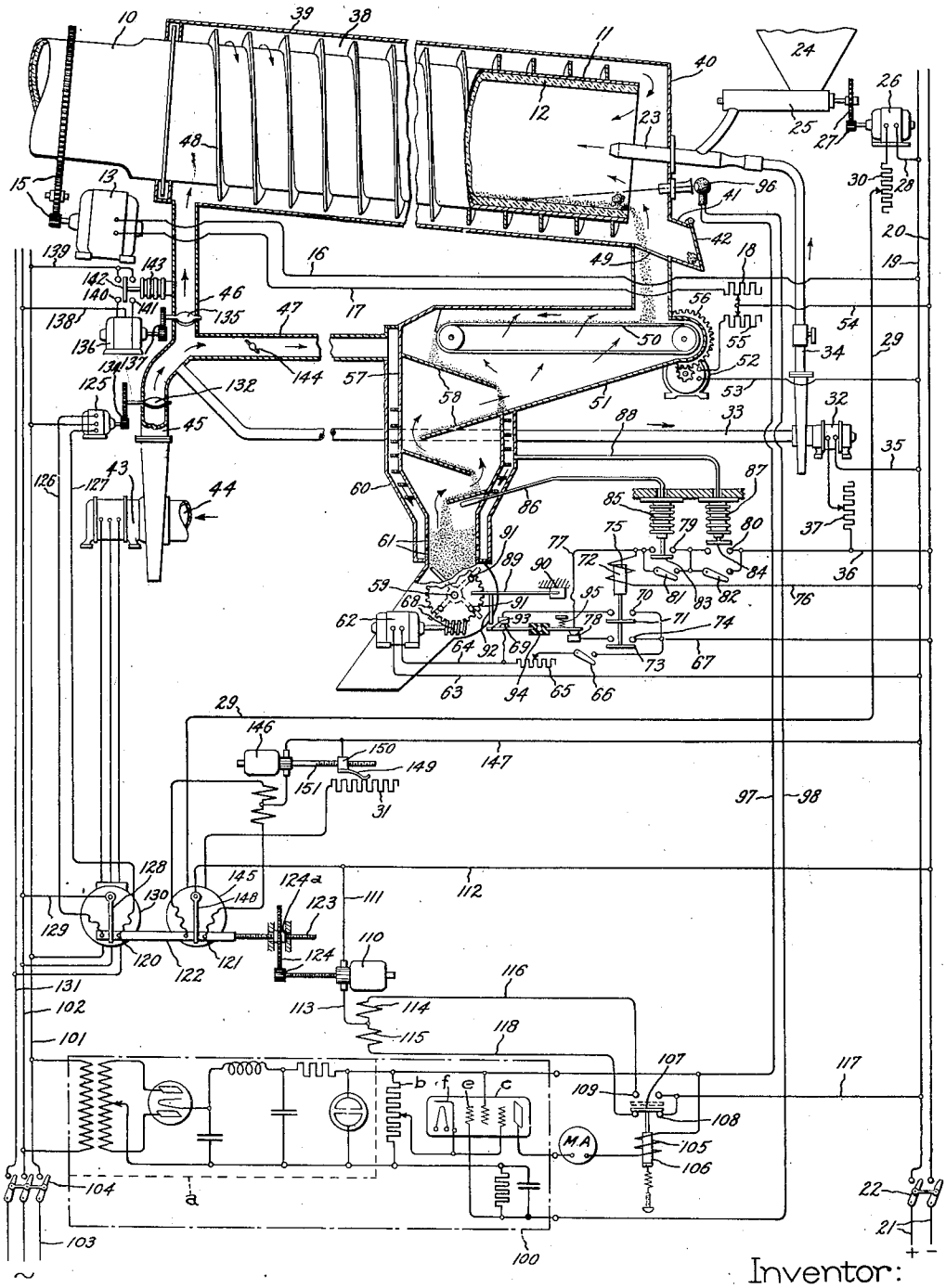
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ROTARY KILN CONTROL ARRANGEMENT

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Inventor:
Aubrey Smith,
by Harry E. Dunham
His Attorney.

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ROTARY KILN CONTROL ARRANGEMENT

Aubrey Smith, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

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The present invention relates to rotary kiln control arrangements, more specifically to the kind of control arrangements used for controlling rotary kilns in cement manufacturing plants, although it is not limited thereto necessarily.

In present day cement manufacturing plants inclined rotary kilns of considerable length are provided to effect incipient vitrification or fusion of two materials, one material rich in lime such as limestone or marl known as calcareous material, and another material rich in silica, alumina and iron oxide such as clay or shale known as argillaceous material. A homogeneous mixture of these materials is fed into the high end of a rotary kiln and during rotation of the kiln passes through the different zones thereof known as dehydration zone, calcining zone, and clinkering zone. At the end of the latter zone the cement clinker is discharged and cooled. The union of the materials within the kiln is effected by the application of heat which in the usual arrangement is produced by a burner projecting into the lower end of the kiln and discharging combustible material therein. The final temperature at which incipient fusion takes place is of the order of 1500° centigrade. It is desirable to maintain substantially constant temperature within the kiln because a considerable variation of the temperature lowers the quality of the produced cement clinker and also the efficiency of the kiln.

The object of my invention is to provide an improved construction and arrangement of rotary kiln appurtenances, especially an improved control mechanism for such equipments whereby the quality of the clinker is improved and the output and thermal efficiency of the kiln increased.

For a consideration of what I believe to be novel in my invention, attention is directed to the following description and the claims appended thereto in connection with the accompanying drawing.

The figure of the drawing shows diagrammatically a kiln control arrangement in accordance with my invention.

The arrangement comprises an inclined rotary kiln 10 which has a sheet steel cylinder 11 lined inside with refractory brick or like heat resistant material 12. The kiln is driven by a motor 13 through a gearing 15 at a speed of about 1 to 2 R. P. M. The motor 13 is connected through wires 16, 17, and 54 and a rheostat 18 to a D. C. line 19, 20, the latter receiving electric energy from a source 21 connected to the line 19, 20 through a switch 22. The speed of the motor 13 and accordingly the kiln 10 may be varied by adjustment of the rheostat 18. In the present instance I have shown the lower end portion only of the kiln in which the clinkering takes place. A burner 23 for supplying combustible material to the lower end of the kiln is directed into the brick-lined cylinder 11. The burner 23 receives combustible material, in the present instance pulverized coal, from a bin 24 through a feed screw 25. The feed screw 25 is driven by a motor 26 through the intermediary of a gearing 27. The motor 26 is connected to lines 19, 20 by means including wires 28, 29, a manually controllable rheostat 30, and an automatically controllable rheostat 31, permitting regulation of the speed of the motor 26, as will be fully described hereafter.

During operation of the motor 26, fuel, in the present instance pulverized coal, is conducted to the burner and discharged therefrom together with vehicle air. This vehicle air is supplied to the burner by a motor driven blower or motor compressor 32. The latter has an inlet or suction conduit 33 and a discharge conduit 34 connected to the burner. The motor 32 is connected to lines 19, 20 by wires 35 and 36 including a manually adjustable rheostat 37. The rheostat 37 permits adjustment of the speed of the motor compressor 32 to vary the amount of vehicle air in accordance with the speed of the motor 26, that is, in accordance with the amount of combustible material conducted to the burner 23.

An important feature of my invention is the arrangement for supplying air into the clinkering zone to maintain combustion of the fuel therein. The air supplied to the clinkering zone is preheated, more specifically a portion of the air is preheated along the outside of the kiln whereby heat from the hotter portions of the kiln shell is recovered and another portion of the air is preheated by the discharged clinker, thus regaining a considerable amount of heat energy of the discharged clinker.

In the present instance the clinkering zone of the kiln is surrounded by a stationary wind box 38 formed by a steel cylinder 39 concentrically surrounding the kiln. The lower end of the cylinder 39 projects beyond the lower end of the kiln and is closed by an end plate 40 carrying the burner 23, and forming a projection 41 with a trap door 42 hinged thereto for permitting the removal of large chunks of clinker diverted by the screen 49. Air is supplied to the higher end of the wind box 38 by a motor compressor 43 having an inlet 44 communicating with the atmosphere, or any

suitable source of air supply, and a discharge conduit 45 with branched conduits 33, 46, and 47, of which the first branch 46 is connected to the wind box 38. Good heat transfer between the rotary kiln and the air supply in the wind box is effected by the provision of a rotating spiral fin 48 secured to the kiln and defining, together with the stationary cylinder 39 of the wind box, a spiral channel for the air. The air flows along the spiral channel and thereby cools effectively the steel cylinder 11 of the kiln, thus avoiding excessive temperatures of this kiln shell with consequent rapid deterioration. At the right hand end of the kiln the preheated air is discharged from the spiral channel into the interior of the kiln where it provides air for the combustion process. With this arrangement the heat otherwise lost from the shell of the kiln is largely recovered, serving to preheat the combustion air. Furthermore, the average temperature of the outer structural shell of the kiln is prevented from reaching a destructive point by the forced ventilation described herein. The clinker working toward the lower end of the rotary kiln and discharged therefrom drops through an opening or openings 49 in the lower portion of the wind box cylinder 39 onto the right hand end of a perforated conveyor 50 disposed in a casing 51. Large chunks of clinker are prevented from dropping onto the conveyor and collect near the trap door 42 whence they are removed from time to time. The perforated conveyor 50 is driven by a motor 52 connected to the lines 19, 20 by wires 53 and 54 including a rheostat 55. The motor 52 is connected to the conveyor 50 by a gearing 56. During operation the clinker dropping onto the right hand end of the conveyor 50 is transported and discharged from the left hand end of the conveyor. The rheostat 55 in the present example is manually adjustable and in accordance with my invention this rheostat is combined with the rheostat 18 of the kiln driving motor 13 whereby both motors for driving the kiln and the conveyor respectively, are regulated simultaneously. In case it is desirable to increase the output of the kiln, the rheostat 18 is adjusted to effect an increase in speed of the motor 13. This adjustment effects simultaneously a similar adjustment of the rheostat 55, causing a corresponding increase in speed of the conveyor 50. The left-hand end of the casing 51 is connected to the top of a cooling tower 57, which latter is provided with baffle plates 58 defining a long zigzag path for the clinker discharged from the left-hand end of the perforated conveyor 50. The lower end of the cooling tower is closed by a dumping wheel or air-locked rotary clinker dumper 59. The wall of the cooling tower 57 is surrounded by an air jacket 60 for receiving air from the aforementioned branch 47 and discharging the air into the lower end of the cooling tower through openings 61. With this arrangement air flowing spirally downward through the air jacket into the lower end of the cooling tower is preheated. It is then forced upward through the clinker in the cooling tower and through the perforated conveyor into the lower end of the kiln where, joining with the air supplied through the wind box 38, it provides air for the combustion process. Thus the heat content of the discharged clinker is regained through preheating of the combustion air, thereby increasing the efficiency of the arrangement. The dumping wheel 59 is operated intermittently by means including a motor 62 having one terminal connected by a wire 63 to the line 19 and another terminal connected by a wire 64, a rheostat 65, a hand-operated switch 66, and a wire 67 to the line 20. Closing of the switch 66 connects the motor to the line, effecting operation of the motor 62 and through a worm gearing 68 rotation of the dumping wheel 59, permitting discharge of clinker from the cooling tower. A single rotation of 90 degrees permits normally the discharge of a substantially definite amount of clinker. The motor 62 may also be operated automatically. To this end the wire 64 is connected through normally closed contacts 69 and relay contacts 70, to the wire 67. The contacts 70 may be closed by a contact-making member 71 forming a part of a relay 72 which also includes another contact-making member 73 for closing holding contacts 74. The relay 72 has an operating coil 75 having one end connected to the line 19 by a wire 76 and another end connected to the line 20 by either of two circuits, a first circuit through a wire 77, contacts 78, through the aforementioned contacts 74 and the wire 67; the other circuit for closing the relay 72 is formed by either of two pairs of contacts 79 and 80, one of two switches 81 and 82 and the wire 36. The contacts 79 and 80 are closed by contact-making members 83 and 84. The contact-making member 83 forms a part of a temperature responsive device comprising a bellows 85 having one end connected to the contact-making member 83 and another end communicating with a closed tube 86 projecting into the cooling tower. During operation, decrease in temperature in the cooling tower causes contraction of a medium enclosed in the tube 86, permitting the bellows 85 to collapse or contract, thereby causing closing of the contacts 79 by the contact-making member 83.

The contact-making member 84 forms a part of a pressure-responsive device comprising a bellows 87 having its lower end secured to the contact-making member 84 and its upper end communicating through a pipe 88 with the air jacket 60 surrounding the cooling tower. Increase in pressure in the air jacket causes increase in pressure in the bellows 87 whereby the latter expands and causes the contact-making member 84 to bridge the contacts 80. The temperature and pressure-responsive devices permit automatic operation of the motor 62 either in response to temperature or pressure conditions in the cooling tower. When it is desired to operate the motor 62 in response to temperature conditions, the switch 82 is closed, and when it is desired to operate the motor 62 in response to pressure conditions in the air jacket, the other switch 81 is closed. Let us assume the switch 82 is closed, causing the motor 62 to be operated in response to temperature conditions in the cooling tower. When this is the case, decreasing temperature in the cooling tower causes collapsing of the bellows 85 until the contact-making member 83 bridges the contacts 79. This causes energization of the operating coil 75 of the relay 72 which then is connected to the line 20 through the contacts 79, the switch 82, and the wire 36. Energization of the coil 75 effects upward movement of the relay, thereby closing the two pairs of contacts 70 and 74. The contacts 74, as stated before, are holding contacts for the relay whose coil 75 is now connected to line 20 through a second circuit comprising the wire 77, the contacts 78, the contacts 74 and the wire 67. The provision of the holding circuit is advantageous in that it prevents deenergization of the relay coil before the necessary operation of the motor 62 is completed.

With relay 72 closed, the motor is energized, more specifically the wire 64 connected to the motor is connected through the contacts 69, the contacts 70, and the wire 67 to the line 20. Energization of the motor 62 causes rotation of the dumping wheel 59, permitting the discharge of clinker from the cooling tower.

Means are provided for limiting the automatic operation of the motor 62, more specifically for automatically disconnecting motor 62 after a partial rotation, in the present instance, after a rotation of 90 angular degrees of the dumping wheel 59. This means comprises a flat spring 89 secured at its right-hand end to a fixed support 90 and having its left-hand end engaged by projections 91 on the dumping wheel 59 during rotation of the latter. Secured to an intermediate portion of the spring 89 is a member 92 having its lower end disposed adjacent a holding member 93 for the contacts 69. The holding member 93 for contacts 69 is secured to a pivotally supported insulating block 94 which also carries one of the contacts 78. The two pairs of contacts 69 and 78 are normally held closed by a biasing spring 95. During a rotation of 90 angular degrees of the dumping wheel 59, one of the projections 91 engages the left-hand end of the flat spring 89 and causes the latter to move downward whereby the member 92 engages the member 93 and causes opening of the contacts 69 as well as the contacts 70 against the biasing force of the spring 95. The two pairs of contacts are opened for a short period of time only, normally sufficient to de-energize the relay coil 75, thus causing dropping of the relay 72 and stopping of the motor 62. If, however, the operating coil 75 of the relay 72 is still connected to the line 20 through contacts 79 and the switch 82, the relay remains closed and causes further dumping operation of the motor 62. This operation will continue until the temperature in the cooling tower has increased sufficiently or in case the automatic operation is effected by the pressure-responsive device 87 until the pressure has sufficiently decreased.

Another important feature of my invention comprises the provision of means for automatically controlling the operation of the motor compressor 43 and the fuel supply motor 26 in response to a condition within the clinker zone of the rotary kiln, more specifically in reponse to temperature changes in the clinker zone in order to maintain substantially constant the temperature at which incipient fusion or clinkering takes place. The means for automatically operating the motor compressor 43 and the fuel supply motor 26 includes a temperature-responsive device, in the present instance, a photo-electric cell 96, secured to or supported near the end plate 40 of the stationary wind box casing and trained onto the clinkering zone or region in the kiln. The photo-electric cell 96 is connected by wires 97 and 98 to an amplifier 100, which latter receives energy from lines 101 and 102 of a three-phase alternating current line connected to a source 103 through a switch 104. Any suitable amplifier 100 may be used. In the present instance, the amplifier 100 includes a rectifier and a wave smoothing filter *a* for supplying a substantially constant D. C. potential across a voltage divider *b*. The latter is connected in a well known manner to a discharge valve or tube *c* having a control grid *e* and a cathode *f*. The grid potential is normally negative with respect to the cathode *f* and varies in response to temperature changes in the kiln. The grid potential determines the magnitude of the current flowing through the tube *c*. As the details of such amplifier form no part of my invention, the amplifier indicated by way of example in the drawing is not further described, it being sufficient to indicate that this amplifier, together with the photo-electric cell 96, serves for energizing a suitable relay, in the present instance an operating coil 105 of an electromagnetic relay 106 in response to temperature changes in the clinker zone. One end of the coil 105 is connected to the line 97 and the other end of the coil is connected through a milliammeter (MA) to the valve *c* of the amplifier. The relay 106 has a contact-making member 107 disposed between two pairs of contacts 108 and 109 respectively. The contact-making member 107 is normally disposed intermediate between the two pairs of contacts 108 and 109, as indicated in dotted lines. The two pairs of contacts serve for closing the circuit of a reversible motor 110 having an armature connected by wires 111 and 112 to the line 20 and through a wire 113 to the field windings 114 and 115. The field winding 114 is connected by a wire 116 and the contacts 109, and a wire 117 to the line 19. The other field winding 115 is connected by a wire 118 to the contacts 108 and the wire 117 to the line 19. With this arrangement, closing of the contacts 108 by the relay 106, in response to decreasing flow of current through the discharge valve *c*, causes energization of the field winding 115 and operation of the motor 110 in one direction and closing of the contacts 109 by the relay 106 in response to increasing flow of current through the discharge valve *c*, causes energization of the field winding 114 and operation of the motor in the opposite direction. The motor 110 serves for adjusting two pairs of contacts 120 and 121 respectively secured to a bar 122, provided with a screw 123, which latter is driven from the motor 110 through a gearing 124 and a nut 124*a*. Operation of the motor 110 in one direction causes movement of the contact bar 122 to the right and operation of the motor 110 in the opposite direction causes movement of the contact bar 122 toward the left. The contacts 120 serve for closing the circuit of a reversible motor 125 which has one terminal connected to the line 101 and two other terminals connected by wires 126 and 127 to the two contacts 120, and a contact-making member 128 and a wire 129 to the line 102. The contact-making member 128 forms a part of a load-responsive device which may be a wattmeter 130 for connecting the motor of the motor compressor 43 to the three-phase alternating current line comprising the aforementioned lines 101 and 102 and a third line 131. The reversible motor 125 serves for adjusting a gate valve 132 connected to the motor by a gearing 134.

An arrangement of this kind is more fully disclosed in the patent to H. V. Crawford, No. 1,783,036, issued November 25, 1930, and assigned to the same assignee as the present invention. The provision of the reversible motor 125 and the load-responsive device or wattmeter 130 in cooperation with the motor of the motor compressor 43 serves to normally maintain the load on the motor 43 constant whereby, with the particular kind of motor compressor, a constant weight of air is normally discharged by the compressor. In case the weight of the air discharged by the motor compressor 43 changes due to change in atmospheric air temperature or pressure, the electric input to the motor compressor

43 changes accordingly, whereby the member 128 is turned, causing closing of the circuit of the reversible motor 125 through either of the wires 126 or 127. The motor 125 then being energized causes adjustment of the gate valve 132, which latter represents in substance a means for varying the resistance to flow in the discharge conduit of the compressor. In case the weight of the discharged air has dropped, the gate valve 132 is turned to reduce said resistance to flow so that the weight of the discharged air is brought back to its normal value. Thus, during normal operation, that is, while the temperature within the kiln remains constant, a constant amount, more specifically a constant weight, of air per minute is supplied to the kiln. A change in temperature in the kiln, as pointed out above, causes operation of the motor 110 which in turn effects the setting of the contact bar 122. In case the temperature of the kiln drops, the contact bar 122 is automatically adjusted to cause an increased supply of energy to the motor compressor 43, resulting in an increased supply of air. Simultaneously the supply of fuel is increased, as will be described later.

As stated above, the air discharged by the compressor is diverted into the branched conduits or branches 46, 47, and 33 respectively. The amount of air flowing into the branch 46 is automatically controlled by means including a gate valve 135 connected to a motor 136 through a gearing 137. The motor 136 is reversible and is connected to the lines 101 and 102 by a wire 138 and another wire 139 and one set of two pairs of contacts 140 and 141. Closing of the contacts is effected by a contact-making member 142 connected to a pressure-responsive device comprising a bellows 143 connected to the contact-making member 142 and communicating with the branched conduit 46 beyond valve 135. When the pressure in the conduit 46 increases, the pressure-responsive device effects closing of one pair of contacts 140 or 141 to cause operation of the motor 136 in such a direction that the gate valve 135 is moved in the closing direction. By this means the amount of air circulating through the kiln jacket may be maintained as desired. The relative amount of air flowing through the branch 47 into the air jacket 60 of the cooling tower may be adjusted by a manually or automatically operable gate valve 144 in the branch 47. The aforementioned conduit 33 for conducting vehicle air to the compressor 32 is also connected to the discharge conduit of the motor compressor 43. Thus, the conduit 33 receives compressed air which is further compressed by the compressor 32. The latter accordingly may be considered a booster, Hence the total amount of air necessary for operating the kiln passes through the motor compressor 43 which is controlled by the load-responsive device or wattmeter 130 and means for setting the contact bar 122.

The circuit for the fuel supply motor 26 includes, as pointed out before, a variable resistance or rheostat 31. This rheostat is automatically controlled in accordance with my invention by means responsive to temperature changes in the kiln. These means including the aforementioned contacts 121 which, together with a load-responsive device, which may be a wattmeter or an ampere meter 145, serve for controlling the circuit of a reversible motor 146. One terminal of the motor 146 is connected to the line 19 by a wire 147. The motor has two fields which are connected to the two contacts 121 and through a contact-making member 148 and the aforementioned wire 112 to the line 20. Engagement of the contact-making member 148 with one of the contacts 121 closes the motor circuit whereby the motor is rotated in a certain direction and causes a part of the resistance 31 to be cut out or in. This is accomplished by securing a handle or lever 149 for the resistance 31 to a member 150 screwed onto a projection 151 of the motor shaft. Rotation in one direction of the motor, as will be readily understood, causes the lever 149 to be moved to the right and vice versa to the left when the direction of the motor is reversed. Adjustment of the resistance 31 causes change in speed of the fuel supply motor 26. The circuit for the motor 26 includes the wire 29, the load-responsive device 145 and the wire 112 connected to the line 20. Under normal conditions, that is, with constant temperature in the kiln, the reversible motor, together with the load-responsive device 145 effect regulation of the rheostat 31 to maintain the speed of the fuel supply motor 26 constant. Constant speed of the motor 26 means substantially constant fuel supply to the burner 23. The arrangement is in this respect similar to the one disclosed in the aforementioned patent. The arrangement is such that with increasing supply of air by the motor compressor 43 the speed of the motor 26 is also increased to effect increased flow of fuel to the burner 23.

Summarizing the operation of the kiln control arrangement, a constant weight of air and a definite amount of fuel is normally supplied to the kiln. This is accomplished by the motor compressor 43 and its control mechanism including the watt-responsive device and the reversible motor 125 and by the fuel supply motor 26 and its control mechanism including the load-responsive device 145 and the reversible motor 146. A portion of the air discharged by the motor compressor 43 flows through the conduit 33 into the motor compressor or booster 32 and is discharged therefrom through the conduit 34 into the burner 23. This portion of the air serves for discharging fuel supplied to the burner 23 by the feed screw 25. A portion of the air in the discharge conduit 45 of the motor compressor 43 flows through the conduit branch 46 into the wind box 38 and another portion of air flows through the branch 47 into the air jacket 60 of the cooling tower. These two portions of the air are preheated in the wind box and in the cooling tower respectively and are supplied to the kiln where they maintain combustion of the fuel discharged by the burner 23. The kiln and the perforated conveyor 50 are driven by the two motors 13 and 52 respectively whose circuits include rheostats 18 and 55 respectively. The two rheostats are adjusted simultaneously whereby an increase in speed of the kiln 10 effects simultaneously an increase in speed of the conveyor 50. If the temperature of the clinker in the clinkering zone changes, for instance decreases, the supply of fuel and air are increased. This is accomplished by means including the photo-electric cell 96, the amplifier 100, and the relay 106 for controlling the circuit of the reversible motor 110 to effect resetting or adjustment of the contact bar 122. In case the temperature in the kiln drops, the contact bar 122 is moved in a direction to effect increased air discharge from the motor compressor 43 and to correspondingly increase the fuel supply by increase in the speed of motor 26.

Clinker discharged into the lower portion of the cooling tower 57 may be discharged there-

from manually or automatically in response to either temperature conditions in the cooling tower or pressure conditions in the air jacket 60.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. The combination of a rotary kiln for heating a material, a motor for driving the kiln at substantially constant speed, a stationary closed wind box surrounding the kiln, means including a motor for supplying fuel into the kiln, means including a motor compressor for forcing air through the wind box into the kiln to maintain combustion, and means for automatically controlling the fuel and air supply means in response to changes of a condition of the material heated in the kiln at constant motor speed.

2. The combination of a rotary kiln for heating a material, a motor for driving the kiln at substantially constant speed, means for supplying fuel and air into the kiln, and means including a photo-electric cell trained onto the material in the interior of the kiln, and an amplifier connected to the cell for automatically controlling the fuel and air supply means in response to temperature changes in the kiln at constant motor speed.

3. The combination of a rotary kiln for heating a material, a motor for driving the kiln at substantially constant speed, means for supplying fuel to the kiln, a cooling tower connected to the discharge end of the kiln for receiving and cooling material discharged by the kiln, means for forcing air through the cooling tower into the kiln, and means for automatically controlling the fuel and air supply means in response to temperature changes of the material heated in the kiln at constant motor speed.

4. The combination of a rotary kiln for heating a material, a motor for driving the kiln at substantially constant speed, means for supplying fuel to the kiln, a cooling tower connected to the discharge end of the kiln for receiving and cooling material discharged by the kiln, means for forcing air through the cooling tower into the kiln, means for automatically controlling the fuel and air supply means in response to temperature changes of the material heated in the kiln at constant motor speed, said cooling tower including an air-locked rotary dumper for intermittently discharging material from the tower, and means for automatically actuating the dumper in response to temperature changes in the tower.

5. The combination of a rotary kiln for producing clinker, a motor for rotating the kiln, means for supplying fuel into the kiln, an enclosed porous conveyor having one end disposed to receive clinker discharged from the kiln, a cooling tower for receiving clinker from the other end of the conveyor, a motor compressor for supplying air through the cooling tower into the kiln, means for automatically regulating the discharge of clinker from the cooling tower in response to temperature changes in said tower, and other means including said motor compressor for supplying additional air to the kiln in response to temperature changes in the kiln at constant motor speed.

6. The combination of a rotary kiln for producing clinker, a motor for rotating the kiln at constant speed, means for supplying fuel into the kiln, an enclosed porous conveyor for clinker having one end for receiving clinker discharged from the kiln, a cooling tower for receiving clinker from the other end of the conveyor, a motor compressor for supplying air through the cooling tower into the kiln, a motor for driving the conveyor, and means for simultaneously regulating the motors for driving the conveyor and the kiln.

7. The combination of a rotary kiln for producing clinker, a motor for normally rotating the kiln at constant speed, means for supplying fuel into the kiln, an enclosed porous conveyor for clinker having one end for receiving clinker discharged from the kiln, a cooling tower for receiving clinker from the other end of the conveyor, a motor compressor for supplying air through the cooling tower into the kiln, and means for automatically maintaining constant the weight of the supplied air at constant temperature of the clinker.

8. The combination of a rotary kiln for producing clinker, a constant speed motor for rotating the kiln, means for supplying fuel into the kiln, an enclosed porous conveyor for clinker having one end for receiving clinker discharged from the kiln, a cooling tower for receiving clinker from the other end of the conveyor, a motor compressor for supplying air through the cooling tower into the kiln, means for controlling the motor compressor in response to temperature changes in the kiln comprising a temperature-responsive device connected to the kiln, and means including a watt-responsive device connected to the motor compressor for varying the resistance to flow to be overcome by the compressor in response to temperature changes.

9. The combination of a rotary kiln for producing clinker, a wind box surrounding the kiln and communicating at the discharge end with the kiln, a cooling tower for receiving and cooling clinker discharged by the kiln, a motor compressor having a branched discharge conduit with one branch connected to the wind box and another branch connected to the cooling tower for preheating air in the wind box and the cooling tower and forcing the air into the kiln, and means for supplying fuel into the kiln including a motor compressor having an inlet conduit connected to the discharge conduit of the first mentioned motor compressor.

10. The combination of a rotary kiln for producing clinker, a wind box surrounding the kiln and communicating at the discharge end with the kiln, a cooling tower for receiving and cooling clinker discharged by the kiln, a motor compressor having a branched discharge conduit with one branch connected to the wind box and another branch connected to the cooling tower for preheating air in the wind box and the cooling tower and forcing the air into the kiln, means for supplying fuel into the kiln including a motor compressor having an inlet conduit connected to the discharge conduit of the first mentioned motor compressor, and means for automatically proportioning the flow of air in at least one of said branches.

11. The combination of a rotary kiln for producing clinker, a wind box surrounding the kiln and communicating at the discharge end with the kiln, a cooling tower for receiving and cooling clinker discharged by the kiln, a motor compressor having a branched discharge conduit with

one branch connected to the wind box and another branch connected to the cooling tower for preheating air in the wind box and the cooling tower and forcing the air into the kiln, means for supplying fuel into the kiln including a motor compressor having an inlet conduit connected to the discharge conduit of the first mentioned motor compressor, and means for simultaneously automatically varying the air supply and the fuel supply in response to temperature changes in the kiln and a motor for driving the kiln at constant speed.

12. The combination of a rotary kiln for heating a material, a constant speed motor for driving the kiln, means including an electric motor for supplying fuel to the kiln, other means including another electric motor for supplying air into the kiln to maintain combustion therein, and means for simultaneously controlling said motors in response to temperature changes in the kiln, said means comprising a pilot motor and a load-responsive device for each of said motors, and an electric circuit for the pilot motors including an element of the load-responsive devices and a contact bar associated with the devices, a reversible motor for adjusting the contact bar, and means including a temperature-responsive device for causing operation of the reversible motor in response to temperature changes in the kiln.

AUBREY SMITH.