(No Model.)

E. F. VON MARXOW.

HÆMOGLOBINOMETER.

No. 353,098. Patented Nov. 23, 1886.

Fig. 1.

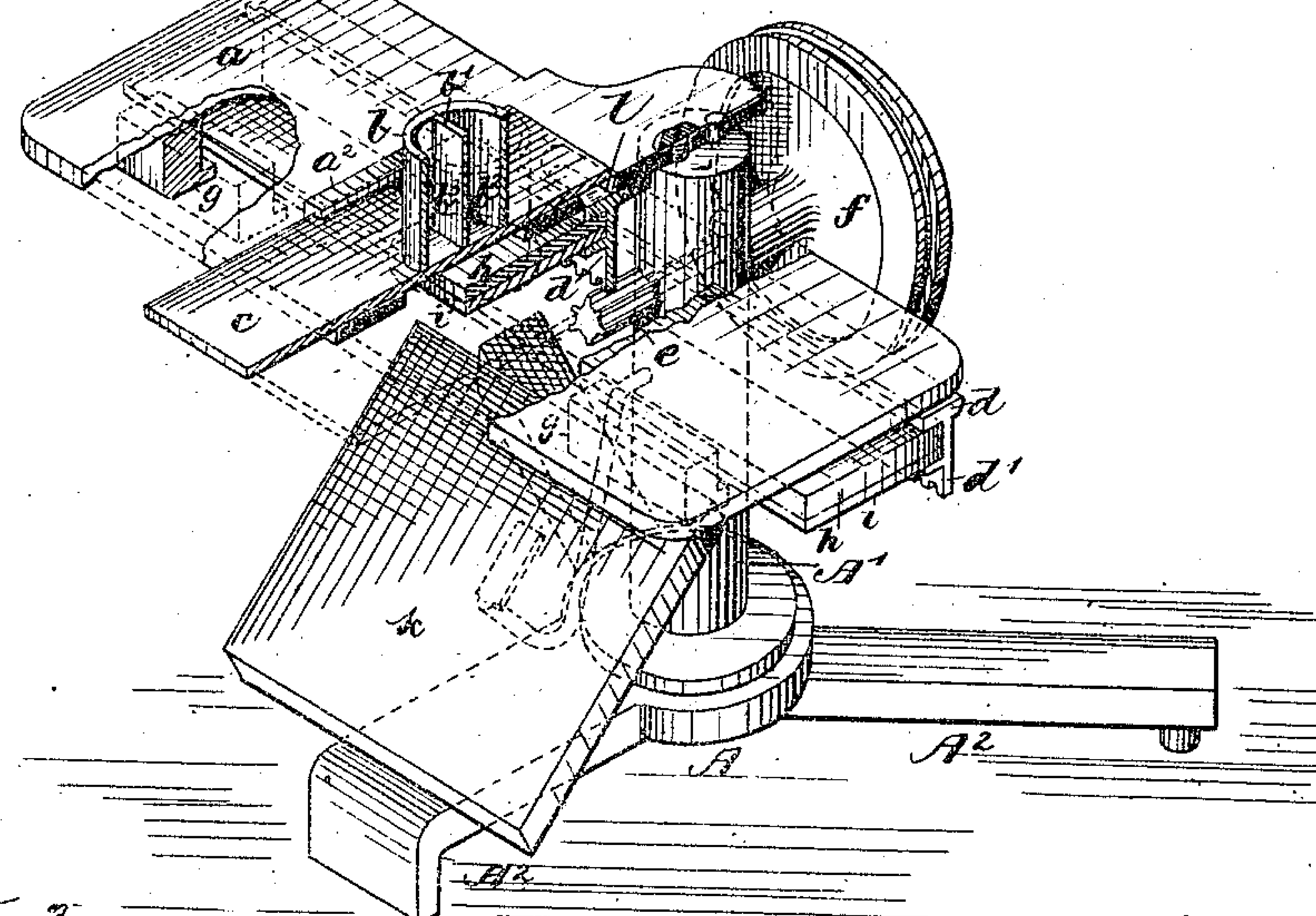


Fig 3.

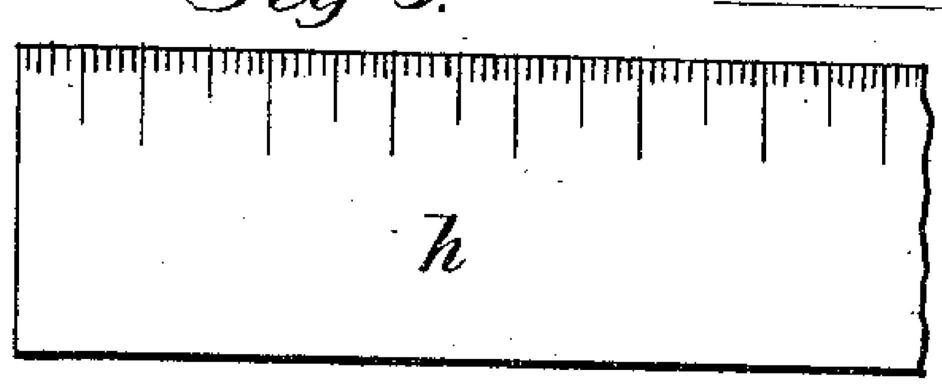


Fig. 4.

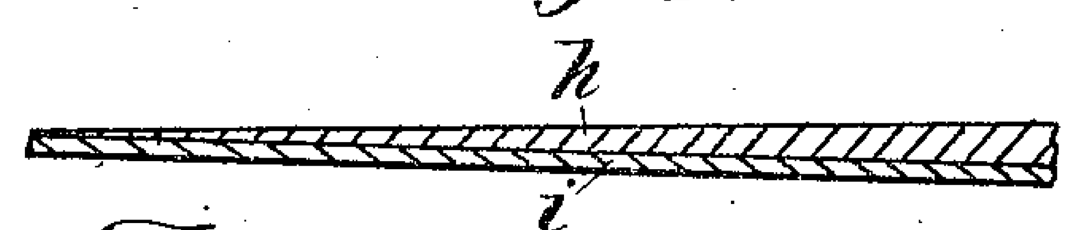
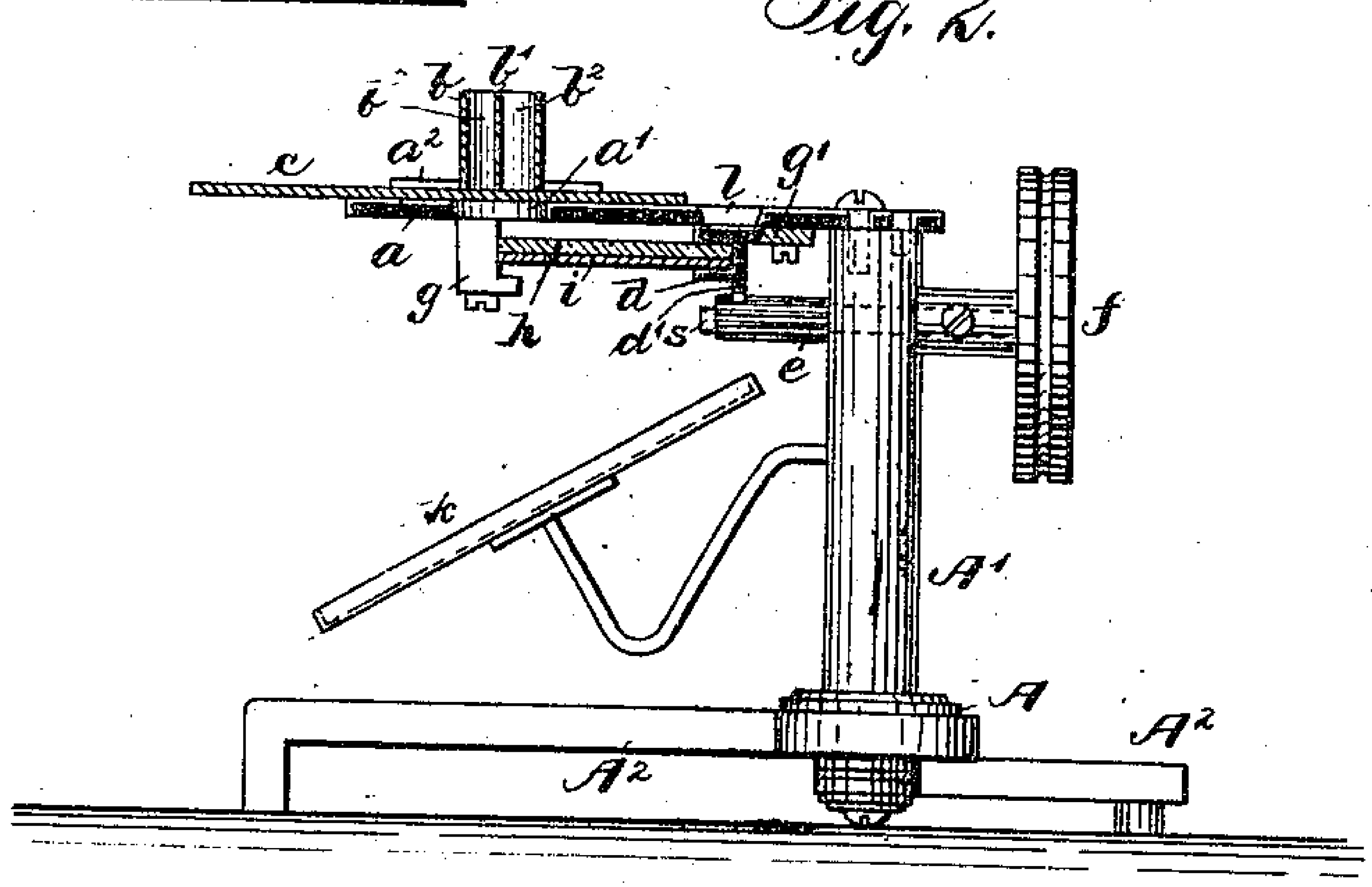


Fig. 2.



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HÆMOGLOBINOMETER.

SPECIFICATION forming part of Letters Patent No. 353,098, dated November 23, 1886.

Application filed May 29, 1885. Serial No. 167,063. (No model.) Patented in France May 15, 1885, No. 168,929; in Belgium May 15, 1885, No. 68,880; in England May 15, 1885, No. 5,991; in Germany May 16, 1885, No. 33,408; in Canada June 9, 1885, No. 21,841; in Italy June 30, 1885, XIX, 18,338, XXXVI, 247, and in Austria-Hungary July 30, 1885, No. 17,266 and No. 39,522.

To all whom it may concern:

Be it known that I, ERNST FLEISCHL VON MARXOW, Professor of Physiology at the Vienna University, a subject of the Emperor of Austria-Hungary, residing at Vienna, in the Province of Lower Austria, in the Empire of Austria-Hungary, have invented certain new and useful improvements in Method of and Means for Ascertaining the Amount of Hæmoglobin in Blood, (for which Letters Patent have been obtained in Austria-Hungary, No. 17,266 and No. 39,522, dated July 30, 1885; in Germany, No. 33,408, dated May 16, 1885; in France, No. 168,929, dated May 15, 1885; in Belgium, No. 68,880, dated May 15, 1885; in Italy, Nos. 18338/247, dated June 30, 1885; in England, No. 5,991, dated May 15, 1885, and in Canada, No. 21,841, dated June 9, 1885;) and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

This invention consists in a method of ascertaining the relative or quantitative proportion of hæmoglobin in blood.

The invention further consists in a mode of preparing standard glasses for comparison, by means of which the above process may be carried into practical effect; and, lastly, the invention consists in an apparatus for convenient use in facilitating the carrying into practical effect of both the above methods, substantially as hereinafter described, and as specifically pointed out in the claims.

The method of ascertaining the quantity of hæmoglobin contained in blood is based upon colorimetric principles—that is to say, by the comparison of the color of a volume of blood or blood solution with that of a plate of glass of the corresponding color.

It is a well-established fact that the impression produced by a luminous ray upon the human eye depends on the nature and number of colored molecules through which the ray of light passes before reaching the eye, while the number and distribution of the colorless molecules exert no influence whatever. A given quantity or volume of blood contained in a vessel provided with a transparent bottom and vertical sides will obviously present the same tint or tone of color, whatever the extent of dilution of the blood may be, when the observer looks through the liquid in the direction of a source of light placed in the axis of the vessel, the visual ray being at right angles to the surface of the solution and to the transparent bottom of the vessel. The intensity of the color of the blood solution depends not only upon its density, but also upon the depth of the solution, or, if I may so express myself, the thickness of the layers or strata thereof through which the light is caused to pass. This is precisely the case with a plate of uniformly-colored glass, and for the purposes described I employ the so-called "true ruby glass," as it most nearly resembles blood; hence it will be obvious that if we take a given solution of blood in water, for instance, both quantitatively, and place the same in a vessel, and ascertain the depth of the layer therein, we have a standard to go by. If, now, we take plates of ruby glass of uniform color and varying thickness and compare them with the solution until we find a thickness in the glass plate the color of which will exactly correspond with the blood solution, and mark the same, we have a standard unit, and if this unit indicates the normal amount or volume of hæmoglobin in blood, fractions of this may readily be ascertained, as will presently appear. Upon these principles my processes are based.

The failure of all attempts heretofore made to ascertain colorimetrically the proportion of hæmoglobin in blood by means of so invariable an agent as suitably-colored glass I have found to be due to the following phenomena of absorption of light by a blood solution and by the glass. When two substances of the same color are to be compared colorimetrically, it is not only necessary that their thickness (or degree of transparency) should be alike; but on multiplying their thickness in equal ratio their color should remain the same. It is therefore essential that their properties of absorption of the rays of light should remain the same under the same conditions. This, however, is not the case with blood and the glass mostly resembling it—namely, true-ruby glass. Although their properties of absorption, so far as the production of the Stokes lines or bands in the blood spectrum is concerned, are the same, yet these conditions are not the same with the violet rays, (between the lines G and H of the solar spectrum.) If, for example, a comparison is made between a solution of blood of a given depth or thickness and a glass plate of precisely the same color as the solution, it will be observed that on doubling the thickness of the blood solution the ratio of absorption of the violet rays relatively to the green rays undergoes changes, while the changes in the ratio of absorption of the violet rays relatively to the green rays by the glass plate are not the same when the thickness of the latter is correspondingly increased. This difficulty I effectually overcome by occluding the violet rays from the light passed through both the glass and the blood solution, and this I accomplish in a most simple manner by using a yellow light, such as that obtained from a lamp, candle, or from gas, for the colorimetric observations. This yellow light, when projected through solutions of blood in layers or strata of varying depth or thickness, will be transmitted with correspondingly-varying intensity, and produces upon the eye of the observer exactly the same series of impressions as would be produced by the light when projected through ruby-glass plates under precisely the same conditions.

The human eye is generally so constructed as to distinguish readily different tones or tints of the same color, and, consequently, of recognizing as readily like tints or tones when the same are brought within view side by side; and upon this faculty is based the principle of operation of my apparatus. Under occlusion of the violet rays of light, when a solution of blood and a ruby-glass plate of the same thicknes are brought into juxtaposition and light allowed to pass through both simultaneously, the observer may readily detect the difference in their intensity of color. If, therefore, a ruby glass is compared with a solution of blood containing a normal proportion of hæmoglobin and the thickness of the plate increased or diminished until the two are of identically the same color, a standard glass plate is obtained, which may then be graduated to indicate various proportions of hæmoglobin in the blood by a varying intensity of color, and this constitutes the basis of my method and the means for obtaining or preparing the standard plates of comparison. The latter I obtain in the following manner, referring to the accompanying drawings, in which—

Figure 1 shows, by an isometrical view, (in which portions of the table are broken away to show underlying parts,) an apparatus constructed according to my invention. Fig. 2 is a sectional elevation of the same. Figs. 3 and 4 are top and longitudinal sectional views of the ruby-glass plate.

A indicates the stand, composed of a standard, A′, and suitable feet, A^2, from which all the parts of the apparatus are supported.

Near the upper end of the standard A′, and passing through the same, is a shaft, *s*, that carries at one end a pinion, *e*, and at its opposite end a thumb-nut or button, *f*. To the upper end of the standard is secured a table, *a*, in which is formed a round opening, *a′*, and on opposite edges of said opening are secured grooved guides a^2, in which slides a colorless plate of glass, *c*, which may thus be moved in or out to cover or uncover the opening *a′* in the table. On its under side the table *a* is provided with guides *g* and *g′*. In the latter guide slides a carriage, *d*, that has a depending flange, *d′*, in which are formed teeth that mesh with the pinion *e* on shaft *s*, so that when the said shaft is rotated in one or the other direction by means of the thumb-nut *f*, the carriage will be moved in one or the other direction below the table *a*. To this carriage is secured the ruby-glass plate at one edge, and which, for the purpose of obtaining a standard plate, is prepared as follows: A plate of ruby glass, ground smooth and polished, is preferably first cemented to a plate, *i*, of colorless glass of the same dimensions, and the upper face of the plate *h* is then ground in the form of a wedge and polished. The ruby glass may then be removed from its backing of colorless glass and fitted or cemented to the carriage *d*. In practice, owing to the fragility of the wedge-shaped plate of glass, I prefer to leave it adhering to the backing-plate of colorless glass *i*, in which case it should be cemented thereto by means of a colorless cement or Canada turpentine. The width of the plates *h i* is such that when they are cemented along one edge to the carriage *d* their opposite edge will not only bear against the guides *g*, but will also bisect the opening *a′* in table *a*, for purposes presently explained.

It is obvious that by the described means any point of the edge of the ruby-glass wedge may be brought under one-half of the opening *a′*, and the thickness of the part brought under said opening varied from zero at the attenuated edge to maximum at the termination of the incline.

To the glass plate *c*, at a point so that it will exactly come over the opening *a′*, is secured by a colorless cement a receptacle, preferably a portion of a glass tube, of a given capacity and of the same diameter as the opening *a′* below it. This cylindrical vessel *b* is divided into two equal compartments, b^2 b^3, by a partition, *b′*, also of glass or other preferred and suitable material.

To obtain a standard plate, or, as I will hereinafter denominate the same, a "standard wedge of comparison," I take a small quantity of blood from a strong and healthy male human being of the age of about forty-two, and dilute the same with a given quantity of water, so as to form a solution of given depth when introduced into the compartment b^3 of vessel *b*.

The compartment b^2, I fill with an equal volume of pure water and place a yellow light in such a position that it will be reflected by the reflector *k* and projected through both compartments $b^2 b^3$. The observer, looking through both compartments, moves the wedge until the color of the latter is seen to be like that of the blood solution. This being found, the wedge or the carriage *d* is marked, there being an opening, *l*, in table *a* for this purpose. This operation is repeated with blood taken from different persons in the same conditions, and if found that the point of thickness of the wedge previously marked is in every instance the same, it may be considered as the normal proportional unit of hæmoglobin in human blood, and may be indicated by 100, for instance, or, as I prefer, by one centimeter. By experience I have found that this fact is established when blood is taken from strong healthy men of about the age given, the volume of hæmoglobin having been found the same in each sample of blood. The space between the unit-mark on the wedge and the attenuated edge of the latter is then divided into millimeters, each representing a fraction of the quantitative unit. Thus, for instance, 9^{mm} next to the unit-mark would indicate ninety per cent.; 8^{mm}, eighty per cent., &c. It will thus be easy to obtain from the described standard wedge other wedges, and from these the relative proportion of hæmoglobin in blood may be readily ascertained by comparison, as above described, the degree of solution of the blood and the volume or depth of the solution and water in compartments b^2 b^3 of vessel *b* being known.

It is obvious that in the reproduction of wedges from the standard wedge all such as are made of the same change of glass will be found of uniform color, and may therefore be cut, grooved, and marked by the standard plate. If, however, there is a difference in the color of the glass and the standard plate, as usually happens when the glass is from different changes or meetings, then a plate of the required dimensions is simply brought under the eye in the apparatus, together with the standard plate, both compartments of the vessel *b* being filled with water. The glass plate is first ground down to the form of a wedge, and then moved along under the compartment b^2 of vessel *b* until a thickness is found that will give the same intensity of color as that of the standard wedge. The new wedge is then marked and the space between the mark and the attenuated edge divided into ten equal parts.

Instead of using one centimeter for unit, ten centimeters may be taken for unit to give the wedge a greater range of use, and these may be divided into one hundred millimeters. When the colorimetric unit has been found by comparison either with a blood solution or with a standard wedge, it will then only be necessary to lay off ten equal parts on one or the other side of the unit-mark, and then grind down to a wedge from the unit to the last division, in order to obtain another wedge of comparison from the standard wedge.

It will of course not be necessary to describe the mode of ascertaining the proportion of hæmoglobin in blood, as this will be readily understood from what has been said above, as it is obvious that the wedge will have to be brought to a position when a given thickness thereof will correspond in intensity of color to that of the blood solution under examination, and the mark on said wedge or on the carriage *d* will indicate the proportion of hæmoglobin in the blood.

Having now described my invention, what I claim is—

1. The herein-described mode of obtaining standard units of comparison, which consists in ascertaining the thickness of a plate of ruby glass that corresponds in intensity of color with that of blood containing a normal proportion of hæmoglobin or a solution of such blood by comparison under occlusion of violet rays of light, then grinding the plate from the unit-mark to one extreme or end of said plate in the form of a wedge, the thickness of which is zero at the attenuated edge, and subdividing the inclined surface into equal spaces, as and for the purpose specified.

2. The mode of preparing wedges of comparison from standard wedges, which consists in grinding a plate of ruby glass to present an inclined surface, and ascertaining the unit standard by colorimetric comparison of the various thicknesses of the plate with the unit thickness of the standard wedge until a thickness is found that in intensity of color will correspond with that of the unit of thickness in the standard wedge, and marking the same on the plate and finishing the latter to correspond with or proportionately with the standard wedge, as described.

3. A plate for colorimetric comparison in hæmoglobinometers, consisting of a ruby or blood-colored transparent plate, the intensity of the color of which gradually decreases from a unit or standard intensity of color, and which plate is provided with graduations corresponding with the variations in the intensity of its color, substantially as and for the purpose specified.

4. The combination, with the wedge-shaped ruby-glass plate *h*, provided with a scale indicating degrees of transparency, of a colorless-glass backing, as described.

5. In an apparatus for determining the volume of hæmoglobin in blood by colorimetric

measurement, which consists of a vessel divided into two chambers having a transparent bottom, a wedge-shaped plate of ruby glass adapted to be moved backward and forward under one of the compartments of the vessel, and a reflector for projecting light from below through both compartments and through the ruby-glass plate, as described, for the purpose specified.

In testimony whereof I affix my signature in presence of two witnesses.

ERNST FLEISCHL VON MARXOW.

Witnesses:
VICTOR KARMIN,
JAMES RILEY WEAVER.