April 9, 1968 G. D. FOX ET AL 3,377,021

CENTRIFUGE ROTORS, BUCKETS AND COMBINATIONS OF SUCH BUCKETS AND ROTORS

Filed May 17, 1965 2 Sheets-Sheet 1

Fig. 1.

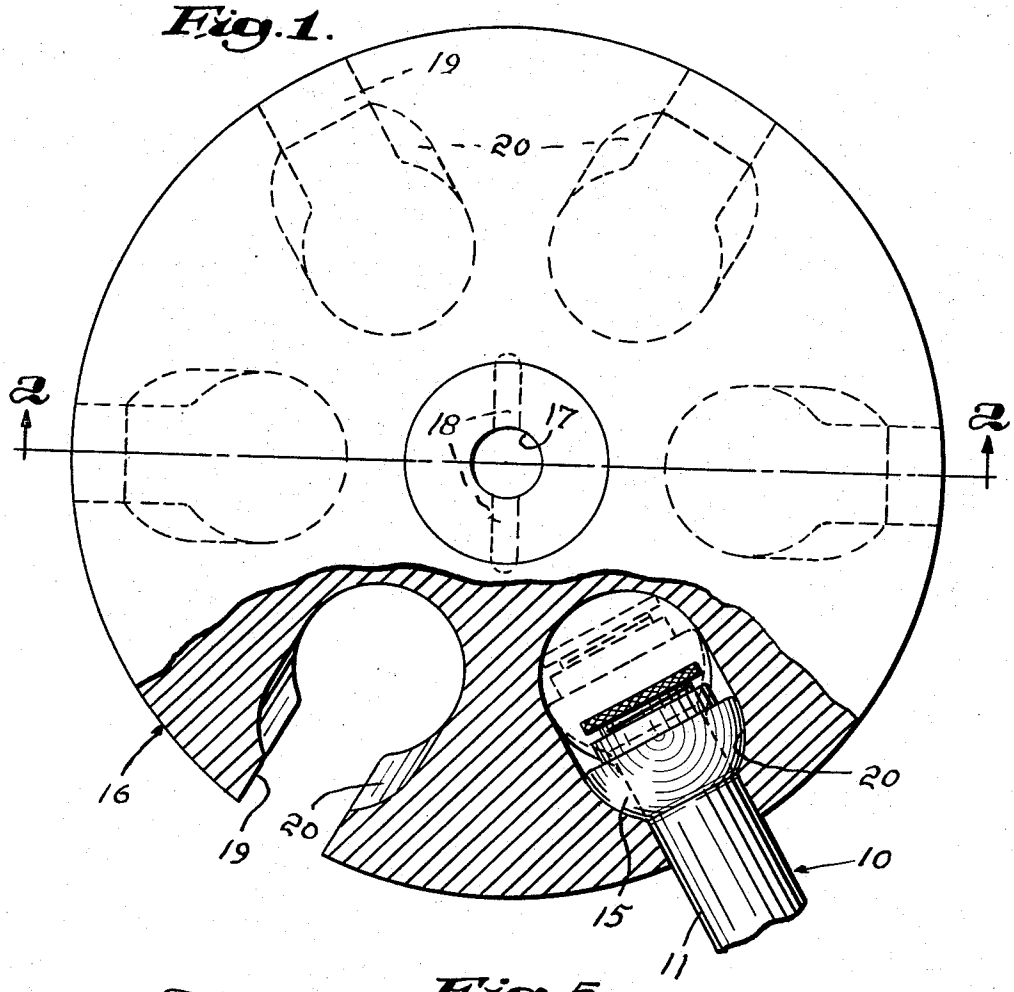
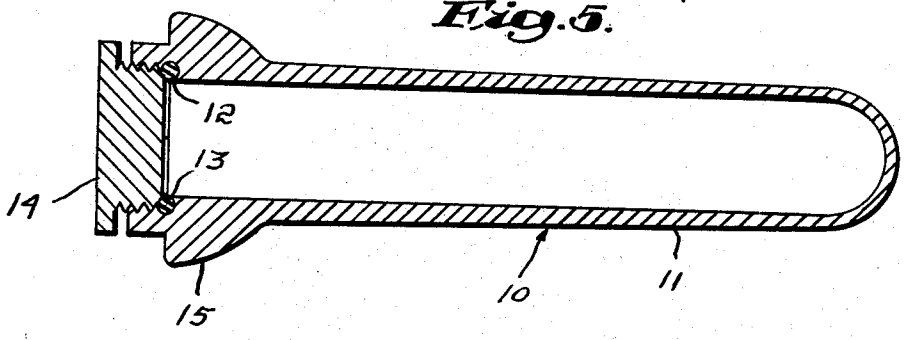



Fig. 5.




Inventors:
Gerald D. Fox,
John E. Joyce,
Robert C. Leif,
by Albert Spencer, Attorney

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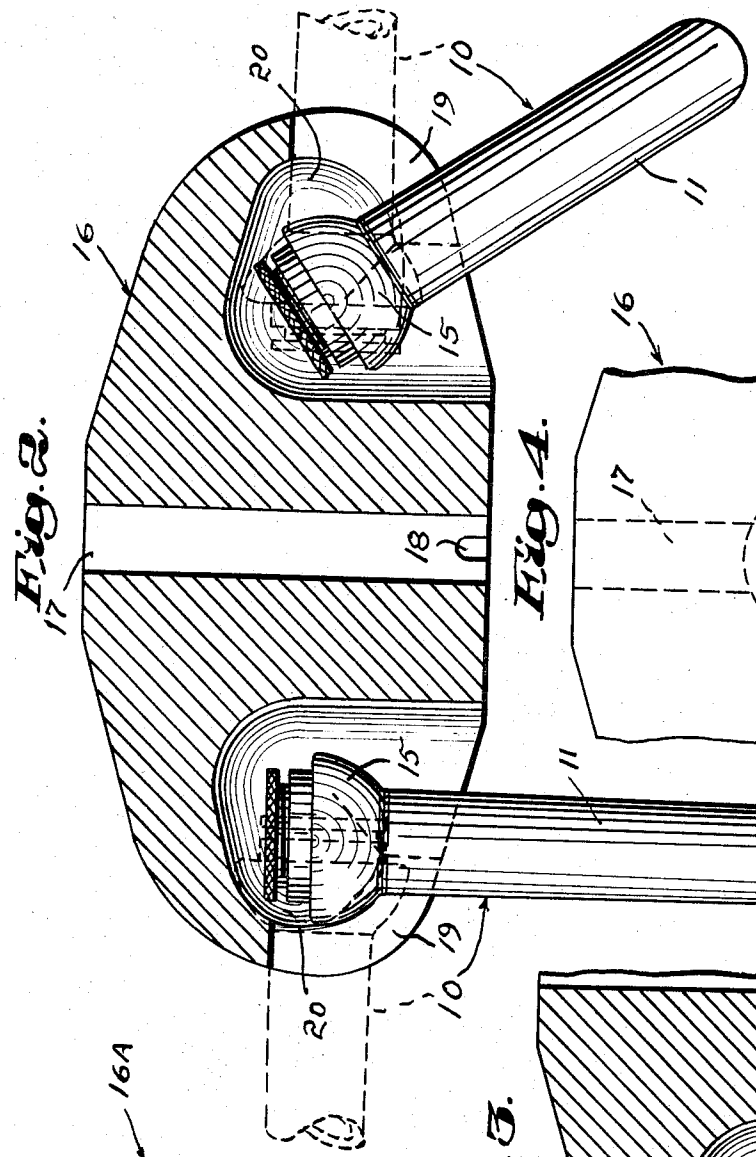


Fig. 2.

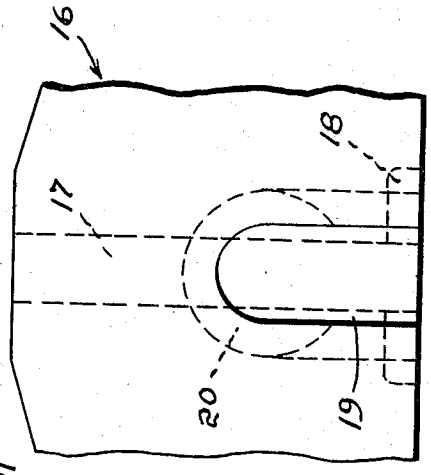


Fig. 4.

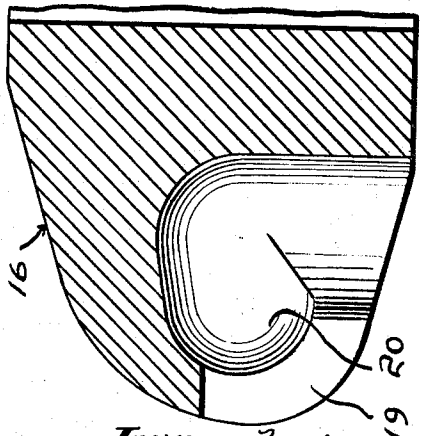


Fig. 5.

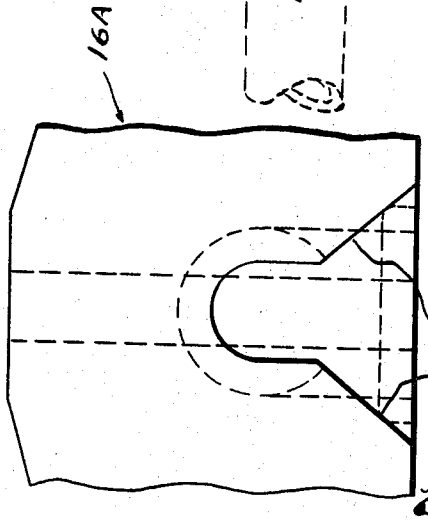


Fig. 6.

Inventors:
Gerald D. Fox,
John E. Joyce,
Robert C. Leif,
by Albert Spencer Attorney

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# CENTRIFUGE ROTORS, BUCKETS AND COMBINATIONS OF SUCH BUCKETS AND ROTORS

Gerald D. Fox and John E. Joyce, Quincy, Mass., and Robert C. Leif, Los Angeles, Calif., assignors to International Equipment Company, Needham Heights, Mass., a corporation of Massachusetts

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## ABSTRACT OF THE DISCLOSURE

Centrifuge rotors and buckets and combinations of buckets and rotors, the buckets and rotors having, respectively, detachably mating, ball and socket connecting portions.

The present invention relates to combinations of centrifuge buckets and rotors of the type where the buckets are detachably connected to a rotor to swing from a depending, vertical position into a position at right angles to the rotor axis in response to centrifugal force. The invention also relates to centrifuge rotors and to the buckets for use in such combinations.

The construction used to effect the attachment of buckets to centrifuge rotors has heretofore placed limits on rotor designs and, accordingly, on such important factors as the number of buckets that a head may carry and the speed at which it may be safely rotated without the risk of breakage. Existing constructions employ pivotal connections between the buckets and the rotors. In one such commonly used construction, the rotors have their peripheries formed with an outwardly disposed flange provided with a circumferentially spaced series of vertical slots, one for each bucket. Each bucket is provided with trunnions adjacent its end that has a removable closure and at the upper end of each bucket-receiving slot there are undercut shoulders receiving the trunnions and pivotally confining them during centrifugation. Any proposal to increase the strength of pivot connections leads, for any size of head, to a reduction in the number of buckets that it can carry, to increased rotor weight, or both. The avoidance of rotor breakage is, accordingly, troublesome and has been considered largely a metallurgical problem.

The general objective of the present invention is to provide centrifuge rotor and bucket combinations in which the connection between each bucket and its rotor is of a ball and socket type.

In accordance with the invention, the objective is attained by providing a centrifuge rotor and bucket for use therewith. Each bucket is of the type including a tubular portion closed at one end and provided with flange structure adjacent the other end, the flange structure providing diametrically opposed portions whose faces that are disposed towards the closed end are spherical. The rotor has top and bottom faces, a plurality of spherical sockets spaced inwardly of but adjacent its periphery and a slot opening upwardly into each socket, and bucket entrances through one of its faces, one entrance for each socket and associated slot. Each socket receives the flanged end of a bucket and the slot in communication with that socket receives the tubular portion thereof and is of a length



enabling the buckets to have a depending portion of rest and a horizontal position of use, each flange structure and each socket being dimensioned to establish a ball and socket type of bucket-to-rotor connection in both positions. Each entrance is dimensioned to receive the flange structure of a bucket and has an outwardly extending portion of which a socket is the outer extremity and which is intersected by the associated slot.

In one embodiment of the invention, the rotor has a plurality of radial slots opening through the lower part of its periphery and its undersurface, each slot being dimensioned to slidably receive the tubular portion of a bucket as it swings from its position of rest into its position of use. Each slot has an entrance through a rotor face adjacent the rotor axis dimensioned to receive the flanged end of a bucket and is undercut to accommodate that end, each undercut terminating in a socket adjacent the periphery of the rotor for supporting a bucket both when the rotor is at rest and when it is brought up to speed with the bucket then at right angles to the rotor axis, the socket and flange being dimensioned so that together they provide a bucket-to-rotor connection of the ball and socket type.

Each centrifuge rotor in accordance with the invention is possessed of adequate strength to ensure against breakage at rotor speeds that are relatively high for its size and weight while providing support for a number of buckets that is relatively large for its size. This result is due not only to the relatively large areas of mutual contact between the rotor and its buckets but also because the invention makes it possible to support the buckets within open slots extending from points adjacent the rotor axis outwardly and upwardly through the lower part of its periphery, leaving the upper part thereof as an annular reinforcement for the upper parts of the sockets.

Another advantage of the ball and socket connections between the rotor and its buckets is that the slots receiving the tubular bucket portions may be shaped to permit the buckets to swing in trailing directions to a desired angular extent as the rotor speed increases or decreases.

In the accompanying drawings, there are shown illustrative embodiments of the invention from which these and other of its objectives, novel features, and advantages will be apparent.

In the drawings:

FIGURE 1 is a partly sectioned, top plan view of a rotor in accordance with the invention showing the flanged end of one bucket in its socket,

FIGURE 2 is a section taken approximately along the indicated lines 2—2 of FIGURE 1 and showing buckets in side elevation,

FIGURE 3 is a fragmentary section of the rotor taken vertically through a bucket-supporting socket and slot,

FIGURE 4 is a fragmentary side elevation of a rotor,

FIGURE 5 is a longitudinal section of a bucket drawn on an increased scale, and

FIGURE 6 is a view similar to FIGURE 4 but illustrating another embodiment of the invention.

The centrifuge buckets shown in the drawings are generally indicated at **10**. Each bucket **10** includes a tubular portion **11** that is closed at one end and has its other end counterbored to provide a seat **12** for a seal **13** and threaded to receive a cap **14**. Adjacent the capped end of each bucket, there is a circular flange **15** whose face that

is disposed towards the closed end thereof is spherical. As will be apparent from FIGURE 5, each tubular portion **11** is externally tapered inwardly towards its closed end in order to achieve the best weight distribution of the tube and its contents during centrifugation, the taper being necessarily slight because the bucket walls are relatively thin and because the inside diameter of the tubular portion **11** is constant.

A rotor in accordance with the invention is generally indicated at **16** and is shown as having an axial bore **17** to receive the centrifuge spindle, not shown, the bore **17** having diametrically disposed channels **18** to receive the driving pins thereof as one example of a conventional way of securing a rotor to its drive. The chamber in which this type of rotor is spun may or may not be a vacuum chamber, vacuum chambers being commonly used when high speeds are desired that would otherwise place undue loads on the motors.

The rotor **16** has a plurality of circumferentially spaced, open slots **19** extending vertically from the bottom of the rotor through the lower part of its periphery. The width of the slots **19** is such that each may accommodate the tubular portion **11** of a bucket **10**.

Each slot **19** is undercut to accommodate the flanged end of a bucket **10**, the undercut being shown as starting in the undersurface adjacent the rotor axis and terminating short of the periphery of the rotor to provide a seat that is sufficiently spherical to provide a socket **20** for the spherical face of a flange of the bucket both when the rotor is at rest and when its speed is such as to cause the buckets **10** to swing outwardly into positions in which their axes are at right angles to the axis of the rotor **16**. Each socket **20** is also shown as slightly elongated and downwardly inclined, say 5°, relative to a plane at right angles to the rotor axis, so that each socket **20** may serve to securely retain a bucket **10** when the rotor **16** is at rest.

Reference is now made to FIGURE 2, wherein the right hand bucket **10** has had its stoppered and flanged end entered upwardly through the open, undercut end of a slot **19** and moved radially outwardly toward its socket **20**. The left hand bucket **10** is shown as fully supported by its socket **20** so that, when the rotor is turning rapidly enough, it will swing smoothly outwardly into its dotted line position.

The production of rotors may be effected as with an appropriately dimensioned spherical cutter utilizing the slots **19** as a guide for the shank of the tool, introducing the cutting head of the tool at the undersurface end of a slot **19** and advancing it first upwardly and then radially outwardly and preferably downwardly at a small angle relative to the horizontal, say 5°, to ensure bucket retention when the rotor **16** is at rest.

A rotor in accordance with the invention is of adequate strength for high speed operations since the area of its contact with the bucket flanges is large due to the ball-and-socket type of connection between the buckets and their rotor.

The smooth and potentially universal motion characteristic of ball-and-socket connections also permits additional advantages in centrifugation. To enable the closed ends of the buckets **10** to trail, as is sometimes recommend, at the start of a centrifuge cycle and also when the rotor slows down, each slot may have its lower end slightly widened and upwardly and inwardly tapered as at **19A**, see FIGURE 6, to an extent permitting desired trailing of the buckets as the rotor is brought up to speed or slows down. As the rotor **16A** shown in FIGURE 6 is otherwise identical to the rotor **16**, it is not otherwise detailed.

We claim:

**1.** A centrifuge rotor for supporting buckets, each bucket of the type including a tubular portion closed at one end and provided with flange structure adjacent its other end, the flange structure providing diametrically opposed portions whose faces that are disposed towards said closed end are spherical with respect to a common center, said rotor having a plurality of bucket entrance passages of circular section and of a diameter to accommodate the bucket flange structure and spaced uniformly from the center of the rotor and from each other, each entrance passage extending into said rotor in a vertical direction and outwardly and downwardly within the rotor in a radial direction and terminating in a retaining socket complemental to said flange structure portions, and said rotor having means for each entrance passage to receive and guide the tubular portion of a bucket as it is positioned within the rotor with its flange structure seated in the passage socket and as the bucket swings upwardly during centrifugation, each of said means being in the form of a radial slot in vertical alignment with an appropriate one of said entrance passages and opening through the periphery and undersurface of said rotor and into the vertically aligned entrance passage and its socket, each slot, in at least a portion thereof, slidably receiving the tubular portion of a bucket and the extent of each slot being such that a bucket may be entered into a socket and swing vertically between positions of rest and use.

**2.** The rotor of claim **1** in which each slot, between the position therein of the tubular portion of a bucket in its position of rest and the position of the tubular portion in its position of use tapers outwardly from the retaining socket to enable the tubular portion to swing into a trailing position during acceleration and deceleration when the rotor speed is below a predetermined rate of rotation to a width such that the tubular portion is maintained radial with respect to the rotor axis when the predetermined rotor speed is attained.

**3.** The rotor of claim **1** in which the entrance passages open through the undersurface of the rotor.

**4.** In combination, a centrifuge rotor and buckets, each bucket of the type including a tubular portion closed at one end including flange structure adjacent its other end, the flange structure providing diametrically opposed portions whose faces that are disposed towards said closed end are spherical with respect to a common center, and said rotor having a plurality of bucket entrance passages of circular section and of a diameter to accommodate the bucket flange structure and spaced uniformly from the center of the rotor and from each other, each entrance passage extending into said rotor in a vertical direction and outwardly and downwardly within the rotor in a radial direction and terminating in a socket complemental to said flange structure portions, and said rotor having means for each entrance passage to receive and guide the tubular portion of a bucket as it is positioned within the rotor with its flange structure seated in the passage socket and as the bucket swings upwardly during centrifugation, each of said means being in the form of a radial slot in vertical alignment with an entrance and opening through the periphery and undersurface of said rotor and into the vertically aligned passage and its socket, each slot, in at least a portion thereof slidably receiving the tubular portion of a bucket and the extent of each slot being such that a bucket may be entered into a socket to have a depending position of rest and swing vertically between positions of rest and use, the tubular portion of each bucket extending through the appropriate one of said slots with its flange structure seated in a socket to provide a ball and socket type of bucket to rotor connection.

**5.** The combination of claim **4** in which each slot, between the position therein of the tubular portion of a bucket in its position of rest and the position of the tubular portion in its position of use, tapers outwardly from the socket to enable that tubular portion to swing into a trailing position during acceleration and deceleration when the rotor speed is below a predetermined rate of rotation to a width such that the tubular portion is maintained

radial with respect to the rotor axis when the predetermined rotor speed is attained.

6. The combination of claim 4 in which the entrance passages open through the undersurface of the rotor.


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HENRY T. KLINKSIEK, *Primary Examiner.*

M. CARY NELSON, *Examiner.*