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M. PHILIPSEN

2,163,467

METHOD AND APPARATUS FOR DETERMINING THE COLOR OF A LIQUID

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FIG. 1.

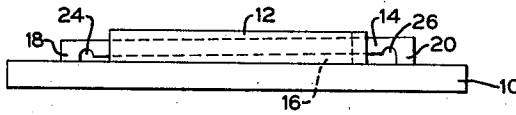


FIG. 2.

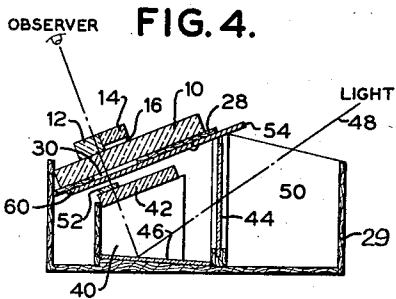
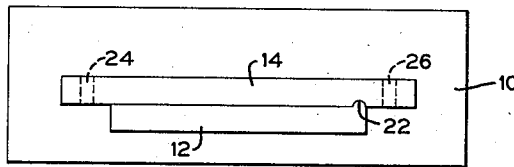


FIG. 4.

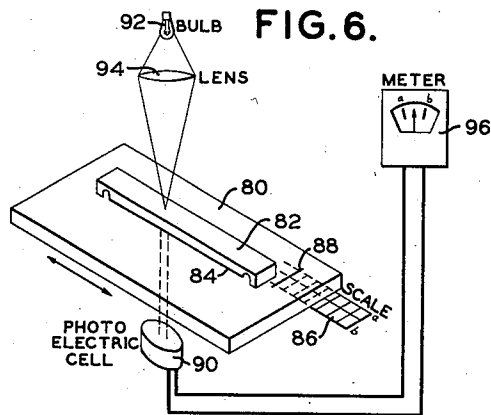


FIG. 6.

FIG. 3.

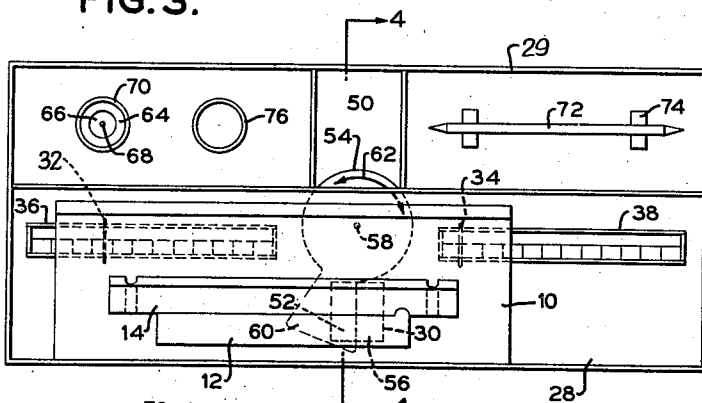


FIG. 5.

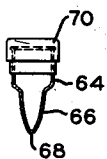
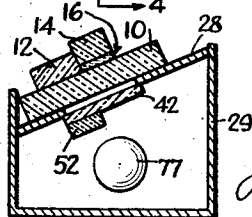


FIG. 7.



MICHAEL PHILIPSEN
INVENTOR

BY

Donald Mac Knight
ATTORNEY

UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR DETERMINING THE COLOR OF A LIQUID

Michael Philipson, Vedbaek, near Copenhagen, Denmark

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This invention relates to a method and apparatus for testing the concentration of a liquid by comparing the color of that liquid to color standards of known value, and more particularly to the measuring of the hemoglobin content of blood. The primary object of the invention is to provide such a method and apparatus whereby these measurements can be made to a high degree of preciseness without the necessity of diluting in any noticeable degree the liquid to be tested.

In all of the colorimetric methods which have been adopted heretofore, it is necessary to dilute the liquid to be tested materially in order to obtain a color which indicates the concentration within the necessary limits. In fact it is quite usual in the testing of the hemoglobin content of blood to dilute the blood more than 100 times. These processes wherein it is necessary to dilute the blood have many disadvantages since it is impossible even in the laboratory to dilute the blood so precisely as to meet the high standards demanded by the physicians. It is usually necessary to conduct the tests on several solutions and to take an average reading in order to eliminate the influence of inaccurate dilution. Former attempts to test such liquids without dilution have failed.

In accordance with the present invention, to reduce the specimen to pure hemoglobin so as to eliminate the influence of fluctuations in oxygen content of the blood, a reducing chemical such as sodium hydrosulfite has been found successful, and this substance is so effective that it can be used in such small amounts that its volume will not influence the concentration to any noticeable degree. In order to render the blood transparent so that it may be compared with the color standards, a hemolysing chemical, for example, saponin, has been used which, like the sodium hydrosulfite, has no appreciable diluting effect on the sample. It has been found particularly effective to compound both of these chemicals using, for instance, 30% saponin and 70% of sodium hydrosulfite so that the hemolysation and a complete reduction of the blood's oxyhemoglobin to red hemoglobin can be produced efficiently and in the shortest possible time. In this connection, in addition to using these materials for reducing oxyhemoglobin to red hemoglobin, it is possible to further alter the structure of the blood such as in fully oxidizing it to oxyhemoglobin and also to make hematin of it.

The reduced and hemolysed blood has an intensity and a color depending upon the thickness of the liquid layer and the concentration. It is,

therefore, necessary to use a standard color which both in intensity and color exactly corresponds to the blood. It has been tried unsuccessfully in the past to compare an unreduced and unhemolysed specimen in a very thin layer to a standard ruby glass wedge, the thickness of the wedge at the point of color coincidence indicating the hemoglobin concentration. A ruby wedge of glass is not "dichromatic", that is, the wedge varies only in intensity but does not show the nuances of color from the thinnest to the thickest portion. It has been found, however, that blood can be compared with such a ruby glass when using a candle, the light of which is poor or lacking in violet, blue and green rays, thus rendering the blood undichromatic. However, with this method the contrast of the blood of various concentrations has been diminished so much that a careful determination of the blood's hemoglobin content within the required narrow limits has been materially handicapped.

The invention herein described discloses a new manner of testing undiluted blood samples in a light which produces and even increases the contrast by the dichromatic effect. Thus, it has been found that one can use a capillary chamber containing the blood in connection with a scale supplied with all combinations of intensity and color necessary for comparing blood of various concentrations. In the preferred form described herein, the capillary chamber is wedge-shaped in order that one, or at the most, a very few standard color glasses will be necessary, and which glasses can easily be made to correspond to a blood sample of a definite concentration and layer thickness. The capillary chamber thus forms a natural "blood-wedge" and this combination can readily be used in a light containing dichromatic rays by filtering this light by means of complementary coloring and the contrast can be increased to a material extent.

One form of the invention particularly adapted to serve as a hemoglobinometer is shown in the accompanying drawing in which

Figure 1 is an elevation of the capillary wedge-formed chamber;

Figure 2 is a plan view of the capillary chamber;

Figure 3 is a plan view of an instrument embodying the invention;

Figure 4 is a sectional elevation taken on the line 4—4 of Figure 3;

Figure 5 is an elevation partly in section showing a suction glass for removing a sample of

blood from the wound and for holding the sample during its reduction and hemolysation, and

Figure 6 is a diagrammatic view showing an adaptation of the capillary chamber to a photo-electric system whereby the concentration may be indicated automatically on a suitable meter.

Figure 7 is a sectional elevation of a modification showing the use of an artificial light contained within the instrument.

The capillary chamber comprises a transparent glass base plate 10 upon which is permanently mounted a transparent ledge or supporting member 12. Removably mounted upon the base plate and disposed adjacent the ledge 12 is a transparent glass member 14 in which the lower side is cut out as shown in Figure 1 so as to form a wedge-shaped chamber 16 when the member 14 is placed upon the flat plate 10.

Preferably the lower surfaces of the end portions 18 and 20 of the member 14 and the upper surface of the base plate 10 are ground smooth as by rubbing these surfaces together with a suitable abrasive or polishing material therebetween so as to provide even contact between the end portions 18, 20 and the base plate 10, and the ledge 12 is provided with a projection 22 adapted to cooperate with a similarly shaped indentation in the member 14 so as to prevent longitudinal movement of the member 14 with respect to the ledge 12. The member 14 is also provided with the openings 24 and 26 at opposite ends of the chamber 16 which openings prevent the blood from wetting the portions 18 and 20. As shown in Figures 1 and 2 of the drawing, the transparent member 14 is shorter than the base plate 10 and longer than the ledge member 12 so that the supporting ends 18 and 20 of the member 14 may rest on portions of the base plate which are distant from the ends of the ledge member and which portions may readily be kept free from dirt which may collect around the ends of the ledge member.

The combination of the base plate 10, ledge 12 and member 14 is adapted to be placed upon a sloping support 28 of a housing 29, as is shown more clearly in Figure 4. The support 28 is opaque except for a cut-out portion or window 30 through which the observations are made. The base plate 10 is slidable in a longitudinal direction on the support 28 with the members 12 and 14 directly over the window 30 and a pair of index lines 32 and 34 etched on the base plate will thus cooperate respectively with scales 36 and 38 suitably inscribed or attached to the fixed support 28.

Within the housing and below the support 28 is another support 40 upon which is mounted a glass color filter plate 42 and another color filter plate 44 is supported vertically between the bottom of the housing 29 and the upper edge of the support 28. A mirror 46 is mounted on the bottom of the housing 29 below the filter plate 42 and in a position such that light rays such as 48 from some outside source will enter through an opening 50 in the rear portion of the instrument, and will pass through the filter 44 to be reflected from the mirror 46 and pass upwardly to the observer through the filter 42, window 30, base plate 10 and the combination of ledge 12 and chambered member 14. In this manner the light rays pass through a set of color filters and may thus be brought into a substantially complementary color to that of the blood specimen.

A standard color glass 52 is shown as mounted on the upper surface of the filter plate 42 in a po-

sition such that part of the rays 48 will pass through this standard glass and the ledge 12 to the observer while another part of the rays will reach the observer through the blood in a section of the chamber 16 without having passed through this standard glass. Thus, the observer will see in one part of the window 30 beneath the ledge 12 the standard color of the member 52, and in the other part of the window he will see in looking through the member 14 the rays which pass directly through the blood in the chamber 16 without having passed through the standard glass 52. Thus, the last mentioned part of the window will show a color which is brighter or darker than that of the standard glass, depending upon the longitudinal position of the chamber 16 on the supporting plate 28, that is, the color will be brighter or darker depending on the height or thickness of that portion of the chamber 16 above the window 30, or, in other words, upon the blood layers' thickness and upon the concentration of the hemoglobin. The observer need only to slide the base plate 10 and thus the chamber 16 into a position where both parts of the window show the same color. He then may read directly the hemoglobin concentration by the position of the index 32 upon the scale 36, or of the index 34 upon the scale 38.

In order to keep at a minimum the amount of blood necessary for a suitable specimen, the instrument is preferably furnished with two standard colors having different values, and it is for this reason that the two scales 36 and 38 are furnished, as well as the two corresponding indexes 32 and 34 showing the hemoglobin concentration. A shutter member 54 permits of a selection of one or the other of the two standard colors 52 or 56, this shutter member being in the form of a disc pivoted at 58 to the support 28. Attached to one edge of the disc is a tongue-like extension 60, and it will thus be seen that by rotating the shutter disc through a few degrees the tongue 60 will cover and thus render invisible either one or the other of the standard color plates 52 and 56. The edge of the shutter disc is provided with a double ended arrow 62, one end of which will always be hidden beneath the support 28 while the other end will point toward either the scale 36 or the scale 38, depending on which of the color glasses 52 or 56 is visible.

Instead of using color standards of solid glass, these may comprise transparent glass receptacles filled with a liquid such as hemolysed and reduced hemoglobin.

When assembling the apparatus thus far described, a sample of blood of known hemoglobin content is placed in the wedge-spaced chamber 16 between the member 14 and the plate 10, and the member 14 is then moved or adjusted longitudinally on the plate 10 until color coincidence is obtained between the color of the blood seen through member 14 and the standard color seen through the lower portion of window 30. The plate 10 is previously adjusted on the support 28 so that the index line 32 or the line 34 coincides with the proper reading on the scale 36 or the scale 38, respectively, depending on which of the two standard colors 52 or 56 is being used. When the proper adjustment of the member 14 with respect to the plate 10 has been found, the member 12 is permanently secured to the plate 10 as by means of a suitable cement. The projection 22 will then hold the member 14 in the proper position.

Since, in accordance with this invention, the

blood sample is not diluted, the usual measuring pipette is dispensable and this is replaced by the small capillary glass receptacle 64, illustrated in Figure 5. The glass 64 has a narrow portion 66 and at the end of this portion is provided with a small hole 68. The upper end of the glass carries a rubber rim 70 and by placing the finger on this rim some of the air within the glass may be forced outwardly through the opening 68, or additional air may be sucked in. In use the glass 64 is held horizontally with the point of the glass containing the opening 68 placed at the wound. The narrow portion 66 then automatically fills with blood, the blood passing through the opening 68 by capillary attraction. As soon as the portion 66 is filled the flow will stop and the necessary quantity is thus automatically obtained. The primary purpose of the glass 64 is, however, to permit mixing of the compound of sodium hydrosulfite and saponin with the blood without the necessity of bringing the specimen in any closer contact with the air, through which evaporation would change the concentration and reoxidation would counteract the reduction. One end of a pin 72, normally maintained in suitable supports 74 at the rear of the instrument, is dipped into a small receptacle 76 also supported by the instrument, and a few grains of the compound will adhere to the pin and may thus be stirred into the blood in the glass 64 where the action of hemolysation can be readily observed. The prepared specimen can then be pressed out of the glass along the chambered member 14 and the chamber 16 will fill automatically due to capillary force. When not in use the glass 64 is preferably supported in the instrument case, as is shown in Figure 3.

Instead of using as a source, daylight or some artificial light outside of the instrument, it may be desirable to install an electric incandescent lamp 77, in the instrument housing 29 as illustrated in Figure 7, thus eliminating errors which might occur due to poor outlining of the optical axis or due to variations in the different lights' spectra.

The adaptation of the capillary wedge-formed space 16 to colorimetry presents another hitherto unavailable advantage. Although there already exist wedge-formed containers for comparing diluted solutions to standard colors, these containers are difficult to manufacture and it is particularly difficult to accurately measure the layer thickness as a function of the position with respect to a standard. On the other hand, the chambered member 14 disclosed herein can readily be checked on a gauge, and furthermore because of the rather small size of the chamber 16 the standard glasses 52 and 56 can be kept in small dimensions. Thus, the standards can be made more precisely and at less expense since a larger number of standard glasses may be cut from a piece of glass which has been proved satisfactory.

In Figure 6 is shown diagrammatically a form of apparatus by means of which a photoelectric cell can be used in the determination of the concentration of a liquid. A base plate 80 similar to the plate 10 of Figures 1 and 2 serves as a support for transparent member 82 containing a wedge-formed chamber 84 for the liquid to be examined. The plate 80 is adapted to rest upon a suitable support, not shown, the support containing a scale 86 adapted to cooperate with an index 88 on the base plate in a manner similar to that of scales 36 and 38 and indexes 32 and 34.

A photo-electric cell 90 is arranged below the device so as to be in the path of light rays passing from a suitable electric or other lamp 92 and through a lens 94 and the chamber 84. The photoelectric cell 90 is connected to a suitable meter 96, the scale of which contains two marks designated *a* and *b*, each of which corresponds to a particular measuring range as is indicated at *a* and *b* on the scale 86. It is merely necessary to shift the base plate 80 longitudinally under the light ray to a position where the pointer of the meter rests exactly at one of the two marks. One may then read by the position of the chamber the hemoglobin content of that scale *a* or *b* corresponding to the mark on the meter indicated by the pointer.

It is to be understood that in assembling the apparatus shown in Figure 6 the correct position of the member 82 on the plate 80 will be found in the same manner as has been previously described with reference to the embodiment illustrated in Figure 3.

Obviously many modifications and variations of the invention may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated by the appended claims.

I claim:

1. A method of measuring the hemoglobin content of an undiluted blood sample comprising the steps of hemolysing the undiluted blood sample by adding thereto a small amount of saponin, placing said hemolysed blood sample in a transparent container having an elongated chamber of uniformly varying capillary thickness, placing said container in close proximity to a fixed standard color glass, passing light rays through said standard and through said container, moving said container relatively to said color glass and in a longitudinal direction with respect to said chamber until a color match is obtained between the color of the standard and the color of the sample in said chamber by transmitted light, and determining the hemoglobin content of the blood sample at the matching point by measuring the thickness of the chamber at said matching point.

2. In the method of measuring the hemoglobin content of blood in accordance with claim 1 the additional step of treating the undiluted blood sample to eliminate fluctuations in the oxygen content and the influence of said fluctuations on the color of the blood by mixing with said blood a small amount of sodium hydrosulfite.

3. A method of measuring the hemoglobin content of an undiluted blood sample comprising the steps of simultaneously hemolysing and reducing the sample by adding thereto a small amount of a mixture of saponin and sodium hydrosulfite, placing said hemolysed and reduced blood sample in a transparent container having an elongated chamber of uniformly varying capillary thickness, placing said container in close proximity to a fixed standard color glass, passing light rays through said standard and through said container, moving said container relatively to said color glass and in a longitudinal direction with respect to said chamber until a color match is obtained between the color of the standard and the color of the sample in said chamber by transmitted light, and determining the hemoglobin content of the blood sample at the matching point by measuring the thickness of the chamber at said matching point.

4. A device for use in the measurement of the color of an undiluted liquid comprising a trans-

parent base plate having a smooth and even upper surface, a transparent member adapted to be set on the upper surface of said base plate and having a cut-out portion in its lower side, said cut-out portion forming with the upper surface of said base plate a wedge-shaped chamber of capillary height and a transparent ledge member permanently secured to the upper surface of the base plate and serving as a support for one side of said transparent member.

5. A device for use in the measurement of the color of an undiluted liquid comprising a transparent base plate having a smooth and even upper surface, a transparent member adapted to be set on the upper surface of said base plate and having a cut-out wedge-shaped portion in its lower side, said cut-out portion forming with the upper surface of said base plate a wedge-shaped chamber of capillary height and a transparent ledge member permanently secured to the upper surface of said base plate and serving as a supporting stop for said first mentioned transparent member, said first mentioned transparent member and said transparent ledge member being provided with means comprising a projection on one member and an indentation on the other member for preventing relative longitudinal movement between said transparent members.

6. A device for use in the measurement of the color of an undiluted liquid comprising a transparent base plate having a smooth and even upper surface, a transparent member adapted to be set on the upper surface of said base plate and having a cut-out portion in its lower side, said cut-out portion forming with the upper surface of said base plate a wedge-shaped chamber of capillary height, a housing having an upper supporting wall, said wall being provided with a sight opening, said base plate being adapted to be moved longitudinally on said wall with said transparent member and said chamber over said sight opening, means for directing light rays through said sight opening and chambered transparent member, means comprising a scale on said wall and a cooperating index on said base plate for indicating the longitudinal position of said base plate on said wall, a support in said housing, a glass color filter plate and a standard color glass mounted on said support in super-imposed relation beneath said sight opening so that said glass can be seen through said sight opening at the same time that the filtered light rays are seen through said chambered transparent member.

7. A device for the measurement of the concentration of an undiluted liquid comprising a housing having a scale plate provided with a sight opening, a transparent member provided with a wedge-shaped chamber adapted to hold the liquid to be tested, said member being adapted to be moved along said scale plate with said chamber over a portion of said sight opening, a support in said housing, a pair of standard color glasses of different color mounted on said support below said sight opening, means for directing light rays upwardly through said sight opening, part of said rays passing through said standard color glasses and part through the chamber containing the liquid being tested, a movable shutter for covering either one of said standard color glasses, a pair of scales on said scale plate each of

which scales shows a measurement range corresponding to one of said standard color glasses, a pair of indexes on said transparent member each of which cooperates with one of said scales, and means on said shutter for indicating which of said scales should be read to show the concentration of said liquid.

8. A device as described in claim 7 in which the indicating means on the shutter comprises a double-ended arrow one end of which is out of view when the other end is pointing to the scale to be read.

9. A device as described in claim 7 provided with color filter glasses and means in said housing for holding said glasses in the path of the light rays.

10. A device as described in claim 7 in which the means for directing the light rays upwardly through the sight opening comprise an opening in the upper portion of the housing and a mirror arranged so as to reflect upwardly through said standard color glasses and said sight opening light rays entering said housing from an outside source through said opening in its upper portion.

11. A method of measuring the hemoglobin content of an undiluted blood specimen comprising hemolysing the specimen so as to render it substantially transparent, reducing the specimen to eliminate fluctuation in the oxygen content thereof, placing the specimen in a transparent container having an elongated wedge-shaped chamber of uniformly varying capillary thickness, placing said container in close proximity to a fixed standard color glass, passing light rays through said standard glass and through said container, moving said container relatively to said color glass in a longitudinal direction with respect to said chamber until a color match is obtained between the color of the standard and the color of the sample in said chamber by transmitted light, and determining the hemoglobin content of the blood sample at the matching point by measuring the thickness of the chamber at said matching point.

12. A method of measuring the hemoglobin content of an undiluted blood sample comprising the steps of hemolysing the undiluted blood sample, placing said sample in a transparent container having an elongated chamber of uniformly varying capillary thickness, placing said container in close proximity to a fixed standard color glass, passing light rays through said standard glass and through said container, moving said container relatively to said color glass and in a longitudinal direction with respect to said chamber until a color match is obtained between the color of the standard and the color of the sample in said chamber by transmitted light, and determining the hemoglobin content of the blood sample at the matching point by measuring the thickness of the chamber at said matching point.

13. A device as described in claim 4 in which the transparent member is shorter than the base plate and longer than said ledge member so that said transparent member may rest on portions of said base plate which are distant from the ends of the ledge member so as to be substantially free from dirt which may collect around the ends of said ledge member.

MICHAEL PHILIPSEN.