Aug. 23, 1955 O. CRAIG 2,716,002

PLURAL STAGE COMMINUTION SYSTEM FOR WET SOLID MATERIALS

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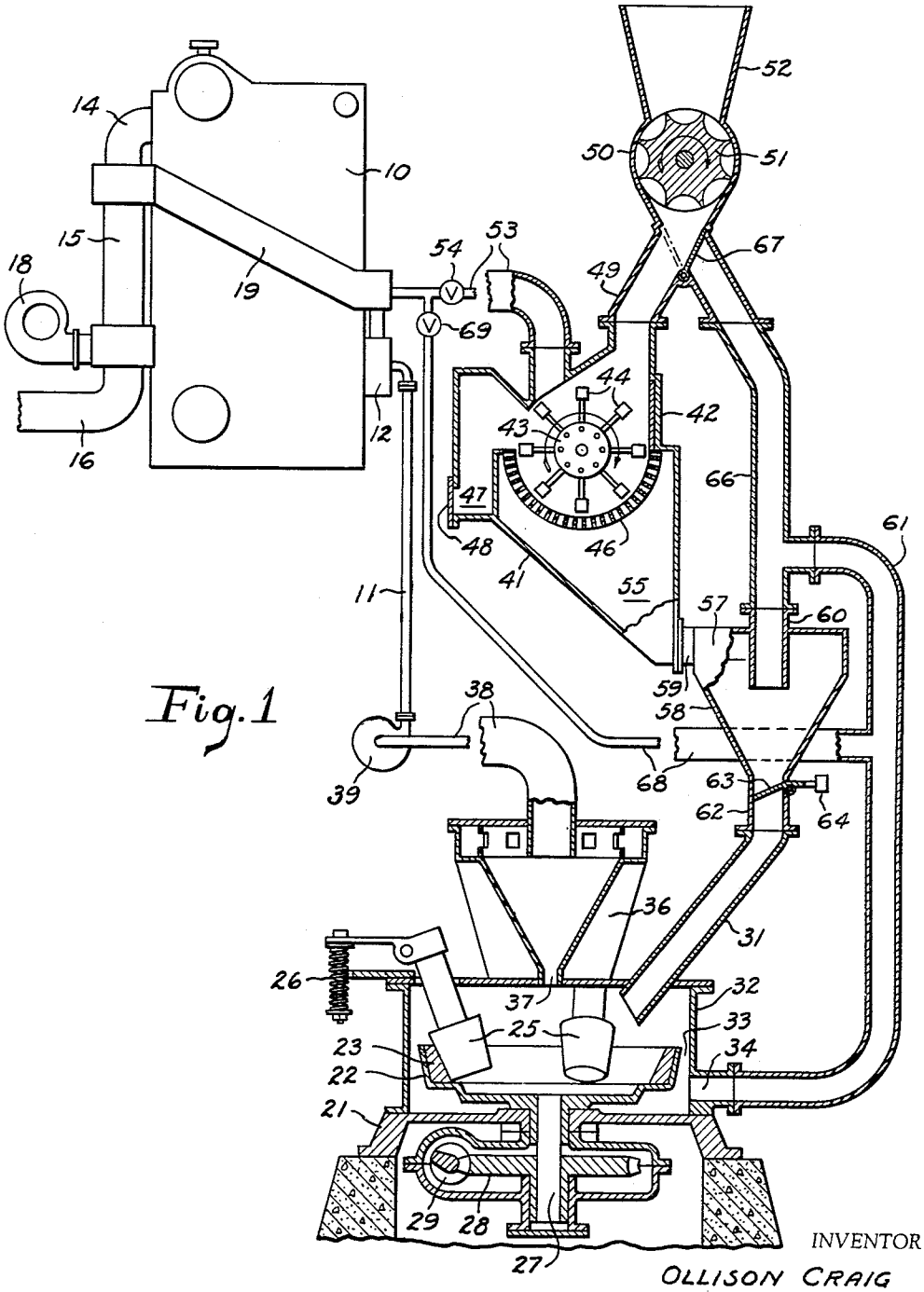


Fig. 1

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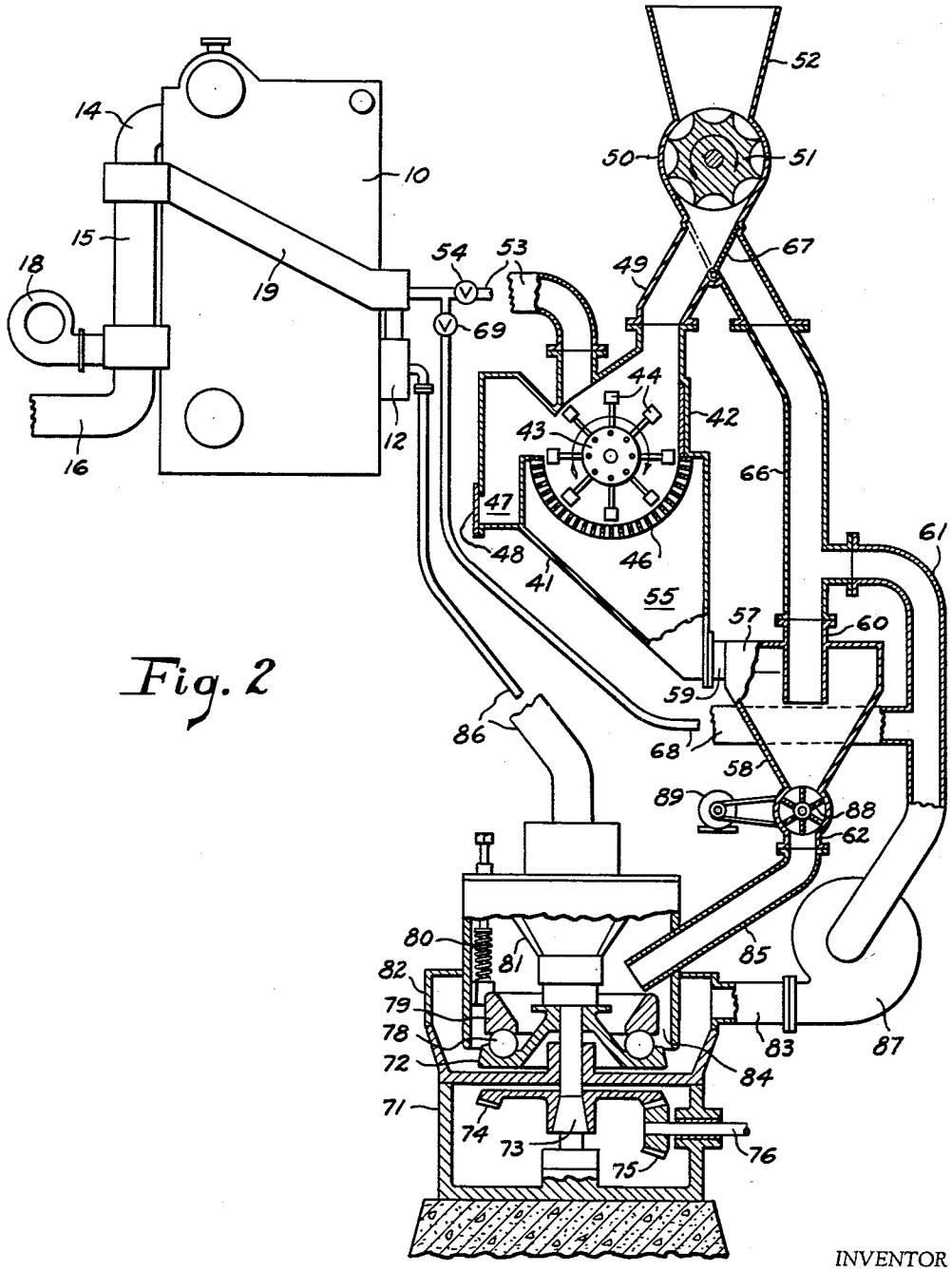


Fig. 2

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PLURAL STAGE COMMINUTION SYSTEM FOR WET SOLID MATERIALS

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3 Claims. (Cl. 241—43)

This invention relates to the comminution of wet solid material, and more particularly to an improved apparatus arranged to receive solid material having an appreciable quantity of surface moisture associated therewith and to reduce the material to a fine powder.

It has long been recognized that the capacity of a pulverizer will decrease whenever surface moisture is associated with the material entering the machine, and that a large percentage of surface moisture in the material may even render it impossible for the machine to operate at all. Various remedies have been suggested, including the provision of a drying apparatus to remove excess moisture from the material before it enters the pulverizer. Another suggestion involves introducing into the pulverizer heated gas, such as air, to aid in drying the material and to carry the fine material out of the machine. A drying apparatus is an expensive piece of equipment, it is often difficult and complicated to operate, and in many installations it is not economically justified since the excess moisture conditions may be encountered rather infrequently. While the feeding of hot gas to the pulverizer is helpful with some types of pulverizer, there are many machines so constructed that such a procedure has very little effect in increasing the capacity.

It is accordingly one object of the invention to provide an apparatus capable of comminuting wet solid material to a fine powder at a very high rate in proportion to the size of the apparatus.

It is a further object of the invention to provide, in combination with a pulverizer of known construction, other apparatus which will greatly increase the capacity of the pulverizer.

It is a further object of the invention to provide an apparatus for producing a fine powder from solid material and having a very high capacity in proportion to its size, the construction being such that no appreciable reduction in the capacity will take place even though the moisture content of the material as received may increase greatly.

It is a further object of the invention to provide an apparatus adapted for comminuting coal or similar solid fuel and delivering the fuel as a fine powder to a furnace for combustion, the capacity of the apparatus being affected very little by a considerable increase in the amount of surface moisture in the coarse fuel.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

In accordance with the invention in its preferred form there is provided a pulverizer, which may be of any suitable and known construction. For example, the pulverizer may include a plurality of rolling elements, such as rollers or balls, arranged to pulverize material in a horizontal annular zone from which the fine material is discharged outwardly into a surrounding upwardly flowing current of air. Or the pulverizer may include a hollow drum rotating about a substantially horizontal axis and

containing loose grinding bodies which pulverize material delivered to the drum, the fine material being removed by a current of air flowing through the drum. Whatever may be the construction of the pulverizer, there is associated therewith a suitable crusher having revoluble hammers arranged to crush the material and deliver it to the pulverizer. The crusher hammers are preferably revoluble about a substantially horizontal axis, with an arcuate grid located beneath the hammers, the hammers serving to force the crushed material through the grid. Hot gas, such as air, is supplied to the crusher and is intimately mixed with the material by the action of the revolving hammers, so that the surface moisture is very rapidly evaporated from the material before it leaves the crusher. Thus the crushed material entering the pulverizer is comparatively dry and the pulverizer can be operated at its full capacity. Furthermore, because of the very appreciable comminution effected by the crusher, there is less work required of the pulverizer, and the capacity of the pulverizer is correspondingly increased. When the construction of the pulverizer is such that different entrances are required for the air and for the material to be pulverized, a separator is provided between the crusher and the pulverizer, the separator being close-coupled to the crusher. This separator may be of the centrifugal type in which the entering mixture is whirled so that the crushed material will be thrown outwardly from the air and led to the pulverizer by one pipe, while the air travels through another pipe to the air entrance of the pulverizer.

Referring to the drawings illustrating one embodiment of the invention, and in which like reference numerals indicate like parts,

Fig. 1 is a somewhat diagrammatic elevation, partly in section, showing an apparatus for preparing pulverized coal and feeding the same to a steam boiler furnace for combustion therein; and

Fig. 2 is a view similar to Fig. 1 but showing a modification.

The embodiment illustrated in Fig. 1 comprises a steam boiler furnace **10** arranged to be fired with pulverized coal supplied through a pipe **11** leading to a burner **12** at the front of the furnace. The hot gaseous products of combustion flow through a duct **14** to an air heater **15** and thence through a duct **16** to a stack or induced draft fan (not shown). Air is supplied to the heater **15** by a forced draft fan **18**, and the hot air leaves the heater through a duct **19** leading to the burner **12**.

The coal to be burned in the furnace **10** is reduced to a fine powder by means of a pulverizer **21** of the general type disclosed in the United States patent to Wood et al. No. 2,237,021 granted April 1, 1941. This machine comprises an upwardly open circular bowl **22** rotatable about a vertical axis and having an annular inner lining **23** which forms a grinding track or ring. A series of idler rollers **25** cooperate with the track **23** to pulverize material, each roller being urged outwardly toward the track by a spring **26**. The bowl **22** is secured to the upper end of a vertical shaft **27** having a worm gear **28** thereon, the gear meshing with a suitably driven worm **29**. The coal is delivered to the interior of the bowl by gravity through a pipe **31**. The bowl is mounted within a casing **32** shaped to leave an annular space **33** around the outside of the bowl. Air enters the casing through an inlet opening **34** located somewhat below the bowl and flows upwardly through the annular space **33** at sufficient velocity to entrain coal which has spilled outwardly from the bowl. The air with the entrained coal flows upwardly through openings (not shown) into a classifier **36** above the casing **32**, the classifier being adapted to separate the coarser particles of coal from the air stream and to return them to the bowl **22** by gravity through a central opening **37** in the top of the casing. The air stream, with the fine

particles of coal entrained therein, flows upwardly from the classifier through a pipe **38** leading to the inlet of a fan **39**, the outlet of this fan being connected to the pipe **11** which leads to the burner **12**.

Before the coal enters the pulverizer **21**, it is subjected to a combined drying and crushing operation. For this purpose there is provided a crusher **41** comprising a casing **42** within which there is mounted a rotor **43** provided with a series of revoluble hammers **44**. The rotor **43** is rotated about a horizontal axis by a suitable motor or other driving means. An arcuate grid **46** is mounted within the casing **42** directly beneath the hammers **44** and extends concentrically with the rotor **43** throughout approximately 180 degrees. A tramp metal pocket **47** having an access door **48** is provided at one side of the grid **46** in position to reecive hard foreign bodies which may enter the crusher with the coal and be thrown outwardly by the hammers **44**. Coarse coal is delivered at a desired rate to the upper portion of the casing **42** through a pipe **49** by a suitable feeder **50** comprising a horizontal pocketed drum **51** located at the bottom of a supply hopper **52**. The drum is rotated at a desired speed by any suitable means, and feeds coal from the hopper **52** to the pipe **49**. Hot air from the duct **19** is delivered to the upper portion of the casing **42** through a pipe **53** provided with a valve **54**. The mixture of air and crushed coal which passes downwardly through the grid **46** enters a chamber **55** in the lower portion of the casing **42**.

From the chamber **55** the mingled air and crushed coal is delivered to a separator **57** arranged to separate the air from the coal. This apparatus is in the form of an upright casing **58** having at its upper end a tangential inlet **59** connected to the crusher discharge chamber **55**, whereby the crusher is close-coupled to the separator. The casing **58** also has a central upwardly extending air outlet **60** which is connected by a pipe **61** to the air inlet **34** of the pulverizer **21**. The casing **58** tapers downwardly to a restricted coal outlet **62** which is connected to the upper end of the coal supply pipe **31** of the pulverizer. In order to prevent air from flowing downwardly through the coal outlet **62**, a pivotally mounted valve plate **63** is mounted therein to form a trap, this valve plate being biased upwardly toward its closed position by a counterweight **64**.

Under certain conditions it may be desirable to by-pass the crusher **41**. For this purpose a pipe **66** leads downwardly from the coal feeder **50** to the air outlet **60** of the separator **57**, and a flap valve **67** is pivotally mounted between the upper ends of the pipes **49** and **66** so that the coal fed by the drum **51** can be diverted into either of these pipes as desired. In addition a pipe **68** with a valve **69** therein connects the hot air duct **19** to the pipe **61**.

The operation of this embodiment will now be apparent from the above disclosure. Normally the valve **69** will be closed, the valve **54** will be open sufficiently to permit hot air from the duct **19** to flow at a desired rate into the crusher **41**, and the flap valve **67** will be placed in the position shown so that the coarse wet coal fed downwardly from the hopper **52** by the rotating drum **51** will travel through the pipe **49** into the crusher **41**. As the hot air and the wet coal enter the crusher, they will be very rapidly, violently, and intimately mixed by the action of the revolving hammers **44**. These hammers will crush the fuel into relatively small particles and distribute the surface moisture over the greatly increased exposed area of such particles. By reason of such distribution of the moisture over a very large surface area, and the exposure of the moisture to intimate contact with the hot air, the moisture will evaporate almost instantaneously and the crushed fuel passing through the grid **46** will be comparatively dry. Any tramp iron or other hard foreign matter too large to pass through the grid will be deposited in the pocket **47**. The air and the crushed coal will travel through the chamber **55** and the tangential inlet pipe **59** to produce a whirling mass within the casing **58** of the

separator **57**. The air, with some of the finest coal particles entrained therein, will flow upwardly through the outlet pipe **60** and through the pipe **61** and the air inlet opening **34** of the pulverizer **21**. Most of the coal will separater from the air by the action of gravity and centrifugal force, and travel downwardly past the trap plate **63** and through the outlet **62** to the coal supply pipe **31**, which will discharge the coal into the rotating bowl **22**. Centrifugal force will cause the coal to move outwardly to the ring **23**, against which the coal will be finely ground by the action of the pressure rollers **25**. The ground coal will spill outwardly over the outer edge of the coal and be picked up by the air stream flowing upwardly through the annular passage **33**. This air stream will carry the coal into the classifier **36**, which will return the coarser particles through the opening **37** to the bowl. The fan **39** will draw the stream of air and fine coal particles from the classifier through the pipe **38** and deliver this stream through the pipe **11** to the burner **12**, where additional air will be supplied from the duct **19** to maintain combustion in the furnace **10**.

Because of the combined drying and crushing action performed upon the coal as it travels through the crusher **41**, it is possible to operate the pulverizer at a much higher grinding rate than would otherwise be the case. The increase in the grinding capacity is of course more pronounced when the coal supply has a high percentage of surface moisture. When the load on the boiler furnace **10** is low, so that a high grinding rate is not required of the pulverizer, and particularly when the coal supply is comparatively dry, it is feasible to take the crusher **41** out of service. For this purpose the flap valve **67** will be swung over to the position indicated by the broken lines, so that the coal which is fed downwardly by the drum **51** will all pass through the pipe **66** to the pipe **60**, past the valve **63** and the separator outlet **62** to the pipe **31** and into the bowl **22** of the pulverizer. At the same time the valve **54** can be closed and the valve **69** opened to admit hot air from the duct **19** through the pipe **68** to the pipe **61** and thence to the air entrance **34** of the pulverizer.

In Fig. 2 there is shown a modification of the invention in which the pulverizer **21** of Fig. 1 is replaced by a pulverizer **71** of the general type disclosed in the United States patent to Schwartz No. 2,275,595 granted March 10, 1942. This machine comprises a central member **72** secured to a vertical rotatable shaft **73** having a bevel gear **74** mounted on its lower portion. A bevel pinion **75** is mounted on a horizontal shaft **76** driven by any suitable means. The pinion **75** meshes with the gear **74** and thus serves to drive the shaft **73**. The outer portion of the member **72** provides a revoluble ring or track for an annular series of balls **78** above which there is located an upper ring or track **79**. Several springs **80** (only one of which is shown) force the upper ring **79** downwardly against the balls **78**. A rotary classifier **81** is mounted on the top of the member **72**. These parts are enclosed within a casing **82** having an air inlet **83** and shaped to provide an annular space **84** through which the air may flow upwardly around the outside of the grinding rings **72—79** to the classifier **81**. The coal to be ground is supplied to the pulverizer **71** by gravity through a pipe **85**, which deposits the coal within the upper ring **79** so that the coal will be pulverized by the rolling action of the balls **78** as it travels outwardly between the rings **72—79**. The ground coal leaving these rings enters the annular space **84** and is entrained by the air current flowing upwardly therethrough. The classifier **81** returns any coarse particles for further grinding, while the air and fine particles continue through a pipe **86** to the burner **12**. The air pipe **61** leading from the separator **57** is connected to the inlet of a fan **87** which discharges into the air inlet **83** of the pulverizer **71**. Since this arrangement places the interior of the pulverizer under pressure, the coal outlet **62** of the separator **57** is preferably provided with a modified form of trap comprising a star wheel **88** suitably

rotated by a motor 89 at a speed sufficient to transfer coal to the pulverizer supply pipe 85 as fast as it accumulates in the bottom of the separator, while preventing upward flow of air through the pipe 85.

The operation of the embodiment disclosed in Fig. 2 will be essentially the same as that already described in connection with Fig. 1, except for the slight differences brought about by the change in the type of pulverizer. Thus the coarse wet coal will be supplied by the feeder 50 to the crusher 41, where it will be crushed and mixed with the hot air supplied through the pipe 53, this air serving to dry the coal very rapidly. Any tramp metal present will be deposited in the pocket 47. The crushed coal and air will be separated in the casing 58, the coal traveling downwardly past the star wheel 88 and through the pipe 85 into the interior of the upper ring 79 and thence outwardly into the path of the balls 78. The air will flow outwardly through the pipe 60 to the pipe 61 and the fan 87, and thence at a higher pressure through the pipe 83 into the pulverizer and upwardly through the space 84, where it will entrain the pulverized coal moving outwardly past the balls 78. The air and coal will flow upwardly past the classifier 81, which will throw back the coarse particles while the air and fine particles continue through the pipe 86 to the burner 12. As in the case of the Fig. 1 embodiment, there will be a very pronounced increase in the grinding capacity of the pulverizer, particularly when wet fuel is encountered.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. Apparatus for comminuting wet, raw coal comprising a mill having revoluble crushing hammers and having an arcuate sifting grid situated therebelow, the said mill being of the type which subjects the coal to violent agitation, means to feed the coal into the path of the hammers, means to direct hot gas into the path of the hammers so that the coal will be simultaneously crushed and dried, a separator, close-coupled means to lead the gas and the dry crushed coal substantially by gravity to the separator so that the coal will be separated from the gas, a pulverizer adapted to grind coal to a fine powder, the pulverizer having an entrance for coal to be ground and a separate entrance for gas to entrain the fine powder, the pulverizer being of the type which subjects the coal to very fine comminution, means to lead the crushed coal from the separator to the coal entrance of the pulverizer, means to lead the gas from the separator to the gas entrance of the pulverizer whereby the same gas which passes through the hammers also passes through the pulverizer, and means for applying additional hot gas to the gas in the said last-named means.

2. Apparatus as set forth in claim 1, wherein the said mill coal feed means includes a by-pass means for selectively feeding coal to the mill or directly to the separator.

3. Apparatus for comminuting wet, raw coal comprising a mill having revoluble crushing hammers and having an arcuate sifting grid situated therebelow, the said mill being of the type which subjects the coal to violent agitation, means to feed the coal into the path of the hammers, means to direct hot gas into the path of the hammers so that the coal will be simultaneously crushed and dried, a separator, close-coupled means to lead the gas and the dry crushed coal substantially by gravity to a separator so that the coal will be separated from the gas, a pulverizer adapted to grind coal to a fine powder, the pulverizer having an entrance for coal to be ground and a separate entrance for gas to entrain the fine powder, the pulverizer being of the type which subjects the coal to very fine comminution, means to lead the crushed coal from the separator to the coal entrance of the pulverizer, and means to lead the gas from the separator to the gas entrance of the pulverizer whereby the same gas which passes through the hammers also passes through the pulverizer, and means for applying additional hot gas to the gas in the last-named means, the mill being provided with a pocket arranged to retain tramp metal and other hard, foreign matter thrown outwardly by the revoluble hammers, the dry, crushed material leaving the separator through a passage having a trap therein arranged to prevent the flow of gas through the passage.

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