Nov. 21, 1961 M. L. POLANYI 3,009,388

APPARATUS FOR DETERMINING FLUID FRACTIONS AND SEDIMENTATION RATES

Filed Dec. 30, 1957 3 Sheets-Sheet 1

Fig. 1.

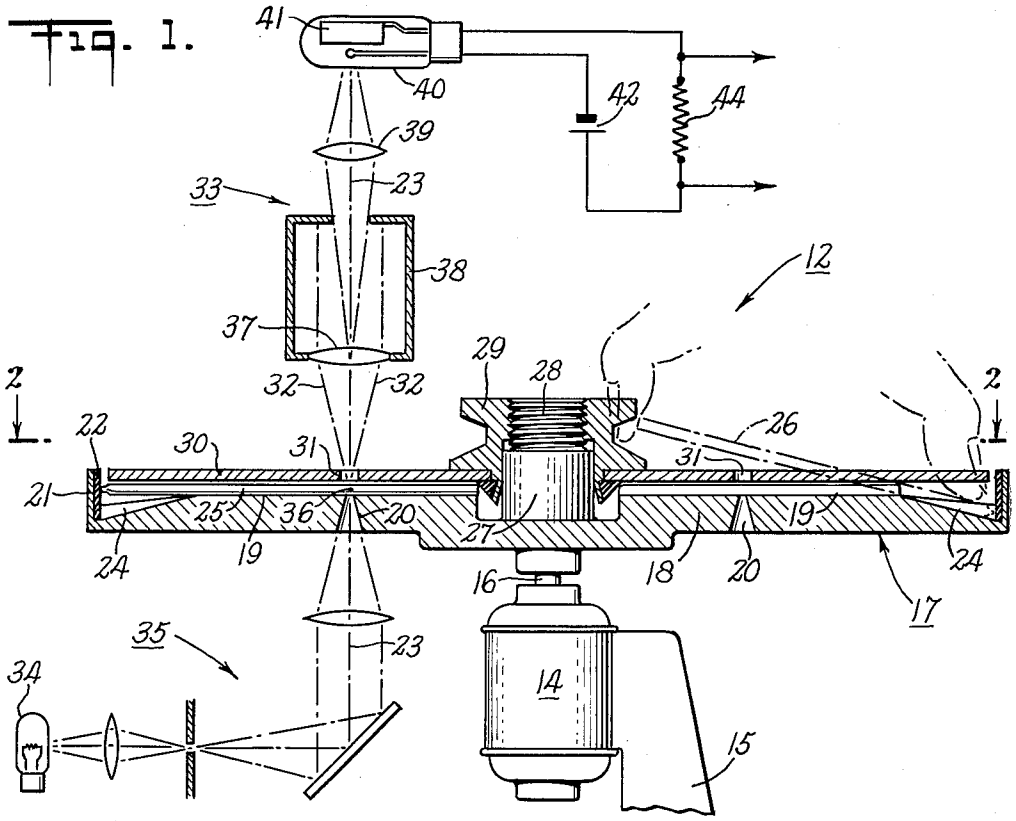

Fig. 2.

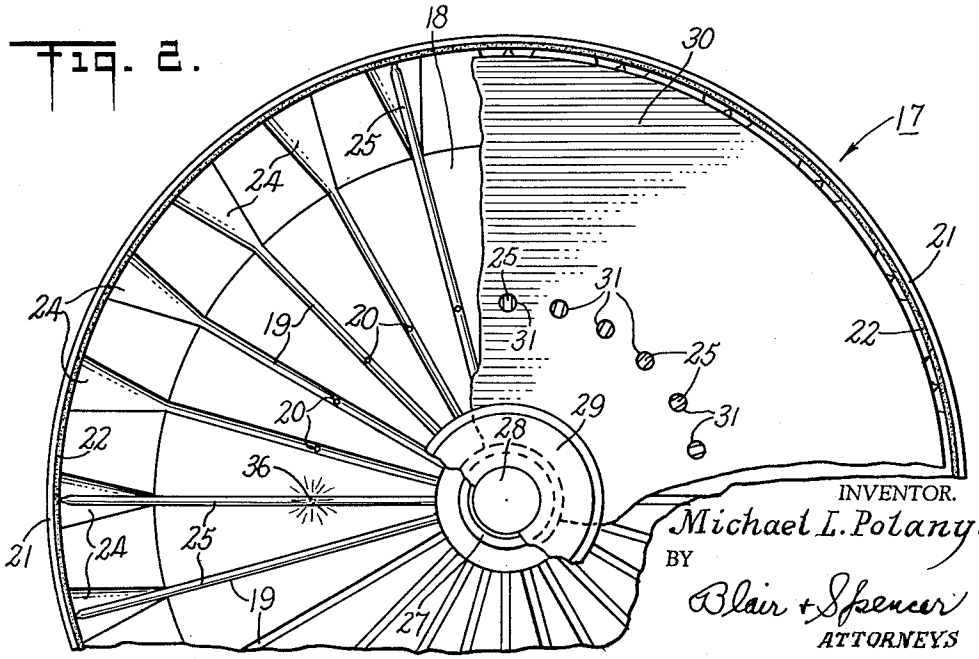

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Fig. 3.

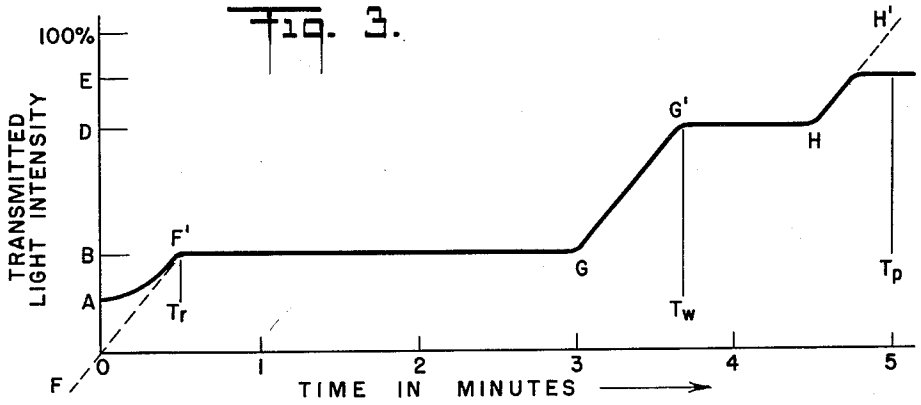


Fig. 4.

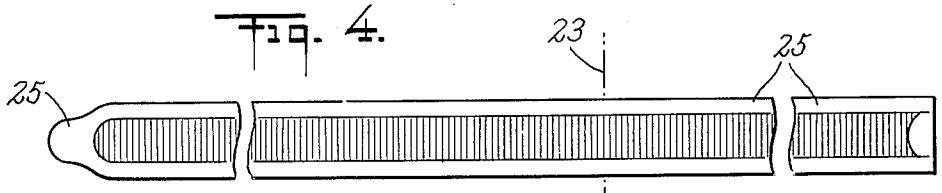


Fig. 5.

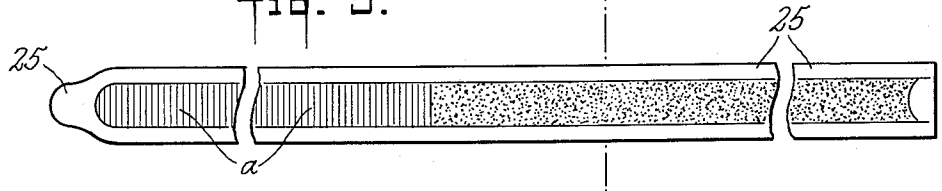


Fig. 6.

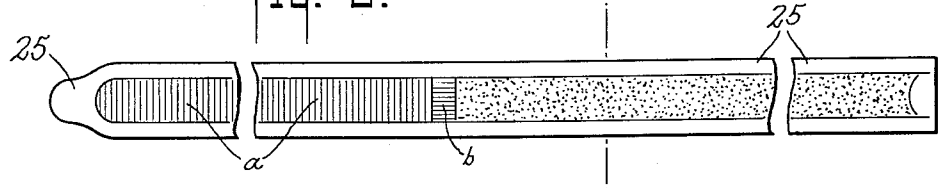
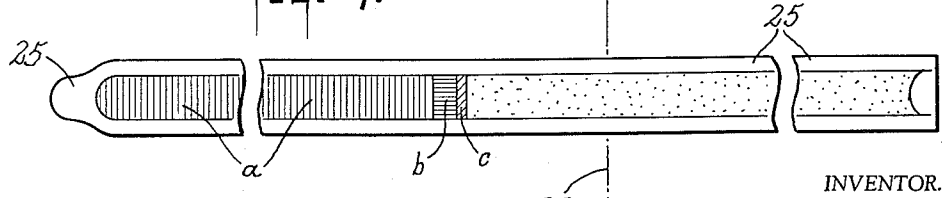


Fig. 7.



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APPARATUS FOR DETERMINING FLUID FRACTIONS AND SEDIMENTATION RATES

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Fig. 8.

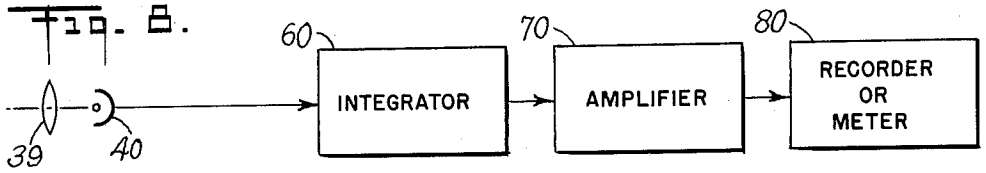


Fig. 9.

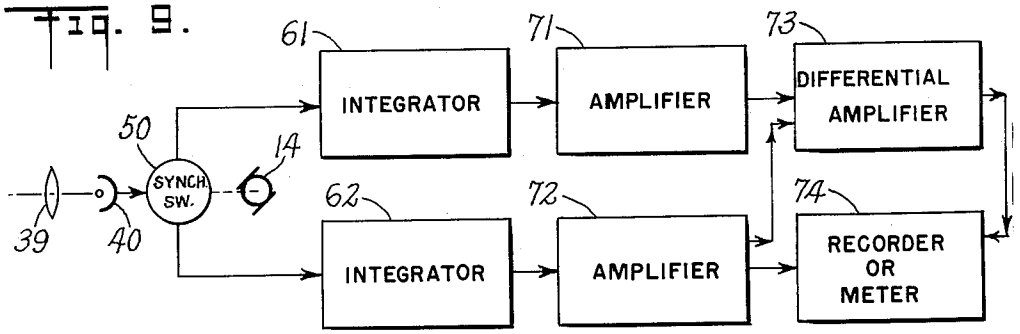
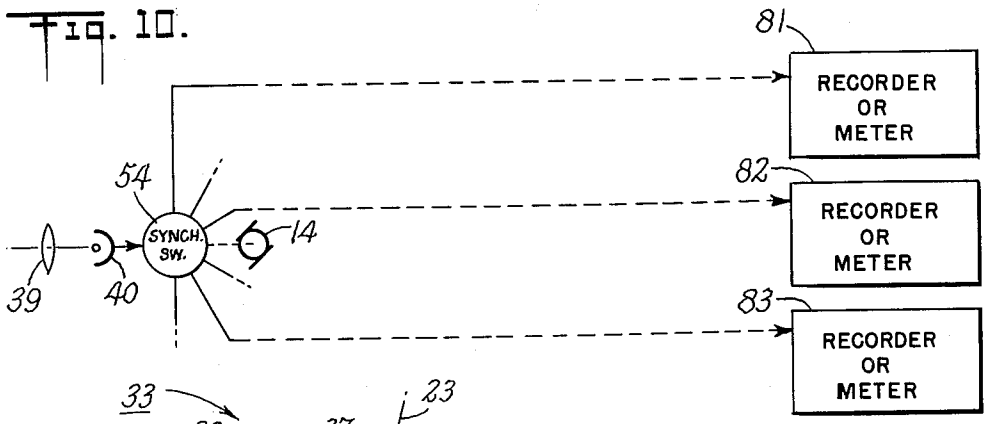


Fig. 10.



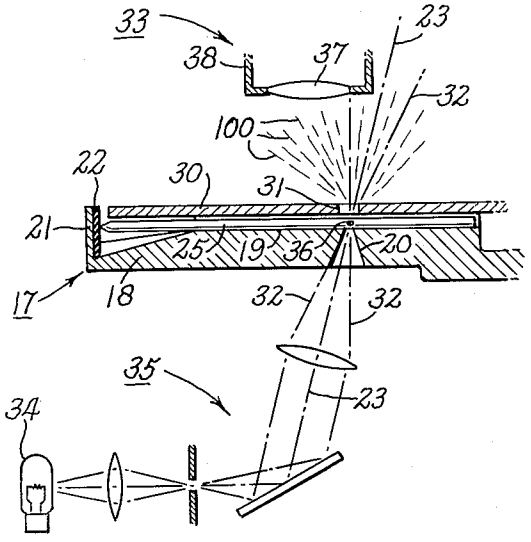


Fig. 11.

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3,009,388

APPARATUS FOR DETERMINING FLUID FRACTIONS AND SEDIMENTATION RATES

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Filed Dec. 30, 1957, Ser. No. 705,859
13 Claims. (Cl. 88—14)

This invention relates to methods and means for determining sedimentation rates and fractional parts in fluid mixtures containing elements of differing specific gravities, and more particularly to processes and apparatus for automatically evaluating the content of red blood cells, white blood cells, and platelets in whole blood samples, and for determining the rates of sedimentation of these various components in blood specimens obtained for clinical testing.

In the art of clinical hematology to which the invention relates it has always been a time consuming and tedious task to determine accurately the number or the fractional composition per unit volume of these several essential elements in blood specimens. The prior art clinical techniques have generally involved the steps of diluting a blood specimen with a pure fluid thinner, as for example a solution of 50 percent propylene glycol and distilled water, to reduce the total number of cells in the test sample, thereby enabling a skilled laboratory technician to count discreet cells as observed under a powerful microscope. With a portion of the diluted sample confined in a small pipette, it has been found that the red blood corpuscles, being heavier, will settle first, and in a properly diluted specimen of normal blood the red corpuscles may settle completely in about one hour. Above the sedimented red corpuscles remains a buffy colored fluid comprising supernatant plasma which contains the leukocytes (white corpuscles), mixed with the colorless and transparent platelets and minuscule particles of debris. From this supernatant fluid it has been possible heretofore for a skilled laboratory technician to make an approximate count of the white corpuscles by staining of the leukocytes, as for example with 0.1% methane blue and 0.1% phloxine each dissolved in 50% propylene glycol and distilled water.

The isolation and measurement of blood platelets, structures whose property is ready agglutination and disintegration, has been much more difficult and has heretofore required the services of an exceptionally skilled laboratory technician. Platelets are difficult to discern because of their small size, because they become attached very readily to particles of debris on the glassware used or in the diluting fluid or in the plasma itself, and because they are substantially transparent and not readily susceptible to staining as are the leukocytes. Details of various complex techniques which have been devised for the detection and enumeration of blood platelets have been published by L. M. Tocantins, "Technical Methods for the Study of Blood Platelets," Archives of Pathology, volume 23, page 850 (1937); and by I. Olef, "The Enumeration of Blood Platelets," Journal of Laboratory and Clinical Medicine, volume 20, page 416 (1935); also "The Differential Platelet Count," Archives of Internal Medicine, volume 53, page 1163 (1936); and "The Determination of Platelet Volume," Journal of Laboratory and Clinical Medicine, volume 23, page 166 (1937).

In general the two prior art methods of counting platelets, as taught by Tocantins and Olef, may be characterized as the direct and the indirect methods. In the direct method, the blood is first diluted in a special silicon-treated glass pipette and a direct count of the platelets is made under a microscope. In the second or indirect method, a sample of blood is taken and a determination is

made of the volumetric ratio between red blood cells and platelets, and subsequently a red cell count is made, from which it is possible to determine by arithmetic ratio the number of platelets per unit volume. However, these techniques are both time consuming and extremely difficult of execution, as indicated by the articles noted above.

One of the difficulties in counting blood platelets by these prior methods is due to the fact that discreet platelets are destroyed by contact with any surface such as glass. This difficulty is partially overcome in the present invention by placing the blood sample to be tested in a capillary tube having a relatively large volume-to-surface ratio in comparison with the diluting pipettes which have been used in the past. Accordingly, by the method and means of the invention a much lower proportion of blood platelets are destroyed by surface contact. Furthermore, as the invention operates on the principle of radiant energy transmission through a blood specimen under test, and a preferred embodiment of the invention utilizes electro-optical means for automatically testing and recording changes in radiant energy transmission as sedimentation progresses, it is no longer necessary to attempt a count of discreet cells or blood component elements.

To expedite and accelerate the sedimentation of blood corpuscles, clinical technicians have heretofore placed a small sample of a diluted blood specimen in a high-speed centrifuge, as taught by Wintrobe in "Clinical Hematology," published in 1947 by Lea and Febiger. If centrifugation is carried out slowly at first and then more rapidly, three layers of corpuscles may be distinguished; a creamy-white layer of platelets, a reddish-gray layer of leukocytes, and a red layer of red corpuscles. This technique, when applied to a test specimen of unknown characteristics, requires that the centrifuge be operated at varying speeds, for short periods of time, and then the centrifuge must be stopped and the sample carefully removed and examined under a microscope, and then subsequently the specimen must be returned to the centrifuge for further periods of centrifuging, with attendant loss of time and continuing uncertainty as to exactly what is transpiring during each momentary interval of interrupted centrifuging. By contrast, the present invention provides a method for instantaneously and continuously observing, testing, and recording the rates of sedimentation throughout a continuous period of centrifuging. A preferred embodiment of the invention utilizes a modified centrifuge in combination with electro-optical means to develop electrical pulses for operating either a calibrated visual register or an automatic recorder.

It is an object of the invention to provide a more rapid method of determining cell fractions in blood samples. Another object of the invention is to provide a method for rapidly and accurately determining sedimentation rates of the various cellular components in blood specimens, or other fluid mixtures containing parts of differing specific gravities. An additional object of the invention is to provide such methods which may be practiced without resort to complicated techniques, and without requiring the development of extraordinary individual skills. Another object of the invention is to provide improved means for automatically measuring cell fractions in blood samples. A further object is to provide means whereby the characteristics of colloidal fluid samples, including blood specimens, may be accurately and automatically recorded. A more particular object is to provide an improved means for rapidly and accurately determining blood cell sedimentation rates from samples of whole blood. Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more such steps with respect to each of the others, and the apparatus embodying fea-

tures of construction, combinations of elements, and arrangement of parts which are adapted to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

As applied to the art of clinical hematology, the invention in general utilizes the difference of light intensity transmitted (or scattered) by the blood plasma alone; and by the plasma plus the platelets plus the white cells, as a measure of the number (or combined volume) of the white cells and platelets respectively. The observation of this transmitted (or scattered) light is made with a microscope while the blood sample, contained in a transparent capillary tube, is being centrifuged. The centrifuge employed may be of the same general type as those normally used for microhematocrits, and for example, may be the International "Hematocrit" centrifuge, with a modified base plate, cover plate, and the addition of associated light source and optical means as will be described more fully hereinafter. This type of centrifuge is adapted to receive capillary tubes of approximately 2 millimeter outside diameter, approximately 75 millimeters in length, and to rotate at approximately 12,000–15,000 revolutions per minute.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings in which:

FIGURE 1 is a schematic drawing of a preferred embodiment of the invention showing in profile section the essential elements of the optical system in their relation to the rotatable portion of the centrifuge, and showing a photo-electric detector cell;

FIGURE 2 is a top view of the rotatable wheel of the centrifuge taken along the line 2—2 of FIGURE 1, with a portion of the cover plate cut away to show a plurality of radial slots in some of which are placed capillary tubes;

FIGURE 3 is a graph showing the percentage of light transmitted through a selected portion of the blood sample illustrated in FIGURES 4, 5, 6, and 7, as the same varies with respect to time of centrifuging;

FIGURE 4 is an enlarged sectional view of a portion of a capillary tube containing a sample of whole blood, before centrifuging;

FIGURE 5 is an enlarged sectional view of a capillary tube containing a normal blood sample as the same may appear after centrifuging for approximately one or two minutes;

FIGURE 6 is an enlarged sectional view of the same blood sample as in FIGURE 5, showing its appearance after approximately 3 to 4 minutes centrifuging;

FIGURE 7 is another enlarged cross-sectional view of the same capillary tube and blood sample shown in FIGURE 5 and FIGURE 6 as the same may appear after approximately 5 minutes of centrifuging;

FIGURE 8 is a block diagram of an electronic indicating system which may be connected to the output of the photo-electric cell shown in FIGURE 1;

FIGURE 9 is a block diagram of an alternative electronic indicating system which may be employed in lieu of the circuit of FIGURE 8, suitable for indicating and/or recording the differential light transmission between a tested sample and a reference sample;

FIGURE 10 is a schematic block diagram showing yet another arrangement of electronic indicating and/or recording means as may be employed for simultaneously testing a plurality of specimens placed in the same centrifuge; and

FIGURE 11 is a schematic drawing of a portion of the optical system of FIGURE 1 showing how the same may be adjusted for response to scattered secondary rays from test samples placed in the centrifuge, rather than responding directly to transmitted illumination.

Referring now in greater detail to FIGURE 1 and FIGURE 2 of the drawings, a centrifuge indicated generally at 12 comprises a high speed motor 14 mounted on a bracket 15 which is rigidly supported on a base plate or table (not shown). Mounted on and rotatable by motor shaft 16 is a circular centrifuge wheel indicated generally at 17. The wheel 17 comprises a rotatable base plate 18 having a plurality of radial grooves 19 formed in its top surface (as more clearly illustrated in FIGURE 2). Aligned with and extending into each of the grooves 19 is a conically shaped orifice 20 which pierces the base plate 18 to allow the transmission of radiant energy therethrough. All of the orifices 20 are equidistant from the axis of shaft 16. The outer periphery of the rotatable base plate 18 is formed in a rigid flange 21 which extends above the top edges of the grooves 19. To the inner face of flange 21 is applied a cushion 22 which may be of rubber. Towards their peripheral ends the grooves 19 are preferably deeper cut into base plate 18, forming an incline at 24, to facilitate easy removal of small capillary tubes 25, as shown in broken lines at 26. Affixed to the center of base plate 18, concentric with shaft 16, is a hub 27 having its upper end 28 threaded to receive a nut member 29 by means of which circular cover plate 30 may be securely fastened over the top surface of centrifuge wheel 17 to hold the capillary tubes 25 snugly in the grooves 19 as the wheel 17 is revolved at high speed. A plurality of orifices 31 are pierced through the cover plate 30 about a circle concentric with the axis of shaft 16 and at spaced intervals corresponding to the angular displacement of grooves 19, to permit passage of radiant energy through the combined base plate and cover plate, as illustrated by the rays 32—32 in FIGURE 1. The orifices 31 may preferably be of larger diameter than the small top openings of orifices 20, to facilitate easy alignment of the cover plate openings 31 with the base plate openings 20 when the removable cover plate 30 is installed in operation position.

As shown in FIGURE 1, a light source 34, together with associated optical elements indicated generally at 35 for directing a convergent beam of radiant energy upwardly along an optical axis 23 and through each base plate orifice 20 when rotated into alignment therewith. Thus the beam will focus on the center of any capillary tube positioned in any of the grooves 19 of wheel 17 when rotated into alignment with the beam. Above the rotatable centrifuge wheel 17 and optically aligned with the optical elements directing the convergent beam upwardly is an optical system, indicated generally at 33, for collecting the rays of radiant energy 32 and forming an image of the spot 36 onto the screen of a detector 40 which may be a photo-electric cell as shown in FIGURE 1. As illustrated schematically, the microscope 33 may comprise an objective lens 37 mounted in a barrel 38 and an adjustable "eye piece" 39 axially aligned therewith for focusing the radiant energy from point 36 in the capillary tube 25 onto the screen 41 of photo-electric cell 40. A suitable source of electrical energy, such as a battery 42, is connected in series with a load resistor 44 and photo-electric cell 40 whereby a voltage may be developed across resistor 44, which voltage is directly proportional to the intensity of radiation transmitted through point 36 of capillary tube 25 in the centrifuge 12.

Let it be assumed that one capillary tube 25 is mounted in the centrifuge wheel 17 and that all of the orifices 20 except the one aligned therewith are blocked off so that no radiation will pass therethrough. As wheel 17 revolves, radiation from source 34 will pass through the point 36 in tube 25 momentarily, i.e., only when orifice 20 is aligned with the optical axis 23—23, to produce an impulse of voltage across resistor 44. Each successive revolution of the wheel will produce additional impulses each time the orifice 20 in base plate 18 comes into alignment with the axis 23—23. Thus, if the wheel 17 revolves at the rate of 12,000 r.p.m., then 12,000 impulses per minute will appear across resistor 44, and the

magnitude of these impulses will be directly proportional to the intensity of radiation passing through capillary tube **25** at point **36** at every revolution during the process of centrifuging. By connecting the resistor **44** through suitable amplifying means to continuous indicating means such as an electrical galvanometer, cathode ray oscilloscope, or graphic recorder, the effect of the centrifuging process on the contents of the capillary tube **25** may be continuously observed without stopping the operation of centrifuge **12**, and these observations may be automatically recorded if desired.

Reference is now made to FIGURE 3 of the drawings, which is a graph, such as may be made by a recording oscilloscope or an electrically operated recording pen, showing the intensity of transmitted radiation passing through the point **36** of a capillary tube such as **25** in the centrifuge **12** as shown in FIGURE 1, with the intensity of transmission being plotted as the ordinate against time of centrifuging as the abscissa. As shown at A in FIGURE 3, at the start of centrifuging very little radiation passes through the specimen because the substantially opaque red corpuscles are uniformly distributed throughout the capillary **25** (as shown in FIGURE 4) As the time of centrifuging progresses the intensity of transmitted radiation gradually increases, following the curve A—F′, until at time T_r an intensity level B is reached. At this point the red corpuscles (being the heaviest particles of the blood specimen) have settled into the outer, peripherally disposed, end of the capillary tube **25** in the centrifuge **12** (as shown at *a* in FIGURE 5), and the radiant energy from source **34** is now being transmitted through the remaining buff-colored fluid in the other two-thirds of capillary **25**, comprising a mixture of supernatent plasma containing white corpuscles mixed with platelets and minuscule particles of debris. The slope of the curve F—F′ indicates the rate of red cell sedimentation. As shown by the graph in FIGURE 3 the intensity of transmitted radiation now remains substantially constant following the portion of the curve F′—G, until centrifuging has progressed for approximately 3 minutes, at which time the intensity of radiant energy transmission begins to increase along the curve G—G′ when a second plateau is reached at the level D. After the elapsed time T_w, which in the curve of FIGURE 3 is approximately 3¾ minutes, the white corpuscles have settled in a thin layer against the red corpuscles (as illustrated at *b* in FIGURE 6), and the intensity of transmitted radiation continues substantially constant as indicated by the curve G′—H, the radiation now being subject only to the filtering action of the transparent platelets and minuscule particles of debris contained in the mixture of supernatent plasma from which both red and white corpuscles have been removed by centrifugation. As centrifuging continues, the platelets will next settle out in a thin layer against the white corpuscles (as shown at *c* in FIGURE 7), and the intensity of transmitted radiation will increase from the level D to the level E, the rate of platelet sedimentation being indicated by the slope of the curve H—H′, until at the time T_p, which in FIGURE 3 is after approximately 5 minutes, the platelets have been separated out from the blood specimen and the intensity of radiant energy is limited only by the transmission characteristic of the remaining plasma. Thus it will be apparent from a consideration of FIGURE 3 that not only may the times of settling of the various components of a blood specimen be determined, but also the rates of sedimentation of each of the several component elements may also be determined and recorded.

FIGURES 4–7 show to a greatly enlarged scale how the contents of the capillary tube in a centrifuge may appear after different times of centrifuging. In FIGURE 4 the red and white corpuscles are mixed with the blood platelets, plasma and whatever foreign matter the specimen may contain. In FIGURE 5 the red cells *a* only have been separated, while in FIGURE 6 the red and white cells *a* and *b* have been separated, and in FIGURE 7 the red and white cells plus the platelets *c* have been separated from the remaining supernatent plasma. The broken line **23—23** drawn through FIGURES 4–7 represents the optical axis along which radiant energy may be directed for observing, determining, and recording the progress of centrifugation, without the necessity of stopping the centrifuge, removing the specimens and examining them individually and successively under a microscope.

Reference is now made to FIGURE 8 of the drawings which shows in block diagram a simplified arrangement for utilizing the impulses from detector **40** as developed across resistor **44** in FIGURE 1, for either indicating or recording changes in transmission during the progress of centrifugation. The integrator **60** in FIGURE 8 may be of the simple condenser type, and the amplifier **70** may be either of the thermionic or transistor types, all as well known in the electrical arts; while the output indicator or recorder **80** may either be a galvanometer, an oscilloscope, or driven pen type recorder of which many suitable models are available commercially, as for example the types of recorders manufactured by Esterline-Angus in Indianapolis.

FIGURE 9 illustrates how the invention may be employed in combination with a synchronous switch or distributor **50** driven by the centrifuge motor **14** to produce an indication or record of the comparative transmission characteristics of a specimen under test and a standard specimen. If two such specimens, a test specimen and a standard specimen, are placed in the centrifuge **12** at the same time, but in different grooves, as for example in diametrically opposite grooves, and a two-position distributor switch **50** is driven by the centrifuge motor **14** so as to connect the output of photo-electric detector **40** alternately to each of two integrators **61** and **62** as first the test specimen and then the standard specimen come into alignment with the optical axis **23—23** (FIGURE 1), then the output indicator or recorder may be adapted to show the difference in the transmission characteristics of the two samples under centrifuging. In this arrangement separate amplifiers **71** and **72** have their outputs both connected into a differential amplifier **73**, the output of which is fed into the indicating recorder **74**. By this means a sample of normal blood may be compared with a specimen of unknown characteristics taken from a patient under examination, for example, or a test specimen may be compared with a specimen of pure supernatent plasma, or even with a sample of distilled water.

FIGURE 10 shows in schematic form a block diagram of an alternative arrangement whereby a plurality of specimens may be simultaneously tested to determine their sedimentation rates and radiant energy transmission characteristics, as may be desired in a large clinic or commercial laboratory. By the means of FIGURE 10, for example, if the synchronous distributor switch **54** is provided with as many contact points as there are capillary receiving grooves in the wheel **17** of the centrifuge **12** shown in FIGURE 1, and if the contacts of switch **54** are adjusted to operate only when each of the corresponding grooves is aligned with the optical axis **23—23**, then as many samples can be tested at one time as there are grooves in the wheel **17**, provided the same number of output indicator-recorders is provided, as indicated by **81**, **82**, **83**, etc., in FIGURE 10. Thus, for example, if it be assumed that the centrifuge wheel **17** in FIGURE 1 is provided with 24 capillary receiving grooves, as many as twenty-four blood specimens can be tested in the same time required to test only one.

While the description hereinabove has referred to a detection system responsive to changes in intensity of transmitted radiant energy, as illustrated by FIGURE 1, it is to be understood that the invention may alternative-

ly employ the effects of scattered radiation, as illustrated by FIGURE 11 of the drawings. In FIGURE 11 the axis 23—23 of optical system 35 is adjusted at an angle so that the beam of radiation from source 34, while being directed through the specimen in capillary 25, does not pass directly into the objective lens 37 of microscope 38 but instead is directed at an angle to the axis of microscope 38. The secondary rays 100 which are scattered from the point 36 in capillary tube 25, by the diffusing action of the capillary specimen contents upon the focused rays of energy 32—32, are collected by lens 37 and directed through microscope 38 to the photo-electric detecting means (40 in FIGURE 1) which thus responds to changes in the scattered rays only.

It will thus be seen that there has been provided by this invention an improved method and means for determining sedimentation rates and fractional composition of fluid mixtures containing parts of differing densities, and that the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention, and as many changes may be made in carrying out the above method and in the construction set forth without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense. Particularly it is to be understood that while the invention has been disclosed as adapted specifically to the art of clinical hematology, its general utility is not so limited but may be employed in other arts wherever there may be a need to observe and record the effects of continuing centrifugation on test samples.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

I claim:

1. Apparatus for accurately and rapidly determining the red cell, white cell, and platelet fractions in a blood specimen comprising means for centrifuging the blood specimen so as to bring about successive sedimentation of said blood fractions, means for intermittently directing radiant energy through a selected portion of said blood specimen while the specimen is being centrifuged, said selected portion of said blood specimen being that portion wherein plasma remains after separation of the fractions, and means for detecting the change in intensity of the intermittent beams of said radiant energy brought about by the removal of each blood fraction from the portion of the specimen subjected to such intermittent radiant energy.

2. Apparatus for accurately and rapidly determining the various colloidal particle fractions in suspension in a colloidal solution comprising means for centrifuging a sample of the colloidal solution so as to bring about successive sedimentation of the colloidal fractions, means for directing intermittent radiant energy through a selected portion of the sample while the sample is being centrifuged, said selected portion of the sample being that portion which remains after sedimentation of the colloidal fractions, and means for detecting the change in intensity of the intermittent beams of said radiant energy brought about by the removal of each fraction from the portion of the sample subjected to such intermittent radiant energy.

3. Apparatus for determining the red cell, white cell, and platelet fractions in a sample of blood comprising, in combination, means for centrifuging a blood sample so as to bring about successive sedimentation of the blood fractions, means for intermittently directing a beam of radiant energy through a selected portion of said sample, said selected portion being that portion wherein plasma will remain after sedimentation of said fraction, means for detecting radiant energy passing intermittently through said sample while said sample is being centrifuged, and means for recording the intensity of the detected energy.

4. Apparatus for determining the proportions of elemental constituents in fluid mixtures containing parts of different specific gravity, comprising, in combination, means for centrifuging a representative sample of fluid mixture so as to bring about successive sedimentation of the elemental constituents, means for intermittently directing radiant energy through a selected portion of said sample while the sample is being centrifuged, said selected portion being that portion which remains after sedimentation of the elemental constitutents, means for detecting said radiant energy passing intermittently through said sample, and means for indicating the intensity of said detected radiant energy during the time of centrifuging.

5. The combination of claim 4 in which said last named means is a graphic recorder.

6. Apparatus for fractionating and measuring the red cell, white cell, and platelet portions of blood samples comprising, in combination, centrifuging means adapted to receive a blood sample and to bring about successive sedimentation of the red cell, white cell and platelet portions of the blood sample, means for intermittently directing a beam of radiant energy through said centrifuging means and through a selected portion of the blood sample therein, said selected portion being that portion wherein plasma will remain after sedimentation of said fractions, radiant energy detecting means responsive to said beam after passing through said sample, means for amplifying said detected energy, and indicating means connected with said amplifying means and calibrated to indicate the intensity of detected radiant energy as a function of time.

7. Apparatus according to claim 6 characterized in that said radiant energy detecting means is responsive to secondary rays scattered from said sample when said beam is directed at an angle other than normal to said sample and said detecting means.

8. Apparatus for automatically measuring the red cell, white cell, and platelet fractions and sedimentation rates in blood specimens comprising, centrifuging means adapted to receive a blood sample and to bring about successive sedimentation of said blood fractions, a source of radiant energy, means for directing energy from said source through a selected portion of a blood sample in said centrifuge, said selected portion of the blood sample being that portion wherein plasma remains after sedimentation of the fractions means for detecting intermittent radiant energy transmitted through a blood sample in said centrifuge while the centrifuge is operating and for translating said energy into electrical impulses, means for integrating said impulses with respect to time, means for amplifying said integrated impulses, and indicating means connected with said amplifying means for instantaneously and continuously indicating impulse amplitude as a function of sedimentation.

9. The combination of claim 8 characterized by graphic recording means as said indicating means for automatically plotting changes of impulse amplitude with respect to time of centrifuging.

10. Apparatus for automatically measuring the red cell, white cell, and platelet fractions and sedimentation rates of blood specimens contained in capillary tubes comprising, centrifuging means adapted to receive a first specimen to be tested and a second specimen as a standard, a source of radiant energy, means for alternately directing energy from said source through a selected portion of said first and second specimens in said centrifuge, said selected portion of said specimens being that portion wherein plasma remains after sedimentation of the fractions, means for detecting the radiant energy transmitted alternately through each of said specimens in said centrifuge while the centrifuge is operating and for trans-

lating said energy into successive electrical impulses, a pair of individual pulse integrators, means driven in synchronism with said centrifuge for connecting the output of said radiation detecting means alternately with each of said integrators, differential discriminating means connected with the outputs of said integrators for deriving a signal proportional to the difference in amplitude between the integrated signals from said separate integrators, and indicating means connected with said discriminating means for instantaneously and continuously indicating the differences in integrated impulse amplitude as a comparison of radiant energy transmission through said separate first and second specimens in said centrifuge.

11. The combination of claim 10 in which said indicating means comprises a graphic recorder for automatically plotting changes in amplitude differences with respect to the time duration of centrifuge operation.

12. Apparatus for simultaneously measuring the red cell, white cell, and platelet fractions and sedimentation rates in a plurality of blood specimens contained in capillary tubes comprising, rotatable centrifuging means adapted to receive a plurality of individual blood samples and to rotate so as to bring about the successive sedimentation of the blood fractions, a source of radiant energy, means for directing energy from said source through a selected portion of each of said samples successively as said centrifuging means rotates, said selected portion of said samples being that portion wherein plasma remains after sedimentation of the fractions, means for detecting the radiant energy transmitted through each of said samples successively and for translating said energy into successive electrical impulses, a plurality of integrating means corresponding in number to said plurality of specimens, distributing means operated in synchronism with said rotatable centrifuging means for successively

connecting each of said integrating means with said detecting means, a plurality of indicators corresponding in number to said plurality of specimens, and means connecting each of said indicators to a different one of said integrating means whereby each of said indicators produces an instantaneous and continuous indication of changes in the intensity of radiant energy detected through one of said specimens as said centrifuging means is operated.

13. Apparatus according to claim 12 characterized by graphic recording means as said indicating means whereby an instantaneous graphic record may be made of the changes in radiant energy intensity for each of a plurality of specimens as said specimens are simultaneously centrifuged.

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