

[54] MATERIAL REDUCING SYSTEM AND APPARATUS

[75] Inventor: Robert M. Williams, Ladue, Mo.

[73] Assignee: Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.

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[58] Field of Search 241/19, 23, 24, 48, 58, 65, 241/68, 79, 81

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Primary Examiner—Roy Lake

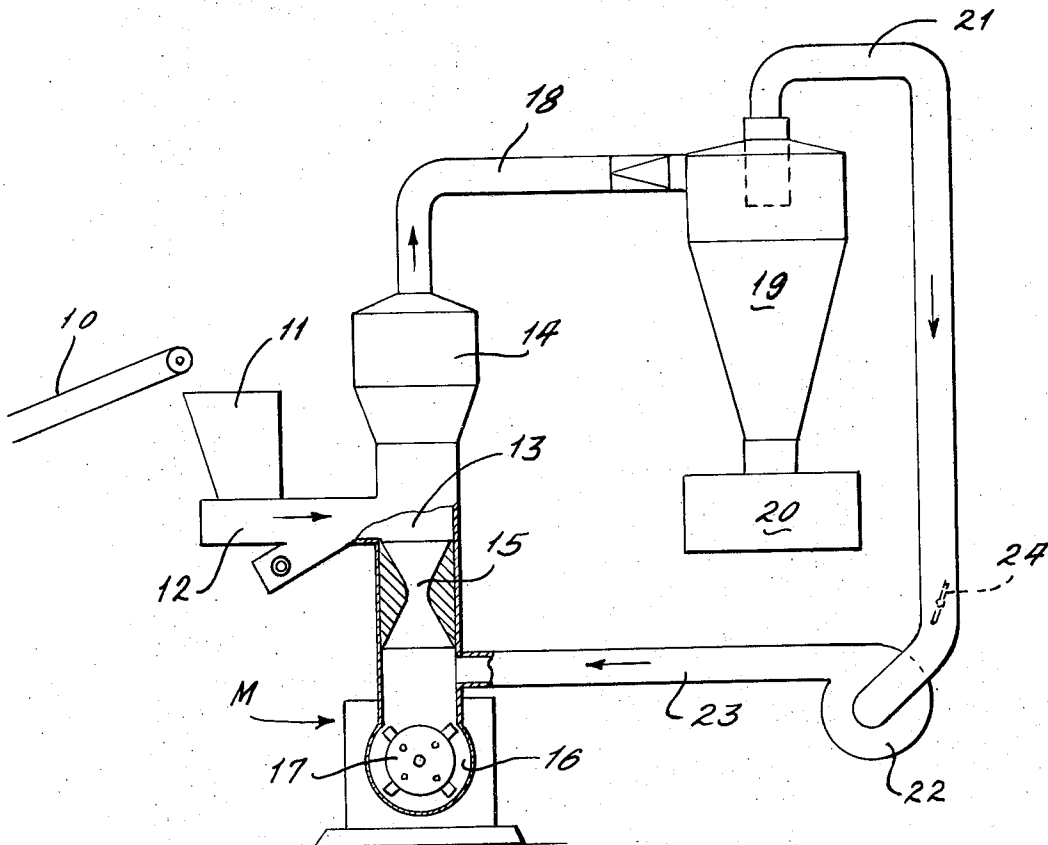
Assistant Examiner—E. F. Desmond

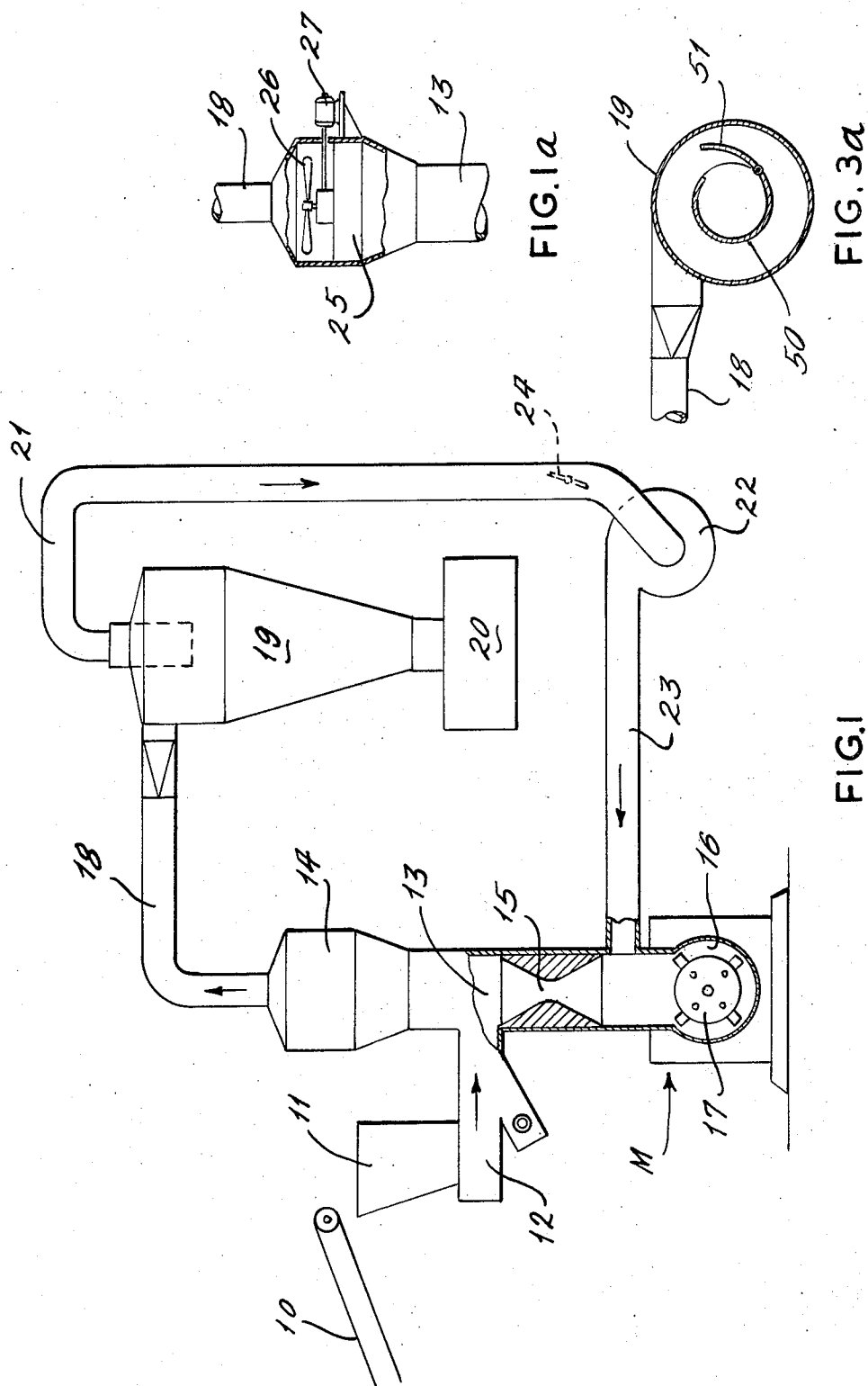
Attorney, Agent, or Firm—Gravely, Lieder & Woodruff

[57] ABSTRACT

A material reducing system having apparatus in which a venturi is inserted in the air circulating means at a point or place to control the size or weight characteristics of material which is allowed to enter a reducing mill which reduces the material and returns it through the venturi to the circulating means. The system includes supporting components to enable operation with heat for drying moisture containing material, for separating the fines from the circulating air, and for supplying fines as a source of fuel to produce the drying heat.

11 Claims, 7 Drawing Figures





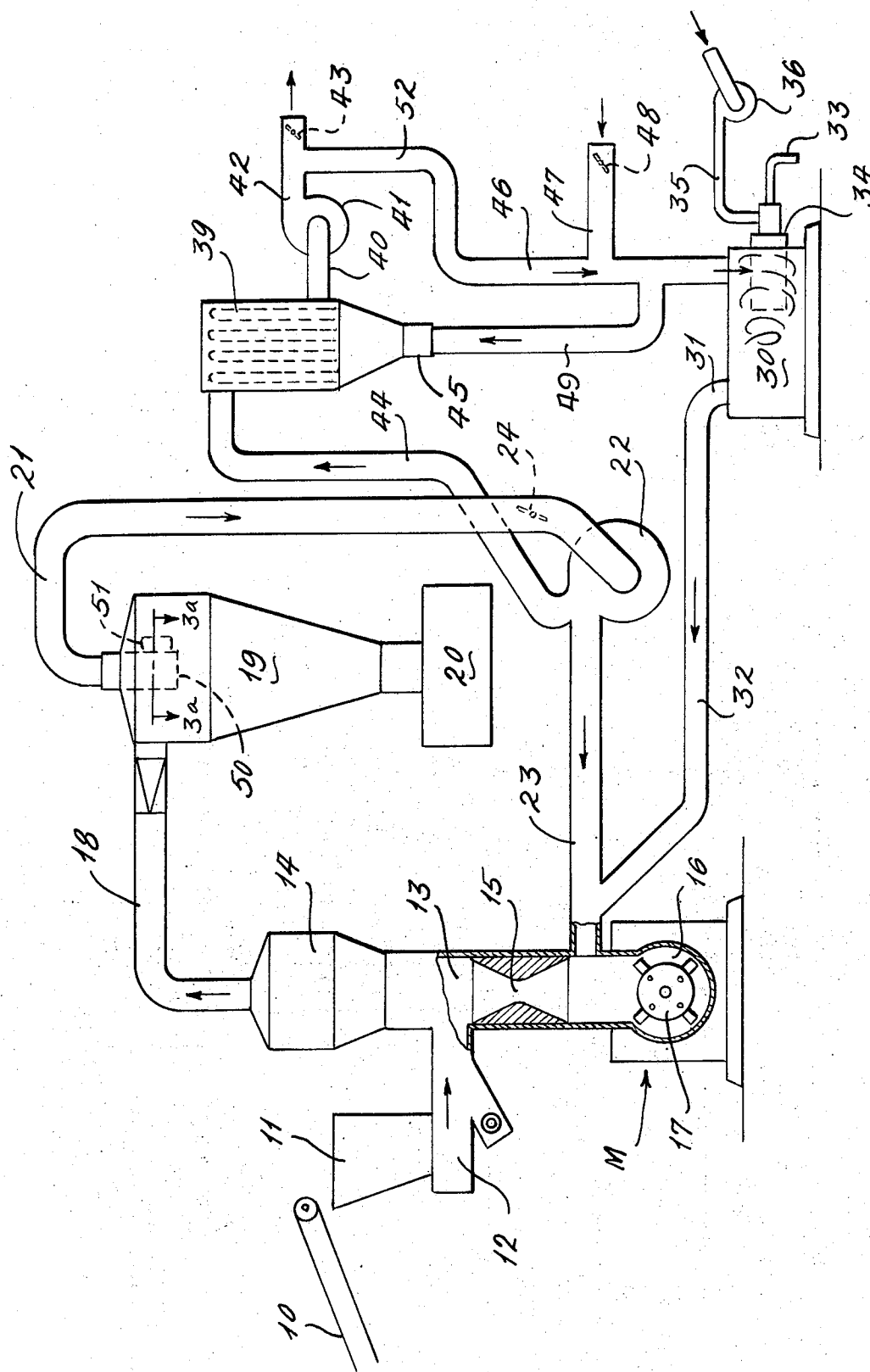


FIG. 3

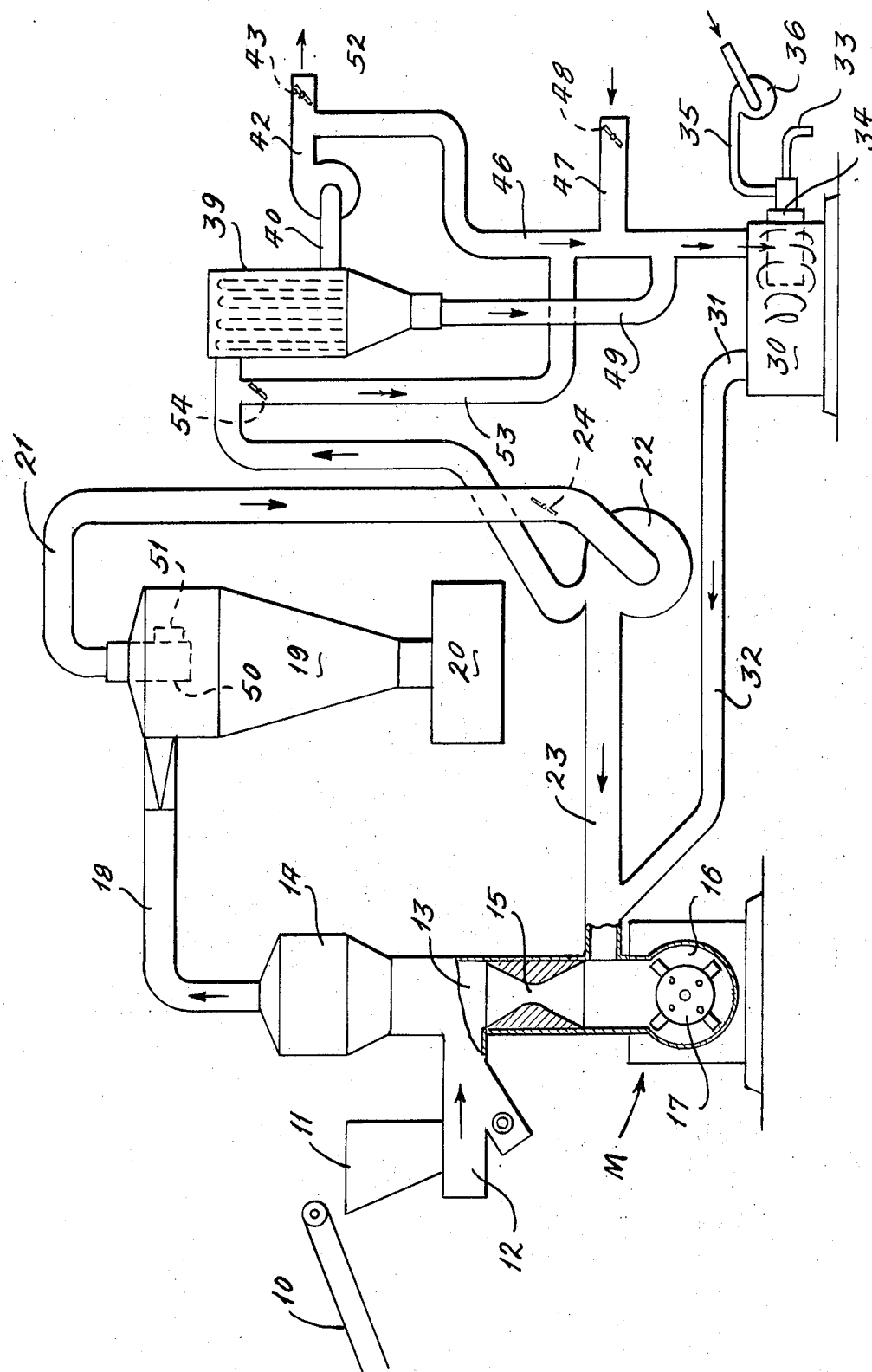


FIG. 4

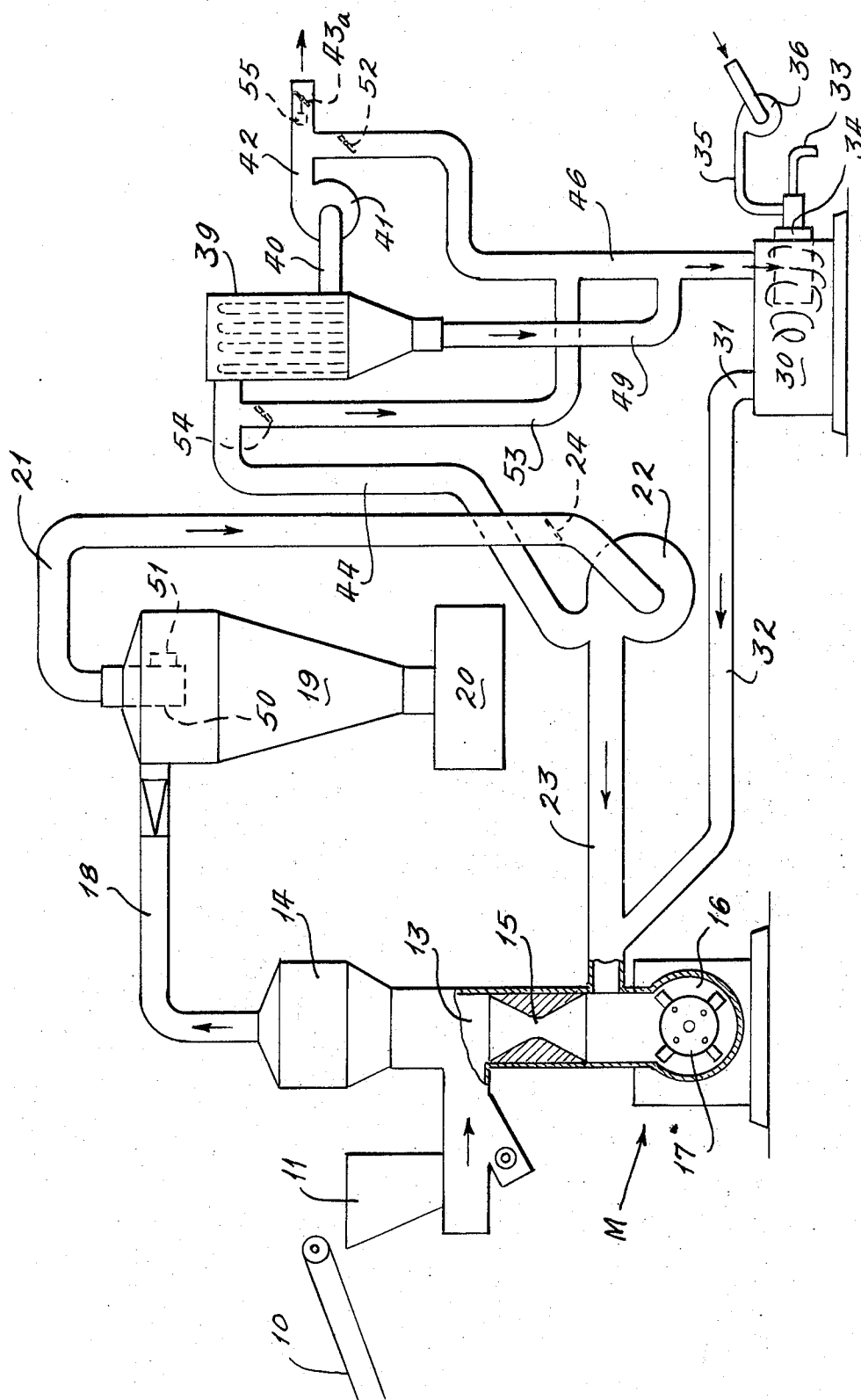


FIG. 5

MATERIAL REDUCING SYSTEM AND APPARATUS

BRIEF SUMMARY OF THE INVENTION

This invention relates to material reducing systems and apparatus therefor, whereby a product may be produced from such materials as wood chips and bark that may be dry or contain a high percentage of moisture.

The produce produced by the apparatus of the present system is typical of the material used in conventional steam generating plants for the consumption of waste materials that have fuel value. The system apparatus may also be utilized to handle friable materials which can be reduced to desired size by impact. Friable materials usually contain a certain percentage of fines which occurs merely by the result of handling procedures, and such fines can be reduced to objectional dust if subjected to impact in the mill apparatus provided for reducing the larger particles.

Should the materials brought to the present system for reduction have a moisture content that would make the reduction difficult, the system apparatus may include heater means for drying the material. When the apparatus applies heat it must be equipped to avoid fire or spontaneous combustion or explosion, as well as turn out a final product that must be confined until cooled below the combustion temperature before being exposed to ambient atmosphere.

The preferred systems hereof embody a novel mill and expansion chamber arrangement whereby a fluid bed of material is established above the mill by an air circulating blower creating a flow through a venturi of a velocity sufficient to suspend the fines in the incoming material while allowing the larger and heavier particles of the material to separate out and pass down through the venturi to be impacted by the mill hammers and forceably returned through the venturi after being reduced to a size capable of being suspended in the flow above the venturi. The particles of the material suspended in the air flow are transported to a cyclone separator for removal in the usual manner so that substantially clean air is returned from the cyclone separator to the blower for recirculation. An initially dry friable material can be handled efficiently in a primary system of the character set forth.

When, however, the material contains moisture it is difficult to reduce properly and the primary system must include means to effect moisture removal. Moisture removal may be accomplished in accordance with the means heretofore set forth in my prior U.S. Pat. No. 3,610,594 in which a heater is embodied in the system in several ways such that drying heat can be supplied with or without attaining an inert atmospheric condition in the system.

The primary objects of this invention, therefore, are to produce a product from friable materials by selective grinding without producing a high percentage of extreme fines, to handle friable material in a manner to keep the fines out of the grinding or hammer mill so that further unnecessary reduction of the fines is avoided, to process moisture containing materials in a system that dries material and exhausts the moisture, to provide a system that may operate with an inert internal atmosphere to suppress and avoid fire, spontaneous combustion and explosion hazards, and to provide certain novel and useful alternate arrangements of apparatus

in material processing systems for turning out a desired product without creating objectionable pollution of the ambient atmosphere around the apparatus.

The system apparatus herein preferred may include, in addition to a primary arrangement of a grinding or hammer mill having a venturi in its outlet and an expansion or flotation chamber beyond the venturi relative to the mill, components and supporting apparatus and duct connections for achieving moisture removal and separation of fines for use as a source of fuel for the drying process.

BRIEF DESCRIPTION OF THE DRAWINGS

Certain preferred embodiments of the apparatus are shown schematically in the accompanying drawings, wherein:

FIG. 1 is a schematic view of a material reducing system showing a primary arrangement of apparatus components for reducing friable materials;

FIG. 1A is a fragmentary view of an alternate component which may be inserted in the system of FIG. 1 and other views of the system;

FIG. 2 is a schematic view of a material reducing system showing the primary arrangement and components combined therewith;

FIG. 3 is a schematic view of a material reducing system of the character of FIG. 2, but with certain modifications for expanding the system operation;

FIG. 3A is a fragmentary sectional view of a modified cyclone separator, the view being taken at 3A—3A in FIG. 3;

FIG. 4 is a schematic view of a material reducing system of the character of FIG. 3, but with certain modifications for expanding the system operation; and

FIG. 5 is a schematic view of a material reducing system of the character of FIG. 4, but with certain modifications to cause the system to operate under internal pressure so that leaks are outward of the duct system.

DESCRIPTION OF THE APPARATUS

Reference will now be directed to FIG. 1 of the accompanying drawing where there is shown schematically apparatus for practicing the invention heretofore briefly summarized. The primary arrangement of apparatus includes a suitable conveyor 10 for bringing the material to be reduced to a hopper 11 which directs the material into a vibratory feed unit 12 of conventional construction. Any feed means can be used, but it is preferred in this instant to use a vibratory feed mechanism and to operate the unit 12 with the hopper 11 continually filled so as to exclude as much as possible the inflow of ambient air. The vibratory feed unit delivers the material into an upwardly directed passage 13 which opens into an expansion chamber 14. The passage 13 communicates with a venturi throat 15 which is both an outlet and an inlet for a suitable mill (M) having a rotor chamber 16 to enclose the usual hammer rotor 17 which is operable to run in one, or either, direction.

The expansion chamber 14 opens into a conduit 18 which delivers material tangentially into a conventional cyclone separator 19 where the material flowing in the airstream is separated out and is collected in a suitable bin 20, while the substantially clean air is delivered through conduit 21 to the suction side of a blower 22. The deliver conduit 23 from the blower 22 returns the air to the passage 13 below the venturi 15.

The apparatus of FIG. 1 is designed to reduce friable material such as wood chips and bark to a uniform product which is delivered into the bin 20. The wood chips and bark is delivered to the hopper 11 and is conveyed by the vibratory unit 12 into the passage 13. The blower 22 is, of course, operated to create a circulation or flow of air upward through the venturi 15 and around the circuit including the expansion chamber 14, the cyclone separator 19 and the return conduit 21 to the blower 22. A damper 24 is operably mounted in the conduit 21 near the suction inlet of the blower 22 so that the velocity of the circulating air through the venturi 15 can be regulated as desired. Usually the material delivered to the passage 13 contains a certain percentage of fines along with the larger chips, chunks and pieces. The flow through the venturi 15 is, therefore, regulated by the damper 24 so that the fines are caused to float upwardly into the expansion chamber 14 while gravity causes the larger and heavier particles and pieces to fall through the venturi 15 where it is ground and reduced by the hammer rotor 17 and flung backwardly through the venturi 15, and exhausted by the flow being delivered through the conduit 23 below the venturi 15. The flow through the passage 13 and expansion chamber 14 will contain a fluid medium composed of fines suspended in air and this medium will traverse the conduit 18 to the cyclone separator 19 where the usual separation occurs and substantially clean air is delivered through the top outlet conduit 21 while the material separated out is collected in the bin 20. The air flowing through the outlet conduit 21 from the cyclone separator is approximately 90% clean of material. What little material is carried over in the flow-through conduit 21 is easily handled by the blower 22 since the blower impeller is suitably designed for that purpose.

In FIG. 1A an alternate unit is disclosed to replace the expansion chamber 14. The replacement unit 25 is provided with a fan 26 suitably driven by a motor 27. The fan 26 operates on the material floating in the air stream to promote acceleration of the particles of a desired size while effecting a separation of the larger pieces which return through the passage 13 and venturi 15 for further reduction.

Turning now to FIG. 2 of the drawing, it will be observed at once that a substantial part of the apparatus therein disclosed has already been shown and described in connection with FIG. 1. Therefore, the same reference numerals will be applied wherever applicable so as to avoid unnecessary repetition in the description.

FIG. 2 adds to the primary apparatus described in FIG. 1 means for adding a source of heat for the purpose of drying the material being reduced in the primary system. Thus, a heat furnace 30 has its heat outlet stack 31 connected by a conduit 32 into the blower delivery conduit 23 at a point close to the passage 13 below the venturi 15. The furnace 30 is supplied with a suitable gas or oil fuel through a pipe 33 to a burner unit 34 which may be supplied with combustion air through conduit 35 from a suitable blower 36. Auxiliary air is supplied to the furnace 30 through a conduit 37 having a suitable damper 38 for regulating the quantity of air admitted.

In addition to the heat source from furnace 30 the system of FIG. 2 includes a dust separator 39 equipped with an outlet conduit 40 connected to the suction of a blower 41 for exhausting cleaned air through conduit

42 controlled by damper 43. The blower 41 creates a suction in separator 39 and that draws a flow through conduit 44 connected into the delivery conduit 23 close to the blower 22. The separator 39 may be a bag-type dry unit, or it may be a wet type, the object being to remove as much residual dust and fines as possible.

In operation of the apparatus included in the system of FIG. 2 the heat from the furnace 30 elevates the temperature in the system to a point where moisture in the incoming material from the vibratory unit 12 can be heated to a temperature level where it can be driven off in the form of steam. The moisture laden air then withdrawn through the conduit 44 and the separator 39 and is discharged from the system at the conduit 42 from the blower 41. The separator 39 collects substantially all of the vestiges of fines and particles of a dust type character so that the ambient atmosphere is not polluted. These fines are collected and periodically discharged through the outlet 45 of the separator 39. In operating a system of the character of FIG. 2 the temperature of the material separated in the cyclone separator 19 may reach a combustion temperature and, therefore, it is desired to periodically discharge such material into a closed bin 20 so as to exclude the heated material reaching ambient air where the oxygen level could cause ignition. While the system of FIG. 2 is not intended to operate with an internal inert atmosphere, nevertheless the internal atmosphere can be controlled as to its oxygen content by regulating the amount of combustion supporting air admitted with the fuel in the furnace 30. The combustion supporting air can be either supplied by the blower 36 or through the value controlled conduit 37 when the blower 36 is shut off.

Turning now to FIG. 3, it is noted that portions of the system correspond to the systems heretofore described in FIGS. 1 and 2. Where possible like reference characters will be used in describing the system of FIG. 3 as have been used in the previous views so that repetition description is avoided. The improvement in FIG. 3, therefore, resides in providing conduit 46 to connect the outlet conduit 42 of blower 41 with the heater 30, thereby replacing the conduit 37 and control valve 38 of FIG. 2. However, conduit 46 is provided with an air supply conduit 47 and control valve 48. In addition, the fines collected in the separator 39 at outlet 45 are fed by conduit 49 into the conduit 46 for delivery to the heater 30 to augment the fuel supply. Thus, the fines are used as a source of fuel.

In addition FIG. 3 includes a modification in the cyclone separator 19 where the air exhaust box 50 is provided with an adjustable skimmer vane 51 (FIG. 3A) which may be adjustably positioned more or less into the vortex flow entering the cyclone 19 from the inlet conduit 18. The vane 51 is positionable to skim out a portion of the material entering the cyclone 19 for flow into the exit conduit 21 and delivery to the blower 22. Simultaneous operation of the blower 41 connected to the separator 39 will create a suction in conduit 44 to entrain a substantial portion of the material skimmed out by the vane 51 for delivery to the separator 39 and eventual delivery through conduit 49 to the heater 30. Thus the fines extracted by the skimming vane 51 will be consumed in the heater 30, while selective portions of the material delivered to the cyclone separator 19 will be collected in the closed bin 20.

The system of FIG. 3, differs from the previously described systems in that it operates at a high temperature

for drying the material delivered into the passage 13. With regulation of the fuel-air ratio for the heater 30, the system operates with an inert or low oxygen content. An oxygen controlling device of the character disclosed in my earlier U.S. Pat. No. 3,610,594, granted Oct. 5, 1971, may be used to govern the fuel to air ratio of one-to-two to assure the attainment of an inert atmosphere. The system also operates so that the moisture laden air exhausted by blower 41 at the valve controlled outlet conduit 42 is at a temperature above the dew point to avoid a condition of free water in the conduit system. In order to obtain the desired air volume return to the heater 30 by way of conduit 46, a control valve 52 is located in conduit 46. Thus, valves 43, 48 and 52 can be selectively adjusted to obtain the desired proportioning of air exhausted from the system at valve 43 and make-up air admitted for the heater 30 to gain an inert internal condition for avoidance of fire or explosive conditions.

The system disclosed in FIG. 4 is similar to that of FIG. 3, and in addition a by-pass conduit 53 around the separator 39 is provided to reduce the size of the separator 39. The by-pass conduit is provided with a control valve 54 for selectively regulating the volume of air and fines in by-pass of the separator 39.

In FIG. 5 the system differs from the system of FIG. 4 in eliminating the ambient air supply conduit 47 in conduit 46, and in employing a pressure controlled valve 43a in the exhaust conduit 42 from the blower 41. The heater 30, thus receives primary combustion air from blower 36, and a substantially lesser volume of combustion supporting air from within the system. The valve 43a is provided with an adjustable weight 55 which determines the degree of valve opening in response to the pressure of the system above atmosphere. Alternatively, the valve 43a may be controlled pneumatically from a suitable pressure regulator (not shown). The effect of the pressure responsive valve 43a is to create a back pressure in the entire system so that all leaks that may occur are outward. In the systems previously described the operation of the blower 41 (FIGS. 2, 3 and 4) will create a negative internal pressure relative to ambient pressure so that leaks will be inward.

In each of the systems above described it will be evident that the incoming material to be reduced is admitted to the passage 13 above the venturi throat 15 and the mill is positioned below the venturi, thereby accommodating the arrangement of the air circulating system to deliver its flow on the mill side of the venturi. In this novel manner the fines present in the incoming material are kept out of the mill and cannot be further reduced to a dust condition. The surfaces of the throat may be suitably coated with a ceramic or other wear resistant material as is generally known in the art.

The flow from the blower 22 can thus be desirably modulated at valve 24 to establish a flow velocity in the venturi throat of a value such that the fines are continually conveyed into the expansion chamber 14 and on to the cyclone separator 19. Only the large chips and chunks are allowed to pass the venturi throat and reach the mill.

The system of FIG. 2 includes a heater for drying the material, where the heater is independent of the circulating system connected with blower 22. On the other hand, the systems of FIGS. 3, 4 and 5 are arranged to recycle a proportion of the circulating air through the

heater for control of the oxygen level in the system and to dispose of some of the fines as fuel for the heater. It is, of course, understood that any of the systems of FIGS. 3, 4 and 5 can be provided with the oxygen analysing means heretofore disclosed in my earlier U.S. Pat. No. 3,610,594.

The foregoing specification has set forth in FIG. 1 a primary material reducing system embodying the novel arrangement of apparatus in which a venturi is inserted in the air circulating means at a point to control the size or weight characteristics of the material which is allowed to enter the hammer mill for reduction and return to the flow means by reason of the action of the hammer mill rotor and hammers. The flow means of the system of FIG. 1, in its broad aspect, includes the passage 13, the expansion chamber 14, the conduit 18 to the cyclone separator 19, the air outlet conduit 21 from the cyclone separator to the blower 22 and the blower delivery conduit 23 which connects into the apparatus between the venturi 15 and the mill chamber 16.

In FIG. 2 and subsequent views of the drawings, there is a second flow means which is connected into the first flow means at the outlet of the blower 22. The connection is exemplified by the conduit 44 which extends to a second material separator 39 which has its own blower 41 for exhausting the air after the dust particles have been substantially separated therefrom. The views of FIGS. 3, 4 and 5 include the addition of various auxiliary conduits for collecting the fines and dust particles from the air flow in the second flow means and feeding it into the heater where it is consumed and acts to augment the external supply of fuel from conduit 33 to the burner 34. Suitable flow control valves are included in the conduits at locations where flow proportioning may be achieved to produce the desired results.

What is claimed is:

1. In a material reducing system the improvement of a material reducing mill having a rotor chamber with a single material inlet and outlet, a passage communicating with said rotor chamber and having a venturi throat therein, means to feed material into said passage on the side of said venturi throat remote from said rotor chamber, air moving means communicating with said passage on opposite sides of said venturi throat, whereby the air moved is delivered for flow into said venturi and out of said passage and the material fed into said passage is acted upon by the air flow to retain fines in the delivered material in said passage while the heavier material moves through the venturi throat and into said rotor chamber, and material reducing rotor means in said chamber to impact the heavier material and reduce it to a state of fines and return it toward said venturi for movement with the air flow in said venturi.

2. The system set forth in claim 1 wherein said passage includes an expansion chamber outwardly from said venturi relative to said mill, said expansion chamber acting to slow the air flow for increasing the quantity of material returnable to said mill for reduction therein.

3. The system set forth in claim 1 wherein a source of heat is connected into said air moving means to deliver heat into said passage between said venturi throat and rotor chamber, and separator means is connected into said air moving means to exhaust a portion of the circulating air containing moisture and remove the

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finer flowing therein, said heat source adding air to replace air exhausted by said separator means.

4. The system set forth in claim 1 wherein said air moving means includes means to control the flow in said venturi throat to determine the respective sizes of material passing countercurrent in said venturi throat and material retained in said passage for movement in said air moving means.

5. The system set forth in claim 1 wherein said air moving means includes a primary separator and blower in series with said venturi throat and passage, a second air moving means connected into said first mentioned air moving means at a zone in advance of the air flow toward said venturi throat, and means to supply heat into said first mentioned air moving means for initiating drying of the material adjacent said venturi throat.

6. The system set forth in claim 5 wherein said second air moving means includes a blower and a separator by which fines are withdrawn from the air flow to said blower and said blower exhausts the air to ambient atmosphere.

7. The system set forth in claim 6 wherein a branch conduit is connected between the suction side of said blower included in said second air moving means and the heat supply means, and valve means in said branch conduit serves to proportion the volumes of air movement exhausted to ambient atmosphere and to said heat supply means.

8. The system set forth in claim 6 wherein a by-pass conduit in said second air moving means is connected to direct flow around said separator in said second air moving means, said by-pass conduit directing the flow toward said heat supply means, and means in said primary separator to vary selectively the proportion of material separated therein and the fines selected to continue movement in said air moving means for increasing the quantity of fines reaching said second air moving means.

9. Apparatus for reducing friable material which consists in a material reducing mill having a rotor operable in a housing formed with an opening for the entry and discharge of material, a passage extending generally

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vertically outwardly from said opening, said passage having a constricted throat therein spaced from said housing opening, blower means connected into said space between said constricted throat and said housing opening to create a flow through said throat and outwardly in said passage, and means to feed material into the flow in said passage outwardly of said throat whereby the material is sorted by size with the larger sizes moving through said throat counter to the flow therein and into said mill housing for reduction.

10. Apparatus for reducing material which apparatus consists in a material impact mill having a common opening for receiving and discharging material impacted therein, a passage extending from said common opening and having an outlet, a first air circulating system connected between said passage outlet and the passage adjacent said common opening of the mill, an air flow velocity increasing venturi throat in said passage between the connections of said air circulating system to said passage, means supplying the material for reduction into said passage beyond said velocity increasing throat from said mill, a source of heat connected into said circulating system adjacent said mill, and a second circulating system connected between said first system and the source of heat, said second system being operative to separate out material fines and supply such fines as a source of fuel to said heat source.

11. In material reducing apparatus the improvement of a material reducing mill having a material receiving top opening, a passage connected with said top opening and formed with a venturi throat therein, means to supply material to be reduced in said mill into said passage above said venturi throat, and air moving means connected into said passage below said venturi throat to deliver a flow of air upwardly in said venturi throat so as to oppose the movement of components of the material to be reduced that are of a size to be moved by the air flow upwardly through said venturi throat, whereby the heavier components of material may fall through said venturi throat and into said reducing mill.

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