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Proni

[11] **3,768,727**

[45] **Oct. 30, 1973**

[54] **CENTRIFUGE WITH SAMPLE HOLDING MEANS FOR SEDIMENTATION STUDY**

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[73] Assignee: **Coulter Electronics Inc.**, Hialeah, Fla.

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[21] Appl. No.: **191,768**

[52] **U.S. Cl.** **233/26**, 23/259

[51] **Int. Cl.** **B04b 9/12**

[58] **Field of Search** ..... 23/259; 233/24, 23 R, 233/23 A, 25, 26, 17; 210/385

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Primary Examiner—George H. Krizmanich

Attorney—I. Irving Silverman et al.

[57] **ABSTRACT**

An improved centrifuge apparatus for blood sedimentation study is described for applying a G force in the range of 6.25 to 8 G laterally to the long axis of plural test sample columns arranged substantially vertically in holders provided on the centrifuge head. Each of the sample columns are rotated about their own vertical axes between each periodic spin cycle of said centrifuge head and only between applications of said G force by means of inertia. A test operation using four 45 second duration applications of said G force is described with rotation of the columns being effected by reversal of the centrifuge head at the end of each 45 second force application.

13 Claims, 5 Drawing Figures

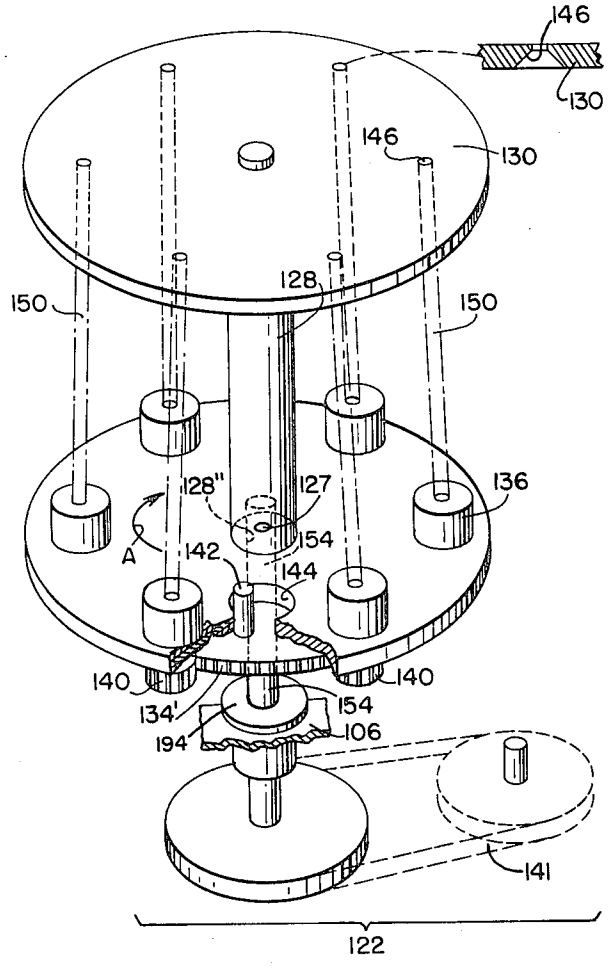


FIG. 1

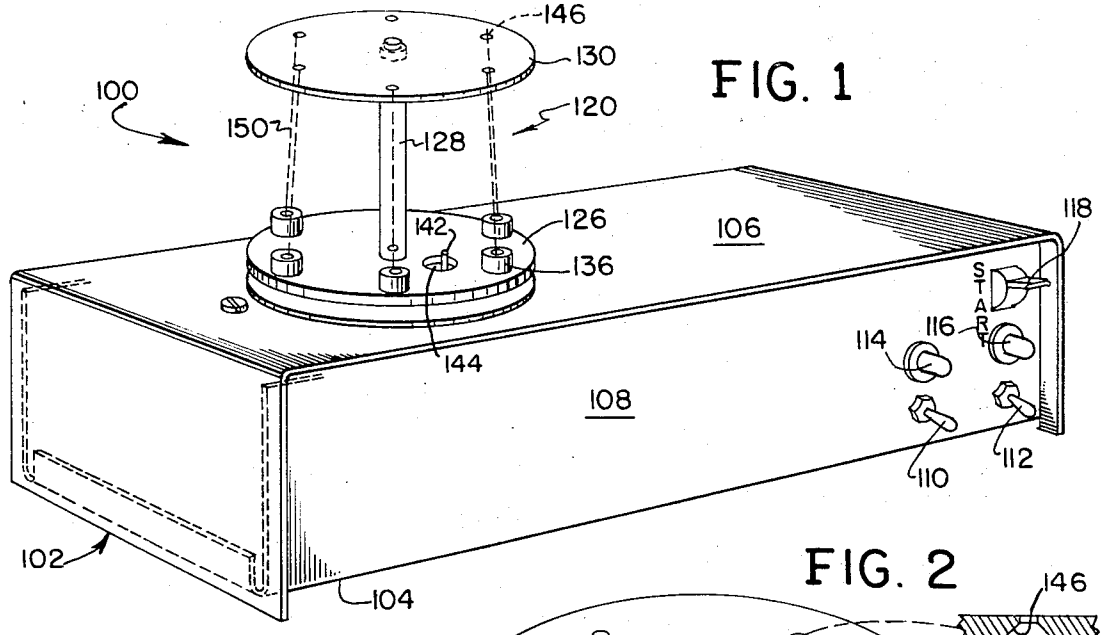


FIG. 2

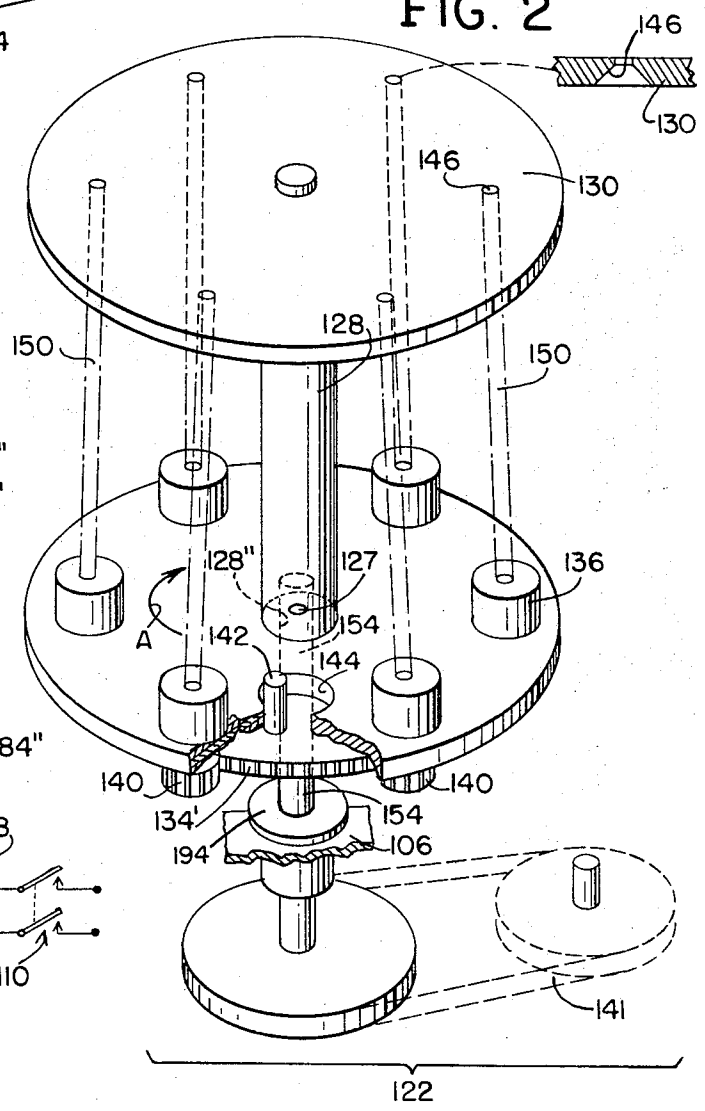


FIG. 3

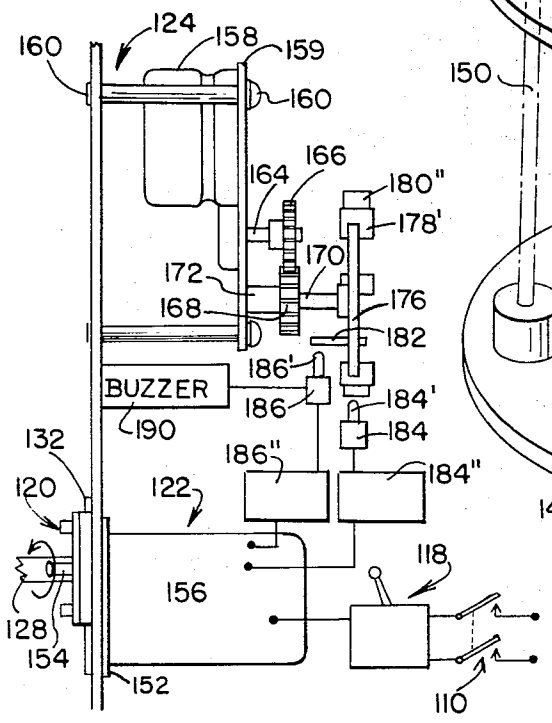


FIG. 4

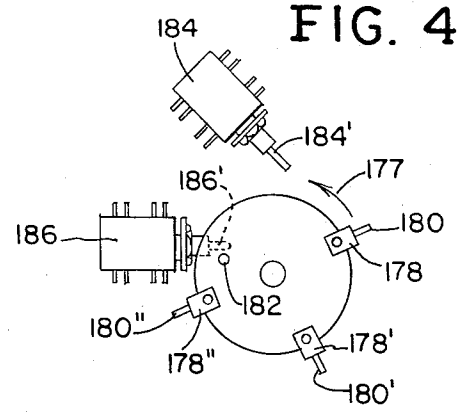
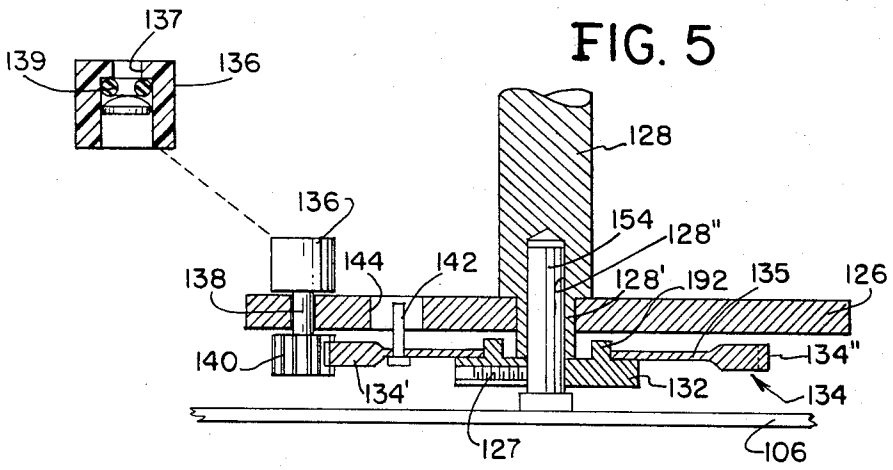

184
184'
186'
177
186
180
178
182
180"
178"
178'
180'

FIG. 5


137
139
136
136
128
154
128"
144
142
138
128'
192
135
126
140
134"
134'
132
134
127
106

CENTRIFUGE WITH SAMPLE HOLDING MEANS FOR SEDIMENTATION STUDY

CROSS-REFERENCE TO RELATED APPLICATION

This application is an improvement of the centrifuge disclosed and claimed in co-pending application of Brian S. Bull, Ser. No. 191,886, filed Oct. 22,1971 entitled "METHOD AND MEANS FOR SEDIMENTATION STUDY" and assigned to a common assignee.

FIELD OF THE INVENTION

This invention relates generally to diagnostic examination of whole blood and more particularly concerns the provision of a centrifuge for whole blood sedimentation study.

BACKGROUND OF THE INVENTION

It is well known that the suspension stability of whole human blood is altered in the presence of many functional disorders. The determination of this characteristic generally has been effected by performance of well-known standardized sedimentation tests in the course of clinical analysis. Using the sedimentation test results, the presence of more or less occult disease can be brought to medical attention. Such results particularly are of importance in the differential diagnosis as between functional disorders having closely similar symptomatic manifestations, as well as in supplying a guide to the progress of certain diseases. Accordingly, it is believed that substantial benefit could be obtained in the diagnosis and treatment of medical disorders by the establishment of sedimentation study procedures which would produce comparative information quickly and economically so that a sedimentation study could become a routine procedure in clinical examination. However, as practiced presently, the sedimentation test is too time consuming, too affected by laboratory introduced artifacts and subject to misinterpretation in anemic individuals, so that the test is not a test offered to every patient as a routine clinical test procedure such as a blood count, for example.

Present methodology involves essentially the mixing of a whole blood sample with a selected anticoagulant, introducing this well mixed sample in a vertically arranged glass tube and permitting the red cells of the sample to sediment under the influence of gravity. This process is slow, usually taking sixty or more minutes. The only accepted variations in this method takes the form, singly or in combination, merely of changing the length of the glass tubes employed, varying the bore of such tubes, careful selection of the anticoagulant employed and/or modification of the degree of dilution utilized. None of these variations have alleviated the principal drawback to adoption of the sedimentation test as a routine procedure, this drawback being that present sedimentation rate tests methods are too time consuming for routine employment or mass studies.

Another important deterrent to adoption of sedimentation testing as a routine procedure has been the extreme sensitivity of this test to the arrangement of the test sample in an absolutely vertical orientation for the duration of the test. It has been found that a sample column which is oriented at only a three degree offset from vertical will result in inconsistent acceleration of the sedimentation rate and reduces the relative differences between the comparative normal and abnormal blood sedimentation characteristics, thereby reducing the value of the test in diagnosis.

The co-pending application provides an improved sedimentation study method for whole blood which meets the requirements for rapidity, economy, accuracy and reliability essential for adoption as a mass applied clinical laboratory test procedure, and, concomitant therewith, provided a sedimentation rate centrifuge particularly adapted for implementing and carrying out the steps of the improved study method.

The principal object of this invention is to provide an improved centrifuge for blood sedimentation study particularly adapted for use with the method of the aforementioned application.

SUMMARY OF THE INVENTION

A centrifuge apparatus is provided for implementing the subject method, including a centrifuge head and a reversible direction motor, the centrifuge head carrying at least a pair of sample tube holders arranged to orient sample columns carried in elongate tubes held in substantially vertical columnar array, drive means connected between the motor and the centrifuge head for rotating same, means associated with the head and tube holders, rotating the tube holders about their own vertical axes and timing means operable on said drive means for operating the centrifuge head in timed cycles with the centrifuge head being brought substantially to a rest condition between cycles and means to restrict the rotation of the tube holders about their own vertical axes to periods during which the centrifuge head is at substantial rest condition, said drive means including a first gear means coupled to said motor, second gear means coupled to said tube holders and the said centrifuge head, said centrifuge head being mounted for free rotation about the drive shaft axis, said means to restrict comprising pin and slot means on the first gear means and centrifuge head, said first gear means transmitting its motion to said second gear means for first rotating said tube holders about their own axes, said means to restrict serving to couple said centrifuge head and first gear means for simultaneous rotation subsequent to said rotation of said tube holders.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the improved centrifuge apparatus in accordance with the invention;

FIG. 2 is a perspective of the centrifuge head and drive means of the centrifuge arrangement of FIG. 1 with portions broken away to show interior detail;

FIG. 3 is a diagrammatic representation of the embodiment illustrated in FIG. 1;

FIG. 4 is a bottom view of the timing means utilized in the embodiment of FIG. 1;

FIG. 5 is a schematic view of the centrifuge head of the embodiment illustrated in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The method of studying the sedimentation characteristics of whole blood described in the co-pending application capitalizes in part upon the fact that the blood from a normal, healthy individual has greater suspension stability than does blood from a sick individual. Three phases are known to occur during the sedimentation of whole blood. The first packing characterized as the phase of rouleaux formation. During this phase, the

red cells of the whole blood stack together in what is defined in the art as rouleaux. This phase occupies the first few minutes subsequent to filling of the sedimentation tube with sample. Next begins the phase of maximum sedimentation wherein about 3 to 5 minutes, the red cell rouleaux reach their maximum velocity of fall. This velocity is dictated by the average density of the rouleaux and the viscosity of the plasma through which they are falling. The last phase concerned is characterized as the package phase. As the rouleaux reach the bottom of the sedimentation tube, they pack and, as a consequence, the average rate of fall decreases and eventually, when packing is complete, no further change occurs.

The sample from both normal and sick individuals, given enough time, will pack to approximately the same extent; but the blood samples from the ill patient goes through the rouleaux formation phase and into the phase of maximum velocity of fall more rapidly than does the blood from a healthy individual. An isolated red cell is so small a particle that even through its density is considerably greater than that of the plasma, the large relative surface area becomes the overriding factor and an isolated red cell in plasma falls very slowly under the influence of gravity. The rate of fall of red cells is thus governed almost entirely by the size of the rouleaux which they form. The blood from a healthy individual forms such rouleaux much more slowly than does blood from a sick person. If both samples are set up simultaneously, there is a period of time when application of force greater than gravity to the blood will affect the blood from a healthy individual minimally and that from a diseased patient maximally. This crucial or critical time is obvious when the healthy blood has just only begun to form rouleaux and the sick blood has formed large rouleaux which have already begun to sediment.

It had been critical to the study of sedimentation rate that the conventional test must be performed under conditions where the sample column is disposed in absolutely vertical orientation. A tilt as little as three degrees from vertical under gravity will accelerate the sedimentation rate considerably, and decrease the relative differences between normal and abnormal blood. It is believed that this effect is due to the fact that red cells falling through the plasma hit the walls of the container and roll down the walls permitting the plasma free egress from the depth of the sample. Whenever the plasma is forced to traverse the descending column of red cells, the sedimentation rate is slowed. Normal red cell rouleaux fall much more slowly than do abnormal red cell rouleaux, probably because the forces holding them together are weaker and the upsweeping plasma either breaks them up or prevents them from forming large enough clumps to sediment rapidly. Accordingly, by applying a greater than gravity force to the sedimenting blood, according to the method, the ascending plasma is forced to traverse the descending red cells. As will be explained, a slight inclination of the column up to about 6° from vertical is permissible with the method of the invention, particularly to avoid spilling of the sample during the run.

According to the method, greater than gravitational force is applied laterally to a long thin column of whole blood sample by rotation thereof in a centrifuge capable of delivering a force in the range of 2 to 12 G with the test taking fron ½ hour at a minimum G to about 1 minute at the high end of the aforesaid range. The higher the G Force, the shorter the elapsed time of the test. The net effect is to force the red cells to traverse the plasma component of the blood over a very short distance since the effective cross-sectional area of the tube is now vast relative to the wall surface area and the red cells cannot collect in one portion of the tube against the wall so as to permit the plasma to escape freely elsewhere. Insofar as the sedimentation process is concerned, the long thin column has been transformed to a shallow wide diameter "pool" and since the force is directed substantially perpendicular to the long axis of the column, the problems of channeling heretofore experienced in sedimentation testing are obviated.

The laterally applied force acts to pack the red cells rapidly, permitting the plasma physically to change location therewith and approach the final packing state over a much shorter time period, than normally would be expected under gravitational force.

The selection of the duration of the centrifugation cycles as well as their number are dependent also upon the speed of the drive or synchronous spinner motor utilized, the diameter of the column and of the sedimentation tube utilized, and the degree of cant or tilt permitted.

A preferred program involves a program selected to use four cycles of applied force laterally to the column and of 45 second duration each. Between the first and second, the second and third and the third and fourth cycle of centrifugation, the columns are rotated about their own vertical axes. Care is taken to assure that the axial rotation of the columns take place only when the force applied laterally to the long axes of the columns is less than one G. This condition occurs when the column is at rest, substantially at rest or, to put it another way, beings its translation in its circumferential rotation with and on the centrifuge head. Abrupt stoppage of the columns must be avoided, and likewise, jarring or other sharp disturbance of the columns are avoided so that the cells which have separated from the plasma and gathered at the inner wall of the tube containing the test sample column will not be broken away from each other or from the tube wall. The cells in the column must rotate with the tube, and the column as the same is rotated about its own axis. Between each application of greater than gravity force, the test sample column is rotated about its own long axis, preferably 180°.

This seems to provide benefical results in obtaining reproducible packing by alternatively permitting resuspension of the cells by rotating the tube and its column contents and again effectively forcing those cells back through the plasma. Thus, cohesive forces are utilized during the centrifugation under the relatively low G force to force the cells against the wall and dispersion forces are utilized when the cells are forced back through the plasma by again centrifuging but after 180° rotation of the tube and column of test sample.

The performance of the method described and claimed in the co-pending application required a centrifuge capable of applying the preferable G force in the range of 6.25 to 8 G in separate cycles of predetermined duration. The centrifuge is required to rotate the tube containing the sample in a circumferential path about the axis of rotation with the tube being in substantially vertically oriented disposition parallel to the axis of rotation of the centrifuge head although a cant

from vertical of up to 6° is permitted, contrary to standard sedimentation rate methods. Additionally, the centrifuge is required not only to permit rotation of the tube along said circumferential path for a predetermined length of time and then the tube periodically must be brought at least to a momentary substantially rest or stationary condition, then rotated about its own axis a predetermined number of degrees, and the rotation of the tube along said circumferential path resumed for the next cycle of greater than G force application. At least, the rotation of the tube about its axis must not occur during the application of greater than G force.

The centrifuge also should have timing means T for selectively controlling and/or varying the duration of the cycles. The column contents of the sample tube must rotate axially with the tube wall and care must be taken to assure only such rotation.

The centrifuge apparatus according to the instant invention is illustrated in FIG. 1 and designated by reference character **100**. Apparatus **100** as described herein particularly is adapted to practice the subject method where the cycle utilized comprises four cycles of 45 second duration applications of greater than gravity force laterally to substantially vertically arranged columns of whole blood with means provided to effect limited rotation of each column about its own axis between each force application by reversal of the direction of rotation of the centrifuge head after each cycle.

The centrifuge apparatus **100** includes a housing **102**, including a troughlike portion **104** and a cover **106**. Wall **108** of housing **102** carries exterior accessible switch levers **110** and **112** for activating the power and buzzer means respectively which will be described hereinafter. Indicator lights **114** and **116** likewise are provided. Start switch **118** for initiating each test operation is provided.

The electrical control components of apparatus **100** are mounted within the troughlike portion while the head, centrifuge **120**, drive means **122**, and the timing means **124** are mounted on the cover portion, the centrifuge head being removably mounted to the protruding portion of the motor drive shaft **154** of means **122**. The drive means **122** and timer means **124** are mounted to be enclosed within the housing **102** when the cover **106** is engaged onto the portion **104**.

The centrifuge head **120** comprises a spool formed by mounting a spinner plate **126** fixedly secured to the shaft **128** and a disc **130** is mounted to the upper end of said shaft **128** with the disc **130** arranged coaxial with said spinner plate **126** and being rotatable therewith to complete the spool. The shaft **128** is mounted removably on the motor drive shaft **154** for free rotation about the axis thereof.

Support means **132** is arranged secured to drive shaft of motor **156** for rotation therewith by set screw **127** and includes a collar portion **192** mounting a spur gear **134**. Gear **134** has a circumferential ring portion **134'** carrying circumferential teeth **134''** and a central disc portion **135** to which it is fixedly mounted and by which the spur gear is mounted for driven rotation with the shaft **154**. The shaft **128** has a depending extension **128'** and carries a bottom opening axial bore **128''** by which spool **120** is mounted on shaft **154** for free rotation thereabout. (see FIG. 5)

Tube holders **136**, are mounted on spinner plate **126** for movement therewith about the axis of shaft **128**. The holders are spaced circumferentially substantially equidistant one relative to the other closely adjacent the peripheral edge of the spinner plate **126**. Each tube holder **136** has a top opening cavity **137** defined therein to receive the lower end of sample tube **150** and has resilient means for gripping said tube seated therein, such as O-ring **139**. Each holder is mounted on the upper end of a shaft **138** which extends through suitable openings formed in said plate **126**. Pinion gears **140** fixedly are secured to the opposite ends of each shaft **138** thereby mounting the holders **136** on plate **126**. The holders **136** are rotatable with rotation of gears **140**.

The teeth **134''** of spur gear **134** are arranged meshed with the plural pinion gears **140**. Thus, rotation of the gear **134** will effect rotation of gears **140** while the plate **126** remains stationary, rotating holders **136** about their own vertical axes. Limit means in the form of the upstanding pin **142** secured to the disc **135** and movable within the substantially circular slot **144** formed in the spinner plate **126** are provided to limit the independence of movement of the spinner plate **126** and gear **134**, thereby limiting the degree of rotation of the gears **140** about their own axes. With the pin **142** at one end of the slot **144**, the rotation of gear **134** in the direction of arrow "A" will cause simultaneous rotation of the plate **126** and hence the tube holders will be translated circumferentially about the axis of shaft **154**. On completion of the first cycle, gear **134** stops. The plate **126** stops with gear **134** or coasts until pin **142** is at the opposite side of slot **144**. In changing direction of rotation of the plate **126**, gear **134** rotates gears **140** until the pin **142**, moving in slot **144**, engages the opposite end of the slot **144**. Then the motion of the gear **134** in the opposite rotational direction is transmitted to the plate **126** and the gear **134** and head **120** rotate together. The tubes within holders **136** are always rotated about their own axes before the head reaches sufficient rotational speed to apply greater than 1 G force laterally to the tubes.

The disc **130** has a plurality of bottom opening recesses **146** formed equispaced about the peripheral edge thereof and arranged in alignment with the axes of the holders **136** but slightly offset inwardly therefrom so that one end of the sample tube **150** can be seated within cavity **137** of holder **136** and the upper end retained within the respectively matching recess **146** to position the tube substantially vertically arranged but canted inwardly at its upper end toward the shaft **128**. Thus, when properly seated, tubes **150** are disposed, canted inwardly from true vertical between 3° and 6°, preferably by 3° and generally not more than about 6°. In this disposition, the tendency for the contents of the tube to be flung outward during the application of higher than gravity force on rotation or spinning of the centrifuge head **120** materially is reduced.

Motor mount **152** is secured to the undersurface of cover **106** with the drive shaft **154** thereof protruding through a suitable opening formed in said cover **106**. The drive means **122** for the apparatus **100** is supplied by a 400 RPM, 60 HZ, 115 volt AC reversible direction motor **156**. Here, motor **156** causes centrifugal force between 6 and 8 G to be applied laterally to the tubes **150** during the spin of header **120**. The particular size and RPM drive motor selected determines the centrifugal force exerted on the tubes **150**, and thereby is an

important factor in selection of the duration of greater than gravity application cycle and program.

The method of study concerned requires application of the greater than gravity force laterally and periodically to the sample in the tube i.e., the sample tube **150** and the column of blood therein. The duration of each cycle generally can be selected to provide results correlative with specifically known blood sedimentation methods.

With apparatus **100**, timer means **124** are provided to effect rotation of the spinner plate automatically through a sequence of four cycles of 45 seconds duration with the reversal of direction and rotation of the columns 180° about their own axes between each application of centrifugal force.

In the apparatus **100** illustrated, the timer motor **156** is an AC 60 cycle, 110 volt motor delivering 20 RPH.

The timing means **124** operates switch means **184, 186** which operates relays **184''** and **186''** automatically taking the sample columns through the selected test program.

A timing means **124** comprises a timer motor **158** mounted on platform **159**, which in turn is secured suspended below the cover **106** by means of bolts **160** and spacers **162.** The resultant drive shaft **164** of motor **158** is passed through a suitable opening in the platform **159** and wheel gear **166** is mounted at the free end thereof for rotation therewith. A second wheel gear **168** is coupled to gear **166** and is driven thereby. Gear **168** is fixedly secured to shaft **170** for rotation therewith. One end of shaft **170** is seated in journal **172** and the other end **174** carries timer disc **176.** Timer disc **176** is secured to shaft **170** and continuously rotates therewith so long as timer motor **158** operates through the complete test program. The timer disc **176** has three paddle assemblies **178, 178'** and **178''** mounted thereto about the periphery thereof with the paddles **180,** and **180'** and **180''** extending outwardly from the circumferential edge thereof in vertical planes normal to the axis of shaft **170.** As illustrated, disc **176** is rotatable in the direction of arrow **177** with the paddle assemblies **178, 178'** and **178''** fixed in an equispaced series along said path. An upstanding pin **182** is secured normal to the disc **176** and rotates therewith. The paddle assemblies **178, 178'** and **178''**, when considering the direction of rotation of the disc, can be said to be substantially equispaced one relative to the others with paddle assemblies **180** and **180''** being disposed 180° apart. A pair of push-button activated switches **184** and **186** are arranged with their actuators **184'** and **186'** mounted to suitable bracket means (not shown) secured to the platform **159** so that the actuator **184'** of switch **184** is arranged in the path of travel of the paddles **180, 180'** and **180''** of paddle assemblies **178, 178'** and **178''** whereby each respective paddle can engage and depress said actuator **184'** by engaging same during passage therepast during rotation of the disc **176.**

The actuator **186'** of switch **186** is positioned to intercept the pin **182** whereby the continuing rotation of disc **176** causes pin **182** first to bear against actuator **186'** to depress same. On passing of said pin **180** past actuator **186'**, said actuator returns to its normal condition. The switch **184** is connected to relay assembly **184''** which is electrically coupled to the reversible sychronous drive motor **156** to cause reversing of the direction of said motor each time the actuator **184'** is depressed. The switch **186** is connected to relay assembly **186''** operatively coupled electrically to both the drive motor **156** and to the buzzer means **190.** Depression of the actuator **186'** energizes the buzzer **190** and release of the actuator **186'** from engagement with the pin **182,** causes de-energization of the drive or spinner motor **156.**

A friction or other drag represented by pad **194** may be applied to the centrifuge head **120** so that application of braking force to the motor **156** on de-energization of the same, causes a braking force to be applied directly to the head.

An example of a testing operation utilizing apparatus **100** now will be described. Samples of whole blood are taken and placed respectively in closed end, elongate tubes known as sedimentation tubes. The tubes are filled with sample to a predetermined level mark. The tubes containing the test samples are placed between the disc **130** and the spinner plate **126,** the lower ends of the tubes seated within the tube holders **136** and held firmly by the resilient means **139** while the upper ends are seated in the recessed holes **146.** The switch levers **110** and **112** are actuated respectively activating the apparatus **100.** The start toggle switch **118** is actuated initiating the test procedure and causing the spinner motor **156** to operate in one direction, say clockwise. Greater than gravity force in the range of 6.25 to 8 G is applied to the column of sample in each tube as the centrifuge head **120** is spun.

When motor **156** is energized to spin gear **134,** motor **158** is energized simultaneously to rotate disc **176.** Timer disc **176** rotates to bring paddle **180** in contact with the actuator **184'.** Disc **176** continues to rotate so as to carry paddle **180** past said actuator **184'.** In passing, the paddle **180** depresses the actuator **184',** causing the spinner motor **156** to reverse direction. This occurs 45 seconds after initiation of the spinner operation.

In reversing direction, the gear **134** and hence the centrifuge head **120** comes to a momentary halt with the pin **142** at one end of the slot **144.** The gear **134** then begins to rotate in the clockwise direction. The plate **126** will remain stationary. The pinion gears **140** being coupled to the gear **134,** will move along the circumference of now moving gear **134** and will rotate about their respective axes until engagement of the pin **142** at the opposite end of the somewhat circular hole **144** will drive the plate **126** to rotate same, limiting the rotation of the pinion gears 140 to 180°. The rotation of the pinion gears **140** rotates the tube holders **136** and with same, the tubes **150** and the column of blood sample will be rotated.

The spinner motor **156** operates to drive the gear **134** and head **120** in a clockwise direction for the next cycle of 45 seconds. At the elapse of **45** seconds, the next paddle **180'** will have brought around to depress the actuator **184'** and cause a second reversal of the drive motor **156.** The gear **134** again is brought to a momentary halt. The plate **126** stops with the gear **134** or coasts until the pin **142** now is at the other end of the slot **144.** The reversal of motor **156** rotates the pinion gears **140** 180° about their own axes until the pin **142** is at the opposite end of the slot **144** and hence before any appreciable centrifugal force has been generated.

On completion of the movement of the pin **142** in the slot **144,** and engagement of said pin **142** with the spinner plate **126,** the spinner plate and the gear **134** are locked for rotation together, now in the counterclock-

wise direction for another 45 seconds until the spinner motor direction is reversed by engagement of the paddle 180'' against the actuator 184' of switch 184 depressing same. The pinion gears 140 and hence, the holders 136, tubes 150 and test sample columns therein, again are rotated about their own axes between applications of centrifugal force by the inertia of the plate 126.

Coupled rotation of the spinner plate 126 and gear 134 is resumed for another and final 45 second interval. The timer plate 176 is continuously rotating during these last described operations, and, accordingly, continues to rotate. Approximately 45 seconds after the last-mentioned motor reversal, the pin 182 is brought into contact with the actuator 186' by the continued rotation of the timer disc 176, the actuator 186' is released from its depressed condition. Now the motor 156 is de-energized and the gear 134 and the centrifuge head is brought to a halt, the program completed.

It should be explained that the centrifuge apparatus of the copending application has means whereby a friction drag was applied to the spool or head driven by the motor 156 with the gear 134 thereof mounted for free rotation about the drive axis. Friction under some circumstances can become unreliable, may change with time and/or may be different from one unit to another. It is for this reason the inertial operation of the instant apparatus is so advantageous.

In FIG. 2, a resilient or elastic belt coupling 141 is utilized between the motor drive shaft and the main drive shaft (dotted line) which aids taking the inertia load off the synchronous motor 156 while it is reversing direction, or at least most of it, making starting of the motor more reliable.

What it is desired to be secured by Letters Patent of the United States is:

1. A centrifuge apparatus for studying the sedimentation characteristics of whole blood by application of greater than gravity force laterally to a generally vertically oriented column of test sample of whole blood; comprising, a centrifuge head having a peripheral edge and a central shaft, a driven shaft and a drive motor coupled to said driven shaft for imparting rotative motion thereto, in intermittent periods of predetermined duration, said central shaft being mounted to said driven shaft for free rotation thereabout, independently rotatable sample tube holder means carried by said head near the peripheral edge thereof, said sample tube holder means having sample tubes each adapted to contain a thin column of blood, said sample tubes being vertically arranged and oriented substantially parallel to the axis of rotation of the centrifuge head and means for causing periodic rotation of said head at high speed about its axis and periodic rotation of each sample tube holder means and the sample tubes therein about its own long axis intermediate the periodic high speed rotation of said head, said last means comprising gear means mounted to said driven shaft for rotation therewith, said gear means being coupled to said holder means for driving said heat to rotate the head in said periodic cycles and pin and aperture means operable to limit the extent of rotation of the holder means about their own axes.

2. The centrifuge as claimed in claim 1 in which the rotation of said holders about their own axes for each rotation in one direction is limited to approximately 180°.

3. The centrifuge as claimed in claim 1 and timing means for periodically controlling the duration of centrifugation.

4. The centrifuge as claimed in claim 3 wherein said drive motor is reversible and means for exerting gradual braking force at each reversal of motor direction.

5. The centrifuge as claimed in claim 3 in which said drive motor is reversible and said timing means comprise a timing motor, a timing disc, first switch means coupled to said drive motor for deenergizing same, second switch means for reversing said motor, means for coupling said timing motor to said timing disc, means on said timing disc constructed and arranged to engage said first switch means after an elapse of time equal to the total cycle duration and second means on said timing disc constructed and arranged to engage said second switch means periodically to reverse the direction of said drive motor, said second means on said timing disc being adjustably positioned thereon whereby to determine the interval between drive motor reversals.

6. The centrifuge as claimed in claim 1 and timing means for controlling the total duration of centrifugation and the respective cycle durations.

7. The centrifuge as claimed in claim 1 wherein the head is mounted removably to the driven shaft for rotation thereabout and the gear means is arranged coaxially relative to said head but for driven rotation with said driven shaft.

8. The centrifuge as claimed in claim 1 and timing means for periodically causing reversal of the direction of rotation of said head.

9. The centrifuge as claimed in claim 1 in which said head is mounted for removal and replacement as a unit.

10. The centrifuge as claimed in claim 1 in which said gear means includes one gear means coupled to the driven shaft and another gear means coupled to the sample holder and engaged with said one gear means, and said pin and aperture means comprise a pin mounted on one of said gear means and head and a substantially circular slot formed in the other of said gear means and head, said pin being disposed within said slot to limit independent relative rotation of said gear means and head.

11. The centrifuge as claimed in claim 1 in which said gear means comprise a spur gear secured to the driven shaft and pinion gears secured to each respective sample holder and operably engaged with said spur gear.

12. The centrifuge as claimed in claim 11 in which said pin and aperture comprise a pin on one of said spur gear and head and an arcuate slot on the other of said spur gear and head, the pin being received and movable within the slot and the length of the slot determining the maximum rotational movement of said pinion gears about their own axes.

13. The centrifuge as claimed in claim 12 in which said motor is of the reversible type, timer means for periodically changing the direction of rotation of the gear means for each period, said gear means being arranged to rotate said pinion gears and said head each time the gear means is rotated in a new direction.

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