April 3, 1962 J. BLUM 3,028,075

SWINGING BUCKET CENTRIFUGE

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Fig. 1.

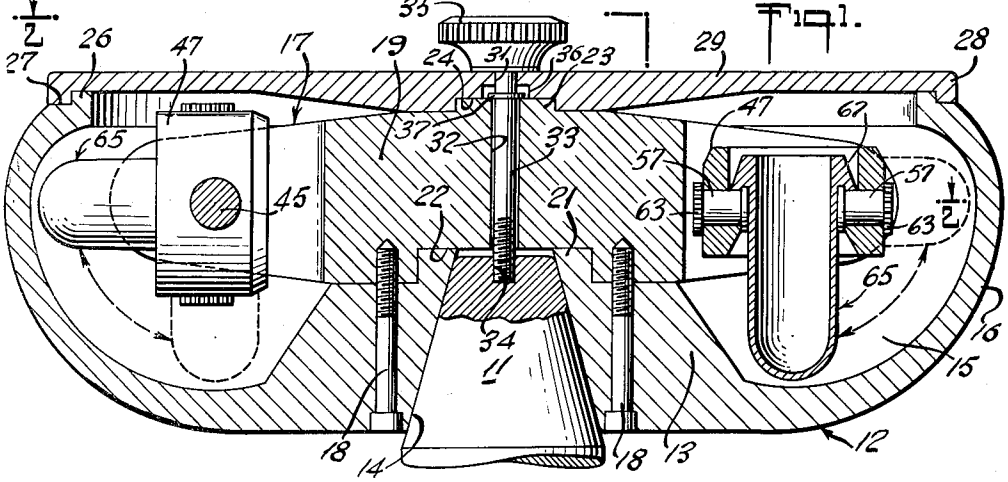

Fig. 2.

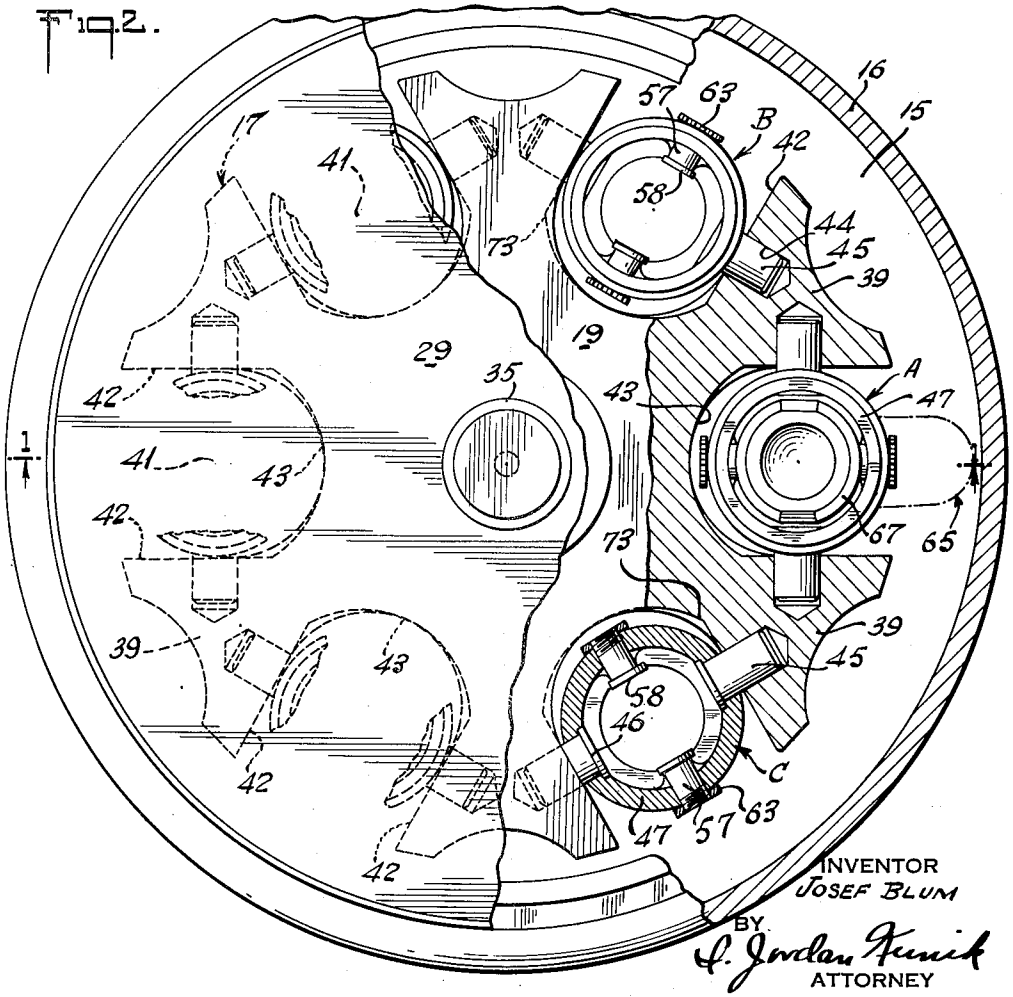

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Fig. 3.

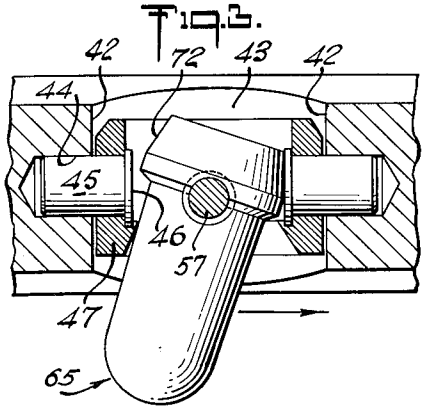


Fig. 4.

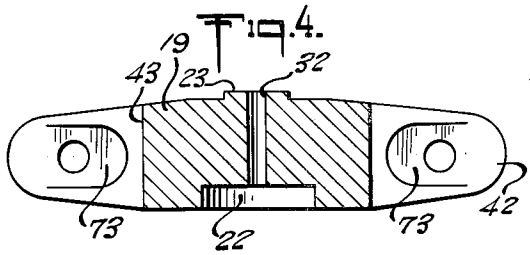


Fig. 7.

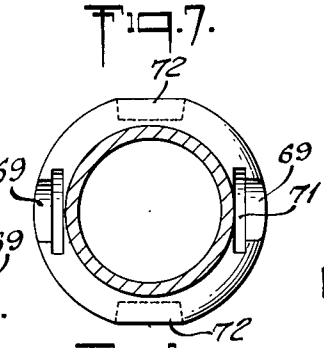


Fig. 5.

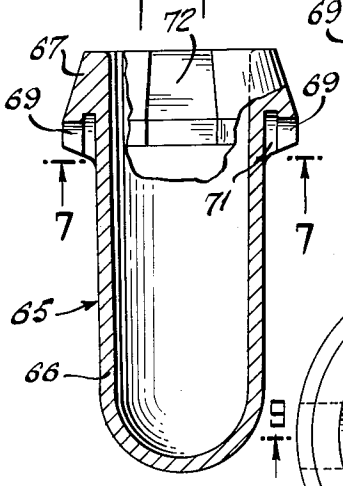


Fig. 6.

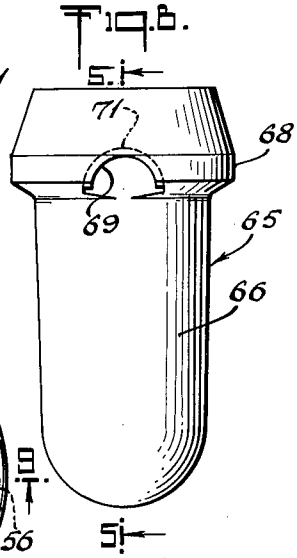


Fig. 8.

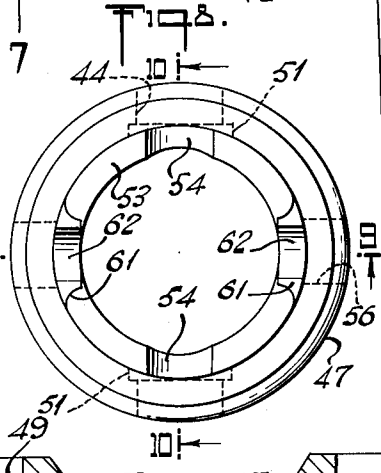


Fig. 9.

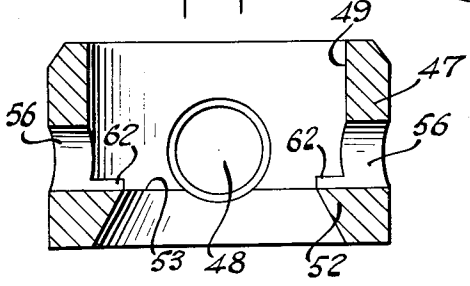
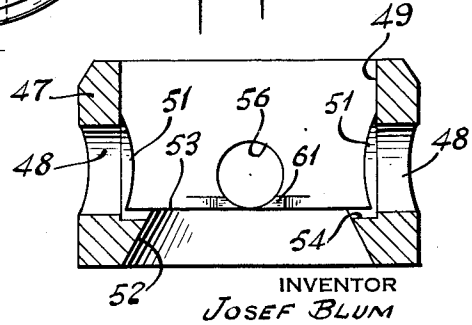


Fig. 10.



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3,028,075

SWINGING BUCKET CENTRIFUGE

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Filed Jan. 12, 1959, Ser. No. 786,136
2 Claims. (Cl. 233—26)

This invention relates to centrifuges, and more particularly to centrifuges of the swinging bucket type.

This invention is directed to improvements in centrifuges wherein swinging bucket tubes or holders for test tubes are mounted so that as the centrifuge rotor accelerates and decelerates the buckets or holders may adjust themselves freely at each moment substantially in the direction of the resultants of the forces acting thereon irrespective of whether the rotational speed of the rotor is high or low. In other words, during the period of acceleration or deceleration of the rotor, the buckets or holders will be permitted to swing in a direction opposite to the direction of rotation, thereby reducing the strains on the buckets or holders, as well as minimizing the amount of turbulence that would otherwise prevail amongst the particles that are to be separated or which have been separated from solution to the bottom of the tubes. Also on deceleration of the rotor, the tubes and the holders thereof will adapt themselves to the decelerating forces whereby the sedimented particles will remain in the lower extremities of the tubes without being agitated therefrom, thereby facilitating the separation of the particles from the super latent liquid in the tubes.

A salient feature of the present invention is the provision of a novel suspension structure for the swinging buckets or holders, whereby a single trunnion ring is utilized instead of a combination of two interacting gimbal rings, as prevails in the prior art. The elimination of one of the gimbal or trunnion rings is accomplished by modifying the structure of the bucket so that pivoting supports are integral therewith.

A further novel feature of the invention is the provision for mounting the single trunnion ring on a pair of diametrically positioned pivot pins which are positioned in respective dead ended apertures in the mass of the centrifuge rotor body whereby added strength is provided for safely maintaining the structure under high centrifuging speeds.

Another feature of the invention is the provision of a novel trunnion ring reinforcing structure which increases its strength for pivotally supporting the swinging bucket therein.

Still other objects and advantages of my invention will be apparent from the specification.

The features of novelty which I believe to be characteristic of my invention are set forth herein and will best be understood, both as to their fundamental principles and as to their particular embodiments, by reference to the specification and accompanying drawings, in which:

FIGURE 1 is a central section view of the rotor head assembly of the centrifuge, taken on line 1—1 of FIG. 2, various parts being shown in elevation, or in phantom outline;

FIG. 2 is a top view, taken on line 2—2 of FIG. 1, various parts being shown in section, broken away, or in phantom outline;

FIG. 3 is an enlarged fragmentary view of a portion of the rotor showing a trunnion arrangement and a swinging bucket mounted thereon, said bucket being shown in position during the acceleration of the rotor;

FIG. 4 is a central section view in reduced size, some portions being shown in elevation, of the rotor minus the trunnion and bucket elements;

FIG. 5 is a greatly enlarged section view, partly in

elevation, of one of the swinging buckets taken on line 5—5 of FIG. 6;

FIG. 6 is a side view of the swinging cup shown in FIG. 5;

FIG. 7 is a bottom view, partly in elevation and partly in phantom outline, taken on line 7—7 of FIG. 5;

FIG. 8 is a greatly enlarged top view of the trunnion ring, partly in phantom outline, which supports the swinging bucket;

FIG. 9 is a section view taken on line 9—9 of the trunnion ring shown in FIG. 8; and

FIG. 10 is a section view taken on line 10—10 of FIG. 8.

Referring now to the drawings in detail, and particularly to FIGS. 1 and 2, there is shown a centrifuge rotor head assembly comprising a hub 11, in the form of a truncated cone, mounted on the top of a centrifuge rotor shaft (not shown), driven by an electric motor. A circular bowl-shaped rotor shell 12 has a solid central core 13 in the bottom of which is a central conical recess 14 with which hub 11 mates intimately. Core 13 is surrounded by an annular chamber 15 bounded by curved shell wall 16.

Mounted upon core 13 of rotor shell 12 is a generally circular rotor body, generally designated 17, secured thereto by means of a plurality of bolts 18 threadably engaging the solid hub 19 thereof. Core 13 of rotor shell 12 has a central upwardly extending boss 21 which mates intimately with recess 22 in the bottom of hub 19 of rotor body 17, whereby lateral motion of said rotor body relative to said rotor shell is prevented during rotation of the assembly. Hub 19 of rotor body 17 has a central upwardly extending boss 23 which mates intimately with a central recess 24 in the bottom of circular rotor cover 25, said boss 23 and said recess 24 cooperating to prevent lateral motion of said cover relative to said hub.

Formed integrally with the upper circular edge of wall 16 of rotor shell 12 is an upwardly extending annular ring 26 surrounded by annular shoulder 27.

Resting upon annular shoulder 27 is the downwardly extending annular rim 28 of circular rotor cover 29, which forms a closure over chamber 15 of rotor shell 12. The inner wall of rim 28 cooperates intimately with the outer side wall of ring 26 to form a close fit therebetween.

Cover 29 has a central aperture 31 and hub 19 of rotor body 17 has a central aperture 32 through which a pin 33 extends freely. The lower end of pin 33 threadably engages a central aperture 34 in the top of hub 11 to the extent limited by the bottom surface of knurled knob 35 secured fast to the upper end of said pin which enables the manual rotation thereof, to secure the centrifuge rotor assembly to said hub. Rotor cover 29 has a bottom central recess 36 to permit slight vertical movement of a ring 37 mounted fast upon pin 33. By lifting knob 35 rotor cover 29 may be removed from rotor shell 12 to provide access to the interior thereof.

When pin 33 is threadably engaged with hub 11, the action of the bottom surface of knob 35 against the top of rotor cover 29, and the action of hub 11 being urged upwardly into recess 14 of rotor shell 12, will cause the three elements, namely, cover 29, rotor body 17 and rotor shell 12, to be secured firmly together for operation as a centrifuge rotor head assembly as shown in FIG. 1.

Rotor body 17 has a plurality of radially extending arms 39 separated by a plurality of recesses 41 arranged symmetrically around its periphery, each of said recesses having a pair of opposing substantially parallel vertical side walls 42 and an inner arcuate wall 43. Each wall 42 has a horizontal circular dead end bore 44 accommodating a ring pin 45 mounted fast therein. See FIGS. 2 and 3. Each ring pin 45 has a flat flanged head 46 which extends partially into the interior of recess 41.

Positioned within each recess 41 of rotor body 19 is a circular trunnion ring 47 having a pair of diametrically opposed axially aligned apertures 48 through each of which extends a corresponding ring pin 45. See also FIGS. 3, 9 and 10. The internal cylindrical wall 49 of ring 47 has a pair of recesses 51 each of which at least partially accommodates head 46 of a respective pin 45 (FIG.10). Each trunnion ring 47 is freely rotatable on its respective pair of ring pins 45.

The provision of bores 44 with interior dead ends serves to preserve the strength of the mass of the arms 39 as opposed to prior art structures where support pin apertures were bored clear through comparable rotor arms, thereby weakening the rotor structure.

It will be noted that in one typical embodiment illustrated and described herein, for example, trunnion rings 47 are positioned in a symmetrical circular array concentric to the rotating axis of rotor body 19, and that each of the trunnion rings move pivotally on an axis substantially perpendicular to a respective radius drawn from the rotor axis to the center of said trunnion ring.

Near the bottom interior of trunnion ring 47, and integrally formed therewith, is an inwardly extending annular ledge 52 having a horizontal shoulder 53. Shoulder 53 has a pair of oppositely aligned recesses 54 which permit the lateral movement of the lower portions of heads 46 of respective pins 45 when the latter are assembled or disassembled with trunnion ring 47 relative to rotor body 19.

Bored through the walls of each trunnion ring 47 is a second pair of axially aligned apertures 56 whose common axis is substantially perpendicular to the common axis of apertures 48. Each aperture 56 accommodates a bucket pin 57, one end of which terminates in a flat flanged head 58.

Extending a short distance above shoulder 53 of ledge 52 is a pair of oppositely disposed bosses 61 adjacent respective apertures 56. The top of each boss 61 has an arcuate recess 62 accommodating the bottom portion of bucket pin 57, whereby support is given to that portion of said pin extending into the interior of trunnion ring 47. The lower portion of the flanged head 58 of bucket pin 57 is caused to bear against the inner vertical surface of boss 61 by ring 63 threadably engaging the outer end of cup pin 57.

Pivotally mounted on each pair of cup pins 57 is a swinging bucket, generally designated 65, comprising a cylindrical tube 66 closed at the bottom thereof, and a head 67 surrounding the mouth on the upper end of said tube. Head 67 slopes downwardly from the upper end thereof to form an integral thick collar 68 having an external diameter somewhat greater than that of the remainder of tube 66. The bottom of collar 68 has a pair of oppositely disposed arcuate recesses 69 which cooperate with top shank portions of respective bucket pins 57, whereby bucket 65 pivots freely relative to trunnion ring 47. The inner portion of each arcuate recess 69 is widened into an arcuate recess 71 which accommodates the upper portion of flanged head 58 of respective bucket pin 57, whereby the pivoting action of bucket 65 relative to trunnion ring 47 is stabilized.

Recesses 69 and 71 may each form an arc no greater than 180° in extent, or may form an arc somewhat less than 180°, whereby bucket 65 may readily be lifted freely from its respective support pins 57 for replacement or other operational requirements.

In the embodiment illustrated in the drawings, the axial alignment of pins 47 is substantially 90° relative to the axial alignment of pins 45 whereby a wide range of positions may be assumed by bucket 65 relative to rotor 17, depending upon the acceleration, deceleration, and speed of said rotor.

The circular sloped surface of head 67 has a pair of oppositely disposed flats 72, one of which, when bucket 65 is caused to pivot relative to trunnion ring 47 during

acceleration or decleration of the rotor assembly, bears against the inner surface of the corresponding head 46 of ring pin 45 to limit the pivotal motion of said bucket. FIGS. 3 and 5.

As seen in FIGS. 2 and 4, a recess 73 is provided at the juncture between each side wall 42 and inner wall 43 intermediate the top and bottom of recess 41 for the purpose of providing just sufficient clearance for trunnion ring 47 to swing to a completely vertical position when the rotor operates at high speed at which time bucket 65 assumes a horizontal position, as shown at the left portion of FIG. 1. The right portion shows bucket 65 in a vertical position when the rotor is at rest.

In FIG. 2, the position designated A shows a top view of the swinging bucket mounted within the trunnion ring; position B shows the swinging bucket 65 removed from the trunnion ring; and position C is a partial section through trunnion ring 47.

As the rotor assembly starts from a dead stop and picks up speed, each of the swinging buckets 65 will pivotally lag, as shown in FIG. 3, until pivotal forces bearing upon the weight of the contents of the trunnion cup cause trunnion ring 47 to move pivotally on its ring pins 45 whereby the bucket ultimately assumes a substantially horizontal position as shown in the left hand portion of FIG. 1, under high speed rotation of said rotor.

By reason of the structures disclosed and described herein, the swinging buckets 65 are enabled to pivot relative to their respective trunnion rings 47 on bucket pins 57 while trunnion rings 47 pivot independently upon their respective pins 45 relative to rotor body 19. In this manner the swinging buckets 65 may adjust to the gradually changing resultant of forces generated by the acceleration and deceleration of the centrifuge rotor assembly.

During acceleration of the centrifuge rotor assembly, the flat 72 on head 67 of bucket 65 may meet and bear against the outer surface of head 46 of pin 45, as shown in FIG. 3, this limitation of the pivoting action of bucket 65 is not of any consequence for the reason that the centrifugal action of the accelerating rotor will soon thereafter have caused said bucket to assume a substantially horizontal position and to extend substantially coaxially with trunnion ring 47.

It will be noted that each bucket 65 is readily positioned upon and removed from its support pins 57 by simple manual dropping and lifting actions. This arrangement provides for the operator's convenience in handling the buckets and their contents. By matching recesses 69 and 71 in the head 67 of each bucket 65 with the heads 58 and the shank of pins 57, the structure of the swinging bucket apparatus is greatly simplified. By providing an enlarged integral collar 68 for swinging bucket 65, the pivot mounting can withstand very great stresses exerted under the centrifuging action of the rotor.

It will be noted that the mounting means formed by support pins 57 and recesses 69 and 71 cooperate by the force of gravity only. In some embodiments heads 58 of pins 57 may be omitted in which case the corresponding recesses 71 of head 67 of each bucket 65 may also be dispensed with.

As for trunnion ring 47, the interior ledge 52 supplies lateral rigidity to said ring in much the same manner as flanges contribute to an I-beam. Furthermore, bosses 61 on said ledge provide support facilities for respective pins 57, thereby reducing to an appreciable extent the bending moment of said pins. Said bosses are given added strength by ledge 52 formed integrally therewith. By this means, the stress for a given load are reduced whereby the net result is that the rotor assembly is capable of operating at a higher speed. Furthermore, the structural arrangement disclosed and described herein permits the design of a rotor assembly which is more compact than prior art rotors and, consequently, requires less power for operation.

It will also be understood that in substitution for pins

57, a pair of suitable elements or bosses formed integrally with trunnion ring 47 may serve as pivotal support for a respective bucket 65 which would be provided with suitable recesses to accommodate such elements or bosses by the force of gravity only. Although the embodiment illustrated and described herein shows that the shank portion of each pin 57 and its respective head 58 have contours which are matched closely by the contours of respective recesses 69 and 71, it is understood that in other embodiments non-matching contours of these respective elements may be utilized provided they permit the free pivotal action between each bucket and its respective trunnion ring, and permit the free insertion and removal of said bucket relative thereto.

In the specification, I have explained the principles of my invention, and the best mode in which I have contemplated applying those principles, so as to distinguish my invention from other inventions; and I have particularly pointed out and distinctly claimed the part, mode or combination which I claim as my invention or discovery.

While I have shown and described certain preferred embodiments of my invention, it will be understood that modifications and changes may be made without departing from the function and scope thereof, as will be clear to those skilled in the art.

It is claimed:

1. A centrifuge comprising a rotor, a plurality of symmetrically distributed trunnion rings positioned in circular array concentric to the axis of said rotor, each of said trunnion rings being mounted pivotally on said rotor, an annular ledge on the interior of each of said trunnion rings and formed integrally therewith, a pair of axially aligned horizontal pins mounted in opposing portions of each of said rings, an inner end portion on each of said pins extending into the interior of its respective ring and being in contact with and supported by said ledge, a tubular bucket insertable into each ring, an outwardly extending annular collar on the exterior of said bucket formed integrally therewith, the external diameter of said collar being greater than the internal diameter of said ledge, and a pair of diametrically opposed recesses in the bottom portion of said collar, said recesses accommodating the inner end portions of said respective pins for the pivoting action of said bucket relative to said trunnion ring, said recesses engaging said pins only by the force of gravity.

2. A centrifuge comprising a rotor, a plurality of symmetrically distributed trunnion rings positioned in circular array concentric to the axis of said rotor, each of said trunnion rings being mounted pivotally on said rotor, an annular ledge on the interior of each of said trunnion rings and formed integrally therewith, a pair of axially aligned horizontal pins mounted in opposing portions of each of said rings, an inner end portion on each of said pins extending into the interior of its respective ring and being in contact with and supported by said ledge, a tubular bucket insertable into each ring, an outwardly extending annular collar on the exterior of said bucket formed integrally therewith, and a pair of diametrically opposed recesses in the bottom portion of said collar, said recesses accommodating the inner end portions of said respective pins for the pivoting action of said bucket relative to said trunnion ring, said recesses engaging said pins only by the force of gravity, said collar extending over said pins and overlapping said ledge whereby the weight of said bucket during centrifugation is supported by the combined structures of said ledge, said pins and said collar in alignment with each other.

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