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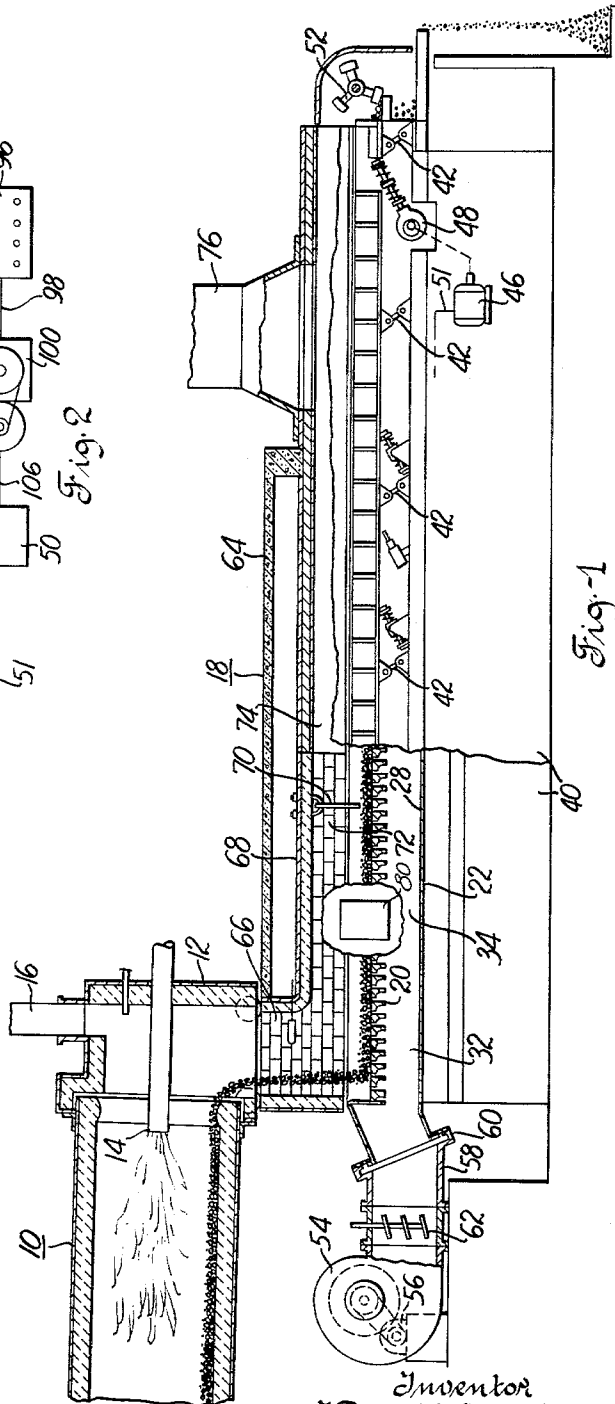
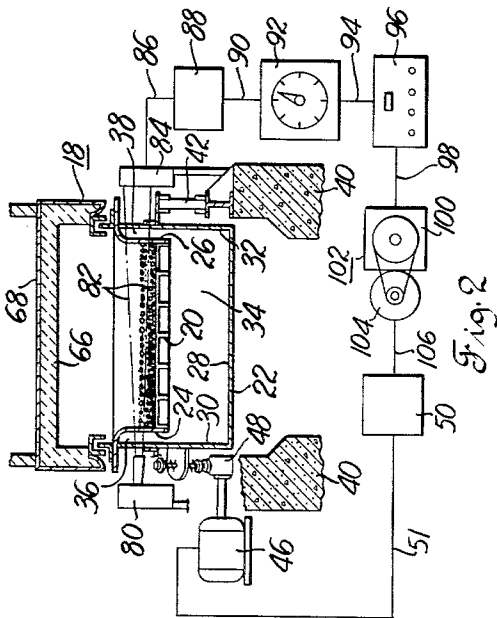
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3,236,358

MEANS FOR CONTROLLING CONVEYER

Filed May 19, 1961

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

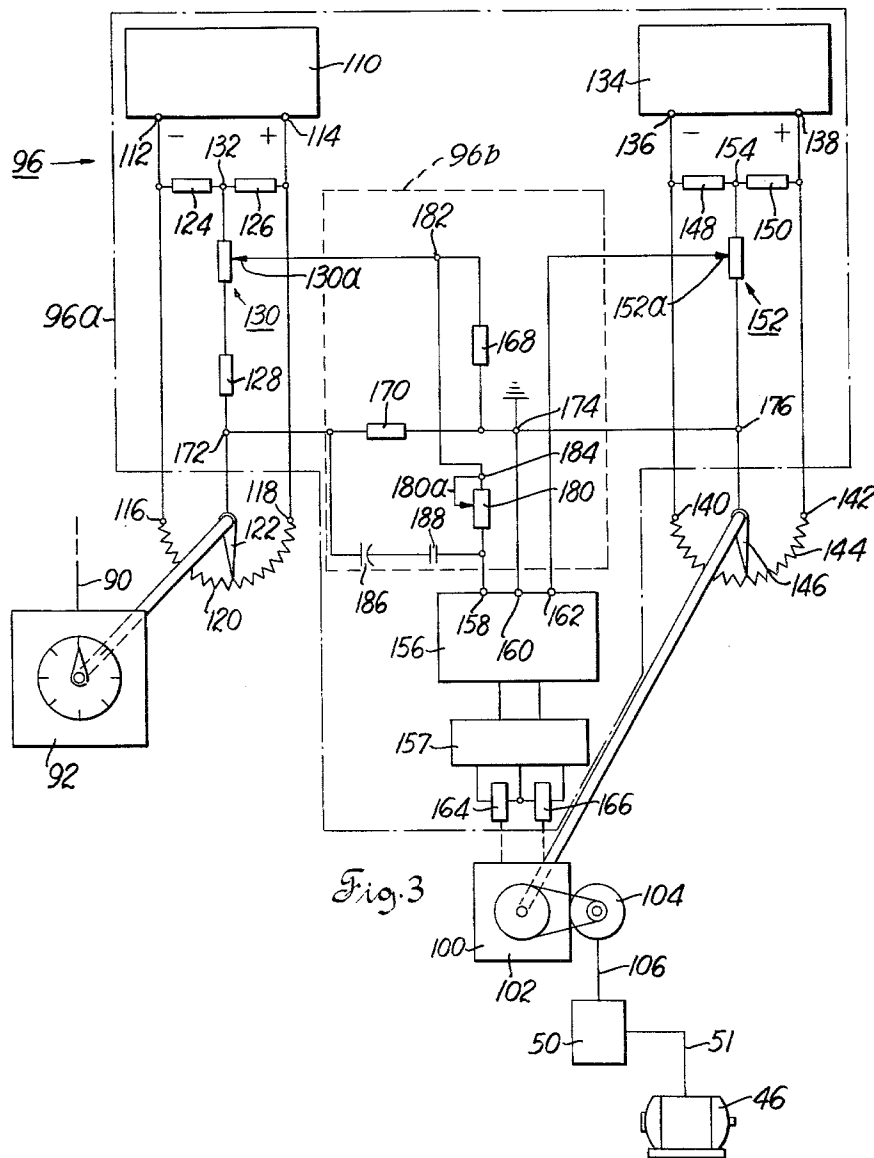


Fig. 3

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3,236,358

MEANS FOR CONTROLLING CONVEYER

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This invention relates generally to means for controlling conveyers. More particularly, it relates to means for regulating the speed of conveyers to maintain a bed of material thereon at constant depth despite variations in the quantity of material being supplied thereto. While not limited thereto, the invention is particularly adaptable for use with clinker cooler conveyers employed with cement kilns.

For example, a typical cement manufacturing installation comprises an inclined rotary kiln having its lower discharge end disposed over the receiving end of the perforated grate of a clinker cooler conveyer which has a wind box beneath the grate. Raw materials used in the manufacture of cement are heated in the kiln to convert them into cement clinker and, due to the inclination and rotation of the kiln, are eventually discharged by gravity onto the receiving end of the grate to form a moving bed of hot clinker thereon. Quenching air from the wind box beneath the grate is forced through the grate and the bed of clinker thereon to enhance its quality and to embrittle it for subsequent grinding. In the interest of thermal efficiency, part of the quenching air thus heated by the clinker is directed into the kiln for use as secondary combustion air. It is desirable for several reasons that the secondary combustion air have a stable temperature and this can be accomplished by maintaining the bed of clinker at constant predetermined depth (and density) on the grate. Normally, however, kiln output varies and it is necessary to employ a control system which detects variations in the amount of clinker being supplied to the grate and which regulates grate speed accordingly to even out the bed of clinker to the optimum predetermined depth.

Such a control system comprises, for example, a gamma radiation source which is adapted to project its rays transversely through the moving bed of clinker on the grate toward a radiation detecting device having Geiger-Mueller tubes. Variations in the depth and density of the clinker bed affect the amount of radiation impinging on the detecting device and the latter produces an output signal related to the depth and density of the clinker bed. Hereinafter, the term depth refers to both depth and density of the clinker. This output signal, after being amplified to a usable millivoltage, is fed to a recording instrument which compares it to a predetermined value and produces an output or error signal if there is a discrepancy indicating that the bed depth of the clinker has departed in either direction from a predetermined desired depth. The error signal is fed to a control unit, is adapted thereby, and is transmitted as a correction signal to a rheostat drive unit which regulates the speed of a motor which drives the clinker cooler conveyer.

The type of control unit heretofore used in the aforescribed control system is adapted to provide proportional band control and reset action control.

Proportional band control means that the control unit can be adjusted to provide a desired proportion between the error signal received by it and the correction signal transmitted by it to the rheostat drive unit, i.e., if the proportional band control is set at 100%, an error signal indicating 1% deviation from normal results in a correction signal of 1%, whereas if set at 50%, a 1% deviation results in a 2% correction signal.

Reset action control means that the control unit continuously compares the amount of deviation of the er-

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ror signal from the set point and injects an additional signal which is superimposed on the correction signal from the proportional band to force the process back to the desired condition or set point. This is required since proportional action alone is usually insufficient to maintain set point condition.

A control system of the aforescribed character is well suited to effect conveyor speed changes necessitated by normal and gradual changes in kiln output. However, the kiln sporadically discharges clinker "rings" or large lumps of clinker onto the grate of the clinker cooler conveyer. The control system overly responds to these lumps, sensing them as a rapid increase in kiln production and effects conveyor speed up until the lump passes. Actually, it is desirable that these lumps be ignored and to have the conveyer respond principally to normal variations in kiln output to permit proper cooling of the clinker and stabilization of secondary air temperature. Accordingly, it is desirable to modify the control unit of the aforescribed control system to accomplish these results by providing for inverted rate action in the control unit.

It is an object of the present invention to provide improved control means of the aforesaid character which discriminates between normal changes in kiln output and the sporadic appearance of lumps on the conveyer and effects conveyor speed changes accordingly.

Another object of the invention is to provide improved means for controlling the speed of conveyers to maintain the depth of material thereon substantially constant despite the sporadic deposit of lumps of material thereon.

Another object is to provide means of the aforesaid character which are responsive to the rate of change of bed depth indications to effect discrimination between normal variations in kiln output and the sporadic deposit of lumps of material on the conveyer before effecting a change in the speed of the conveyer.

Another object is to provide means of the aforesaid character which effect an increase or decrease in conveyor speed in response to a normal increase or decrease in the amount of material being deposited on the conveyer and which effects no significant change in conveyor speed in response to a large momentary apparent increase due to occasional large pieces of material passing on the conveyer.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawings illustrate a preferred embodiment of the invention but it is to be understood that the embodiment disclosed herein is susceptible to modifications with respect to details thereof without departing from the scope of the appended claims.

In the drawings:

FIG. 1 is a side elevational view, partly in section, of a portion of a cement kiln and clinker cooler conveyer assembly showing how the invention is employed therewith;

FIG. 2 is an enlarged cross sectional view of the clinker cooler conveyor assembly of FIG. 1 showing the control system therefor in schematic form; and

FIG. 3 is a diagrammatic view of a portion of the control system shown in FIG. 2.

Referring to FIG. 1, the numeral 10 designates a kiln which is supported for rotation about a slightly inclined axis. The kiln is refractory lined and adapted to deliver a hot granular material, such as cement clinker, by gravity from the discharge end thereof. A firing hood 12 is positioned over the discharge end of the kiln and has a bottom opening through which clinker discharged from the kiln may pass. Kiln 10 is fired by means of a burner arrangement which produces a flame which is directed into the kiln from the discharge end thereof to effect the

desired heat treatment of the raw materials therein to convert them into cement clinker. The burner arrangement includes a nozzle 14 which extends through firing hood 12 and through which a combustible mixture of fluent fuel such as powdered coal and primary combustion air is blown. The primary combustion air is to be understood to be obtained in preheated condition from firing hood 12; being drawn therefrom through a pipe 16. As will hereinafter appear, the heated air drawn from firing hood 12 is excess quenching air, not utilized as secondary combustion air, which is supplied to the firing hood from a wind box 22, hereinafter described.

A clinker cooler conveyer assembly 18 is positioned horizontally below the level of the bottom opening of firing hood 12 and has its receiving end disposed beneath the latter. As FIGS. 1 and 2 show, the conveyer assembly 18 comprises a perforate support or grate 20 which is fabricated of crossbars which are spaced a small distance apart from each other, for example, one-sixteenth of an inch, to accommodate the upward flow of cooling or quenching air. Grate 20 is adapted to receive hot clinker from kiln 10 thereon and to advance it therealong in the form of a moving bed. Grate 20 is rigidly attached to and suspended within wind box 22 by means which include longitudinally extending side plates 24 and 26. Wind box 22 comprises an imperforate floor portion 28 and side walls 30 and 32.

Wind box 22 is of sufficient width and depth so that grate 20 and its attached side plates 24 and 26 are spaced, respectively, from floor portion 28 and side walls 30 and 32 of the wind box. This arrangement provides an air duct 34 below grate 20 and longitudinally extending spaces 36 and 38 between the side plates 24 and 26 and the side walls 30 and 32, respectively, of wind box 22.

Wind box 22 in which grate 20 is mounted is supported for reciprocating movement on stationary foundation members 40 by means, for example, of a Ferraris type suspension which includes rearwardly inclined links 42 attached to the foundation members and the wind box. The links are prevented from collapsing by opposed coil spring assemblies 44 which also control the reciprocation of wind box 22. Reciprocating motion is imparted to the wind box and grate by means such as a conveyer motor 46 and a spring coupled eccentric member 48, shown in FIG. 1, which is attached to wind box 22 and driven by motor 46. Motor 46 is provided with means such as a controller 50 for regulating the speed thereof which is connected thereto by means of a cable 51. Regulation of the speed of motor 46 regulates the frequency of reciprocation and the length of the reciprocating stroke of wind box 22 and grate 20 and thus affects the speed at which the bed of clinker is moved along the grate. When the conveyer is in operation, wind box 22 and grate 20 move together with a short backward and forward motion with a slight rise on the forward stroke which conveys the material in a stream; the direction of advancement of the stream being away from the discharge end of the kiln. Preferably, the wind box has a total travel of approximately three-quarters of an inch at a rate of about 280 strokes per minute but this frequency and consequent stroke is variable as will hereinafter appear. Hot material from kiln 10, such as cement clinker, falls directly on grate 20 and forms a moving bed of clinker which is continuously discharged at the discharge end thereof into a hammer mill 52 which reduces oversize pieces of clinker to a size suitable for succeeding grinding operations.

Since grate 20 and wind box 22 are rigidly connected and vibrate as a unit, the fine material falling through the grate and collecting on floor portion 28 of the wind box is advanced simultaneously with the coarser clinker on the grate above, joining it at the discharge end of the cooler conveyer.

Cooling or quenching air is forced into wind box 22 by a blower 54 which is driven by a motor 56. Blower

54 is rigidly connected to a discharge pipe 58 which is joined by means of a flexible connection 60 to wind box 22. An adjustable louver damper 62 in discharge pipe 58 regulates the quantity of cooling air being supplied to wind box 22.

A stationarily mounted hood or arch 64, comprising a refractory portion 66 and a sheet metal portion 68, is arranged above wind box 22 and grate 20 and is adapted to collect the quenching air which is directed upwardly through the grate and the moving bed of hot clinker thereon. Arch 64 is provided with a baffle member 70 to assist in channeling the quenching air from beneath grate 20 in to the chambers 72 and 74 above the grate. Chamber 72 of arch 64 provides a passage for the flow of secondary air into firing hood 12 and from thence into kiln 10 or pipe 16, as required. Arch 64 is provided with a waste air stack 76 which connects chamber 74 to the atmosphere.

In operation, kiln 10 is charged with suitable quantities of finely ground and blended limestone, clay or shale, hematite or mill scale, and other materials in the form of a dry mix or wet slurry. As the charge advances through the kiln and is burned, certain chemical reactions take place and the raw material is converted into hot cement clinker.

The hot cement clinker is eventually discharged from kiln 10 at a temperature, for example, of about 2400° F. through the bottom opening of firing hood 12 onto the receiving end of grate 20 of clinker cooler conveyer assembly 18. The vibrational movement of grate 20 results in a conveying action which causes the clinker deposited thereon to be formed into a moving bed which advances toward the discharge end of the clinker cooler conveyer assembly. The speed and amplitude of vibration determine the depth of the bed of clinker on grate 20 and the depth should average, for example, about four inches.

Normally, kiln 10 discharges clinker at an even rate, or at a gradually increasing or decreasing rate. Occasionally, however, large lumps or masses of clinker are sporadically discharged from kiln 10 onto grate 20. This occurs, for example, when a "ring" of clinker material which has built up around the inside of the rotating kiln is suddenly dislodged and falls onto grate 20.

Air for cooling the bed of clinker on grate 20 is supplied by blower 54 and its quantity is regulated by damper 62. As mentioned hereinbefore, the temperature of the secondary air entering firing hood 12 is of considerable importance in the cement making process and is largely determined by the temperature and quantity of hot clinker moving along grate 22 of clinker cooler conveyer assembly 18. Thus, in order to stabilize secondary air temperature, it is desirable that a constant bed of clinker be maintained on grate 22 despite variations in kiln output. Since the width of the bed of clinker is a predetermined constant established by the transverse dimension of grate 42, a constant bed can be maintained by providing control means which sense the depth of the clinker or grate 42 and regulate grate speed accordingly.

In accordance with the present invention, control means are provided to sense the depth of the bed of clinker on grate 20 of clinker cooler conveyer apparatus 18, for establishing when bed depth departs from a predetermined level, for measuring the rate of such departure so as to discriminate between gradual departures and sporadic departures, and to regulate the speed of the clinker cooler conveyer so as to bring bed depth back to the predetermined desired value in the case of gradual departures.

As FIGS. 1, 2 and 3 show, such control means comprise a gamma radiation source 80 which is mounted on the foundation member 40 outside of side wall 30 of wind box 22. A suitable gamma radiation source designated as the Model LS-102 is manufactured by the Industrial Nucleonics Corporation of Columbus, Ohio, and

is described in detail in their publication entitled "Instruction Manual-Continuous Level Measuring System," Manual No. B-C-S-11455, April 1960.

Radiation source 80 is adapted to project a beam of radiation, indicated by the dotted lines 82 in FIG. 2, transversely through side wall 30 of wind box 22, through side plate 24, through an over the bed of clinker on grate 20, through side plate 26, and through side wall 32 of the wind box, toward a gamma radiation detector 84, comprising Geiger-Mueller tubes, for example, which is mounted on the foundation member 40 outside of side wall 32 of the wind box directly opposite the radiation source. A suitable gamma radiation detector designated as the Model LD-104-C is described in detail in the aforesaid publication.

As FIG. 2 shows, radiation detector 84 is electrically connected by a cable 86 to a signal amplifier 88 which is adapted to amplify an electrical output signal from the radiation detector to useful magnitude. A suitable amplifier designated as the Model LA-101-C is described in detail in the aforesaid publication.

Amplifier 88 is electrically connected by a cable 90 to a recorder device 92. Recorder device 92 is an instrument which is adapted to receive an electrical input signal representing some measurable quantity or variable, to measure it, to compare it to a predetermined value, to give visual indication of such comparison, and to produce an output or error signal of its own whenever the input signal departs from the predetermined value to which it is compared. A suitable recorder device designated as the "Speedomax H" is manufactured by the Leeds & Northrup Company of Philadelphia, Pennsylvania and described in their publication entitled "Manual for Speedomax H," No. 077990, Issue 5. "Speedomax" is a registered trademark of the Leeds & Northrup Company.

Recorder device 92 is electrically connected by a cable 94 to a control unit 96. Control unit 96 is an instrument which is adapted to receive the error signal from recorder device 92 and to provide, as hereinafter explained, proportional band control and reset action control in response thereto and thus provides a correction signal of its own. Control unit 96 is further adapted in accordance with the present invention to provide inverted rate action control. With inverted rate action, control unit 96 can be adjusted to provide for a momentary decrease in the correction signal in proportion to the rate of apparent increase in bed depth as indicated by the error signal received by the control unit. A control unit designated as the "Series 60 Control, 3-Action, Position Adjusting Type Control Unit," manufactured by the aforesaid Leeds & Northrup Company and described in their publication entitled "Series 60 Control Using 3-Action P.A.T. Control Unit, No. 077992, Issue 4 is a suitable control unit for use provided it is modified in accordance with the invention, as will hereinafter be explained in connection with FIG. 3.

Control unit 96 is electrically connected by a cable 98 to a rheostat drive 100 of a combination rheostat and rheostat drive unit 102. A rheostat 104 of combination unit 102 is electrically connected by a cable 106 to controller 50 of conveyer motor 46. In practice, rheostat 104 of combination unit 102 is usually connected in circuit with the field windings of conveyer motor 46 through controller 50, if motor 46 is a D.C. motor. Rheostat drive 100 is adapted to be operated alternatively in the forward or reverse directions to drive rheostat 104 of combination unit 102 in the forward or reverse direction, respectively, to effect speed up or slow down, respectively, of conveyer motor 46.

FIG. 3 is a diagrammatic view of control unit 96, indicated by the broken line designated 96a, showing its relationship to recorder device 92 and rheostat drive 100 of combination unit 102.

Within control unit 96, indicated by broken line 96a

in FIG. 3, that portion of the circuit enclosed with a broken line designated 96b is modified in accordance with the present invention and is an improvement over the prior art. That portion of the circuit outside of broken line 96b but within broken line 96a was heretofore known in the prior art and in substance is incorporated in a control unit designated as the "Series 60 Control, 3-Action, Position Adjusting Type Control Unit," hereinbefore referred to.

In FIG. 3, a rectified power source 110 has its negative output terminal 112 and its positive output terminal 114 connected to the end terminals 116 and 118, respectively, of a resistance slidewire 120. Slidewire 120 is to be understood to be part of recorder device 92 and a movable contact finger 122 is relatively movable with respect to slidewire 120 whenever recorder device 92 produces an error signal. It is to be understood, for example, that when recorder device 92 produces an error signal indicating that clinker bed depth is above a predetermined level, movable contact finger 122 moves counterclockwise with respect to FIG. 3 and that when the error signal indicates that bed depth is below a predetermined level, movable contact finger 122 moves clockwise. A pair of voltage dividing resistors 124 and 126 are connected in series with each other across the output terminals 112 and 114 of power source 110. A resistor 128 and a resistance element in a proportional band rheostat 130, having a movable contact 130a, are connected in series with each other between contact finger 122 of slidewire 120 and a point 132 between voltage dividing resistors 124 and 126.

A rectified power source 134 has its negative output terminal 136 and its positive output terminal 138 connected to the end terminals 140 and 142, respectively, of a resistance slidewire 144. Slidewire 144 is understood to be part of rheostat drive 100 of combination unit 102 and a movable contact finger 146 is relatively movable with respect to slidewire 144 whenever rheostat drive 100 is in operation. It is to be understood, for example, that when rheostat drive 100 is in operation in the forward direction, movable contact finger 146 moves counter clockwise with respect to FIG. 3 and that when the rheostat drive is in operation in the reverse direction, movable contact finger 146 moves clockwise. A pair of voltage dividing resistors 148 and 150 are connected in series with each other across the output terminals 136 and 138 of power source 134. A resistance element in a proportional band rheostat 152, having a movable contact 152a, is connected between contact finger 146 of slidewire 144 and a point 154 between voltage dividing resistors 148 and 150.

It is to be understood that the movable contacts 130a and 152a of the proportional band rheostats 130 and 152, respectively, are mechanically connected together by suitable means which permit their simultaneous adjustment to provide for the proportional band control hereinbefore referred to.

Control unit 96 further comprises a converter 156 which is provided with three input terminals 158, 160 and 162. Converter 156, as will hereinafter appear, is adapted to effect, through an amplifier 157, alternative energization of the relays 164 and 166 which are connected thereto and to rheostat drive 100 of combination unit 102. It is to be understood that the relays 164 and 166 are normally deenergized. However, energization of relay 164 effects operation of rheostat drive 100 in the forward direction to cause speed up of conveyer motor 46. Energization of relay 166 effects operation of rheostat drive 100 in the reverse direction to cause slow down of conveyer motor 46.

Movable contact 152a of proportional band rheostat 152 is connected to input terminal 162 of converter 156. A resistor 168 is connected between movable contact 130a of proportional band rheostat 130 and input terminal 160 of converter 156. A resistor 170 is connected

at one end to a point 172 between resistor 128 and contact finger 122 for slidewire 120 and at its other end to a point 174 between resistor 168 and input terminals 160 of converter 156. Point 174 is connected to a point 176 between the resistor of rheostat 152 and contact finger 146 for slidewire 144.

To provide inverted rate action, a resistance element of an inverted rate action rheostat 180 has one end connected to a point 182 between movable contact 130a of proportional band rheostat 130 and resistor 168, and has its other end connected to input terminal 158 of converter 156. Inverted rate action rheostat 180 has its movable contact 180a connected to a point 184 between one end of the resistance element of rate action rheostat 180 and point 182.

A capacitor 186 and a normally open switch 188 are connected in series with each other between point 172 and input terminal 158 of converter 156. It is to be understood that switch 188 is mechanically connected to movable contact 180a of rate action rheostat 180 so that when switch 188 is open, movable contact 180a is moved to a position that effectively shunts the resistance element of rate action rheostat 180 from the circuit between point 182 and input terminal 158 of converter 156.

The invention operates as follows.

Assume that kiln 10 is in operation and that clinker is being discharged therefrom onto grate 20 of clinker cooler conveyer apparatus 18. Further assume that controller 50 has effected energization of conveyer motor 46 and that the latter is running at constant speed and is effecting vibration of grate 20 and wind box 22 to convey clinker along the grate. Further assume that the control system is in operation but that initially switch 188 is open and the resistance element of rate rheostat 180 is bypassed so that inverted rate action is not provided for.

Radiation from gamma radiation source 80 traverses the clinker on grate 20 and impinges on radiation detector 84 in an amount which is inversely proportional to the depth of clinker on the grate. Radiation detector 84 produces an output signal related to clinker depth and this output signal, amplified to useful magnitude by amplifier 88, is fed to recorder device 92 wherein it is automatically compared to a predetermined reference signal or "set point." If the signal from amplifier 88 compares favorably with the reference signal, thus indicating that the clinker bed is at the desired depth, no error signal is produced by recorder device 92 and consequently no change is effected in the speed of conveyer motor 46.

Assume, however, that the output of clinker from kiln 10 begins to increase and that the depth of clinker on grate 20 gradually begins to increase beyond the desired depth. Radiation detector 84 senses this change and the amplified output signal therefrom, when compared to the reference signal in recorder device 92, causes the recorder device to provide an error signal in the appropriate direction for as long as the condition exists.

Referring now to FIG. 3, it is to be understood that the error signal in recorder device 92 effects proportional counterclockwise movement of contact finger 122 along slidewire 120. This movement causes an electrical imbalance to appear in the circuit branch in which slidewire 120 and contact finger 122 are located and causes a potential difference to exist between the points 172 and 182 in the circuit shown in FIG. 3. It is to be understood, for example, that counterclockwise movement of contact finger 122 along slidewire 120 causes point 182 to become more negative with respect to point 172. Because of the voltage drop across resistor 168, a potential difference also exists between points 182 and 174 which are connected to the input terminals 158 and 160, respectively, of converter 156.

It is to be understood that converter 156 is adapted so that a potential difference between the input terminals 158 and 160 thereof causes energization of either relay 164 of 166, provided, however, that input terminal

162 is not at the same potential as input terminal 158. It is to be further understood, for example, that, if input terminal 158 of converter 156 is more negative than input terminal 160, then forward relay 164 will be energized and that, if input terminal 158 is more positive than input terminal 160, then reverse relay 166 will be energized until input terminal 162 is brought, in either case, to the same potential as input terminal 158, as will hereinafter be explained.

Thus, with input terminal 158 of converter 156 becoming increasingly more negative with respect to input terminals 160 and 162 as movable contact finger 122 of slidewire 120 moves in the counterclockwise direction, forward relay 164 is energized to effect forward operation of rheostat drive 100 of combination unit 102. This effects a speed up in the operation of conveyer motor 46 and consequent speed up in the conveying action of grate 20 of clinker cooler conveyer apparatus 18 tending to bring clinker bed depth back to the desired level.

Simultaneously, however, forward operation of rheostat drive 100 of combination unit 102 effects continuous counterclockwise movement of movable contact finger 146 of slidewire 144. This causes continuous and increasing electrical unbalance in the branch of the circuit in which contact finger 146 and slidewire 144 are located and causes current flow through the resistance element of proportional band rheostat 152. Thus, a potential difference exists between movable contact 152a of proportional band rheostat 152 and point 176. It is to be understood that counterclockwise movement of contact finger 146 along slidewire 144 causes point 176, which is connected to input terminal 160 of converter 156, to become more positive with respect to movable contact 152a of proportional band rheostat 152, which is connected to input terminal 162 of converter 156. Thus, the potential of input terminal 162 of converter 156 gradually becomes more negative and equal to the potential of input terminal 158 of converter 156. When equality of voltages is achieved, forward relay 164 becomes deenergized and forward operation of rheostat drive 100 of combination unit 102 ceases. Thus, conveyer motor 46 no longer increases in speed but continues in operation at the new speed level, higher than initially.

Since clinker cooler conveyer apparatus 18 is conveying at a higher speed, the depth of the bed of clinker on grate 20 is partially adjusted towards the desired level by the proportional band control action as described above. It is to be understood that control unit 96 is further adapted to provide reset action control, hereinbefore referred to, which effects repetition of the proportional band control action described hereinbefore, to effect repeated changes in the speed of motor 46 until the bed of clinker on grate 20 is brought to the desired predetermined level.

It is to be understood that if the depth of clinker on grate 20 begins to fall below the desired depth, radiation detector 84 senses this decrease and amplified output therefrom, when compared to the reference signal in recorder device 92, causes the recorder device to produce an error signal which effects continuous clockwise movement of contact finger 122 along slidewire 120. In this event control unit 96 operates as hereinbefore described except that polarities in the circuit in FIG. 3 are reversed to effect energization of reverse relay 166 and consequent reverse operation of rheostat drive 100 of combination unit 102. This effects a slow down in the operation of conveyer motor 46.

To provide for inverted rate action, assume that switch 188 is closed to place capacitor 186 in circuit between point 172 and input terminal 158 of converter 156 and that a portion of the resistance of inverted rate action rheostat 180 is placed in circuit between point 182 and input terminal 158 of converter 156. Further assume, as hereinbefore described, that the bed of clinker on grate 20 is increasing in depth due to increase in the output of kiln 10, that radiation detector 84 is sensing this devia-

tion and feeding a signal through amplifier 88 to recorder device 92, and that the recorder device provides an error signal to control unit 96. Again, assume that a potential difference appears between points 172 and 182, shown in FIG. 3. Capacitor 186 charges to the potential difference existing between points 172 and 182 through the resistance element of inverted rate rheostat 180 and the charging current depends upon the rate at which the potential across points 172 and 182 appears. This charging current flows through inverted rate rheostat 180, producing a voltage across the in circuit portion of the resistance element of inverted rate rheostat 180 opposite to that developed in resistor 168 thus reducing the voltage appearing between converter terminals 158 and 160.

The charging rate of capacitor 186 depends upon the difference of voltage across the capacitor and the voltage appearing across points 182 and 172. As these voltages become equal, the charging current diminishes, the opposing voltage across the in circuit portion of the resistance element of inverted rate rheostat 180 decreases and the full voltage produced across resistor 168 is impressed between converter terminals 160 and 158. By adjusting the resistance of inverted rate rheostat 180, the charging rate of capacitor 186 can be regulated so as to account for rapid deviations of recorder device 92 due to momentary passage of large pieces of clinker past radiation source 82 which produce a rapid change in the potential difference between 182 and 172, so that little or no change in the speed of motor 46 occurs during these momentary sporadic changes of bed level. The control system is thereby enabled to follow and maintain a true average bed level condition.

In the case of gradual increases in the amount of clinker being deposited on grate 20, inverted rate action has no appreciable effect on the speed of conveyer motor 46. However, when large lumps of clinker or clinker rings are deposited on grate 20 and sensed by the radiation detector 84, there is a rapid and substantial increase in potential differences between points 182 and 174 in FIG. 3. Without inverted rate action, the amount of the increase would cause temporary speed up of conveyer motor 46. With inverted rate action, there is temporary reduction in the potential differences between the input terminals 158 and 160 of converter 156. Consequently, the temporary speed up of conveyer motor 46 is not as great as it normally would be.

Having now particularly described and ascertained the nature of my said invention and the manner in which it is to be performed, I declare that what I claim is:

1. In a system for controlling a conveyer, in combination, a conveyer, means for supplying variable quantities of material to said conveyer, and control means for controlling the speed of said conveyer to maintain a predetermined depth of material thereon despite variations in the quantity of material being supplied to said conveyer, said control means comprising sensing means for sensing the depth of material on said conveyer and for producing a signal related thereto, measuring said control means further comprising means for measuring said signal to determine a change in depth and the rate of said change in depth and for providing an output signal for effecting a gradual change in conveyer speed in the event of a gradual change in depth and for preventing a substantial change in conveyer speed in the event of an abrupt momentary change in depth.

2. In a system for controlling a conveyer, in combination, a conveyer, means for supplying variable quantities of material to said conveyer, and control means for controlling the speed of said conveyer to maintain the material thereon at a predetermined depth despite variation in the amount of material being supplied thereto, said control means comprising detector means for sensing the depth of material on said conveyer and for providing an output signal quantitatively related thereto, comparing means for comparing said output signal to a value rep-

resenting said predetermined depth of material on said conveyer and for providing an error signal whenever there is a discrepancy between said output signal and said value, said error signal being quantitatively related to the amount of said discrepancy, and electroresponsive means for measuring the quantitative value of said error signal and for translating said error signal into a correction signal for changing the speed of said conveyer in proportion to the quantitative value of said error signal and for measuring the rate of change of said error signal and for temporarily modifying said correction signal so as to effect gradual conveyer speed changes when the rate of change of said error signal is gradual and to substantially reduce the amount of change in the speed of said conveyer which would otherwise be effected by said correction signal in the event of abrupt rate of change of said error signal.

3. In a system for controlling a clinker cooler conveyer, in combination, a clinker cooler conveyer, a kiln for discharging variable quantities of clinker onto said conveyer, some variation being due to normal changes in kiln output and some variation being due to sporadic discharge of masses of clinker, and control means for regulating the speed of said conveyer to maintain a bed of clinker of substantially constant predetermined depth on said conveyer, said means comprising a motor for driving said conveyer, detecting means for continuously sensing the depth of the bed of clinker on said conveyer and for producing an output signal related thereto, recording means for comparing said output signal to a predetermined value to determine deviations from said predetermined depth and for producing an error signal related thereto, and motor control means for controlling the speed of said conveyer motor and for measuring the magnitude and rate of change of said error signal and to effect changes in the speed of said motor in the event of gradual rate of change of bed depth, and to prevent a substantial change in motor speed in the event of abrupt change in rate of bed depth.

4. In a system for controlling a conveyer, in combination, a conveyer, means for supplying variable quantities of material to said conveyer, and control means for sensing the depth of material on said conveyer and any change therein, for gradually changing conveyer speed in the event of gradual changes in depth to maintain the depth substantially constant, and for maintaining conveyer speed substantially unchanged in the event of abrupt momentary changes in depth.

5. In a system for controlling a conveyer, in combination, a conveyer, means for supplying variable quantities of material to said conveyer, and control means for sensing the depth of material on said conveyer and any change therein, for gradually changing conveyer speed in the event of gradual increases or decreases in depth to maintain the depth substantially constant, and for maintaining conveyer speed substantially unchanged in the event of abrupt momentary changes in depth.

6. In a system for controlling a conveyer, in combination, a conveyer, means for supplying variable quantities of material to said conveyer, and control means for sensing the depth of material on said conveyer and any change therein, for responding to the rate of change in depth to effect changes in conveyer speed in the event of gradual depth changes, and for maintaining conveyer speed substantially unchanged in the event of abrupt momentary changes in depth.

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