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(54) **SOLID WASTE COMMUNICATOR**

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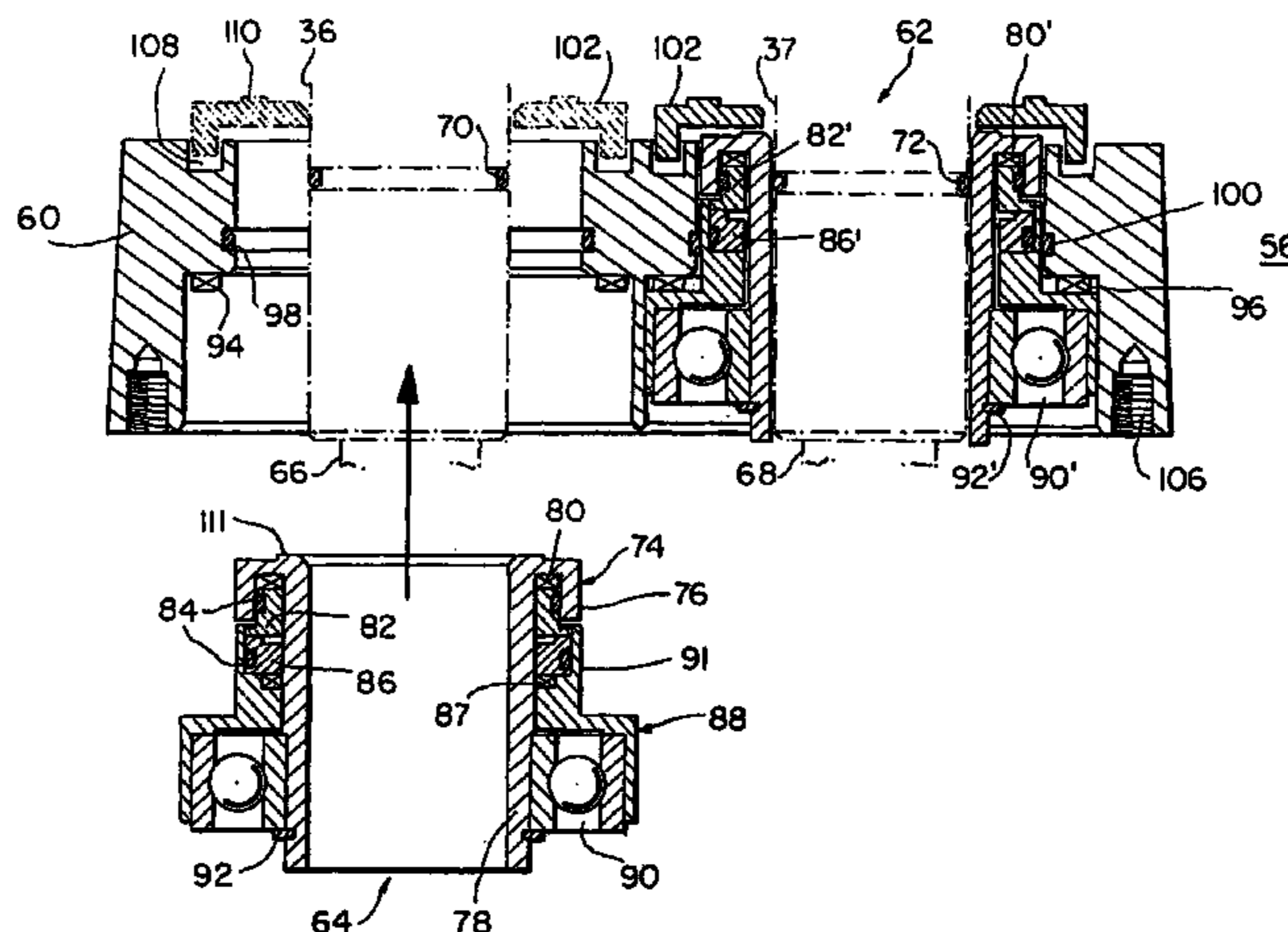
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(57) **ABSTRACT**

A solid waste material comminuting system having [a] an electric motor for providing rotary motion, a pair of cutter stacks with cutter elements of one stack interleaved with cutter elements of the other, and gear means to transmit the rotary motion of the electric motor to counter-rotate cutter elements of one stack with cutter elements of the other. Each of the cutter stacks [comprise] comprises a central shaft journaled for rotation and a seal-bearing assembly/module at each end of the central shafts. Each [bearing] assembly/module comprises an end housing, and a pair of insertable pre-assembled seal-bearing elements/assemblies mountable in each of said end housings. One seal-bearing element/assembly has a thru-hole for journaling a first shaft for rotation and a second seal-bearing element/assembly has a thru-hole for journaling a second shaft for rotation.

43 Claims, 2 Drawing Sheets



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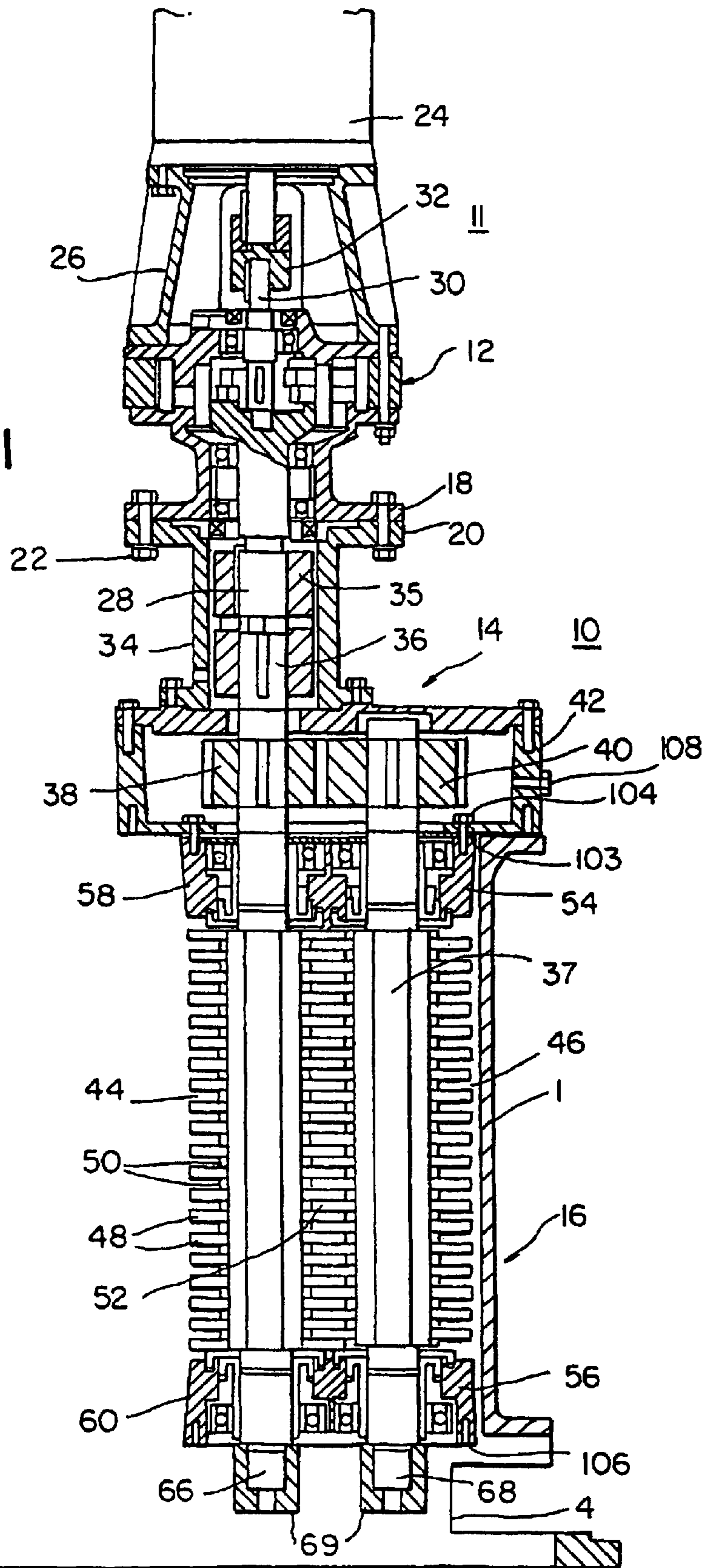
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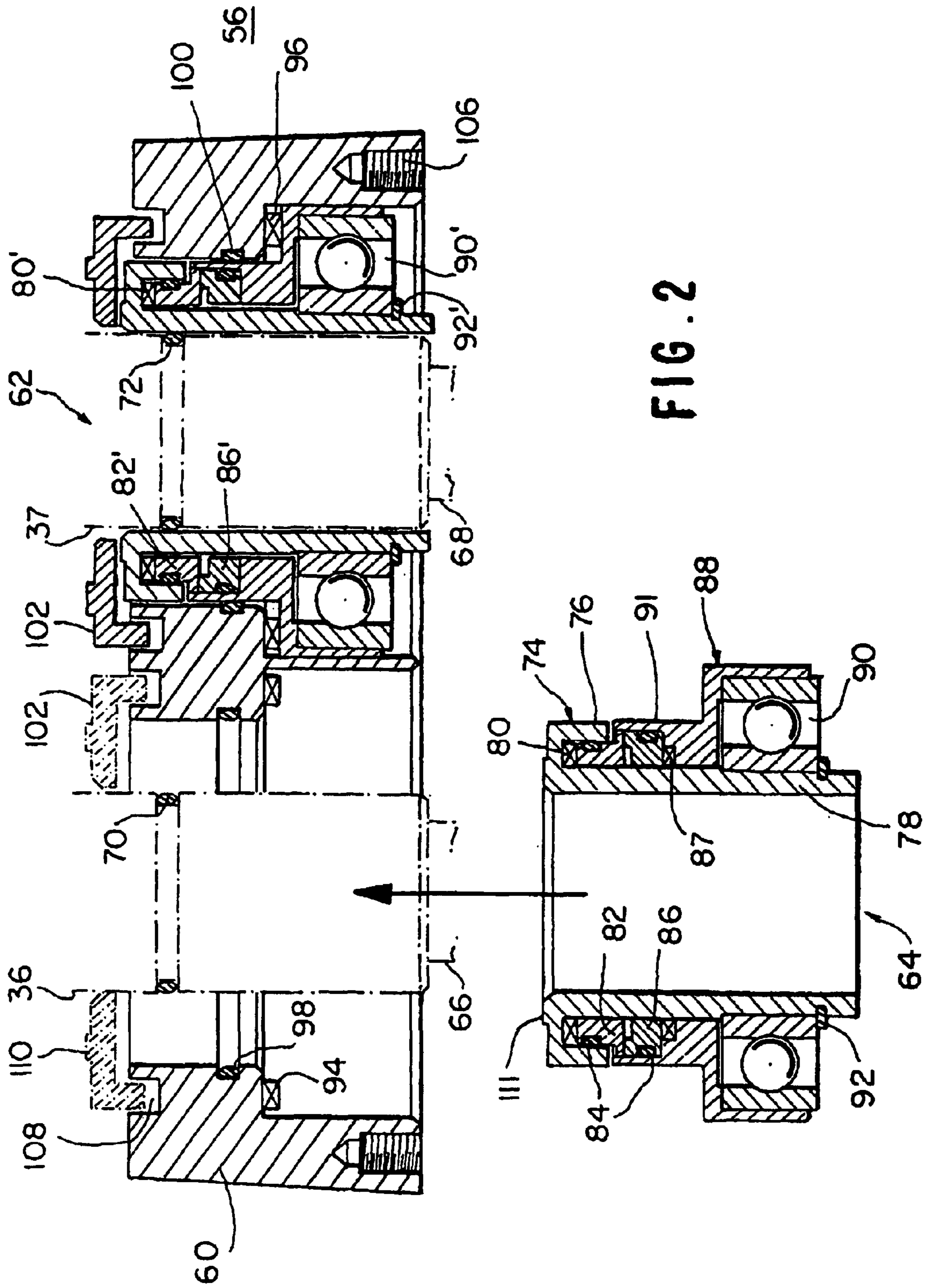
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FIG. 1





SOLID WASTE COMMUNICATOR

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF INVENTION

This invention relates to a solid waste comminuting apparatus. Such devices have been established in the art and are now widely used in a variety of industrial applications, such as municipal waste treatment and industrial applications. Reference is made to U.S. Pat. No. 4,046,324, which discloses such a basic system that has achieved commercial success.

By definition, comminution is the reduction of particle size of solid waste material to minute particles. It is generally performed by shearing, shredding and crushing of the waste material. As set forth in the '324 patent, comminution occurs by utilizing a pair of counter-rotating intermeshed cutting members.

The solid waste material is fed into the interface between cutting elements, typically utilizing a fluid carrier medium, and shearing action occurs because the two cutters overlap each other such that opposing forces of counter-rotation of the cutting elements on the different stacks act on the solid material as it passes through the device.

In practice, such devices are generally used in an influent path. That is, the solid material is generally entrained in a liquid and the device is placed directly in the liquid stream. By having the solid material entrained in a liquid stream transportation of the material to and from the unit occurs. Further, by softening the solid particles, a greater degree of comminution is achieved. Devices of the type disclosed in the '324 patent have found commercial success and are widely used in waste treatment facilities, shipboard use and the like. As can be appreciated, the environment of use is very harsh for the equipment and as such, routine maintenance is required in both a preventative sense and also to immediately repair break downs when they occur thus minimizing system down-time.

An important aspect of such maintenance and repair is the integrity of the seals which provide the cutter stacks to rotate while minimizing friction. Given the mass of the cutter stacks together with high motor torque, loads on the seals are large and thus seal integrity is a primary consideration. In the past, two-shafted machines such as the '324 device required that the seal assembly be an integral part of the device. Such is illustrated in FIG. 1 of the '324 patent. As a result, if there was a seal failure other critical components of the device were likely to be effected. This failure of a seal could thus mean that bearings could fail and seize up the cutter stack.

Importantly, to repair the seal assembly, in the prior art, there was a requirement that the device be disassembled and completely reassembled. In the context of a unit which is used in fluid waste treatment that down-time, in some cases as long as a day could have detrimental effects in the ability of a plant to process waste. Such would require rerouting solid waste, shutting down a portion of the facility and otherwise result in an inefficient operation.

Moreover, in prior art two-shafted machines, the cutter stack and the various seal components were integral and in-line with a fixed geometry. Consequently, tightening of the cutter stack, by compression, resulted in compression of the seals. Again, such is illustrated in FIG. 1 of the '324 patent. It has been recognized however, that under normal

operating conditions the cutter thickness experiences wear and thus the overall thickness of the stack tends to reduce over time. The result is an effective reduction in the overall stack height and the stack therefore tends to become loose. As a consequence, initial compression of various seal components is lost and the seal faces tend to separate. The result is leakage across the seal with the subsequent result of bearing failure.

Another deficiency in the prior art was the use of a labyrinth between the main fluid chamber and the seal faces. The labyrinth was generally incorporated into the seal components as sacrificial components. Because such devices are used in applications which include a high grit content, the labyrinth tended to be a relatively high wear component. As a consequence, seal components had to be removed to replace the labyrinth with the potential for seal damage upon reassembly.

SUMMARY OF THE INVENTION

Given these deficiencies in the prior art, it is an object of this invention to provide an improved solid waste comminutor that overcomes the operational and assembly problems of prior devices.

It is a further object of this invention to provide a solid waste comminutor which employs a cartridge with a balanced seal-bearing design to produce a constant seal face pressure.

A further object of this invention is to provide a solid waste comminutor of improved seal and bearing life by improved seal effectiveness which is independent of stack tightness.

Yet another object of this invention is to provide a seal cartridge for a solid waste comminutor which has an independent labyrinth that can be replaced without disassembly of the seal-bearing structure.

Another object of this invention is to provide an improved solid waste comminutor that utilizes a separate wear piece independent of the seal cartridge which itself may be pre-loaded to provide a spring force for the cutter stack.

These and other objects of this invention are achieved by a dual stack solid waste comminutor having preassembled bearing-sealing elements that are replaceable individually. That modular assembly improves system life while minimizing down-time. In accordance with this invention a cartridge type seal is employed utilizing two modular assemblies, one on each end of the cutter stack. Each of the modular bearing-seal assemblies comprises a pair of identical bearing-seal cartridges. Two identical bearing-seal cartridges are assembled into the end housing to thus form top and bottom modular pairs.

Further, in accordance with this invention the bearing-seal cartridges float within the housing to provide movement with shaft movement thereby reducing the stress on the shafts and bearings.

A quick exchange of the mechanical subassembly, which includes bearings, O-ring seals and cartridge housing itself can be effectuated. As a result of this modular assembly, an individual seal cartridge can be installed quickly without the need to disassemble the entire subassembly.

Another advantage of this technique is that the bearing-seal cartridge is identical for the top and bottom of the cutter stack. As a consequence, a deficiency in the prior art which used two different assemblies has been eliminated. The bearing-seal cartridge is an item which is pre-assembled and installed as received. Thus, there is no requirement that the

individual items, the various races, bearings and the like be assembled at the job site. Rather, the cartridge is interchangeable as a unit and is inserted into the end housing.

Further, in accordance with this invention by retorquing of the cutter stack can be accomplished while the unit is still in-line and installed. It has been demonstrated that in practice, the most common preventative maintenance function is re-torquing the cutter stack to maintain stack compression for maximum cutting efficiency.

Prior to this invention a loss of stack compressibility lead directly to premature seal and bearing failure, primarily of the bottom seal assembly. In accordance with this invention, the tightness of the seal assembly is independent of total stack height, since it is designed as a self contained unit no disassembly is required.

Another advantage of this invention is an early warning seal failure detection system which can be used to prevent premature bearing failure. The invention provides for a drain port and/or weep holes in the shafts that allow fluid permeating from the seal to escape to the exterior. This can thus be viewed by maintenance personnel during routine checks of the system.

These and other objects of this invention will become apparent by a review of the attached drawing and the description of the preferred embodiment which follows.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 cut-away side view of the overall comminution system of this invention; and

FIG. 2 is a schematic view illustrating the [seal] cartridges and their assembly [to form a dual seal cartridge].

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, a cut-away side view of the overall system is depicted. In FIG. 1 the housing 1 has an inlet and outlet, not illustrated. At the bottom of the housing, a pair of access cut-outs 4 are provided to permit stack tightening, to be described herein, without disassembly of the device. The unit employs, three essential subsystems, which comprise a complete comminution apparatus 10. These are a drive subsystem 11 with a motor 24 and speed reducer 12, a gearing subsystem 14, and a cutting subsystem 16. The housing 26 for the speed reducer 12 is mounted to the gear and cutter system 14, 16 by a pair of conforming flange elements 18, 20, which are clamped together by means of bolts 22. The motor is typically an electric drive motor 24, the details of which need not be discussed in detail. It will be recognized by those skilled that a suitable motor and drive system can be employed consistent with the scope of intended use. The speed reducer is contained in a housing 26 and employs an input shaft 30 and an output shaft 28. The input shaft 30 is journaled for rotation using a coupling 32 to the motor 24. This provides axial and radial alignment of the motor unit 24 with the speed reducer 12.

The output shaft 28 of the speed reducer 12 passes through a transition piece 34 in which the output shaft 28 is keyed in a drive shaft 36 of one cutter stack by means of a coupling 35. The drive shaft 36 carries a gear 38. The drive shaft 37 of the other cutter stack carries a gear 40. Both gears 38 and 40 are housed in housing 42 of the gear unit 14. The two gears provide counter-rotation to a pair of cutter stacks 44, 46. That is, shaft 36 is the drive shaft and shaft 37 is the driven shaft which counter-rotates due to gears 38, 40.

Each of the cutter stacks 44, 46 comprises an alternating sequence of cutting elements 48 and spacers 50. As illus-

trated in FIG. 1, the interface is such that by beginning the stack 44 with a cutter element and stack 46 with a spacer element the cutter elements interleave with each other in the area between the two cutter stacks, which has been denoted by numeral 52. It is this interactive pair of stacks in zone 52 which provides the shredding of material as it passes through the cutter elements.

The cutter elements themselves may be either the same on each stack or differ from stack to stack. For example, it has been found that having eleven teeth on one cutter element and five on the opposing element improves the clean-out efficiency of the unit. Moreover, the geometry of the cutter elements may also be different in addition to the variations in the number of teeth.

As illustrated in FIG. 1, the cutter stack 16 is supported top and bottom by means of a pair of bearing-seal assemblies/modules 54, 56. FIG. 2 illustrates in greater detail those two subassemblies.

Referring now to FIG. 2, the assemblies/modules 54 and 56 are explained in greater detail. It will be understood from reference to FIG. 1 that the assembly on top 54 is the same as the assembly on the bottom 56, the unit simply being inverted. FIG. 2 illustrates the seal bearing assembly 56. The units are assembled into respective end housings, 58 and 60. FIG. 2 illustrates the end housing 60. As illustrated, two identical bearing-seal cartridges are employed in the end housing. FIG. 2 illustrates one [seal] element/assembly 62 in place with a second [seal] element/assembly 64 being inserted into the end housing 60.

Illustrated in phantom line in FIG. 2 are the ends 66, 68 of the shafts 36 and 37 for the respective cutter assemblies 44 and 46. It will be understood that the shaft ends 66 and 68 protrude through the respective seal cartridges but are held in place by end nuts 69. Stack tightness is achieved by tightening the end nuts 69. Access is via the cut-outs 4 so that an individual stack may be tightened. O-rings 70, and 72 are employed to provide a fluid tight seal for each shaft.

As illustrated in FIG. 2, the bearing-seal cartridge comprises a cartridge housing 74 with an outer flange 76 and an inner tubular portion 78. A spring 80 is inserted between the flange portion 76 and the cylindrical portion 78. A dynamic race 82 sealed by means of an O-ring 84 is placed proximate the spring 80 and the cylindrical portion 78. This spring provides a means by which the race 82 is provided with float.

A static race 86 with an O-ring 84 forms the dual race structure. The race is held in place by means of the bearing cartridge 88 having a flange element 91 to cage the static race into position and to also limit axial travel of the dynamic race. The dynamic race 82 has a face in contact with a confronting face of static race 86. A bearing structure 90 is housed inside the bearing cartridge and is held in place by means of a retaining ring, such as a snap ring illustrated as element 92.

A second spring 87 may optionally be used to allow the races 82 and 86 to axially float. The advantage is prevention of potential skew of the faces of the races relative to each other.

As illustrated in FIG. 2, the second [seal cartridge] element/assembly has an identical construction of its elements. The units are held in place and are biased by means of springs 94, 96. Those springs provide float for the bearing-seal cartridges 62, 64, 66.

Sealing occurs by means of O-rings 98, 100. It will be appreciated that with respect to the [seal] cartridge illustrated in its installed position on the right hand side of FIG. 2 the same elements are present. They have been denoted with prime numbers to connote the same numbering sequence.

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While not illustrated, it is apparent from FIG. 1 that the upper end housing, inverted having a pair of identical [seal] cartridges is employed. The upper end seal-bearing module may be provided with an upper spacer 103. This spacer rests on the outer race to preload the top bearing stack as the housing 42 is mounted on the housing 58 via bolts 104.

Importantly, in accordance with this invention the labyrinth illustrated by dotted lines with numeral 102 is not a part of the seal-bearing assembly. Rather, the labyrinth is considered to be a part of the stack assembly and is separated from the [seal] cartridge [assembly] itself. The labyrinth 102 protrudes to the [enfluent] effluent stream where it is subjected to particles and the like while the device is in operation. Hence, it is a component that wears and must, from time to time be replaced. In accordance with this invention, the labyrinth 102 can be replaced as a single component since it is merely placed into the annular groove 108 of the housing 60. It is compressed into position by a force applied through annular raised surface 110 that loads the labyrinth on surface 111, and causes it to slightly deflect. This deflection serves to compensate for wear in the cutter stack.

As is apparent from FIGS. 1 and 2, this construction offers a number of important advantages. First, given the fact that the seal-bearing[-seal] assemblies [are a] include modular [cartridge assembly] cartridges, repair [of a seal assembly] requires only that a pre-assembled cartridge 64 be installed in place of the defective unit. Thus, the seal and bearing components [and the bearing elements] are combined into a single cartridge [assembly] 64. This allows for important advantages over the prior art in that the individual components do not have to be disassembled at a job site.

Secondly, by this invention stack tightening occurs independent of compression forces on the seal components. This occurs because, in accordance with this invention, the cartridges themselves are positioned and loaded independent of the cutter stack. That is the housing 58 is attached to gear housing 42 by means of the bolts 104. Tightening the cutter stacks by means of the nuts 69 does not increase the forces on the bearings or seals. Rather, the force is a function of the spring force of the spring 80.

In the case of the upper assembly, axial positioning is obtained by the spacer 103 which opposed by spring 94 as the unit is bolted by means of bolts 104. The bottom assembly is allowed to float. The bottom assembly is mounted by the mounting bolts 106. No spacer is used. It is understood that the cover plates and mounting structure of the housing 1 have been eliminated.

This invention also includes a provision of leak detection by means of a leak detection plug 108. Thus, an upper seal failure can be ascertained by fluid in the upper housing via the leak detection plug 108. If there is any water in the area, it will alert personnel that there is a potential failure in the upper bearing-seal.

Additionally, a leakage path can be provided in each of the shafts 36, 37. To the extent that fluid permeates the seal it will thus escape to the exterior where it can be viewed during routine maintenance checks.

As set forth in this invention, in accordance with this invention a cartridge type bearing-seal 64 allows for replacement of units on an individual basis as opposed to replacement of the entire seal pair at the top or bottom of the cutter stack. Additionally, the entire assembly with the bearings intact can be removed from the housing for servicing. Given the construction of those cartridge elements tightening of the cutter stack can be accomplished without impairing the effectiveness of the seal. That is, compression of the seal

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components themselves occurs during the assembly of each of the seal cartridge units illustrated in FIG. 2. Thus, the integrity of those units is accomplished independent of the tightness of the cutter stack.

Moreover, as illustrated in FIGS. 1 and 2 the labyrinth 102 is placed between the main fluid chamber and either of the seal faces. In this invention the labyrinth 102 is distinct and separate from each of the seal cartridges. To the extent that the labyrinth requires replacement, it can be done by removing the cartridge, inserting a new labyrinth and then reinstallation of the cartridge 56, 60 without any disassembly of the seal components.

It will be apparent to those of skill in this technology that modifications of this invention can be made without departing from the essential scope thereof.

We claim:

1. Apparatus for comminuting solid waste material comprising:

drive means for providing rotary motion, a pair of cutter stacks with cutter elements of one stack interleaved with cutter elements of the other, and gear means to transmit the rotary motion of said drive means into counter-rotation of cutter elements of one stack with cutter elements of the other, each of said cutter stacks comprising a central shaft journaled for rotation proximate each end, a seal-bearing assembly at each end comprising an end housing, a pair of insertable pre-assembled seal-bearing elements mountable in each of said end housings, one seal-bearing element having a thru-hole for journaling a first shaft for rotation and a second seal-bearing element having a thru-hole for journaling a second shaft for rotation and a seal for each of said first and second seal-bearing elements to provide fluid isolation between said seal-bearing element and said end housing.

2. The apparatus of claim 1, wherein each of said pre-assembled seal-bearing elements comprises a seal cartridge, a spring mounted on the seal cartridge, a dynamic race biased by said spring, a bearing cartridge, a static race mounted on said bearing cartridge, a bearing of said seal-bearing element being mounted in said bearing [element] cartridge and means to secure said bearing in said bearing cartridge and to urge said static race into contact with said dynamic race.

3. The apparatus of claim 2 [further comprising] wherein a seal of said seal-bearing element comprises means to [fluid] fluidly isolate said bearing from said static race.

4. The apparatus of claim 2 further comprising spring means to bias said bearing cartridge in said end housing.

5. The apparatus of claim 2, further comprising a spring to bias said static race and provide axial float for said static and dynamic races.

6. The apparatus of claim 1 further comprising a labyrinth positioned on top of both seal-bearing elements, said labyrinth insertable onto said end housing and having a flange conforming in shape to a portion of each end housing proximate to said cutter stacks.

7. The apparatus of claim 1 further comprising an inspection port in said gear means.

8. The apparatus of claim 1 further comprising a labyrinth mountable on said end housing and protruding in part into the [enfluent] effluent stream, said labyrinth having a bearing surface that causes said labyrinth to elastically deform and compensate for variations in cutter stack height.

9. The apparatus of claim 1 further comprising a housing for said gear means, and means to mount one of said end housings to said housing for said gear means.

10. The apparatus of claim 1 further comprising a *shaft* seal disposed on each central shaft to isolate ends of said shafts from said seal-bearing assembly, each of said *shaft* seals positioned in said housing.

11. A solid waste material comminuting system comprising:

an electric motor for providing rotary motion, a pair of cutter stacks with cutter elements of one stack interleaved with cutter elements of the other, and gear means to transmit the rotary motion of said electric motor to counter-rotate cutter elements of one stack with cutter elements of the other, each of said cutter stacks comprising a central shaft journaled for rotation, a seal-bearing module at each end of the central shafts, each seal-bearing module comprising an end housing, and a pair of insertable pre-assembled *seal-bearing* assemblies mountable in each of said end housings, one *seal-bearing* assembly having a thru-hole for journaling a first shaft for rotation and a second *seal-bearing* assembly having a thru-hole for journaling a second shaft for rotation and a seal for each of said *seal-bearing* assemblies to isolate it from said end housing.

12. The apparatus of claim 11, wherein each of said pre-assembled *seal-bearing* assemblies comprises a seal cartridge, a spring mounted on the seal cartridge, a dynamic race biased by said spring, a bearing cartridge, a static race mounted on said bearing cartridge, a bearing of said *seal-bearing* assembly being mounted in said bearing cartridge and means to secure said bearing in said bearing [assembly]cartridge.

13. The apparatus of claim 12 [further comprising] wherein a seal of said *seal-bearing* assembly comprises means to [fluid] *fluidly* isolate said bearing from said static race.

14. The apparatus of claim 12 further comprising spring means to bias said bearing cartridge in said end housing.

15. The apparatus of claim 12, further comprising a spring to bias said static race and provide axial float for said static and dynamic races.

16. The apparatus of claim 11 further comprising a labyrinth positioned on top of both *seal-bearing* assemblies to provide a wear interface between said *seal-bearing* assemblies and the [enfluent] *effluent* flow, said labyrinth conforming to a portion of each end housing to provide a removable mounting surface.

17. The apparatus of claim 11 further comprising an inspection port in said gear means.

18. The apparatus of claim 11 further comprising seal means carried by each of said shafts and positioned in each of said thru-holes to provide fluid isolation for the ends of each of said shafts.

19. The apparatus of claim 11 further comprising a housing for said gear means, and means to mount one of said end housings to said housing for said gear means.

20. The apparatus of claim 11 further comprising a *shaft* seal disposed on each central shaft to isolate ends of said shafts from said [seals] *seal-bearing* module, each of said *shaft* seals positioned in said housing.

21. The apparatus of claim 1, wherein said pre-assembled *seal-bearing* elements each include a seal housing.

22. The apparatus of claim 21, further comprising a dynamic race and a static race, wherein said dynamic race and said static race are at least partially retained by a flange of said seal housing.

23. The apparatus of claim 21, wherein each of said seal housings defines a thru-hole for journaling said first and second shafts respectively.

24. The system of claim 11, wherein said pre-assembled *seal-bearing* assemblies each include a bearing housing and a seal housing.

25. The system of claim 24, wherein said bearing housing is configured to receive a bearing structure of said pre-assembled *seal-bearing* assembly.

26. The system of claim 25, wherein said bearing structure is fixedly retained in said bearing housing.

27. The system of claim 11, wherein said pre-assembled *seal-bearing* assemblies each include a seal housing.

28. The system of claim 27, further comprising a dynamic race and a static race, wherein said dynamic race and said static race are at least partially retained by a flange of said seal housing.

29. The system of claim 27, wherein each of said seal housings defines a thru-hole for journaling said first and second shafts respectively.

30. Apparatus for comminuting solid waste material comprising:

drive means for providing rotary motion, a pair of cutter stacks with cutter elements of one stack interleaved with cutter elements of the other, and gear means to transmit the rotary motion of said drive means into counter-rotation of cutter elements of one stack with cutter elements of the other, each of said cutter stacks comprising a central shaft journaled for rotation proximate each end, a seal-bearing assembly at each end comprising an end housing, a pair of insertable pre-assembled *seal-bearing* elements mountable in each of said end housings, one seal-bearing element having a thru-hole for journaling a first shaft for rotation and a second seal-bearing element having a thru-hole for journaling a second shaft for rotation and a seal for each of said first and second seal-bearing elements to provide fluid isolation between said seal-bearing element and said housing, and further comprising a housing for said gear means, and means to mount one of said end housings to said housing for said gear means.

31. The apparatus of claim 1, wherein said pre-assembled *seal-bearing* elements each include a bearing housing and a seal housing.

32. The apparatus of claim 31, wherein said bearing housing is configured to receive a bearing structure of said pre-assembled *seal-bearing* element.

33. The apparatus of claim 32, wherein said bearing structure is fixedly retained in said bearing housing.

34. Apparatus for comminuting solid waste material comprising:

drive means for providing rotary motion, a pair of cutter stacks with cutter elements of one stack interleaved with cutter elements of the other, and gear means to transmit the rotary motion of said drive means into counter-rotation of cutter elements of one stack with cutter elements of the other, each of said cutter stacks comprising a central shaft journaled for rotation proximate each end, a seal-bearing assembly at each end comprising an end housing, a pair of insertable pre-assembled *seal-bearing* elements mountable in each of said end housings, one seal-bearing element having a thru-hole for journaling a first shaft for rotation and a second seal-bearing element having a thru-hole for journaling a second shaft for rotation and a seal for each of said first and second seal-bearing elements to provide fluid isolation between said seal-bearing element and said housing, said insertable pre-assembled *seal-bearing* elements each comprising a seal-bearing housing and a seal housing.

35. The apparatus of claim 34, wherein said bearing housing is configured to receive a bearing structure of said pre-assembled seal-bearing element.

36. The apparatus of claim 35, wherein said bearing structure is fixedly retained in said bearing housing.

37. The apparatus of claim 34, further comprising a dynamic race and a static race, wherein said dynamic race and said static race are at least partially retained by a flange of said seal housing.

38. The apparatus of claim 34, wherein each of said seal housings defines a thru-hole for journaling said first and second shafts respectively.

39. A solid waste material comminuting system comprising:

an electric motor for providing rotary motion, a pair of cutter stacks with cutter elements of one stack interleaved with cutter elements of the other, and gear means to transmit the rotary motion of said electric motor to counter-rotate cutter elements of one stack with cutter elements of the other, each of said cutter stacks comprising a central shaft journaled for rotation, a seal-bearing module at each end of the central shafts, each seal-bearing module comprising an end housing, and a pair of insertable pre-assembled

seal-bearing assemblies mountable in each of said end housings, one seal-bearing assembly having a thru-hole for journaling a first shaft for rotation and a second seal-bearing assembly having a thru-hole for journaling a second shaft for rotation and a seal for each of said seal-bearing assemblies to isolate it from said end housing, said insertable pre-assembled seal-bearing assemblies each comprising a seal-bearing housing and a seal housing.

40. The apparatus of claim 39, wherein said bearing housing is configured to receive a bearing structure of said pre-assembled seal-bearing assembly.

41. The apparatus of claim 40, wherein said bearing structure is fixedly retained in said bearing housing.

42. The apparatus of claim 39, further comprising a dynamic race and a static race, wherein said dynamic race and said static race are at least partially retained by a flange of said seal housing.

43. The apparatus of claim 39, wherein said seal housing defines the thru-hole for journaling said first and second shafts.

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