Aug. 17, 1948. J. GREBMEIER 2,447,330

ROTOR FOR ULTRA CENTRIFUGE MACHINES

Filed May 16, 1946

Fig. 1.

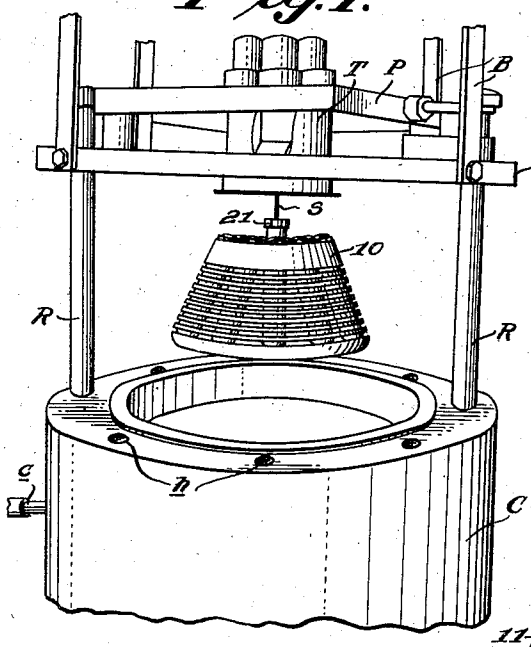


Fig. 4.

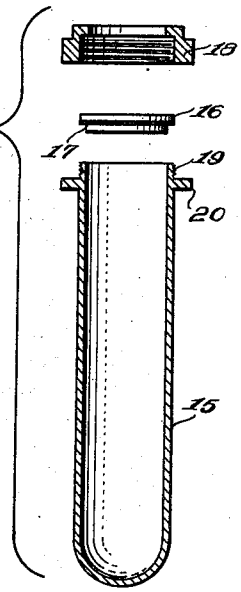


Fig. 2.

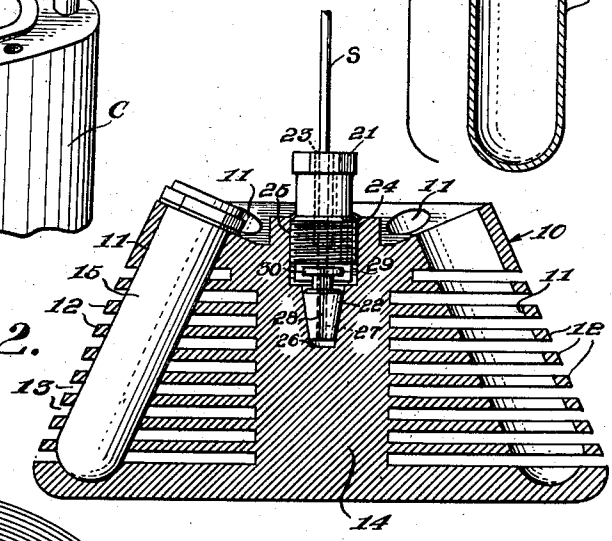
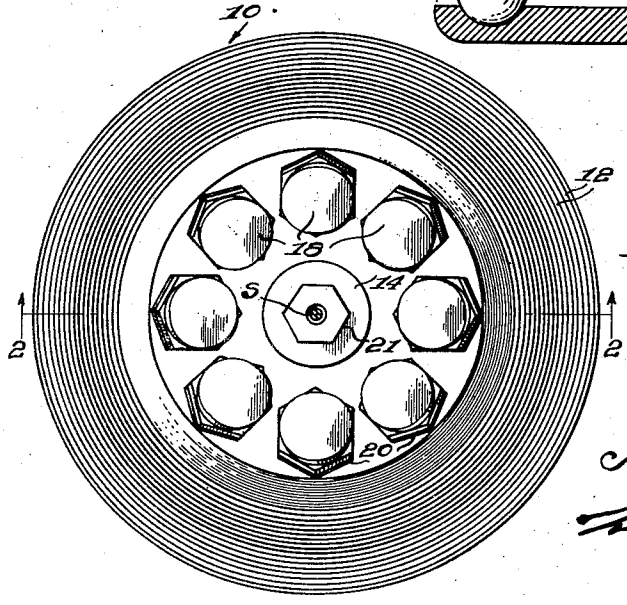


Fig. 3.



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ROTOR FOR ULTRACENTRIFUGE MACHINES

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6 Claims. (Cl. 233—26)

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This invention relates to an ultra-centrifuge. Such devices as are now in general use comprise a rotor in the form of a substantially solid frusto-conical metal block, slightly cored out at the upper end from which a plurality of circumferentially spaced cylindrical wells or cavities extend obliquely into the block. These wells are arranged to receive test tubes which carry the substance to be centrifuged. A removable top or lid is screwed or otherwise secured over the open top of the chambered rotor and serves, through the medium of an interposed gasket, to seal the chamber into which the open top tubes extend from interfering with the relatively high vacuum in which the rotor is operated.

The rotor, when in operation, is usually confined within a steel chamber having very thick walls which act as a guard in the event of breakdown or explosion of the rotor under strain occasioned by the very high speed (1000 R. P. S.) at which these devices are rotated, to effect the centrifugation desired.

The steel chamber for this purpose is usually provided with an air-sealing cover so that a high vacuum may be effected therein after placement of the tube-laden rotor therein. Such an organization permits rapid acceleration of the rotor and the high speed of rotation required. It also prevents generation of heat in the rotor.

Usually the rotor is supported by a fine steel shaft from which it is driven, the shaft having one end thereof removably connected to the rotor and the other end thereof operatively connected with a driving mechanism.

The tubes which contain the substance to be centrifuged are preferably constructed of stainless steel or plastic, as more fragile materials such as glass, would not stand the strain resulting from the centrifugal force produced under the high speed of rotation required.

The tube supporting wells or cavities in the rotor are disposed adjacent to and parallel with the conical wall of the rotor with the result that the axes of such cavities converge upwardly toward the axis of the rotor and the walls communicate with the chambered upper end of the rotor. Chambered rotors of this type now in use are provided with a detachable cover and the tubes which are carried in the rotor are, therefore, not provided with closures or cover means. As a result the open tubes cannot be well filled

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with the substance to be treated due to their normally inclined supported positions in the rotor and the further fact that the surface of the substance in the tubes changes from a horizontal to a vertical position under centrifugal force. To the best of my knowledge, the rotors as now generally used are substantially solid except for the chambered upper end and the communicating tube receiving wells or cavities, as a result of which the rotors are of considerable weight even though they may be constructed of a light metal such as Duralumin, dow metal, or the like. For the usual size such rotors weigh seven to eight pounds.

It is important to note, therefore, that the rotor must be operated at a very high speed of rotation (1000 R. P. S.) which is necessary for throwing small particles, such as virus, bacteria, or bacteriophage to the bottoms of the inclined supported tubes in the segregating of same from the liquid in which they are originally suspended.

Due to such high speed of rotation it is necessary that the rotors be constructed to withstand the strain occasioned by the centrifugal force exerted and that they also be capable of supporting the tubes in a way to avoid breakage thereof.

The rotors above referred to due to their substantial weight and accordingly high inertia, require 30 to 40 minutes in their acceleration from rest to maximum operating speed and a like interval of time for their deceleration from operating speed to rest, or a period of from one hour to one hour and 20 minutes for acceleration and deceleration. Since from one to two hours are required for a centrifuging operation, relatively few operations can be carried out in a day since the time used for acceleration and deceleration is lost so far as the actual centrifugating operation is concerned.

The connection of the driving shaft and rotor above referred to, has been made with the cover or at least to a point at or adjacent the top of the rotor which is substantially above the center of mass thereof. This point of connection is not conducive to smooth running of the rotor, which, particularly upon acceleration thereof is subject to more or less vibration in planes at right angles to the axis of the drive shaft.

A primary object of this invention is the pro-

vision of a rotor for ultra-centrifugating machines which substantially overcomes the above noted objections.

A further object of the invention is the provision of a rotor for centrifugating machines which is of a single piece in the elimination of a cover, and wherein the substance supporting tubes are separately provided with lids, whereby they may be filled with the substance to be centrifugated.

A still further object of the invention is the provision of a rotor for centrifugating machines which is in the approved form of the frusto-conical blocks of the prior art, but which includes vertically spaced flanges or fins in the provision of intervening circumferentially extending slots whereby the rotor is rendered relatively light in weight while having sufficient tensile strength to withstand the strain occasioned by centrifugal force in operation.

A still further object of the invention is the provision in a centrifugating machine of a frusto-conical rotor and a drive shaft having a driving connection with the rotor body directly and at a point substantially below the upper end thereof whereby to avoid vibration on acceleration and insure smoother running of the rotor in operation.

With the above objects in view, together with others that will present themselves in the course of the following description, reference will be had to the accompanying drawing wherein is illustrated a preferred embodiment of the invention, and wherein—

Fig. 1 is a fragmental perspective view showing the installation of the improved rotor to a standard ultra-centrifugal machine, the rotor being suspended above the vacuum chamber in normal inoperative position;

Fig. 2 is a vertical sectional view of the rotor and drive shaft connection therewith as observed in the plane of line 2—2, Fig. 3;

Fig. 3 is a top plan view of the rotor showing the drive shaft in transverse section;

Fig. 4 is a view showing one of the substances containing tubes in vertical axial section, a lid therefor in side elevation, and a lid retaining nut in transverse section.

Referring now in detail to the drawing, by use of reference characters, 10 designates the improved rotor which in use is rotatively supported in a thick walled steel chamber C (Fig. 1) which acts as a guard in the event of breakage of the rotor as well as a vacuum receptacle for the rotor.

The rotor is driven by a relatively light weight shaft S which is connected with suitable driving means and illustrated as an air turbine T carried by the chamber cover C' and a plate P supported thereabove. The cover, turbine and rotor are vertically movable on guide rods R through the instrumentality of bars B.

In Fig. 1 the rotor is shown in raised or inoperative position and with tubes inserted therein. Prior to the starting of a centrifugating operation, the rotor is lowered by means of bars B into the chamber until the cover engages the top of the chamber. The cover is then secured in position as by means of bolts engageable in the tapped holes *h* in the top of the chamber wall. A vacuum is then provided in the chamber through connection *c* and the rotor is then set into rotation by means of the power source T.

The present invention pertains particularly to the rotor construction which as is more clearly shown in Figs. 2 and 3 consists of a metal block

of substantially frusto-conical form. The block is provided with a plurality (Nos. 8, 10, or 12) of cavities or wells 11 extending from the upper end of the block to points adjacent the lower end thereof, and with their axes parallel with the conical face of the black and converging in the direction of the shaft S.

The cavities or wells 11 are preferably provided by drilling the block which during such operation is solid throughout. In order to substantially reduce the weighth of the rotor while retaining sufficient strain resisting properties thereof, the block is materially reduced in weight by removing a substantial volume of its material after having provided the wells 11 therein.

In the removal of the material, it is highly important that the rotor retain its balanced relation to the drive shaft, and the remaining material in the block be so disposed as to withstand the strain occasioned by centrifugal force and that the tubes be so supported as not to be subject to breakage under centrifugal force.

While the rotor may be substantially reduced in weight by the removal of portions of its material in the provision of voids in different ways, intensive experimentation has shown however that the most satisfactory way is in the removal of thin sections of the material of uniform thickness in vertically spaced relation circumferentially of the block in the provision of vertically spaced circumferential flanges, webs, or fins 12 with intervening slots or voids 13 of substantially the same thickness as that of the fins.

The central portion 14 of the block remains solid from top to bottom thereof and the fins 12 and intervening voids 13 extend substantially from the top to the bottom of the block with the result that substantially one-half of the metal in the original block is removed outwardly of the solid central portion 14.

Experimentation in the provision of the improved rotor herein disclosed has shown that the uniformly spaced webs 12 of uniform thickness have sufficient tensile strength to support the tubes and withstand the strain occasioned by centrifugal force, and that by providing the voids 13 of substantially the same thickness as the fins relatively short sections of the tubes are unsupported and will not become broken under the centrifugal force.

The wells 11 are adapted to removably receive the substance containing tubes 15 which may be of stainless steel or dural, and such tubes are each provided with a small lid or cover 16 having a rubber washer or gasket 17 and a hexagonal nut 18 engageable with threads 19 on the outer end of the tube beyond a hexagonal flange 20 thereon, the nut serving to draw the lid into firm sealing contact with the open end of the tube after same has been filled with the substance to be centrifugated. The hexagonal forms of the nut and flange facilitate application and removal of the nut to and from the tube.

Contrary to the general practice heretofore in vogue, the rotor is not provided with a lid and the tubes rest by gravity within the wells 11. By the provision of the spaced sections or fins 12 proper support is given the tubes 15 while the weight and accordingly the inertia of the rotor are substantially reduced, the weight of the present rotor being substantially 4.75 pounds as compared with prior similar rotors and their lids which weigh approximately 8 pounds.

With the reduced weight and correspondingly reduced inertia of the present rotor the accelera-

tion and deceleration periods are approximately 10 minutes as compared with 30 to 40 minutes required with prior rotors. Thus, it will be appreciated that with the present improved rotor several more centrifugating operations can be performed in a given interval of time than was possible with the prior rotors.

By the provision of the individually covered tubes, same can be filled with the substance to be centrifugated since there is no actual flow of any liquid taking place in the tubes and thus the capacity of the tubes is substantially increased, since the open ended tubes in the old form rotor contained about 10 cc. of substance, while the present closed tubes contain about 16 cc. of substance which in addition to the substantial reduction in time for acceleration and deceleration is a material factor in the centrifugating operation.

The invention further provides a simplified form of chuck or releasable connection between the rotor body and the drive shaft as well as the location of such connection nearer the center of mass of the metal block whereby providing for less vibration and smoother running of the rotor.

As indicated in Fig. 2, such chuck comprises a hexagon headed nut 21 and a steel collet 22. The nut is provided with an axial aperture 23 for reception of the shaft S, and the threaded portion 24 thereof threads into the internally threaded hole 25 opening into the upper end of the central solid portion 14 of the block and extending a substantial distance thereinto. The lower end of hole 25 communicates with the upper end of a frusto-conical recess 26 in which the correspondingly shaped body portion of the collet 22 rests.

The collet is provided with a central aperture 27 and is split throughout its length as at 28 for contraction and expansion thereof. The nut 21 is provided with a slot 29 which receives the head 30 of the collet. Thus, upon inserting the lower end of the shaft S within the aperture in the collet and turning the nut 21 inwardly, the shaft is firmly gripped and held in driving connection with the rotor.

From an inspection of Fig. 2 it will be seen that the gripped end of the shaft S is disposed a substantial distance within the block or below the top end thereof, or substantially nearer the center of mass of the block than if disposed on a cover or the upper end of the block as in prior constructions, whereby providing a better balanced driving connection.

Experimentation has shown, however, that the shaft driving connection should not be located beyond one-third of the distance from the top to the bottom of the block for the reason that if the central solid portion 14 be too deeply pierced the tensile strength of the rotor will not be sufficient to withstand the strain under centrifugal force occasioned by the high speed of rotation of the rotor.

Many advantages of the improved construction herein disclosed should be appreciated from the foregoing disclosure, principal ones of which are are follows:

1. Lighter weight with consequent less inertia and shorter acceleration and deceleration periods;

2. Increased capacity by the utilization of closed tubes completely filled with the substance to be centrifugated;

3. Suspension point of drive shaft nearer the center of mass or gravity with less vibration and smoother running of the rotor.

While I have disclosed my invention in accordance with a single specific embodiment thereof, such is to be considered as illustrative only, and not restrictive, the scope of the invention being defined in the subjoined claims.

What I claim is:

1. A rotor for ultra-centrifugating machines comprising a block of generally frusto-conical form having its smaller end upward, said block comprising a central solid portion and vertically spaced circumferential fins extending normal to the axis of the rotor from the central portion between the upper and lower ends of the block, and tube receiving wells in the block adjacent to and parallel with its conical wall and extending in part through said fins.

2. A rotor according to claim 1 wherein said fins occupy the major distance between the upper and lower ends of the block and extending inwardly beyond the innermost walls of the wells, and wherein said fins are relatively narrow and are separated by voids of substantially the same width.

3. A rotor for ultracentrifugating machines, comprising a block of generally frusto-conical form having its smaller end upward, a plurality of tube supporting wells in said block opening through the upper end thereof and disposed adjacent the conical walls with their axes parallel therewith, and vertically spaced weight reducing slots extending circumferentially of the block, said slots intersecting the wells and opening through the conical wall of the block providing intervening fin-like portions extending normal to the axis of the rotor.

4. A rotor for ultracentrifugating machines, comprising a block of generally frusto-conical form having its smaller end upward, said block including a solid axial portion of substantial radius and a plurality of horizontal disposed vertically spaced fins extending normal to the axis of the solid portion to the conical outer wall of the block, and a plurality of tube supporting wells parallel with said conical wall and extending through said fins.

5. A rotor for ultracentrifugating machines, comprising a body of generally frusto-conical form having its smaller end upward, said body including a substantially solid cylindrical axial central portion, a vertical series of circumferential weight reducing slots in the body outwardly of said solid axial portion providing annular radiating fins of increasing diameters therebetween extending normal to the axis of the rotor to the conical outer surface, said fins having registering apertures at circumferentially spaced points providing a plurality of tube supporting wells in the body adjacent to and parallel with its conical outer surface, and means for releasably supporting the end of a drive shaft disposed axially within said solid portion.

6. A rotor for ultra-centrifugating machines, comprising a block of generally frusto-conical form having its smaller end upward, a plurality of tube supporting wells in said block opening through the upper end thereof and disposed adjacent the conical wall with their axes parallel therewith, and a vertical series of circumferentially disposed slots in the block providing intervening fins extending normal to the axis of the rotor, and slots intersecting the wells therein for substantially reducing the weight of the block

with a corresponding reduction of inertia and acceleration and deceleration periods.

JOSEPH GREBMEIER.

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