

Oct. 13, 1959

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2,908,907

APPARATUS FOR COUNTING RED BLOOD CORPUSCLES IN BLOOD

Original Filed March 27, 1956

Fig. 1

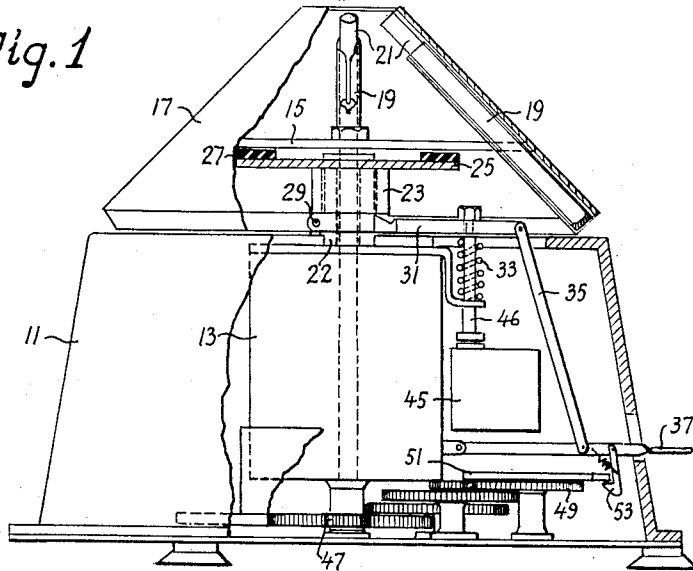
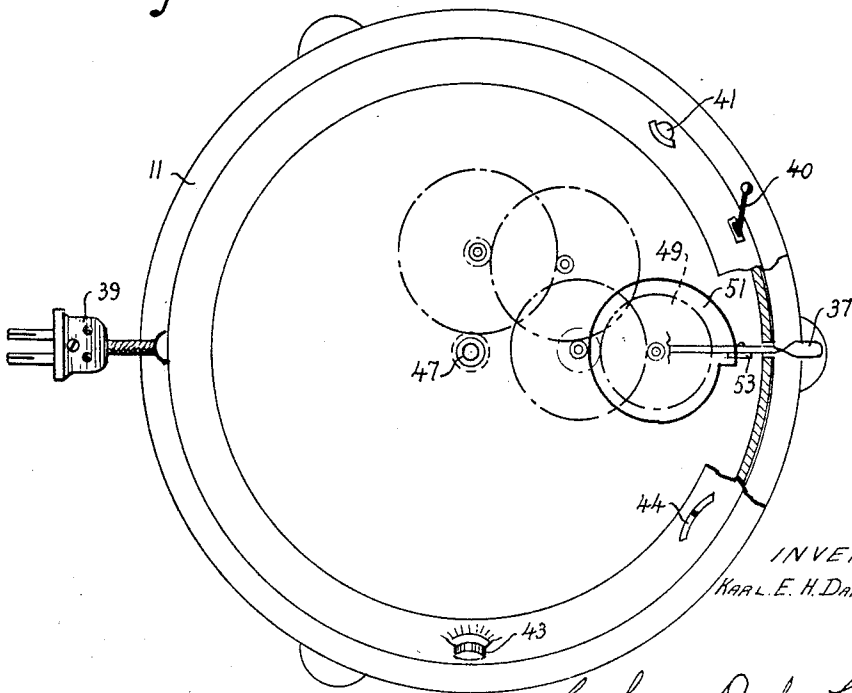


Fig. 2



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APPARATUS FOR COUNTING RED BLOOD CORPUSCLES IN BLOOD

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Original application March 27, 1956, Serial No. 574,306.
Divided and this application February 2, 1959, Serial No. 790,509

Claims priority, application Sweden March 29, 1955

1 Claim. (Cl. 233—26)

This application is a division of my copending application Serial No. 574,306.

The method hitherto almost exclusively used for the determination of the number of red blood corpuscles per unit of volume consists in a very great dilution of the blood and counting of the number of blood corpuscles in a thin layer of the diluted blood enclosed in a chamber formed between two glasses, a so called Bürker chamber. Said method involves many sources of errors, is therefore inaccurate and is also circumstantial and time-consuming.

The present invention has for its object to create a method for the determination of the number of red blood corpuscles, which is quicker than the above-mentioned method and which, above all, gives more accurate results and eliminates personal errors to a great extent. The method according to the invention consists essentially therein, that a tube filled with blood of the investigated sample is centrifuged, whereby the blood corpuscles sedimentate and a border line is formed in the tube between a lower column enriched with blood corpuscles and an upper blood plasma column practically devoid of blood corpuscles, that the centrifugal treatment is cut off after an accurately set time period equal to a predetermined time period chosen for the apparatus used and being of such a short duration that the downward displacement of the border line is considerably less than the displacement that would be reached as a final result of a very long period of centrifugal treatment, and that that the downward displacement of the border line obtained for the sample is compared with displacement values obtained by the centrifuging, under the same conditions, of a series of different samples having a number of red blood corpuscles per unit of volume, accurately determined by known methods, said values preferably being used for calibrating a scale, on which the number of red blood corpuscles per unit of volume of the investigated sample can be directly read off. The method is based upon the experience (verified by a great number of comparative determinations) that the border line drop values obtained after a short centrifugal treatment are closely related to the number of red blood corpuscles, whereas the final value obtained after a very long centrifugal treatment, i.e. the hematocrit value, does not give any true information about the number of red blood corpuscles but merely about their total volume, wherein the average size of the blood corpuscles is a factor.

The present invention also relates to a centrifugal apparatus particularly suited for carrying out the above-mentioned method and being of such a construction as to eliminate personal errors in the handling thereof, which errors would endanger the accuracy of the new blood-counting method.

As the centrifugal treatment should be cut off after a relatively short time, when the border line in the test tube is still dropping rapidly, it is obvious that the accuracy of the new method is dependent thereupon that the

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centrifugal conditions are reproduceable with a high degree of precision. To this end, according to the invention, the centrifugal apparatus is provided with means for automatically maintaining constant the centrifugal work accomplished upon the blood samples during each period of operation of the centrifugal apparatus. Said work is determined by many factors, out of which some are invariable, such as the dimensions and the location of the test tube in the centrifugal apparatus, some factors may vary within tolerable limits, such as the frequency and the voltage of the electric network, to which the drive motor of the centrifugal apparatus is connected, the temperature etc., whereas the time curve for the speed of rotation of the centrifugal apparatus during a period of operation is of a predominant importance for the value of the drop of the border line in the test tube and for the value of the number of blood corpuscles per unit of volume derived therefrom. Therefore, a main object of the invention is to provide that the time period of electric connection of the drive motor of the centrifugal apparatus is held accurately constant and at a predetermined value.

According to the invention, in order accurately to provide the desired time period of operation the centrifugal apparatus is provided with a time switch for disconnecting the motor of the apparatus after a predetermined time of connection. Said time switch may be driven by the drive motor of the apparatus, so that the switch is released when said motor has run a certain number of revolutions. Furthermore, it is important that the period of acceleration and the period of deceleration are short in comparison to the period during which the centrifugal apparatus rotates with full speed. In order to get a rapid acceleration a powerful motor should be chosen, and in order to get a rapid deceleration, according to a feature of the invention, the centrifugal apparatus is provided with a braking means, which is engaged automatically and preferably simultaneously with the motor being disconnected.

The invention will be more closely described hereinbelow, reference being had to the accompanying drawing, in which Fig. 1 is an elevational view, partly in cross-section, and Fig. 2 is a top plan view, with certain parts removed, of a preferred embodiment of the centrifugal apparatus forming part of the invention.

In the drawing, the numeral 11 designates a stationary cover, within which an electric motor 13 with a vertical shaft is arranged. Attached to the upper protruding end of the motor shaft is a horizontal plate 15, which in its turn carries an exactly centered, conical shell 17. Four holders 19, in which test tubes 21 may be inserted, are evenly spaced around and attached to the inside of said shell. In operation of the apparatus, test tubes are inserted in all of the holders, and in those test tubes that are not filled with blood, there is inserted a metal pin of the same weight as a filling of blood, whereby the rotary part of the centrifuge always has the same weight and is fully balanced. The motor shaft is surrounded by a stationary sleeve 22, and another sleeve 23 is axially displaceable on the sleeve 22, but is held against rotation relatively thereto. Attached to the sleeve 23 is a horizontal plate 25, the periphery of which carries an annular friction lining 27. Normally said lining is pressed against the plate 15 on the rotary top of the centrifuge by means of a fork 31 which is fulcrumed about pivots 29 and pressed by a helical spring 33 against the lower side of the sleeve 23. Said fork is connected by means of a link 35 to a lever 37, the end of which extends out through the cover 11 so as to be operable manually. In the position shown, the lever 37 is depressed and the fork 31 is swung down, compressing the

spring 33, so that the brake consisting of the members 23, 25, 27, is out of action and the top of the centrifuge is free to rotate.

Mounted on the cover 11 are an electric connection wire with plug 39 for connection to an electric network of 220 volts, a main switch 40, a control lamp 41 for indicating connection to the network, an adjustment knob 43 for adjusting the tapping point on a resistance connected between the terminals of the network, and a voltmeter 44 for indicating the voltage supplied to the electric motor 13. Connected in series with the motor is another switch 45, which is located within the cover 11 and is operable by means of a push rod 46 connected to the fork 31. The lower end of the motor shaft carries a pinion 47 which by means of a train of gears is coupled to a gear wheel 49 carrying a cam disk 51. The gear ratio is 2000:1, and thus the gear wheel 49 and the cam disk 51 make one single complete revolution when the motor shaft makes 2000 revolutions. The lever 37 is retained in its shown depressed position by means of a hitch 53, and the above-mentioned cam disk 51 is made to cooperate with said hitch in such a manner, that the lever 37 is released when the step of the cam disk passes said hitch.

The blood used for the counting method according to the invention may be blood taken by a syringe from a cubital vein and may be diluted with one part of sodium citrate in four parts of blood. A test tube having a length of 110 mm. and an inner diameter of 2 mm. is filled with said blood mixture to a predetermined level, which may be marked by an etched line or may be the upper edge of the tube. The filled test tube is inserted in a holder 19 in the centrifugal apparatus. The main switch 40 is turned on, the lamp 41 being lighted. By means of the knob 43 the voltage is adjusted to a certain prescribed value, e.g. 200 volts. Then the operator depresses the lever 37. When the lever reaches its lower end position it is caught by the hitch 53, so that the operator immediately can leave hold of the lever. This causes the disengagement of the brake and the simultaneous throwing-in of the switch 45, whereby the motor is connected to the adjusted voltage of 200 volts. The motor now accelerates during a period of say 20 seconds, after which it reaches its full speed. When the motor has run 2000 revolutions after its start, which always requires the same total time, say 45 seconds, the curve disk 51 has turned one complete revolution and when the step therein passes the hitch 53, the same is let loose. In this way the lever 37 is released and is raised by the spring 33, whereby the motor current is cut off and the brake is simultaneously engaged, so that the motor stops in approximately 2 seconds. The test tube is now removed, and it proves that the red blood corpuscles have sedimented, so that there is a rather sharp border line at the middle of the tube, which separates a lower column enriched with red blood corpuscles and an upper pale column of blood plasma practically free from red blood corpuscles. The period of centrifugal treatment has been so chosen that said lower column contains not only the blood corpuscles but also a considerable quantity of blood plasma, for instance as great volume of blood plasma as the volume of blood corpuscles, and therefore the length of said column is practically independent of the average size of the blood corpuscles. Therefore, had the centrifugal treatment been continued, the border line would have dropped further on, and after a long time the lower column would have contained practically nothing but blood corpuscles. In this way the hematocrit value could have been obtained, which also is of interest in certain cases but which does not have any definite relation to the number of red blood corpuscles.

The length of the upper pale column in the test tube is measured, and by comparison with the result of earlier tests a figure on the number of red blood cells per cubic millimeter of the undiluted blood is obtained. For in-

stance, if it has been found earlier, that a drop of the border line of 31 mm. is obtained when blood having 5 millions of red blood cells per cubic millimeter is treated in the apparatus above described and during the same time, then it is stated in a table or in a diagram, that 31 mm. corresponds to 5 millions of blood corpuscles. In the same way corresponding values of border line drop and number of blood corpuscles are ascertained for a series of different blood samples, said number being determined as accurately as ever possible by using the best methods hitherto known, such as taking the average of a great number of determinations according to Bürker. These pairs of corresponding values are then tabulated or shown in a diagram. Said interrelation should be worked out beforehand for the apparatus used; it is evident that it is valid only for certain predetermined conditions of centrifuging, such as time duration, speed etc. Therefore, these conditions must always be truly reproduced when making the blood tests.

The values obtained during the above-mentioned preliminary tests can preferably be used for calibrating a scale for directly reading off the number of red blood cells per unit of volume of the blood contained in a test tube taken out of the centrifugal apparatus. When a standardized test tube is held against said scale with its bottom resting against an end support associated with the scale, the border line in the test tube points to a figure on the scale stating the number of millions of red blood corpuscles in a cubic millimeter of the blood being investigated. In accordance with the above-mentioned example, the numeral 5 will be found on said scale at a spot situated 31 mm. below the upper end of the scale, which end is flush with the upper edge of the test tube or the filling mark engraved thereon.

An extensive statistical investigation has proved that the above-described method affords a high degree of accuracy and that the white blood corpuscles (leukocytes) do not disturb the result, not even when their number is pathologically increased. The method is rapid and can be performed by untrained personnel, because it does not call for special care and attention. The course of centrifugal treatment is wholly automatic, and the speed and the time period are maintained with an accuracy dependent upon the design of the apparatus and considerably higher than if the apparatus were started and stopped manually.

The above-described design of the centrifugal apparatus is merely given as an example, and may be modified in several respects without departing from the spirit of the invention. Instead of deriving the motor stopping and braking impulse from the motor shaft, a time switch driven by a clock movement or similar may be used. It is to be observed that the time periods and the number of revolutions mentioned above are merely given as examples, and that it is possible to standardize the method and the apparatus on the basis of other numerical values. It is important, however, that the centrifugal apparatuses put upon the market afford predetermined time periods and/or number of revolutions that are set for good, so that the operator does not have any possibility of readjusting the same, thereby endangering the accuracy of the new blood-counting method.

I claim:

A centrifugal apparatus for use in the determination of the number of red blood corpuscles per unit of volume of a blood sample, comprising a motor having a vertical shaft, a rotary head attached to the upper end of said motor shaft, a test tube holder mounted in an inclined position in said head, a switch for electrically connecting and disconnecting the motor, a braking means adapted to cooperate with said head in order to bring it to a rapid stand-still, a manually operable lever, means connecting said lever to said switch and to said braking means in order to connect the motor simultaneously with disengaging the braking means, means for automatically discon-

necting the motor and engaging said braking means a pre-determined time after the operation of said lever, a hitch for locking said lever in an operative position, and a tripping mechanism driven by the motor for releasing said hitch and allowing said lever to return to its inoperative position.

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