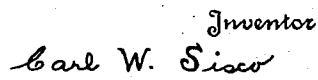


Filed Feb. 6, 1948

ORE TREATING FURNACE

6 Sheets-Sheet 1



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attorneys

July 28, 1953

C. W. SISCO
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Fig. 2.

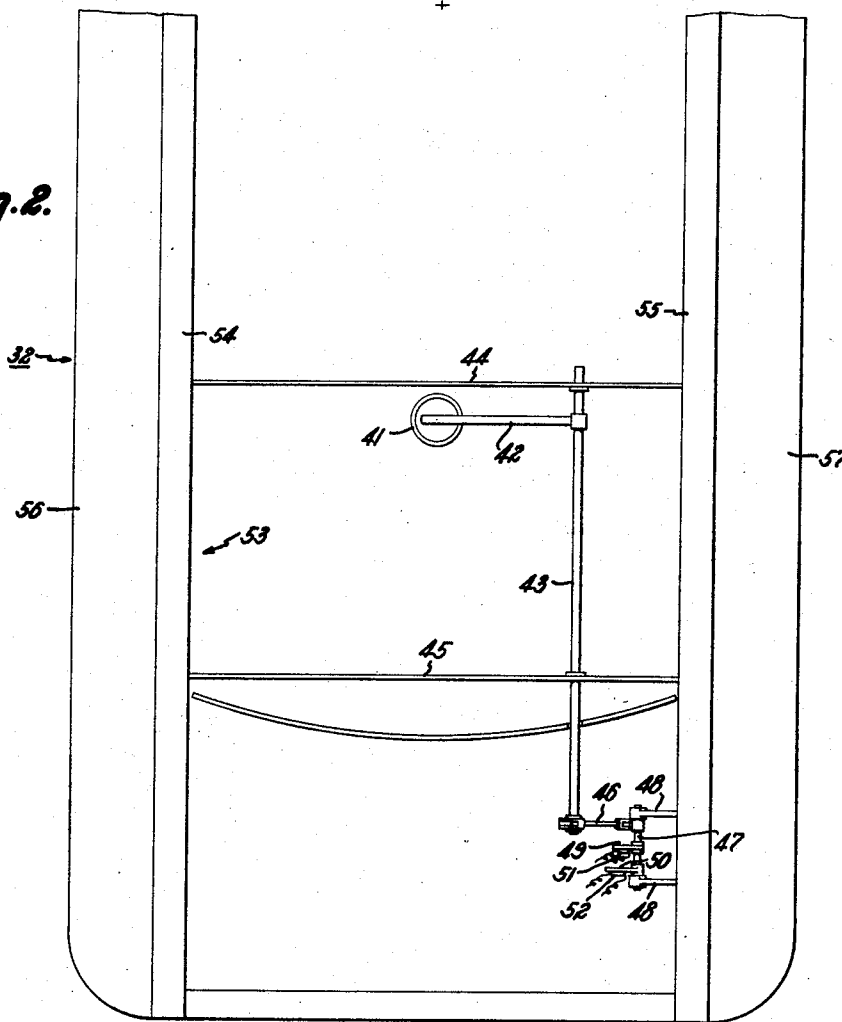
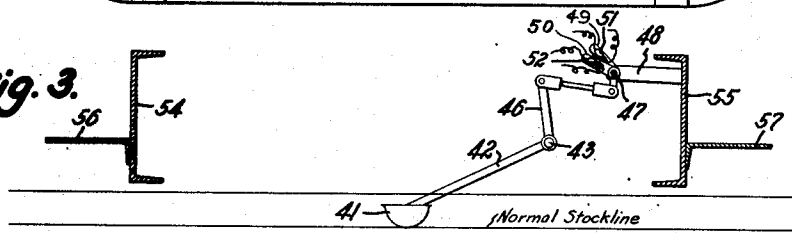


Fig. 3.



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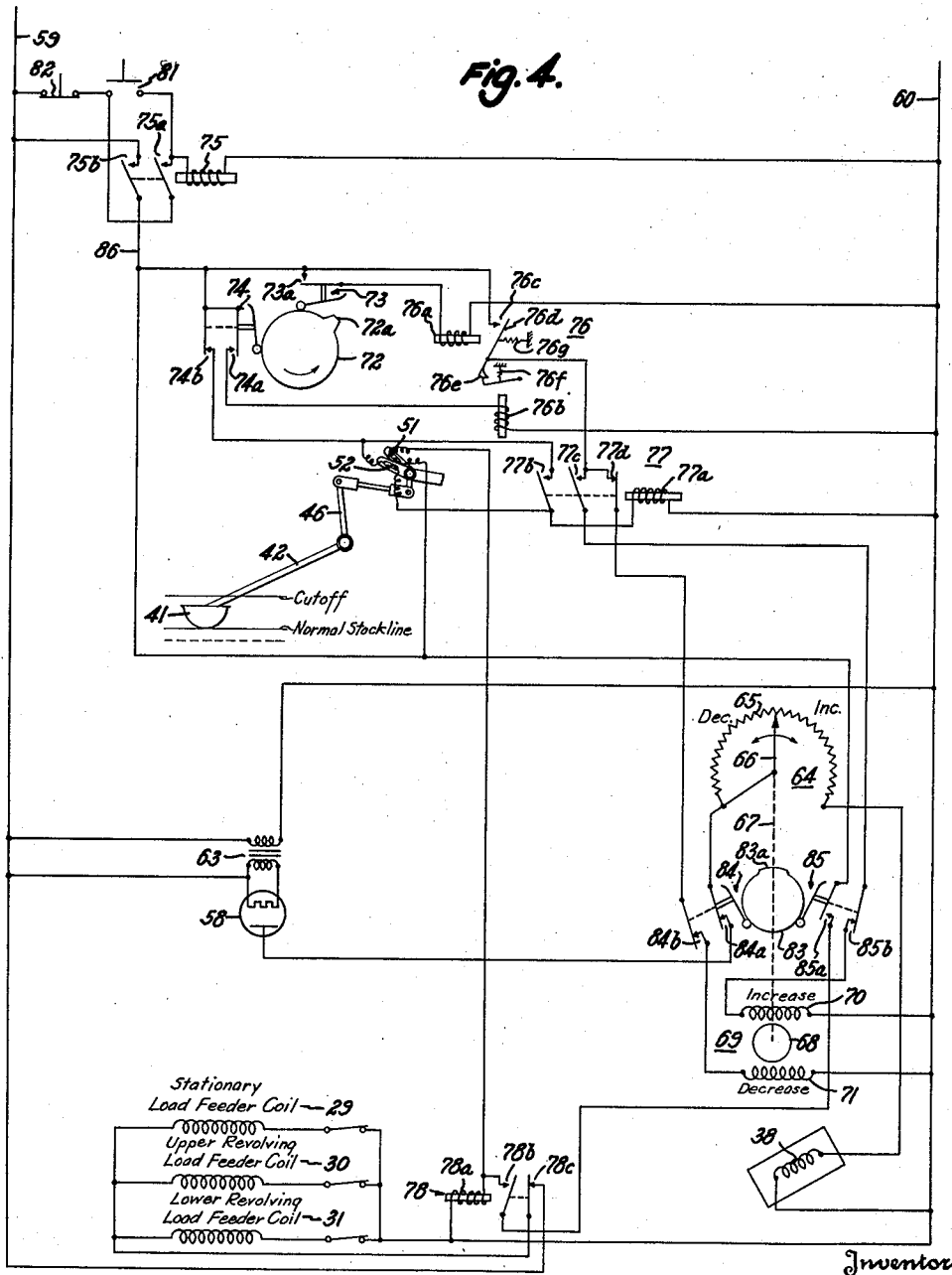
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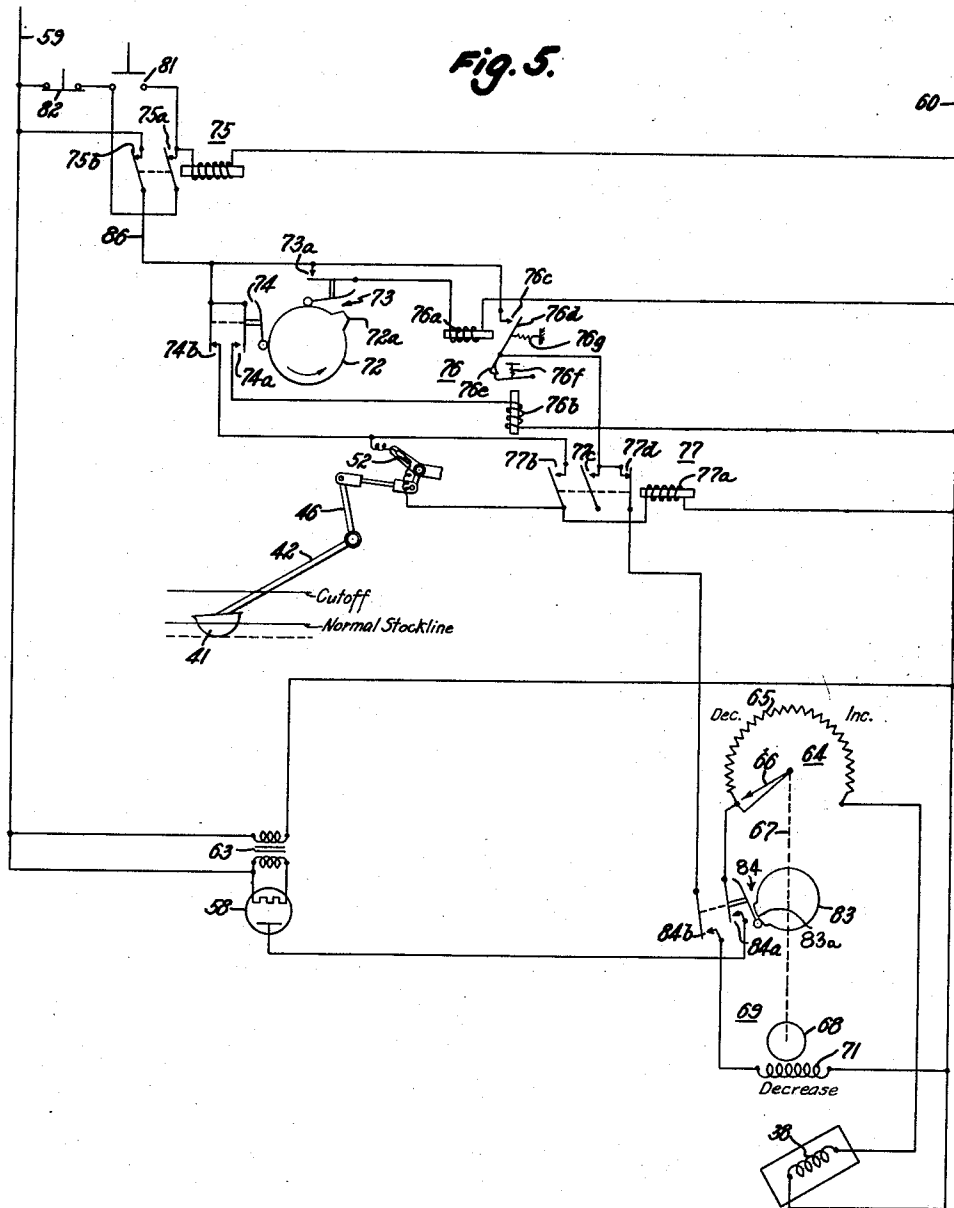
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ORE TREATING FURNACE

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6 Sheets-Sheet 4



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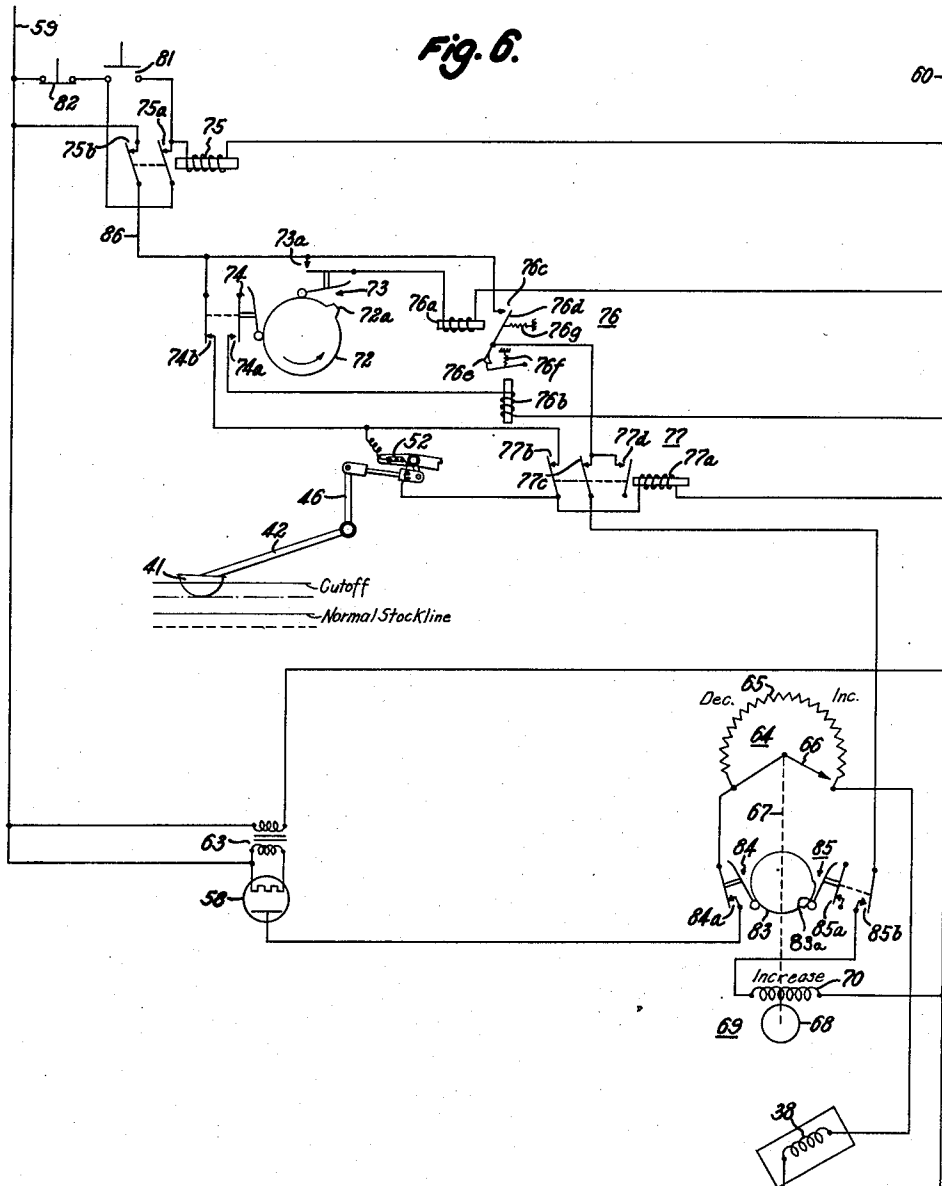
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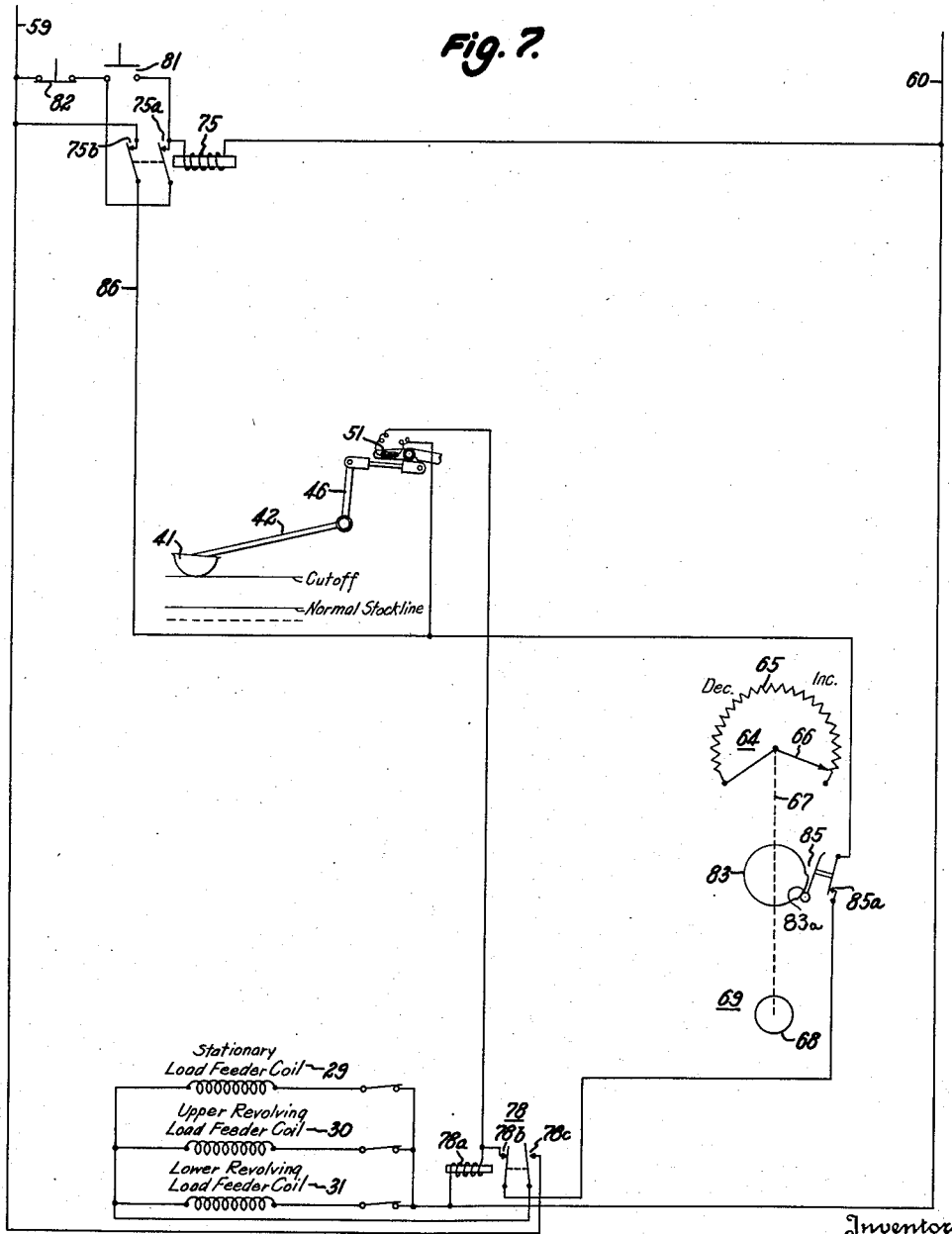
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UNITED STATES PATENT OFFICE

2,646,900

ORE TREATING FURNACE

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Application February 6, 1948, Serial No. 6,743

12 Claims. (Cl. 214—18.2)

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This invention relates in general to furnaces and in particular to an improved method of and apparatus for maintaining the stockline of a furnace for thermally treating solids such as ore fragments, pellets of finely divided mineral solids such as ore concentrates and the like, at a preselected level.

The invention is particularly adapted to stockline control in an ore furnace of the pellet-indurating type disclosed and claimed in an application for United States letters patent Serial No. 605,861, filed July 19, 1945, now Patent No. 2,533,142, by Percy H. Royster, entitled "Heat Treating Solids," and will be so described and illustrated in the present application. However, I wish it to be understood that the invention is not limited to this particular type of furnace but rather can be applied to any other type of shaft furnace wherein the fluent solid material to be treated is continuously fed into the furnace at the top and discharged at the bottom thereof.

Generally speaking, the new method of stockline control involves the steps of continuously measuring the stockline in the furnace and controlling the rate of the discharge from the latter in accordance with the measurements taken to the end that a rise in the stockline above the preselected level results in an increase in the discharge rate of the furnace while a fall in the stockline below the preselected level results in a decrease in the rate at which the material is discharged from the furnace. In the present application, the new method involves the additional steps of stopping the discharge device of the furnace completely when the stockline sinks to what can be considered as a dangerously low level, and conversely stopping the device by which the material is fed into the furnace in the event that the stockline rises to a dangerously high level. These latter two steps are highly desirable when the invention is applied to an indurating furnace of the type described in the above mentioned Royster patent application but can be omitted under some circumstances in other furnace applications. Various arrangements for practicing the method can be employed but in the present application, the preferred apparatus is comprised in general of a "feeler" type of level measuring device which rides continuously in substantially surface contact with the stockline in the furnace, except when the stockline sinks to a very low level, and an associated electrical control circuit which transforms any change in the measured level of the stockline into a change in speed of the discharge device.

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Another aspect of the invention is to provide a discharge control for a furnace of the class described whereby the motion of a part of the device by which the material is fed into the furnace and the varying level of the material in the furnace combine to effect a change in the rate of operation of the discharge feeder for the material.

A still further aspect of the invention is to provide a discharge control system for furnaces in which fluent material is treated, the conditions requisite to its functioning being the uniformly moving part of a device that feeds the material into the furnace and the variable level of the material by means of which a discharge feeder is automatically regulated to maintain the level of the material, i. e. the stockline, substantially at a preselected height in the furnace.

The foregoing and other objects and advantages of the invention will become more apparent from the following description and the accompanying drawings which illustrate a preferred embodiment of the invention as applied to the type of indurating furnace disclosed in the aforesaid Royster patent application.

In the drawings, Fig. 1 is a diametral vertical section of the furnace, the feeders for loading the material into the top thereof and the feeder for discharging the material from the bottom being shown somewhat schematically in order to simplify the drawings; Figs. 2 and 3 are larger scaled plan and side elevations, respectively, of the "feeler" mechanism by which the stockline of the material is measured; Fig. 4 is a schematic diagram showing the circuit arrangement for the principal operating components of the new control; and Figs. 5, 6 and 7 are sub-circuit diagrams illustrating the positions of the various elements in the control for widely different levels of the stockline.

Referring now to the drawings, and to Figs. 1-3 in particular, the ore pellet indurating furnace designated generally by numeral 9 is seen to be comprised of a pair of thermally insulated chambers 10, 11 disposed one above the other and which are interconnected by a central communicating passageway 12 of restricted cross-sectional area through which the ore pellets 13 descend by gravity during the heat treating process from the upper chamber 10 to the lower chamber 11. The furnace wall structure is so designed that the ore pellets during their downward course through the furnace leave a substantially annular void 14 between the lower part of the upper chamber 10 and the tapered free surface 15 of the pellet charge, and a similar

annular void 16 between the upper part of the lower chamber 11 and the tapered free surface 17 of the pellet charge. The upper and lower annular voids 14, 16 are connected through conduits 18, 19 to the exit and intake ends of a combustion chamber 21 having a burner unit 22 by which fuel is injected and burned.

Functionally associated with the combustion chamber 22 is a blower 23 for carrier gas such as air, the discharge from which takes place through a distribution head 24 located within the lower part of the lower chamber 11. Blower 23 forces a current of the carrier gas in an initially unheated state upwardly through the ore charge in the lower chamber 11 to the annular void 16, thence through conduit 19 into combustion chamber 21 where it takes on heat from the burning fuel. The now hot gas passing outwardly through conduit 18 is distributed around the void 14 and flows upward through the ore pellet charge in the upper chamber 10 to heat treat and harden the pellets. The carrier gas is ultimately discharged to atmosphere through the open top of chamber 10 at a temperature which in the ideal case is not materially above that at which the cool pellets enter the furnace.

Under ideal operating conditions, the volume of carrier gas per unit of time introduced into the lower end of chamber 11 from the blower 23 is so adjusted with regards to its heat capacity and the heat capacity of the ore pellets in the lower chamber that substantially all, or at least a very large part of, the heat carried into the lower furnace chamber by the heat treated pellets descending from the upper furnace chamber 10 is abstracted from the pellets during their downward progress through the lower furnace chamber to the end that the pellets are ultimately discharged from the bottom of the lower chamber at a temperature which is not materially higher than that of the carrier gas as introduced into the lower chamber.

The ore pellets to be heat treated can be loaded into the top of chamber 10 by various known types of loaders but the particular type preferred is described in detail in a pending application for United States Letters Patent, Ser. No. 734,220, filed November 5, 1947, by Ernest G. de Coriolis and Rollie P. Campbell for a "Furnace Loading Mechanism." In the present application, this particular type of loader, shown somewhat diagrammatically in Fig. 1, is seen to be comprised of a power driven vertical spindle 25 rotating on an axis coincident with the vertical furnace axis and three motor driven loaders 26, 27, 28 located in a vertical spaced relation and having downwardly inclined reciprocating trays which overlap. The motor elements of the loaders are shown schematically by coils 29, 30 and 31. The topmost loader 26 is stationary and receives the ore pellets in a "raw" i. e. initially moist state from an ore processing station (not shown) ahead of the furnace. The two lower loaders 27, 28 are mounted upon a rotatable carriage 32 that is secured to and driven by the spindle 25 at a relatively slow speed which, for example, can be of the order of one revolution per minute. As the loaders 27, 28 reciprocate and simultaneously slowly rotate, the ore pellets will be ultimately discharged from chutes 33 associated with the lowermost loader 28 and deposited in layers onto the stockline 34 of the pellet charge within the furnace chambers.

Electrical power for driving the spindle 25 and the loaders 26—28 is obtained from a suitable

source over a circuit which is described later in more detail and the motor connections for the two rotating loaders 27, 28 are made by way of slip rings 35.

During a normal operation of the complete system for forming and treating the pellets, the latter are fed continuously into the top of the furnace and progress downwardly therethrough to a discharge feeder capable of being operated at a variable rate, the latter being adjusted automatically in accordance with the principles of the present invention to maintain the stockline 34 at a substantially constant level. The discharge feeder may be of any conventional type such as a star gate, rotary disc, belt unloader or reciprocating unloader. The latter type is illustrated in the present application and is seen to be constituted by an inclined chute 36 leading from a bottom opening in the lower furnace chamber 11 to a motor driven, reciprocating tray 37. The motor element of the unloader is shown schematically as a coil 38 that is energized with direct current of variable amplitude over a control circuit that will presently be described, so as to automatically adjust the discharge rate of the pellets from the furnace as may be required to maintain the pellet stockline 34 at the preselected level near the top of the upper furnace chamber 10.

The device for measuring the stockline level 34 is comprised of a cup 41 or "feeler" secured to the lower end of an arm 42. The upper end of the latter is fixed to a shaft 43 which is journaled in openings in spaced plates 44, 45 for rotation on a horizontal axis with the rise and fall of cup 41 which floats on the surface of the pellet charge, i. e. at stockline 34. Rotation of shaft 43 is imparted through linkage 46 to another shaft 47 also arranged for rotation on a horizontal axis and supported by journal brackets 48. Projecting radially from shaft 47 and non-rotatable with respect thereto are a pair of arms 49, 50 arranged at different angles with respect to the axis of shaft 47. Arm 49 carries a mercury type switch 51, and arm 50 similarly carries a mercury switch 52 but at a different angular position (see Fig. 3) as regards the switch contact axis so that the two switches open or close a circuit through their contacts at different angles of repose. Linkage 46 is so arranged that a rise in the cup 41 resulting in clockwise rotation of shaft 43, as viewed from Fig. 3, effects a counterclockwise rotation of shaft 47 and the switches 51, 52 supported thereon, and vice versa.

When the feeler cup 41 occupies the position shown in Fig. 3 where the stockline 34 is at the "normal" level, switches 51, 52 will both be open. A drop in the stockline below the "normal" level will have no effect upon either of the switches 51, 52 so far as the circuits through their contacts are concerned but, nevertheless, results in a decrease in the operating rate of the pellet discharge device 37 at the bottom of chamber 11. However, a limited rise in the stockline above "normal" causes switch 52 to close; and a still further rise in the stockline to a so called "cut-off" level causes switch 51 to close. Closure of switch 52 effects an increase in the operating rate of discharge device 37 while closure of switch 51 is effective to stop the three pellet loading devices 26—28. More about these controls will be said later.

I prefer that the stockline measuring device be arranged to rotate with the two rotatable loading devices 27, 28. Accordingly as seen in

Figs. 1 and 2, the plates 44, 45 and the bearing brackets 48 for the cup 41, shaft 43, linkage 46, shaft 47 and switches 51, 52 are secured upon the loader carriage 32 that is comprised of a pair of spaced channel beams 54, 55 and plates 56, 57 which extend horizontally at the top of the furnace. The cup 41, as seen in Fig. 1 is located on carriage 32 diametrically opposite the two rotatable pellet loaders 27, 28. In Fig. 2, the entire length of the carriage 32 has not been shown but the center line of the furnace, i. e. the axis of spindle 25 is designated by the symbol (+). Hence as the spindle 25 rotates to rotate the loaders 27, 28, it will also rotate the cup 41 and the other associated components of the stockline measuring device.

The control circuit by which the operating rate of the pellet discharge feeder is varied in accordance with a change in level of the stockline 34 is shown schematically in Fig. 4. As previously explained, the discharge feeder includes a tray 37 that is reciprocated electrically by a motor of the vibrator type, represented schematically by coil 38. Pulsating direct current for energizing coil 38 in rapid succession is derived from a diode 58 that functions as a half wave rectifier, the latter operating off an alternating current source indicated by lines 59, 60. Transformer 63 is used to supply the power for heating the filament of diode 58.

The operating rate of the discharge feeder is varied by varying the magnitude of the current that passes through coil 38. An increase in current will effect an increase in the rate at which the pellets are removed from the furnace chamber 11 while a decrease in current is effective to slow down the pellet discharge. Regulation of the current flow through motor coil 38 is obtained from a rheostat 64 including a resistance winding 65 connected in series therewith. The effective or in-circuit resistance of the rheostat is adjusted by a wiper arm 66 that is attached to and rotated by a shaft 67 that is coupled to the armature 68 of a drive motor 69 operated from the A. C. lines 59-60. Motor 69 is provided with a pair of field coils 70, 71 which are alternatively energized for driving it in one direction or the other. The motor is of conventional type and includes a set of reduction gears (not shown) for reducing the speed of shaft 67 to approximately 1/5 R. P. M. for driving the rheostat arm 66.

Motor 69 is energized only periodically and runs for a brief period during each revolution of the pellet loaders 27, 28 and the stockline level measuring cup 41; the direction of motor rotation will depend upon the stockline level and the duration is controlled by a metering cam 72 having a raised cam surface 72a extending through an arc of approximately 20°, in conjunction with a pair of limit switches 73, 74 that are actuated by this cam. The metering cam 72 is mounted to rotate with shaft 25 which as will be remembered rotates quite slowly at 1 R. P. M.

If the stockline is above the "normal" level as measured by the cup 41, the armature 68 of motor 69 will rotate clockwise thereby also turning rheostat arm 66 from the mid position on the resistance winding 65 clockwise and reduce the amount of resistance in circuit with the motor coil 38 driving the discharge feeder tray 37. If the stockline be at or below the "normal" level, rheostat arm 66 will be turned counterclockwise to increase the in-circuit resistance of

rheostat 64 and thereby reduce the current through motor coil 38.

Associated in circuit with the limit switches 73, 74 and the control in general are four relays 75, 76, 77 and 78. Relay 75 has a pair of contacts 75a, 75b and functions to place the entire control into operation or stop it. Energization of relay 75 is obtained from the line conductors 59, 60 and is controlled by a pair of push button "Start" and "Stop" switches 81, 82, respectively.

Relay 76 is of the latch type having a latching coil 76a and a trip coil 76b. Momentary energization of coil 76a effects a closure of the relay contact 76c and the blade 76d for the latter is then held in this position by a latching device consisting of pawl 76e and spring 76f. When the trip coil 76b is momentarily energized, pawl 76e is pulled away from the blade 76d allowing spring 76g to open the contact 76c. As will be seen from the circuit diagram, closure of limit switch 73 by cam 72 energizes the latch coil 76a of relay 76 and the subsequent closure of limit switch 74 by this same cam energizes the trip coil 76b.

Relay 77 has an energizing coil 77a and three sets of contacts 77b, 77c and 77d. In the deenergized state, relay contacts 77b, 77c are open and contact 77d closed. When relay coil 77a is energized, contacts 77d open and contacts 77b, 77c close.

Relay 78 has an energizing coil 78a, and a pair of contacts 78b, 78c. Contact 78b closes and 78c opens when coil 78a is energized; when deenergized, contact 78b opens and 78c closes.

The control circuit is completed by a cam 83 mounted on the shaft 67 to rotate therewith and which includes a raised cam surface 83a the center of which is radially aligned with the rheostat arm 66. Actuated by the cam surface 83a are a pair of limit switches 84, 85. Switch 84 is actuated by the cam surface 83a when the rheostat arm 66 has turned to an extreme position in a counterclockwise direction and switch 85 is actuated when arm 66 has shifted to a corresponding position in a clockwise direction. As will be explained later in more detail, limit switch 84 functions to stop the operation of the discharge feeder 37 completely, while switch 85 functions to stop the loaders 26-28.

Operation

In general the control system is arranged so that once during each revolution of the pellet loaders 27, 28, the pellet discharge feeder 37 receives an impulse to increase or decrease its speed depending upon the level of the stockline 34. The relative adjustment in angular displacement around the metering cam 72 of limit switches 73 and 74 will determine the period that the rheostat drive motor 69 is energized and therefore governs the change in setting of the rheostat arm 66 for each revolution of the pellet loaders 27, 28. In the illustrated circuit, limit switches 73-74 are approximately 90° apart. Hence for each revolution of cam 72, motor 69 will be energized for 15 seconds. During this period, shaft 67 driving the rheostat arm 66 will have turned through 18° since shaft 67 was stated to operate at 1/5 R. P. M.

It should be made clear that the control system "hunts" continuously. That is to say, the setting of the rheostat arm 66 changes by an increment of 18° for each revolution of the loaders 27, 28 and cup 41, either clockwise or counterclockwise dependent upon the position of the

cup 41. When the latter is at or below the normal stockline level indicated on the drawing in Fig. 4, mercury switch 52 remains open and the discharge feeder 37 decreases its operating rate by one increment for each revolution of the loaders 27, 28 that this condition prevails. When the cup 41 rises above the normal level, mercury switch 52 will close and the discharge feeder 37 increases its operating rate by one increment for each revolution of the feeders 27, 28 that this condition obtains.

A change in level of the stockline may be due to one or a combination of several conditions. The rate at which the "raw" initially moist pellets of ore fines (e. g. concentrates) are supplied to the loaders 26—28 may vary slightly thus causing a temporary drop or rise in the stockline. Then too, the ore pellets are somewhat irregular in shape and this leads to the formation of temporary voids in the column of pellets within the furnace that cause the stockline level to vary temporarily. Whatever may be the cause of the stockline variation, it is most essential that the stockline of the pellet column be maintained as closely as possible at the level designated on the drawing as "normal."

For a more detailed explanation of the manner in which the control system operates, reference is now made to the circuit diagrams shown in Figs. 4 to 7. To place the system in operation, the "Start" push button 31 is pressed momentarily. This completes a circuit starting from line 59 through "Stop" button 82 and "Start" button 31 to the coil of relay 75 and to the other side of the line 60. This energizes relay 75 closing its contacts 75a and 75b. Closure of contacts 75a establishes a holding circuit for the coil of relay 75 to keep it energized after the "Start" button 31 is released. Closure of contacts 75b energizes line 86 which supplies power for the remainder of the control components in the system.

The control system for regulating the rate at which the discharge feeder 37 removes the pellets from the bottom of the pellet column is so adjusted that when cup 41 is positioned at the "normal" level, arm 66 of control rheostat 64 will be in a more or less central position and likewise the cam 83 will be in a central position with both limit switches 84 and 85 released and their contacts in their normal positions as shown in Fig. 4. This being the case, a circuit will have been established starting at line 59 through the filament and plate of diode 58, closed limit switch contact 84a, approximately one half of the resistance winding 65 of rheostat 64 to the discharge feeder coil 38 and to the other side of the line 60. Since this circuit passes through the diode 58 the current reaching the discharge feeder coil 38 is unidirectional in character and is pulsing at the rate of the 60 cycle alternating current impressed on the system. Under these conditions, the discharge feeder 37 will remove the ore pellets from the pellet column in lower chamber 11 at a rate that is substantially the mean between its minimum and maximum rates.

Let it now be assumed that the cup 41 is positioned at the "normal" level as the carriage 32 rotates and metering cam surface 72a actuates limit switch 73 to close switch contact 73a. Relay 77 controlled through mercury switch 52 will remain deenergized and its contacts will remain in the positions shown in Figure 4. That is, contacts 77b and 77c will be open and contact 77d closed. Closure of contact 73a will now

complete a circuit from line 59 through closed relay contact 75b, limit switch contact 73a to the latch coil 76a of relay 76 and then to the other side of the line 60. This energizes relay 76 closing its contact 76c which completes a circuit from line 59 through relay contact 75b, relay contact 76c, relay contact 77d, limit switch contact 84b to the "decrease" winding 71 of the rheostat drive motor 69 and then to the other side of the line 60.

The rheostat drive motor starts in a counter-clockwise direction to drive rheostat arm 66 in the decrease speed direction. This increases the in-circuit resistance of rheostat 64 thereby reducing the current supplied to feeder coil 38, decreasing the magnitude of its vibrations and thus reducing the rate at which the ore is being discharged. The pulsing rate of the unidirectional current being impressed on the feeder coil 38 remains unchanged. As the ore loaders 27—28 continue to revolve, cam surface 72a releases limit switch 73 opening its contact 73a and deenergizing latch coil 76a of relay 76 but its contact 76c still remains closed because of the latch mechanism. As the loaders 27—28 continue to revolve, cam surface 72a contacts limit switch 74 closing its contact 74a. A circuit is completed from line 59 through relay contact 75b, limit switch contact 74a to the trip coil 76b of relay 76 and then to the other side of the line 60. Relay contact 76c opens, breaking the circuit to the "decrease" winding 71 of the rheostat drive motor 69. The motor armature 68 stops and the rheostat arm 66 is positioned one increment lower on winding 65 than the previous revolution. As the loaders 27, 28 continue to revolve, cam surface 72a releases limit switch 74 opening its contact 74a. This deenergizes trip coil 76b of relay 76 and the system is now reset and ready for the next cycle.

Since the discharge feeder 37 is now operating at a slower rate, the ore level will tend to rise above the normal level. The corresponding rise in the feeler cup 41 will result in a closure of mercury switch 52. This completes a circuit from line 59 through relay contact 75b, limit switch contact 74b, mercury switch 52 and slip rings 87 on spindle 25 to the coil 77a of relay 77 and thence to the other side of the line 60. This energizes relay 77, closing its contacts 77b, 77c and opening contact 77d. Closing of contact 77b establishes a holding circuit for relay 77 to keep it energized in case the stockline might drop slightly and open mercury switch 52 before the revolution of the loaders 27—28 is complete. As the loader mechanism revolves, metering cam surface 72a contacts limit switch 73, closing its contact 73a, completing a circuit from line 59 through closed relay contact 75b, limit switch contact 73a, to the latch coil 76a of relay 76 and then to the other side of the line 60. This energizes relay 76, closing its contact 76c which completes a circuit from line 59 through relay contact 75b, relay contact 76c, relay contact 77c, limit switch contact 85b to the "increase" winding 70 of the rheostat drive motor 69 and then to the other side of the line 60.

The armature 68 of the rheostat drive motor starts in a clockwise direction to drive rheostat arm 66 in the "increase" speed direction. This decreases the in-circuit resistance of rheostat 64 thereby increasing the current through feeder coil 38, increasing the magnitude of its vibrations and thus increasing the rate at which the ore is being discharged. As the ore loaders 27,

28 continue to revolve, cam surface 72a releases limit switch 73 opening its contact 73a, and de-energizing latch coil 76a of relay 76, but its contact 76c still remains closed because of the latch mechanism. As the loader continues to revolve, cam surface 72a contacts limit switch 74 closing its contact 74a and opening contact 74b which breaks the circuit to the energizing coil 77a of relay 77. Relay contacts 77b and 77c now reopen and contact 77d recloses. At the same time, a circuit is completed from line 59 through relay contact 75b, limit switch contact 74a to the trip coil 76b of relay 76 and then to the other side of the line 60. Its contact 76c opens breaking the circuit to the "increase" winding 70 of the rheostat drive motor 69. The motor armature 68 stops and the rheostat arm 66 is positioned one increment faster than the previous revolution. Since the discharge feeder 37 is now operating at a faster rate, the ore level will tend to lower. As the loader continues to revolve, cam surface 72a releases limit switch 74, opening its contact 74a. This deenergizes trip coil 76b of relay 76 and the system is now re-set and ready for the next cycle.

Assuming that the stockline falls to the "normal" level before the metering cam 72 again actuates limit switch 73, the cup 41 will have likewise dropped to the "normal" level. Thus the next time contacts 73a of limit switch 73 are closed, motor 69 will drive the rheostat arm 66 in a counter-clockwise direction and thereby once again decrease the operating rate of the discharge feeder 37. The stockline 34 now rises above the "normal" level which then results in an increase in the operating rate of the discharge feeder 37.

This periodic and alternate decrease and increase in the operating rate at which the pellets 13 are removed from the bottom of the pellet column in chamber 11 will continue under normal operating conditions thus maintaining the stockline 34 at substantially a constant level.

Next, let it be assumed that for operational causes the stockline 34 has sunk to an abnormally low level as shown in Figure 5. This might happen if the loader mechanism should stop suddenly or if a large void might have occurred in the furnace during the operation, and the ore suddenly dropped to fill this void. In this case, it is desirable to stop the discharge feeder 37 to prevent the stockline of the furnace from dropping too low. In this event, the stockline would remain below the "normal" level for several revolutions of the loaders 27, 28 and cup 41. As previously described, for each revolution of the loaders that the stockline is at the "normal" level or below, the rheostat arm 66 will be displaced one increment (i. e. 18°) counter-clockwise so that after a few revolutions, the motor driven rheostat arm 66 will have taken the position shown in Figure 5. Cam 83 likewise will have taken a position similar to rheostat arm 66, since it is driven from the same shaft 67. Cam surface 83a now actuates limit switch 84, opening its contacts 84a and 84b. This will break the impulse circuit which has previously existed from line 59 through relay contact 75b, relay contact 76c and relay contact 77d, limit switch contact 84b to "decrease" winding 71 and then to the other side of the line 60. Opening of limit switch contact 84a opens the circuit to motor coil 38 of the discharge feeder tray 37 thus stopping the latter. The discharge feeder will now remain cut off until the stockline rises above the "normal" level.

Next let it be assumed that for operational causes, the stockline 34 has risen to an abnormally high level, as indicated in Figure 6. In this case, it is desired that the discharge feeder 37 operate at its maximum rate. As explained previously, in the operation of the system, when the stockline 34 rises above the "normal" level, the corresponding rise in cup 41 results in a closure of mercury switch 52. If this condition persists during successive revolutions of the loader, the rheostat arm 66 would be advanced clockwise by increments of 18° increasing the ore discharge rate of the discharge feeder 37 with each revolution of the loader, until the maximum rate is reached. This will require several revolutions of the loader. When this happens, cam surface 83a will actuate limit switch 85, opening its contact 85b. This breaks a circuit from line 59 through relay contact 75b, relay contact 76c, relay contact 77c, limit switch contact 85b to the "increase" winding 70 and then to the other side of the line 60. The rheostat arm 66 will now remain at this maximum rate position until such time as the stockline 34 drops back to the "normal" level or below.

Let it now be assumed that for operational causes, the rate at which the pellets are fed onto the stockline 34 is greater than the maximum rate at which the ore can be removed from the bottom of the column by the discharge feeder 37. If this occurs, the stockline 34 would ultimately rise above the rim of the upper furnace chamber 10 and spill over the side. To prevent such an occurrence, a circuit has been arranged to stop the loader feeders 26-28 when the stockline 34 and hence cup 41 reach the level labeled "cut-off." Referring now to Figure 7 which indicates this condition, when cup 41 reaches the "cut-off" level, mercury switch 51 closes. This completes a circuit from line 59 through relay contact 75b, mercury switch 51 and slip rings 37 to the coil 78a of relay 78 and to the other side of the line 60. This energizes relay 78, closing its contact 78b and opening contact 78c. Closing of contact 78b, establishes a holding circuit through limit switch contact 85a to keep relay 78 energized. Opening of contact 78c breaks the circuit by which the coils 29-31 of the ore loaders 26-28 are energized from the line conductors 59, 60 thus stopping the loaders until the stockline 34 has dropped to the "normal" level. When this occurs, the rheostat arm 66 will begin to move by increments in a counter-clockwise direction thus permitting contacts 85a of limit switch 85 to open and break the holding circuit for relay coil 78a. Relay contact 78c now recloses and restarts the loaders 26-28.

In conclusion, it will be appreciated that the novel method of an apparatus for controlling the discharge rate of a furnace of the class described makes it possible, under normal operating conditions, to maintain the stockline of the column of material being treated at a substantially constant level. Any tendency on the part of the stockline to drop below the predetermined normal level for an appreciable period is met by a decrease in the rate at which the material is removed from the bottom of the column, and the extent of the decrease varies directly with the length of time that the stockline remains below the normal level. Conversely, a rise in the stockline above the normal level for an appreciable period is met by an increase in the rate at which the material is removed from the bottom of the column, and in this case also, the

extent of the rate increase varies directly with the time that the stockline remains above the normal level.

By so adjusting the change in rate at which the material is removed from the bottom of the column of material, it is self evident that restoration of the stockline to its normal range in level from a higher or lower level caused by an abnormal condition in the descending material column is assured within the least possible time. Then too, automatic cut-off of the feeders for loading the material onto the stockline in the event of an extremely high rise in the stockline coupled with automatic restarting of these feeders when the stockline has returned to the normal level, as well as an automatic cut-off of the discharge feeder for removing the material from the bottom of the column when the stockline sinks to an extremely low level coupled with subsequent automatic restarting thereof when the stockline has returned to its operating range in level also are of material assistance in improving the recovery factor of the system.

Finally, I wish it to be understood that while in accordance with the patent statutes, I have described and shown a preferred arrangement by which the present invention may be practiced, various modifications of the construction may be made by those skilled in the art without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. In a furnace of the type for heat treating a column of fluent material continuously descending therethrough, a feeder mechanism movable over the mouth of said furnace for loading the material onto the stockline of the column, means for ascertaining the actual level of the stockline, a device having a variable discharge rate for normally removing material continuously from the bottom of the column, means for periodically effecting predetermined incremental changes in said discharge rate, and means controlled by said level-ascertaining means for determining the sense of said rate change in accordance with the actual level of said stockline as related to a predetermined normal level.

2. A furnace as defined in claim 1 and which further includes means actuated in response to a predetermined abnormal rise in said stockline above said normal level for stopping said feeder mechanism, and means actuated in response to an abnormal stay of said stockline below said normal level for stopping said material removing device.

3. A furnace as defined in claim 1 and which further includes means stopping said device for removing material when the latter reaches a predetermined minimum discharge rate, and means stopping said feeder mechanism upon a predetermined rise in the stockline above said normal level after said device for removing material reaches a predetermined maximum discharge rate.

4. In a furnace of the type for heat treating a column of fluent material continuously descending therethrough, a feeder mechanism movable over the mouth of said furnace for loading the material onto the stockline of the column, a device having a variable discharge rate for normally removing material continuously from the bottom of the column, means for periodically effecting predetermined incremental changes in said discharge rate, and a stockline measuring device cooperative with said discharge rate

changing means for determining the sense of the rate change in accordance with the actual level of said stockline as related to a predetermined normal level.

5. In a furnace of the type for heat treating a column of fluent material continuously descending therethrough, a feeder mechanism movable over the mouth of said furnace for loading the material onto the stockline of the column, a device having a variable discharge rate for normally removing material continuously from the bottom of the column, means operated in timed relation with the operation of said feeder mechanism for periodically effecting predetermined incremental changes in said discharge rate, a stockline measuring device for ascertaining the actual level of said stockline, and means cooperating with said stockline measuring device for determining the sense of said rate change in accordance with the actual level of said stockline as related to a predetermined normal level.

6. In a furnace of the type for heat treating a column of fluent material continuously descending therethrough, a feeder mechanism rotatable about the major axis of the column for loading the material onto the stockline of the column, a float on said stockline rotatable with said feeder mechanism, a device having a variable discharge rate for removing material from the bottom of the column, means operated in timed relation with the rotation of said feeder mechanism for periodically effecting predetermined incremental changes in said discharge rate, and means including said float for determining the sense of said rate change in accordance with the float position.

7. In a furnace of the type for heat treating a column of fluent material descending therethrough, a feeder mechanism for loading the material onto the stockline of the column, a device for removing material from the bottom of the column and which includes an adjustable control member for varying the rate at which the material is removed, a reversible motor coupled to said control member, circuit means for effecting periodic energization of said motor to run for predetermined periods in one direction or the other to thereby effect corresponding changes in the adjustment of said control member, and means determining the running direction of said motor in accordance with the actual level of said stockline as related to a predetermined normal level.

8. In a furnace of the type for heat treating a column of fluent material descending therethrough, a feeder mechanism rotatable about the major axis of the column for loading the material onto the stockline of the column, an electric motor driven device for removing material from the bottom of the column and which includes in the motor circuit thereof a rheostat for varying the operating rate of the motor to thereby vary the rate at which the material is removed, a reversible motor coupled to said rheostat, means operated in timed relation with the rotation of said feeder mechanism for effecting periodic energizations of said rheostat motor to run for predetermined periods in one direction or the other to thereby effect corresponding changes in the adjustment of said rheostat, a float member on said stockline, and means controlled by said float member for determining the running direction of said rheostat motor.

9. In a furnace of the type for heat treating

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a column of fluent material descending there-
through, a feeder mechanism for loading the
material onto the stockline of the column, an
electrically operated device for removing mate-
rial from the bottom of the stockline and which
includes in circuit therewith an adjustable con-
trol member for varying the rate at which ma-
terial is removed, a reversible motor coupled to
said control member, circuit means for periodi-
cally energizing said motor to run for prede-
termined periods in one direction or the other to
thereby effect corresponding changes in the ad-
justment of said control member, and means deter-
mining the running direction of said motor in
accordance with the actual level of said stockline
as related to a predetermined normal level.

10. A furnace as defined in claim 9 wherein
said means for determining the running direc-
tion of said motor is comprised of a float mem-
ber on said stockline, and relay means in said
motor circuit means controlled by said float
member.

11. In a furnace for heat treating a column
of fluent material descending therethrough, an
electrically operated feeder mechanism for load-
ing the material onto the stockline of the col-
umn, an electrically operated device for remov-
ing material from the bottom of the column
and which includes in circuit therewith an ad-
justable control member for varying the rate
at which material is removed, a reversible motor
coupled to said control member, circuit means
controlled in timed relation with the operation
of said feeder mechanism for periodically en-
ergizing said motor to run for predetermined
periods in one direction or the other to thereby
effect corresponding changes in the adjustment
of said control member, a float member on said
stockline, relay means in said motor circuit con-
trolled by said float member for determining the

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running direction of said motor, a pair of limit
switches actuated alternatively upon predeter-
mined totalized runs of said motor in opposite
directions, means controlled by one of said
switches to open the respective energizing cir-
cuits for said material removing device and said
motor, a relay controlling the circuit through
which said feeder mechanism is energized, switch
means actuated by said float member upon a
predetermined rise in said stockline for energiz-
ing said relay to interrupt the energizing circuit
for said feeder mechanism, and means controlled
by the other of said limit switches for likewise
opening the energizing circuit to said motor and
completing a holding circuit for said relay.

12. In a shaft furnace of the type for heat
treating a column of fluent material continu-
ously descending therethrough, a feeder mech-
anism movable over the mouth of said furnace
for loading the material onto the stockline of
the column, a float on said stockline movable
with said feeder mechanism, a device having a
variable discharge rate for normally removing
material continuously from the bottom of the
column, means periodically effecting predeter-
mined incremental changes in said discharge
rate, and means including said float for deter-
mining the sense of said rate changes in accord-
ance with the float position.

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