Aug. 9, 1949. E. B. COLEGRAVE ET AL 2,478,372

APPARATUS FOR RECORDING THE DILATATIONS OF AN ARTERY

Filed Nov. 2, 1945 2 Sheets-Sheet 1

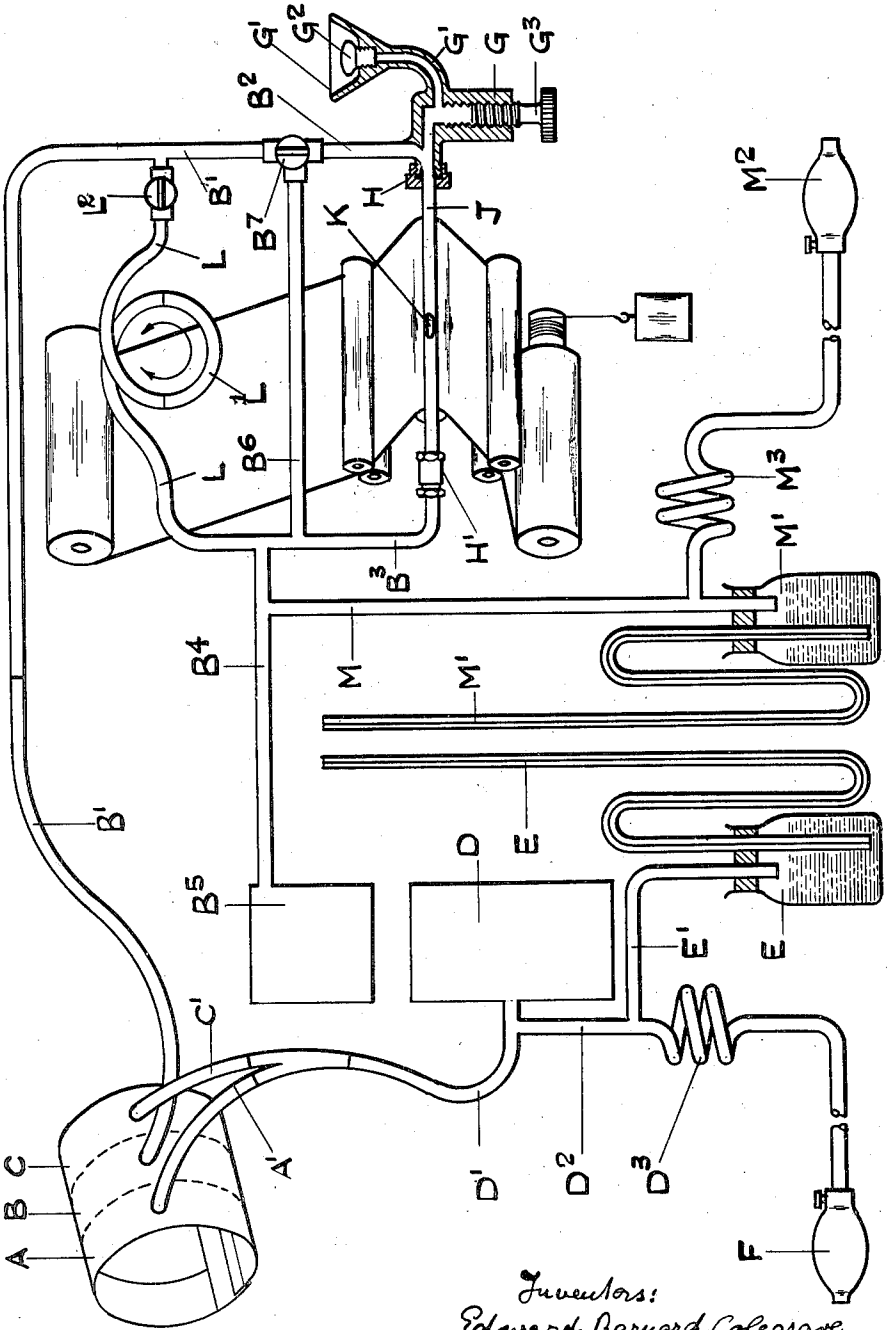


FIG. 1.

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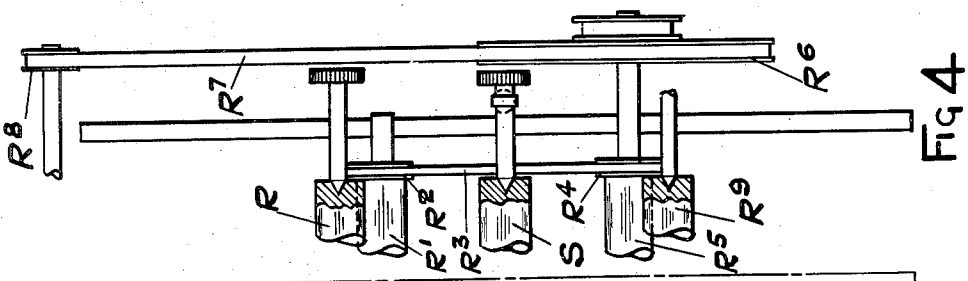


FIG 4

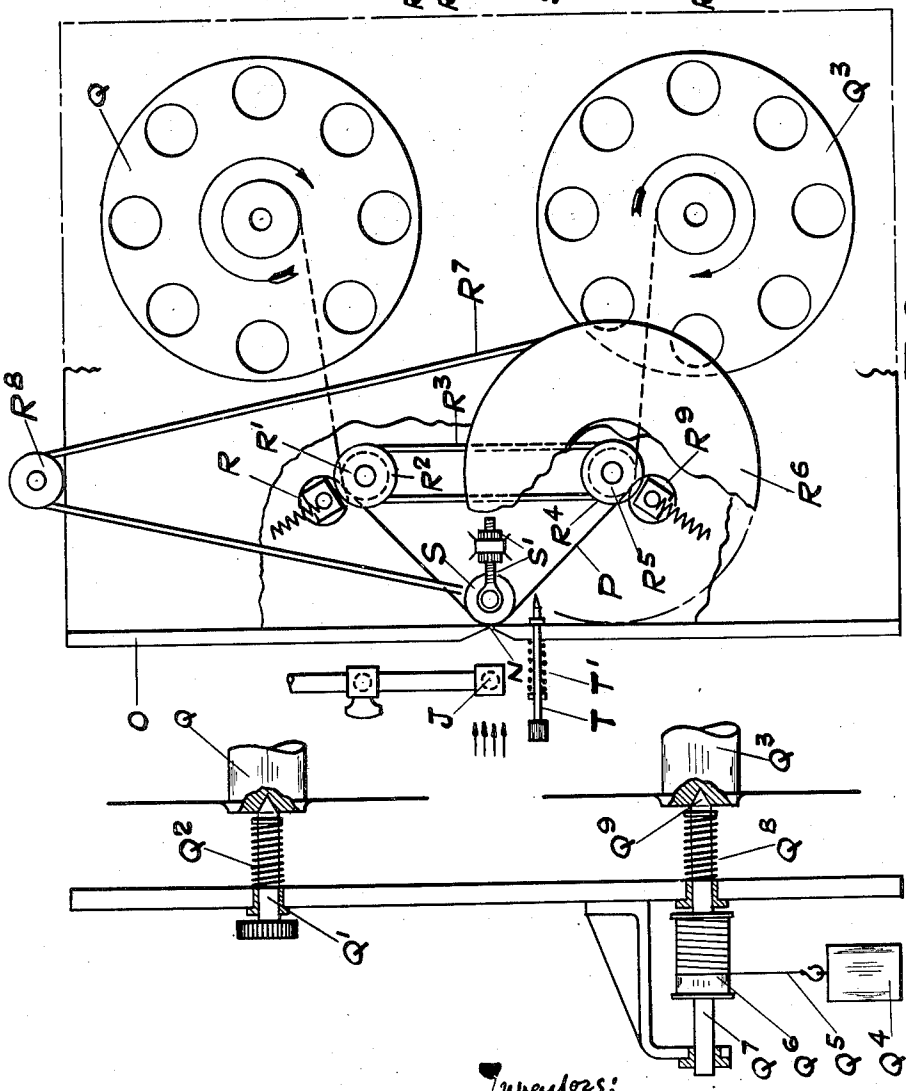


FIG 2

FIG 3

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Patented Aug. 9, 1949 2,478,372

UNITED STATES PATENT OFFICE

2,478,372

APPARATUS FOR RECORDING THE DILATATIONS OF AN ARTERY

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Application November 2, 1945, Serial No. 626,394
In Great Britain August 17, 1944

Section 1, Public Law 690, August 8, 1946
Patent expires August 17, 1964

10 Claims. (Cl. 128—2.05)

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This invention relates to apparatus for recording the dilatations of an artery at all stages of the pulse cycle, at any constant pressure applied. It has been designed to further knowledge of the circulation, the special references to the physical conditions of the artery wall, and the greater interpretation of heart and circulatory disease. It will enable the pulse cycle to be analysed in terms of time to one two-hundredths of a second and such dissections have meaning with this apparatus.

The apparatus depends upon the movement of a volume of air controlled only by the dilatation of an artery, which in turn causes to move in a horizontal plane a small body of liquid of negligible inertia. This liquid acts as the lens of a camera and its movements are recorded on a photographic surface moving at a constant speed at right angles to the direction of movement of the lens. A curve of movement is obtained as a permanent record.

The movement of the volume of air is obtained by the application of an improved construction of pneumatic bag to the limb which bag is constructed, arranged and adapted to operate in such a manner that the movement of the volume of air is controlled only by the dilatation of the artery.

Illumination for photographic purposes is supplied by an electric lamp connected to the 50 or other cycle supply, and time appears on the photograph as a series of exposure bands, the number of cycles multiplied by two giving the number of bands which are registered in one second of time, which can in turn be estimated to a half. Thus with a 50 cycle supply each band equals one one-hundredth second and reliable estimate of time can be made to one two-hundredth second. With, say, 40 cycles each band is one eightieth second and estimations can be made to one one-hundred and sixtieth second, and so on.

In the accompanying drawings:

Fig. 1 is a diagram of the apparatus.

Fig. 2 is a section taken through the camera.

Fig. 3 is a view of part of the camera showing the spools for a photographic film or paper and a gravity actuated taking-up motion.

Fig. 4 is another view of part of the camera showing the drive for the photographic film or paper.

The pneumatic bag by which the arterial impulses are transmitted to the apparatus is conveniently made in the form of an arm band after the style of the Riva-Rocci bag. It differs however from the latter in that it is separated into three compartments A, B and C which are isolated from one another and that its outer surface is enclosed by an inextensible flexible wall or outer casing which may be constructed from chain work after the style of chain mail. In the construction shown the arm band is made in one unit but it may if desired be made in separate units contained in one outer casing. The inner compartment B acts as the actual recording bag from which the records are obtained and the two outer compartments A and C act as guard bags to guard the recording bag from impulses which would otherwise impinge on the edge of the recording bag, thereby vitiating the accuracy of the work. The side impulses are taken by the guard bags A and C and the unwanted air movement they cause is allowed to discharge into a reservoir D of such a size that no measurable pressure change takes place. Thus it is that only the movements of the artery wall immediately beneath the recording bag B are measured. With this arrangement it is possible to have equal or unequal pressures in the three compartments A, B, C. The two outer compartments may be connected by flexible tubes A^1C^1 terminating in a tube D^1 with a closed air circuit containing the aforesaid reservoir D while means for adjusting the air pressure in the circuit and guard bags and means for indicating the pressure in the circuit are incorporated as a manometer E in the circuit. In the construction shown means for adjusting the air pressure in the circuit and guard bags comprise a hand pump F which communicates with the receiver D through a pipe D^2 containing an air cooling coil D^3 and such pipe communicates with the manometer E through a branch pipe E^1.

The recording bag B is connected by a tube B^1 with a tube B^2 which is shown by way of example as forming part of a fitting G that is connected by a union joint H to one end of a calibrated recording tube J of which the other end is connected by a union joint H^1 with a tube B^3 which may form part of a tube B^4 that is connected with an air receiver B^5 appertaining to the recording tube J and constitutes a closed circuit. The tube J is constructed from transparent material and it may have a bore which may for the purposes of description be about ⅛ of an inch in diameter and in the horizontal tube is the liquid lens K which may be ½ an inch long or thereabouts. In the diagram the supply for the liquid lens is obtained from a reservoir formed in the fitting G and such reservoir is

provided with a filling aperture G^1 closed by a stopper G^2 and provided with an adjusting screw G^3. Connecting the tubes B^3 and B^2 is a tubular connection L containing a U tube L^1 that is connected with the tube B^1 through a two way cock L^2. The U tube L^1 can be tilted in either direction for adjusting the position of the liquid lens K in the recording tube J. The actual size of the liquid lens can be adjusted by moving it by means of the lens positioning tube L^1 to the extreme end of the tube J nearest to the reservoir in the fitting G where liquid can be added or extracted by turning the screw G^3 in one direction or the other. In an alternative arrangement a small hypodermic needle may be connected with one end of the tube J through which can liquid be added or extracted by a pump plunger. The tube B^4 is connected by a tube M with a manometer M^1 connected with a hand pump M^2 through an air cooler coil M^3 for adjusting the air pressure in the recording tube circuit and for indicating the pressure. The tubes B^2 and B^3 are connected by a tube B^6, a three way cock B^7 being situated at the junction of the tube B^6 and B^2. The tube B^6 is used for isolating the tilting U tube L when recording. The recording tube J is situated in close proximity to a fine slit N, Fig. 2, in a screen or wall which may form part of a camera O such as that shown in Figures 2 to 4 and such slit may be adjustable in width. The photographic paper or film P comes from a distributing spool Q that may be rotatable between centres one of which may consist of a spring loaded locating pin Q^1 that is slidable in the camera wall and can be withdrawn against the action of the spring Q^2 for the insertion and removal of the spool. The strip P coming from the spool passes between a pair of rollers R, R^1, the roller R being spring loaded as shown. The roller R^1 is provided with a pulley R^2 which is connected by a belt R^3 with a pulley R^4 appertaining to a roller R^5 that is driven by a pulley R^6 and belt R^7 from a pulley R^8 on the shaft of an electric motor. This motor which may be mounted on the top of the camera or otherwise may be a variable speed motor, or any suitable form of variable speed mechanism may be provided for varying the speed of the roller R^5. After the photographic paper or film has passed between the rollers R, R^1, it is taken over a focusing roller S which can be moved towards and away from the slit N by a screw and nut S^1 or other form of adjustment. After the film or paper has been taken over the focusing roller it is passed between the driven roller R^5 and a spring loaded roller R^9 and wound on to a taking up spool Q^3 which may be turned in the direction indicated by the arrow in Figure 2 by a weight Q^4 attached to a cord Q^5 that is wound on a drum Q^6 fixed on a shaft Q^7 that is rotatably mounted in bearings in the camera and is maintained in driving connection with the spool Q^3 by a spring Q^8. The inner end of the shaft Q^7 may be made in the form of a conical centre Q^9 which enters a counter sink in the end of the spool spindle, a positive or fractional drive being transmitted thereto by the weight Q^4. T indicates a paper marker which is normally held out of contact with the paper by a spring T^1. This marker is used to mark the beginning and end of each recording on the paper, for example by punching or pricking a hole therein. This enables the paper to be cut into correct lengths for developing. Behind the tube J is an electric or other lamp the rays of light from which (not shown) pass in the direction of the arrows through the lens and on to the paper or film.

The light source is preferably emitting a light beam which covers the entire slit throughout its length so that the liquid lens K will be in the path of the light beam independently from its position within the recording tube J. Thus, this liquid lens K will influence the light rays passing through it and form a visible image on the light sensitive surface of the photographic paper or film within the camera. This image will move according to the movement of the liquid lens so that a wavy line will be recorded upon the paper or film; the form of this line will conform to the movement of the liquid lens which in turn is proportionate to the dilatations of the artery upon which the pneumatic bag is placed.

To take a recording, the armlet bag is fixed in position on the arm. The pressure is then raised in the system by means of the hand pump or pumps until the required pressure is attained as indicated by the manometers.

The three way cock B^7 is then turned to the operating position and the position of the lens K in the recording tube adjusted by the lens positioner L^1, during which adjustment the two way cock L^2 is opened and subsequently closed for taking the record.

The paper is then set in motion and run until a suitable length has passed the slit. The three way stop cock B^7 is then turned to the by-pass position to enable the pressure in the system to be altered to the next required value at which a recording is to be made and so on until the complete set of recordings have been taken.

The apparatus described is as far as we are aware the only apparatus so far designed, that will give absolute recording of arterial movement.

Previous forms of apparatus fail either through mechanical losses, or because they record by virtue of pressure or velocity changes, which are themselves indeterminate. Thus, such apparatus will give pictures which resemble the true picture, but which are distorted in one way or another.

What we claim as our invention and desire to secure by Letters Patent of the United States is:

1. In apparatus involving the use of a recording bag interposed between two guard bags, the combination with the three bags of two closed air circuits, one of which appertains to the guard bags and the other to the recording bag, the closed air circuit appertaining to the guard bags containing an air pressure absorbing reservoir, means for adjusting the air pressure in the circuit and guard bags, and means for indicating the air pressure in the circuit, the closed air circuit appertaining to the recording bag containing a recording tube, a liquid lens movable therein by the movement of a volume of air controlled only by the dilatation of an artery, means for positioning the liquid lens in the recording tube, an air pressure absorbing reservoir, means for adjusting the air pressure in the circuit and recording bag and means for indicating the air pressure in the circuit.

2. In apparatus involving the use of a recording bag interposed between two guard bags, the combination with the three bags of two closed air circuits one of which appertains to the guard bags and the other to the recording bag, the closed air circuit appertaining to the guard bags

containing an air pressure absorbing reservoir, means for adjusting the air pressure in the circuit and guard bags, air cooling means for preventing a detrimental rise in air temperature when increasing the air pressure in the circuit and guard bags, and means for indicating the air pressure in the circuit, the closed air circuit appertaining to the recording bag containing a recording tube, a liquid lens movable therein by the movement of a volume of air controlled only by the dilatation of an artery, means for positioning the liquid lens in the recording tube, an air pressure absorbing reservoir, means for adjusting the air pressure in the circuit and recording bag, air cooling means for preventing a detrimental rise in temperature when increasing the air pressure in the circuit and recording bag and means for indicating the air pressure in the circuit.

3. In apparatus involving the use of a recording bag interposed between two guard bags the combination with the three bags of two closed air circuits one of which appertains to the guard bags and the other to the recording bag, the closed air circuit appertaining to the guard bags containing an air pressure absorbing reservoir, means for adjusting the air pressure in the circuit and guard bags, air cooling means for preventing an unwanted rise in temperature when increasing the air pressure in the circuit and means for indicating the air pressure in the circuit; the closed air circuit appertaining to the recording bag containing a recording tube, a liquid lens of negligible inertia freely movable therein by the movement of a volume of air controlled only by the dilatation of an artery, a tiltable U-shaped tube for positioning the liquid lens in the recording tube, means for adjusting the size of the liquid lens, an air pressure absorbing reservoir, means for adjusting the air pressure in the circuit and recording bag, air cooling means for preventing an unwanted rise in temperature when increasing the air pressure in the circuit, means for indicating the air pressure in the circuit, and a photographic surface movable at a constant speed at right angles to the direction of movement of the lens.

4. In apparatus according to claim 1 a camera formed with a narrow horizontal slit, a strip of material having a photographic surface situated within the camera in proximity to the slit, means for traversing the strip at a constant speed at right angles to the slit, a transparent recording tube situated outside the camera in line with the slit and in proximity thereto, the said tube containing the freely movable liquid lens and means for passing rays of light through the lens and slit onto the photographic surface.

5. In apparatus according to claim 1, a camera formed with a narrow horizontal slit, a strip of material having a photographic surface situated within the camera in proximity to the slit, means for traversing the strip at a number of constant speeds at right angles to the slit, a transparent recording tube situated outside the camera in line with the slit and in proximity thereto, the said tube containing the freely movable liquid lens and means for passing rays of light through the lens and slit onto the photographic surface.

6. In apparatus according to claim 1, a camera formed with a narrow horizontal slit, a strip of material having a photographic surface situated within the camera in proximity to the slit, means for focusing such surface, means for traversing

the strip at a constant speed at right angles to the slit, means for marking the beginning and end of each recording on the photographic surface, a transparent recording tube situated outside the camera in line with the slit and in proximity thereto, the said tube containing the said movable liquid lens, and means for passing rays of light through the lens and slit onto the photographic surface.

7. Apparatus for recording the dilatations of an artery comprising in combination a pneumatic bag placeable upon the artery the dilatations of which have to be recorded; a transparent container; an air conduit connecting said transparent container with said pneumatic bag so as to create within said transparent container an air movement being proportional to the air movement within said pneumatic bag caused by dilatations of said artery; a small liquid body within said transparent container adapted to be moved by said air movement in the same in accordance with the dilatations of said artery; and cinematographic means combined with said transparent container so as to be adapted to record the movement of said small liquid body and thus create a permanent record of the dilatations of said artery.

8. Apparatus for recording the dilatations of an artery comprising in combination a pneumatic bag placeable upon the artery the dilatations of which have to be recorded; a transparent horizontal recording tube; an air conduit connecting said transparent horizontal recording tube with said pneumatic bag so as to create within said transparent horizontal recording tube an air movement being proportional to the air movement within said pneumatic bag caused by dilatations of said artery; a small liquid body within said transparent horizontal recording tube adapted to be moved by said air movement in the same in accordance with the dilatations of said artery; a cinematographic camera formed with a narrow slit-shaped horizontal exposure aperture arranged parallel to said transparent horizontal recording tube at a slight distance thereof; a strip of light sensitive material arranged within said camera behind said narrow slit-shaped horizontal exposure aperture; and transporting means for moving said strip of light sensitive material in vertical direction past said narrow slit-shaped horizontal exposure aperture.

9. Apparatus for recording the dilatations of an artery comprising in combination a pneumatic bag placeable upon the artery the dilatations of which have to be recorded; a transparent horizontal recording tube; an air conduit connecting said transparent horizontal recording tube with said pneumatic bag so as to create within said transparent horizontal recording tube an air movement being proportional to the air movement within said pneumatic bag caused by dilatations of said artery; a small liquid body within said transparent horizontal recording tube adapted to be moved by said air movement in the same in accordance with the dilatations of said artery; a cinematographic camera formed with a narrow slit-shaped horizontal exposure aperture arranged parallel to said transparent horizontal recording tube at a slight distance thereof; a strip of light sensitive material arranged within said camera behind said narrow slit-shaped horizontal exposure aperture; a light source arranged so as to emit light rays passing through said horizontal recording tube and said

narrow slit-shaped horizontal exposure aperture and impinging upon said strip of light sensitive material; and transporting means for moving said strip of light sensitive material in vertical direction past said narrow slit-shaped horizontal exposure aperture.

10. Apparatus for recording the dilatations of an artery comprising in combination a pneumatic bag placeable upon the artery the dilatations of which have to be recorded; a transparent horizontal recording tube; an air conduit connecting said transparent horizontal recording tube with said pneumatic bag so as to create within said transparent horizontal recording tube an air movement being proportional to the air movement within said pneumatic bag caused by dilatations of said artery; a small liquid body within said transparent horizontal recording tube adapted to be moved by said air movement in the same in accordance with the dilatations of said artery; a cinematographic camera formed with a narrow slit-shaped horizontal exposure aperture arranged parallel to said transparent horizontal recording tube at a slight distance thereof; a strip of light sensitive material arranged within said camera behind said narrow slit-shaped horizontal exposure aperture; a light source arranged so as to emit light rays passing through said horizontal recording tube and said narrow slit-shaped horizontal exposure aperture and impinging upon said strip of light sensitive material; means associated with said cinematographic camera for focusing said strip of light sensitive material at a proper distance from said transparent horizontal recording tube; and transporting means for moving said strip of light sensitive material in vertical direction past said narrow slit-shaped horizontal exposure aperture.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,521,563	Pfleegor	Dec. 30, 1924
2,099,938	Lockhart	Nov. 23, 1937

FOREIGN PATENTS

Number	Country	Date
551,084	France	Dec. 26, 1922
776,604	France	Nov. 8, 1934