

[54] **FLEXIBLE SHAFT STABILIZER**

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[58] Field of Search **233/1 R, 1 C, 23 R,**
233/23 A, 26; 64/1 V, 2 R

[56] **References Cited**

UNITED STATES PATENTS

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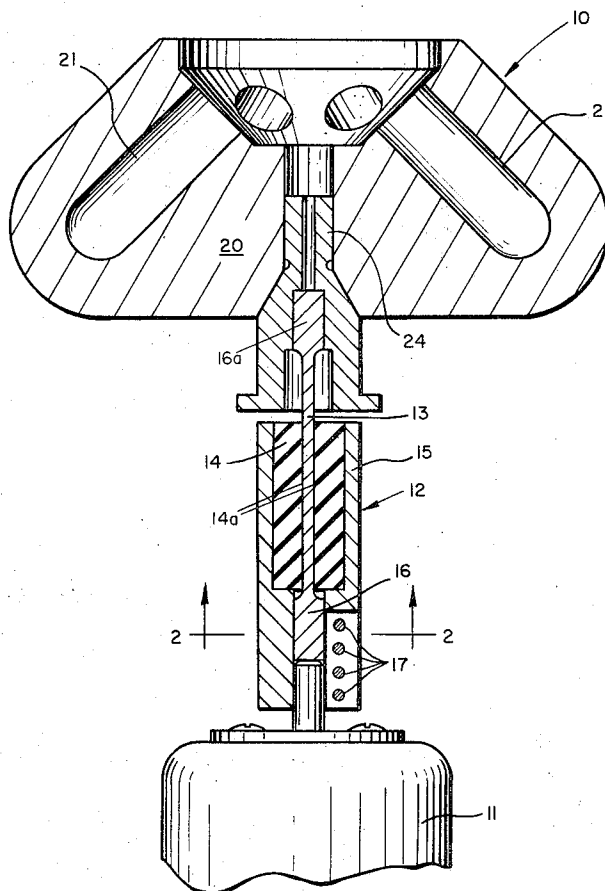
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[57] **ABSTRACT**

A flexible shaft construction to transmit rotational energy between a motor and a centrifuge rotor having a thin, long flexible shaft surrounded by a resilient sleeve and a stiff tubular member. The shaft, sleeve and tubular member are arranged so that there is no relative rotational motion between them.

4 Claims, 2 Drawing Figures



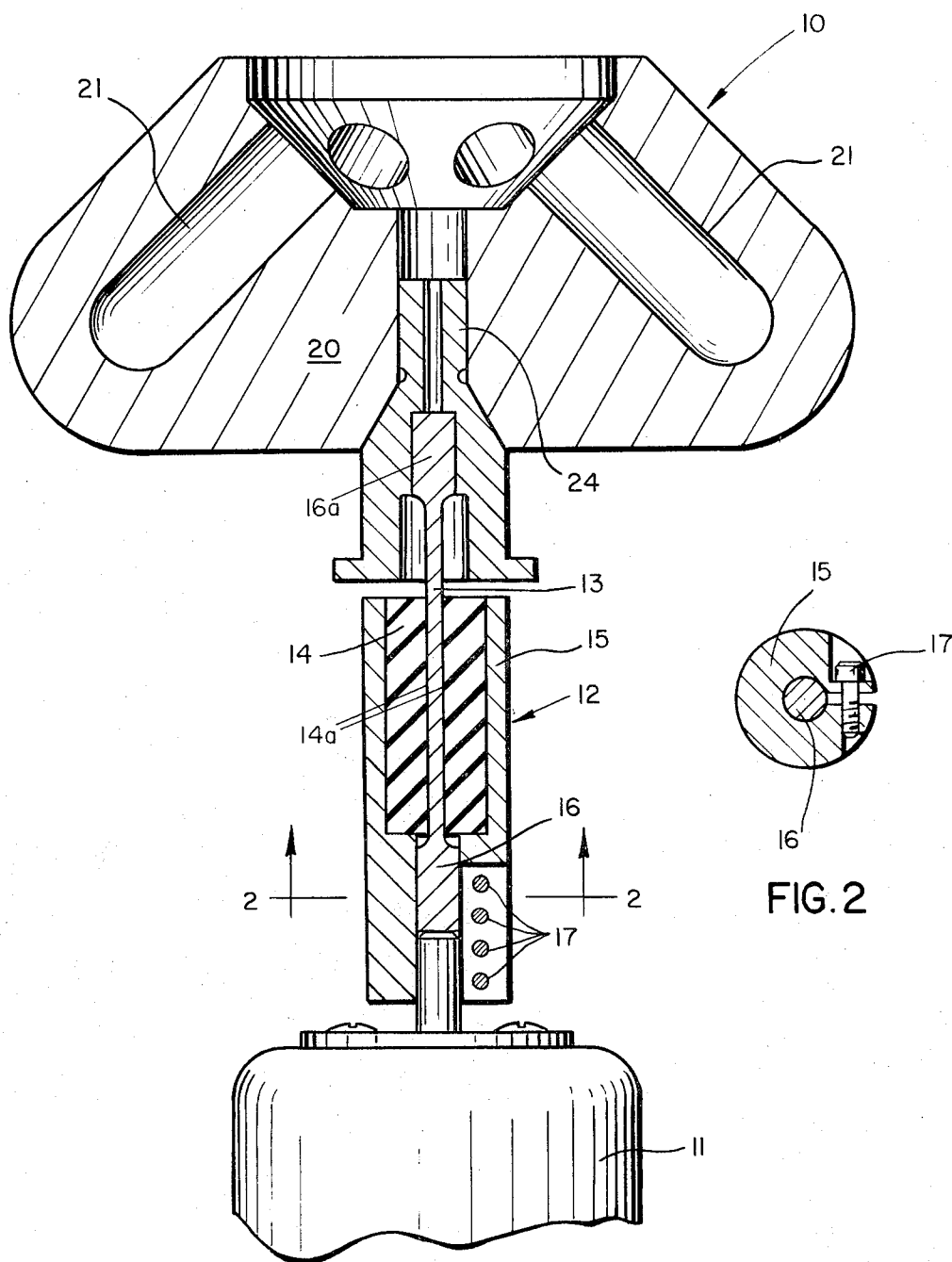


FIG. 1

FIG. 2

FLEXIBLE SHAFT STABILIZER

FLEXIBLE SHAFT CONSTRUCTION

This invention relates to a flexible shaft construction employed to transmit rotational energy between a motor and a centrifuge rotor.

BACKGROUND OF THE INVENTION

In bringing the rotation of a centrifuge rotor up to the desired rotational speed, the shaft connecting the rotor and the motor passes through a phase known as the "critical speed" wherein greatly increased vibrations are encountered. It is desired to minimize vibrations to minimize the load on the motor bearings and to minimize vibrations in a gradient formed while centrifuging a sample in the rotor. The speed at which this occurs is dependent primarily upon the geometry of the shaft and its elastic characteristics. Relatively stiff or thick short shafts encounter much more severe vibrations than do flexible or relatively thin long shafts. Therefore, it is preferred to employ flexible, relatively thin, long shafts to obtain good sample separation. It also has been proposed to employ dampening means to reduce the vibrations encountered at the critical speed. However, while the dampening means reduces the severity of vibrations over a wider range of rotational speeds as compared to an undampened shaft the degree of vibration encountered still is undesirably high. Thus, the use of dampening means has proven unsatisfactory for reducing the overall vibrational effect on the samples in the centrifuge rotor.

In applications wherein the vibrational effect must be minimized, such as in blood separation, it is necessary to employ a flexible shaft as a coupling between the motor and the centrifuge rotor. Unfortunately, a flexible shaft having a long thin configuration is damaged easily, particularly while loading the centrifuge rotor with samples. Accordingly, it has been proposed to encase the rotating shaft with a flexible material structured so that the flexible material contacts ball bearings which in turn contact a flexible race attached to a stationary housing such as shown in U.S. Pat. No. 2,827,229. While the coupling remains flexible in this construction, the construction has two serious drawbacks. First, it is very expensive to produce because of the high precision with which a large number of parts must be assembled and second, the bearings within which the shaft rotates tends to confine the shaft thereby reducing its flexibility and thereby increasing the vibration the shaft experiences while rotating at the critical speed.

SUMMARY OF THE INVENTION

The present invention provides a flexible rotatable shaft coupling between a motor and a centrifuge rotor. The construction comprises a long, thin, shaft being confined within a sleeve formed of a resilient material along a portion of its length and a cylindrical hollow tube which surrounds the shaft and do not move relative to the shaft. The shaft is provided with coupling means for the motor and the rotor.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully described with reference to the accompany drawings.

FIG. 1 is an elevational view, in partial cross section of the apparatus of this invention.

FIG. 2 is a cross sectional view taken along line 2—2 of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1, the apparatus comprises generally a centrifuge rotor 10, a motor 11 and a coupling shaft construction 12. The coupling construction 12 comprises a relatively thin elongated shaft 13 which is surrounded by a sleeve 14 made from a resilient material such as natural or synthetic rubber. The sleeve 14 is enclosed by a tubular member 15 made from a non-resilient structurally strong material preferably a metal. The sleeve 14 and shaft 13 are held together by the frictional force between the adjacent surfaces thereof which prevents relative motion between shaft 13 and sleeve 14 during rotation. The tubular member 15 is attached to the lower end 16 of shaft 13 by screws 17 and to the drive shaft 18 by screws 17 which clamps the tubular member 15 around end 16 and drive shaft 18. The centrifuge rotor 10 is of conventional construction and comprises a metal body 20 and compartments 21 into which are placed samples which are to be separated. In use, the centrifuge rotor 10 is placed upon drive shaft coupling 24 and is retained thereon by conventional means. Shaft 13 is attached to the shaft coupling 24 such as by press fitting the upper end 16a into a bore of the shaft coupling 24. Thus, during loading any deformation that is effected to the shaft 13 is limited by means of bearing surfaces 14a on sleeve 14 which sleeve 14 in turn is restricted by the rigid tubular member 15. With this construction, the chances of damaging shaft 13 are greatly decreased particularly during this loading operation. Generally, the deformation on shaft 13 caused by unequal loading is in the order of about 5/1000 of an inch from the axial center of shaft 13. During rotation, very little force is transmitted to the motor after the critical speed has been reached because the shaft 13 becomes permanently deflected and the center of gravity of the centrifuge rotor 10 is then over the axial center of the shaft 13. The mass added to the shaft 13 by the tubular member 15 and the sleeve 14 cause little or no increase in vibrations when the shaft 13 passes through the critical speed. Thus, there is no transmission of additional vibration to the motor 11 and the bearings associated therewith as compared with the shaft 13 alone. Accordingly, the present construction provides substantial advantages in view of the simplicity of construction, the minimization of the vibrational effect on the shaft 13 caused by the additional mass of the tubular member and the sleeve and the safety from permanent damage to the shaft caused by deformation thereof particularly during loading the rotor 10.

The shaft 13 should be flexible and have a length to diameter ratio such that there is sufficient flexibility to permit self-balancing to occur without effecting yield stresses on the shaft. Preferably the shaft length to diameter ratio is between about 15 to one and 30 to one. The shaft should be sufficiently flexible to permit its deformation without being permanently deformed. The sleeve 14 and tubular member 15 preferably have equal lengths and extend to enclose nearly all the length of the flexible shaft 13. The sleeve prevents restraint of the shaft by a force transferred directly from the tubular member 15 and because the tubular member is relatively inelastic, it effectively prevents transmission of large forces to the shaft. It is understood that the sleeve

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14 is not required in the present invention since the permanent deflection of the shaft 13 during rotation is not sufficient to effect contact thereof with the tubular member 15. Alternatively, the interior of the tubular member at the top portion thereof can be provided with an elastic material such as rubber.

I claim:

1. A flexible shaft construction for transmitting rotational energy between a centrifuge rotor and a motor which comprises a shaft having a regular horizontal cross section about its vertical axis, said shaft being sufficiently flexible when attached to a centrifuge rotor to permit self-balancing of the shaft to occur during rotation, said shaft having means on a first end for being coupled to a motor and having means on a second end for being coupled to a centrifuge rotor, a tubular member attached to the first end of said shaft so that the shaft and tubular member do not rotate relative to each other during rotation, a resilient sleeve between said tubular member and shaft to prevent contact of said shaft and tubular member during rotation, said tubular member having means at a first end for being coupled to a motor and to said first end of said shaft, said tubular member at a second end being unattached and surrounding said shaft, said second end of said tubular member positioned so that said shaft is located along the vertical axis of the tubular member and said tubular member and resilient sleeve positioned to prevent said shaft to be permanently deformed while permitting said shaft to be deflected by virtue of self balancing.

2. The construction of claim 1 wherein the length to

diameter ratio of the shaft is between about 15 to one and 30 to one.

3. A centrifuge comprising a centrifuge rotor, a motor, a housing for said motor and a flexible shaft construction for transmitting rotational energy between the centrifuge rotor and the motor which comprises a shaft having a regular horizontal cross section about its vertical axis, said shaft being sufficiently flexible when attached to the centrifuge rotor to permit self balancing of the shaft to occur during rotation, said shaft having means on a first end for being coupled to the motor and having means on a second end for being coupled to the centrifuge rotor, a tubular member attached to the first end of said shaft so that the shaft and tubular member do not rotate relative to each other during rotation, a resilient sleeve between said tubular member and shaft to prevent contact of said shaft and tubular member during rotation, said tubular member having means at a first end for being coupled to the motor and to said first end of said shaft, said tubular member at a second end being unattached and surrounding said shaft, said second end of said tubular member positioned so that said shaft is located along the vertical axis of the tubular member and said tubular member and resilient sleeve positioned to prevent said shaft to be permanently deformed while permitting said shaft to be deflected by virtue of self-balancing.

4. The centrifuge of claim 3 wherein the length to diameter ratio of the shaft is between about 15 to one and 30 to one.

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