Aug. 20, 1963 R. C. STALLMAN ETAL 3,101,322

CENTRIFUGE APPARATUS

Filed Aug. 3, 1960

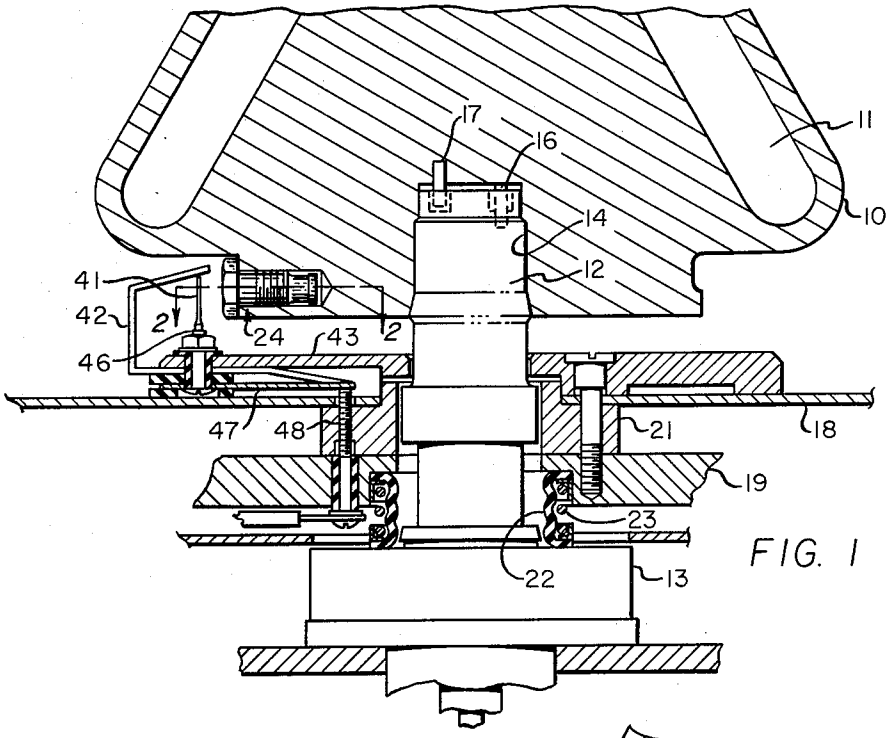

FIG. 1

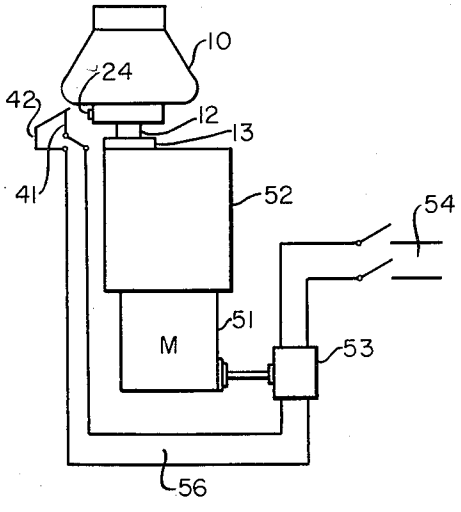

FIG. 3

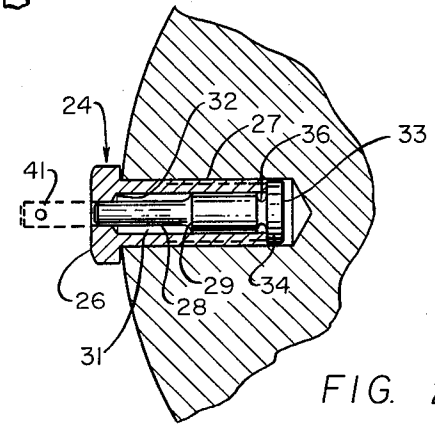

FIG. 2

RICHARD C. STALLMAN
EDVARD M. PEDERSEN
INVENTORS

BY Fleht and Swain
ATTORNEY

United States Patent Office 3,101,322 Patented Aug. 20, 1963

3,101,322

CENTRIFUGE APPARATUS

Richard Clifford Stallman, San Carlos, and Edvard Martin Pedersen, Palo Alto, Calif., assignors to Beckman Instruments, Inc., a corporation of California

Filed Aug. 3, 1960, Ser. No. 47,271
2 Claims. (Cl. 233—24)

This invention relates generally to a centrifuge apparatus and more particularly to ultra-centrifuges which utilize high rotative speeds.

Because of the high rotative speeds employed in ultra-centrifuge equipment, it is not possible to design rotors with a safety factor as high as might be normally considered good by engineering practice. Excessive speed may cause bursting of the rotor with resulting damage to other parts of the equipment and possible injury to an attendant.

Ultra-centrifuges are generally intended for laboratory use and the rotor drive is arranged to make available any one of many possible speeds of rotation. Several sizes and types of rotors are generally supplied to accommodate for various types of work and different rotative speeds. Thus, one rotor may be adapted to separating work and designed for speeds ranging up to 20,000 r.p.m., while another may be designed for rotative speeds, for example, ranging up to 40,000 r.p.m. or more.

There is always the possibility that the attendant may employ the wrong rotor for the speed of rotation selected with the result that the safety speed of operation for a particular rotor is exceeded.

In most instances, electrical speed control means are employed. However, if such means fails to function properly, the rotor may achieve excessive speeds and burst.

In Patent No. 2,666,572, there is described a centrifuge apparatus which includes a rotor having a mechanical speed limiter. The mechanical speed limiter operates upon failure of a pin under shear due to centrifugal forces created by rotation of the rotor. The pin is employed as a cross pin to support an actuating shaft within a housing.

It is hard to control the hardness and diameter of the pins during manufacture. Different wire diameters are needed for different operating speeds.

The shear characteristics of the pins depend also upon the sharpness of the shearing edges and the diametrical fit of the actuating shaft and housing. Either burrs on the shear pin holes or excessive de-burring which breaks the edges can cause considerable variation in the speed at which the shear pin fails.

It is a general object of the present invention to provide an improved centrifuge apparatus having a means whereby when safe speed of operation of the rotor is exceeded, a member fails under tension and interrupts the drive to the rotor.

It is another object of the present invention to provide an improved means of the above character which is relatively simple in construction and which is operated in response to the magnitude of centrifugal force applied to a member carried by the rotor.

It is another object of the present invention to provide a simple unit adapted to be mounted directly upon a centrifuge rotor and which will cause a member to fail under tension and extend outwardly to perform a safety control operation.

These and other objects of the invention will appear more clearly from the following description in which the preferred embodiment of the invention has been set forth in detail in conjunction with the accompanying drawing.

Referring to the drawing:

FIGURE 1 is a side elevational view illustrating a centrifuge apparatus incorporating the present invention;

FIGURE 2 is an enlarged sectional view taken along the line 2—2 of FIGURE 1; and

FIGURE 3 is a schematic view illustrating suitable electrical circuit means for controlling and driving the motor.

The apparatus illustrated in FIGURE 1 includes a centrifuge rotor 10 having sample receiving wells 11. A vertically extending shaft 12 is carried by a journal mounting 13 and is adapted to be driven by an electric motor through suitable gearing. The lower end of the rotor has a socket opening 14 which accommodates the upper end of the shaft 12. The shaft also carries an eccentric driving pin 16 adapted to extend into driving relationship with pin 17 affixed to the rotor.

The rotor may be enclosed within a refrigerated liner of a suitable vacuum chamber, the top of which is removable to facilitate access for removal and insertion of rotors. The lower wall 18 of the liner can be secured to the lower wall 19 of the vacuum chamber by collar 21. A vacuum sealing member 22, formed of rubber or the like resilient material, extends between wall 19 and the journal mounting 13, and is expanded by compression spring 23 to hold its end faces in sealing engagement with the cooperating metal surfaces.

The driving motor and gearing are carried by cushion mounting members whereby the shaft 12 is permitted a substantial amount of lateral displacement. This makes possible self-balancing action of the rotor as it is rotated at the relatively high operating speeds to which it is subjected.

The safety control means employed in the present invention make use of a centrifugal operated unit designated generally by the reference numeral 24. The unit is removably mounted in the lower portion of the rotor mount. This unit includes a tubular housing 26 which is externally threaded for engaging the threaded bore 27 formed in the rotor body. A pin 28 is slidably disposed in the housing 26 and is stepped to provide an annular shoulder 29. The bore 31 which accommodates the pin likewise has stepped diameter to provide a shoulder 32 which is engaged by the shoulder 29 when the pin is projected radially outwardly.

The pin carries a head or shoulder 33 at one end thereof. The head abuts the adjacent end 34 of the housing to normally lock the pin 28 in its retracted position within the housing 26. A section of reduced diameter 36 forms a neck in the pin. The neck has the lowest tensile strength in the complete pin whereby as the speed of the rotor increases and the centrifugal force increases, the tension applied will cause tensile failure at the neck. The tensile strength of the neck portion is selected so that for a predetermined outward centrifugal force applied by the pin 28, the neck will break under tensile forces to permit the pin 28 to move to the projected position illustrated in dotted line in FIGURE 2. The neck section diameter is varied to suit different operating speeds.

The body portion of the pin may be made of steel and annealed after machining to remove all traces of work hardening. This and the full radius used in the neck section reduces stress concentration effect at the neck.

It is apparent that the breaking or rupture speed may be controlled by controlling the diameter of the body of the pin to add more or less weight to thereby control the amount of force applied to the neck portion.

A tensile pin constructed in accordance with the foregoing was suspended and loaded to test creepage. It was established that the creepage effect was negligible. Fur-

thermore, a pin was subjected to a large number of instantaneous starts to see if the neck portion would fatigue. There was no indication that the pin fatigues under repeated starting and stopping operations. Also, upon testing the pin, it was found that the pin breaks at the ultimate tensile strength rather than from stresses or concentrations of stresses introduced by the neck.

Adjacent to the path of movement of the unit **24** there is an electrical conductor **41** (FIGURE 1) in the form of a vertically extending wire or knock-out pin. The upper end of the pin is shown pressing against a spring metal strip **42**. This strip is bent to extend inwardly beneath the annular plate **43** in electrical connection with the upper end of a terminal bolt (not shown). The lower end of the pin **41** is attached to the upper end of a bolt **46** which, in turn, is electrically connected to a strip **47** with the terminal bolt **48**. The lower ends of the terminal bolts are available for electrical connection to a circuit serving to control energization of the driving motor.

As illustrated in FIGURE 2, the pin **41** is disposed in the path of movement of the pin **28** when the pin is in its projected position, illustrated in dotted line. It is evident that when the pin **28** is projected during high speed operation of the rotor, it immediately strikes and breaks the electrical circuit by breaking or knocking out the conductor pin **41**.

The actual connections between the knock-out pin **41** and the driving motor can vary in practice, but should be such that the breakage of the pin either discontinues current supply to the motor in its entirety, or modifies operation of the motor or drive through the speed control means employed to reduce the driving torque and the speed of operation.

One suitable arrangement is illustrated schematically in FIGURE 3. In this instance, the variable speed electric driving motor **51** is shown driving the rotor **10** through the speed multiplying gear **52**. The customary magnetic starter box **53** connects between the motor and the current supply lines **54**. The starting box **53** has a control circuit **56** which when open causes the motor **51** to be de-energized. The conductor **41** is connected in series with the circuit **56** so that when the conductor **41** is broken, the circuit is open to de-energize the motor **51**.

It will be evident that our apparatus provides positive means to protect ultra-centrifuge rotors from being subjected to excessive speeds of rotation. The safety unit may be factory installed and constructed to provide the required protection against excessive speeds for the particular piece of equipment. When several different rotors are being used in the same equipment but designed for different speeds of rotation, protection is automatically

provided in accordance with the rotor design. The protection is positive and dependable in its action and can be made to operate within relatively close limits. After the prescribed speed of operation has been exceeded and the pin has been projected to interrupt the driving motor, it is a relatively simple matter to remove the housing after which a new tension pin is placed in the unit and the housing re-installed in the motor. The knock-out pin **41** can likewise be readily replaced to restore the machine to normal operating condition.

We claim:

1. A high speed centrifuge apparatus comprising a rotor, means for driving the rotor, a radially extending well formed in the lower portion of said rotor, a pin housing mounted in said well, said housing including a bore of first diameter having a shoulder at its outer end to form an opening of a reduced diameter, a pin slidably received in said housing, said pin having a first portion of reduced diameter projecting radially outwardly through said opening, a body portion slidably received in the bore and forming a shoulder with said first portion, the inner end of said housing being spaced from the bottom of said well, a head portion at the inner end of said body portion and having a diameter less than the diameter of the rotor well and greater than the housing bore diameter whereby movement of the pin radially outwardly within the bore is initially limited by abutment of the head portion against the inner end of the pin housing, a neck portion formed in the body portion adjacent the head to provide less resistance to rupture by tension than the remaining portion of said pin as to fail under tension created by centrifugal forces so that the neck portion controls the tension failure, upon rupture of the pin under centrifugal forces the outward movement of the pin is limited by abutment of the pin shoulder against the housing shoulder, and means responsive to rupture of said neck portion for controlling said driving means.

2. A high speed centrifuge apparatus as in claim 1 including additionally an electrical circuit for energizing said driving means, a knock-out electrical conductor connected in said electrical circuit and mounted in spaced proximity to the periphery of the lower portion of the rotor, said pin serving to knock out the conductor when it is in its outward position to thereby control the driving forces to the rotor.

References Cited in the file of this patent

UNITED STATES PATENTS

2,438,676	Nickle et al.	Mar. 30, 1948
2,620,832	Alix et al.	Dec. 9, 1952
2,666,572	Pickels	Jan. 19, 1954
2,964,931	Sorenson	Dec. 20, 1960