HEAT PROCESSING SYSTEM AND FURNACE

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2 Sheets-Sheet 1

FIG. 1.

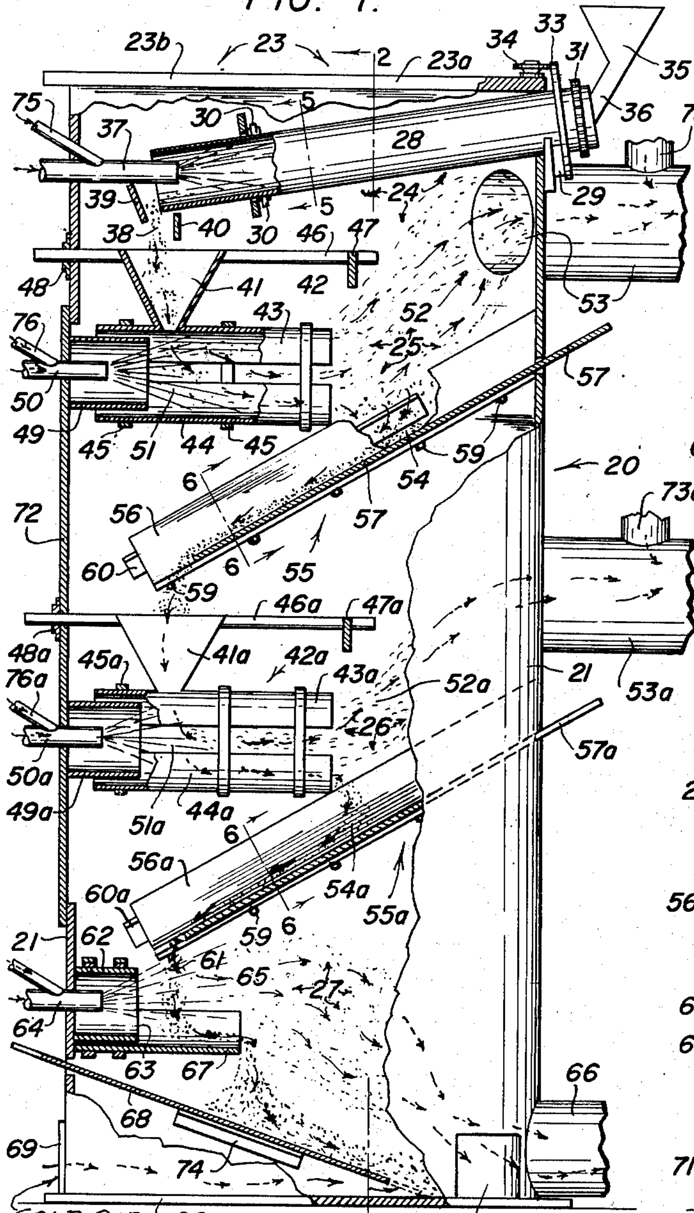

FIG. 2.

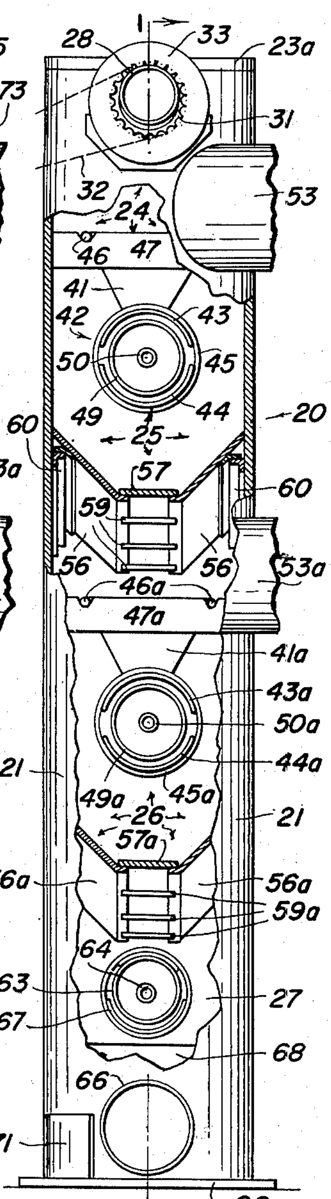

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FIG. 3.

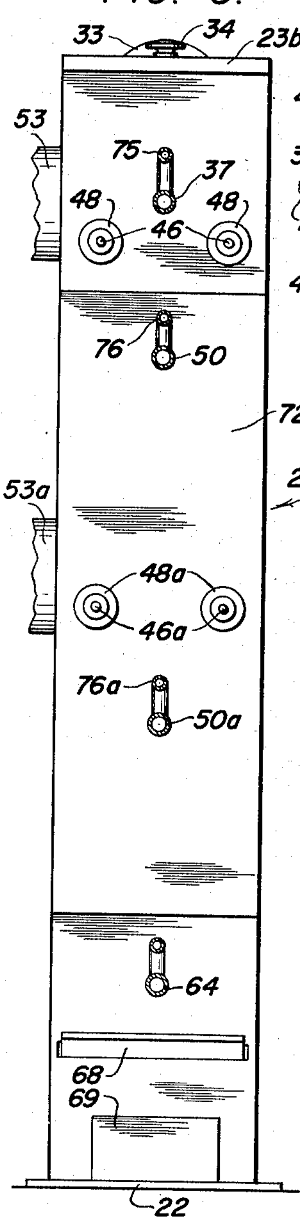
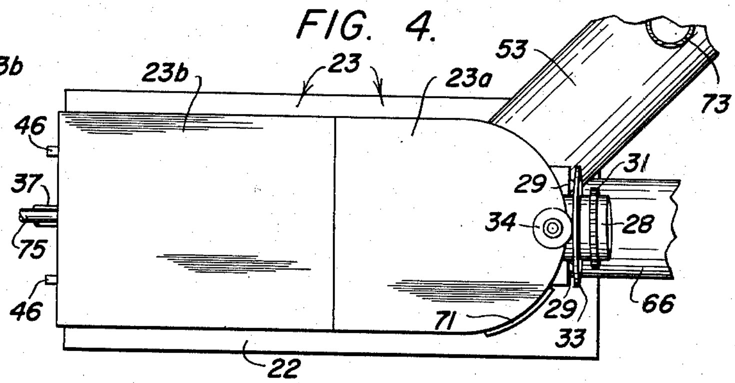


FIG. 4.



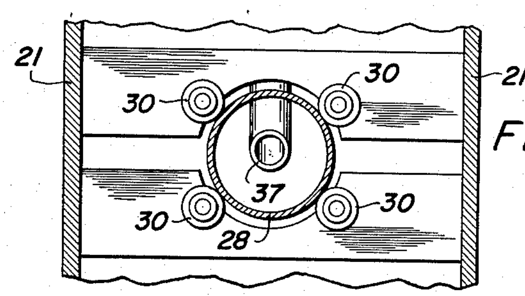


FIG. 5.

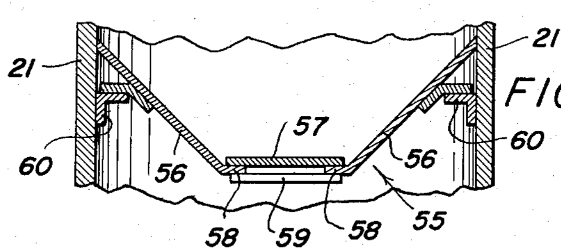


FIG. 6.

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HEAT PROCESSING SYSTEM AND FURNACE

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14 Claims. (Cl. 263—21)

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This invention relates to a heat processing system and furnace.

Principal objects of the invention are:

To provide a multiple-zone furnace structure wherein greatly varying requirements in the heat treatment of certain substances are controlled step by step so as to achieve complete processing in a single pass through the furnace.

To economize fuel by making efficient use of the generated heat.

To be adaptable to the efficient production of finished materials of many different kinds.

To attain a high degree of precision and uniformity in meeting given material specifications.

To attain simplicity, convenience and durability in the furnace structure.

Other objects will become evident hereinafter.

A feature of the invention is that it is especially adapted to the processing of all kinds of raw materials that require heating in successively increasing temperature stages. In the successful treatment of many different kinds of substances we have found that it is highly advantageous as a first step of processing, to remove the film of moisture which, in the natural condition, surrounds the individual particles of the material. We accomplish the removal of the moisture film immediately after the raw material enters the furnace, by subjecting the particles simultaneously to moderate degrees of agitation and of heat. Furthermore, the successive stages or steps of a process are accomplished in a single pass of the material through the furnace.

Some of the peculiar conditions encountered in the processing of discrete raw materials such as ores, earths, minerals and so on, are that different specimens vary greatly in composition. In the sizing of such materials it is practically impossible to bring about any substantial uniformity in the actual dimensions of the individual particles. Obviously, large particles require a longer time to reach a critical processing temperature than is the case with small particles.

It is a further feature of the invention that various zones are provided in which the temperature and other processing conditions are graduated and are selectively regulable according to the varying compositions and sizes of the particles passing through those zones.

Some materials are most efficiently and economically processed when exposed to the direct action of a flame obtained from the combustion of natural gas, artificial gas or oil. The elapsed time interval of exposure of a material to the action of a flame to effect the desired degree of

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treatment, will vary with the size of the particle.

As a means of controlling the elapsed time interval required, an adjustable device is provided whereby the length of time particles are suspended or held in the flame, can be sensibly varied.

It happens, too, that in cases where large ore particles are exposed to the sustained action of a flame for the length of time required to raise the center portions of the particles to the required critical temperature, fracturing occurs. Fracturing is not desirable since many commercial products require the utilization intact of the larger particles.

Therefore, as soon as an ore particle has approached the critical point, it must be coincidentally cooled to avoid over-treatment. For this purpose, cooled air is introduced into a cooling chamber which is a part of the exhaust system provided for each burner unit of the multiple burner feature of the furnace. An adjustable device is also provided to enable an operator to control the volume of cool air necessary to quench the particles.

Since the density of a material greatly affects its capacity for heat absorption, and since proper dispersion of the particles in a mass affects the extent of exposure to heat absorption, the selective control of these factors afforded by the invention is important.

In the furnace of the invention it is advantageous to arrange the successive treatment zones vertically in the form of a stack or shaft. In a preferred arrangement, the first or moderate heating zone is at the top and in proximity to the point where the raw material enters. Thus, all portions of the raw material are first subjected to a light processing heat for removal of surface moisture. After such removal of surface moisture, those particles which require only a moderate temperature, are removed after passing into or through the second zone. In the subsequent lower zones, those particles which are not susceptible of complete treatment in the preceding zones, automatically determine their own zones of process completion and ejection from the furnace.

In the accompanying drawings, which illustrate one embodiment of the apparatus of the invention:

Fig. 1 represents a side elevation largely in section taken on the line 1—1 in Fig. 2;

Fig. 2, a rear elevation largely in section taken on the line 2—2 in Fig. 1;

Fig. 3, a front elevation;

Fig. 4, a top plan;

Figs. 5 and 6, fragmentary sections taken on the lines **5—5** and **6—6**, respectively, in Fig. 1, these figures being drawn to an enlarged scale.

Referring to the drawings: The numeral **20** denotes a housing structure having the walls **21**, the base **22** and the cover or top **23**. The cover is in two parts, the stationary part **23*a*** and the removal part **23*b***. Within the housing **20**, as presently shown, are successive processing zones **24, 25, 26, 27**. Processing commences in the upper zone **24** and is continued in the successive zones **25** to **27**. Rotatably disposed in the upper zone **24** is a tubular feeder and drier **28**. The feeder for illustration, is supported by trunnions **29** and **30**. The tube **28** is driven by any suitable means, in this instance, by an annular sprocket wheel **31** fixed on the tube. In turn the sprocket wheel may be driven by any suitable means, for example, a sprocket chain **32** that extends to an electric motor (not shown). The front portion of the tube **28** is retained in place by means of an annular thrust collar **28*a*** that bears against a thrust roller **33**, while the rear portion of the tube is subject to the guard rollers **34**. At **35** is a hopper disposed to receive raw material which flows from the spout **36**, the latter being extended into the tube **28**. The tube can be rotated in either direction, the action upon the material passing through the tube being the same in both cases. The tube **28** is particularly well adapted for use with the present invention, for the reason that in rotating, the material passing through the tube tends to be carried upwardly because of its frictional cohesion to the inner surface of the tube, until gravity acts to pull the material back. Thus the path described by the material with reference to the inner surface of the tube, as it slides back in successive steps, is largely zigzag. This zigzag motion constantly distributes and redistributes the passing material, thereby exposing fresh particles to both contact with the tubular shell and to a current of air that enters through a pipe **37** at the lower end of the tube. As will subsequently appear, the tube is heated largely by the hot gases which ascend from the lower zones of the furnace. In the gradual descent of the material through the tube, it is constantly exposed to the current of air coming in through the pipe **37**, which current assists to efficiently dry the raw material. The upper end of the tube **28** is open so that there is no obstruction to the passage of the air and vapor through the tube, which is inclined.

The dried material that is discharged from the tube, as indicated at **38**, is guided by means of baffles **39** and **40** into a hopper **41** forming part of a traveling material distributer **42**. This distributer **42** includes the upper, or head section **43** and the lower trough section **44**, these sections being held together by exterior bands **45** which are welded or otherwise connected to the respective sections. The upper section **43** is rigidly connected to the hopper **41** by means of welding or otherwise, and the hopper in turn is rigidly connected to two guide bars **46**. These guide bars are movable longitudinally on a supporting beam **47** and in a guide bearing **48**, the latter being attached to the wall **21**. The beam **47** is preferably stationary and extends rigidly from side to side of the housing **20**.

Substantially concentric axially with the distributer **42** and extending into the space between the hood **43** and trough **44** is a burner which includes a fuel tube **50**. Fluid fuel such as gas,

enters through the tube **50** under pressure and after ignition tends to create a blast somewhat after the manner as indicated at **51**. The blast is composed largely of products of combustion and carries forward and distributes the stream of material that drops from the drier **28** into and through the hopper **41**. The fluid current **51** is designed to be selectively controlled by suitable valve means, not shown, to effect the proper conditions demanded by the dried material which drops into the current in a further processing step. Such particles of the material as have been susceptible to light treatment, are carried upwardly as indicated at **52**, into and through an outlet pipe **53** which leads to a suitable point of disposal (not shown). This lightly treated, discharged material constitutes as a rule, a finished product ready for market. Such portions of the material which require a greater degree of treatment, are discharged from the distributer approximately as indicated at **54**.

The greater portion of the particles rejected along the lines **54** drop into a chute **55** which in this instance, is composed of the side plates **56** and a slidable bottom plate **57**. The side plates **56** are inclined inwardly and are spaced apart so as to accommodate the slide **57**, as indicated in Fig. 6. The side plates **56** are flanged at **58** and are rigidly connected to each other by means of cross bars **59**, the latter being welded or otherwise attached to flanges **58**. The upper portions of the side plates **56** may be suitably attached to supporting angles **60**, which in turn are connected to the respective walls **21**. The rejected material from the distributer **42** descends by gravity along slide **57** which may be adjusted so as to drop the material into a traveling hopper **41*a*** that constitutes part of a second traveling distributer **42*a***.

The second distributer preferably is similar to the one at **42** which has previously been described in detail. This second distributer **42*a*** is provided with a burner **49*a***, served by a fuel tube **50*a***, these being similar to the burner **49** and fuel tube **50** previously described. The products of combustion which are discharged through the burner **49*a*** act along the lines **51*a*** in a manner similar to that described in connection with the lines **51**. It will be understood that the rejected material **54** which gravitates along the slide **57** is discharged into and passes through the hopper **41*a*** and in turn encounters the second current **51*a*** of combustion gases. In the current **51*a***, those particles which have been incompletely processed, are here subjected to such selectively changed processing conditions as may seem desirable. Some of the particles which are discharged from the distributer **42*a***, and more especially the lighter portions thereof, may travel upwardly as indicated by the lines **52*a***, and pass into the discharge pipe **53*a***. The heavier and less completely treated particles are deposited in a chute **55*a***, which is similar in construction and operation to chute **55** hereinbefore described. The chute **55*a*** is provided with a slide **57*a*** which is manipulated in a manner similar to that shown at **57**. The result is that those particles of the material which require still other processing conditions, are discharged from the distributer **42*a*** substantially along lines indicated at **54*a***. These particles gravitate along the slide **57*a*** and are discharged somewhat as indicated at **61**. The particles at **61** are subjected to a blast **62** of combustion gases coming through a burner **63** which is served by a fuel tube **64**. The lighter of the particles at **61** are carried forward by the blast along the lines 65 and pass directly out of the furnace through the pipe 66. The heavier of the particles at 61 pass along and out from a trough 67 with a tendency to settle on the inclined plate 68 which is slidable on supporting angles 74, the latter being fast on the housing wall.

At 69 is located an adjustable cold air inlet and at 70 is an inspection opening normally covered by a plate 71. A removable end plate 72 is provided for access to the interior of the furnace.

Connected to the discharge pipes 53 and 53*a*, respectively, are adjustable cold air inlets 73 and 73*a* which function as suction controls for the purpose of regulating the current of finished material passing through pipes 53 and 53*a* respectively.

The slides 57 and 57*a*, as well as the inclined plate 68, protrude from the housing so as to be easily manipulated by an operator to the required adjusted position for any particular purpose. Similarly, the guide bars 46 and 46*a* protrude for adjustment or other purposes.

The pipe 37 has a branch 75, and the tubes 50 and 50*a*, the respective branches 76 and 76*a*. These branches are largely for the purpose of introducing reagents, for example, in the form of gases or vapors in the treatment of the materials passing through drier 28, and through the distributers 42 and 42*a*.

The zones 24 to 27 are not sharply defined, but have more or less variable limits that are brought into being by the selective manipulation of the operative devices provided in the respective zones.

The apparatus of the invention is peculiarly suited to practice a system of heat manipulation based on the principle of a thermal interval. This term we choose to define as the time intervening between recurrences of similar processing states. In other words, it makes positive heat exchange or heat transfer at any given or required period of time in recurring or multiple states or stages. This system has many advantages over the prolonged or sustained method of heat application and heat transfer.

Employment of the thermal interval principle permits diffusion of heat throughout the absorbing mass thus maintaining greater uniformity of temperature and avoiding extreme contrasts between the outer or exposed surfaces and the interior or center of the mass.

Each terminal interval may be one of high or low degree of temperature as required.

The number of superposed zones of processing can be indefinitely increased depending upon the nature of the thermal intervals employed. Each additional zone means the repetition of the mechanical determinants.

The apparatus may be used for dehydrating, calcining, sintering, nodulizing or other process where uniform heat diffusion is required or desired.

In the invention, an important difference is recognized between merely removing the surface film of natural moisture from discrete material, as mentioned earlier herein, and dehydration. Dehydration, as that term is herein used, means largely the handling of the combined water of a substance, such as the water of crystallization, in a way or ways that a predetermined result is advantageously reached. For illustration, in some materials as found in nature, if the water of crystallization is removed gradually, either in a single step or in multiple steps, the end product may have certain characteristics. But if, on the contrary, the same water of crystallization is subjected to heat gradations that are speeded up, an end product having far different physical or chemical characteristics may be inevitable.

The manner of applying the requisite heat selectively by means of the adjustable distributers 42 and 42*a* and the respective burners and appurtenances, appear to make results possible which have heretofore been unattained. The superposed arrangement alone of these distributors and the intercombined feed chutes effects an economy in fuel consumption and in heat distribution that are distinctly new.

What is claimed is:

1. A multiple-stage processing furnace comprising a furnace structure enclosing a plurality of successive processing zones superposed one upon another, each zone being nominally defined by means of a blast-generating burner directed transversely of the furnace; means operative to selectively control each blast-generating burner; distributer means associated with each burner for receiving and disseminating within it the blast of the burner; each said distributer means after the first zone including a longitudinally extending trough; an inverted trough in opposition to, and spaced longitudinally apart from, the first-mentioned trough, to provide longitudinal openings between the troughs for causing the furnace atmosphere and the blast to blend with each other; and means for delivering comminuted material to each distributer means.

2. A processing furnace according to claim 1, wherein each longitudinally extending trough is a channel having in cross-section approximately the shape of a crescent with upstanding horns; wherein each inverted trough is a channel having in cross-section approximately the shape of a crescent with downstanding horns; and wherein each distributer means after the first zone includes a material-receiving traveling means from which comminuted material from a previous zone passes into the corresponding distributer means.

3. A processing furnace according to claim 2, wherein each distributer means after the first zone includes guide means along which it is selectively movable with respect to the burner.

4. A processing furnace according to claim 1 wherein the distributer means of the first zone consists of an inclined, rotatable, tubular conduit extending across, and substantially defines, the uppermost of said processing zones.

5. A processing furnace according to claim 4 wherein is included nozzle means disposed to selectively direct draft fluid into and through said rotatable, tubular conduit.

6. A processing furnace according to claim 5 wherein is included a source of fluid reagent; and means operative to selectively dispense fluid reagent into and through said nozzle means.

7. A multiple-stage processing furnace comprising a plurality of superposed processing zones, the uppermost of said zones being equipped with mechanism operative to convey material to be processed, transversely through said uppermost zone; means operative to heat and dry said material in its passage through said conveying mechanism; traveling hopper means operative to direct material from the conveying mechanism down through the lower zones; and means disposed to feed material into said conveying mechanism.

8. A multiple-stage heat processing furnace comprising a plurality of superposed zones, the uppermost of said zones containing heating and drying equipment disposed to conduct material

across such uppermost zone and to discharge the material at one end thereof; a traveling processing unit disposed to receive the material from the heating and drying equipment and to disperse such material through the space of the next lower zone; said traveling processing unit being adapted to at least partially define a blast dominated space; a burner adapted to direct a processing blast into and through said space and to propel at least considerable portions of the dispersed material upwardly in a stream; suction means disposed to conduct such considerable portions away for disposal; and a source of raw material feeding into the heating and drying equipment.

9. A processing furnace comprising a shaft-type vertically disposed structure having enclosing walls that define a multiple-zone processing space; an inclined tubular feeder located transversely in the upper portion of the shaft structure, said tubular feeder having a material intake terminal outside and a material discharge terminal inside said shaft structure; a source of material; a nozzle pipe disposed to direct a fluid current into the tubular feeder so as to pass from the material discharge terminal out through the intake terminal; actuating means disposed to rotate the tubular feeder; a traveling processing unit disposed to receive material falling from the tubular feeder; blast means disposed to selectively direct a fluid blast into said processing unit so as to engage material passing therethrough and to discharge the same so as to cause the discharging material to be divided into a fully processed portion and a partially processed portion; means disposed to receive and to conduct away, the fully processed portion; chute means disposed to receive the partially processed portion and to convey the same by gravity into a succeeding processing unit; another chute means disposed to convey the material from said succeeding processing unit for delivery into the lower part of the shaft; and means operative to remove the delivered material out of said shaft.

10. A processing furnace according to claim 9 wherein each of the said traveling processing units comprises a hopper mounted on longitudinally adjustable guides; a hood depending from said hopper; a trough depending from said hood; and blast-generating means disposed to selectively direct a fluid current through the space included between said hood and said depending trough.

11. A processing furnace according to claim 9 wherein each of the chute means includes transversely inclined side portions spaced apart from each other; and a longitudinal slide disposed to be moved back or forth and to variably cover the space included between said side portions.

12. A processing furnace according to claim 9, wherein said removing means for delivered material comprises fluid blast means; and outlet means extending from the fluid blast means through a wall portion of said shaft structure.

13. A processing furnace according to claim 12 wherein said outlet means includes an inclined plane located below and between the blast means and said wall portion.

14. A processing furnace according to claim 13, wherein said inclined plane is slidably adjustable along the length thereof; and wherein a cold air inlet leads into the space below said inclined plane.

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