

UNITED STATES PATENT OFFICE

2,442,462

APPARATUS RESPONSIVE TO VARIATIONS
IN THE LIGHT TRANSMISSION OF BLOOD
OF LIVING ANIMALS FOR INDICATING
VARIATIONS IN THE OXYGEN CONTENT
THEREOF

Harry M. Kirschbaum, Detroit, Mich.

Application December 13, 1943, Serial No. 514,151

2 Claims. (Cl. 88-14)

1

The invention relates to means responsive to changes in the oxygen content of the blood in living animals and forms a continuation in part of my former application for patent, Serial No. 449,489, filed July 2, 1942, which issued as Patent No. 2,414,747, January 21, 1947. The invention is particularly designed for use by aviators but is also useful in hospitals, laboratories and other places.

It is the primary object of the invention to provide means for quickly determining whether or not there is dangerous oxygen deficiency in the blood of the subject and also to produce corresponding variations in an electric current which, if desired, may be used to automatically administer oxygen so as to correct this deficiency.

It is a further object to obtain indicating means which may be easily adjusted to compensate for individual characteristics so as to give the same reading for all subjects having the same condition of blood with respect to oxygen content. With these objects in view the invention consists in the apparatus as hereinafter set forth.

In the drawings:

Fig. 1 is a diagram illustrating the circuits for the testing apparatus;

Fig. 2 is a longitudinal section through one of the testing units; and

Fig. 3 is a side elevation of the casing containing the testing apparatus showing the indicator mounted thereon and signal lights.

As described in my earlier application, the blood is tested in a portion of the animal tissue through which it is circulated. A convenient point of application is the lobe or other portion of the ear which is thin enough for penetration by a light beam. The testing apparatus includes a light sensitive cell and a light generator together with means for holding the same on opposite sides of the tissue. The light generating bulb performs the additional function of moderately heating the tissue so as to dilate the blood capillaries therein and to maintain a substantially constant rate of blood flow therethrough. The radiation from the bulb may be of various wave lengths including those corresponding to the lower portion of the spectrum. When the blood in the tissue becomes deficient in oxygen, this results in a change of color from red to blue and an increase in obstruction to the rays. Consequently, the light falling upon the light sensitive cell will be proportionately decreased to produce a corresponding variation in the electric current generated or controlled by the cell.

Airplanes travelling at high altitudes carry

2

in addition to the pilot a crew and frequently other passengers. If the cabin is not pressurized or even if it is, in case something goes wrong all will be in danger of oxygen deficiency. I have therefore, devised an apparatus for testing all persons travelling on a plane and indicating the condition of blood of each without regard to variation in individual characteristics. The oxygen administering apparatus may be either automatically or manually controlled but the indicator will show instantaneously whether or not treatment is necessary.

The system as diagrammatically represented in Figure 1 includes a source of D. C. electrical current at constant voltage, a series of light sensitive cells and a plurality of amplifiers for the current alternatively controlled by said cells, one of which is a bridge amplifier. The gauge or indicator which is preferably a milliammeter is connected in the bridge circuit, one side of which is controlled by the light sensitive cell while the other side is adjustable for individual characteristics of the user. In order that the same indicator may be used for all of the cells, a multiple switch is provided by which the operator may alternatively connect the cells into the indicator circuit. A series of signal lights corresponding to the cells are simultaneously operated by the switch so as to indicate the particular cell that is being tested at any time.

More in detail, A is a transformer having a primary coil A' connected with any source of A. C. current and a secondary coil A² for stepping up the voltage which leads to a rectifying tube A³. The latter in cooperation with a choke A⁴, tubes A⁵ and A⁶, resistances A⁷ and A⁸, and suitable circuit connections constitutes a power pack for delivering D. C. current at constant voltage to lines B and B'. The voltage maintained on the line B is preferably +125 volts and that on line B' -125 volts. C, C' are light sensitive or photoelectric cells which correspond in number to the number of persons on the plane, only two cells being illustrated. D, D' are signal lights corresponding respectively to the cells C, C' and E, E', E² represent a multiple switch for simultaneously controlling the cells, signal lights and adjustment means hereinafter described. F is an amplifier tube. G is a bridge amplifier tube containing two triodes and H is a gauge or indicator. The connecting circuits include a potentiometer I connected with the positive line B for supplying current at the proper voltage through a conductor I' containing a resistance I² to the photoelectric cells C, C'. The tube F has its plate F'

3

directly connected to the line B so as to be maintained at the same voltage. The cathode F³ is connected by a conductor J to the grid G' on one side of the bridge amplifier tube G. A branch conductor J' containing a resistance J² leads to a ground. The grid F³ of the tube F is alternatively connected with the photoelectric cells C, C' by means of the switch E. As shown, this switch connects a conductor K from the photoelectric cell C' to a conductor K' leading to the grid F³, while a branch K² containing a resistance K³ leads to a ground. A conductor K⁴ leads from the photoelectric cell C to the switch E and in one position of this switch will be connected to the conductor K'. The signal lights D, D' are supplied with current from a secondary coil A³ of the transformer A through a conductor D² and connectors D³ and D⁴ lead from the lights to the switch E'. The grid G² on the other side of the bridge amplifier tube G is connected by a conductor G³ with the switch E² and through said switch is alternatively connected through conductors G⁴ and G⁵ to potentiometers G⁶ and G⁷, the latter being connected through the conductor G⁸ to the line B. The plates G⁹ and G¹⁰ on the opposite sides of the bridge amplifier are supplied with voltage from the line B respectively through a conductor G¹¹ having a resistance G¹² and a conductor G¹³ having a resistance G¹⁴. The cathodes G¹⁵ and G¹⁶ are connected to the negative line B' through a resistance G¹⁷. For simplicity, the heating circuits for the amplifier tubes are omitted and the lamps with their circuits for the photoelectric cells C and C' are also omitted. Also, the circuits are provided with condensers at suitable points which need not be described in detail.

With the construction as thus far described, it will be understood that any one of the series of photoelectric cells may be connected to the amplifier tube F through the switch E and simultaneously the switch E' will close the circuit of the corresponding signal light so as to indicate which of the photoelectric cells is used. Also simultaneously the switch E² will connect the corresponding potentiometer G⁶ or G⁷ with the grid G² of the bridge amplifier G. This potentiometer has been previously adjusted to correspond to individual characteristics of the person whose blood is being tested as will now be described.

Each of the individual testing units comprises a frame L preferably formed of light metal, such as aluminum or magnesium and being of U-shaped form having at one end a casing L' for containing the photoelectric cell. Different types of photoelectric cells may be used such as photoemissive or photoconductive. I prefer, however, to use a photoconductive cell such as a selenium cell, the controlled current of which is not subject to the rapid fluctuations characteristic of the photoemissive cells. The lamp L² which furnishes the light for operating the cell is mounted on the other arm of the U frame L to be directly opposite an aperture L³ in the casing L'. Surrounding this lamp is a tubular casing L⁴ exteriorly screw-threaded to engage an adjustable correspondingly threaded sleeve L⁵. This sleeve is used for clamping the unit to the lobe of the ear of the user or to any other portion of the body to which it may be applied. As illustrated, the sleeve has been screwed against the one side of the ear lobe pressing the other side thereof against the casing L' so that the light from the lamp L² will pass through the tissue into the opening L³ of said casing. The photoelectric cell

4

is not illustrated as it is of known construction. However, the conductors for supplying current to the lamp L² and for carrying the controlled current of the cell pass through a flexible cord M, the other end of which leads to a plug connector N. The plug N is connected with one of a series of sockets mounted on a casing O which contains the apparatus and displays the signal lights D, D' and the indicator gauge H.

Operation

In the use of the apparatus as, for instance, on an airplane which is to travel at high altitudes, all of the occupants of the plane are provided with the testing units L, each being attached to the ear as previously described. The units are very light and will not inconvenience the user while the conductor cord is of sufficient length and sufficiently flexible to permit the user to move about in the plane. Before flight the apparatus is adjusted to compensate for individual characteristics of each user, this being accomplished by adjustment of the potentiometers G⁶, G⁷. Assuming that the oxygen content of the blood is normal in each of the users, there will still be differences such as, different thickness of the ear which would give a different reading on the indicator H. However, as this indicator is in a bridge circuit between the plates G⁹ and G¹⁰ of the bridge amplifier tube G, the reading of the dial may be adjusted by a variation in the potential of the grid G². This is controlled by the individual potentiometer such as, G⁶, which corresponds to a particular photoelectric cell. Consequently, by raising or lowering the voltage of the grid G², the index hand of the indicator may be moved to the point indicating full oxygen content of the blood.

When adjustments have thus been made for all the passengers, some one person may be given the responsibility for all of the others and at frequent intervals he can make tests by manipulation of the switch E which cuts in the different photoelectric cells. Should the indicator show less than the minimum safe oxygen content the particular individual tested should be given oxygen treatment or, if desired, the administration of the oxygen may be automatically performed by the apparatus which operates the indicator. However, the specific construction of apparatus for this forms the subject matter of my former application and, therefore, will not be further described.

What I claim as my invention is:

1. An apparatus for indicating variations in the oxygen content in the blood of a living animal comprising a source of light at constant intensity, a photoconductive light sensitive cell, means for positioning said light source and cell on opposite sides of a portion of the animal tissue in which blood is circulating whereby the light transmitted through said animal tissue will be modified by changes in the blood circulating through said animal tissue due to oxygen deficiency, amplifying means including a bridge amplifier having the grid on one side thereof connected to said cell to control the voltage of said grid by the current from said cell and means for adjusting the grid voltage on the other side of said bridge amplifier whereby the current in the bridge circuit is modified to compensate for the characteristics of the particular animal tissue being tested, and an instrument connected to said bridge amplifier responsive to variations in the current flowing therethrough.

5

2. An apparatus for indicating variations in the oxygen content in the blood of a living animal comprising a source of light at constant intensity, a photoconductive light sensitive cell, means for positioning said light source and cell on opposite sides of a portion of the animal tissue in which blood is circulating whereby the light transmitted through said animal tissue will be modified by changes in the blood circulating through said animal tissue due to oxygen deficiency, amplifying means including a bridge amplifier having the grid on one side thereof connected to said cell to control the voltage of said grid by the current from said cell, means for adjusting the grid voltage on the other side of said bridge amplifier to modify the current in the bridge circuit so as to compensate for the characteristics of the particular animal tissue being

6

tested, and an indicator for the oxygen content of the blood connected to said bridge amplifier to be operated by the current of said bridge circuit.

HARRY M. KIRSCHBAUM.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,762,748	Smith	June 10, 1930

OTHER REFERENCES

Review of Scientific Instruments, October 1942; article by G. A. Millikan on pp. 434 to 444.