PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : B02C 13/286

A1

(11) International Publication Number: WO 92/04120

(43) International Publication Date: 19 March 1992 (19.03.92)

(21) International Application Number: PCT/US91/06268

(22) International Filing Date: 30 August 1991 (30.08.91)

(30) Priority data:
575,918 31 August 1990 (31.08.90) US

(60) Parent Application or Grant
(63) Related by Continuation
US 575,918 (CIP)
Filed on 31 August 1990 (31.08.90)

(71) Applicant *(for all designated States except US):* DFM, INC. [US/US]; 11506 Glenora Drive, Houston, TX 77065 (US).

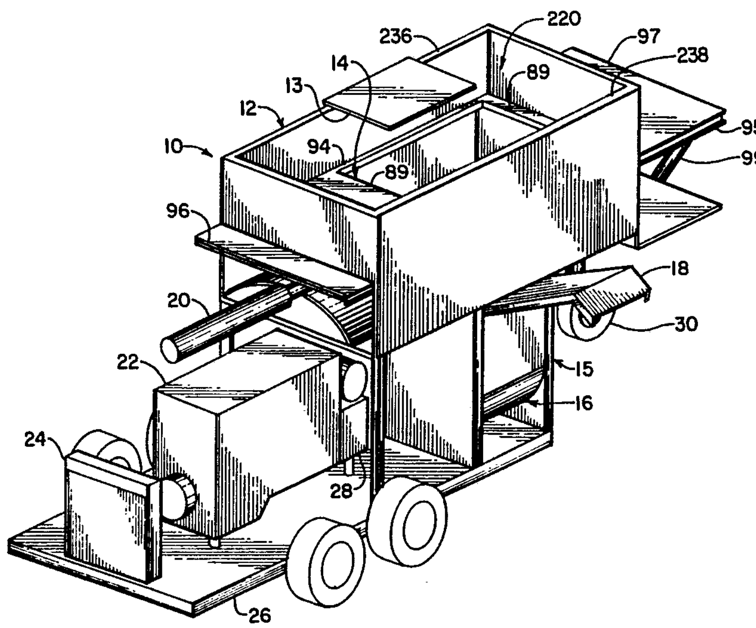
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : EDDY, William, A. [US/US]; 11506 Glenora Drive, Houston, TX 77065 (US).

(74) Agent: YOUNG, James, R.; Chrisman, Bynum & Johnson, 1401 Walnut Street, Suite 500, Boulder, CO 80302 (US).

(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.

Published
With international search report.

(54) Title: RECIPROCATING ACTION MILLER



(57) Abstract

A self-contained reciprocating action miller (10) having a grinding rotor (46) mill housed within a mill housing (15) and rotating about a grinding rotor axis (72). A refuse material hopper (12) mounted above the mill housing (15) has a convex floor (70) with an opening (19) therein to expose the grinding rotor (46). Reciprocating feed apparatus (14) mounted within the refuse hopper (12) reciprocates two parallel, spaced-apart vertical push walls (42, 44) along an axis parallel to the grinding rotor axis (72) to feed the material into the grinding rotor (46) at a steady rate. Control projections (60) are positioned adjacent the rotor (46) for selectively handling and controlling the flow of different sized materials in the hopper (12) into the grinding rotor (46). Shear plates (86) in the form of segments of a circle are positioned adjacent the rotor (46) for comminuting shreddable or grindable material while guiding non-comminutable materials through the mill (10). A reversible rotor (46), stator (16), and discharge chute (18) allow the comminuted material to be discharged from either side of the mill (10) with no loss of grinding efficiency.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland			SN	Senegal
CI	Côte d'Ivoire	KR	Republic of Korea	SU+	Soviet Union
CM	Cameroon	LI	Liechtenstein	TD	Chad
CS	Czechoslovakia	LK	Sri Lanka	TG	Togo
DE*	Germany	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		

+ Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

RECIPROCATING ACTION MILLER

Description

Cross-Reference to Related Patent Applications

This patent application is a continuation-in-part of patent application serial number 07/575,918, filed in the United States Patent and Trademark Office on 31 August 1990.

Technical Field

This invention relates to grinding and comminuting apparatus in general, and in particular to an industrial hammer mill having a reciprocating feed, reversible operation, and special shear plates in the grinding stator to increase comminuting efficiency while reducing jamming of and damage to the mill by material that cannot be comminuted.

Background Art

Grinding mills have been utilized for some time in a variety of applications. For example, grinding mills have been commonly used in the past for grinding grains, corn, hay, and other forage materials for livestock feed, as well as paper for cellulose insulation and other commercial uses. Many varieties of grinding mills for comminuting such materials have been developed, such as stone mills, burr mills, hammer mills, and roller mills. Because forage materials tend to be fibrous and stalky, hammer mill type grinders have been found to be the most effective in comminuting these forage or roughage materials. However, handling and feeding these bulky, fibrous, stalky materials into a hammer mill in a uniform manner proved to be quite difficult and required a good deal of tedious manual labor, because they do not flow in a uniform manner like grains.

Some of the more recent developments in larger grinding apparatus to alleviate the problems in feeding bulky, fibrous, and stalky materials into hammer mills include the grinders now known generically as tub grinders because of their rotating tub feeders. Typical examples of such tub grinders can be found in the following patents: U.S. Patent No. 2,659,745, issued to W. Wortman; U.S. Patent No. 3,615,059, issued to E. Moeller; U.S. Patent No. 3,743,191, issued to R. Anderson;

U.S. Patent No. 3,912,175, issued to R. Anderson; U.S. Patent No. 3,966,128, issued to J. Anderson, et al.; U.S. Patent No. 4,003,502, issued to E. Barcell; U.S. Patent No. 4,087,051, issued to C. Moeller; and U.S. Patent No. 4,106,706, issued to H. Burrows. These tub grinders were designed initially to feed very large bales of hay and other forage materials into hammer mill apparatus without the need for excessive manual labor. Tub grinders come in various sizes depending on the type of duty for which they are designed, but all have relatively large rotating tubs positioned over the hammer mill cylinders for containing bales or piles of forage material and feeding the forage material gradually into the hammer mills. In a typical tub grinder, the hammer mill cylinder is positioned under and extends partially through the floor or bottom of the tub, and the rotating tub feeds the bottom of the bale or pile of material to be comminuted over the hammer mill. The hammers on the hammer mill cylinder rotate at a high angular velocity and "chew" off the forage on the bottom of the bale as the base of the bale rotates over the hammer mill cylinder in the floor of the tub.

Such tub grinders are quite effective for grinding large quantities of forage or roughage materials. Therefore, with the exception of expensive, large, stationary grinders in more or less permanent industrial grinding installations with special, custom designed conveyors and other feed apparatus for specific purposes, the tub grinders have become the standard for larger, portable, mid-priced, general purpose grinding machines. Consequently, tub grinders are also now being used with marginal success for comminuting other kinds of bulky materials where large quantities of such materials have to be handled, and particularly where the materials are dumped into the hammer mill in batches, such as with a front end loader vehicle. For example, some tub grinders are being used to comminute waste materials, such as wood and other construction industry wastes, tree branches and landscaping waste, refuse, rubbish, and the like, and a few heavier duty models are being made especially for those uses.

Unfortunately, however, even the largest tub grinders or millers are not really well-suited to the task of such heavy waste or industrial grinding. The rotating tub concept, which worked so well for grinding hay bales that it revolutionized large scale, portable batch feed grinding, does not work as well with waste wood, cement chunks, metal, and other materials from construction sites, tree branches and grass and weed cuttings from landscape maintenance operations, refuse, rubbish, volcanic rock, and the like.

In the past, there was not a great need for grinding mills that could reliably grind such tough or odd-shaped materials, since most of these materials were simply hauled to the nearest landfill site for disposal. Nowadays, however, the decreasing availability of landfills for rubbage or refuse disposal has placed a greater emphasis on the need to transform such materials into more compactable and readily decayable forms before disposal. Consequently, most local and municipal governments are beginning to require city workers to grind waste materials, such as large tree branches, wood, assorted rubbish, and other waste collected from parkways, parks, schools, etc., into more readily decayable forms before hauling them to the landfills, thereby easing the refuse disposal problem. Moreover, this idea of grinding rubbish or refuse into a more disposable and quickly decayable form is spreading into other areas, such as garbage collection companies, which have to dispose of large amounts of these materials. Therefore, there is a steadily increasing need for an industrial grinder or miller that is capable of grinding large quantities of such difficult or heavy materials more reliably and efficiently. Such an industrial grinder should be capable of reliably grinding all types of shreddable materials such as garbage, refuse, waste, glass, plastics, paper, clay, wood, branches, yard waste, manure, bark, wet leaves, grass clippings, weeds, compost, and other common, but shreddable waste materials, yet not jam when certain non-comminutable material, such as chunks of metal, rock, or concrete might accidently find its way into the mill.

Further, because of the very common use of front end loader vehicles to handle and move such waste materials, the industrial grinder should be capable of receiving fairly large batch quantities of such materials and feeding them uniformly and efficiently into the hammer mill rotor for comminuting. It should also be capable of handling not only bulky, irregular-shaped objects, but also capable of taking occasional chunks of non-comminutable material, such as metal, rock, concrete, and other hard objects without damaging or jamming the hammer mill rotor or concave apparatus. Prior to this invention, no such industrial grinder existed.

Disclosure of Invention

Accordingly it is an object of this invention to provide an industrial grinder particularly adapted for grinding a variety of waste and other materials that heretofore were difficult to handle, feed, and grind in large, batch quantities.

It is another object of this invention to provide an industrial grinder with a jam-resistant grinding mechanism.

It is yet another object of this invention to provide an industrial miller with a batch container feed apparatus that is capable of reliably and gradually feeding a wide variety odd-shaped and difficult to handle, bulky materials into the grinding mechanism.

It is still yet another object of this invention to provide an adjustable grinding mechanism to vary the sizes of the comminuted fragments.

It is a further object of this invention to provide an industrial miller having a reversible grinding apparatus and discharge chute to discharge the comminuted material from either side of the miller.

It is still yet a further object to provide an industrial miller that is capable of handling large batch quantities of industrial waste, yet which is mobile and self-contained.

To achieve the foregoing and other objects and in accordance with the purpose of the present invention, as embodied and broadly described herein, the self-contained reciprocating action miller of this invention may comprise a grinding rotor housed within a mill housing and rotating about a grinding axis, a refuse hopper mounted above the mill housing with a convex floor, and an opening in the floor to expose a portion of the grinding mill. Reciprocating feed apparatus mounted within the refuse hopper includes two parallel, spaced-apart vertical walls that are moveable in a reciprocating manner along an axis parallel to the grinding rotor axis for gradually feeding the refuse into either cutting end of the grinding rotor at a steady rate. A set of shear plates are positioned on a moveable concave or stator adjacent a portion of the peripheral surface of the mill or grinding rotor for interaction with the mill rotor in comminuting materials in the mill housing, but which are also positioned to provide inclined surfaces for guiding chunks of hard, non-comminutable materials through the mill housing. A reversible rotor, stator, and discharge chute allow the comminuted material to be discharged from either side of the mill with no loss of grinding efficiency. Several other features are also included to enhance the performance and reliability of the grinder.

The method of this invention includes alternately feeding the material to be comminuted to opposite ends of the grinding rotor, whereupon the material is pulled into the mill housing and comminuted by the action of hammers attached to the rotating grinding mill and the moveable concave or stator. After being comminuted, the material is ejected from the mill housing by the rotation of the hammers.

Additional objects, advantages and novel features of the invention shall be set forth in part in the description that follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by the practice of the invention. The objects and the advantages of the invention may be realized and attained by means of the instrumentalities and in combinations particularly pointed out in the appended claims.

Brief Description of the Drawings

The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate the preferred embodiments of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

Figure 1 is a perspective view of the reciprocating action miller of the present invention showing the overall arrangement of the components of the miller;

Figure 2 is a side view in elevation of the reciprocating action miller of the present invention with part of the hopper broken away to show the reciprocating feed, log ramps, and grinding rotor;

Figure 3 is a plan view of the reciprocating action miller of the present invention with part of the decking plates of the feed apparatus broken away to more clearly show the structure thereof;

Figure 4 is a cross-sectional view of the reciprocating action miller taken along the line 4-4 of Figure 2, showing the arrangement of the grinding rotor and the eccentric, adjustable stator;

Figure 5 is a cross-sectional view of the grinding rotor and the eccentric, adjustable stator taken along the line 5-5 of Figure 4;

Figure 6 is a side view in elevation of the grinding rotor taken along the line 6-6 of Figure 5, showing how a retaining screw is used to secure a hammer pivot pin;

Figure 7 is a front view in elevation of the grinding rotor and eccentric, adjustable stator, showing the position of the stator in a fine grind position and with a coarse grind position illustrated in broken lines; and

Figure 8 is a schematic diagram of an electrical and hydraulic system that can be used to reciprocate the feed mechanism according to this invention.

Figure 9 is a perspective view of the grinding rotor to illustrate the grinding cylinder defined by the grinding rotor as it rotates about its rotor axis; and

Figure 10 is a cross-sectional view taken along lines 10-10 of Figure 3 illustrating the initial chopping area of the grinding rotor as it appears from the perspective of material to be comminuted approaching the grinding rotor according to the present invention.

Best Mode for Carrying Out the Invention

The reciprocating grinder or miller 10 of the present invention is shown in Figure 1 and comprises a hopper 12 mounted over a hammer or grinding mill housing 15, which houses a concave stator 16 and a grinding rotor 46 (not shown in Figure 1, but shown in Figure 2), and a reciprocating feed mechanism 14. A splinter guard 13 may be optionally attached to the top of hopper 12 to prevent splintered refuse from flying out of the hopper 12. A wheeled chassis 26 supports the mill housing 15 and hopper 12, along with engine 22, radiator 24, reversible transmission 28, and other associated hydraulic pumps and miscellaneous apparatus (not shown in Figure 1, but shown schematically in Figure 8), required to drive the reciprocating feed mechanism 14 and grinding rotor 46, as will be described in more detail below.

In operation, the refuse, garbage, or other material to be comminuted (not shown) is deposited into the hopper 12, usually in batches, and is axially fed into either cutting end of the grinding rotor 46 by reciprocating feed mechanism 14, which is reciprocated back and forth across the interior of hopper 12 by hydraulic cylinder 20, as will be described in more detail below. The reciprocating feed mechanism 46 pushes and sweeps the material to be comminuted over an opening 17 (Figure 3) in the floor of the hopper 12 and into grinding rotor 46, which protrudes upwardly into the hopper 12 through said opening 17 in the floor of the hopper 12. Hammers 50 extending radially outward from the periphery of the grinding rotor 46 (Figure 3) tear at the material in the hopper 12 adjacent the opening 17 and pull it down into the grinding mill housing 15, where it is comminuted and discharged. The direction of the ejected discharge is guided by adjustable discharge chute 18, shown in Figure 1.

An adjustable jack stand 38 is shown in Figure 2 attached to the front of the mill housing 15 for supporting the front of the miller 10 during use. A conventional goose neck connection 33 is provided extending from the front of the hopper 12 for connecting to a truck in a conventional manner for towing from one place to another. Finally, an optional pivotally mounted pilot or maneuvering wheel 30, which can be rotated by a hydraulic motor 31 for self-propulsion (Figure 2), can be used to move or propel the entire reciprocating action miller 10 from place to place, particularly for short distances in the vicinity of the grinding operation, without having to hook up and tow it with another vehicle.

In the preferred embodiment, the reciprocating action miller 10 of the present invention is quite large in size and built very heavy and tough to perform well in industrial grinding conditions. The hopper 12, for example, is preferably sized to receive and contain at least 6 to 12 cubic yards, which can hold several buckets full from a large front end loader, or even an entire load from a conventionally sized dump truck or garbage truck. The miller 10 need not necessarily be of this large size, and it can be made smaller if desired. However, if the mill is downsized too much, it will lose its ability to comminute larger, tough materials, because of the reduced rotational inertia and physical strength of such a downsized grinding rotor 46. Thus, the overall large size of the miller 10 of the preferred embodiment enhances its ability to comminute tough materials and to handle chunks, such as metal, rock, or concrete because of the high inertia of the large-sized grinding rotor 46 and the heavy components comprised in its structure. Moreover, the large size of the machine 10 increases material throughput such that it can quickly comminute large amounts of refuse in an industrial environment for which it was designed. Finally, as mentioned above, the stationary hopper 12 with reciprocating feed mechanism 14 enhances the feed operation of the miller, simplifies construction, and reduces cost by dispensing with the need for large, complex, and cumbersome rotating tubs or other specialized conveyors and feed apparatus.

Other unique features of this invention, which will be described in detail below, include an adjustable, jam-resistant grinding stator 16, which is easily adjustable to regulate the sizes of the comminuted fragments discharged by the miller. Furthermore, the grinding stator 16 and discharge chute 18 are also designed to be easily switchable from one side of the symmetrical mill housing 15 to the other, thus allowing the comminuted material to be discharged from either side of the miller 10. When the grinding stator 16 is moved from one side to the other, the direction of rotation of the grinding rotor 46 must also be changed. This change of rotation of the rotor 46 is easily accomplished in this invention by driving the grinding rotor 46 via a fully reversible transmission 28.

The structural details of the reciprocating action miller 10 of the present invention are best understood by referring to Figures 2, 3, and 4 simultaneously. Specifically, rotatable grinding rotor 46 is mounted on a shaft or axle 58 that is journaled in bearings 34, 36. These bearings 34, 36 are mounted on the forward and aft vertical sidewalls 69, 67, respectively, of mill housing 15. The grinding rotor 46 is rotated about grinding rotor axis 72 by the engine 22 via the fully reversible transmission 28 and driveshaft 32. Grinding concave or stator 16 is disposed below rotor 46, also between the forward and aft vertical sidewalls 69, 67 of mill housing 15, as will be fully described below.

The grinding rotor 46 and stator 16 arrangement according to the present invention are best seen in Figures 5 and 7. Essentially, the grinding rotor 46 comprises a plurality of rotor plates 48 attached to a rotor hub 56 in parallel, spaced-apart relation, between which are mounted a plurality of hammers 50 and, preferably, although not necessarily, a plurality of chipping knives 64. The hammers 50 are pivotally mounted by a series of retaining pins 54 in angular intervals around the peripheries of the rotor plates 48. The angularly spaced intervals between sets of hammers 50 are preferably about 60 degrees, although they could be more or less as desired or appropriate for a particular application, as long as dynamic balance is maintained.

Referring also now to Figure 9 in combination with Figures 5 and 7, the grinding rotor 46, as described above, is rotatably mounted on the axle 58 to rotate about the rotor axis 72, which is defined by the axle 58. As the grinding rotor 46 rotates at a high angular velocity during operation, as described above, the inertia of the hammers 50 cause them to extend radially outward, as shown in Figures 5, 7, and 9, such that they trace a path that defines a grinding cylinder 200, as illustrated in Figure 9. The grinding cylinder 200 has a cylindrical radius R that is defined by the radial distance between the rotor axis 72 and the distal ends of the hammers 50, and it has a cylindrical peripheral surface 202 defined by the distal ends of the hammers 50. The cylindrical peripheral surface 202 extends between the radially outermost extremities of a first cylinder end 204 and a second cylinder end 206, which are defined by the paths traced by the lateral sides of the outside hammers 50.

The grinding rotor 46 rotates in the direction of arrow 208 for purposes of this description, although it can be operated in the reverse direction with some modifications, as will be described in more detail below. As will also be described in more detail below, a significant feature of this invention is that the material to be comminuted is fed into the grinding cylinder 200 in a reciprocal manner, alternately into a portion of the first end 204 and then into the second end 206, as indicated by arrows 212, 214 substantially along a feed axis 210 that is essentially parallel to the rotor axis 72. These end portions 204, 206 define first and second chopping paths where the material M is initially contacted by the grinding rotor 46.

Hopper 12, positioned over the mill housing 15, is essentially a four sided structure that encloses a chamber 220 for receiving and containing material to be comminuted. It has a floor 70 with a central aperture or slot 17 through which the mill hammers 50 and chipping knives 64 (Figure 4) extend as they are rotated by rotor 46. The top of hopper 12 is preferably left open to receive material to be comminuted into the chamber 220. It is particularly adapted for receiving batch dumps of such material, such as from a conventional front end loader (not shown). Hopper 12 also houses the reciprocating feeder 14 for shifting or moving the material M in the hopper 12 back and forth in relation to the grinding rotor 46 and in a direction essentially parallel to the rotor axis 27, as described above, to feed material alternately and sequentially into the first end 204 of grinding cylinder 200 and then into the second end 206.

The floor 70 of hopper 12 preferably has convex portions 222, 224 extending from opposite sides of aperture 17, respectively, to opposite end walls 226, 228 of the hopper 12. While not absolutely essential, it is preferred that these convex floor portions 222, 224 be somewhat in the shape of partial cylindrical or semi-cylindrical surfaces with respective radii that are less than the radius R of grinding cylinder 200, as best seen in Figures 3 and 10. Flat portions 232, 234 of floor 70 extend from the convex portions 222, 224, respectively, laterally outward to the sidewalls 236, 238 of hopper 12.

With this floor structure, the material M to be comminuted, which is in the hopper 12, is presented to an initial grinding portion 230 of the grinding cylinder 200 in a profile as best seen in Figure 10. This initial grinding portion 230 is essentially the radially outermost segment of the sector of the grinding cylinder 200 that extends radially outwardly beyond the convex semi-cylindrical portions 222, 224 of the hopper floor 70 into the chamber 220. Consequently, as the reciprocating feeder 14 moves the material M in hopper 12 back and forth over the grinding rotor 46 parallel to the rotor axis 72, gravity acting on the material M in combination with the feeder 14 causes the portion of the material M that is next to the floor 70 to be fed first from one direction into one side 204 of the grinding portion 230 of grinding cylinder 200 and then sequentially into the opposite side 206 of the grinding portion 230. Since the diameter of the grinding cylinder 200 is approximately the same as the width of the chamber 220 in hopper 70, this structure results in a very effective and efficient feed of essentially the full width of the material M in chamber 220 into essentially the full diametric width of the grinding cylinder 200, yet having only the hammers 50 of the grinding rotor 46 making the initial contact with the material M. The reciprocal feed also has the beneficial effect of fully utilizing the hammers 50 on both sides or ends 204, 206 of the grinding rotor 46, which not only increases efficiency and feed capacity, but also distributes wear on the hammers 50 equally to both sides of the grinding rotor 46. This profile also has the beneficial effect of allowing each hammer to strike material M at the same angle of attack as the others, regardless of which side of the hopper or floor where the initial attach occurs. This angle of attach is essentially tangential to the grinding cylinder 20, which is always essentially perpendicular to the hammers, which maximizes striking power and momentum. Further, the sequential shifting or reversal of direction of movement of the material M tends to break down bridging of the material M in the hopper 70 that could inhibit feed into the grinding cylinder 200.

One of the significant features of this invention is the overhanging relationship of the edges 71, 73 of the opening 17 in floor 70 with respect to the grinding rotor 46, as is best seen in Figures 2 and 5. This overhang of the edges 71, 73 preferably extends over the outer plates 48 of rotor 46, thus prevents material M from falling into the spaces between the aft-most rotor plate 48 and aft vertical sidewall 67, or between the forward-most rotor plate 48 and forward vertical sidewall 69, as the material is being axially fed into either end 204, 206 of rotor 46 in the hammer mill housing 15. If material were to become lodged in these spaces, it could possibly jam the rotor 46, or at least cause rapid wear to rotor plates 48 and sidewalls 67, 69.

A plurality of triangular-shaped material control projections or log ramps 60 attached to the cylindrical cross-sectioned floor 70 of hopper 12 near forward and aft edges 73, 71, guide larger chunks of refuse, such as stumps or logs radially outward toward the outermost peripheral extremities of the rotor 46 to aid in gradually feeding such larger chunks of refuse into the rotating hammers 50 and knives 64 of rotor 46. Finer material, on the other hand, can be pushed between these ramps 60 for feeding into a larger portion of the rotor 46. The ramps 60 also tend to hold some smaller and medium-sized chunks, such as smaller branches or boards, in place while the hammers 50 of rotor 46 knock off their leading ends, rather than being able to fling them laterally or tangentially away from the rotor 46.

Actually, these log ramps 60 need not be of triangular cross-section, as is seen in Figures 2, 3, and 4, and may be of a rectangular cross-section, as in the rectangular log ramps 62, as seen in Figure 7. However, it is important to realize that the triangular log ramps 60 oriented as shown in Figures 2, 3, and 4, only work well for holding chunks in place when the rotor 46 is turning in the direction indicated by arrow 76 in Figure 4, which means that the discharge cannot be moved to the opposite side of the miller 10. However, in the preferred embodiment, the side of the miller 10 from which the comminuted material can be discharged is reversible, which requires that the rotor 46 rotate in either direction depending on where the discharge side is located. In this case, the rectangular cross-section ramps 62 must be used to provide efficient holding and feeding of material, regardless of the direction of rotor rotation.

As is best seen in Figures 5 and 6, each retaining pin 54 of the grinding rotor 46 has a substantially half-round slot, or groove 53 around or in its circumference at a location corresponding to one of the rotor plates 48. See Figure 5. A retaining screw 57 is threaded into a hole 74 in rotor plate 48 such that the shoulder 59 of retaining screw 57 engages the groove 53 of pin 54, thereby axially retaining pin 54. A counter sink 75 in the peripheral surface of rotor plate 48 protects the head 61 of retaining screw 57 from wear during the grinding operation.

Likewise, the chipping knives 64 are mounted to the perimeter of the rotor plates substantially half way between the successive sets of hammers 50, i.e., also in approximately sixty (60) degree intervals. The chipping knives 64 are not pivotally mounted, but each is retained by two bolts 55, thus allowing for easy reversal thereof when changing the direction of rotation of rotor 46, or to allow for the easy removal and replacement of damaged or worn knives. The knives 64 can be mounted in any conventional manner, as will be readily obvious to persons having ordinary skill in the art after becoming familiar with this invention, so it is not deemed necessary to illustrate in detail any particular mounting structure for purposes of this disclosure.

Referring now to Figures 4 and 7, the inlet end 78 of the arcuate grinding concave or stator 16 is pivotally mounted to vertical cross member 68 of hopper 12 by pivot 150, which can be either a bolt or a pin, such that the center of curvature of the stator 16 is eccentric with respect to the center axis 72 of grinding rotor 46, thereby resulting in a continually decreasing clearance, thus decreasing grinding volume, between the hammers 50 and knives 64 and the stator 16. See Figure 7. The outlet end 80 of stator 16 is preferably attached to and supported by an adjustable air shock 82, which is used to adjust the spacing between the hammers 50 and knives 64 and the inside grinding surface 84 of the stator 16, thus adjusting the sizes of the comminuted particles. The adjustable air shock 82 positions the stator 16, as could also be done with a hydraulic or mechanical screw-type jack, but with the additional advantage of providing a significant degree of yielding or shock absorption action in the event a heavy slug of material or a large, non-comminutable object finds its way into the grinding mill. Specifically, the air shock 82 will allow the stator 16 to pivot or move radially outward to some extent in relation to the rotor 46, thus allowing the non-comminutable object, which might otherwise jam or damage the mill, to be passed through the mill and ejected.

A plurality of shear plates 52 in the shape of segments of a circle are attached to the inside surface 84 of stator 16 in spaced-apart relation to each other near the outlet end 80. These shear plates 52 are positioned to extend into the periphery of the rotor 46 a sufficient distance such that the hammers 50 extend into the spaces between the shear plates, as shown in Figures 5 and 7. These shear plates 52 contribute to the comminution of material in the mill housing 15 as the hammers 50 force the material to shear and be torn and shredded into smaller pieces as the hammers 50 drag the material between the shear plates 52. However, the shapes and positions of the shear plates 52 in the manner shown in Figure 7 is such that the exposed edges 86, which substantially define a chord of a circle defined by the rotor 46, provide a smoothly inclined surface for guiding hard objects 90, such as chunks of iron, rock, concrete, or the like, through the mill housing 15 and out discharge end 80 without jamming.

In the preferred embodiment, the degree of eccentricity of stator 16 with respect to center axis 72 and the adjustment range of air shock 82, are such that when air shock 82 is fully extended to produce the smallest sizes of comminuted particles, the stator 16 is in the position indicated by solid lines in Figure 7. That is, the outboard ends 51 of hammers 50 just clear the inside surface 84 of stator 16 where the hammers 50 pass the closest to the inside surface 84, which is near the outlet end 80. This close fit in the "fine" grinding position not only grinds the refuse into relatively fine or small particles, because they are forced to pass between the close clearances between the shear plates 52, the inside surface 84, and the hammers 50, but also the hammers 50 sweep the inside surface 84 clean of nearly all residue and eject it out the discharge end 80. Conversely, when the air shock 82 is fully retracted, the stator 16 moves to the position indicated by the broken lines 16' in Figure 7. In this "coarse" grinding position, the outboard ends 51 of the chipping hammers 50 just clear the outside edges 86 of shear plates 52. Note also that the discharge angle, indicated by arrow 92 in Figure 7, changes little with the adjustment of the stator 16. Finally, a plurality of grinding teeth 88 can also be attached to the inside surface 84 of stator 16 between the inlet end 78 and shear plates 52 to aid in pulverizing and breaking-up the material to comminute it even finer.

The details of the reciprocating feed apparatus 14 are best seen and understood by referring to Figures 2, 3, and 4 simultaneously. Essentially, reciprocating feed apparatus 14 comprises a rectangularly shaped frame 250, which extends longitudinally through the chamber 220 of hopper 12 over the floor 70. The frame 250 comprises two longerons 94, 95 in parallel, spaced-apart relation to each other and has forward and aft cross members 97, 96 attached at either end. The external side of each of the two longerons 94, 95 is channeled adjacent the sidewalls 236, 238, respectively, to receive the guide rollers 66, which are mounted on the interior surfaces of the sidewalls 236, 238 to support and guide the frame 250 of feed apparatus 14 as it moves in a reciprocal manner within the hopper 12, as shown in Figures 2 and 4. Forward and aft vertical push walls 44, 42 are attached to and extend downwardly from longerons 94, 95 to floor 70 and are braced by forward and aft wall braces 99 and 98. A decking plate 89 is positioned on the frame 250, but not between the two push walls 42, 44, to form platforms 246, 248 at the fore and aft ends of the reciprocal feeder 14. The space between the push walls 42, 44 forms a well 249 that extends downwardly in chamber 220 to the floor 70. These platforms extend through openings 252, 254 (Figure 2) in end walls 242, 244, respectively, of hopper 12.

In operation, the entire feed apparatus 14 is reciprocated back and forth within chamber 220 in hopper 12 in directions parallel to the rotor axis 72 to axially feed material M contained in the well 249 between the two push walls 42 and 44 back and forth into either end 204, 206 of the grinding cylinder 200, as described above. The reciprocating feed apparatus 14 is shown in Figure 3 in its aft-most position, with forward push wall 44 nearly adjacent log ramps 60 and with rearward push wall 42 nearly adjacent end wall 242. When the feed apparatus 14 is reciprocated all the way to the forward position, vertical push walls 42, 44 will be in a similar positions 42', 44', as indicated by broken lines in Figure 3. The reciprocating feed apparatus 14 is reciprocated by hydraulic cylinder 20, with the blind end of the cylinder 25 attached to cross member 21 and with piston rod 23 attached to wall 42.

As material M to be comminuted is dumped through the open top of hopper 12 into chamber 220, such as in batches by a conventional front end loader (not shown), some will fall into the well 249 between push walls 42, 44, and some will fall onto the platforms 246, 248. Then, as the feeder 14 moves in a forward direction, the push wall 42 will push material in well 249 into the one side 204 of the grinding portion 230 of grinding cylinder 200, and the end wall 244 will restrain material on platform 248 from moving, thus causing it to reposition and drop into the well 249. Conversely, as the feeder 14 moves in the opposite or rearward direction, the opposite push wall 44 will push material in the well 249 into the opposite side 206 of the grinding portion 230 of grinding cylinder 200, while the end wall 242 resists movement of material on platform 246, causing it to reposition and drop into the well 249. This reciprocal motion of feeder 14 continues until all of the material in the hopper 12 is fed into the grinding cylinder 200, and it continually repositions and agitates the material to prevent bridging and to positively push the material alternately into one side 204 and then the other side 206 of grinding cylinder 200 until that is accomplished. The bottom edges of the push walls 42, 44 are preferably shaped to conform to the convex floor portions 222, 224, and to the lateral side portions 232, 234, so they accomplish essentially clean sweeps of material in the well into the grinding cylinder 200.

As described above, the reciprocating feed apparatus 14 is actuated by hydraulic cylinder 20, which reciprocates the forward and aft vertical walls 44, 42 within the interior of the hopper 12, thus pushing and sweeping the refuse or material to be comminuted into the hammer mill rotor 46, which pulls it down into the mill housing 15 for further grinding. Reciprocation of the feed apparatus 14 can be accomplished by an electro-hydraulic system, such as that shown schematically in Figure 8, although any other suitable control system can also be used. Essentially, a hydraulic pump 100 driven by engine 22 draws hydraulic fluid through a filter 102 from reservoir 104. The high-pressure hydraulic fluid is then pumped through an oil cooler 106 and into an auto flow control valve 108 and its associated control box. Auto flow control valve 108 can be a model A1044 Governor Valve. Then, depending on the position of the three (3) position valve 110, the fluid is either returned to the reservoir 104, or is directed to either the blind end or the rod end of the dual action hydraulic cylinder 20, which either extends or retracts the piston rod, thus reciprocating the feed apparatus 14. The position of valve 110 can be electrically controlled by two (2) solenoids 109, 111, which actuate the valve 110 to cross-feed the lines, thus extending the rod of cylinder 20, or direct-feed the lines, thus retracting the rod of cylinder 20. When neither solenoid 109, 111 is activated, the valve 110 "short circuits" the flow and returns the pressurized hydraulic fluid to the reservoir 104.

The electrical control system for activating the solenoids 109, 111 is straightforward, and comprises an engine driven alternator 300, two 12 volt storage batteries 302, 304, a latching type relay 306, two (2) normally open proximity switches 308, 310, and an on-off switch 312. Upon closing the switch 312, current flows through proximity switch 308 and through the latching relay 306, which then energizes solenoid 109, which pulls the valve 110 to the left, thus cross-feeding the hydraulic fluid to extend cylinder 20. As soon as target 328, which is attached to the reciprocating feed 14, clears proximity switch 308, switch 308 opens. However, latching relay 306 continues to energize solenoid 109 until target 330 closes proximity switch 310, which is a characteristic of latching relay 306, at which time relay 306 de-energizes solenoid 109 and energizes solenoid 111, which pulls the valve 110 to the right, and thus retracts cylinder 20, and thus reciprocating feed apparatus 14, where the process of reciprocation begins all over again.

To begin grinding, the engine 22 is started, and the rotor 46 is brought up to its operating speed. The refuse or material to be comminuted is then dumped into hopper 12. Closing on-off switch 312 activates the hydraulic cylinder 20 as previously discussed, which begins to reciprocate the feed mechanism 14 to move the refuse back and forth in hopper 12, thus feeding the material alternately into both sides of the grinding cylinder 20 defined by the rotor 46, as described above. The refuse or material is then drawn into the inlet end 78 of stator 16 by hammers 50, where it is pulverized, cut, torn, shredded, and otherwise comminuted by the action of the hammers 50 and knives 64 co-acting with grinding teeth 88 and shear plates 52 on the stator 16. Note that the grinding volume, or space between rotor 46 and stator 16, is constantly decreasing as the refuse travels from the inlet end 78 to the outlet end 80 of stator 16. This decreasing space provides for efficient grinding and jam-resistant operation, since the tougher, more difficult material tends to remain near the inlet end 78 of stator 16 until it has been sufficiently pulverized to travel further down the stator 16 where it is finally ejected. Of course, the sizes of the comminuted particles can be adjusted as described above by adjusting the position of stator 16 by adjustable air cylinder 82.

Likewise, the position of the discharge chute 18 can be adjusted by jack 19. See Figure 4.

Should the operator deem it necessary to have the comminuted material discharged from the opposite side of the mill 10, all he would need to do is to disconnect the inlet end 78 of stator 16 from pivot 150 (Figure 4), and the discharge chute from pivot 152, and interchange the two, thus moving the material discharge to the opposite side. Similarly, the adjustment jacks 82 and 19 are removed from their respective pivots 154, 156, and relocated on the opposite side by pivots 158, 160, respectively. Finally, before milling can start with the changed discharge side, the rotation of the rotor 46 needs to be reversed, i.e., it needs to rotate in the direction opposite from that indicated by arrow 76 in Figure 4. This change of direction is accomplished by reversing transmission 28 by actuating the reversing lever (not shown). Such reverse operation is facilitated in this invention with a reversible transmission 28 that operates with the same input-to-output speed ratios in both the forward and reverse directions. The mill 10 will then comminute material and discharge it from the opposite side with no loss of efficiency.

This completes the description of the structure and operation of the reciprocating miller 10 of the present invention. While the basic features have been shown and described, many modifications will become apparent to those skilled in the art, and should be considered as falling within the scope of the invention. For example, any number of rotor plates 48 could be arranged on rotor hub 56 to increase or decrease the numbers of hammers 50 and knives 64 attached thereto. Of course, if this is done, there must be corresponding changes in the numbers of shear plates 52, and in the overall width between sidewalls 67, 69, and the width of opening 17 in floor 70. Likewise, changes in the width of the stator 16 and discharge chute would also be required. It would also be possible to replace the hammers 50 and knives 64 with other devices which would pulverize the refuse. Similarly, while the hammers 50, and knives 64 used in the preferred embodiment are replaceable, which is desirable, non-replaceable hammers and knives could also be utilized. Numerous other modifications are also possible, and should also be considered as falling within the scope of the present invention.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be considered as falling within the scope of the invention as defined by the claims which follow.

Claims

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Grinding apparatus for comminuting material and ejecting it through an outlet, comprising:

grinding means for comminuting said material including a rotatable grinding rotor mounted for rotation about a rotor axis such that said grinding rotor, when rotating, defines a grinding cylinder with a first end and a second end on opposite sides of a cylindrical peripheral surface and wherein portions of said first and second ends adjacent said peripheral surface define respective first chopping path and second chopping path, for initially cutting, breaking or tearing said material;

a hopper defining an interior chamber for receiving and containing said material, said hopper having a floor with an opening therein dividing said floor into forward and aft portions, said hopper being positioned adjacent said grinding means in such a manner that a portion of said grinding rotor protrudes through said opening into said chamber to expose material in said hopper to said grinding means;

reciprocating feed means associated with said hopper for moving said material in said chamber reciprocally along a second axis that is substantially parallel to said rotor axis to direct portions of said material alternately into said first chopping path and then into said second chopping paths.

2. The grinding apparatus of claim 1, wherein said grinding cylinder has a rotor radius, and wherein said floor has a semicylindrical convex portion with a longitudinal floor axis that extends in the same direction as said rotor axis and with a floor radius that is smaller than said rotor radius.

3. The grinding apparatus of claim 2, wherein said rotor axis and said floor axis coincide with each other.

4. The grinding apparatus of claim 2, wherein said interior chamber of said hopper is approximately the same width as the diameter of said grinding cylinder.

5. The grinding apparatus of claim 2, wherein said grinding rotor has a plurality of hammers mounted around its periphery, the radially distal ends of which hammers define the periphery of said grinding cylinder, said hammers being longer than the difference between said rotor radius and said floor radius, such that the radially outward portions of said hammers are included in said first chopping path and in said second chopping path.

6. The grinding apparatus of claim 1, wherein said reciprocating feed means includes a first push plate and a second push plate positioned in spaced-apart relation to each other in said chamber and on respectively opposite sides of said grinding rotor, and wherein said push plates are reciprocally moveable in a direction parallel to said rotor axis.

7. The grinding apparatus of claim 6, wherein said push plates are moveable in unison with each other.

8. The grinding apparatus of claim 7, wherein said reciprocating feed means includes a first platform that extends from said first push plate in the opposite direction of said grinding rotor and a second platform that extends from said second push plate in the opposite direction of said grinding rotor.

9. The grinding apparatus of claim 8, wherein said hopper has walls extending upwardly from said floor and surrounding said interior chamber and wherein said first and second platforms extend outwardly from said interior chamber beyond said walls.

10. The grinding apparatus of claim 9, wherein said first platform moves in unison with said first push wall and said second platform moves in unison with said second push wall, and wherein said walls are close enough to said platforms such that material positioned on said platforms cannot move out of said chamber beyond said walls.

11. The grinding apparatus of claim 1, wherein said reciprocating feed means comprises:

first and second reciprocating walls in parallel, spaced-apart relation slidably mounted along said second axis within the interior chamber of said hopper and said interior chamber having a forward portion and an aft portion, said first reciprocating wall being located and reciprocated within the forward portion of said interior chamber and said second reciprocating wall being located and reciprocated within the aft portion of said interior chamber; and

linear actuating means attached to said reciprocating walls for moving said first and second walls back and forth simultaneously within the forward and aft portions of said interior chamber of said hopper, respectively, to alternately sweep the material from the forward and aft portions of the interior chamber into said opening in said floor and into said grinding means.

12. The grinding apparatus of claim 1, including an arcuate stator positioned adjacent said grinding rotor and having an inlet end and an outlet end, and said arcuate stator being mounted eccentrically with respect to said grinding rotor such that said stator is closer to said grinding rotor near said outlet end than it is near said inlet end.

13. The grinding apparatus of claim 12, further comprising stator adjusting means for moving said arcuate stator toward and away from said rotor.

14. The grinding apparatus of claim 12, further comprising means for reversing the direction of rotation of said cylindrical grinding rotor, and wherein the inlet and outlet ends of said stator can be interchanged, such that the comminuted material can be discharged from the opposite side.

15. The grinding apparatus of claim 13, wherein said arcuate stator is pivotally mounted at its inlet end to said hopper, and including adjustable air shock means connected to said arcuate stator for adjustably positioning the outlet end of said stator.

16. The grinding apparatus of claim 1, further comprising:

a goose neck support chassis attached to the forward end of said hopper; and

a goose neck attached to said goose neck support chassis and depending downward therefrom.

17. The grinding apparatus of claim 16, further comprising a maneuvering wheel attached to said goose neck.

18. The grinding apparatus of claim 5, wherein said grinding rotor includes a plurality of rotor plates, two of which are outside plates positioned at opposite ones of said first and second ends of said grinding cylinder, and which are spaced apart form each other and mounted on a rotor shaft that coincides with said rotor axis, said hammers having proximal ends that are mounted between said rotor plates, and wherein said convex floor portion has a first lip that overhangs one of said outside plates and a second lip that overhangs the other of said outside plates.

19. The grinding apparatus of claim 18, wherein said proximal end of each hammer is mounted on a pivot shaft that extends through said rotor plates near their peripheral surfaces, and wherein said pivot shaft has a circumferential clearance slot substantially about its midportion and including a retaining screw secured to one of said rotor plates along an axis that is substantially orthogonal to said pivot shaft, and engaging said circumferential clearance slot in said pivot shaft to axially retain said pivot shaft in said rotor plate.

20. The grinding apparatus of claim 12, wherein said arcuate stator further comprises:

a plurality of grinding teeth mounted on the surface of said arcuate stator that is adjacent said grinding rotor; and

shear plate means mounted on the surface of said arcuate stator near the outlet end for enhancing discharge of comminuted material and discouraging jamming of the apparatus by unbreakable material.

21. The grinding apparatus of claim 5, wherein said hammers are pivotally mounted and said grinding rotor also includes a plurality of rigidly mounted knives mounted on the periphery of said grinding rotor and dispersed angularly around the periphery of said grinding rotor between said hammers.

22. The grinding apparatus of claim 20, wherein said shear plate means comprise a plurality of shear plates attached along a predetermined arcuate portion of the inside surface of said

stator, said shear plates having arcuate curved bottom surfaces such that said shear plates can be attached to the inside surface of said arcuate stator, and flat upper surfaces which together define a planar top surface, said plates also being positioned in parallel, spaced-apart relation on the inside surface of said stator to define a hammer clearance space therebetween that is substantially parallel to the path of said pivotally mounted hammer as it is rotated by said grinding rotor, and wherein said shear plates are sized such that said pivotally mounted hammer passes substantially completely through the hammer clearance space.

23. The grinding apparatus of claim 2, including a plurality of material control means protruding outwardly from said convex floor portion in spaced-apart relation to each other adjacent said grinding rotor for grinding larger material particles outwardly away from said floor, retaining longer intermediate sized material particles against movement in directions that are not parallel with the rotor axis, and for allowing smaller material particles to pass therebetween into said chopping path.

24. Comminuting apparatus for comminuting material, comprising:

a rotor with comminuting projections extending radially outward and mounted to rotate about a rotation axis in such a manner that the rotor when rotating defines a rotor cylinder;

rotor drive means for rotating said rotor about said rotation axis;

a mill housing substantially surrounding said rotor cylinder, but leaving a portion of the periphery of the rotor cylinder exposed;

a hopper positioned over said mill housing in such a manner that the exposed portion of the periphery of the rotor extends into said hopper, said hopper being adapted to receive and contain material to be comminuted; and

reciprocating feed means for moving said material in said hopper to be comminuted in a reciprocal manner over the exposed portion of the periphery of said rotor and in opposite directions that are substantially parallel to said rotation axis.

25. A method of comminuting material comprising the steps of:

positioning a rotary hammer assembly comprising a rotor that is rotatable about a rotor axis and having a plurality of hammers mounted at their proximal ends thereon such that their distal ends extend radially outward in relation to the rotor axis in a grinding chamber with a hopper adjacent the grinding chamber such that a portion of the rotary hammer assembly protrudes into said hopper;

rotating the rotary hammer about the rotor axis in such a manner that the rotary hammer assembly defines a cylinder of rotation with the distal ends of the hammers defining a peripheral cylindrical surface and lateral sides of the hammers defining opposite cutting ends of the cylinder of rotation; and

moving material to be comminuted alternately into the portion of one cutting end of the cylinder of rotation that protrudes into the hopper and then into the portion of the opposite cutting end that protrudes into the hopper of said cylinder.

26. The method of claim 23, including the step of moving said material in said hopper reciprocally in opposite directions along a line that is substantially parallel to said rotor axis.

27. A method of comminuting material, comprising the steps of:

rotating a rotatable comminuting rotor having projections extending radially outward about a rotation axis in such a manner that said rotor and projections define a rotor cylinder with a peripheral surface;

positioning material to be comminuted adjacent and in contact with a portion of said peripheral surface; and

moving said material in a reciprocal manner back and forth in relation to said rotor cylinder and substantially parallel to said rotation axis, allowing said projections to contact and comminute said material.

28. The method of claim 27, including the step of allowing said projections to propel said material through spaces between a plurality of shear plates that are positioned to protrude into a

different portion of the peripheral surface of said rotor cylinder to an extent that defines a segment section of said rotor cylinder.

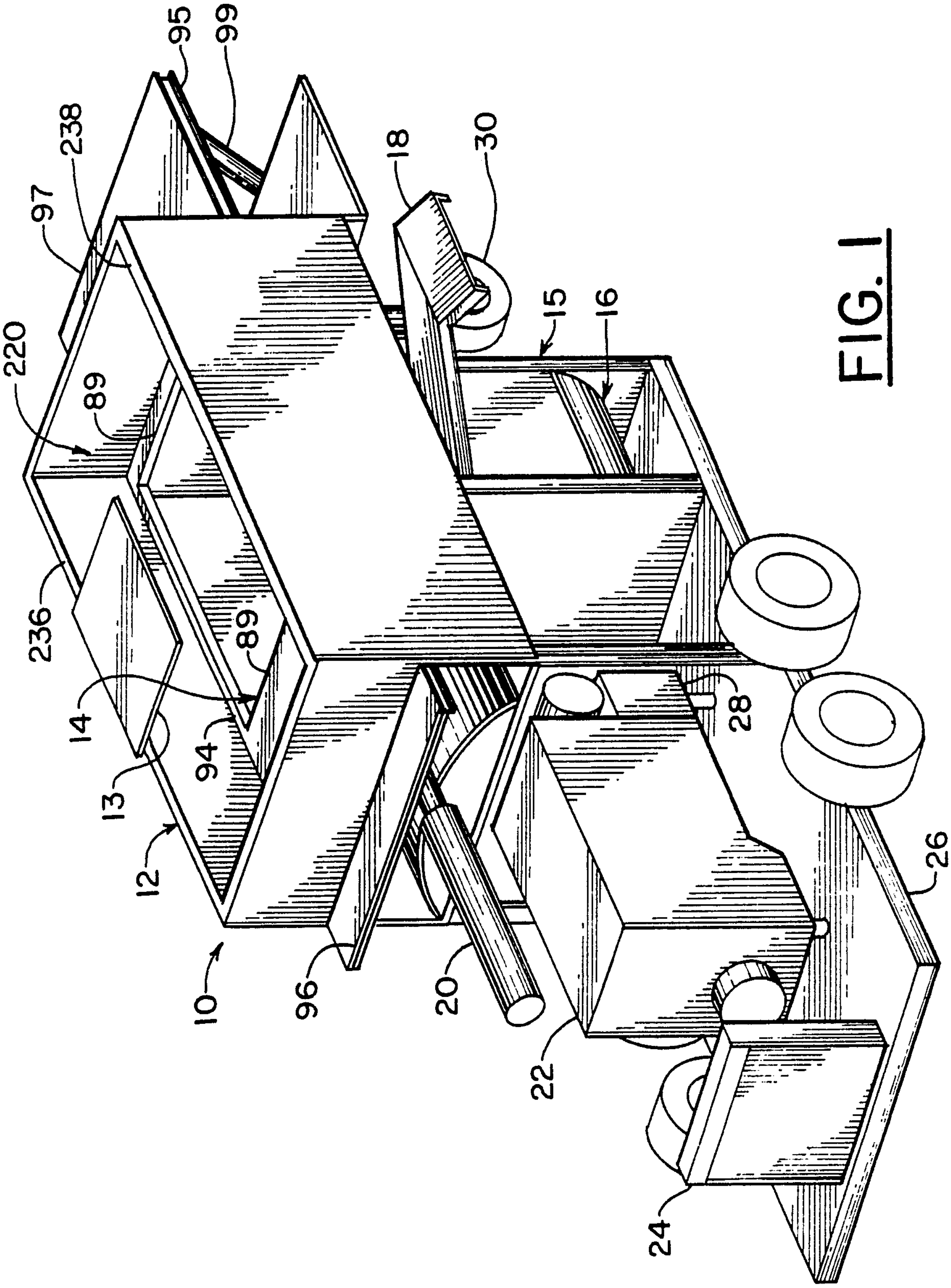


FIG. 1

2/8

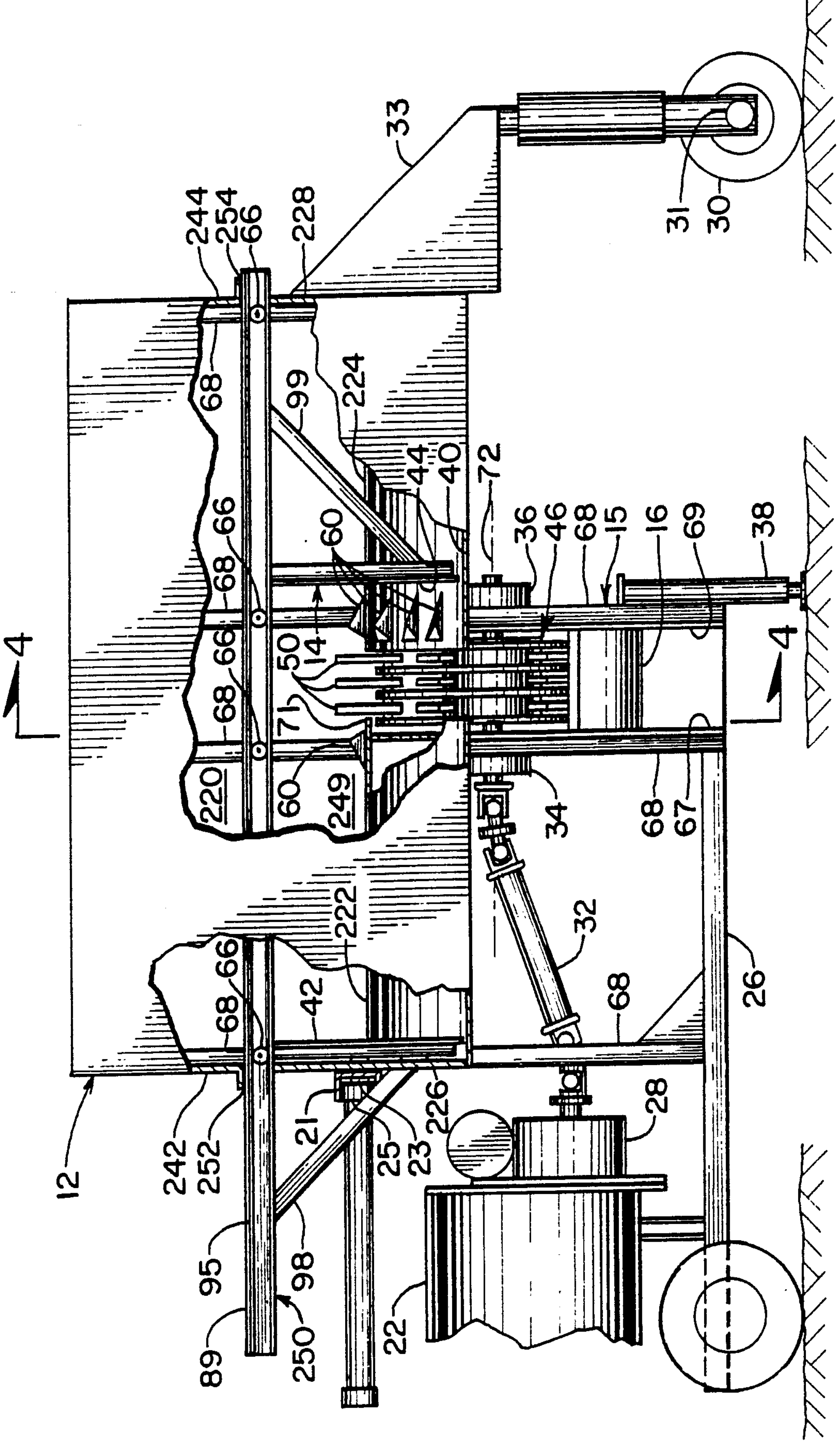

33
31
30
244
254
66
228
68
99
224
44
40
72
36
46
68
15
16
69
38
60
66
68
66
50
14
4
4
68
71
60
220
249
34
68
67
222
32
66
42
68
26
68
242
252
21
25
23
226
28
95
98
89
250
22
12

FIG. 2

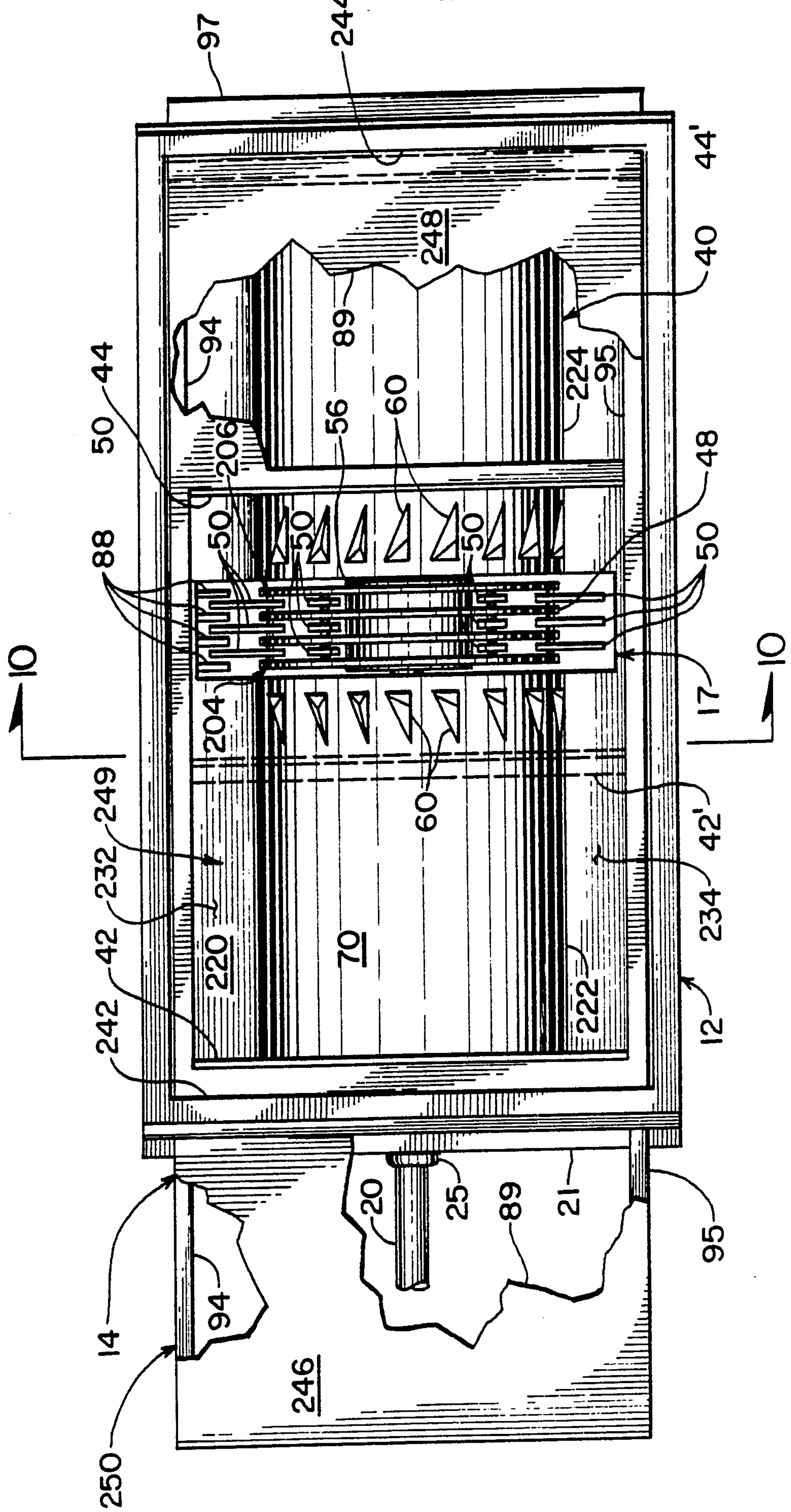
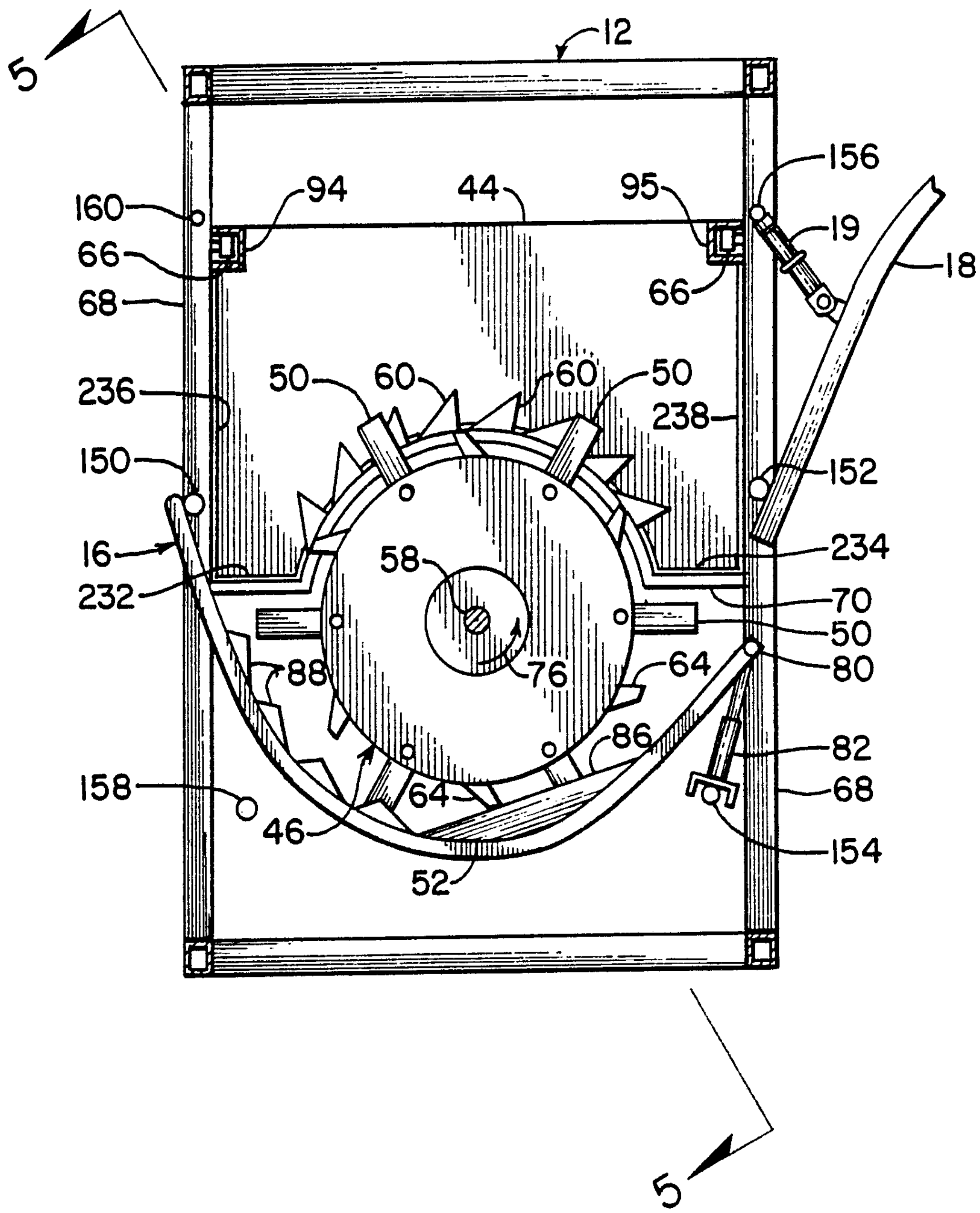

97
244
44'
248
40
89
94
224
95
60
56
50
44
206
48
88
10
17
204
60
42'
249
232
234
220
70
42
222
242
12
20
25
89
21
95
14
94
246
250

FIG. 3



5
12
156
160
94
44
95
19
18
66
66
68
236
50
60
60
50
238
150
152
16
58
234
232
70
50
80
88
76
64
86
82
158
64
68
46
154
52
5

FIG. 4

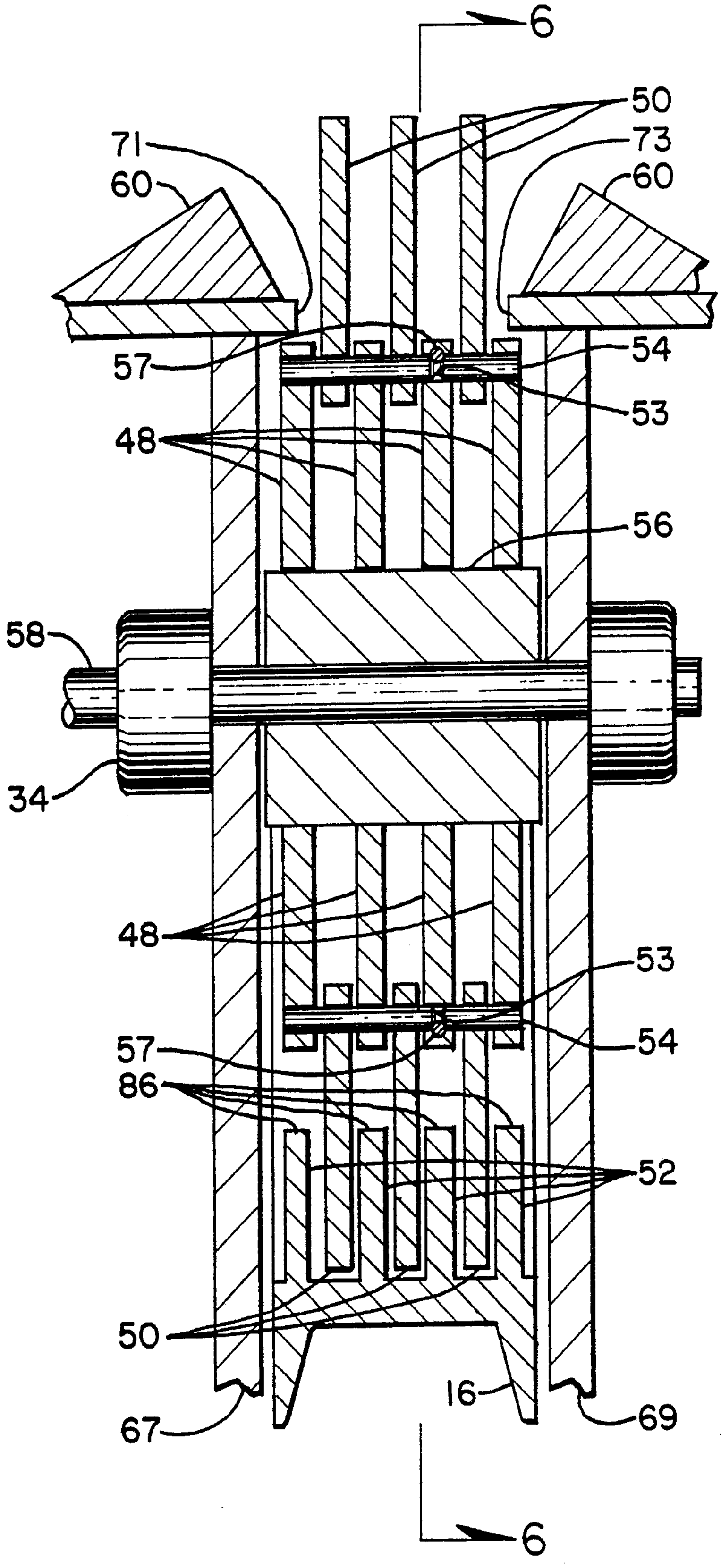


FIG. 5

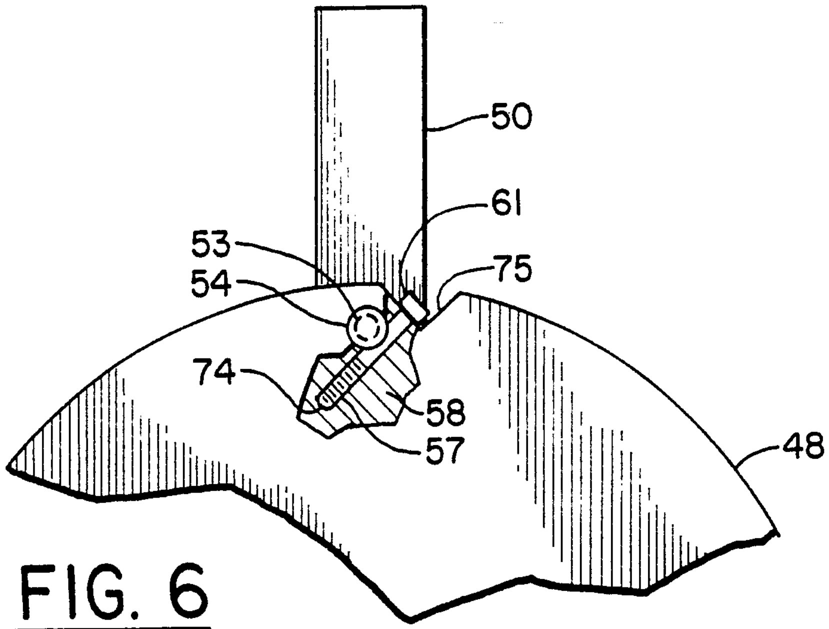


FIG. 6

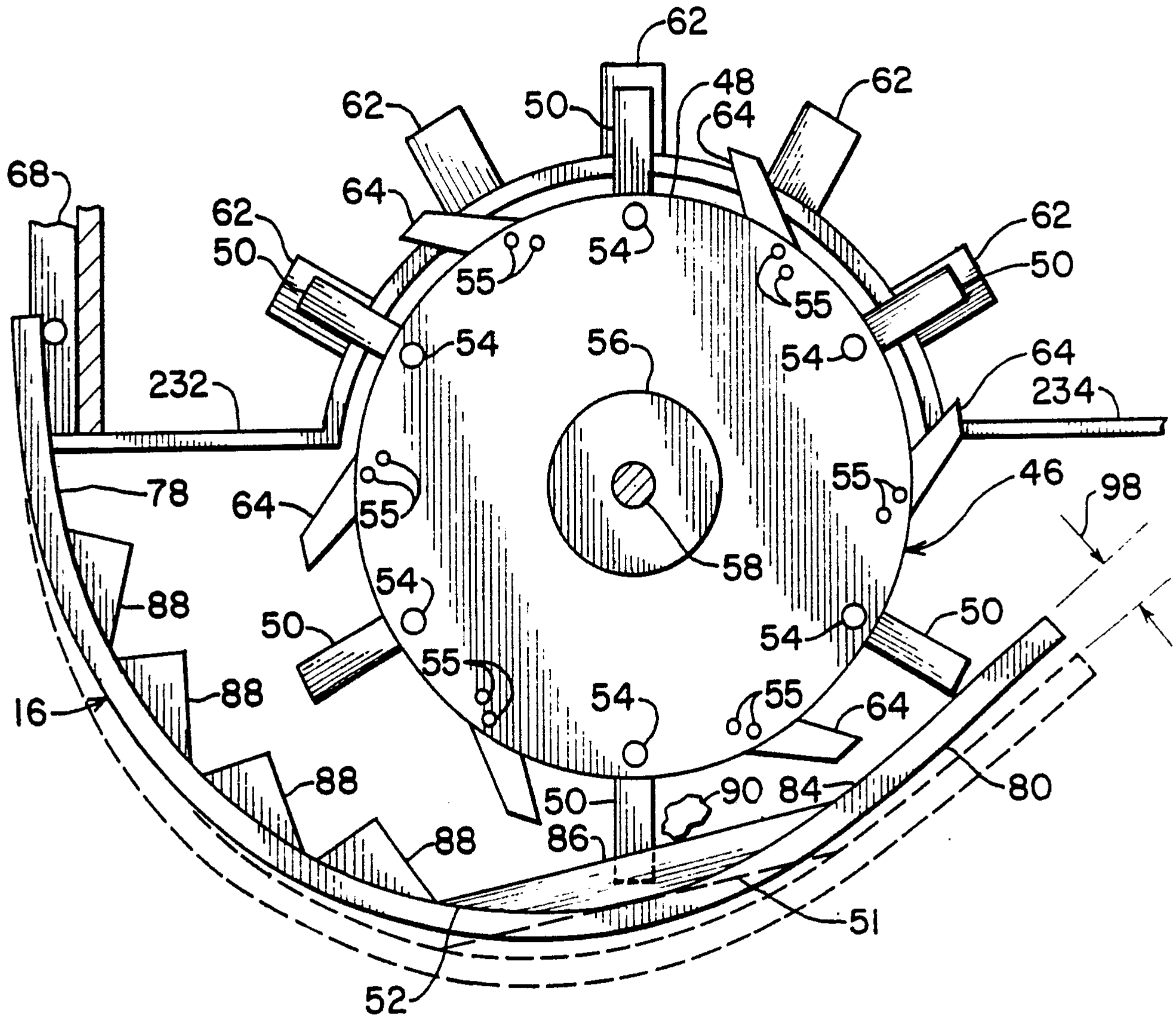


FIG. 7

SUBSTITUTE SHEET

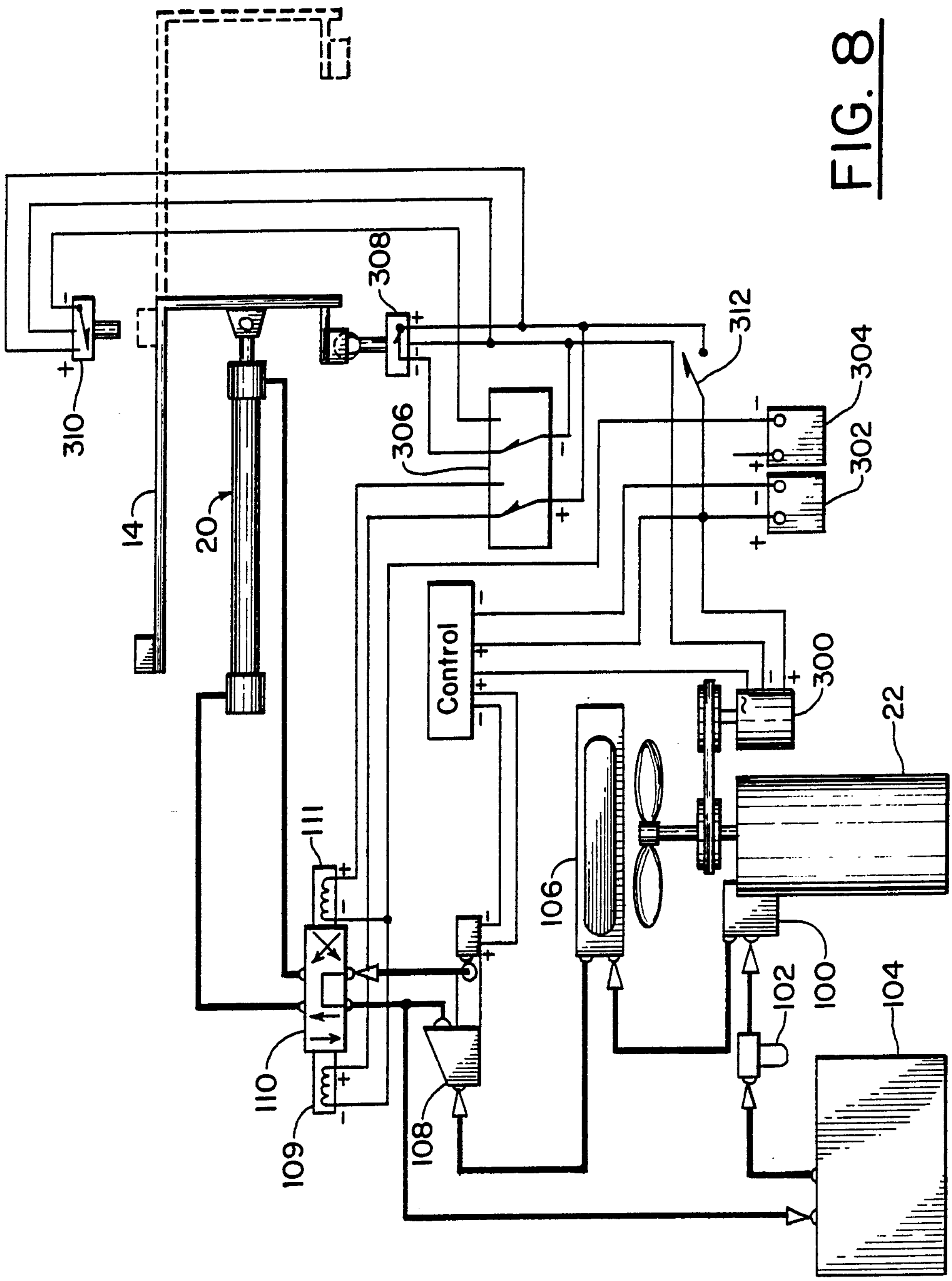

308
310
312
304
302
306
14
20
Control
300
22
111
106
110
109
108
102
100
104

FIG. 8

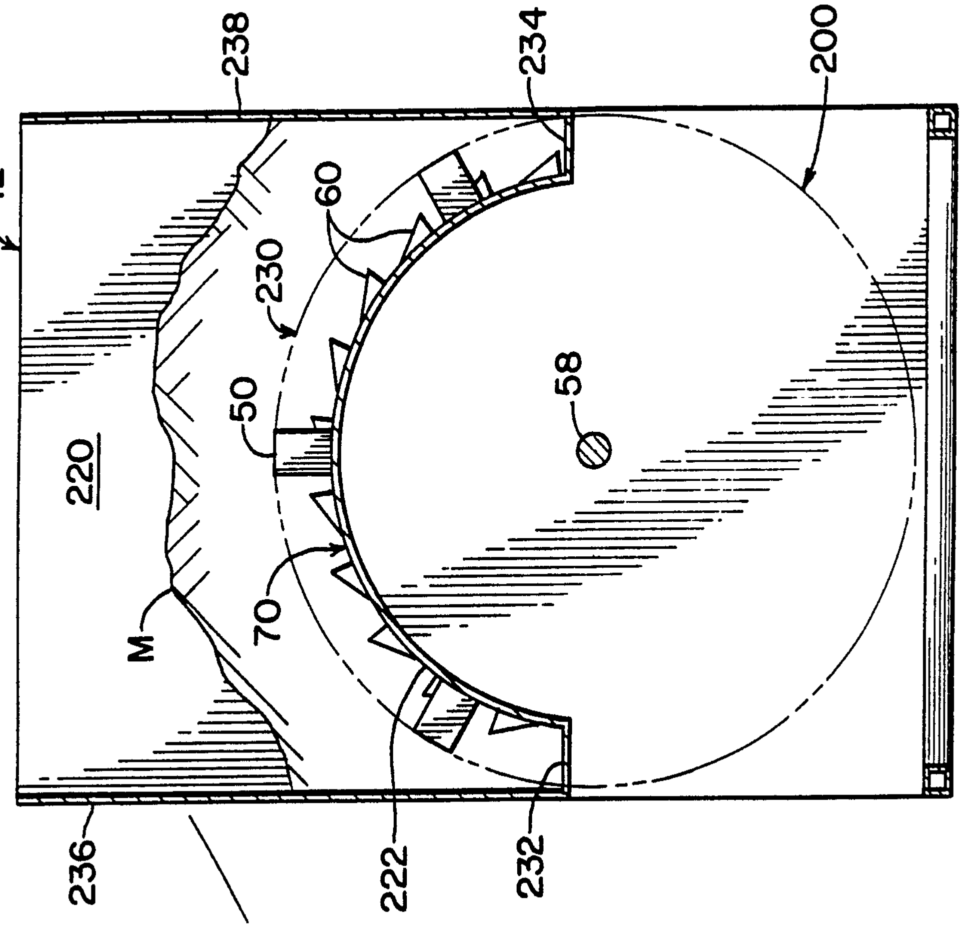

12
238
234
200
220
230
60
50
58
M
70
222
232
236

FIG. 10

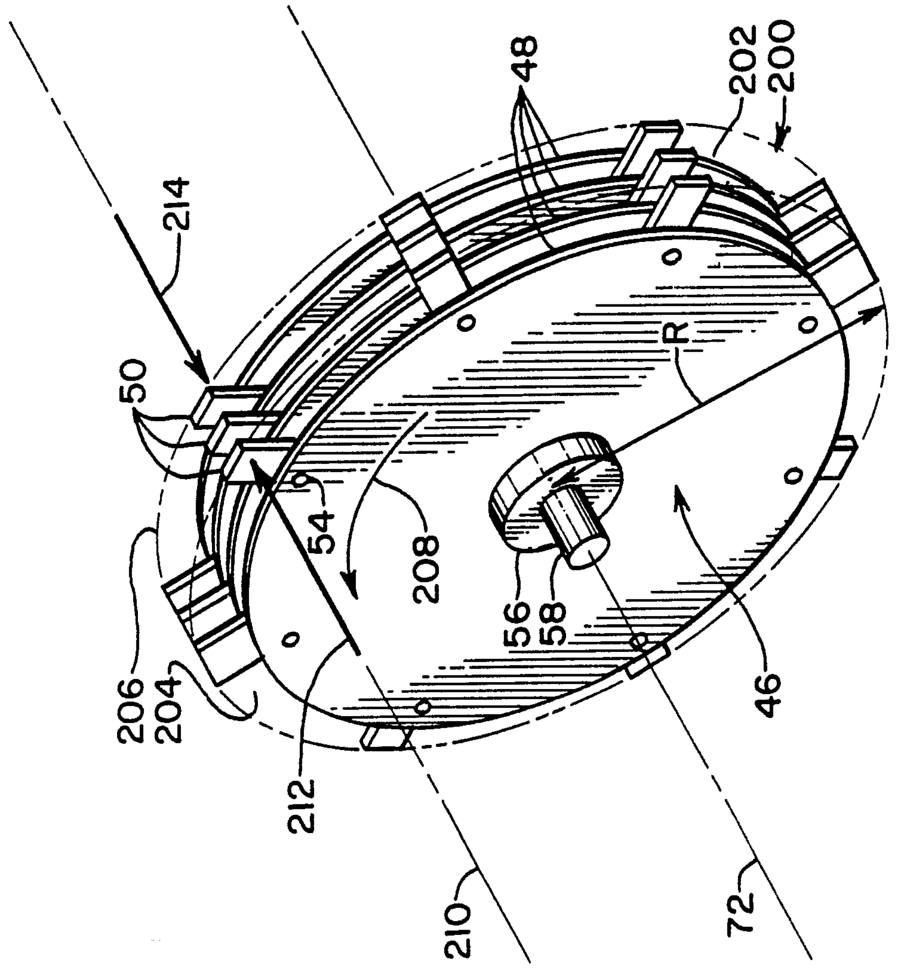

214
50
48
202
200
R
54
208
56
58
46
206
204
212
210
72

FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No PCT/US91/06268

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): B02C 13/286
US CL : 241/186.3, 189R

II. FIELDS SEARCHED

Minimum Documentation Searched

Classification System	Classification Symbols
U.S	241/DIG. 38, 101.7,30,190,194,186R,189R,294,280 281,186.4,189A,186.2,57,27,186.3

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched

III. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 4,412,659 (CRAWFORD ET AL.) 01 NOVEMBER 1983 See figure 6.	1-28
A	US, A, 4,767,066 (WILLIAMS) 30 AUGUST 1988 See the entire document.	1-28
A	US, A, 4,106,706 (BURROWS) 15 AUGUST 1978 See the entire document.	1-28

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search

12 NOVEMBER 1991

Date of Mailing of this International Search Report

13 DEC 1991

International Searching Authority

ISA/US

Signature of Authorized Officer

Mark Rosenbaum

Form PCT/ISA/210 (second sheet) (Rev.11-87)