

[54] **DEVICE FOR MEASURING VENOCAPILLARY FILLING TIME**

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[58] Field of Search ...128/2 R, 2 A, 2 L, 2 S, 2.05 A, 128/2.05 E, 2.05 F, 2.05 P, 2.05 V; 250/217, 227, 239

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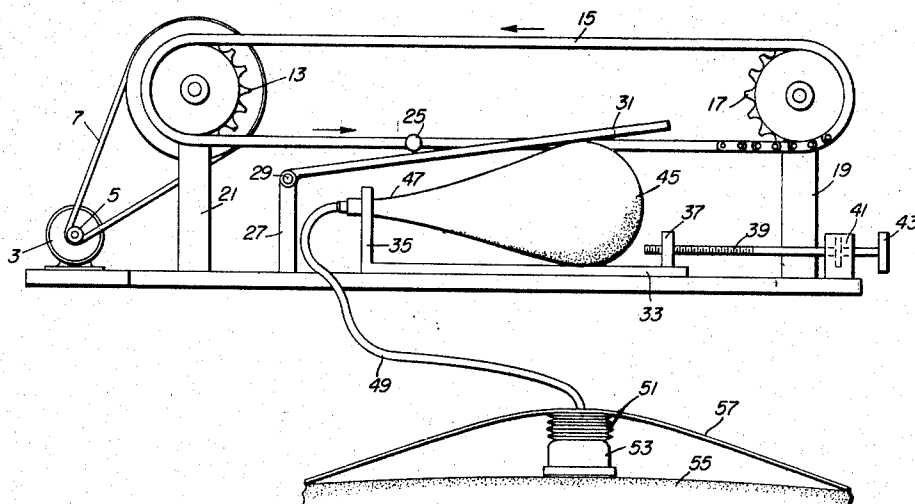
Primary Examiner—Kyle L. Howell

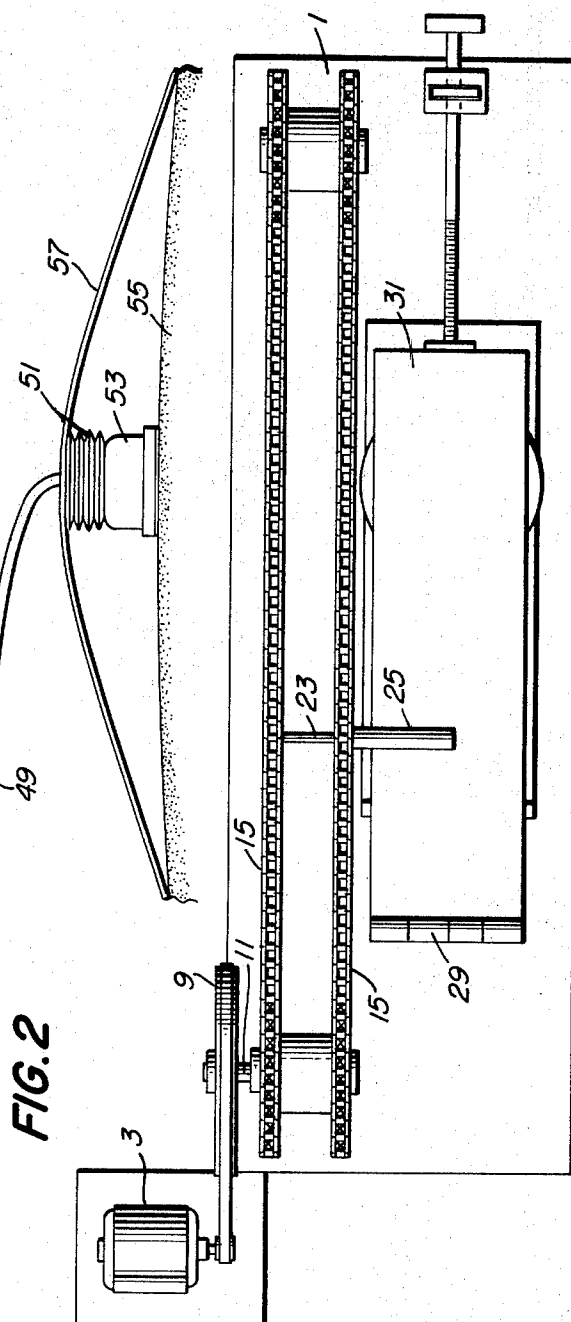
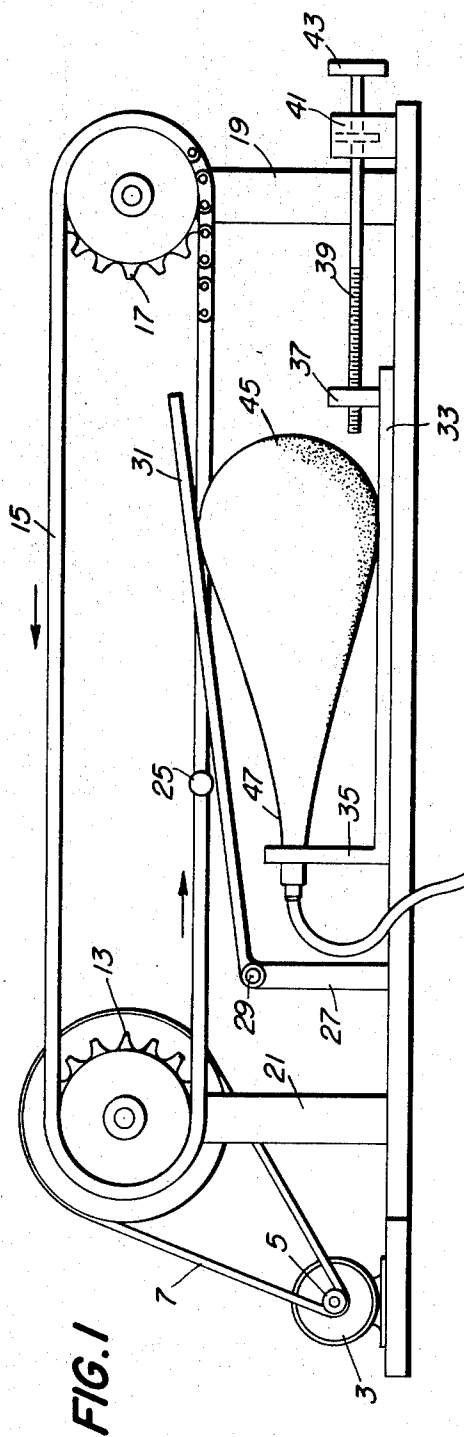
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[57] ABSTRACT

Apparatus for automatically applying intermittent and uniform pressure to the skin of a patient at predetermined and variable time intervals, in order to force blood from the blood vessels subjacent to the skin area to which pressure is applied, and further apparatus for measuring the rate of return of the blood into the collapsed blood vessels upon release of pressure from the skin.

9 Claims, 6 Drawing Figures





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FIG. 3

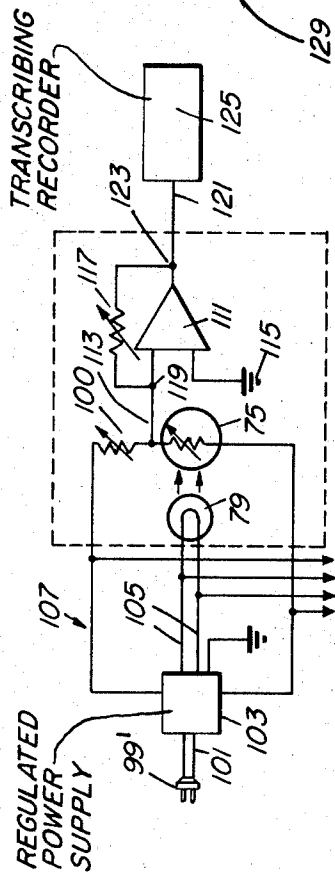


FIG. 5

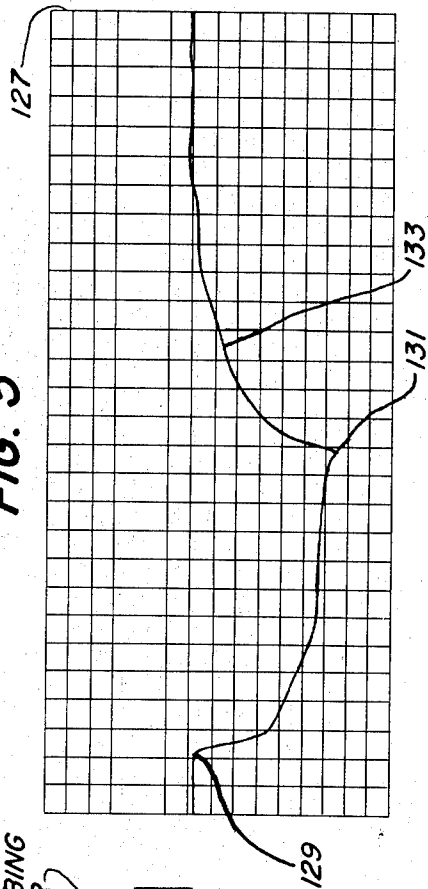


FIG. 4

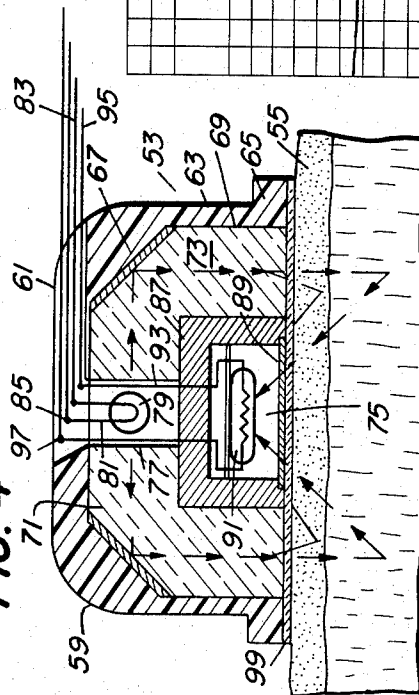
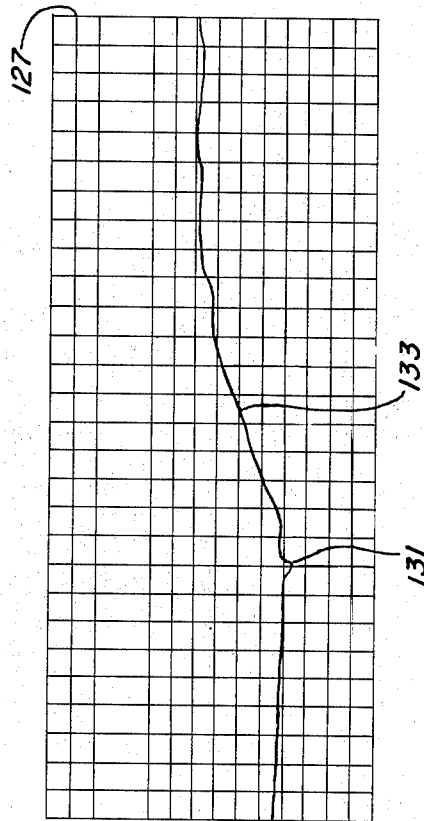


FIG. 6



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DEVICE FOR MEASURING VENOCAPILLARY FILLING TIME

This invention relates broadly to the art of measuring venocapillary filling time and in its more specific aspects it relates to either automatic or non-automatic means for intermittently applying uniform pressure to the skin and measuring the rate of return of blood into the collapsed blood vessels; and the nature and objects of the invention will be readily recognized and understood by those skilled in the arts to which it relates in the light of the following explanation and detailed description of the accompanying drawings illustrating what I at present believe to be preferred embodiments or mechanical expressions of my invention from among various other forms, arrangements, combinations and constructions, of which the invention is capable within the spirit and scope thereof.

It is well known that upon the application of pressure to the skin of a patient the blood vessels subjacent to the area upon which pressure is applied are collapsed and the blood is forced therefrom, and that upon release of the pressure the blood will flow back into the formally collapsed blood vessels.

It is also a well known fact in medical science that it is significant in the diagnosis of certain conditions in a patient to be aware of the rate of return flow of the blood into the blood vessels which have previously been collapsed to force the blood therefrom. As an example of the broad general concept involved in my invention, when a person is frightened he turns white due to constriction of blood vessels so that less blood gets into the skin. Vasoconstriction is a manifestation of abnormal stress and may be prolonged and severe in impending shock. When a patient is under anesthesia the anesthetist applies pressure to the skin of the forehead so that this pressurized area becomes white, and upon release of pressure the anesthetist watches the rate at which the color comes back and this rate of return of color is of substantial significance, since the rate of return of color if delayed is indicative of vasoconstriction and that the patient may be going into shock, and additionally the rate of return of color or blood to the previously collapsed blood vessels is determinative of the degree of vasoconstriction and the likelihood of shock.

My invention has been designed not only to automatically apply uniform pressure to the skin of a patient at desired intermittent intervals but to also monitor and graphically display the rate of return of blood to the area from which pressure has been removed. This graphic representation of the rate of return will indicate to the physician the degree of vasoconstriction and the likelihood of shock in the patient.

While I have disclosed in this application an apparatus for automatically applying intermittent and uniform pressure to the skin of the patient and then monitoring and graphically displaying the rate of return of blood to the collapsed blood vessels, it is within my contemplation to apply such pressure to the skin by non-automatic means and then to monitor the rate of return of blood to the collapsed blood vessels by means of the novel apparatus which I have disclosed for monitoring this rate of return of blood.

With the foregoing general objects, features and results in view, as well as certain others which will be apparent from the following explanation, the invention

consists in certain novel features in design, construction, mounting and combination of elements, as will be more fully and particularly referred to and specified hereinafter.

Referring to the accompanying drawings:

FIG. 1 is a side view in elevation of one from among many automatic means for applying intermittent pressure to the skin of a patient.

FIG. 2 is a top plan view of the apparatus illustrated in FIG. 1.

FIG. 3 is a schematic diagram of the circuitry employed to graphically represent the rate of return of blood into the previously constricted blood vessels.

FIG. 4 is a vertical sectional view of the transducer which is in engagement with the skin and to which pressure is applied, the transducer comprising a part of the monitoring apparatus of my invention.

FIG. 5 is a view of a tracing indicating a normal rate of return of blood to the collapsed blood vessels.

FIG. 6 is a further tracing illustrating a different and slower rate of return of blood to the collapsed blood vessels.

In the accompanying drawings, and particularly FIGS. 1-4, I have used the numeral 1 to designate the base or platform upon which the apparatus is mounted and is operable to apply intermittent and uniform pressure to the skin of a patient at predetermined time intervals.

Mounted at one end of the platform 1 is a power means 3, such as an electric motor, having a pulley 5 extending outwardly of the motor 3 and fixedly attached on the rotary shaft thereof. An endless strap 7 extends about the pulley 5 and is operated thereby and extends therefrom about a further pulley 9 to cause rotation of the pulley 9 when electric motor 3 is energized. A rotary shaft 11 is fixed to and extends from the pulley 9 and rotates therewith, and fixed on said rotary shaft in spaced relation are a pair of sprockets 13. Mounted about each sprocket is a chain 15 which extends from said sprockets 13 to the opposite end of the platform where a further pair of aligned sprockets 17 are rotatively mounted on the upper end of a supporting post 19, the sprockets 13 being operatively mounted on the upper end of a post 21. The posts 19 and 21 being fixed on the platform 1 and upstanding with respect thereto.

Fixed to and extending between the chains 15 is a rod 23 which extends laterally to one side of the chains, and fixed on this lateral extension for relative rotation with respect thereto is, what I shall term, a flap board depressing roller 25. Inwardly spaced from the post 21 is a further post 27 which is fixed to and extends upwardly from the platform 1. Hingedly fixed, as at 29, on the upper end of the post 27 is a flap board 31 which, as will become apparent as this description proceeds, functions under the abutting operating of the roller 25 to intermittently depress a bulb which, when depressed, provides air pressure to cause pressure on the skin of the patient. Consideration of the drawings, particularly FIG. 2, indicates that the flap board 31 is positioned so as to be in the path of travel of the roller element 25 as it travels with the chains 15 in the direction as indicated by the arrows in FIG. 1.

Slidably mounted in any suitable manner on the base or platform 1 is a bulb supporting member or platform

33 at one end of which is provided an upstanding flange 35, and adjacent the other end a nut 37 is fixed to and extends upwardly from the member 33. Extending through the nut 37 is a screw 39 which extends through a retaining post 41 which is fixed on the platform 1. The screw 39 at its outer end is provided with a screw head 43 which is in accessible position for operation by the technician or physician who is operating the device. It will now be evident that the position of the bulb supporting member 33 may be varied longitudinally of the platform 1 by merely turning the screw head 43, the purpose of this adjustment will become apparent hereinafter. It will be further apparent from consideration of the drawings that the slidable bulb supporting member 33 is positioned on the base 1 below and in substantially the same vertical plane as that in which the flap board 31 is positioned.

Mounted on the bulb supporting platform 33 is an air pressure bulb 45 which is formed of a material which resists deformation. The stem end 47 of the bulb 45 extends through an aperture in the upstanding flange 35 and is fixed therein in any suitable manner. Since the movable platform 33 is positioned relative to the flap board 31, as hereinbefore described, and since the bulb 45 is mounted on the movable platform or member 33, it will be apparent that the bulb 45 is in substantially the same vertical plane as the flap board 31. Consideration of FIG. 1 of the drawings indicates that the bulb 45 at its area of greatest diameter extends upwardly in a horizontal plane which is above the projected horizontal plane of the hinge 29 so that in normal inoperative position the flap board 31 rests on the bulb 45 and thus in inoperative position inclines upwardly from its hinged connection to the post 27.

Extending from the stem end 47 of the bulb is an air duct 49 which is adapted to receive air pressure from the bulb when it is depressed. The air duct at its exhaust end is fixed, in any suitable manner, to a transducer 53 which is in engagement with the skin 55 of the patient. While it is within my contemplation to employ several different methods of operatively arranging the bellows 51 and the transducer 53 in their proper operative positions, for purposes of example only I have illustrated in the drawings such mounting and maintaining means as involving a non-elastic retaining strap 57 which extends over the bellows 51 and is provided with an opening therein through which the duct 49 extends and the non-elastic strap 57 is adapted to extend about the head of the patient and to be tied thereabout in position thereon so that the transducer 57 will be in engagement with the skin 55 in the forehead area of the patient.

When the electric motor 3 is energized and the drive sprockets 13 are running the chains 15 are driven and the roller 25 in its course of travel will engage and depress the flap board 31 to thereby depress the bulb 45 thereby forcing pressured air through the duct 49 and to the bellows 51 thereby expanding the bellows to cause the transducer 53 to be pressed against the skin of the patient. It will be clear that when the roller 25 passes over the end of the flap board 31 the pressure on the transducer 53 will be immediately released. The amount of pressure may be regulated by adjusting the screw 39 in the nut 37 to thereby cause longitudinal movement of the base 33 and consequently such movement of the bulb 45.

The electric motor 3 is a variable speed motor so that the rate of the intermittent application of pressure on the skin of the patient may be varied by varying the speed at which the motor is operating.

As I have stated, the application of pressure to the transducer (which will be explained in detail hereinafter) may be caused by non-automatic means and such will still fall within the spirit and scope of my invention, since the monitoring means which will be explained hereinafter will measure and graphically display the rate of return of blood to the collapsed blood vessels, such monitoring means being sensitive to the coloration of the skin area.

The transducer 53 comprises an exterior housing 59 formed of an opaque material, having a cup-like configuration including a top portion 61, an annular skirt portion 63, and a radial flange 65 forming a light screen. The upper interior of the housing 59 carries an annular light reflector 67. Mounted within the housing 59 is a light pipe 69, such as Lucite, having a top body portion 71 and an annular skirt 73 terminating in the same horizontal plane as the flange 65. This configuration provides a central recess 75 in the light pipe which is open at its lower end.

The top body portion 71 of the light pipe is molded or otherwise formed to provide a centrally disposed opening or duct 77 therein and extending therethrough, which, at its lower end opens into recess 75 and extends upwardly through body portion 71 of the light pipe.

Positioned within the opening or duct 77, in the body portion of the light pipe, is a light source 79 having leads 81 which extend upwardly from their connection with the light source and into top 61 of the housing where they are suitably connected to power leads 83 as at 85. Consideration of the drawings indicates that the leads 81 and 83 are electrically connected together at 85 within the top 61 of the housing 59 in which they are molded. Positioned within the concentric recess 75 is a photoelectric resistor or sensor casing 87 which is preferably, though not necessarily, formed of aluminum or the like light reflecting material. The photoelectric resistor casing 87 is secured by adhesive, or in any other suitable manner, to the light pipe 69. The photoelectric resistor casing 87 is formed with an open lower end which is closed by means of a transparent window 89, so that light rays may pass therethrough. Operatively positioned within the casing 87 is a photoelectric resistor 91, which may be a cadmium sulphide photoelectric resistor, which is sensitive to light stimulus. Leads 93 connected to the resistor 91 extend through the top of the casing 87 and through the duct 77 and into the top 61 of the housing 59 where they are connected to power leads 95 as at 97. As in the case of the light source leads 81 and 83, the connections for the leads 93 and 95 are molded within the top 61 of the housing 59. This feature of the leads and the power leads and their connections being molded within the housing 59 provides an effective method of protecting such leads and electrical connections during use of the transducer.

Referring particularly to FIG. 4 of the drawings, wherein we have illustrated one of our transducers applied to a skin area by means of a transparent adhesive, or the like, 99, which is applied by a brush, or in any

other suitable manner to the lower surface of the foot or base 65 of the skirt 63, to the lower surface of the annular depending skirt or portion 73 of the light pipe 69 and to the lower annular surface of the resistor casing 87. Thus, with the transparent adhesive applied, in any suitable manner, to the lower surface of the transducer, as just described, it will be recognized that the transducer may be removably attached to the skin.

It will be recognized that my monitoring system for measuring the rate of return of blood to the collapsed blood vessels functions and the tracing is significant, following the quick release of pressure on the transducer 53 by means of the expanded bellows 51. In order to secure an accurate reading it is essential that when the pressure on the transducer is released the transducer will maintain the snug attachment to the skin and this is accomplished by the attachment of the transducer to the skin by means of the transparent adhesive, or the like, 99.

The circuitry of FIG. 3 is fed from any suitable power source by means of an electric plug 99' having leads 101 extending therefrom into any suitable regulated power supply 103. The light source 79 is connected by leads 105 with the regulated power supply 103 and the photoelectric resistor 75 is connected in a bridge circuit designated generally by the reference numeral 107, and one arm of this circuitry includes a variable resistor 109 which functions as a balance. An operational amplifier 111 is connected by a conductor 113 to the bridge circuit between the variable resistor 109 and the photoelectric resistor 75, the other side of the amplifier 111 being grounded as at 115. A variable resistor 117 in parallel with the amplifier 111 is connected to conductor 113 at 119 and to the output 121 at 123. The output 121 feeds to an oscilloscope or transcribing recorder 125.

In FIG. 5 of the drawings I have illustrated a tracing or graphic representation of the rate of return flow of the blood to the collapsed blood vessels as monitored by the transducer and associated apparatus. I have used the numeral 127 to designate the line when the transducer 53 is at rest and the numeral 129 to indicate the point at which pressure is applied on the transducer, and thus on the skin, to force the blood out of the subjacent blood vessels. The point 131 indicates when the pressure on the transducer is released when the curve 133 illustrates the rate of return of blood to the collapsed blood vessels. FIG. 5 graphically illustrates a tracing indicating the rate of return of blood in a normal patient.

FIG. 6 is a further tracing indicating a slow rate of return of blood to the collapsed blood vessels which will be significant to the technician or physician indicating the degree of shock in which the particular patient may be. It will be clear from consideration of the disclosure of the illustration of FIG. 6 that the curve 133 is substantially less acute than the curve 133 in FIG. 5 to thereby indicate a relatively slow rate of return of blood to the collapsed blood vessels.

I claim:

1. Means adapted for intermittently applying uniform pressure to a skin area of a patient to cause the blood vessels adjacent said area to collapse and force the blood therefrom, and further means for measuring and graphically representing the rate of return flow of

the blood to said blood vessels when the pressure on the skin is released, said means for intermittently applying uniform pressure including a movable means which is movable upon the application of pressured fluid thereto, a fluid supply means in communication with said movable means for intermittently supplying pressured fluid thereto, automatic means intermittently engageable with said fluid supply means for intermittently supplying pressured fluid to said movable means, means connected to said automatic means for causing the automatic means to operate, said further means including a transducer electrically connected to a recording oscillograph, an electric circuit, and said transducer being adapted to be placed in contact with the skin area of a patient, means connected to said transducer and adapted to be connected to the skin of a patient for maintaining said transducer in contact with said skin, said movable means being connected to said transducer and causing said transducer to press against the said skin area of a patient upon application of pressured fluid to said movable means to thereby force blood from blood vessels adjacent said transducer.

2. Apparatus in accordance with claim 1, wherein said movable means is extensible and is connected to said transducer in pressure applying relationship with said transducer upon the application of pressured fluid to said extensible member to cause extension thereof to thereby press said transducer against the skin of a patient.

3. Apparatus in accordance with claim 1, wherein said automatic means includes an element intermittently engageable with said fluid supply means, and means for fully and rapidly disengaging said element from said fluid supply means between engagements therewith, thereby providing a quick release of said pressure following each engagement of said element with said fluid supply means.

4. Apparatus in accordance with claim 1, wherein said fluid supply means comprises a deformable container for said fluid and said automatic means includes a traveling means and said element is fixed thereto and travels therewith said deformable container being mounted in the path of travel of said element for intermittent deformation thereby to force pressured fluid to said movable member.

5. Apparatus in accordance with claim 4, wherein said deformable container is in the form of a bulb, the walls of which converge from the point of the greatest diameter of said bulb providing a stem through which fluid may flow and said point of largest diameter of said bulb being in the path of travel of said element.

6. A method of measuring and graphically recording the rate of return flow of blood to collapsed blood vessels, comprising those steps of fixing a transducer in snug engagement with the skin area to which pressure is applied, automatically applying intermittent uniform pressure to said transducer, quickly releasing the pressure on said transducer following each application of pressure thereto and measuring and graphically recording by said transducer and associated electrical apparatus the rate of return of color to the skin area following quick release of pressure thereon by said transducer.

7. Means adapted for intermittently applying uniform pressure to a skin area of a patient to cause the

blood vessels adjacent said area to collapse and force the blood therefrom and for measuring and indicating the rate of return flow of the blood to said blood vessels when the pressure on the skin is released, said means comprising; automatic means adapted to be connected to said skin area for applying variably periodic intermittent uniform pulses of pressure to said skin area; a transducer means adapted to be located between said automatic means and said skin area for detecting the color of said skin area as it varies in accordance with the amount of veno capillary blood in said skin area at a given time and including means for transmitting signals having characteristics which correspond to said variations; and means operatively connected with said transmitting means for receiving said signals and indicating the color condition of said skin areas during and after each application of pressure in correspondence with said signals.

8. Means for indicating the rate of return flow of blood to collapsed blood vessels, comprising automatic means adapted for intermittently applying uniform pressure to a skin area and for quickly releasing the pressure following each application of pressure; an electrical transducer means adapted to be located between said automatic means and said skin area for detecting the color of the skin in said skin area; means

adapted for maintaining said transducer adjacent the skin area to which the pressure is applied; said automatic means adapted for intermittently applying uniform pressure to skin area being connected to said transducer to cause said transducer to apply uniform pressure to the skin area; and means electrically connected with said transducer for measuring and indicating the rate of return of color to the skin area following each quick release of pressure thereto.

9. Means adapted for intermittently applying uniform pressure to a skin area of a patient to cause the blood vessels adjacent said area to collapse and force the blood therefrom, and further means for measuring and graphically representing the rate of return flow of the blood to said blood vessels when the pressure on the skin is released, said means adapted for intermittently applying uniform pressure including automatic means adapted to be connected to a skin area of a patient and to intermittently apply pressure thereto, said further means including a transducer electrically connected to a recording oscillograph, an electric circuit, and said transducer being adapted to be located between said automatic means and said skin area for detecting the color of the skin in said skin area.

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