April 26, 1966 J. P. FELTMAN, JR., ETAL 3,248,046

HIGH SPEED ROTOR USED FOR CENTRIFUGAL SEPARATION

Filed July 2, 1965

Fig. 1.

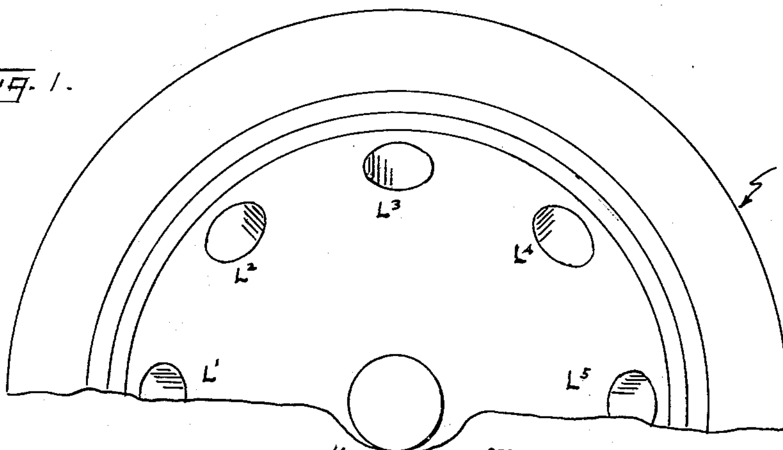


Fig. 3.

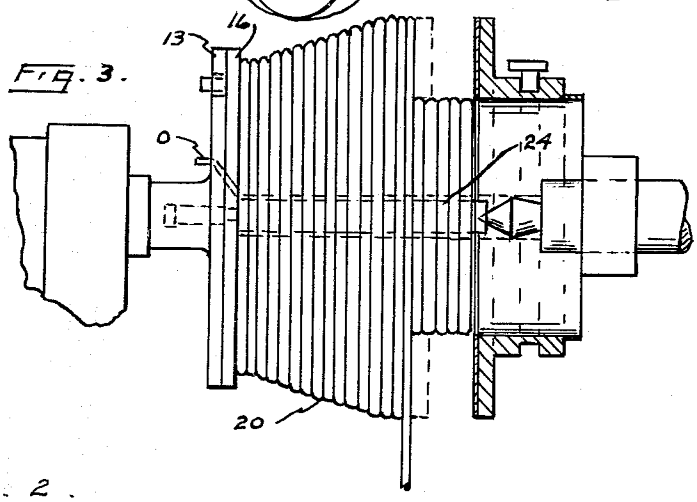
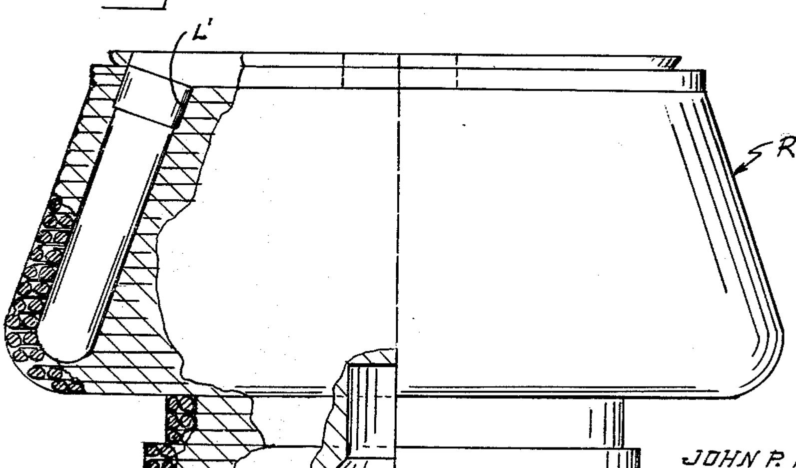


Fig. 2.



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HIGH SPEED ROTOR USED FOR CENTRIFUGAL SEPARATION

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2 Claims. (Cl. 233—26)

This is a continuation-in-part of application Ser. No. 361,967, filed April 23, 1964, and now abandoned.

This invention relates to high speed rotors used in centrifuges and more specifically in the construction of a rotor built up of superposed layers of glass fibers that are bonded together to form a balanced solid rotor provided with small tube holding apertures or bores.

Rotors of aluminum, heat treated steel and titanium are well known in the art. However, all of these rotors are limited to a degree of centrifugal force at which they break down and will disintegrate, for example, the tensile strength of the materials.

Aluminum will not exceed 85,000 lbs. per square inch.

Titanium will not exceed 170,000 lbs. per square inch.

Heat treated steel will not exceed 250,000 lbs. per square inch.

The density of the materials must be considered:

Aluminum	.097
Titanium	.165
Heat treated steel	.285

Thus the strength to weight ratio is approximately 880,000 lbs. per square inch.

It is also to be noted that spinning buckets are well known in the art. In spinning buckets for rayon or artificial silk, the bucket is formed as a bowl with a central open chamber. These buckets are designed for normal operating speeds of 9000 r.p.m. and according to Patent No. 2,965,220 they will, under test, rupture at 14,900 r.p.m. It is also to be noted that in all of the prior art relating to spinning buckets, the bucket or rotor is constructed as a cylindrical wall extending from a supporting base in which the walls of the bowl are comparatively light or thin and in which the wall may be composed of a fibrous strip with a binder as in Patent No. 2,028,040, or a cellulosic fabric material impregnated and bonded together with a phenolic resin as in Patent No. 2,965,220, or as a fibrous material impregnated with resinoid and reinforced with a circumferentially placed wrapping of stainless steel wire as in Patent No. 2,436,716, or of glass yarn as disclosed in Patent No. 2,594,693, or as a molded bucket having fiber glass in the wall on a reinforcing medium as disclosed in Patent No. 2,525,469, or the combination of a glass fiber warp with a cotton fill in a molded bucket of artificial resins as disclosed in Patent No. 2,372,983, or the use of a glass fiber thread or strand as reinforcement in a molded resinous roller as in the Dutch Patent No. 87,740, or the molding of a plurality of layers of a mixture of an organic fibrous material and an acid resistant asbestos woven into a fabric as in Patent No. 2,128,097, but in all the art on spinning buckets the speeds or r.p.m. indicated is a modest 14–15,000 r.p.m.

It is also to be noted that pipe is constructed by wrapping glass fibers about a mandrel and impregnating the glass fibers with a thermo setting plastic binder. In all pipe formed by this method there is a comparatively thin pipe wall formed that is exceedingly strong, but never subject to centrifugal forces.

In the presently known rotors the centrifuge that may be constructed of aluminum, titanium or heat treated steel the strength to weight ratio is low, that is while aluminum is light it has a low tensile strength and

where heat treated steel has a high tensile strength it is heavy. The presently known rotors using metal are operating up to 60,000 r.p.m. In one example of their use that is in the separation of viruses, the rotors operating at 60,000 r.p.m. take from 60 to 70 hours for actual separation of the virus. In the present invention the rotors will operate at 100,000 r.p.m. and the same separation of viruses will be performed in from 2 to 3 hours.

In the present invention the article or rotor is formed as a solid body as in all rotors designed for holding tubes or bottles for centrifugal separation processes. Also in the present invention the rotor must be capable of extremely high r.p.m. to produce a centrifugal force over 250,000 X gravity and up to 325,000 *g*'s, for the separation of certain viruses in a reasonably minimum time in clinical study.

It is an object of the invention to provide a high speed rotor for holding tubes or bottles for centrifugal separation of substances requiring a force of over 250,000 X gravity.

It is a further object of this invention to provide a high speed rotor for holding tubes or bottles in a centrifuge in which the rotor is constructed solely of glass fiber filament wound in superposed layers and impregnated with a thermosetting binder to form a solid body that is capable of withstanding a centrifugal force in excess of 250,000 X gravity.

Other objects of this invention will be apparent by reference to the detailed description and the drawings in which

FIG. 1 is a plan view of a rotor.

FIG. 2 is a side view partially in cross section, and

FIG. 3 is an elevational view illustrating the method of forming the rotor.

Referring to the drawings there is illustrated a rotor member R, FIGS. 1 and 2 which is constructed as illustrated in FIG. 3 by winding upon a mandrel **24** a narrow strip or strand of glass fiber material **10** while a plastic material such as resin is sprayed by gravity upon each convolution of the glass fiber material simultaneously with the winding of the glass fiber material. The glass fiber strand is fed through a guiding member **66** passing through a hub member **12** which is slotted lengthwise so as to exert friction upon the glass fiber thread to cause the thread to wind over the mandrel **24** with a uniform predetermined tension. The rotation of the mandrel **24** and the simultaneous back and forth operation of the glass fiber thread **10** by means of the movement of the guiding member **66** back and forth produces a uniform coiling of the strand **10** over mandrel **24** and continues to superpose layers of strand one upon the other to build up the rotor body R. One end of mandrel **24** as shown in FIG. 3 is supported by the point **18** fitted in the tail stock spindle of a winding machine while the opposite end of mandrel **24** is supported by the head stock of the winding machine. The head stock is provided with a disc **13** having a drilled hole **14** for receiving the reduced end **15** of mandrel **24**. Positioned between disc **13** and the superposed layers of strand **10** is a second disc **16** having a pin **17** extending laterally therefrom for engaging an opening in disc **13** thus keying the disc member **16** to disc **13** of the head stock. To assist in forming the rotor R there is provided a cylindrically shaped member **19** mounted on the tail stock for rotary movement only. A hub **20** is mounted on the cylindrically shaped member **19** for sliding movement. Member **20** is formed with a disc portion **21**, the disc portion having a diameter corresponding to the larger coiled diameter of the rotor to be formed, the cylindrical member **19** and the disc **21** serving to hold the glass fiber strand **10** in a plane at right angles to the axis of the mandrel during the coiling of the glass fiber thread. The sliding movement of disc **21** on the cylindrically shaped member **19** is affected manually and is set by a pin **23** engaging a groove **50** as shown in FIG. 3. Thus the disc may be set in the dotted position for winding and forming rotor R as illustrated. A sleeve **26** may be placed over the mandrel **24** to prevent the adherence of the plastic material to the mandrel and thus permit removal of the rotor after the cooling of the plastic material. Likewise a disc **25** of an appropriate material may be placed against the face of disc **21** and another disc **25** may be placed against the face of disc **16**. Thus the strand **10** will not adhere to either disc or to the mandrel and the rotor R may be easily removed. To start the winding of the strand **10** upon mandrel **24**, one end **0** of strand **10** is hooked to the discs **13** and **16** and coiled over the sleeve **26** at a pitch corresponding to the size of the fiber glass thread used and the winding is continued with the strand **10** being fed through hub member **12** and by movement of guide member **66**, the actual desired contour of rotor R may be formed as shown in FIG. 3. The rotor R is removed from mandrel **24** and then cured forming an integral body from the wound strand **10**. The rotor R may then be treated as a solid body for machining its outer periphery to provide a perfect balance or any variation in shape as desired. It may also be drilled to provide a plurality of cylindrical bores L1, L2, L3, L4, L5, etc., of a size to permit the insertion of laboratory tubes as illustrated in FIG. 2 thus completing the rotor R for use in a centrifuge. The glass fiber material or strand **10** approximates .075 lb. per cubic inch. The tensile strength of this strand is approximately 200,000 plus lbs. per square inch. Thus the strength to weight ratio

$$\frac{200,000}{.075}$$

equals 4.75 which is a strength to weight ratio of 2,700,000 inches approximately. Thus the tensile strength of the rotor R, because of the relatively low density and high strength of the glass fiber as bonded together, possesses a weight to strength ratio of approximately 240% above that of any other material heretofore used for rotors and due to its build up of superposed layers into a solid or integrally formed rotor, the rotor R does not provide any weakness in its contour. The centrifugal force developed in operation of the rotor in a centrifuge is divided in a balanced relation over the entire rotor. The bores L1, L2, etc., are positioned concentrically and adjacent to the outer area of the rotor and spaced sufficiently apart to have little or no effect upon the structural strength and balance of the rotor.

Although we have illustrated a rotor of a particular configuration for retaining tubes or bottles for centrifugal separation of materials, it is to be understood that the bores may be varied in their shape to retain any desired type of tube or bottle and the number of bores may be varied according to the particular type of rotor utilized and the size of the rotor may be varied, that is, a small rotor will be utilized for the extremely high r.p.m. while a larger rotor may be utilized for a lesser r.p.m. and desired centrifugal force for separation. It is also to be understood that the rotor R is solely constructed of the lightest weight toughest tensile strength strand, namely, glass fiber bonded together to provide the strongest possible rotor for extremely high r.p.m. operation and extremely high centrifugal force for separation as a centrifuge. Changes in the glass fiber as to its contour whether round, square, etc., may be made as long as the fiber retains its lightweight and high tensile strength without departing from the spirit of this invention and this invention shall be limited only by the appended claims.

We claim:

1. A centrifugal rotor comprising a solid core with a base, said core comprising a plurality of internal and external layers of glass fiber impregnated with a resinous binder, the external layers of said core being provided with at least two small bottle holding bores that are radially spaced in equal and dynamically balanced relationship, said bores extending radially into said rotor so that the base of the bores are positioned in a greater diametrical relation than the upper portion of said bores.

2. A solid rotor for a centrifuge which may be subjected to a stress of 250,000 X gravity during its operation, comprising a generally cylindrical form having its lower portion with a greater diameter than its upper portion and formed of superposed layers of binder treated glass fiber with the turns of one layer being overlapped by the turns of the next layer whereby the glass fiber filaments of all layers are interlocked into an internal balanced rotor having uniform density, the external layers of said rotor provided with at least two small bottle holding bores that are radially spaced in equal and dynamically balanced relationship, said bores extending radially into said rotor.

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