Jan. 11, 1955 S. HAMILTON 2,699,465

DEVICE FOR INDICATING THE CESSATION OF CARDIAC FUNCTION

Filed Oct. 16, 1952

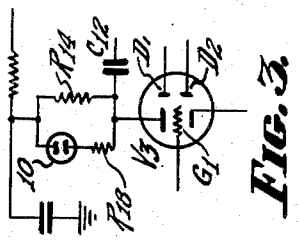

Fig. 3.

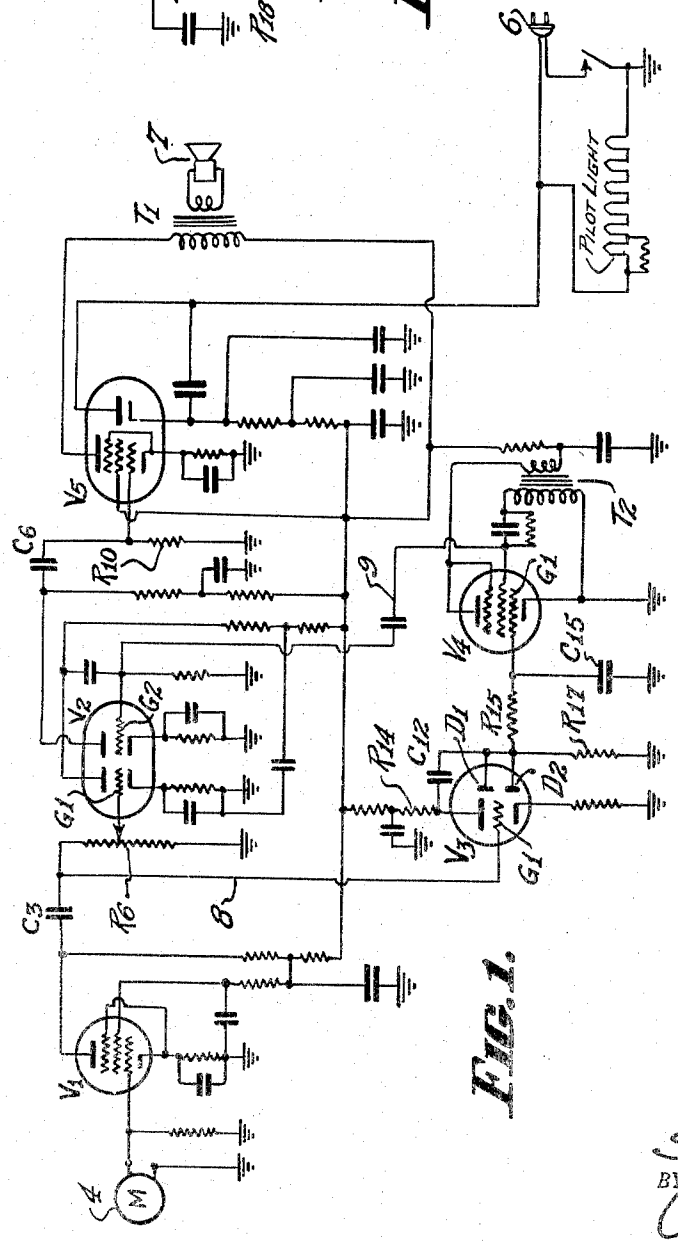

Fig. 1.

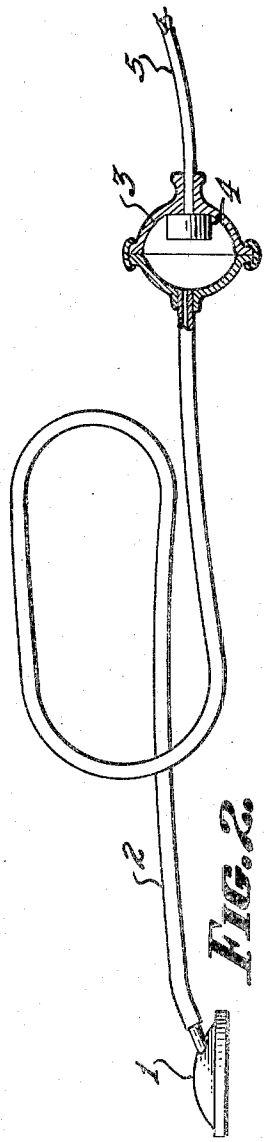

Fig. 2.

INVENTOR.
SELDEN HAMILTON,
BY
Allen & Allen
ATTORNEYS

United States Patent Office 2,699,465
Patented Jan. 11, 1955

2,699,465

DEVICE FOR INDICATING THE CESSATION OF CARDIAC FUNCTION

Selden Hamilton, Cincinnati, Ohio

Application October 16, 1952, Serial No. 315,106

6 Claims. (Cl. 179—5)

My invention relates to a device for indicating the cessation of cardiac function and more particularly to an electronic device which will give an unmistakable audible and/or visual warning when the heart stops beating.

The device finds particular utility where a patient is undergoing a surgical operation and there is the possibility that the heart may stop beating, or may beat in such a way—known as ventricular fibrillation—as to cause no circulation of blood. Since the tissues of the human body must have a constant supply of oxygen to function properly, or even to survive, whenever the blood stops circulating only the small amount of oxygen contained in the blood stream at the moment is available for use by the tissues. As soon as this small supply of oxygen is exhausted, the tissues begin to suffer, and unless fresh oxygen is immediately made available, the individual tissue cells will begin to die. Some tissues are more hardy than others and can withstand lack of oxygen for a considerable length of time. Exactly when damage to the body tissues becomes irreparable is not precisely known, but one leading authority places the maximum time limit for brain tissue, which is the first to suffer, at three minutes and twenty-five seconds after the heart stops beating. It therefore becomes imperative that the stoppage of cardiac activity be known immediately.

During a surgical operation it is customary for the anesthetist to keep a close watch on the function of the patient's heart. However, the anesthetist is often kept preoccupied with other details of the anesthetic and precious moments may pass between the onset of cardiac arrest and its discovery.

It is, therefore, a principal object of my invention to provide a device which will sound an audible warning or give a visual indication within seconds of the cessation of cardiac function so that proper measures may be instituted to restore the circulation of blood and, eventually, cardiac activity while the body tissues are still in good condition and before irreparable damage has been done.

It is another object of my invention to provide an electronic amplifier adapted to pick up the heart sounds, amplify them so that they may be heard throughout the operating room, and sound an audible warning which all operating room personnel may hear within seconds of the cessation of heart sounds.

Another object of my invention is the provision of an electronic device for the purposes described which can be conveniently set up in the operating room in an out-of-the-way place where it will in no way interfere with the operation, the only connection to the patient being a non-electronic chest piece which is strapped to the patient. The chest piece has a single tube through which the heart sounds are mechanically transmitted to a microphone which can be located with the amplifier or at some remote point in the operating room remote from the operating table.

Still another object of my invention is the provision of an amplifying system which will amplify the heart beat so that it may be heard throughout the operating room, the amplifying system including means which will act automatically upon the cessation of the heart sounds to give a distinct, audible warning indicating the failure of the patient's heart.

These and other objects of my invention which will be set forth hereinafter or which will be apparent as this description proceeds, I accomplish by that construction and arrangement of parts of which I shall now describe an exemplary embodiment.

Referring now to the drawings:

Figure 1 is a circuit diagram of an electronic amplifying and signalling device made in accordance with my invention.

Figure 2 is a sectional view of exemplary means adapted to pick up and transmit the heart beat to a microphone.

Figure 3 is a partial circuit diagram illustrating modified circuit means for giving a visual indication of heart activity.

Referring first to Figure 2 of the drawings, the reference numeral **1** indicates a chest piece adapted to be secured to the patient's chest at a point where the heart sounds can be picked up. The chest piece is quite similar to the chest piece of an ordinary stethoscope and may be of the bell or disc type, and it can be conveniently secured to the patient's chest by means of adhesive tape. A length of flexible tubing **2** connects the chest piece **1** to a soundproof housing **3** in which a microphone **4** is contained, the leads of the microphone being indicated at **5**. The heart sounds picked up by the chest piece **1** will be mechanically transmitted through the flexible tubing **2** to the enclosed microphone **4** which will translate the sounds into electrical impulses.

The flexible tubing **2** is preferably formed of rubber or plastic materials such as are employed in conventional stethoscopes. The soundproof housing **3** is preferably formed in two parts, as illustrated, which can be conveniently disassembled to expose the microphone. The nature of the material from which the soundproof housing is formed does not constitute a limitation on my invention, although it will be understood that it must be of such nature that it will insulate the microphone from external noises. While for some uses, the microphone itself may be strapped directly to the patient's chest, the assembly just described is preferred since it substantially eliminates extraneous sounds and also avoids the presence of electrical apparatus in close proximity to the patient where an electrical spark might act to cause an explosion of the anesthetic or shock the patient.

Referring now to Figure 1 of the drawings, which illustrates a preferred circuit means for carrying out the objects of my invention, the heart sounds transmitted to the microphone **4**, which is preferably of the crystal type, are converted into electrical impulses generated by the microphone. These impulses are then amplified by an amplifying system powered from power source **6**, which is a source of conventional A. C. or D. C. current.

The amplifying system comprises an audio frequency amplifying tube V_1, which is a high gain pentode tube. From the tube V_1 the amplified frequencies are passed through condenser C_3 to resistor R_6. The condenser C_3 is suitably chosen to pass the amplified frequencies and resistor R_6 is preferably a volume control by means of which any desired level of electrical impulses may be passed to the grid G_1 of the first half of the twin triode tube V_2, from which the impulses are passed to the grid G_2 of the second half of the tube. The impulses thus generated may be further amplified by tube V_5, being first passed through condenser C_6 and resistor R_{10}, in a manner well understood by the skilled worker in the art. From the tube V_5 the amplified frequencies are passed to a sound reproducer comprising an audio out-put transformer T_1 and a speaker **7**.

The speaker **7** may be conveniently placed in the operating room so that the amplified heart sounds may be heard by all operating room personnel. In place of the loud speaker, the amplified frequenciees may be fed to an earphone worn by the anesthetist or any other designated person assisting with the operation.

A branch circuit **8** is provided to pass a portion of the microphone signal to an amplifying and rectifying tube V_3. Thus, the audio frequency voltage built up across the resistor R_6 is impressed upon the grid G_1 of the duplex-diode triode tube V_3, where it is amplified to produce voltage across resistor R_{14}. As illustrated in Figure 1, the amplified voltage is next passed through condenser C_{12} to the diodes D_1 and D_2 which act to rectify the current and build up direct current voltage across resistor R_{17}, from which the rectified current is fed to grid G_1 of oscillator V_4, being first filtered through resistor R_{15}. A condenser C_{15} is also imposed in the cir-

cuit, and the resistor R_{17} and the condenser C_{15} are chosen to have a predetermined time constant, the purpose for which will be explained hereinafter.

The oscillating means comprises a sharp cut-off pentode tube V_4 and a transformer T_2. In the circuit arrangement illustrated, the direct current voltage is impressed upon grid G_1 of tube V_4. The tube and transformer are connected as an electromagnetic coupled oscillator; and it will be understood that the oscillator may comprise any type of oscillator tube which includes an additional grid for blocking the oscillations.

The operation of the tube V_4 and the transformer T_2 may be explained as follows: the negative voltage built up across resistor R_{17} and impressed upon grid G_1 of tube V_4 effectively blocks the flow of space current in the tube V_4 as long as direct current voltage is present at grid G_1. However, when the patient's heart stops beating, the microphone **4** will cease to produce a signal, the audio frequency current will no longer be built up across the resistor R_6, and consequently the direct current voltage built up in the branch circuit will gradually leak off through resistor R_{17} and condenser C_{15} which will be selected to have a predetermined time constant, preferably of the order of approximately five seconds. Thus, when the patient's heart has stopped beating for a short period of time, such as the above mentioned five seconds, which will exclude any irregularities inherent in the patient's heartbeat, the current supplied to the grid G_1 of the tube V_4 will leak off; and in the absence of this current, the blocking action of the grid G_1 will cease and the space current will flow in the tube V_4 causing the tube to break into oscillation. The oscillations of tube V_4 are preferably transmitted through circuit **9** to the second half of tube V_2 where they will be amplified and passed to audio out-put transformer T_1 and speaker **7**. The amplified oscillations will serve as an audible warning that the patient's heart has stopped beating.

The warning signal created by the oscillations of the tube V_4 will continue until the resumption of heart activity, whereupon the microphone signal will again act to block the space current in the tube V_4 and oscillation will cease.

Where a visual indication of the heart activity is desired, the circuit means just described may be modified in the manner illustrated in Figure 3 of the drawings. As seen therein, the alternating current amplified by the tube V_3 is passed through a resistor R_{18} and neon tube **10** which will flash as long as the pulsating current flows in the branch circuit **8**. The neon tube will, of course, no longer flash when the patient's heart stops beating and the current no longer flows in the branch circuit, thereby giving a warning of the condition of the patient's heart. It will be understood that the neon tube just described may be used in conjunction with the oscillator described above in connection with Figure 1, the current being rectified and passed to the tube V_4 as before, thereby providing both an audible and a visual warning of the stoppage of the patient's heart.

It will be evident that other modifications may be made in my invention without departing from the spirit of it. For example, the oscillations of the tube V_4 may be transmitted directly to the speaker or they may be amplified, where amplification is necessary, by a separate amplifying system. It will also be evident that my invention will find utility in places other than the operating room whereby it is desired to keep close watch on cardiac activity.

Having, however, described my invention in an exemplary embodiment, what I desire to secure and protect by Letters Patent is:

1. In combination in a device for indicating the cessation of cardiac activity, a chest piece for picking up heart sounds, a flexible tube for transmitting the heart sounds to a soundproof housing containing a microphone, an amplifying system including a sound reproducer connected to the out-put of said microphone, a branch circuit for a portion of the microphone signal, and signal producing means in said branch circuit responsive to the cessation of said microphone signal, said microphone signal normally serving to block said last mentioned signal producing means, and means in said branch circuit having a predetermined time constant through which the said microphone signal is passed to said signal producing means, whereby to activate the said signal producing means only after the passage of a predetermined time interval following cessation of the microphone signal.

2. In combination in a device for indicating the cessation of cardiac activity, a chest piece, a flexible tube connecting said chest piece to a soundproof housing containing a microphone, an amplifying circuit including a sound reproducer connected to the out-put of said microphone, a branch circuit for a portion of said microphone signal, said branch circuit including a rectifier and signal producing means including a grid blocked oscillator, the rectified microphone signal serving to block said oscillator, said branch circuit also including means having a predetermined time constant through which the rectified microphone signal is fed to the said oscillator, said signal producing means being effective upon the termination of said microphone signal for a predetermined time interval to sound a warning indicating the cessation of cardiac activity.

3. The combination claimed in claim 2 including a connection between said signal producing means and said sound reproducer, whereby said last mentioned signal is reproduced in the same manner as said microphone signal.

4. A warning system for indicating the cessation of a received signal, said system comprising an amplifying circuit including a sound reproducer for amplifying and reproducing the received signal, a branch circuit including a rectifier for a portion of the received signal and a blockable oscillator adapted to be blocked by the rectified signal, said oscillator being adapted to produce an independent signal upon being freed for oscillation, and means in said branch circuit having a predetermined time constant through which the rectified signal is fed to said oscillator, said last named means acting to permit the oscillator to break into oscillations only after the passage of a predetermined time interval following cessation of the received signal.

5. A warning system for indicating the cessation of a received signal, said system comprising an amplifying circuit including a sound reproducer for amplifying and reproducing the received signal, a branch circuit including a rectifier for a portion of the received signal and a blockable oscillator adapted to be blocked by the rectified signal, said oscillator being adapted to produce an independent signal upon being freed for oscillation, a condenser-resistor combination in said branch circuit through which the rectified signal is fed to said oscillator, said condenser-resistor combination having a predetermined time constant acting to permit the oscillator to break into oscillation only after the passage of a predetermined time interval following cessation of the received signal, and circuit means connecting said oscillator to said amplifying circuit and sound reproducer, whereby oscillations produced by said oscillator will be amplified and reproduced.

6. In combination in a device for indicating the cessation of cardiac function, a chest piece for picking up the heart sounds, a flexible tubing for transmitting the heart sounds picked up by the chest piece, a sound proof housing containing a microphone for receiving said heart sounds, an amplifying system including a sound reproducer connected to the out-put of said microphone for amplifying and reproducing said heart sounds, and a branch circuit including a rectifier for a portion of the microphone signal, said branch circuit also including a blockable oscillator, the rectified microphone signal serving to block said oscillator, said oscillator being adapted to produce an independent signal upon the cessation of said microphone signal as determined by the stoppage of the heart beat, and a condenser-resistor combination in said branch circuit through which the rectified signal is fed to said oscillator, said condenser-resistor combination having a time constant of approximately five seconds.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 21,151	Adair	July 18, 1939
2,077,552	Findley	Apr. 20, 1937
2,264,018	Case	Nov. 25, 1941