July 7, 1970 D. E. SANDBROOK 3,519,815

APPARATUS FOR AND METHOD OF CONTROLLING THE DENSITY
OF RAW MATERIALS FLOWING THROUGH A ROTARY KILN

Filed July 14, 1966 2 Sheets-Sheet 1

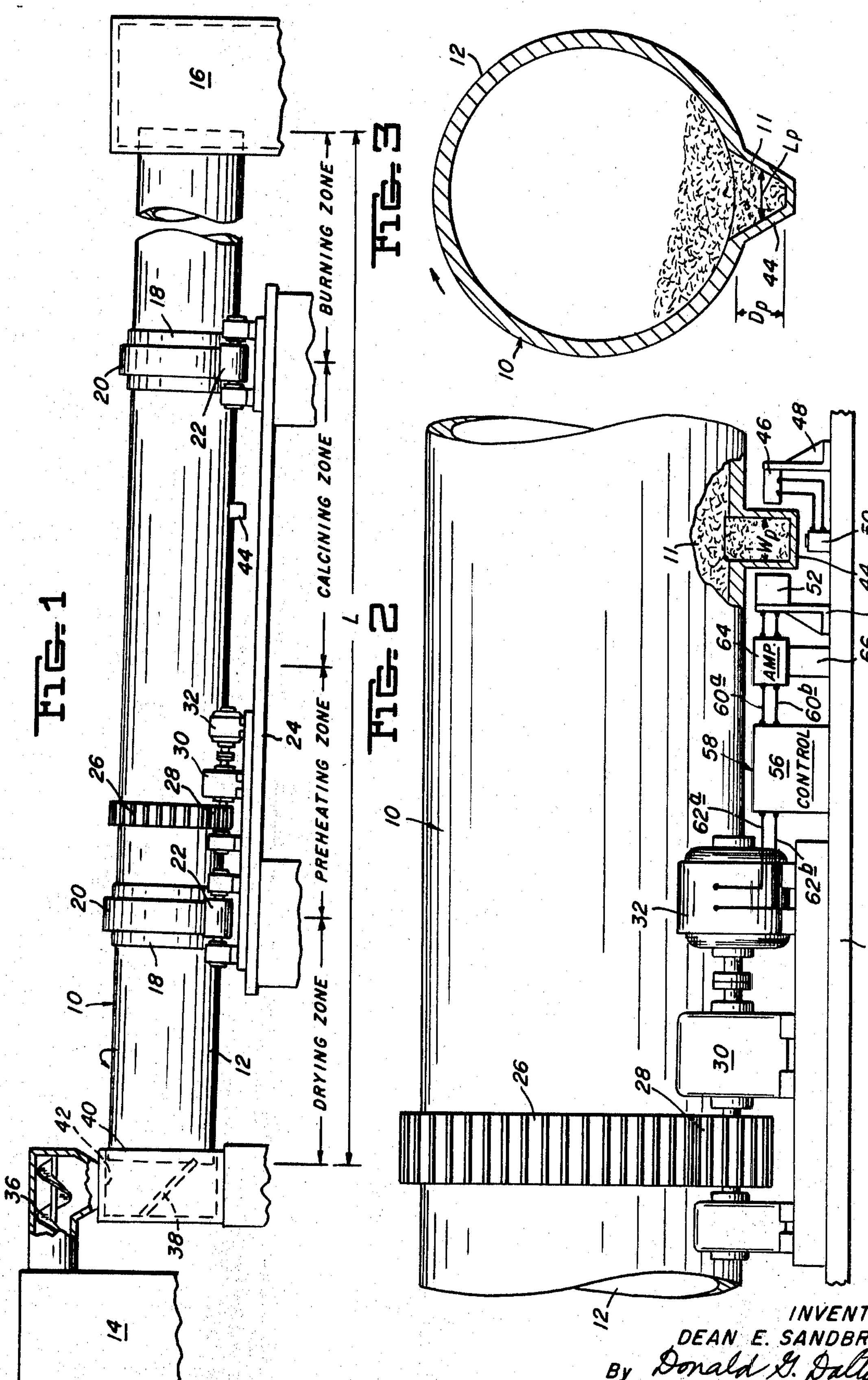

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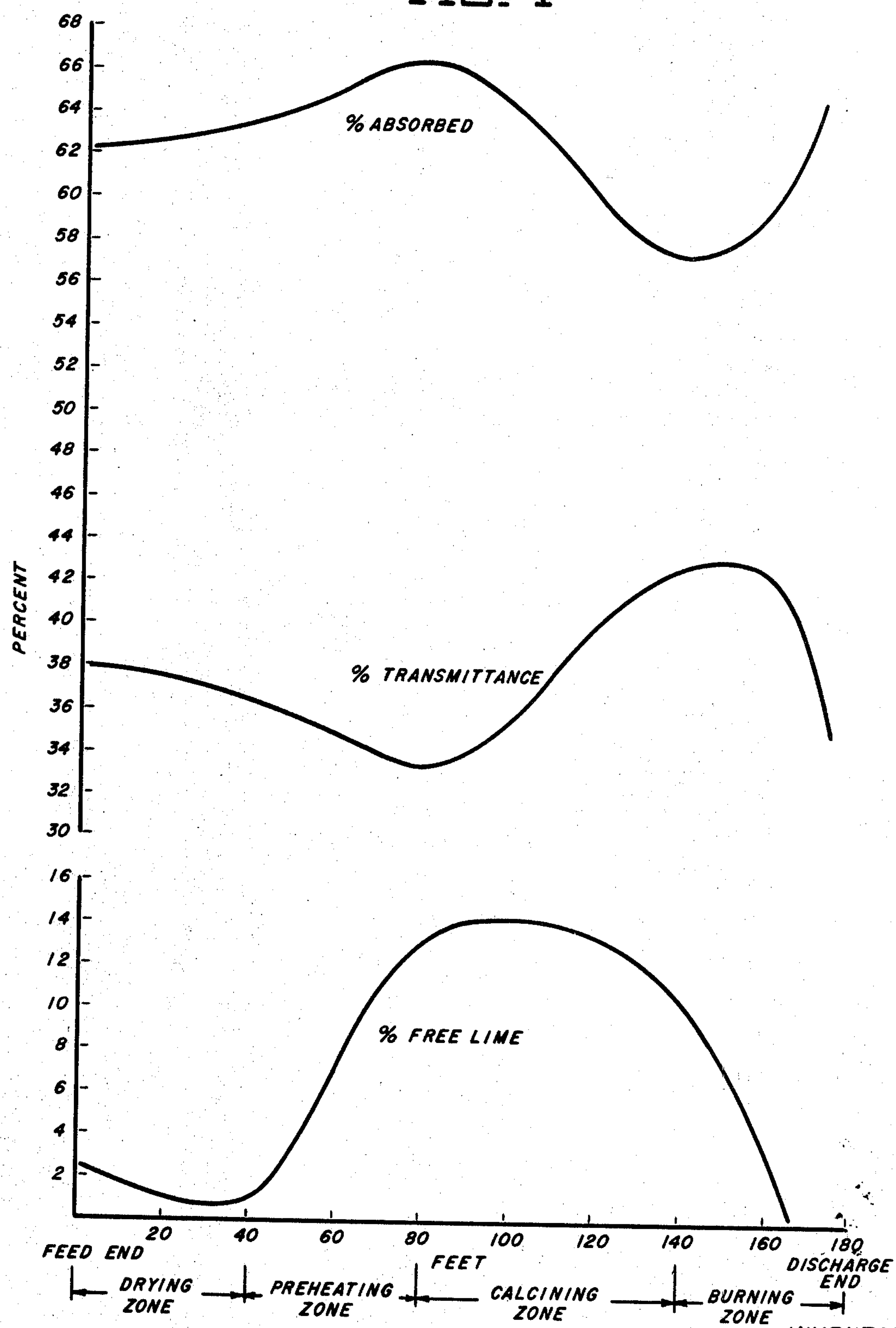
FIG. 4



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APPARATUS FOR AND METHOD OF CONTROLLING THE DENSITY OF RAW MATERIALS FLOWING THROUGH A ROTARY KILN

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U.S. Cl. 250—43.5 10 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to rotary kilns, and more particularly to an improved apparatus for and method of controlling the density of material in a rotating kiln. The apparatus for controlling the density of the raw material flowing through a rotary kiln has a frame, a rotatable kiln rotatable on the frame and adapted to receive the raw material at one end and move the raw material through a work zone to the other end, pocket means provided on the periphery of the kiln adjacent a detecting position and adapted to contain raw material and to move along a rotary path of movement, radioactive source means disposed along the rotary path of movement and operable by movement of the pocket means to direct a beam of radioactive energy through the pocket means and the raw material, detector means disposed adjacent the path of movement and the radioactive source means and adapted to receive radioactive energy transmitted through the raw material and to convert the radioactive energy into an electrical signal, control means connected to the detector means and actuated by the electrical signal, drive means connected to the kiln and the control means, the control means being operable to change the speed of rotation of the kiln and thereby control the density of the raw material in the kiln.

Conventional cylindrical kilns are used to manufacture products, such as portland cement clinker, which clinker is produced by heating or roasting of the raw material to promote chemical reactions therein. The kiln is usually driven by a variable speed drive providing an angular velocity in the range of .75 to 3 minutes per revolution depending on the size of the kiln. The slope of the kiln is generally in the order of about ½ inch per foot or slightly steeper. The raw material which is fed into the upper or feed end of the kiln may comprise either dry powder, filter cake containing 18 to 22 percent moisture, or a slurry containing 30 to 50 percent moisture.

In operation the kiln has a drying zone which begins inside the feed end. In a wet process kiln large quantities of chain are suspended from the shell as a heat transfer medium to expedite drying of the kiln feed. In the raw materials preheating zone the raw material or kiln feed is heated to a temperature where the chemical reactions take place. In the calcining zone the actual pyro-process chemical reactions take place, the calcium carbonates are decomposed and quick lime is produced. In the burning zone the kiln feed is further heated to a temperature where an exothermic reaction takes place producing silicates, aluminates and ferrites. Thereafter, the treated kiln feed or clinker is discharged from the kiln, quenched, cooled and conveyed to storage.

Conventional apparatus for controlling the density of the raw material flowing through a portland cement clinker kiln are of the type shown in the following United States patents: 1,937,094, L. E. Palmer, Nov. 28, 1933; 1,945,652, C. W. Martin, Feb. 6, 1934; 2,303,843, K. R. Knoblauch, Dec. 1, 1942; 2,303,910, D. G. Hare, Dec. 15, 1942; 2,316,239, D. G. Hare, Apr. 13, 1943; 2,661,550, O. W. Graham, Dec. 8, 1953; 2,722,609, G. W. Morgan et al., Nov. 1, 1955; 2,737,529, P. E. Ohmart, Mar. 6, 1956; 2,763,789, P. E. Ohmart, Sept. 18, 1956; 2,807,523, J. Q. Wood, Sept. 24, 1957; 2,958,777, B. S. Sieswerda et al., Nov. 1, 1960; 2,959,932, P. Spergel, Nov. 15, 1960; 3,011,662, H. R. Dailey, Dec. 5, 1961; 3,060,313, P. E. Ohmart et al., Oct. 23, 1962; 3,070,692, P. E. Ohmart et al., Dec. 25, 1962; 3,075,756, D. H. Gieskieng, Jan. 29, 1963; 3,100,841, J. E. Reider, Aug. 13, 1963; 3,128,786, C. O. Badgett, Apr. 14, 1964; 3,160,745, D. G. Foster, Dec. 8, 1964; 3,164,019, G. M. Burgwald et al., Jan. 5, 1965; 3,180,985, G. J. Leighton, Apr. 27, 1965.

In conventional kilns and conventional control apparatus the flow of kiln feed through the four work zones to insure the required reaction time in each zone is difficult to regulate. The density of the kiln feed is uncontrolled prior to the entry of the kiln feed into the burning zone. Delayed exothermic reaction in the burning zone upsets the kiln heat balance. Reduced kiln production and poor quality clinker are also problems.

OBJECTS OF THE INVENTION

It is the general object of the present invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of an improved apparatus for and method of controlling the density of the raw materials flowing through a portland cement clinker kiln, which impoved method and apparatus effectively regulate the flow of kiln feed through the work zones and insures the required reaction time in each zone. Another object is to automatically control the density of kiln feed by automatically regulating kiln velocity prior to entry of the kiln feed into the burning zone. A further object is the elimination of delayed exothermic reactions in the burning zone. Yet another object is to maintain kiln heat balance. A still further object is to provide maximum kiln production and good quality clinker.

BRIEF SUMMARY OF THE INVENTION

The aforesaid objects of the present invention, and other objects which will become apparent as the description proceeds, are achieved by providing an apparatus for controlling the density of the raw material flowing through a rotary kiln. The apparatus has a frame and a rotatable kiln rotatable on the frame and adapted to receive the raw material at one end and to move the raw material through a work zone to the other end. Pocket means are provided on the periphery of the kiln adjacent a detecting position and are adapted to contain raw material and to move along a rotary path of movement. Radioactive source means are disposed along the rotary path of movement and operable by movement of the pocket means to direct a beam of radioactive energy through the pocket means and the raw material. Detector means disposed adjacent the path of movement and the radioactive source means are adapted to receive radioactive energy transmitted through the raw material and to convert the radioacive energy into an electrical signal. Control means are connected to the detector means and actuated by the electrical signal. Drive means connected to the kiln and the control means are operable by the control means to change the speed of rotation of the kiln and thereby control the density of the raw material in the kiln.

The invention also contemplates a method for controlling the density of the raw material flowing through a rotary kiln, the method comprising the steps of rotating the kiln and the raw material to move the raw material from one end of the kiln through a work zone to the other end of said kiln; depositing the raw material in a pocket means on the kiln and moving the pocket means and the contained raw material along a rotary path of movement; directing a beam of radioactive energy through the pocket means and the raw material during the rotary path of movement; and receiving the radioactive energy transmitted through the raw material and covering the radioactive energy into an electrical signal. Such method also includes the stops of actuating a control means by the electrical signal and of changing the speed of rotation of the kiln to control the density of the raw material.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a better understanding of the present invention reference should be had to the accompanying drawings, wherein like numerals of reference indicate similar parts throughout the several views and wherein:

FIG. 1 is a side elevational view partially in section of a rotary kiln incorporating the apparatus of this invention;

FIG. 2 is an enlarged fragmentary side elevational view of the apparatus of the present invention;

FIG. 3 is a vertical sectional view taken along the line III—III of FIG. 2 in the direction of the arrows; and

FIG. 4 is a graph showing length of the kiln in feet plotted against percentage of free CaO in the raw material, percentage of radioactive energy transmitted and percentage of radioactive energy absorbed by the raw material.

Although the principles of the present invention are broadly applicable to rotary kilns, the present invention is particularly adapted for use in conjunction with a rotary kiln for the manufacture of portland cement clinker and hence it has been so illustrated and will be so described.

DETAILED DESCRIPTION

With specific reference to the form of the present invention illustrated in the drawings, and referring particularly to FIG. 1, a rotary inclined kiln of this invention is indicated generally by the reference number **10** and is employed for heat treating a material, such as kiln feed **11**.

As shown in FIGS. 1, 2, 3 the rotary inclined kiln **10** has an inclined member, such as cylindrical shell **12**, which shell **12** extends from a feed house **14** to a burner building **16**. Such shell **12** is provided at spaced intervals with reinforcing sleeves **18** and tires **20** which ride on rolls **22** mounted on a frame **24** of the kiln **10**. This shell **12** is rotatable in a direction, such as indicated by the arrow in FIG. 1, by drive means, such as girth gear **26** (FIGS. 1, 2), pinion gear **28**, gear reduction unit **30** and motor **32**. The rotary inclined kiln **10** may be employed to heat treat a material, such as raw material **11** for cement clinker. This raw material **11** is conveyed by a supply means, such as a screw conveyor **36** (FIG. 1), from the feed house **14** into a feed means **38**, disposed adjacent the shell inlet to a drying zone for introduction of the raw material **11** into the rotary kiln **10**. This raw material or kiln feed **11** may comprise crushed limestone, shale, sand and iron ore. The feed means **38** may comprise, by way of example, a stationary housing **40** disposed about the outer shell **12** and having an inlet **42** from the screw conveyor **36**.

Referring to FIGS. 2 and 3, the apparatus for controlling the density of the raw material **11** flowing through the rotary kiln **10** has in addition to the frame **24**, the shell **12** rotatable on the frame **24** as described above. This shell **12** is adapted to receive the raw material **11** at the left hand end, as viewed in FIG. 1, and move such raw material **11** through work zones, such as the drying zone, preheating zone, calcining zone, burning zone, and quenching and discharging zone to the other or right hand end (FIG. 1) of the kiln **10**.

Pocket means, such as the pocket **44** (FIGS. 1–3), may be provided on the periphery of the shell **12** at a plurality of points along the length L (FIG. 1) of the kiln **10**. For purposes of illustration one such pocket **44** has been shown in FIGS. 1–3 in the calcining zone. The pocket **44** is adapted to contain raw material **11** and moves along a rotary path of movement indicated by the arrows in FIGS. 1 and 3. Such pocket **44** has a width W_p in the range of about 3.0–12.0 inches, a length L_p-to-width W_p-to-depth D_p ratio of about 2 to 1 to 1 and is generally rectangular in horizontal cross section.

A radioactive source means, such as the radioactive source **46** of the type manufactured by Industrial Nucleonics Corporation, Columbus, Ohio, as a Model LS102 or of the type manufactured by the Ohmart Corporation, Cincinnati, Ohio, as a Caesium 137 or Cobalt 60 Source, is mounted on a bracket **48** upstanding from the frame **24** along the rotary path of movement of the pocket **44**. Switch means, such as a normally open microswitch **50**, connected to the radioactive source **46**, is operable by the pocket **44** to close and to cause the source **46** to direct a beam of radioactive energy through the pocket **44** and the raw material **11** in the pocket **44**. Such penetrative radiation may be selected from the group consisting of X-rays, gamma rays, beta rays and neutrons.

A detector means, such as a Geiger Mueller type detector **52** (FIG. 3) of the type produced by the Ohmart Corporation or Industrial Nucleonics Corporation, is disposed adjacent the rotary path of movement of the pocket **44** and the radioactive source **46** on a bracket **54** and is adapted to receive radioactive energy transmitted through the raw material **11** and to convert such transmitted radioactive energy into a measurable electrical signal. The detector **52** usually contains two electrodes (not shown) separated by a filling gas, which gas is ionized by exposure to the nuclear radiation. Positive ions are attracted to the positive electrode (not shown), thus generating an electrical current in the detector **52**.

Control means, such as the controller **56** of the type manufactured by Leeds-Northrup, Philadelphia, Pa., is mounted at **58** (FIG. 3) and connected by leads ***60a***, ***60b*** to the detector **52** and by conductors ***62a***, ***62b*** to the motor **32** of the drive means. Such controller **56** is actuated by the electrical signal produced by the detector **52** and is operable to change the speed of rotation of the kiln **10** thereby controlling the density of the raw material **11** in the kiln **10**.

As hereinafter mentioned the drive means includes the motor **32**, gear reduction unit **30**, pinion gear **28** and girth gear **26**.

It will be understood by those skilled in the art that amplifier means, such as a simple bridge-type amplifier **64** (FIG. 3) of the type manufactured by the Ohmart Corporation, is mounted at **66** and is connected between the detector **52** and the controller **56** for amplifying the electrical signal from the detector **52**. The amplifier **64** has a vacuum tube (not shown) in one arm of the bridge (not shown) and is provided with temperature regulation for the electrometer tube and input load resistor (not shown).

It has been found that the raw material **11** should have a density in the range of 1200–1800 grams/liter. The kiln **10** should rotate at a peripheral speed in the range of 7.0–14.0 inches/second and have a diameter in the range of 10–18 feet. The detector **52** is provided with a measure time of about 1.5–3.5 seconds and the spacing between the radioactive source **46** and detector **52** is in the range of 3.0–13.0 inches. Under these conditions the results shown in FIG. 4 achieve the objects of the present invention.

METHOD

It will be understood from the above description of the apparatus that an improved method of controlling the density of the raw material **11** in the kiln **10** has been provided. This method comprises the steps of rotating the kiln **10** and the raw material **11** to move the raw material 11 from one end of the kiln 10 through work zones (such as the drying zone, raw material preheating zone, calcining zone and burning zone) to the other end of the kiln 10; depositing the raw material 11 in a pocket 44 and moving the contained raw material 11 along a rotary path of movement; directing a beam of radioactive energy through the pocket 44 and raw material 11 during the rotary path of movement; and receiving the radioactive energy transmitted through the raw material 11 and converting the radioactive energy into an electrical signal. Thereafter, are the steps of actuating a control means 56 by the electrical signal and changing the speed of rotation of the kiln 10 to control the density of the raw material 11.

SUMMARY OF THE ACHIEVEMENT OF THE OBJECTS OF THE INVENTION

It will be recognized by those skilled in the art that the objects of the present invention have been achieved by providing an improved apparatus (FIGS. 1–3) for and method of controlling the density of the raw materials 11 flowing through a portland cement clinker kiln 10, which improved method and apparatus effectively regulate the flow of kiln feed 11 through the work zones and insures the required reaction time in each zone, automatically control the density of kiln feed 11 by automatically regulating kiln velocity prior to entry of the kiln feed 11 into the burning zone, eliminate delayed exothermic reactions in the burning zone, maintain kiln heat balance, and provide maximum kiln production and good quality clinker.

While in accordance with the patent statutes preferred and alternative embodiments of the present invention have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

I claim:

1. Apparatus for controlling the density of the raw material flowing through a rotary kiln, said apparatus comprising

(a) a frame,
(b) said rotary kiln rotatable on said frame and adapted to receive said raw material at one end and move said raw material through a work zone to the other end,
(c) pocket means provided on the periphery of said kiln adjacent a detecting position and adapted to contain raw material and to move along a rotary path of movement,
(d) radioactive source means disposed along said rotary path of movement,
(e) switch means adjacent said rotary path of movement, connected to said radioactive source means and operable by movement of said pocket means to cause said radioactive source means to direct a beam of radioactive energy through said pocket means and said raw material,
(f) detector means disposed adjacent said path of movement and said radioactive source means and adapted to receive radioactive energy transmitted through said raw material and to convert said radioactive energy into an electrical signal,

(g) control means connected to said detector means and actuated by said electrical signal, and
(h) drive means connected to said kiln and said control means, said control means being operable to change the speed of rotation of said kiln and thereby control the density of said raw material in said kiln.

2. The apparatus recited in claim 1 and having amplifier means connected to said detector means for amplifying said electrical signal.

3. The apparatus recited in claim 1 wherein said kiln has a diameter in the range of 10–18 feet.

4. The apparatus recited in claim 1 wherein said raw material has a density in the range of 1200–1800 grams/liter.

5. The apparatus recited in claim 1 wherein said kiln has a peripheral speed in the range of 7.0–14.0 inches/second.

6. The apparatus recited in claim 1 wherein said pocket means has a length-to-width-to-depth ratio of about 2 to 1 to 1.

7. The apparatus recited in claim 1 wherein detector means has a measure time in the range of about 1.5–3.5 seconds.

8. A method for controlling the density of the raw material flowing through a rotary kiln, said method comprising the steps of

(a) rotating said kiln and said raw material to move said raw material from one end of said kiln through a work zone to the other end of said kiln,
(b) depositing said raw material in a pocket means on said kiln and moving said pocket means and said contained raw material along a rotary path of movement,
(c) actuating a switch means disposed adjacent said rotary path of movement and connected to a radioactive source means by said pocket means to direct a beam of radioactive energy from said radioactive source means through said pocket means and said raw material during said rotary path of movement, and
(d) receiving the radioactive energy transmitted through said raw material and converting said radioactive energy into an electrical signal.

9. The method recited in claim 8 and including the step of actuating a control means by said electrical signal.

10. The method recited in claim 9 and including the step of changing the speed of rotation of said kiln to control the density of said raw material.

References Cited

UNITED STATES PATENTS

2,565,963 8/1951 Graham.

FOREIGN PATENTS

151,054 1962 U.S.S.R.

RALPH G. NILSON, Primary Examiner

M. J. FROME, Assistant Examiner

U.S. Cl. X.R.

250—83.3

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,519,815 July 7, 1970

Dean E. Sandbrook

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 71, "2,303,910" should read -- 2,304,910 --. Column 2, line 59, "acive" should read -- active --. Column 3, line 5, "covering" should read -- converting --; line 6, "stops" should read -- steps --; line 57, cancel "shell". Column 4, line 11, after "46" insert -- (Figure 3) --; line 46, "hereinafter" should read -- hereinbefore --.

Signed and sealed this 16th day of February 1971.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents