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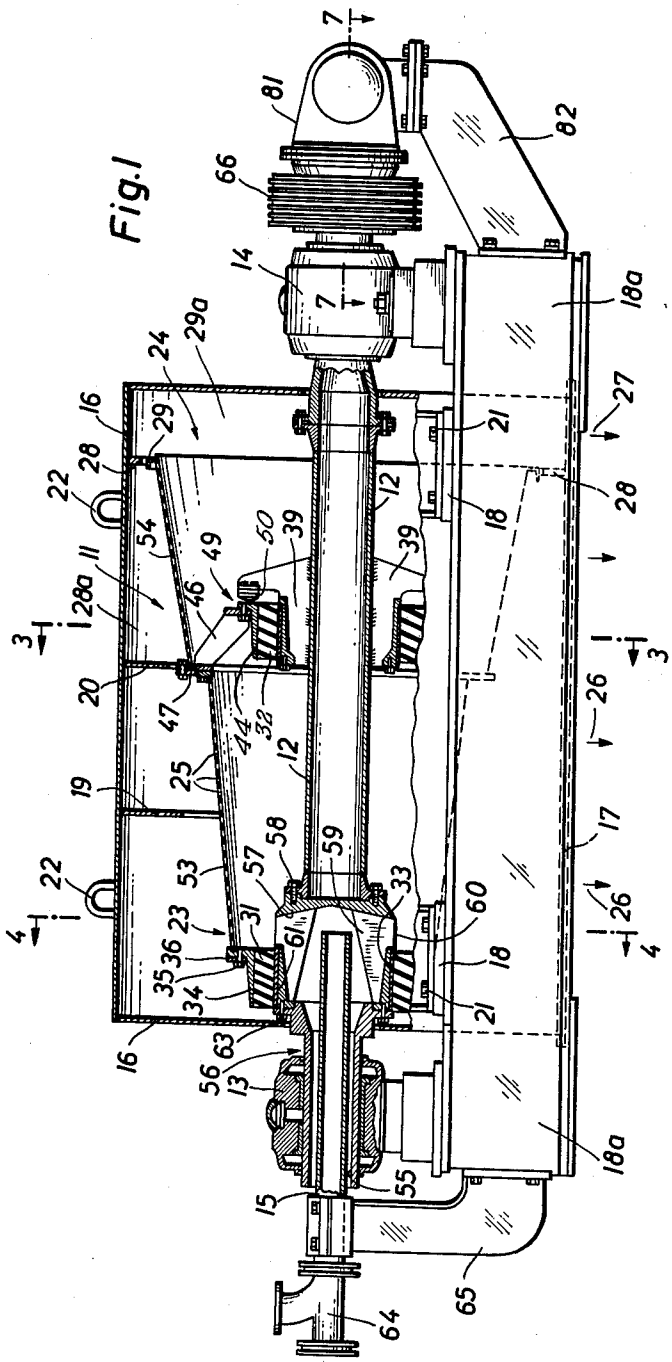
AXIALLY OSCILLATING, HORIZONTAL CENTRIFUGE

Filed April 4, 1960

5 Sheets-Sheet 1

Fig. 1



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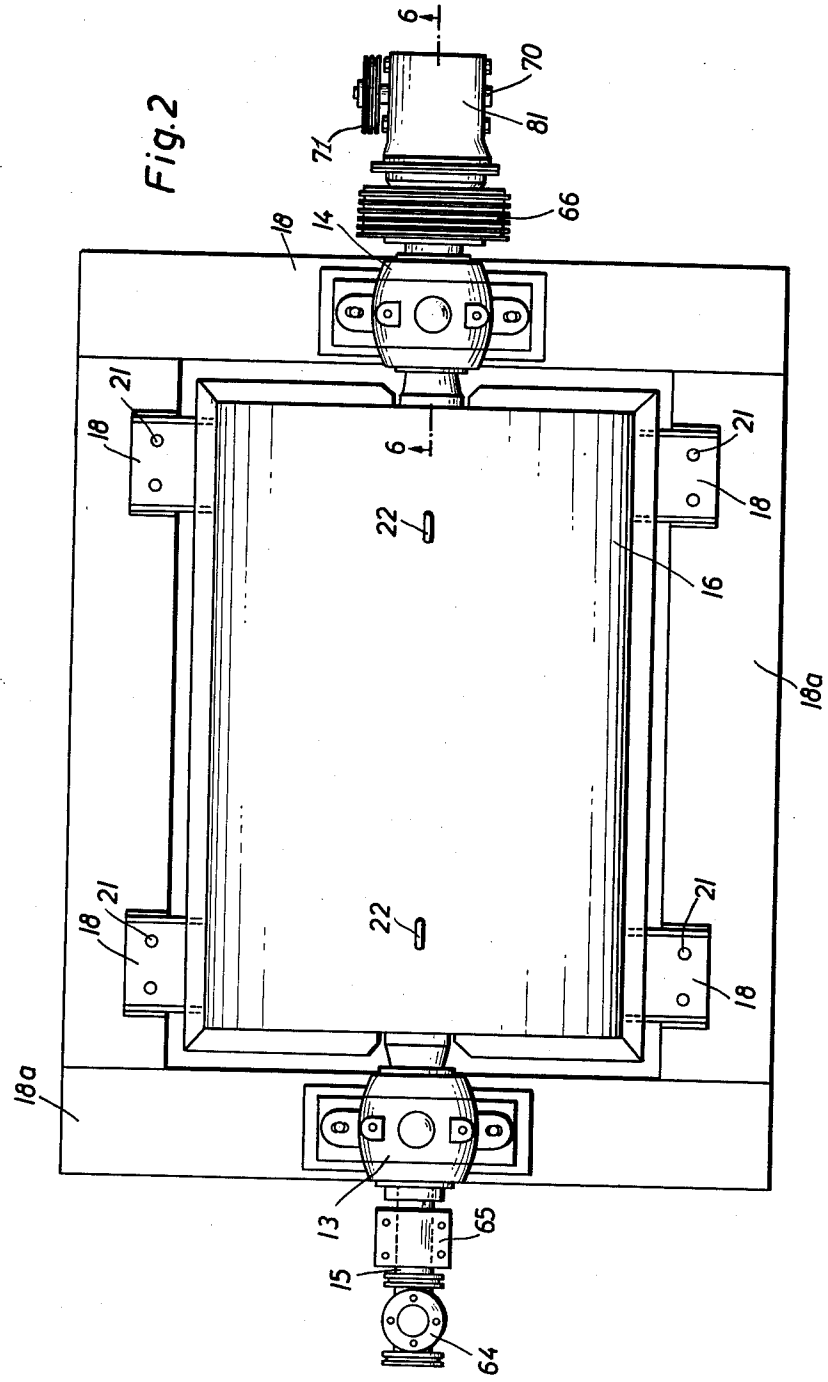
5 Sheets-Sheet 2

Fig. 2



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AXIALLY OSCILLATING, HORIZONTAL CENTRIFUGE

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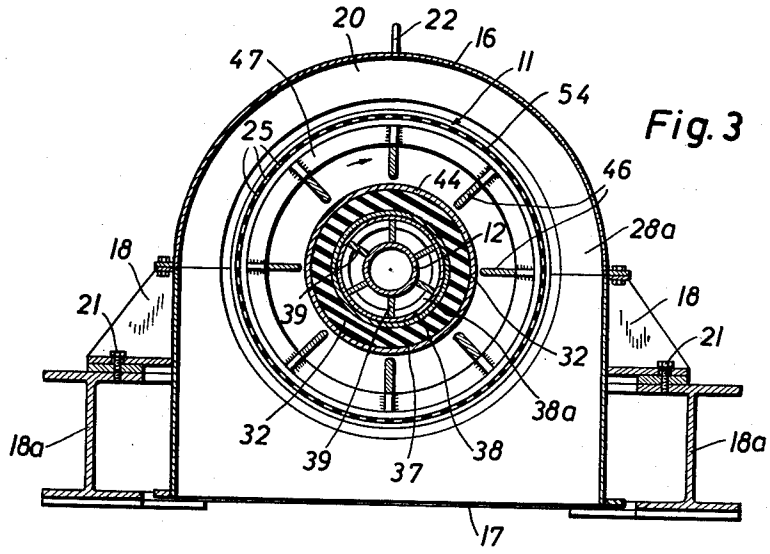

Fig. 3

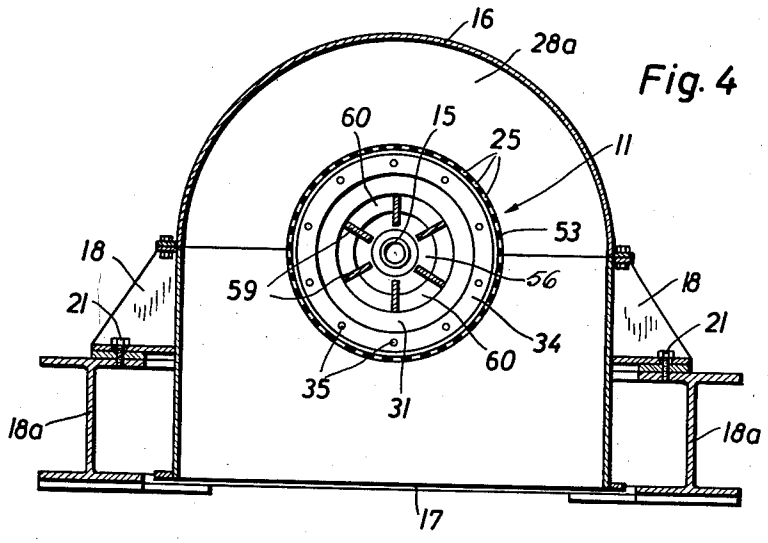

Fig. 4

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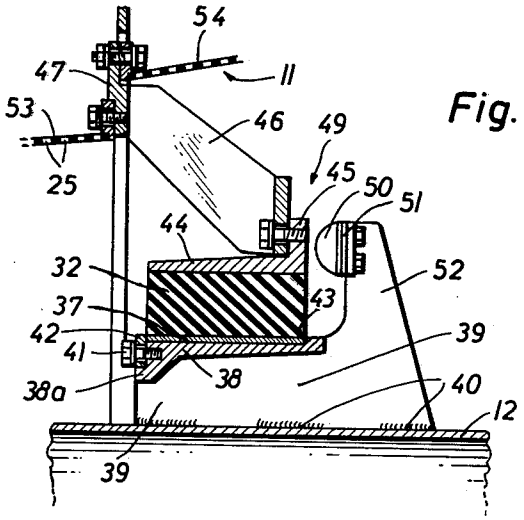

Fig. 5

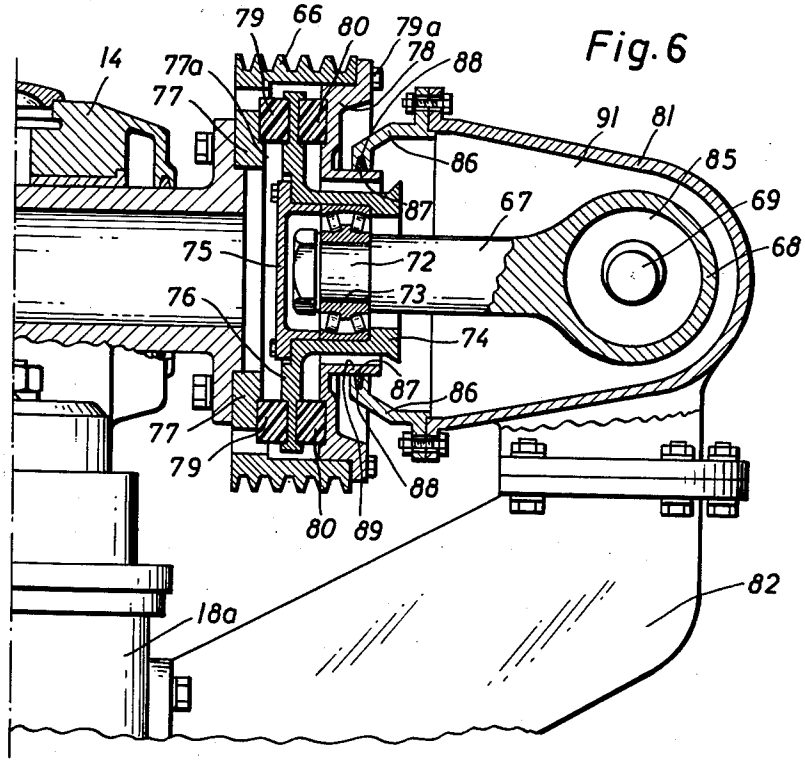

Fig. 6

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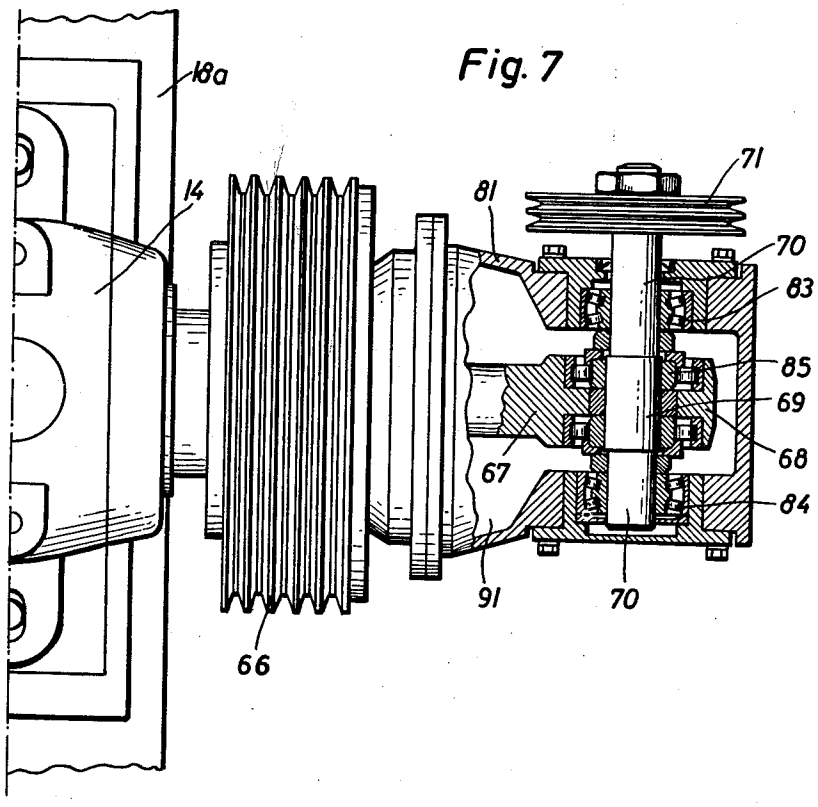
Fig. 7



United States Patent Office 3,133,879 Patented May 19, 1964

3,133,879

AXIALLY OSCILLATING, HORIZONTAL CENTRIFUGE

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6 Claims. (Cl. 210—370)

This invention relates to horizontal centrifuges useful, for example, in desiccating finely divided, wet solids. More particularly, the invention is concerned with horizontal centrifuges adapted for continuous operation wherein material to be treated is continuously fed into one end of the centrifuge and continuously discharged from the other end, and further is provided to operate in the manner that an oscillating motion is imparted to the rotating centrifuge basket whereby the discharge of the dry solids is facilitated.

It is an object of the invention to provide an improved manner of mounting the centrifuge basket on the shaft, whereby the machine is better adapted for operation under varying load conditions.

Another objection of the invention is to provide a resilient basket mounting for positive transmission of rotatory motion of the shaft to the basket and out-of-phase transmission of oscillating motion of the shaft to the basket.

Another object of the invention is to provide for the centrifuge an improved material feeding means.

Still another object of the invention is to provide means for abruptly arresting oscillatory travel of the basket toward the discharge end thereof, whereby passage of the material through the basket is facilitated.

Still another object of the invention is to provide an improved manner of imparting oscillating motion to the shaft.

A further object of the invention is to provide a configuration for the basket which facilitates passage of the material being treated through the basket.

Another object of the invention is to provide a construction whereby materials containing a considerable amount of water may be fed to and treated in the centrifuge without previous desiccation.

The manner in which the objectives of the invention are attained will be apparent from the following description wherein the invention is described with reference to the accompanying drawings.

In the drawings:

FIG. 1 is an elevation view of a centrifuge according to the invention, a part of the machine being broken away to show part of the machine in cross-section;

FIG. 2 is a plan view of the centrifuge shown in FIG. 1;

FIG. 3 and FIG. 4, respectively, are taken on line 3—3 and line 4—4 in FIG. 1;

FIG. 5 is an enlarged view of a portion of the centrifuge of FIG. 1 and showing in detail a bumper arrangement for arresting motion of the centrifuge basket;

FIG. 6 is an enlarged view of a portion of the centrifuge shown in FIG. 1, taken on line 6—6 of FIG 2, and showing in detail means for imparting oscillating motion to the shaft;

FIG. 7 is an enlarged view of the structure shown in FIG. 6 and taken on line 7—7 in FIG. 1.

According to the invention, there is provided an axially oscillating, horizontal centrifuge including a horizontally disposed basket and a drive shaft which extends through the basket and is connected to the basket in a manner shortly to be described. Means are provided for rotating the shaft, and means are provided for imparting oscillating motion to the shaft, and by operation of the interconnection between the shaft and basket, such motion is transmitted to the basket.

The connecting means interconnecting the drive shaft and basket is of a type to provide positive transmission of the rotary motion and out-of-phase transmission of the oscillating motion. Thus, the connecting means causes the basket to rotate in the direction in which the shaft rotates, and causes or tends to cause the basket to oscillate out of phase, for example 180° out of phase, with the shaft oscillation. Advantageously, the connecting means is in the form of an annular ring of elastomer material coaxially mounted on the drive shaft and joined to the drive shaft by fixed connection thereto of a radially inwardly disposed portion thereof, and joined to the basket by fixed connection thereto of a radially outwardly disposed portion of the ring.

It has been found that substantially improved operation is obtained when the basket is connected to the shaft at two or more places which are in axially spaced relation with respect to each other. The mounting of the basket in this manner provides better performance of the centrifuge under varying load conditions as where rate of material through-put changes. The advantage of the mounting becomes more pronounced as the magnitude of the load is increased.

Another feature of the centrifuge is bumper arrangement whereby travel of the shaft towards the discharge end of the basket during the oscillating motion, is arrested. Thus a bumper is mounted on the shaft adjacent the basket discharge end, and a bumper for cooperation with the shaft mounted bumper, as set forth above, is mounted on the basket. In this manner, provision is made for relatively abrupt stopping of the basket travel toward the discharge end, and, due to inertia of the material, this causes the material to advance toward the basket discharge end.

Further to facilitate travel of the material through the basket, the basket can diverge toward the discharge end, and the rate of divergence adjacent the discharge end is advantageously greater than the rate of divergence adjacent the inlet end. This construction is particularly advantageous where wet solids are being desiccated with the centrifuge. For such service, the basket is perforated to permit discharge of the water. The rate of travel of the solids toward the discharge end tends to fall as water is removed and by providing increased divergence adjacent the discharge end, the tendency referred to can be counteracted and therefore a more uniform loading can be obtained.

The drive shaft is advantageously mounted so as to protrude from both ends of the basket, and has its end portions axially slidably mounted in drive shaft bearings. Means for driving the shaft can be produced at one end thereof and means for feeding material to the centrifuge can be provided at the other end of the shaft.

At the material feed end, the drive shaft can be hollow so as to provide a shaft passageway into which a feed pipe can be installed in a manner to discharge material into the passageway. Further, openings can be provided which afford communication between the shaft passageway, and therefore the feed pipe disposed therein with, the inside of the basket. Thus, a convenient means of feeding material to the centrifuge is provided.

For driving the shaft, both to impart rotational and oscillating motion thereto, the driving means can be connected to an end portion of the shaft. The rotary motion can be provided in various ways, for example, by way of a belt driven pulley mounted on the shaft. The means for imparting oscillating motion to the shaft advantageously

comprises a crank driven connecting rod and a flexible coupling which connects the output end of the connecting rod with the drive shaft. The shaft bearings in which the drive shaft is axially slidably mounted define the axial movement of the shaft and the flexible coupling permits the required articulation of the crank driven connecting rod and the drive shaft.

Referring more particularly to the drawings, the centrifuge includes a basket **11** mounted on a drive shaft **12** which is journaled in sliding bearings **13** and **14**. Referring to FIGS. 1, at the left hand end of the drive shaft **12**, there is provided a feed pipe **15** which supplies material to be treated to the centrifuge in a manner shortly to be described; and at the right hand or other end of the drive shaft there is connected means for imparting rotating and oscillating motion to the shaft, also as described herein below.

The basket **11** is contained within an enclosure **16** which has an open bottom **17**, and the enclosure **16** is mounted by way of brackets **18** on the frame **18***a* which serves as a foundation for the device. Ribs **19** and **20** are provided to strength the enclosure **16** and U-hooks **22** are used for facilitating the removal of the enclosure from the basket **11** and frame **18***a*. The enclosure **16** is secured to the frame by bolts **21**, and hence connection of the enclosure **16** and frame **18***a* can be released by removal of the bolting.

In the operation of the centrifuge as thus far described, wet material is introduced to within the basket **11** via the feed pipe **15**. Rotation and oscillation of the basket, provided by means shortly to be described, advances the material from the feed end **23** of the basket to the discharge end **24** thereof. The basket is perforated throughout its length by openings **25**, and centrifugal force developed by rotation of the basket **11** causes liquid carried by the material to be expelled through these openings. The expelled liquid falls through the open bottom **17** of the centrifuge enclosure **16**, as is indicated by the arrows **26** (FIG. 1). Also, the relatively dry solids issuing from the discharge end of the basket **11** fall through the open bottom of the enclosure **16**, as is indicated by the arrow **27** (FIG. 1).

A plate **28** is provided to separate the space through which water or other liquid is discharged from the space through which solids are discharged; and to provide a close fitting relation between basket **11** and plate **28**, an angle iron **29** is welded to the basket periphery at the basket discharge end **24**. In this manner two chambers **28***a* and **29***a* are provided.

Turning now to the connection of the basket **11** to the drive shaft **12**, the mounting is designed for positive transmission of rotary motion of the shaft to the basket but out-of-phase transmission of the oscillation motion of the shaft to the basket. Thus, the basket rotates with the shaft, and at the same r.p.m., while the basket oscillates in response to shaft oscillation but does not oscillate in phase with the shaft as would be the case were the basket and shaft rigidly connected. The connection between the shaft and basket is non-rigid and is a resilient connection. As shown in the drawings, this connection is by way of annular rings **31** and **32** which are each of elastomer material such as rubber. The rings **31** and **32** are mounted coaxially on the shaft **12**, at a considerable distance from one another and the radially inwardly disposed sides thereof are fixedly secured to the shaft, and the radially outwardly disposed sides thereof are fixedly secured to the basket **11**.

Referring to the mounting of connecting ring **31**, disposed adjacent the inlet end **23** of the basket **11**, the shaft at this end of the basket is constructed to facilitate feeding and the ring mounting is associated with the structure provided for feeding. Fixedly secured to this structure is shaft-mounted sleeve **33** and opposite the sleeve **33** is flanged basket sleeve **34**, which is secured to the basket **11** by bolting **35**, the bolting being threaded through the collar **36** which is secured as by welding to basket inlet end **23**. The elastomer ring **31** is vulcanized to the shaft sleeve **33** and basket sleeve **34** and thereby provides a fixed connection between the shaft **12** and basket **11**.

The mounting of the other annular rings **32** is generally similar. See FIG. 5. Thus, the inwardly disposed portion of the ring **32** is vulcanized to an inner sleeve **37**, which in turn is fixedly and rigidly secured to the shaft by way of rim **38** and the radially extending plates **39** which connect the rim **38** to the shaft **12**. The plates **39** are secured to the shaft by welds **40**, and the inner sleeve **37** is secured to the rim by bolting **41** which presses the rim collar **42** into tight engagement with the inner sleeve **37** and forces it into tight engagement with the rim shoulder **43**. The radially outwardly disposed portion of the ring **32**, is vulcanized to the flanged sleeve **44**, the flange **45** of the sleeve being bolted to brackets **46** which extend radially out to the basket **11** and are secured to the annular ring **47** of the basket.

It is desirable to make the resilient connectors **31** and **32** of the same dimensions so that they are interchangeable.

To improve the effectiveness of the oscillating motion in transferring materials through the basket, there is provided a bumper arrangement **49** whereby travel of the basket toward the discharge end **24** is prematurely arrested, i.e. the travel is stopped abruptly, and hence, by inertia effects, the material being treated is advanced toward the discharge end **24**.

As can be best seen in FIG. 5, for the bumper arrangement, rubber buffers **50**, culcanized to base plates **51** which are bolted to arms **52** of radial plates **39**, provide a bumper which is fixedly secured to the drive shaft **12**; and, for cooperation with the shaft mounted bumper **50**, the flange **45** of the flanged sleeve **44**, provides a bumper which is fixedly secured to the basket **11**. The spacing of the bumpers is such that the arresting action is obtained during movement of the basket toward the discharge end. Preferably, the arresting occurs just before the basket comes to what, in the absence of the bumper arrangement, would be the end of its travel toward the basket discharge end **24**.

Further to facilitate movement of material through the basket, the basket is constructed so that it diverges toward the discharge end **24**. Advantageously, the rate of divergence adjacent the discharge end is greater than the divergence adjacent the inlet end **23**. As shown in the drawings, the basket **11** is formed of inlet-adjacent section **53**, and outlet-adjacent section **54**, the former section having a relatively small angle of divergence and the latter having a relatively large angle of divergence. These sections are joined by the aforementioned radially extending annular ring **47** to which there are secured the brackets **46** of the shaft-basket interconnection which includes the resilient connector **32**.

For feeding of material to the basket **11**, a feed pipe **15** is provided which is disposed in a passageway **55**, provided by the hollow end portion **56** of the drive shaft, which end portion protrudes from the inlet end of the basket **11**. The construction of the shaft adjacent the basket inlet end **23** includes a closure plate **57** which is secured to the shaft by bolting **58** and serves to limit axial movement of the material traversing the feeding path, and further includes axially-extending, circumferentially spaced webs **59**, which provide circumferentially spaced openings **60** (see FIG. 4) for passage of the material from the hollow end portion of the shaft to within the basket **11** and also serve to rigidly connect the main portion of the shaft with the end thereof protruding from the inlet portion **23** of the basket. For the rigid connection, the webs are secured, as by welding, to the closure plate **57** and also to the inwardly flanged rim **61**, to which in turn there is secured by bolting **63** the shaft extension **56**. The shaft extension extends axially out-

wardly through the sliding bearing **13** to the termination of the shaft. The feed pipe **15** has a T-fitting **64** secured to its inlet end, and is mounted on the frame **18***a* by way of bracket **65**.

From the foregoing, it will be seen that the feed pipe **15**, the shaft passageway **55**, and the openings **60**, which provide a communication between the shaft passageway and the inside of the basket **11**, serve as a delivery path for material to the interior of the centrifuge.

For features having to do with driving the shaft, reference is made in particular to FIGS. 1, 6 and 7. Rotary motion is imparted to the drive shaft **12** by way of pulley **66**, indicated as adapted for being belt driven. Oscillating motion is imparted to the drive shaft **12** by a crank or eccentric driven connecting rod **67** (see FIG. 6) which is interconnected with the drive shaft **12** by way of a flexible coupling shortly to be described. Referring again to the drive shaft sliding bearings **13** and **14**, disposed at either end of the shaft, these bearings as well as being constructed for rotational sliding of the drive shaft, are provided so as to permit axial sliding of the drive shaft. Thus, the bearings **13** and **14** permit the axial oscillation of the drive shaft and also define the axial movement of the shaft. The flexible coupling interconnecting the connecting rod **67** and drive shaft **12** permits articulation of the connecting rod and drive shaft, whereby to accommodate for the axially oscillatable shaft, the connecting rod motion responsive to the cranking thereof.

As can be best seen in FIGS. 6 and 7, the cranked end **68** of the connecting rod **67** is received by the eccentric **69**, which is integral with the shaft **70** provided for driving the eccentric. This shaft has mounted thereon the pulley **71** adapted for a belt drive (not shown). The work output end **72** of the connecting rod is received in the roller bearing **73** which advantageously can be a self-aligning barrel-shaped roller bearing. The roller bearing, in turn is mounted in a sleeve **72** and is firmly held therein by end flange **75** which presses the rolling race of the roller bearing **73** into holding engagement with the sleeve **74**. A radially extending plate **76** is integrally joined to the sleeve **74** and extends radially outwardly from the sleeve in a cavity **77***a* formed within the drive shaft pulley **66**. The cavity is defined on one side by the pulley side wall **77** and on the other side by the pulley side wall plate **78** which is bolted to the pulley periphery by bolting **79***a*. Within the cavity **77***a* the radially extending plate is spaced from each of the pulley side walls and there are operatively interposed between the plate **76** and the pulley side walls **77** and **78**, respectively, axially extending resilient connecting members **79** and **80**. These resilient connecting members **79** and **80**, on the one hand, are gripped sufficiently tightly between the plate **76** and the pulley side walls **77** and **78** so that the plate rotates with the drive shaft pulley **66**, and, on the other hand, sufficiently loosely so that the place can rock within the cavity **77***a* so as to permit articulation of the connecting rod and drive shaft. In operation of the centrifuge described, the basket drive shaft end bearings **13** and **14** permit axial sliding of the drive shaft **12** and additionally limit motion of the shaft in response to force impulses having an axial component, to axial movement. Thus, as oscillating impulses are imparted to the basket drive shaft by cranking of connecting rod **67**, the shaft **12** oscillates in the direction of its axis and the required articulation of the connecting rod **67** and basket drive shaft **12** is accommodated by the resilient connecting members **79** and **80**. These connecting members can be formed of rubber or other elastomer material.

Further regarding the flexible coupling, the drive shaft **70** for the eccentric **69** is contained within a housing **81**, which is secured to the centrifuge frame **18***a* by a bracket **82**. Within the housing **81**, there are mounted end bearings **83** and **84** for the eccentric drive shaft **70**, and also eccentric bearing **85** for the eccentric. The housing is hollow and is intended to be flooded with oil. In the

vicinity of the output end of the connecting rod, the housing is provided with a shoulder piece **86** which defines and end opening **87** through which the connecting rod extends. About the periphery of the opening **87** is a seal ring **88** which is arranged for sliding and sealing engagement with the axially outwardly extending neck **89** of the basket drive shaft pulley **66**, the neck piece being formed integrally with the basket drive pulley side wall **78**. For providing lubrication of the roller bearing **73** of the connecting rod output end, the sleeve **74** within which the roller bearing **73** is disposed, is spaced from the connecting rod **67**, and thus the cavity **91** of connecting rod housing **81** is communicated with the roller bearing **73** and hence lubricant from the cavity is available to the roller bearing.

From the foregoing description, it will be apparent the centrifuge according to the invention provides a resilient mounting of the basket on the drive shaft so that a two-mass system—the basket and drive shaft—is provided. The manner in which the mounting is effected results in dependable and satisfactory operation of the machine. Resiliently connecting the basket to the drive shaft at axially spaced points along the basket adapts the machine to varying load conditions and tends to preclude the commencing of any pendular motion of the basket about the shaft in response to uneven loading. If desired, connection to the basket can be made at more than two points. Further, the use of the bumper arrangement **49** limits the amplitude of the oscillatory motion.

It is advantageous to make the counter oscillating masses (the basket **11** and drive shaft **12**), and the constants of the resilient connecting members **31** and **32** so that the oscillation will be slightly below resonance. The drive shaft **12** can be made hollow in furtherance of attaining such construction.

An advantage of the centrifuge of the invention is that it can be of greater length than has hitherto been feasible. Thus, the length can be at least equal to the diameter, and can suitably be more, for example 1.5 or more times the diameter. In this manner it is possible to feed to the centrifuge materials without previous desiccation or concentration, which carry along 20 to 30% by weight of water, or more, and drying them in the centrifuge to a high degree of desiccation.

As an example, the clear length can be 1.4 meters and the mean diameter 0.8 meter, for a ratio of length of drum to mean diameter of 1.75. For a basket so dimensioned, the divergence of the inlet end section **53** can be about 5° to the horizontal, and the divergence of the discharge end section **54** can be about 10° to the horizontal.

This centrifuge can be used to desiccate coal sludge of grain size up to 2 millimeters and 50% by weight water. For this service, the rotation of the basket can be about 400 r.p.m. to develop an average centrifugal force at the periphery of 70 *g*, and oscillation can be at a frequency of 30 hertz and an amplitude of 3 millimeters. In the course of traveling through the basket the coal will be dried to a high degree of desiccation and then dicsharged from the basket while the water will be thrown radially outwardly and through the basket perforations **25**.

While the invention has been described in detail with reference to particular embodiments thereof, these embodiments are merely representative of the invention and are not in limitation thereof.

What is claimed is:

1. A centrifuge for separating liquids and solids in suspension, comprising a stationary enclosure, a shaft extending into said enclosure, a basket within said enclosure having a diverging screen surface, an inlet through said enclosure to the inside of said basket, first and second bearings spaced apart for supporting said shaft and permitting rotation and axial reciprocation of said basket, first flexible coupling means on said shaft supporting said basket and permitting axial reciprocation of the basket with respect to the shaft, means to impart rotation to said

shaft, means to impart axial reciprocation to said basket, second flexible coupling means supporting said basket and permitting rotation and axial reciprocation of said basket, said second flexible coupling means being axially spaced from said first flexible coupling means, said flexible coupling means including annular rings of elastomeric material, one of said coupling means further including spaced web members for supporting said basket, and wall means in said enclosure to define discharge passages for solids and separated liquids.

2. A centrifuge according to claim 1, wherein said inlet passes through one of said bearings and one of said coupling means.

3. A centrifuge according to claim 1, wherein said shaft is horizontal and the length of said basket is greater than its diameter.

4. A centrifuge according to claim 3, wherein one of said coupling means is connected to the inlet end of said basket and the other coupling means is connected to said basket intermediate its ends.

5. A centrifuge for separating liquids and solids in suspension, comprising, in combination, a stationary enclosure, a shaft extending into said enclosure, bearings rigid with said enclosure to support said shaft and to permit rotation and axial movement thereof, a basket within said enclosure having a diverging screen surface and two separate portions having adjoining edges of different diameters, an annular member in the region of said edges for interconnecting said basket portions, an inlet through said enclosure to the inside of said basket, first flexible supporting means supporting said basket on said shaft and permitting axial movement of said basket with respect to said shaft, second flexible supporting means supporting said basket and spaced from said first supporting means, at least one of said supporting means including radial web members and an annular elastomeric member interposed therebetween, said one flexible supporting means also including bracket means interposed between said web members and said interconnecting annular member for resiliently supporting said basket portions with respect to said shaft, and wall means in said enclosure to define discharge passages for solids and separated liquid.

6. A centrifuge for separating liquids and solids in suspension, comprising, in combination, a stationary enclosure, a shaft extending through said enclosure, bearings rigid with said enclosure to support said shaft and to permit rotation and axial movement thereof, a basket within said enclosure having a diverging screen surface and two separate portions having adjoining edges of different diameters, an annular member in the region of said edges for interconnecting said basket portions, an inlet through said enclosure to the inside of said basket, first flexible supporting means on said shaft supporting said basket and permitting axial movement of said basket with respect to said shaft, second flexible supporting means on said shaft spaced from said first supporting means, one of said supporting means including radial web members and an annular elastomeric member interposed therebetween, the other of said supporting means including an annular elastomeric member connected to said shaft on one side and engaged by said basket on the other, whereby said basket is uniformly and concentrically supported with respect to said bearings, and wall means in said enclosure to define discharge passages for solids and separated liquids.

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