Dec. 4, 1956 S. LOSNER 2,772,672

MEANS AND METHODS FOR EXAMINING
THE NATURE OF CARDIAC ACTIVITY
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Fig. 1

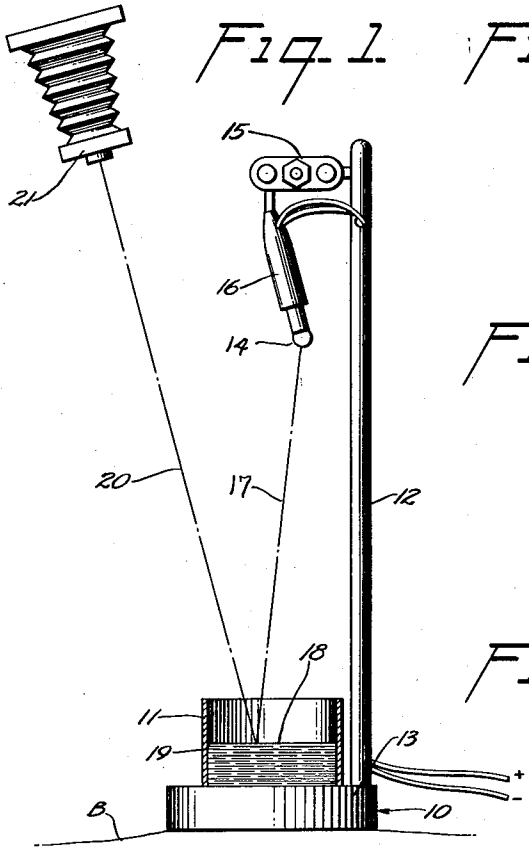


Fig. 3

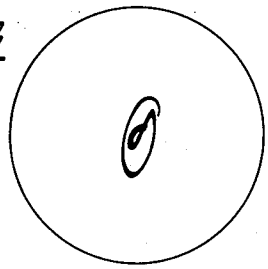


Fig. 4

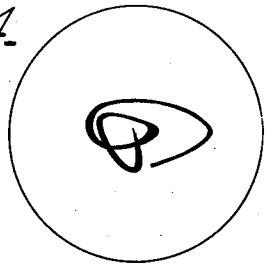


Fig. 5

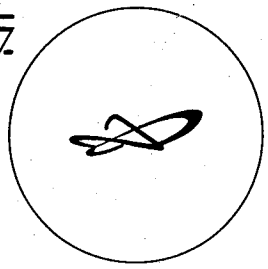
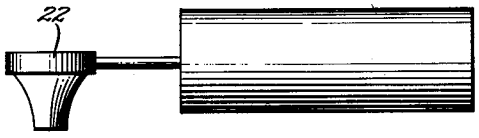
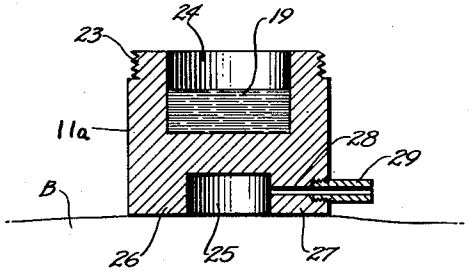


Fig. 2





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MEANS AND METHODS FOR EXAMINING THE NATURE OF CARDIAC ACTIVITY

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Application March 30, 1953, Serial No. 345,555

7 Claims. (Cl. 128—2.05)

This invention relates to means and methods for examining the nature of cardiac activity and relates, in part, to the subject matter published in my paper: An Instrument for the Study of Cardiac Impulse, Proceedings of the Society for Experimental Biology and Medicine 1952, vol. 81, pages 1–3.

An object of the invention is to provide an instrument which indicates movements in both lateral and longitudinal directions so that the vector of the motion may be detected.

Another object is to provide an extremely simple and compact device which indicates cardiac conditions and which may be easily carried in a physician's satchel without material increase in the size and weight of its usual load.

The attainment of these and other objects which become apparent as the description proceeds is accomplished by placing a small cup containing a dark reflective liquid upon a portion of the body, or object responsive to sudden body movement of cardiac origin, and shining a light onto the surface of the liquid. Movements due to cadiac activity cause a disturbance of the liquid surface and the image of the reflected light will move in a manner dependent on the relative movement of different parts of the body. An observation of the motion or tracing of the image is compared with a norm or with paths or tracings associated with or characteristic of known abnormalities of cardiac action.

In the accompanying drawing showing, by way of example, two of many possible embodiments of the invention,

Fig. 1 shows one form and embodiment of the invention;

Fig. 2 shows another form of the invention;

Fig. 3 is an image tracing of a normal individual;

Fig. 4 is an image tracing of a patient with mitral stenosis and insufficiency; and

Fig. 5 is an image tracing of a patient with hypertensive cardiovascular disease and evidence of an old posterior wall infarction.

In the embodiment of Fig. 1 the device comprises a heavy brass cylindrical base **10** about 2.5 cm. high and about 6.25 cm. in diameter having mounted thereon, as by soldering, a cup **11** of brass about 5 cm. high and about 3.75 cm. inside diameter and about 4.0 cm. outside diameter or with a wall thickness of about 1.5 mm.

A light pole **12** of aluminum secured to the marginal portion **13** of the base carries an otoscope bulb **14** near the upper end thereof, the bulb being mounted by means of a universal bracket **15** and lamp socket **16**. The pole is about 1 cm. in diameter and about 20 cm. high.

The rays **17** from the bulb are reflected from the surface **18** of a liquid **19** which about half-fills the cup.

The liquid should have appreciable viscosity so that if the device is placed on the chest the liquid level will not be greatly disturbed by the relatively slow motion of breathing. Also it is preferable that the liquid be

dark so as to get an easily observed sharp reflected image. Commercial lubricating oil SAE No. 40 has been found quite satisfactory.

The reflected rays **20** may be observed directly or caused to trace an image on a photographic film in a fixed camera **21** suitably positioned. A suitable distance from the bulb to the liquid level is 18 cm.

If the observation without recording is to be made, a conventional electrically lighted pocket otoscope **22** may be simply held fixed or by hand above an oil cup and such an otoscope supplies a light source as well as an observation instrument. However the cup, being made of homogeneous material such as brass, must have rather definite shape and weight in order to provide the necessary properties of inertia when the above mentioned liquid is used. Such a cup or container is shown at **11***a* in Fig. 2. The cup **11***a* is 2 inches high, cylindrical in shape and has an outside diameter of between 2¼ and 2¾ inches except for a small threaded portion **23** at the upper rim for a cover (not shown). A concentric cylindrical oil cavity **24**, one inch deep and 1½ inches in diameter is provided and about half way filled with No. 40 oil.

A lower central cylindrical cavity **25** is provided in the bottom face **26** of the cup. The resulting depending annular flange **27** is provided with a radial passageway **28** into which is mounted a tube **29** for connection to a stethoscope. The lower cavity **25** and the surrounding structure perform the functions similar to those performed by the "bell" of conventional stethoscopes. The cavity **25** is preferably one inch in diameter and one half inch in height. Of these dimensions, the height is most important and, if the No. 40 oil is used, should not vary more than about ¼ inch in either direction nor should the height of the level of the liquid above the lower face **26** vary more than about one eighth of an inch. The depth of oil should be approximately ½ an inch and the diameter of the upper cavity may not vary from the preferred dimension more than about an eighth of an inch. Dimensions of the lower cavity **25** are not so critical and the cavity **25** and passageway **28** may be omitted provided the weight is within limits next below specified.

The weight of such a container (empty) must not vary more than one and a half ounces from the preferred weight of nine ounces, else the motion and tracings become too erratic and confused to be identified as belonging to any one type. The weight seems to be more critical than the distribution of the weight in a container of the size and shape of Fig. 2.

In use, either the base **10** of the device of Fig. 1 or the container **11***a* of Fig. 2 is placed on an appropriate portion of the body B such as the lower third of the sternum with the body in supine position. If the body is prone the device may be placed upon the back. The device need not rest directly on the body but may be placed on a bar across the lower legs as in the determinations of ballistocardiographic patterns by Dock and Taubman Am. J. Med. 1949, v. 7, 751.

The type of reflection or image may be determined by observation by means of the otoscope **22** or by recording on a photographic plate as described in connection with the camera **21**. In the latter instance the camera is focused upon the image or flash within the cup, which is photographed with a 0.5 second exposure. To identify the beginning and end of the tracing, and therefore its direction, the light of the otoscope bulb is switched on immediately after opening the shutter, causing the tracing to initiate as a thin thread, increasing steadily in thickness while the bulb is lighting up. When the shutter closes

automatically, the light is interrupted suddenly, and the tracing ends therefore abruptly.

As seen from Fig. 3 the tracing of a normal individual as obtained over the sternum is slightly elliptical, the long axis being in a longitudinal, and the short axis in a lateral, direction. The main portion of the tracing has a counterclockwise direction, and follows the first heart sound. It is succeeded by a short portion in a clockwise direction, which seems to follow the second heart sound when the making of tracings is combined with auscultation. If the device is placed upon a bar across the lower legs according to the Dock procedure, the configuration of the flash seems to duplicate the typical ballistocardiographic pattern.

Figs. 4 and 5 give examples of specific changes of the image pattern in patients with cardiac disease. Fig. 4 from a patient with mitral stenosis and insufficiency, is characterized by a clockwise direction of the tracing. The long axis is no longer longitudinal but more in a lateral direction. Fig. 5 from a patient with hypertensive cardiovascular disease and electrocardiographic evidence of an old posterior wall infarction, shows again a clockwise direction of its main portion, as well as a very pronounced lateral direction of its long axis. It is succeeded by a short swing in the opposite, namely counterclockwise, direction. The amplitude of both tracings (Figs. 4 and 5) appears larger than normal.

The high viscosity of the fluid within the container produces a considerable damping effect, so that the relatively slow respiratory motion of the anterior chest wall does not produce any direct alteration of the configuration of the flash as caused by the forceful cardiac impulse. It produces, however, indirect alterations which can be interpreted as respiratory variations. The damping characteristics of the fluid are also responsible for the failure to register vibrations coincident with heart sounds or murmurs.

The action of the device seems to reside in the formation of a sloping reflecting surface during the ballistic movement of the underlying surface, such as the anterior chest wall. The degree of slope depends upon the magnitude of the cardiac impulse. Since the excursion of the reflex increases with the degree of slope, it will necessarily indicate the magnitude of the cardiac impulse provided the distance between object and mirror, in this case the distance between otoscope bulb and fluid surface within the container, is constant. If the distance between the bulb and fluid surface is increased, the excursion of the image will also increase.

Whereas the ballistocardiograph, in its usual form, is an instrument with one degree of freedom, namely, in a longitudinal direction only, my device indicates movements in both longitudinal and lateral, as well as any other intermediate direction. It therefore can be considered an instrument with freedom in a two-dimensional plane, providing both factors of a vector, i. e. direction and amplitude.

It has hitherto been pointed out that lateral ballistic movements may be of considerable importance. In view of its mechanical simplicity, my device lends itself particularly well for determining at a glance whether the main ballistic motion is longitudinal or lateral, and also furnishes an idea about the amplitude. It can serve

as a screening instrument at the bedside for further ballistocradiographic investigation.

The weights and dimensions and other characteristics set forth above have been determined by a large number of experiments and so far as is known their relationships specified are largely empirical. The specific values set forth are optimum values for best results.

I claim as my invention:

1. A combination for studying cardiac impulses including a container substantially of cylindrical shape of about two inches in height and two inches in diameter and provided with a cavity about one inch deep and one and one half inches in diameter, the container weighing between eight and ten ounces; a dark liquid having a viscosity of S. A. E. No. 40 oil in the cavity and about half filling same, and a lighted otoscope above the level of the liquid for shining a light onto the surface of the liquid and for observing the reflection of the light from the surface.

2. A device for use in studying cardiac action comprising a flat circular base of brass having a height of about 2.5 cm. and 6.25 cm. in diameter; a brass cup secured on said base and having a side wall about 5 cm. in height, about 1.5 mm. in thickness and about 3.75 cm. in diameter; S. A. E. No. 40 lubricating oil in the cup and about half filling same; a rod of aluminum about 20 cm. in height secured to the base and in vertical position; a universally movable bracket secured to the upper end portion of the rod, and a light source mounted on the bracket for shining on the oil.

3. In combination, the device claimed in claim 2, and a camera fixed in a position to receive light from said source reflected from the surface of the oil.

4. A device for studying cardiac action comprising a container of substantially cylindrical shape of between 1¾ and 2½ inches in height, and between 2¼ and 2¾ inches outside diameter and having a coaxial cylindrical cavity in the upper face thereof having a depth between about ⅞ of an inch and 1⅛ inches and a diameter between 1⅜ inches and 1⅝ inches, the container weighing between 7½ and 10½ ounces.

5. A device as in claim 4, and liquid in the container, and a luminary otoscope above the container for shining a light on the surface of the liquid and for detecting an image of reflection therefrom.

6. A device as in claim 4, the container having a lower cavity in the lower face thereof and downwardly open, and a tube mounted on the container and communicating with the lower cavity.

7. A device as in claim 4, the container having a lower cavity in the lower face thereof and downwardly open and a tube piercing the outer shell and connecting a stethoscope with the lower cavity allowing simultaneous auscultation of the heart sounds and observation of the ballistic vector loop for the purpose of proper timing and identification of the particular visual phase with the corresponding acoustic phase.

References Cited in the file of this patent

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