glass varying in tint with known quantities of hæmoglobin. 2. A well divided into two equal parts of known depth. 3. A capillary tube of known capacity.

The instrument is used as follows:

Puncture is made in the usual way and the tip of the capillary tube touched to the drop, as seen in illustration

FIG. 579.—Von Fleischl's Hæmoglobinometer. Washing drop of blood from capillary tube with water into one side of double well.

(Fig. 578). No air space must occur in the tube. If the drop at first taken is not enough to fill the tube, in adding more, care should be exercised that the blood is flush with the end of the tube before again touching it to the blood drop. By gently tapping the tube this can be accomplished.

When the tube is quite full we *at once* insert the end into one of the subdivisions of the well, and with the medicine dropper send a stream of clear water forcibly through the tube (Fig. 579). This must be done promptly or the blood will clot in the capillary. The dropper need not be fitted on to the capillary tube, a procedure which often causes the latter to break. If the stream of water has been sent through with sufficient force the capillary will be entirely freed from blood. We then fill the well by dropping water with the dropper through the capillary. This fills the well and at the same time makes sure that all the blood has been washed through.

When the water has reached the top of the well a meniscus, which cannot be avoided, will be observed. When, however, we fill the opposite well with clear water, which we shall proceed to do directly, we must see that the meniscus in each well is of the same depth.

If the well should be full before all the blood has been washed from the capillary tube, then the dropper emptied of the water may be filled with the diluted blood already in the well and this passed through the capillary tube again until the latter is free of all trace of blood. Then the capillary tube is immersed into the well and the contents of the well stirred.

The other subdivision of the well is now filled with clear water, care being taken not to allow the contents of the two wells to mix over the division wall; also that the meniscus in each is of the same depth, as already mentioned.

Attention is called to the fact that the upper portion of the well unscrews for the purpose of cleaning the glass window at the bottom. These two portions should be tightly screwed together before using, so that the fluids will not mingle at the bottom of the well. Moreover, though the wells are the same in all instruments, the prisms of glass vary one from the other in intensity of color. It is necessary, therefore, for the maker to test each prism and ascertain *what is the amount of normal blood* which will correspond to the color opposite the 100 mark. This amount is fixed by the capacity of the capillary tubes. Hence it follows that the capillary tubes tested for a certain instrument should be used only with that instrument. To insure this, the number upon the handle of the capillary tube should be observed, to see that it corresponds with the number on the screw of the stand, just behind the round opening for the well. Then, again, the prism of glass must correspond with the stand, and this is insured by seeing that the number on the stand and that on the metal frame of the glass prism are the same.

The above is a most clumsy method of numbering, arising probably from the fact that different workmen make different parts of the same instrument. The point to be borne in mind is that *the glass prism and the capillary tube must correspond*, and this can be made certain only by observing the above unnecessarily complicated system of numbering. *The wells are of the same depth in all instruments.* The figures on the handle of the capillary tube refer to the capacity of the tube.

We have now filled the two divisions of the well, the one with clear water, the other with a fixed quantity of blood and water.

The frame with the glass prism is now put in place, and the well over the prism, so that the prism shall be opposite that division which contains the clear water.

We now transfer our operations to a dark room lighted only by a small candle. The instrument is placed about eighteen inches away from the candle, and a dark tube is placed over the well in order to shut off the surrounding light from the eye. The plaster-of-Paris reflector is adjusted so as to throw the light into the well, and then the screw of the glass prism frame is turned until the color of the diluted blood and that of the the colored glass correspond (see Fig. 580). The figure which appears in the oval opening is now read, and this is taken as the percentage of hæmoglobin in the blood under observation. Some observers claim that there is a difference of several degrees between observations made with the operator in the position as shown in Fig. 580, and when he is to one

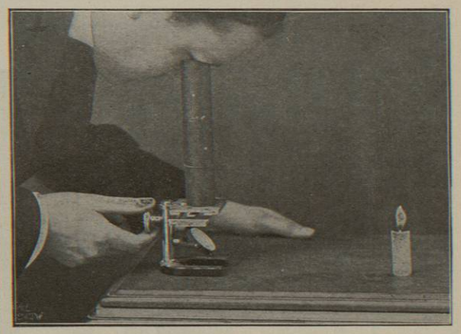

FIG. 580.—Making Observation of Percentage of Hæmoglobin with von Fleischl's Instrument. (Dark room.)

side of the instrument. This claim, based upon difference in color appreciation of the eye in the two positions, seems a trivial one, and has not been borne out by the experiments of the writer.

As observers differ so greatly with one another in the comparison of colors, it is better to report a percentage of

hæmoglobin over a range of 5; for example, 65 to 70 per cent., 80 to 85 per cent., etc.

The quantity of hæmoglobin in grams may be estimated from this by the following simple equation:

$100 : 14 :: y : x$

100 gm. of blood contains 14 gm. of hæmoglobin.

y = the reading on the von Fleischl scale.

x = amount in grams of hæmoglobin in 100 of the blood under observation.

Suppose the reading to be 50, then $100 \times 14 \div 50 = 7$ gm. of hæmoglobin.

This instrument is very convenient for bedside work. Its chief objection is its expensiveness.

Professor Miescher, of Basel, has devised a means by which the blood to be used in Fleischl's instrument may be more accurately diluted. The parts of the von Fleischl-Miescher instrument are shown in the illustration (Fig. 581). The principal changes are, that instead of the capillary tube a graduated pipette is used, by means of which very accurate quantities of blood with accurate dilution may be obtained, and that wells of different depths are employed. There are a few minor changes also. We have been unable to discover any superiority in this instrument over the ordinary von Fleischl apparatus.

If the precautions already laid down by us in speaking of the von Fleischl apparatus are observed (*i.e.*, to see that all the parts correspond), the instrument will be found quite reliable. Certainly we deprecate anything which increases the cost of the already too expensive von Fleischl instrument.

Taylor's Hæmoglobinometer.—The following description and cut (Fig. 582) are from the advertisement of this in-

FIG. 581.—Von Fleischl-Miescher Hæmoglobinometer.

strument. I have had no experience with Taylor's hæmoglobinometer, though evidently it offers no improvement over the von Fleischl instrument. The price is $30.

"This apparatus was suggested . . . by Dr. A. E. Taylor, of the William Pepper Clinical Laboratory of the University of Pennsylvania Hospital. It consists of a fine capillary tube and mixing bulb with bead, similar to that supplied with the Zeiss hæmacytometer, a glass wedge of gradually increasing depth of color (the same as is used with the von Fleischl hæmometer), and a rectangular glass plate with a square raised platform in the centre. This

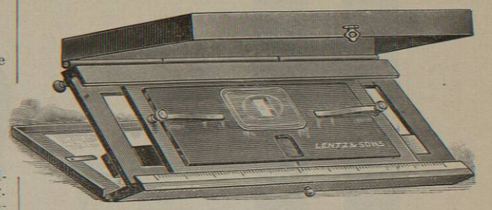

FIG. 582.—Taylor's Hæmoglobinometer.

raised platform, which is cemented to the plate nearer to one side, has in its centre a circular cavity or cell of exactly 1 mm. in depth. The rectangular plate is accurately fitted in a metal frame sliding in grooves, so that the cavity with its contents can be brought successively to any part of the wedge for color comparison.

"To use the apparatus a drop of blood is carefully drawn into the mixing tube up to the engraved mark, and distilled water is then drawn up till the bulb is entirely filled to the second engraved mark on the upper constricted end; the diluted blood is then mixed (by means of the contained bead) by shaking the bulb. The portion remaining in the capillary tube is then blown out and discarded. A part of the diluted blood is then blown out into the cavity in the platform of rectangular plate until it is filled. A ground and polished square cover glass (supplied) is placed on top and the contents of cell are compared with successive parts of the wedge by reflected light from the white background until the color, as seen through both narrow rectangular diaphragms, agrees in depth, when the percentage of hæmoglobin is indicated on the scale. . . .

"The blood examined is of *a known accurate* dilution made with a pipette, which is very much greater in length than that employed in the von Fleischl instrument, so there is less risk of inaccuracy. The quantity of the diluted blood to be compared with the Reichert wedge is *constantly* and *accurately fixed* by the use of a cell of 1 mm. depth, somewhat similar to the cell employed in the Thoma hæmacytometer. . . . The instrument can be closed and easily carried in the pocket, being about the same size as the case of the smaller Thoma hæmacytometer.

"The capillary pipette supplied allows of a dilution of 1 to 10 or 1 to 20."

Oliver's Hæmoglobinometer. — Dr. George Oliver, of London, at the same time that he devised his hæmocytometer constructed a hæmoglobinometer upon the principle of the tintometer of commerce.

As stated in describing the hæmocytometer, the term tintometer is wrongly applied to the corpuscle-counting instrument. The hæmoglobinometer of Oliver, however, does depend for its principle upon the comparison of tints, and it may therefore be called a tintometer.

The principle on which the instrument is based, namely, that every colored liquid, upon dilution or concentration, has a distinctive color curve (the same being true of colored glass) as characteristic as the specific heat of a substance (see quotation from Lovibond, p. 54), places this instrument in point of accuracy above that of Gowers, in which picrocarmine is used, and above that of von Fleischl, in which a gradation of colors is employed.

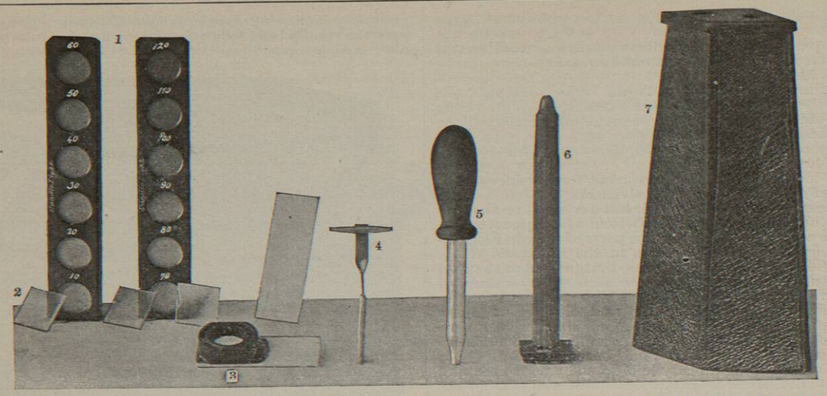

FIG. 583.—Oliver's Hæmoglobinometer. 1, Series of tinted glasses; 2, glasses with more delicate variation in tint to be used as riders; 3, well for reception and dilution of blood; 4, capillary tube for taking blood; 5, dropper; 6, candle and stand; 7, collapsible dark tube.

In Gowers' instrument, while the standard is fixed, yet the blood is continually changing in degree of dilution, and consequently the true color curve is destroyed. Moreover, as already stated, the standard picrocarmine changes color with age. In von Fleischl's instrument the dilution is fixed, but there is no uniformity of color in the area under observation. In Oliver's instrument there is a fixed dilution of a fixed quantity of blood compared with a fixed tint. The diluted blood and the glass that is compared with it must therefore have the same color curve.

The instrument consists of: twelve tinted glasses, in two sets of six each, mounted on white backgrounds of calcium sulphate* and ranging from 10 to 120; a capillary tube (5 cm. capacity) similar to but larger than that employed in the von Fleischl instrument; a dropper; a well with a white background of calcium sulphate; a thick cover slip (Fig. 583).

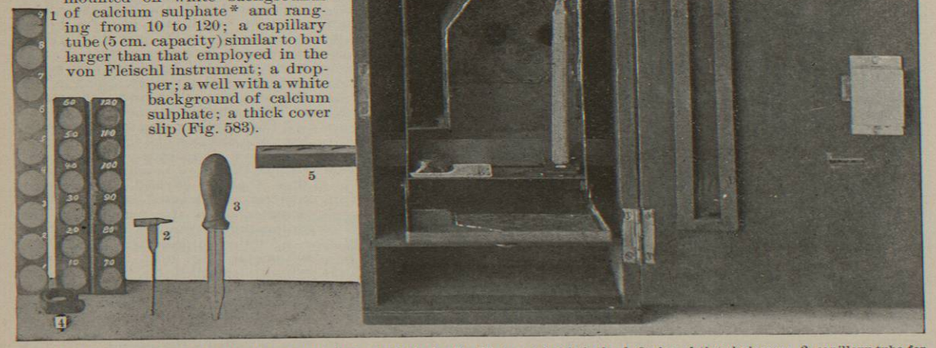

FIG. 584.—Dark Box for Estimating Percentage of Hæmoglobin by the Tintometric Method. 1, Series of tinted glasses; 2, capillary tube for blood; 3, dropper; 4, well for diluted blood; 5, tinted glasses in position to one side of 4, in position, both of which can be seen and compared by looking through 6 when the door 7 is closed and the candle is lighted.

To use the instrument: Puncture is made in the usual way and the blood (quite a large drop) allowed to pass into the capillary tube, care being taken that no air spaces are formed; excess of blood is wiped away. The blood in the tube is then washed into the well by means of a stream of water applied with the dropper. As stated in describing the hæmocytometer of von Fleischl, it is unnecessary and awkward to attach the rubber tube to the capillary. The well is filled to the top, the blood and water thoroughly stirred, and the blue cover glass adjusted. A good light—preferably daylight (see Lovibond quotation, p. 54)—is obtained, and the eye screened as with the von Fleischl instrument; but the dark tube is to be held *about eight inches away* from the well, instead of upon it, as is done in using the last-named instrument. An expensive and, it would seem, unnecessary tube, called a camera tube, is supplied with the instrument.

*This, of many substances tested, was found by Oliver to produce the least confusing influence upon the appreciation by the eye of different tints.

In order to detect differences between 10 and 20, 20 and 30, etc., it is necessary to use riders each of which is equal to 1 degree.

By superimposing these riders until the exact shade of color is reached, and by then adding the number of riders employed to the next lowest figure on the scale, the percentage of hæmoglobin is ascertained. For example, 40 + 3 riders = 43 per cent. of hæmoglobin.

A candle flame may also be used for these observations; the illustration (Fig. 584) shows a box for making observations by candle flame. If such a box is not made use of, the candle should be placed about three inches from the point of observation.

The instrument has the disadvantage of being very expensive. It may be had of I. H. Smith and Co., Zürich, and of Tintometer Co., 6 Farrington Avenue, London, E. C.; price, about $30.

Dr. T. W. Tallqvist, of the Medical Clinic of the University of Helsingfors, Finland, reports in Nothnagel's "Specielle Pathologie und Therapie," Bd. viii., Th. i., Heft i., p. 10, under "Die Anæmie," by Ehrlich and Lazarus, a method for quick estimation of the amount of hæmoglobin by color comparison. By means of a carefully prepared table of colors representing known percentages of hæmoglobin, he compares the blood under examination received upon a piece of filter paper.

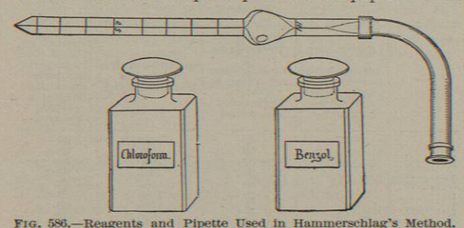

FIG. 586.—Reagents and Pipette Used in Hammerschlag's Method. (Drawn by Dr. E. Dunning.)

By aid of the von Fleischl-Miescher hæmoglobinometer Tallqvist has tested this method and finds ten per cent. the degree of error.

Dr. Arthur Dare has lately devised an instrument for estimating hæmoglobin without dilution of the blood. The instrument is somewhat on the plan of the Henocque hæmatoscope, but is much simpler and cheaper.

3. SPECIFIC-GRAVITY METHODS.—It having been shown (by Siegel and Schmaltz) that the specific gravity of blood varies with the amount of hæmoglobin contained, these methods of estimating hæmoglobin have been placed among the important clinical tests.

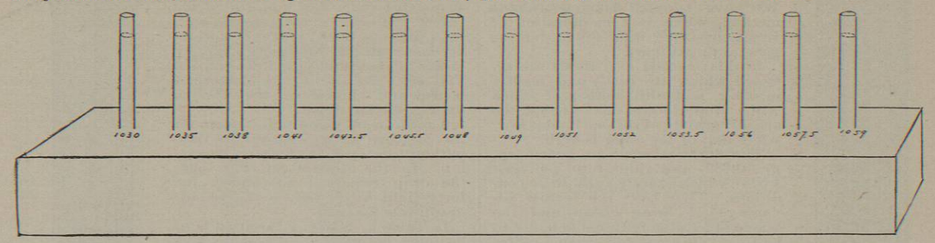

FIG. 585.—Roy's Specific-Gravity Method. (Drawn by Dr. E. Dunning.)

A number of methods have been devised, the most important of which are those of Roy and Hammerschlag. These two methods have for their principle the comparison of blood with heavier and lighter fluids of known specific gravity and such as are non-miscible with blood.

Roy, in his method, employs glycerin and water, fluids of widely different specific gravity. A series of test tubes, as shown in Fig. 585, 4 cm. in diameter and having a capacity of from 80 to 100 c.c., are filled with the two fluids, and the specific gravity of each is determined and marked. Blood is obtained in a pipette or capillary by the usual way. A drop is blown into each test tube, *after the pipette has been submerged in the liquid*, and when that tube is reached in which the blood neither floats on the surface nor sinks to the bottom, the specific gravity of the liquid contained in that tube is read off.

FIG. 587.—Specific-Gravity Method for Estimating Percentage of Hæmoglobin. Blowing drop of blood from capillary tube into receiver containing benzol and chloroform.

Hammerschlag's method, which is clinically the more applicable, makes use of only one tube. In this method benzol and chloroform (Fig. 586) are the liquids employed, which, as before, differ widely in specific gravity and are freely miscible. The blood is introduced as in Roy's method, and the chloroform or the benzol is added until the blood floats in the mixture. The specific gravity of the mixture is then ascertained, which will also be that of the drop of blood.

Dr. Scott, the writer's assistant, working in our laboratory, offers the following comparative observations on the different methods of hæmoglobin estimation:

Comparison between the Gowers and von Fleischl Instruments and the Specific-Gravity Methods for Hæmoglobin Estimation.—In the accompanying tables von Fleischl's and Gowers' instruments and Hammerschlag's specific-gravity method were used. In these experiments the utmost care was taken to fulfil every requirement in the technique of each method. As a description of von Fleischl's and Gowers' instruments, and of their methods of use, have been given in another part of this article, we

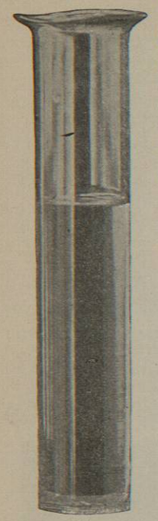

FIG. 588.—Specific-Gravity Method for Estimating Hæmoglobin. Drop of blood suspended in the fluid (chloroform and benzol).

will here describe only the specific-gravity method as employed in making these comparative observations. We have adopted Hammerschlag's method, which is a modification of Roy's, as being best suited for the general practitioner.

In this method two fluids are selected which are easily and readily miscible, and with neither of which will a drop of blood mix; further, the specific gravity of the one fluid is low, while that of the other is high.

The fluids selected are benzol (sp. gr., 0.889) and chloroform (sp. gr., 1.526), which exactly fulfil these conditions. They have the further advantage of being cheap, and the whole apparatus required is likely to be found in every physician's office. We place some of the mixture (sp. gr., 1.050–60) in a dry clean cylinder, and carefully take a drop or two of blood in a Thoma-Zeiss mixer (any capillary pipette, however, will do); we then insert the end of the tube *just below the surface of the mixture*, and blow out a drop of the blood (Fig. 587). The blood is seen as a bright red globule which does not mix with the fluid, but either sinks to the bottom, floats on the top, or remains suspended in the fluid (Fig. 588). If it sinks to the bottom this is because it is heavier than the fluid, and more chloroform must be added. If it floats on the top, more benzol is required (Fig. 589). If it remains suspended, it is of the same specific gravity as the fluid (Fig. 590). It is well to add the necessary benzol or chloroform only one drop at a time from a medicine dropper (see Fig. 589), and to stir the fluid with a glass rod to cause complete mixture. It has been found that matters are very considerably simplified, and much time and patience are

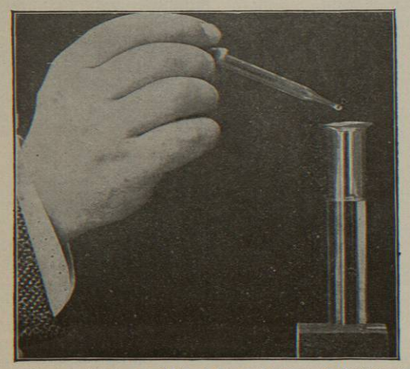

FIG. 589.—Specific-Gravity Method for Estimation of Percentage of Hæmoglobin. Adding fluids (benzol or chloroform) until drop of blood is suspended.

saved, by having the mixture of such density that the drop of blood will sink to the bottom. It is much easier to make the globule rise by the addition of chloroform drop by drop than it is to cause it to sink by the gradual addition of benzol. Let the drop of blood remain suspended for a few minutes to see that it will neither float nor sink, and, then, when satisfied that it is stationary, ascertain the specific gravity by means of an ordinary hydrometer (see Fig. 590). By filtering the mixture of benzol and chloroform they can be used again and again.

The drop of blood will remain in the mixture for a considerable time without its specific gravity changing. In the illustration (Fig. 590) the drop remained suspended for forty-eight hours before the photograph was taken.

In Table I., below, a variation is to be noted between von Fleischl's and Gowers' estimates, but the variation is not constant in either direction. There is more steady agreement between those of von Fleischl and of Hammerschlag respectively; and this is more particularly seen in Table II., which gives comparative estimates of hæmoglobin of the blood from each ear of the patient. Here, too, it will be seen that the specific-gravity readings are quite constant; while the von Fleischl readings vary somewhat, and those of Gowers vary considerably.

Dr. Scott's tables show very satisfactorily how little is the variation between the specific-gravity method, which is so simple in cost, and the expensive instruments. Even with the von Fleischl instrument one prefers to report his observations over a range of five points—75 to 80 per cent., for example; while with the specific-gravity method the observations can be more precise—as in Dr. Scott's tables, where in most instances the observations are within a range of two or three points. Such reading would also include the reading with Gowers' or von Fleischl's instrument. It was for the purpose of determining the accuracy of the specific-gravity method that Dr. Scott made these observations, and our conclusion is that this method is, clinically, perfectly reliable and satisfactory.

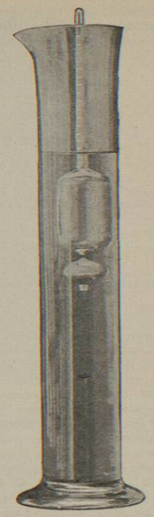

FIG. 590.—Specific-Gravity Method for Estimating Percentage of Hæmoglobin. Taking specific gravity of fluid. Drop of blood seen suspended in fluid.

TABLE I.

No.	Percentage of hæmoglobin according to von Fleischl's hæmoglobinometer.	Percentage of hæmoglobin according to Gowers' hæmoglobinometer.	Specific-gravity. Method of Hammerschlag.	Percentage of hæmoglobin corresponding with this specific gravity.
1	68	69	1050	65
2	71	69	1052	68–9
3	68	67	1050	65
4	63	59	1049	60
5	75	69	1055	75
6	73	69	1054	72
7	78	71	1056	80
8	76	77	1054	72
9	78	77	1056	80
10	93	89	1059	91–2
11	81	81	1056	80
12	68	67	1052	68–9
13	73	69	1054	72
14	65	68	1051	67–8
15	92	87	1059	91–2
16	64	62	1050	65
17	91	92	1059	91–2
18	53	57	1048	55
19	82	88	1057	85
20	61	55	1049	60
21	52	49	1047	51–2
22	65	66	1050	65
23	78	76	1056	80
24	81	73	1056	80

TABLE I.—*Continued.*

No.	Percentage of Hæmoglobin According to von Fleischl's Hæmoglobinometer.	Percentage of Hæmoglobin According to Gowers' Hæmoglobinometer.	Specific-gravity Method of Hammerschlag.	Percentage of Hæmoglobin Corresponding with This Specific Gravity.
25	78	77	1057	85
26	77	73	1056	80
27	96	91	1060	95
28	62	69	1049	60
29	85	66	1057	85
30	58	57	1050	65
31	71	69	1053	70
32	68	68	1052	68–9
33	86	79	1058	88–9
34	82	83	1057	85
35	81	83	1057	85
36	78	73	1056	80
37	80	74	1057	85
38	80	78	1056	80
39	87	83	1058	88–9
40	90	90	1059	91–2
41	75	72	1055	75
42	68	67	1052	68–9
43	81	83	1056	80
44	81	84	1056	80
45	78	76	1055	75
46	88	88	1058	88–9
47	86	83	1057	85
48	78	72	1056	80
49	85	87	1057	85
50	82	80	1056	80

TABLE II.

No.	Left Ear.			Right Ear.		
	Von Fleischl.	Gowers.	Specific Gravity.	Von Fleischl.	Gowers.	Specific Gravity.
1	87	83	1058	88	84	1058
2	90	90	1059	90	90	1059
3	75	72	1055	75	73	1055
4	68	67	1052	68	67	1052
5	81	83	1056	81	83	1056
6	81	84	1056	81	83	1056
7	78	76	1055	78	76	1055
8	88	88	1058	88	86	1058
9	86	83	1057	86	82	1057
10	78	72	1056	78	74	1055
11	85	87	1057	85	86	1057
12	82	80	1056	82	80	1056

Color Index.—This refers to the relation between the number of red cells and the percentage of hæmoglobin.

Suppose the red blood corpuscle count to be 5,000,000; this being the normal, we may designate it as 100; then:

5,000,000	red	blood	corpuscles	= 100
4,500,000	"	"	"	= 90
4,000,000	"	"	"	= 80
3,500,000	"	"	"	= 70
3,000,000	"	"	"	= 60, etc.

Suppose the hæmoglobin to be 100 per cent. This is the normal. Then $\frac{100}{100} = 1$, represents the normal state of the blood; 1 is the normal color index.

A general formula by which the color index may be arrived at would be the following:

$\frac{A}{B}$ = color index, in which A = percentage of hæmoglobin and B the number of red blood corpuscles reduced to terms of 100.

Examples: Chlorosis, $\frac{50}{100} = 0.5$ color index. Pernicious anæmia, $\frac{40}{50} = 0.8$ color index. Secondary anæmia, $\frac{60}{80} = 0.75$ color index.

Chlorosis, it will be seen, has the lowest index, pernicious anæmia the highest; that is, in pernicious anæmia each corpuscle is carrying more hæmoglobin than is the case in chlorosis. This is the *value globulaire* of French writers.

The Anæmias—detected by the use of the blood-counting and hæmoglobin-estimating apparatus. (For complete table, see page 69.)

- Anæmia
  - Primary
    - Chlorosis,
    - Pernicious.
  - Secondary
    - Hemorrhage
      - Purpura,
      - Menses,
      - Hemorrhoids, etc.
    - Poisons
      - Arsenic,
      - Lead,
      - Mercury,
      - Silver, etc.
    - Diseases
      - Wasting diseases,
      - Malaria,
      - Inanition,
      - Tuberculosis,
      - Chronic suppuration,
      - Chronic Bright's,
      - Pyrexia, etc.

Terms: Oligæmia—*ὀλιγος*, too little, *αἷμα*, blood—too little blood. Oligocythæmia—*ὀλιγος*, too few, *κυτος*, circle, *αἷμα*, blood—too few blood cells. Oligochromæmia—*ὀλιγος*, too little, *χρῶμη*, coloring matter, *αἷμα*, blood—too little coloring matter. Leukæmia,—*λευκος*, white, *αἷμα*, blood—white blood. Leucocytosis—*λευκος* white, *κυτος*, circle, *οσις*, full of—full of white corpuscles.

IV. Blood-Clotting.

The fact that normal blood requires a fixed time for clotting, and that in certain diseases this time varies, makes the phenomenon of blood-clotting of clinical value. However, in the description of apparatus and technique employed in the clinical examination of blood, the discussion of the various causes, etc., producing this phenomenon can have no place. Text-books on physiology and the article on *Coagulation* should be consulted for information on this subject. Therefore, beyond describing the apparatus employed and mentioning the diseases in which variations in the time required for clotting occur, the subject will receive no further consideration.

Two methods for determining the rate of coagulation may be employed:

1. The rough test, in which two drops of blood, as nearly equal in size as possible—one from the case under observation and one from a normal individual—are compared as to clotting time.

2. The more accurate test, in which Wright's coagulometer tubes are employed.

1. *The Rough Test.*—A drop of blood from the case under observation is received on a glass slide, and simultaneously a drop as nearly as possible of the same size as that from the suspected case is taken from a normal case and placed upon another glass slide. The time at which the operation is begun is noted. The two slides are placed side by side, and by means of a pin touching the edge of the drop, the stage of the process of clotting is ascertained from time to time. The moment of complete clotting is determined when the pin, being drawn from within outward, no longer leaves a small projection at the periphery of the drop. The time is noted and compared with that of the normal blood. This is a test by comparison. The actual time should not be taken.

2. *The More Accurate Test.*—In this test, equal quantities of blood are taken by means of accurately graduated tubes. These tubes are blown through, one after another, until that tube is reached which cannot be blown out, and in which, therefore, the contained blood has clotted. The time from the taking of the blood to the moment when the blood has clotted is noted, and this is termed the "coagulation time."

Wright's coagulometer tubes are of two kinds (Fig. 591): 1. Those for testing the coagulation time of the

blood. 2. Those for testing the coagulation power of certain substances.

1. *Those for Testing the Coagulation Time of Blood.*—These tubes have a centimetre scale, 6 cm. in all, and are

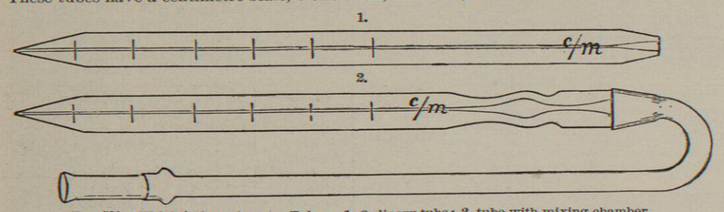

FIG. 591.—Wright's Coagulometer Tubes. 1, Ordinary tube; 2, tube with mixing chamber.

shaped as seen in Fig. 591. There are eight such tubes in a set. There is also a round tin receiver, surrounded by a jacket, in which there are nine pockets—eight for the reception of the tubes, the ninth being for the reception of a thermometer (Fig. 592). This part of the apparatus is for the purpose of heating the tubes to blood heat before use by placing heated water in the centre tin. This is not essential, as the normal blood is found to be coagulated in the same time without previous heating of the tubes as when such heating is carried out. If heating is resorted to, the thermometer should register 18.5 cm. (half blood heat), or, if clotting is very slow, 37.0 cm. (blood heat).

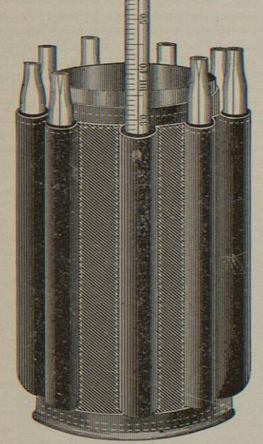

FIG. 592.—Case and Warm Chamber for Wright's Coagulometer Tubes. Chamber for warm water in centre surrounded by leather jacket containing tubes and thermometer.

The test is made as follows: The tubes, as seen in illustration (Fig. 591), are laid out (if the heating tin is not used) on a sheet of white paper on a table at the bedside. An open watch is also laid upon the table. A fairly large puncture is made in the skin in the usual way. A rubber tube with mouthpiece (similar to that used with the Thoma-Zeiss mixer) is attached to the first tube and blood is drawn up to the fifth division, the time by the watch being noted. Taking the point of the tube away from the blood drop, the column of blood is drawn up to the sixth marking, thus removing the end of the column from the immediate influence of the air. This tube is laid upon the white paper, and the moment at which the observation is begun noted down. In about half a minute the second tube is treated in the same way, in another half-minute the third, and so on for the whole set. After the lapse of about one minute the first tube is gently blown through; if the blood is still liquid the second tube is blown through; and so on until a tube is reached from which the blood cannot be blown. The time at which this condition is observed is at once noted and compared with the time, as marked on the paper, at which the observation of the blood in that tube was begun. The difference between the two numbers constitutes the time required for this specimen of blood to clot, and is therefore the "coagulation time." *The time is taken from the moment the blood is drawn into the tube to that at which it cannot be blown from the tube.*

2. In using the instrument to determine the coagulation power of certain substances, the tubes with the mixing space are employed (see illustration, Fig. 591, 2). The substance to be tested is drawn up to one of the divisions on the tube, say the second. Blood is then also drawn up, and the blood and substance to be tested are thoroughly mixed in the mixing space. Unmixed blood is now drawn into another tube, and the different coagulation times for the two tubes are noted. Prof. Wright exhibited at the Paris Congress, August, 1900, an improvement upon this instrument. The author has obtained the first of these improved instruments placed upon the market, but has not as yet tested it sufficiently to warrant him in expressing an opinion.

Cleansing the Tubes.—This is one of the annoyances of the Wright tubes, for unless cleaned *at once* the tubes become hopelessly clogged. It is well, therefore, to have an attendant draw clear water into each tube the moment the observation has been made upon that tube. It is evident that as the observer is occupied with his observations, those tubes already tested, and containing traces of blood, will become dried out and clogged. A wire should be passed down the tubes to break up the clotted blood.

When *all trace* of blood has been removed, and *not till then*, 95 per cent. alcohol should first be drawn through the tubes, and afterward ether. The tubes will then be ready for use again. The importance of prompt action in the matter of cleaning the tubes cannot be too emphatically stated; disregard of this promptness will render the tubes useless.*

Comparative Time of Coagulation in Certain Diseases.

(*Normal, two to three minutes.*)

Coagulation Rapid.	Coagulation Delayed.
Malignant disease: inflammation or sloughing in progress.	Malignant disease: uncomplicated.
Pneumonia.	
Hæmoglobinæmia: in severe grade of malaria; in severe grade of septicæmia; in yellow fever; in typhus fever; in burns.	Jaundice (important in operation for gall stones, as one of the most common complications causing fatal results is post-operative hemorrhage due to reduced coagulability of the blood.
Poisons: snake poisoning; chlorate of potassium; antipyrin and antifebrin; hydrocyanic acid; phenacetin; phosphorus; carbonic acid; illuminating gas.	Obscure conditions associated with frequent attacks of epistaxis: hæmophilia; scurvy; erythema multiforme; pernicious anæmia; anæmia, delayed in accordance with severity; purpura hæmorrhagica.

* The Wright apparatus may be had of Alfred E. Dean, 73 Hatton Garden, London, E. C., for £2 5s; the improved instrument of T. Hawksley, 357 Oxford Street, London, for £1 15s.

The coagulation time may be increased by

1. Inhalation of carbonic acid gas.
2. Ingestion of calcium chloride.
3. The gelatin treatment for aneurism. (*a*) Lancereaux's method: 4–5 gm. white gelatin dissolved in 200 c.c. of 0.7 per cent. sodium chloride solution and sterilized at 120° C. (*b*) Futcher's method: 250 c.c. of one-per-cent. gelatin solution in normal salt solution (*Journal of American Medical Association*, January 27, 1900).

Detection of Blood when in Small Quantities.—For full information upon the more complicated apparatus and technique (spectroscopic and chemical) employed in the detection of blood for medico-legal purposes, the reader is referred to the article on *Blood Stains*.

A simple clinical test is the following: Allow a few drops of the fluid supposed to contain blood (urine, gastric contents, etc.) to dry upon a glass slide. Add to the margin of the dried fluid a few grains of common salt. Now from a pipette allow a drop or two of glacial acetic acid to attack the salt and dried fluid. Gently heat the slide until the acid has dried entirely; examine with low power. If blood is present crystals of hæmin will have formed. Hæmin is a derivative of hæmatin (or hydrochlorate of hæmatin) which is thus produced. If no blood be present no crystals will be formed.

VI. Staining of Dried Specimens of Blood.

Through the labors of Ehrlich we have learned that the blood corpuscles react variously to the aniline dyes: that some of the white corpuscles contain specific granules which in health react to these dyes in one way, while in disease these same granules react in a different way. So constant is this peculiarity that an entire system of diagnosis has become possible simply through the process of staining the blood.

As this branch of the study of the blood depends entirely upon the peculiar reaction, not of the corpuscles as a whole, but of certain parts of the corpuscles, our technique must be even more delicate than in any system of diagnosis already described.

There are two methods of preparing the blood for staining: (1) The slide method. (2) The cover-slip method.

(1) *The Slide Method.*—Puncture is made in the skin

FIG. 593.—Method of Taking Dried Specimen of Blood. First step.

in the usual way. A drop of blood is received at one end of an absolutely clean glass slide. The edge of another glass slide is dipped into the drop of blood and drawn gently along the surface of the first slide. This produces a large and fairly thin smear of blood. The objections to this method are: (*a*) Too large a smear; (*b*) smear not thin enough; (*c*) unequal spread, thicker in one place than in another; (*d*) apt to mutilate the corpuscles.

(2) *The Cover-Slip Method.*—Several No. 1, ¼ inch, square Bausch and Lomb cover slips are *thoroughly* cleaned with alcohol and ether. Every trace of dust and cloudiness must be removed. These cover slips are placed on a sheet of white paper on a table near the patient. It is hardly necessary to state that they should be held

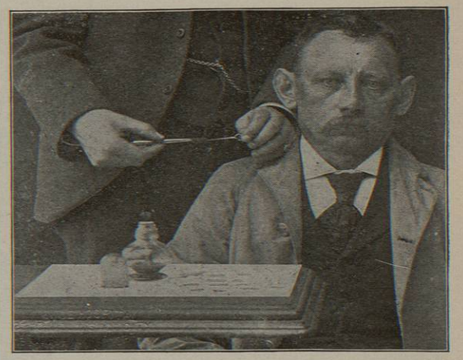

FIG. 594.—Method of Taking Dried Specimen of Blood. Second and third steps.

by the edges and not by the flat surface—that portion which comes in contact with the blood, and which, therefore, we should take every precaution to keep clean. A lighted spirit lamp should also be at hand. The point of puncture is cleaned with alcohol and ether; this is more important in taking the dried specimen than in taking the fresh specimen. One of the cleaned cover slips is placed in the clamp forceps, as shown in Fig. 540, No. 4 *b*, p. 33, and the forceps thus armed laid upon a table near at hand. Puncture is made in the usual way. After removing the first drop, the clamp forceps holding the cover slip is held in the left hand, and the second drop is received upon a cover slip held by the open forceps (see Fig. 540, No. 5, p. 38) in the right hand. This is the first step, and is shown in Fig. 593.

The cover slip with the drop of blood is *immediately* transferred to the cover slip held in the clamp forceps, as follows: The edge of the cover slip upon which is the drop of blood and which is held in the open forceps is placed against the end of the limb of the clamp forceps holding the other cover slip. Thus held, the cover slip is slowly lowered until the drop of blood almost touches the undermost cover slip. The right hand forceps is then opened and withdrawn, which allows the cover slips to come together with the blood between and spreading equally in all directions. This is the second step, and is shown in Fig. 594. If these steps have been carefully carried out, the blood specimen should appear as in the illustration (see Plate XIII., Fig. 1).

Directly the blood is no longer seen to spread the two slips are drawn apart, in such a manner, however, that they shall at all times be *parallel with each other*. This drawing apart must be *quickly done*, for if performed too slowly it will be found very difficult to keep the slips parallel with each other—an essential point,—the upper slip rising at the last and making a great clump of blood on the lower slip

In order to act thus quickly, and to be sure of the slips coming away at one pull, it is well to take an additional hold upon the clamp forceps far down the limbs, near to