Feb. 13, 1951 E. HEFTMANN 2,541,056

SCREENING METHOD FOR BLOOD GLUCOSE

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Fig. 1.

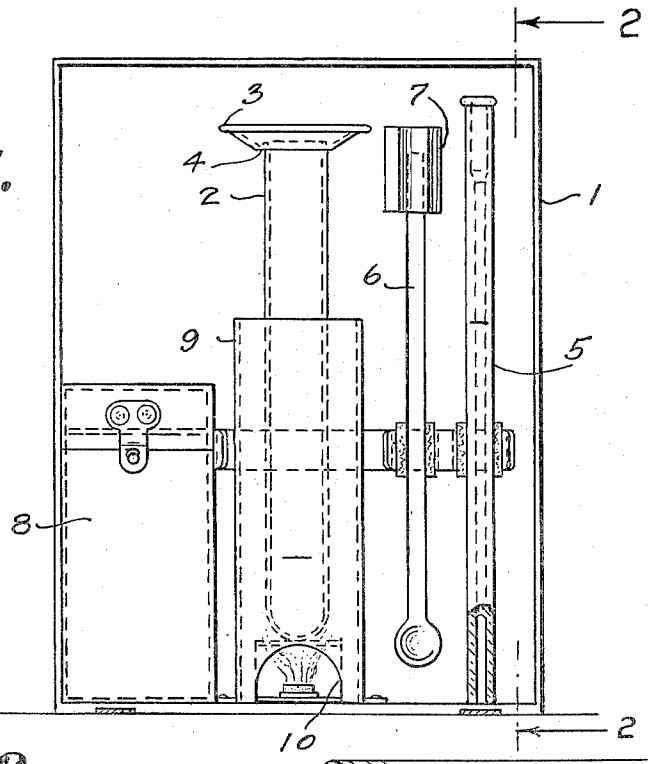


Fig. 2.

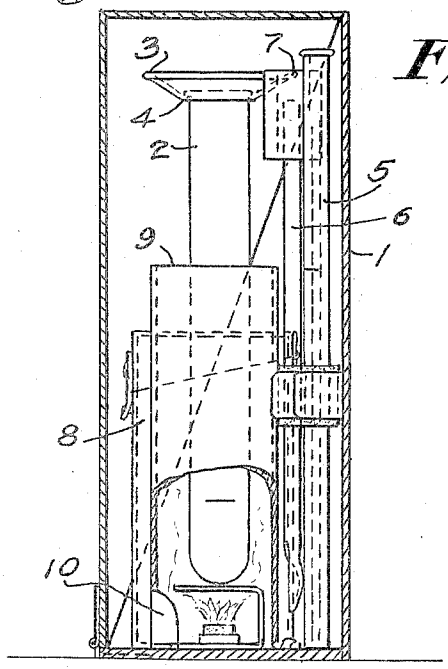
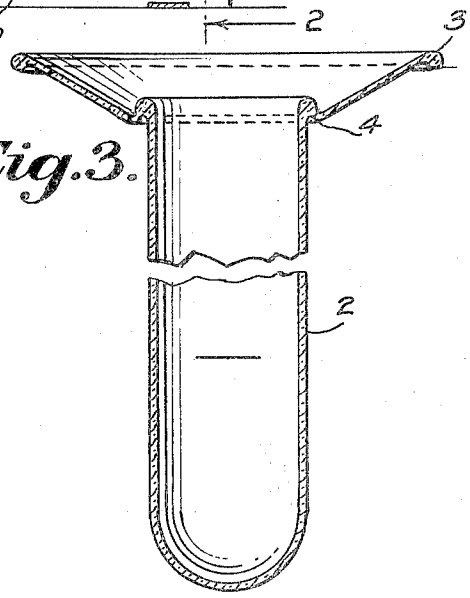


Fig. 3.



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SCREENING METHOD FOR BLOOD GLUCOSE

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5 Claims. (Cl. 23—230)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the act of April 30, 1928 (Ch. 460, 45 Stat. L. 467).

This invention relates to a method and apparatus for checking or determining the sugar content of a blood sample.

In checking or determining the sugar content of a blood sample it is not necessary in ordinary circumstances to determine the exact quantity of sugar present. For the practising physician it normally is necessary merely to discover whether or not the sugar content lies within tolerable limits. The ordinary physician has neither the skill nor the facilities for making a blood sugar determination employing the usual and known methods of sugar analysis.

It is an object of this invention to afford a simple method for making a quick check of the blood sugar content and to provide compact apparatus for conducting the test.

It is a further object to provide a method which will require no special laboratory skill or technique.

It is still another object to provide suitable reagents in a handy tablet form, thus eliminating the necessity for careful measurement by the person conducting the test or making the analysis.

In describing the invention, reference will be made to the accompanying drawing which illustrates the preferred form of the apparatus to be employed in carrying out the process, and in which

Fig. 1 is a front elevation of a kit containing the testing apparatus;

Fig. 2 is a side elevation of the kit of Fig. 1; and

Fig. 3 is a cross-sectional view of a special test tube making up a part of the kit shown in Fig. 1.

Referring to Fig. 1 of the drawing, in which similar reference characters designate corresponding parts, 1 is a carrying case which permits a practising physician to make tests while on call. The kit is provided with a graduated test tube 2, shown in detailed section in Fig. 3. The test tube is made of a heat-resistant glass or other suitable material. The lower portion of the tube is of more or less conventional design. At its upper end, however, it is provided with a flared mouth 3, which has an annular depression or lip 4. A pipette 5 provides a means for measuring liquids used in the test or analysis. At 6

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is shown a stirring rod equipped with a scoop or ladle 7. A box 8 contains a supply of reagents used in conducting the test. The test tube 2 is mounted in a holder 9, provided with an opening 10 for the insertion of solid fuel tablets which are burned to heat the reagents during the test.

In carrying out the test or analysis, reagents in predetermined quantities are made up into tablets for convenient use. The tablets used have the following compositions:

Tablet I

	Mg.
$ZnSO_4.7H_2O$	10
NaCl	90

Talc, sufficient to act as binder.
Mineral oil, as lubricant.

Tablet II

	Mg.
KI	100
$NaHCO_3$	10

Tablet III

	Mg.
$K_3[Fe(CN)_6]$ recrystallized	1.28
Na_2CO_3 anhydrous	6.5
Starch (soluble)	1
NaCl	92

Tablet IV

	Mg.
Tartaric acid	80
$ZnSO_4.7H_2O$	20

Starch, as binder.

The heating tablets are composed of 0.16 mg. of hexamethylenetetramine. Other combustible fuel tablets may be employed for heating the reaction mixture.

In conducting an analysis employing the method and apparatus of this invention, the following procedure is carried out.

The test tube 2 is filled to the 5 ml. mark with water. An 0.1 ml. sample of blood is added to the water, care being taken that the entire quantity of the blood sample is added. The blood may be measured in a capillary pipette and the pipette rinsed in the water in the test tube. Thereafter one Tablet I and one Tablet II are added to the test tube, which is then heated by igniting two heating tablets in the space 10 of the holder 9. The blood proteins are coagulated and form a scum which floats on top of the liquid. As the solution boils, the cake of protein is forced to the top by the steam and may be readily re-

moved with the scoop or ladle carried by the stirrer 6. The flared mouth of the test tube prevents loss of liquid or reagent by boiling over, and the annular lip or depression catches the protein cake and prevents its return to the solution.

After the removal of the protein another heating tablet is ignited and one Tablet III is added to the solution. When the heating tablet is consumed the test tube is cooled by immersion in cold water. Thereupon one Tablet IV is added to the solution. The solution will then appear blue if free iodine is present, or will remain substantially colorless if there is no free iodine.

The blood proteins are coagulated by the zinc-hydroxide formed by the reaction of the zinc sulphate of Tablet I and the sodium bicarbonate of Tablet II. During the subsequent heating in the presence of Tablet III the glucose present in the blood reacts with the $K_3[Fe(CN)_6]$. In the hot solution, alkaline due to the sodium carbonate, glucose reduces $K_3[Fe(CN)_6]$ to

$$K_4[Fe(CN)_6]$$

The amount of potassium ferricyanide in Tablet III is so adjusted that it will be completely reduced by the glucose present in 0.1 ml. of blood when the glucose concentration is 180 mg. per 100 ml. of blood. Cooling and the addition of the tartaric acid of Tablet IV interrupts the reaction. If the glucose concentration is less than 170 mg. per 100 ml. there will be some unreacted potassium ferricyanide left which will react with the KI in Tablet I releasing iodine. In the presence of the zinc sulphate of Tablets I and IV, the released iodine produces a blue color by reaction with the starch of Tablets III and IV.

This procedure provides a quick method for classifying blood samples as containing above 180 mg. per 100 ml. of glucose, or below 170 mg. per 100 ml. of glucose. This is accomplished by the fixing of the quantities of the reagents and the heating periods.

It is obvious that by adjusting the quantities of the reagents, and the size of the heating tablets that any selected range of concentrations of glucose may readily be determined. Thus tablets designed to check the blood sugar concentration between the limits 80 mg. to 70 mg. per 100 ml. may be useful in the emergency diagnosis of hypoglycemia (abnormally low blood sugar content due to overdose of insulin, etc.). In this case the composition of Tablet III is altered by reducing the $K_3[Fe(CN)_6]$ content from 1.28 mg. to 0.53 mg. The other tablets remain the same.

It is also apparent that equivalent reagents, for example other alkaline reagents or acid reagents, may be used without departing from the spirit or scope of my invention.

Numerous other changes may be made in the method and apparatus in applying the underlying principles of my invention, and the inventor is not to be limited to the form shown or described.

Having described the invention, what is claimed is:

1. A method for the determination of the blood sugar concentration of a sample of blood, which comprises making an aqueous solution of a predetermined quantity of blood in a predetermined quantity of water, coagulating the protein of the blood while heating the solution and then removing the precipitate, adding a predetermined quantity of potassium ferricyanide, starch and potassium iodide in the presence of an alkaline reagent, heating the solution for a predetermined time, then cooling while adding an acid reagent to check the reaction.

2. A method for checking to determine the blood sugar concentration in a blood sample which comprises adding 1 ml. of blood to 5 ml. of water, heating the solution for a predetermined period in the presence of 10 mg. of $ZnSO_4.7H_2O$; 90 mg. of NaCl; 100 mg. of KI and 10 mg. of $NaHCO_3$, to precipitate the protein content of the blood and preheat the solution, removing the precipitate, continue heating the solution for a predetermined time in the presence of 1.28 mg. of $K_3[Fe(CN)_6]$, 6.5 mg. of Na_2CO_3, 1.0 mg. of starch and 92 mg. of NaCl, then cooling the solution while adding 80 mg. of tartaric acid, 20 mg. of $ZnCO_4.7H_2O$ and starch.

3. An apparatus for conducting chemical reactions which comprises an open container provided with an outwardly flaring funnel like extension at its mouth said extension joining the main body of the container at the exterior thereof and below the upper edge of the mouth to form a gutter like depression around the mouth.

4. A method for analyzing the sugar content of a sample of blood which comprises heating a 5 ml. aqueous solution containing 1 ml. of blood, coagulating the protein content of the blood by adding zinc sulphate and sodium carbonate to the solution, removing the coagulated protein, adding KI and 1.25 mg. of $K_3[Fe(CN)_6]$ and starch while continuing the heating, then cooling and adding tartaric acid.

5. A method as set forth in claim 3, in which the amount of potassium ferricyanide is 0.53 mg.

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