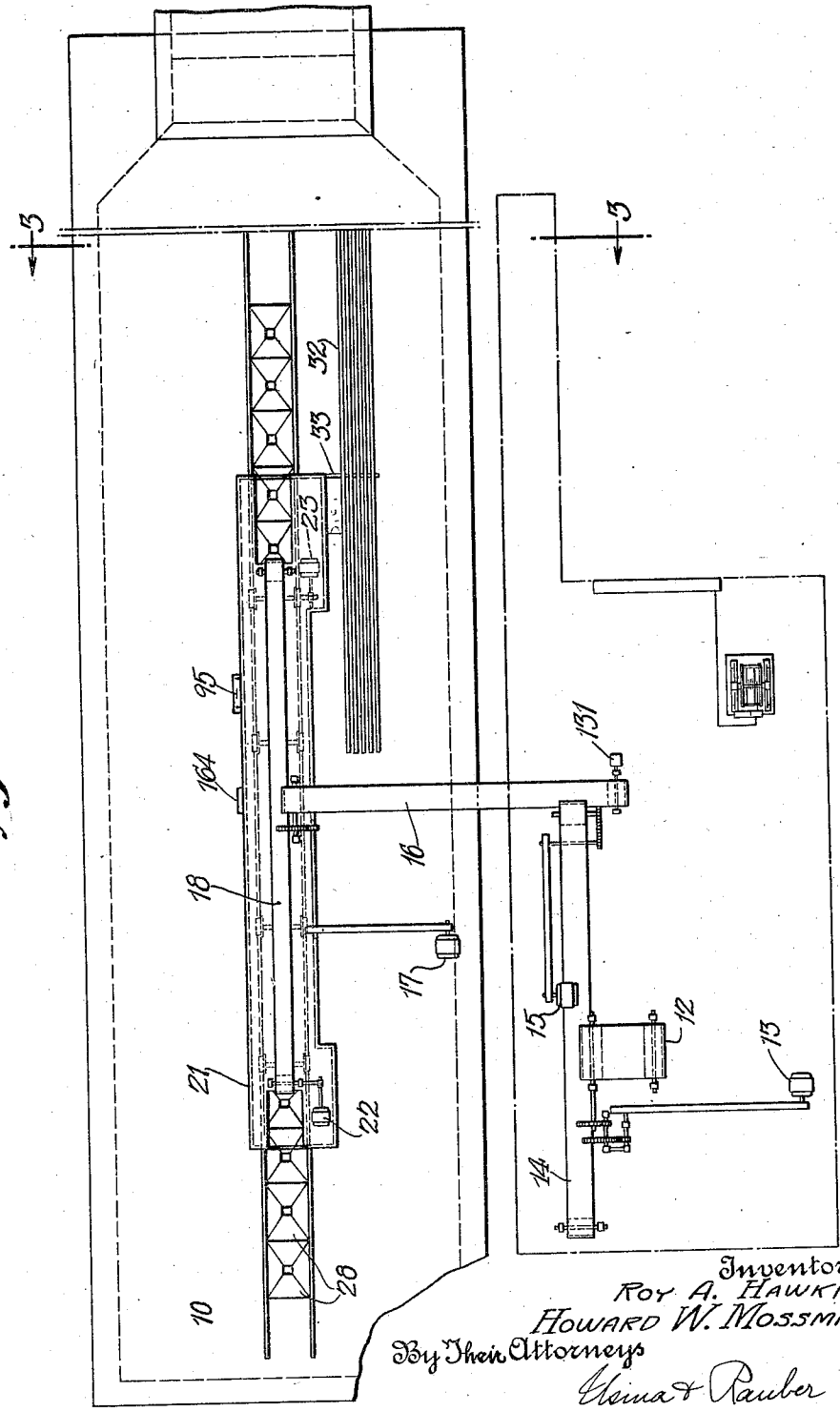

Fig. 2.

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FURNACE FEEDING APPARATUS

Filed July 31, 1930 7 Sheets-Sheet 3

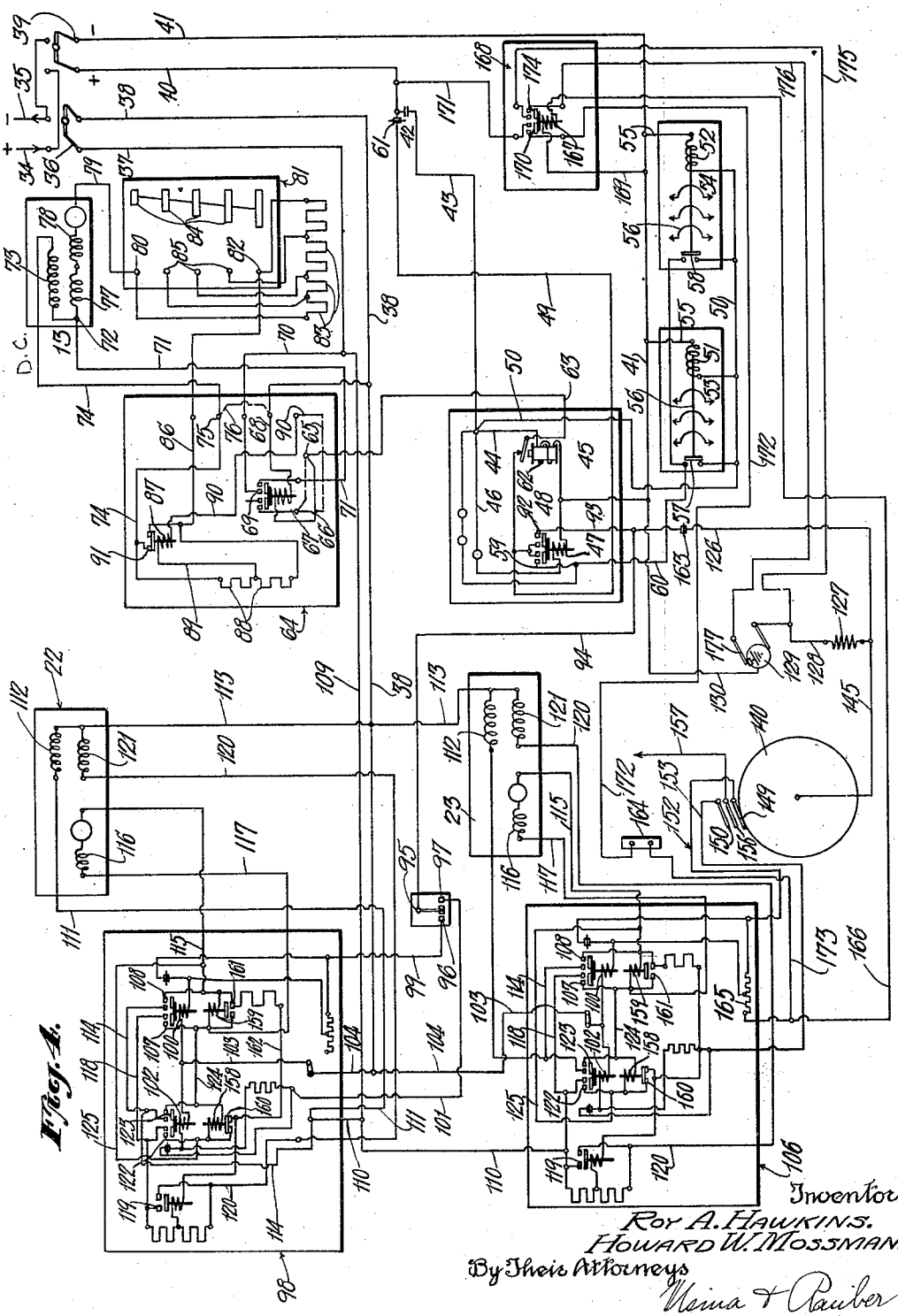

Fig. 4.

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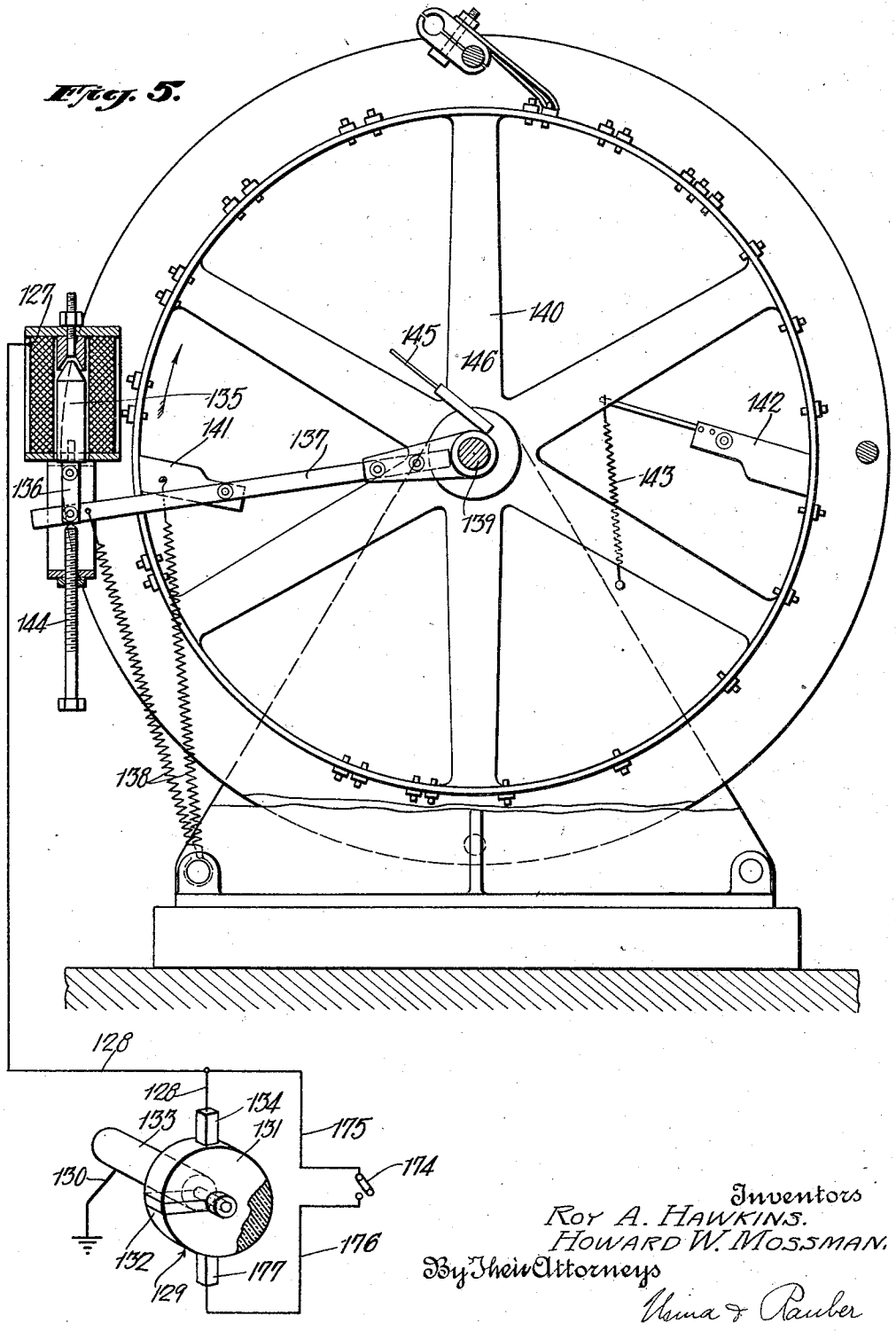
May 10, 1932. R. A. HAWKINS ET AL 1,857,592

FURNACE FEEDING APPARATUS

Filed July 31, 1930 7 Sheets-Sheet 4

Fig. 5.



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FURNACE FEEDING APPARATUS

Filed July 31, 1930 7 Sheets-Sheet 5

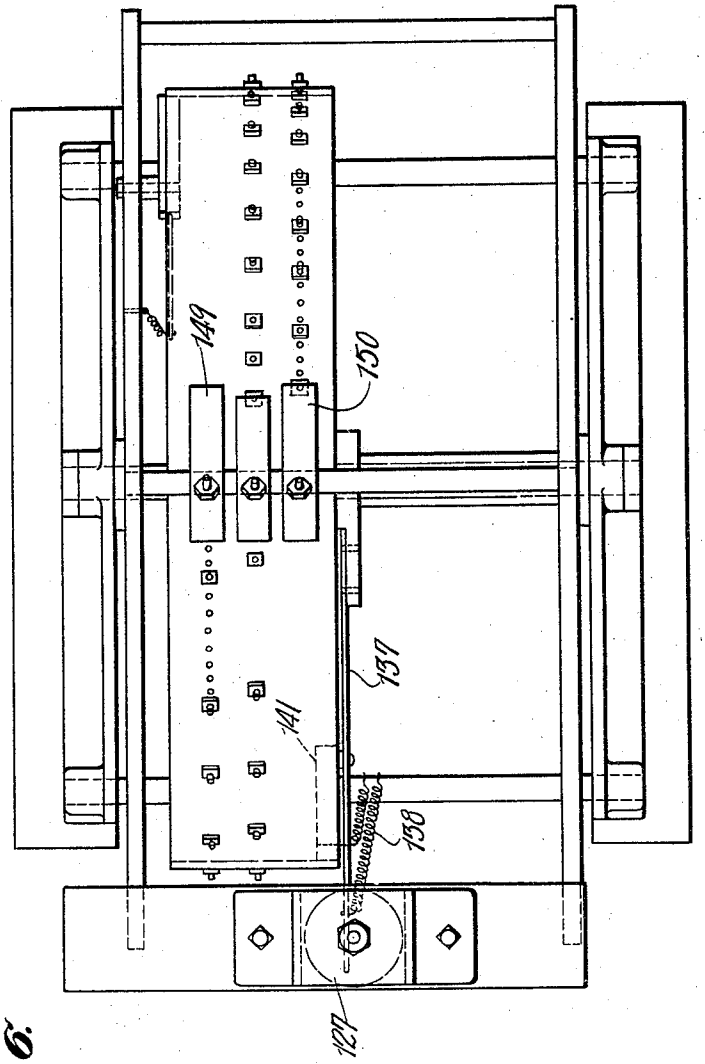

Fig. 9.

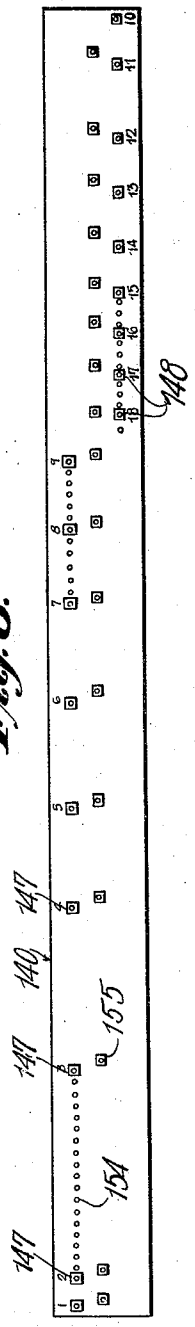

Fig. 8.

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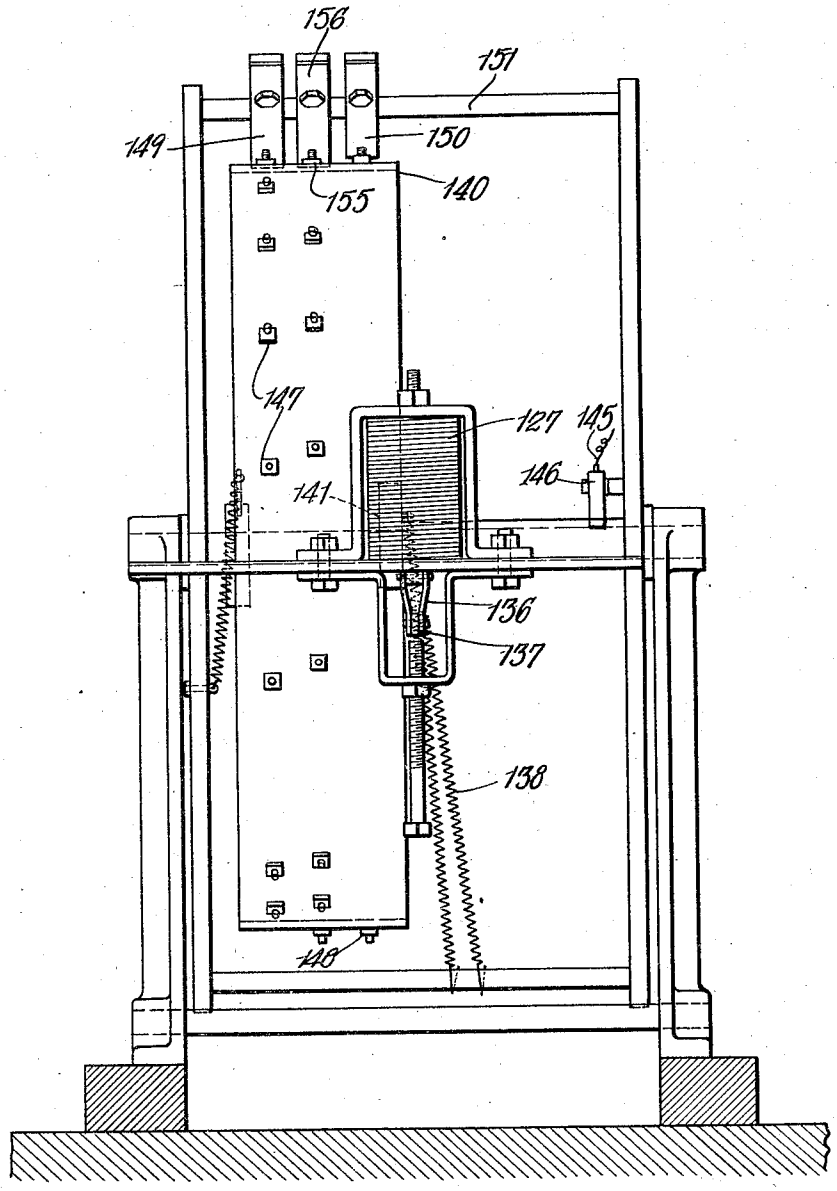
FURNACE FEEDING APPARATUS

Filed July 31, 1930 7 Sheets-Sheet 6

Fig. 7.



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FURNACE FEEDING APPARATUS

Filed July 31, 1930 7 Sheets-Sheet 7

Fig. 9.

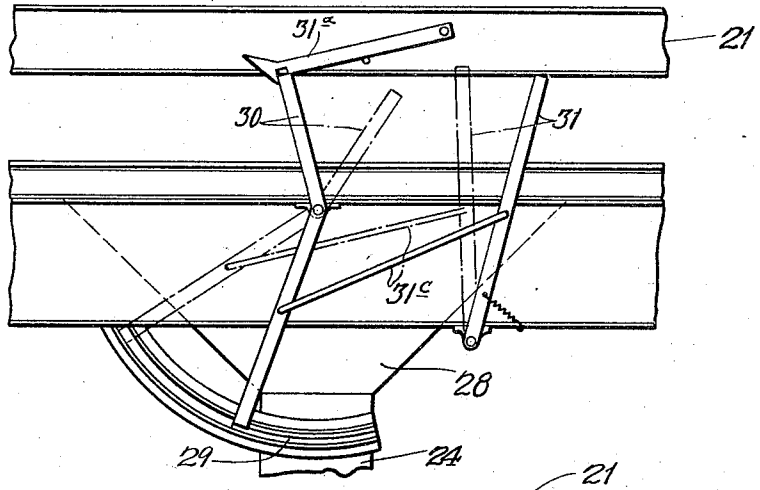


Fig. 10.

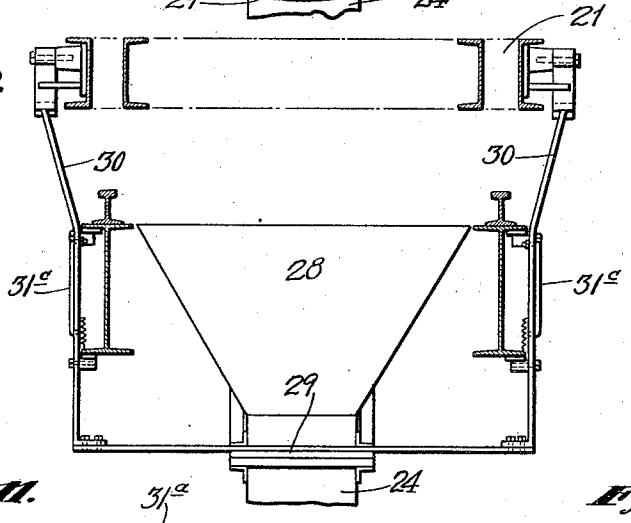


Fig. 11.

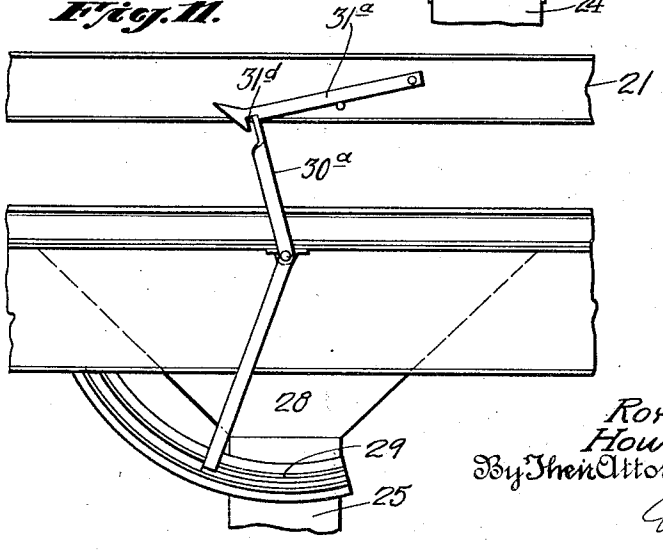
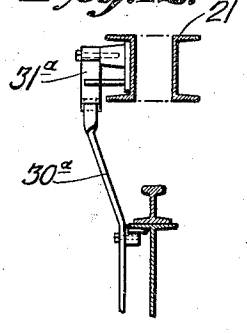


Fig. 12.



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UNITED STATES PATENT OFFICE

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FURNACE FEEDING APPARATUS

Application filed July 31, 1930. Serial No. 472,044.

This invention relates to apparatus for feeding charges to metallurgical furnaces. More particularly it relates to an apparatus for automatically feeding charges at spaced distances in a furnace of the reverberatory type and for proportioning the charges to the rate of smelting at the various parts of the furnace.

In feeding materials to a reverberatory furnace such as is used for smelting copper ores, the material to be smelted is fed at spaced distances throughout the length of the furnace. The amount of material charged is proportioned to the rate of smelting of the charge in the furnace so as to maintain the proper amount of material in the furnace without creating an excess or deficiency of the charging material. The smelting rate in a reverberatory furnace is, however, not the same throughout the entire length of the charging zone but varies with the temperature in the furnace. It is a maximum at the point of maximum temperature which, when the furnace is fired from one end, is near that end; for example, at about ten feet from the firing end in an oil fired furnace, and is a minimum at the opposite end of the charging zone which the heating gases reach after having given up heat to the materials nearer the firing end.

The objects of our present invention are to provide an apparatus in which the charges of material to be fed to the furnace will be automatically distributed throughout the length of the zone of the furnace and fed at the proper rate thereto; to provide apparatus whereby the quantity of material fed at each part of the length of the firing zone is proportioned to the rate of smelting of the material at the respective parts of the zone; and to provide means whereby the relative quantity of material supplied to each part of the charging zone may be adjusted to suit the particular conditions of the furnace.

In the accomplishment of the above objects according to a preferred form of the invention, the charging material is continuously fed to a conveyer and the delivery end of the conveyer is brought in succession in position to deliver the charging materials at determined successive intervals in the length of the charging zone. In this embodiment the delivery end of the conveyer is "spotted" above each of a series of feed openings spaced in the length of the furnace for an interval of time in proportion to the quantity of charging material to be fed at the respective charging opening, then moves to a succeeding opening and thus progresses throughout the length of the furnace. The conveyer is preferably so arranged that it charges one part of the zone from one end, and the other from the opposite end of the conveyer, its direction of movement and the direction of "spotting" being reversed when passing from one part to the other.

Further objects of the invention are to provide means whereby the feeding means is accurately "spotted" over the respective charging openings; to provide means whereby the stoppage of the delivery end of the feeding conveyer between a pair of successive feed openings is prevented; to provide a simple and effective reversing control for the conveyer and to provide a control mechanism for the conveyer and feeding materials so timed as to prevent any undue accumulation of material to be charged.

Further objects will appear from the following description of the invention.

The various features of the invention are illustrated in the accompanying drawings, in which—

Fig. 1 is a vertical sectional elevation of a reverberatory furnace of the center feed type and a feeding mechanism embodying a preferred form of the invention.

Fig. 2 is a plan view of the furnace shown in Fig. 1.

Fig. 3 is a section of the furnace taken on line 3—3 of Fig. 1.

Fig. 4 is a wiring diagram of electric circuits controlling the feeding mechanism.

Fig. 5 is a detail view of a mechanism and circuit for timing the feeding of charging materials to the charging openings of the furnace.

Fig. 6 is a plan view of the timer mechanism of Fig. 5.

Fig. 7 is an end elevation of the timer mechanism.

Fig. 8 is a development of the surface of a wheel or drum containing timer elements.

Figs. 9, 10, 11 and 12 are views in side, in cross elevation and in detail of hopper opening and closing mechanism forming part of the feeding apparatus.

Referring more particularly to the accompanying drawings, the invention is shown as applied to the central feeding of a reverberatory furnace 10. The material to be charged to the furnace is discharged from a charging car into a track hopper 11, Fig. 3, the bottom of which consists of a pan or apron feeder 12 driven through suitable mechanism from a motor 13 to discharge the material in a uniform, continuous stream to a side conveyer 14. The side conveyer 14 is driven continuously from a motor 15 and, in turn, discharges onto a cross conveyer 16 driven by a motor 17. The charging material is conveyed by the conveyer 16 to the central part of the furnace 10 and is there discharged onto a reversible shuttle conveyer 18. The shuttle conveyer 18 is of an endless belt type trained over pulleys 19 and 20 carried on a reversible carriage 21 which is supported on suitable rails to move backwardly or forwardly lengthwise of the furnace. The conveyer 18 is one-half the length of the charging zone plus overrun length of one hopper and is driven alternately from a reversible motor 22 through a train of gears. The carriage 21 is moved back and forth lengthwise of the furnace by means of a reversible motor 23 and a suitable worm gear connected to the front wheels of the carriage. The motor 23 is given an intermittent movement by means of a timer which causes the carriage 21 to move a distance between two successive charging openings 24 in the roof of the furnace 10, there being eighteen such openings in the furnace illustrated; to then remain stationary for a determined period of time and, thereafter, to move to a succeeding charging opening and thus to progress until its discharge end has reached the ninth charging opening 25.

The opposite end of the conveyer extends beyond the eighteenth charging hole 26 by the length of one charge hopper. This is known as the "over-run". The direction of motion of the carriage 21 is then reversed so that the end of the conveyer 18, which is not at this time the discharge end, is brought to and "spotted" at the eighteenth charging hole 26. In moving back from this over-run position the reversing switch 95 is thrown over so that the movement of the conveyer 18 is reversed. In moving back from this over-run position the carriage operates a reversing switch which reverses the direction of rotation of the motor 22 and of the conveyer 18 so that it now discharges from its opposite end. The discharge end of the conveyer 18 is then brought successively over the charging holes from the eighteenth towards the mid-point of the charging zone until it reaches the tenth charging hole 27. The opposite end of the conveyer is then beyond the first charging hole 24 by the length or "over-run" of one charge hopper. The direction of motion of the carriage 21 is then reversed so that the end of the conveyer 18 is brought to and then spotted at the first charging hole 24. In moving back from the over-run position past the first charging hole 24, the reversing switch of the motor 22 is thrown to reverse the direction of movement of the conveyer 18 and to cause it to discharge from the opposite end. The discharge end of the conveyer is then brought successively from the first charging hole 24 towards the mid-point of the charging zone until it reaches the ninth charging hole 26. The cycle of operation is then repeated.

Each of the charging openings is provided with a feed hopper 28 and a gate 29. The gate 29 is controlled through a suitable linkage by a pair of levers 30 and 31 which are so positioned as to be engaged by one of a pair of swinging hook arms 31*a* and 31*b* positioned at the opposite ends of the carriage 21, the first nine levers of openings 29 being operated by the hook arm 31*a*, and the levers of openings 10—18 being operated by the hook arm 31*b*. When the carriage 21 is moving from the first to the ninth opening the hook arm 31*a* successively engages first the lever 30 of each charging opening and rotates it in a clockwise direction. Thereupon a swinging radial gate 29 secured to the lower end of the lever 30 is swung in a counter-clockwise direction about the pivot of the lever 30 to open a passage from the hopper 28 to the opening 24. When the lever 30 and the swinging radial gate have reached the limit of their clockwise direction, as indicated by the dotted lines in Fig. 9, the hook arm 31*a* rides over the end of the lever. In this position the lever 31 will have been rotated counter-clockwise to the position indicated in dotted lines in Fig. 9 by means of a connecting link 31*c*. When the carriage 21 resumes its movement to the right, the swinging hook arm 31*a* engages the end of the lever 31 and swings it clockwise to the full line position, thereby drawing the link 31 to the right and swinging the lever 30 and the gate 29 counter-clockwise to closed position. The further movement of the carriage 21 brings the swinging hook arm 31 into engagement with the lever 30 of the next succeeding opening, whereupon the sequence of movements is completed.

This operation of the opening gate 29 continues for openings 1—8 when the carriage is moving from the firing end and in reverse direction for openings 18—11 when the car-

riage is moving towards the firing end. When the carriage reaches the opening 29 it engages the lever 30*a* of the ninth charging opening 25, as indicated in Fig. 11. The upper end of the lever 30*a* is narrowed so that it is received in a notch 31*d* of the swinging lever 31*a*. The movement of the carriage 21 is such that it stops in the "over-run" position when the lever 30*a* of the opening 25 is in open position so that the hook arm 31*a* does not override the end of the lever 30*a* and the upper end of the latter remains in the notch 31*d*. When the carriage 21 resumes its reverse movement, the lever 30*a* being engaged by the notch 31*d* is rotated counter-clockwise, closing the opening 25. The operation of the closure for the opening 27 is similar but in a reverse direction. The openings 25 and 27 do not, therefore, require a lever 31 or a link 31*c* to close the gate 29. Preferably there is a set of opening and closing levers 30 and 31 and of links 31*c* on each side of each charging opening as indicated in Fig. 10. This gives a balanced construction which eliminates any slewing and enables the construction to be much lighter than if a one-sided construction were used.

Current for driving the motors 22 and 23 is supplied through a trolley 32 and a contactor arm 33. The amount of feed per unit of time is controlled by the speed of the pan feeder 12 and also by the amount of the gate opening above this feeder. Any adjustment of the rate of feed is, therefore, proportionate for each of the charging openings 24 to 27.

The motors 13, 22 and 23 are direct current motors and the motors 15 and 17 are alternating current motors. Power for driving the motors 13, 22 and 23 is taken from direct current power mains 34 and 35, Fig. 4, through a switch 36 to mains 37 and 38. Current for controlling the various motors 13, 15, 17, 22 and 23 is also taken from the mains 34 and 35 through a double knife switch 39 to the control circuit lines 40 and 41.

In starting the apparatus it is desirable to have the side conveyer 14 and the cross conveyer 16 in motion before the apron feeder 12 starts in order to ensure that the material delivered by the feeder 12 to the side conveyer shall be conveyed away continuously and not accumulate before the side conveyer is in motion. The starting of the motor 13 is, therefore, automatically delayed after the starting of the motors 15 and 17.

In starting the apparatus a push button 42 is closed, thereby closing a circuit from the wire 40 through a wire 43 and a branch wire 44 to a time limit relay 45. A circuit is also closed through a branch wire 46 to a control relay 47. A return circuit then leads from the relays 45 and 47 through branch wires 48 directly to the wire 41. When the above circuits are closed current also flows from the wire 43 through a wire 50, to solenoids 51 and 52 of line starters 53 and 54 of the alternating current motors 15 and 17 and thence returns through branch wires 55 to the return wire 41.

The solenoids 51 and 52 thereupon actuate contactors 55 and 56, respectively, to close the three alternating circuits through the alternating current motors 15 and 17 and, at the same time, close the contactors 57 and 58. Upon the closing of the contactors 57 and 58 the circuit through the push button or switch 42 is by-passed from the wire 40 through a wire 49, thence through a closed contactor 59 of the relay 47 and then through a wire 60 to the contactor 57 and through the wire 50 and solenoids 51 and 52 to the return wire 41. The wire 50 being thus connected to the wire 40 also connects the wire 40 to the wires 44 and 46, thereby establishing a by-pass circuit through the relays 45 and 47 to the return wire 41. The push button 42 may thereupon be opened without interrupting the circuit through the relays 45, 47, 51 and 52 which remain closed through the by-pass wire 49 until a normally closed push button or switch 61 is opened. When the relay 45 is closed a circuit is closed from the wire 40 through the by-pass wire 49 and contact 62 and thence through a wire 63 to a line starter 64. Any suitable line starter may be used. In the type shown in the accompanying drawings the wire 63 is connected to a terminal 65 in the line starter 64 from which current flows through a connecting wire 66 to a relay 67 and thence through a return wire 68 to the return main 38 of the motor circuits. Inasmuch as both the wires 38 and 41 are connected to the return main 35, a connection of the circuit from the wire 40 through the relay 67 to the return main 38 completes a circuit through the relay and is somewhat more convenient in the preferred installation than would be a return to the wire 41.

When current passes through the relay solenoid 67 it closes a contact 69 thereupon closing a circuit from the main 37 through a branch wire 70, thence through the contact 69 to a wire 71 leading to a terminal 72 of the motor 13. From the terminal 72 the circuit continues through a shunt winding 73 and return wire 74 to a terminal 75 and connecting wire 76 to the return circuit wire 68 and 38. From the terminal 72 current also flows through a series field winding 77 and armature winding 78 and thence through a wire 79 to a terminal 80 of a drum controller 81. The circuit from the terminal 80 is then connected to an outgoing terminal 82 either through the resistances 83 or through the rotatable connecting contacts 84, or through any suitable combination of resistances and contacts through the intermediate terminals 85. From the outgoing terminal 82 the current flows through a connecting wire 86 to a

terminal of the cut-out relay 87 and thence through resistances 88 in series to an extension of the wire 74. From this wire the current returns to the return wire 38 through the connecting wires 76 and 68. As current passes through the resistances 88 a circuit is established from these resistances through a branch wire 89 to the relay 87 which is of a retarded or slow acting type, and thence through a return wire 90 which connects with the terminal 65 and wire 63. Current being thus established through the relay 87 causes the latter to close a contact 91, thus short circuiting the resistances 88 and connecting the return wire 86 directly through the contact 91 and wires 74, 76 and 68 to the return main 38.

It is to be understood that the time limit relay 45 requires a considerable time for its operation, for example, five seconds, whereas the relay 47 is quick acting. Accordingly the closing of the contact 62 and the starting of the motor 13 is delayed for a corresponding period after the closing of the contacts 55 and 56 and the starting of the motors 15 and 17.

When the relay 47 is energized it also closes a contact 92. Thereupon, a circuit is closed from the control circuit line wire 49 through the contact 92 to a wire 93 and thence through a wire 94 to a reversing switch 95. The reversing switch 95 controls the direction of rotation of the motor 22 for driving the conveyer belt 18 and is itself controlled by the movement of the shuttle car or carriage 21 in such a manner that when the shuttle car has reached the limit of its movement in one direction, and starts back from the over run position it swings the reversing switch 95 to contact with a terminal 96 and, when it has reached its limit of movement in the opposite direction, and starts back from the over run position it swings the reversing switch 95 into contact with a contact terminal 97.

The terminals 96 and 97 connect to a reversing line starter 98 for the motor 22 in such a manner as to connect the field circuits and armature circuits of the motor 22 in reversed directions as one or the other terminal is connected. Any suitable reversing starter may be used, the specific construction of the starter in itself not being our invention. When the reversing switch 95 contacts with the terminal 96 it closes a circuit from the wire 40 through the wire 43, and later through wire 49, contact 92 and wires 93 and 94 to a wire 99 which leads to a control relay solenoid 100.

Similarly when the reversing switch 95 is connected to the terminal 97 a circuit is closed through a wire 101 and through suitable resistances to a control relay solenoid 102. From the relay solenoids 100 and 102 the circuit returns through a return wire 103 to a wire 104 leading to return main 38 and also connecting to a terminal 105 of a reversing line starter 106 for the motor 23, the line starter 106 being similar to starter 98. When the solenoid 100 is energized it closes a pair of contacts 107 and 108. A circuit is at all times closed from the main 37 through branch wires 109, 110 and 111 to a shunt field winding 112 and thence through return wire 113 to the return main 38. The direction of current through the shunt winding 112 is, therefore, always the same. A circuit is also established through the wires 109 and 110 through a wire 114 to the contact 108. When this contact is closed the circuit is, therefore, closed through a wire 115 to the armature windings 116 of the motor 22 and thence through a return wire 117 to the contact 107. The contact 107 being closed, a circuit is established through a wire 118 and through a starting resistance and cut-out 119 to a wire 120 leading to a series field winding 121 and thence through the wire 113 to the return main 38. When the reverse switch 95 contacts with the terminal 97 the circuit through the line 99 and the solenoid 100 is broken, thereby opening contacts 107 and 108 and breaking the circuit through the armature winding 16 and series field winding 121. Simultaneously a circuit is established through the wire 101 and the solenoid 102 thereby closing a pair of contacts 122 and 123 arranged similarly to the contacts 107 and 108. Thereupon current flows from the wire 114 through the contact 123 to a branch wire 124 connecting with the wire 117 and the armature 116 and thence to the wire 115.

It will be observed that in this arrangement the direction of current through the armature windings 116 is reverse to that when the reversing switch 95 is connected to the terminal 96. At the same time current passes from the wire 115 through a connecting wire 125 and thence through the closed contacts 122 to the resistances and cut-out 119, thence through wire 120 to the series field winding 121, wire 113 and return main 38. In this circuit the direction of the current through the series winding 121 is the same as when the reversing switch 95 contacts with the terminal 96 so that in either position of the reversing switch 95 the direction of current through the shunt and series field winding 112 and 121 is not reversed, whereas the direction of current through the armature winding 116 is reversed. Consequently, when the reversing switch 95 contacts with the terminal 96, the motor is driven in one direction and when it contacts with the terminal 97 it drives the motor 22 in the opposite direction.

The starter 106 for the carriage motor 23 is similar in construction to the starter 98 and, therefore, the description of the starter 98 is applicable to the description of the

starter 106, similar reference numerals being used in the drawings. Instead of being controlled merely by a reversing switch, however, the starter 106 is operated by a timer and reversing switch intermittently operating the motor 23 and varying the periods between successive periods of operation and alternately reversing the direction of the motor after a series of movements in one direction. The timer is driven electrically by a commutator on the tail pulley shaft of the cross conveyer 16. Consequently the timer is driven in direct relation to the speed of the feeding conveyers and a definite interval of rest of the motor 23, while the discharge end of the conveyer 18 is "spotted" over a charging opening and corresponds to a definite amount of charged material. The tail pulley commutator for driving the timer serves to provide an intermittent current to an electromagnetic drive mechanism for the timer.

The current for the commutator is taken from the wire 40 through the branch wire 43 or 49, through the contacts 92 as described above, thence through wire 93 to a branch wire 126 to an actuating solenoid 127 shown diagrammatically in Fig. 4, and in detail in Figs. 5, 6 and 7. From the solenoid 127 the current returns through a wire 128, thence through the commutator 129, shown in detail in Fig. 5, and thence through to ground or to the return wire 41 by means of a connecting wire 130.

As shown in Fig. 5 the commutator comprises a rotating insulating disc 131 having a conducting or metallic insert 132 that is connected to the supporting and rotating shaft 133 of the tail pulley of the cross conveyer 16, and thence through the wire 130 to ground or to the return wire 41. The current conveying wire 128 is provided with a brush 134 which bears against the periphery of the insulating disc 131 and thus comes into contact once in each revolution of the disc with the conducting insert 132, thereby intermittently closing a circuit between the wires 128 and 130 and establishing, once in each revolution, an intermittent circuit through and intermittently energizing, the solenoid 127. With each energization of the solenoid 127 it lifts a magnetic core 135 in the solenoid and, through a link 136 secured to the core 135, lifts the outer end of a crank or lever 137 against the action of the springs 138. With each lifting of the lever or arm 137 it rotates a limited distance on a shaft 139 on which a timer wheel 140 is also loosely and rotatably mounted. Pivoted to the arm 137 is a fiber dog 141 that engages the inner periphery of the wheel 140 so that with each lifting of the arm 137 a limited rotational movement in the direction of the arrow, Fig. 5, is imparted to the wheel 140. When the solenoid 127 becomes de-energized by the interruption of the current through the commutator 131, the arm 137 is drawn reversely by the springs 138 causing the dog 141 to slip reversely on the inner periphery of the wheel 140.

The wheel 140 is prevented from rotating reversely with the dog 141 by means of a retaining pivoted fiber dog 142 which is held in engagement with the periphery of the wheel 140 by means of a spring 143. The wheel 140 is thus advanced a definite amount with each rotation of the commutator 131 which, in turn, is controlled by the rotation of the tail pulley of the cross conveyer 16.

The extent of movement of the wheel 140 with each energization of the solenoid 127 may be controlled by adjusting a threaded stop 144 which limits the downward movement of the link 136 and arm 137. The time intervals between the energizing of the solenoid 127 may also be controlled by inserting additional conducting inserts or segments in the commutator 129.

The wheel 140 or its periphery is of metal and is connected to the circuit wire 126 and thus to the wire 40 by means of a branch wire 145 which contacts with the wheel 140 or its periphery by means of a brush 146 bearing against an axial or other conducting part of the wheel 140. The wheel 140 is provided with two series of circumferentially spaced contacts 147 and 148, one series being spaced axially of the other on the periphery of the wheel, and said contacts being in position to contact successively with contacts 149 and 150 respectively mounted on a fixed insulating rod or bar 151. When one of the contacts 147 contacts with the fixed contact 149 it closes a circuit from the wire 145 to a wire 152 leading to the relay 100 of the starter 106 and thereby serves to connect the motor 23 in position to run in one direction as long as the contacts 147 and 149 remain in contact.

Similarly when the contact 150 is brought into contact with the projecting contact 148 a circuit is closed through a wire 153 to the relay 102 of the starter 106.

The relative positions of the series of contacts 147 and 148 are shown in the development of the periphery of the wheel in Fig. 8 of the drawings. The series of contacts 147 contains nine contacts, each contact corresponding to one of the openings in the first nine charging openings from the firing end of the furnace and being so positioned that when the contact 149 is in contact with any of the contacts 147, the shuttle car is caused to move away from the firing end toward the up-take end of the furnace. The first contact of 147 and 149 causes the carriage to start up from the over-run position one hopper's length beyond the first charging hole 24. The spotting switch then stops it at the first hole. The space of the interval on the timing wheel between the first and the second hole provides time for the reversing of the conveyor 18, which in one installation was about six

seconds, and for the time of actual discharge into the first charging hole. The second contact of 147 and 149 causes the carriage to move off the first charging hole, and to move towards the second charging hole, and so on until the ninth contact of 147 and 149 causes the carriage to move off the eighth charging hole and towards the ninth charging hole. Similarly, contact of the eighteenth contact 148 and 150 causes the carriage to start up in the opposite direction from the over-run position one hopper length past the eighteenth charging hole. The seventeenth contact causes the carriage to start off the eighteenth charging hole, and so on until the tenth contact causes the car to start up from the eleventh charging hole and move on to the tenth charging hole.

The interval on the timer between the eighteenth and the seventeenth contacts provides time both for the time of reversing of the conveyer 18, which in the installation referred to above was six seconds, and for the time of discharge into the furnace through hole eighteen. The time of discharge into the ninth charging hole is determined by the interval between the ninth contact of 147 with 149, and the eighteenth contact of 148 with 150. The time of discharge into the tenth charging hole is determined by the interval on the timer between the tenth contact of 148 with 150 and the first contact of 147 with 149. The relation of the timer spacings, charging opening spacings, time of charging and percentage of charge of a typical installation is as follows:

Hole No.	Distance from end of furnace	Number of timer intervals	Seconds	Percentage of charge
"Bridge"	0'- 0"			
1	6'- 6"	5	{6 (Reversing) {7 1.5	
2	10'- 2"	30	77	16.7
3	13'-10"	25	65	14.1
4	17'- 6"	14	36	7.6
5	21'- 2"	14	36	7.6
6	24'-10"	14	36	7.6
7	28'- 6"	10	26	5.5
8	32'- 2"	10	26	5.5
9	35'-10"	8	21	4.5
10	39'- 6"	8	21	4.5
11	43'- 2"	8	21	4.5
12	46'-10"	8	21	4.5
13	50'- 6"	7	18	3.8
14	54'- 2"	6	15	3.2
15	57'-10"	6	15	3.2
16	61'- 6"	6	15	3.2
17	65'- 2"	4	10	2.1
18	68'-10"	3	{2 0.4 {6 (Reversing)	
		186	480	100.0

It will also be apparent that the use of two series of contacts 148 serves not only to drive the car intermittently and to proportion the length of time between movements, but also serves to reverse the direction of movement of the driving motor 23 at the proper time interval.

It will be understood that the arrangement of the timer and contacts 147 and 148 on the periphery of the wheel 140, shown by way of example in Figs. 5, 6, 7 and 8, is arbitrary and that these contacts may be arranged in any desired sequence to meet any particular condition. Preferably, the contacts 147 and 148 are so made that they may be inserted in holes 154 so that the peripheral position of the contacts may be readily varied or adjusted to suit any desired sequence.

From the above it will be apparent that the starting of the cross conveyor motor 17 starts the commutator contacts revolving with the tail shaft of the conveyer and as the current impulses are received by the solenoid magnet from the commutator the timer wheel is caused to slowly revolve. As each contact with the charging openings 1–9 is made, the shuttle car is caused to move to the opening on which it is to be spotted until the ninth opening is reached.

The shuttle car is now at the front end of the charging zone, being spotted one hopper length past the eighteenth hole. The next contact made is that of the number eighteen charging opening which causes the shuttle car to move back toward the firing end of the furnace and its next spotting position takes place in the number eighteen charging opening. The backward movement of the car operates the reversing switch 95 for the shuttle belt motor, causing the belt to reverse and the feed is charged into the eighteenth opening. As the successive contacts are made the car is successively spotted over the openings numbers eighteen to ten. At the opening ten a similar reversal of both car and shuttle belt takes place and the conveyer again starts, feeding charging opening number one.

A third series of contacts 155 may be provided having eighteen contacts spaced adjacent the respective contacts of the series 147 and 148 and positioned to successively contact with a fixed contact 156 for each contact of the series 147 and 148 with their respective fixed contacts 149 and 150. The contact 156 connects to a wire 157 of an alarm circuit, not shown, through which warnings of the starting of the shuttle car are given.

It is desirable to have the conveyer belt 18 and the shuttle car 21 stop instantly upon the interruption of the current to their respective driving motors. This is particularly true of the shuttle car 21, because if it be carried by its momentum past the charging opening over which it is to be spotted, the operation of the apparatus is correspondingly unsatisfactory.

To secure a prompt stopping of the car the starters 98 and 106 for the motors 22 and 23, respectively, are so arranged as to short circuit the armature 116 of their respective motors and thus provide a dynamic braking for these motors. For this purpose high resistance solenoids 158 and 159 are interposed between the contacts 122 and 123 and the

contacts 107 and 108, respectively, so that when these respective contacts are closed their respective solenoids 158 and 159 will be energized. Each of the solenoids 158 and 159 controls a normally closed switch 160, 161, respectively. The contacts 160 and 161 are inserted in a circuit 162 connecting the wires 124 and 125 respectively which, as pointed out above, connect to the terminal wires 117 and 115, respectively, of the armature 116. It will be apparent, therefore, that when either of the contacts 107 and 108 or 122 and 123 is closed, the corresponding contact 160 or 161 is opened and the circuit between the wires 115 and 117 through the connecting wire 162 is broken. When all of the contacts 107, 108, 122 and 123 are open, which is the case when the motor is idle, both of the contacts 160 and 161 are closed, thus short circuiting the armature 116 through the wire 162. This short circuiting acts as a dynamic brake on the motor 22 or 23, respectively, causing it to stop immediately upon the opening of its driving circuit.

It is undesirable to have the shuttle car stop at any point between any two consecutive charging openings 24. To prevent such a stopping or "spotting" of the shuttle car between any two consecutive charging openings as might be caused by an opening of or tampering with the switch 61, or with the motor control switch 163 in the control line 126, means are provided for preventing the stopping of the shuttle car between any pair of consecutive charging openings.

It is also desirable to have the contactors 149 or 150 clear the contacts 147 or 148 preferably upon the shuttle car reaching its proper position above the charging opening. This is accomplished by increasing the speed of the timer wheel 140 during the period while the contacts 149 or 150 are in contact with the projecting contacts 147 or 148, respectively, so that the time is proportionately more accurate during the periods while contact is made through the motor circuits.

For these purposes the motor 23 is provided with a spotting switch 164 which is so constructed and arranged as to be closed while and only while the motor 23 is running. Any suitable device may be used for this purpose, such as a solenoid controlled by the current through the armature of the motor 23 or by a mechanical device. The closing of the spotting switch 164 serves to by-pass the circuits through the wires 43 and 49. In by-passing the circuit in this manner current is taken from the wire 152 or 153 through a resistance 165, thence through a wire 166 leading to a relay solenoid 167 in a lock-out relay 168 and thence returns to the wire 41 to a connecting wire 169. The relay 167 is thereby energized and closes a switch 170.

Current thereupon flows through a branch wire 171 through the closed switch 170 to a wire 172 to the spotting switch 164 and thence through a connecting wire 173 to the return wire 166. The closing of the switch 170, therefore, by-passes the current from the wire 40 directly to the spotting switch 164 so that should any of the switches 42, 61 or 163 be opened, the current would be supplied through the motor 23 until the circuit is broken by the contacts 149 or 150 moving out of contact with the respective contacts 147 or 148.

The energization of the lock-out relay solenoid 167 also closes a switch 174, one terminal of which is connected through a wire 175 to the wire 128 of the timer driving solenoid 127 and to the brush 134, and the other terminal of which is connected through a wire 176 to a brush 177, as shown more in detail in Fig. 5. It will, therefore, be apparent that whenever the conducting insert 132 of the commutator 131 contacts with either the brush 134 or the brush 177, an energizing current passes through the solenoid 127. The number of energizations of the solenoid 127 per revolution of the commutator 131 is thus doubled. Consequently, the speed of the timer wheel 140 is doubled while the shuttle car is in motion so that the clearing of the contacts 147 and 148 is more promptly and accurately accomplished.

The operation of the apparatus is, therefore, briefly as follows:

When the switches 36 and 39 are closed the push button 42 is closed and held closed for a period of time. Current thereupon flows from the wire 40 through the wires 43 and 50 to the three phase starters 53 and 54 for the alternating current motors 15 and 17, thereby starting the conveyers 14 and 16 in motion. In the starters 53 and 54 the current passes through the solenoids 51 and 52, respectively, and thence returns to the wire 41. The solenoids 51 and 52 also close contacts or switches 57 and 58. Current also flows from the wire 40 through the wire 43 to the solenoid 47 and quick acting relay and thence returns by wire 48 to the return wire 41. The solenoid 47 immediately closes a contact 59. The switch 42 is thereupon by-passed through the wire 49, contact 59, thence through wire 60 and through closed contacts 57 and 58 to the wire 50, thence through the solenoids 51 and 52 to the return wire 41. The normally open contactor or push button 42 may thereupon be released without interrupting the starters 53 and 54. The solenoid 47 also immediately closes a contactor 92, thereupon connecting the wires 40 through the wire 49 and contactor 92 and thence through wires 94 and 96 to the reversing switch 95 of the timer 140 respectively. The reversing switch is placed in contact either with the contact 96 or 97, thereby actuating

the reversible motor starter 98 of the motor 22.

The reversible starter 98 serves to connect the armature 116 and the field windings 112 and 121 of the motor 22 in one or the other of two relatively reverse connections so that the motor is driven in one direction when the switch 95 contacts with the contact 96 and in the opposite direction when it contacts with the contact 97. The motor 22 thus serves to drive the conveyer 18 in one direction or the other. The periphery of the timer 140 is connected to the wire 145 thus connecting each of the contacts 147 and 148, Figs. 5—8, of the timer wheel 140 to the wire 40. As the wheel 140 rotates the contacts 147 are successively brought into contact with the contact 149, thereby at these intervals connecting the reversible starter 106 in such a manner that it connects the motor 23 of the conveyer carriage 21 in such manner as to move the carriage back from the over-run position and then from one of the spotting openings 24 to the next opening farther from the charging end, that is, to the right of Fig. 1. When the contact eighteen of the series 148 is reached, the contacts 148 successively contact with the fixed contact 150, thereby connecting the wire 40 through the connecting wire 53 to the reversible starter 106 so as to rotate the motor 23 at respective intervals in the reverse direction and move the carriage 21 successively towards the firing end of the furnace, that is, to the left in Fig. 1. The intervals between the contacts 147 and 148 correspond to the charging intervals for their respective openings and, as shown in Fig. 8, are so positioned as to provide longer periods of charging at the openings nearer the firing end, except the nearest one, and of progressively decreasing time intervals towards the off-take end.

The motors 22 and 23 are so arranged as to cause the upper surface of the conveyer 18 to move to the charging end, that is, to the left in Fig. 1, when the car 21 is spotted above the first nine openings from the firing end, and to move in the reverse direction when the car is spotted above the nine openings nearest the off-take end.

A lock-out switch 163 is closed when the car 21 is in motion, thereby closing by-pass circuit through the wires 166 and solenoid 167 in the lock-out relay 168 and thence to the return wire 41. The switch 164 is also closed when the motor 23 is in motion, thereby closing a circuit through the wires 172 and 173 and contact 170, closed by the solenoid 167, and thence through wire 171 to the wire 41. This by-passes the contacts 42, 61 and 163 and prevents the motor from stopping until it reaches a position in which it is spotted over one of the charging openings 24. The solenoid 167 also closes a contact 174 which, through the wires 175 and 176, doubles the action of the motor 129 and consequently the speed of the timer 140, while the circuit through the motor 23 is closed, and thus provides a more prompt and accurate timing of the stopping of the motor. The solenoids 158 and 159 serve to short circuit the armatures of the motors 22 and 23 when the latter are in stop position, thereby providing a dynamic braking and ensuring an automatically prompt stopping of the motor.

It will be understood that through the above connections the motors 15, 17 and 22 and 23 will start immediately upon the closing of the push button 42 inasmuch as the contact 92 is immediately closed upon the energizing of the solenoid 47. Current also passes from the wire 43 or from the short circuit wire 49 through a second slow acting or retarded solenoid 45 and thence through the return wire 48 to the wire 41. The solenoid 45 acts to close a contact 62 some time after the closing of the contacts 59 and 92 by the solenoid 47. Upon the closing of the contact 62 current flows from the wire 40 through the wires 49 to the contact 62 and thence through a wire 63 to a motor starter 64 for the motor 13. The motor 13 thereupon starts driving the apron feeder 12 and the speed of the motor may be controlled by means of a drum controller 81. It will be evident, therefore, that all of the conveyers 14, 16 and 18 are started and the carriage 21 is in operation before any ore is fed by the apron feeder 12, thus ensuring against a piling up of ore before the feeding begins such as might occur if the conveyers 14, 16 and 18 were not in motion when the feeder 12 starts.

Various modifications may be made by those skilled in the art without departure from the invention as defined in the following claims.

What we claim is:

1. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to successive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving circuit to reverse said driving means with the reversal of said conveyer, and means for interrupting said circuit for successive intervals.

2. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the

reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to successive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving circuit to reverse said driving means with the reversal of said conveyer, and means for interrupting said circuit for successive intervals of progressively varied lengths.

3. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to successive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving circuit to reverse said driving means with the reversal of said conveyer, means for interrupting said circuit for successive intervals, and means for reversing the direction of driving of said motor at definite intervals.

4. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to successive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving circuit to reverse said driving means with the reversal of said conveyer, means for interrupting said circuit for successive intervals, and means to prevent the interruption of said circuit between said timed intervals.

5. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to successive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving circuit to reverse said driving means with the reversal of said conveyer, means for interrupting said circuit for successive intervals, and means to brake said motor at the beginning of said intervals of interrupted circuits.

6. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to sucessive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving means to reverse said driving means with the reversal of said conveyer, means for interrupting said circuit for successive intervals, means to prevent the interruption of said circuit between said timed intervals, and means to brake said motor at the beginning of said intervals of interrupted circuits.

7. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to successive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving circuit to reverse said driving means with the reversal of said conveyer, means for interrupting said circuit for successive intervals, said timing means comprising a stationary contact and a drum having contacts at intervals positioned to contact with said contact during the rotation of said drum.

8. The apparatus of claim 7 having a pair of contacts one connected to a circuit to drive said motor in one direction and the other in a circuit to drive said motor in the reverse direction, and two successive series of contacts on the drum, one for one contact and the other for the opposite contact.

9. Apparatus for feeding charging materials to metallurgical furnaces which comprises, a continuous feeding conveyer, means for feeding materials to said conveyer, means for driving said conveyer alternately in opposite directions, electric circuits for controlling said driving means and for timing the reversal of said driving means, a carriage for said conveyer to move the discharge ends thereof to successive positions on said furnace, means for driving said carriage in alternately reversed directions, an electric circuit for timing said driving circuit to reverse said driving means with the reversal of said conveyer, means for interrupting said circuit for successive intervals, motors for said conveyer and for said feeding means, and means

to automatically start said feed motor in advance of said conveyer motor.

10. Apparatus for charging material at spaced positions in a furnace which comprises a conveyer, means for feeding charging materials to said conveyer, electrically driven means for moving the discharge end of said conveyer to the spaced charging positions of said furnace, a timer for interrupting said electrically driven means at intervals while spotted above a charging position, and means for preventing the interruption of said circuit through said electrically driven means while said means is between charging positions.

11. The apparatus of claim 10 having means whereby said electrically driven means may be interrupted for different periods of time and at different charging openings.

12. The apparatus of claim 10 having an alarm for indicating the movement of said electrically driven means.

13. Apparatus for charging materials at spaced positions in a furnace which comprises a conveyer, means for feeding charging materials to said conveyer, electrically driven means for moving the discharge end of said conveyer alternately in opposite directions to the spaced charging positions of said furnace, means for reversing the direction of movement of said conveyer when the direction of said electrically driven means is reversed, and a timer for interrupting said electrically driven means at intervals while the discharge end of said conveyer is above a charging position of said furnace.

14. The apparatus of claim 10 in which said timer is speeded between said intervals

15. The apparatus of claim 10 in which said timer is driven from the feeding means.

16. Apparatus for charging materials at spaced positions in a furnace which comprises a conveyer, means for feeding charging materials to said conveyer, a commutator driven by said feeding means, electrically driven means for moving the discharge end of said conveyer to the spaced charging positions of said furnace, and a timer driven by said commutator for interrupting said electrically driven means at intervals while spotted above a charging position of said furnace.

17. Apparatus for charging materials at spaced positions in a furnace which comprises a conveyer, means for feeding charging materials to said conveyer, a commutator driven by said feeding means, electrically driven means for moving the discharge end of said conveyer to the spaced charging positions of said furnace, a timer for interrupting said electrically driven means at intervals while spotted above a charging position of said furnace, an intermittent electro-magnetic drive for said timer controlled by said commutator, and means for multiplying the electric impulses through said electro-magnetic drive and commutator while said electrically driven means is in motion.

18. The apparatus of claim 10 having a pair of series of spaced contact pins on said timer wheel and contacts for one of said series in circuit to drive said electrically driven means in one direction, and contacts for the other series of said pins to drive said electrically driven means in the opposite direction.

19. The apparatus of claim 10 having means for dynamically braking the said electrically driven means.

20. An apparatus for charging materials at spaced positions in a furnace which comprises a conveyer, a motor for driving said conveyer in opposite directions, a carriage for carrying said conveyer in opposite directions lengthwise of said furnace, means for driving said carriage in one direction, means for reversing the direction of movement of said conveyer at the time of reversal of the direction of said carriage, and means for interrupting the movement of said carriage at intervals with the discharge end of said conveyer spotted above a charging position of said furnace.

In witness whereof I have hereunto set my hand.

ROY A. HAWKINS.

In witness whereof I have hereunto set my hand.

HOWARD W. MOSSMAN.