April 28, 1936. H. HESSE 2,039,000

HEMADYNAMOMETER OPERATING ACCORDING TO THE COMPENSATION METHOD

Filed Sept. 7, 1932 3 Sheets-Sheet 1

Fig. 1

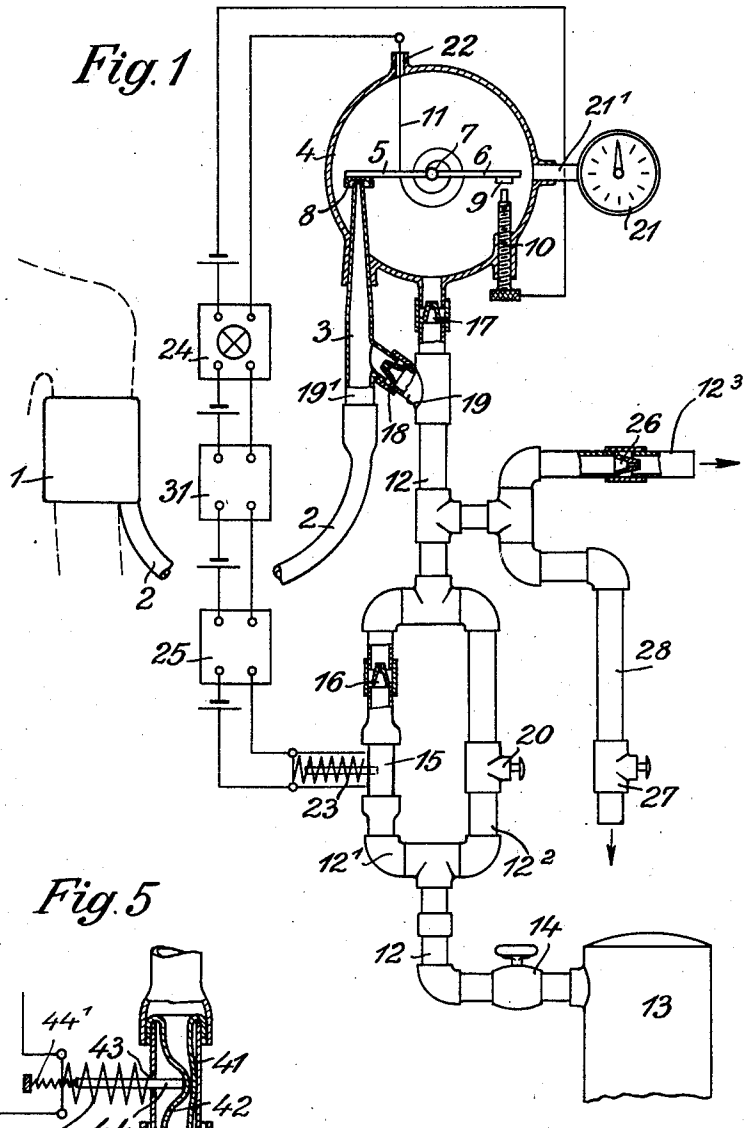


Fig. 5

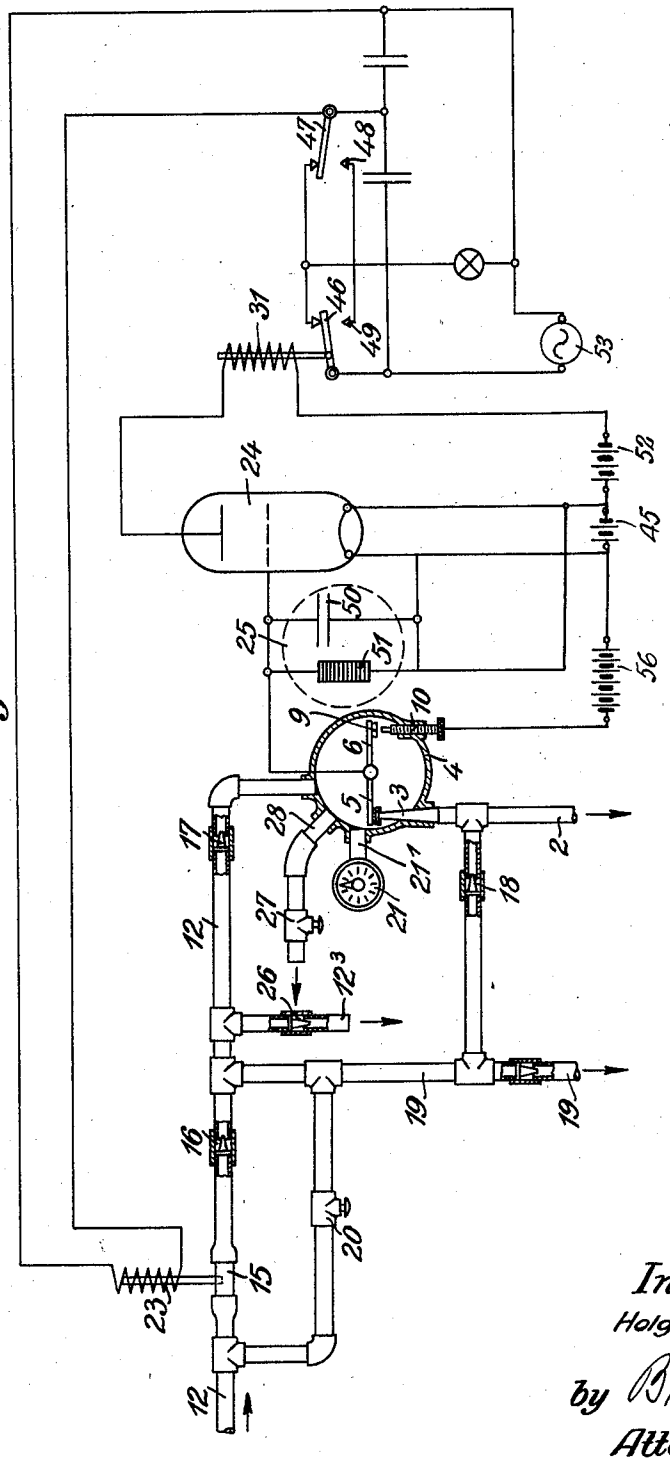
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Fig. 2



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Fig. 3

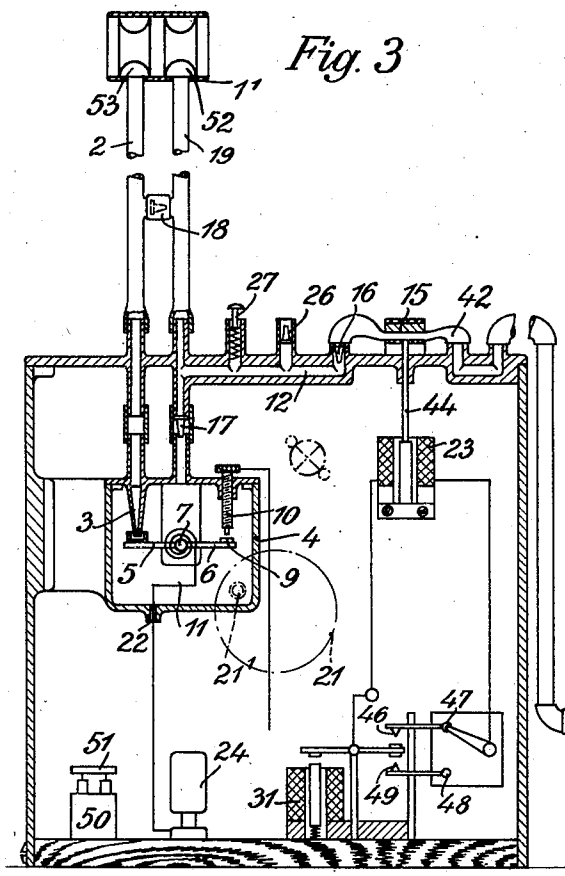


Fig. 4

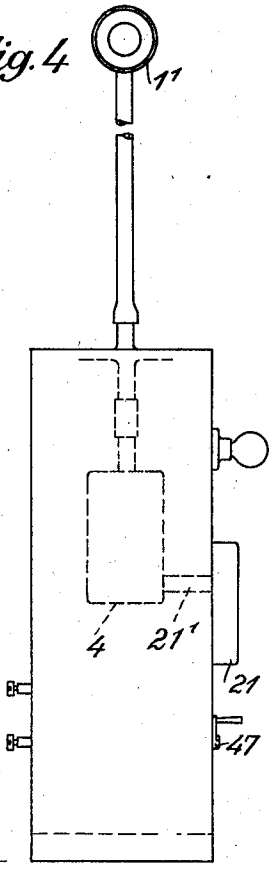


Fig. 6

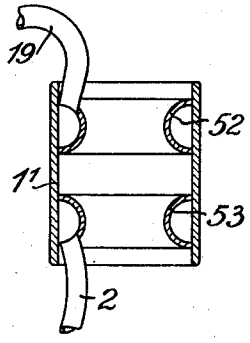
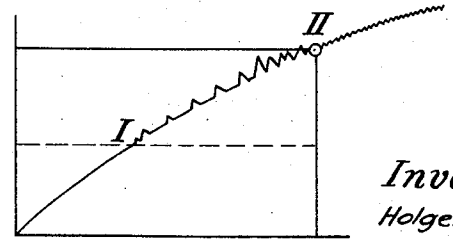


Fig. 7



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UNITED STATES PATENT OFFICE

2,039,000

HEMADYNAMOMETER OPERATING ACCORDING TO THE COMPENSATION METHOD

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Application September 7, 1932, Serial No. 632,076
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8 Claims. (Cl. 73—44)

This invention relates to an improved hemadynamometer operating according to the compensation method, in which the air pressure is increased within a pneumatic arm bandage or cuff until fluctuations of the pressure (observed at a gauge) are noted which result from the pulse beat and the commencement of which is considered to be the lower limit of the pressure of the blood, viz. the so-called diastolic limit. On a further increase of the air pressure in the pneumatic bandage the fluctuations caused by the pulse beat cease, and this ceasing is considered to constitute the upper limit of the pressure of the blood, viz. the so-called systolic limit which up to now has chiefly been used as basis for the measurements in question.

In effecting measurements according to the compensation method it is customary to connect the arm-bandage that is to be placed over the upper-arm artery with a compressed-air storage receptacle, and to regulate the supply of this air to the bandage by means of the oscillations of the pulse, in such a manner that a contact device operated by the pulse beat is arranged over the radialis pulse, whereby this contact device in turn actuates a valve located in the air connection between said compressed-air storage receptacle and the said arm-bandage.

Devices of this type do not only require the provision of two separate devices which are to be attached to the arm, but are also not always reliable, because, if the contact device should be pressed against the pulse too tight or too slight or is applied otherwise in an incorrect manner, the result of the measurement is likely to be incorrect.

The principal object of the invention consists in an air-tight space which is connected with a pneumatic arm cuff or bandage and in which is arranged a device controlling the supply of the air to the cuff and to said space, said device being influenced by the air shocks produced in the cuff and being caused by the oscillations of the pulse, whereby the operation of the apparatus is made independent of the absolute height of the pressure.

Another object of the present invention consists in the provision of regulating members by which the speed of the air or other gas supplied to or withdrawn from the cuff and the air-tight space is so limited that the air shocks which the pulse produces are not detrimentally affected.

A regulating member arranged in the pipe supplying the air etc. to the cuff and to the hermetically closed space is kept open or closed, respectively, as the case may be, as long as air shocks are produced in the cuff or bandage owing to the action of the pulsations, or the oscillations of the pulse respectively, whereby too high a speed of the air entering said hermetically closed space and into the said cuff is prevented, thus, avoiding uncertainties or inaccuracies of the measurements. As long as pulsations are produced, that is to say, as long as, for example, the maximum of the blood pressure has not been attained, the air-supply valve remains open and a slow speed of the continually supplied air is, therefore, sufficient.

According to this invention, the air shocks produced in the hermetically closed space can be caused to act in such a manner upon the controlling device arranged in said space that the supply of air to the cuff is interrupted either by the commencement or by the ceasing of the oscillations of the pulse, whereby it is rendered possible that the lower, as well as the upper limit of the blood pressure can be measured or recorded.

In order to render the device particularly sensitive, there may be provided in the hermetically closed space a contact device designed in the manner of an electric instrument with rotary spools, one arm of this instrument being acted on by the air shocks and the other arm serving for producing the contacts.

A hemadynamometer operating after the compensation method and improved according to the present invention is illustrated diagrammatically and by way of example on the accompanying drawings, on which Figure 1 shows the complete arrangement and combination of parts constituting the apparatus; Figure 2 is a similar illustration showing a modification; Figure 3 is a vertical section through an apparatus corresponding with Fig. 2; Figure 4 is a side-view of this apparatus; Figures 5 and 6 show certain details more fully dealt with hereinafter, and Figure 7 is a blood pressure diagram which will assist in thoroughly understanding the invention.

Referring to Fig. 1, 1 denotes the pneumatic arm cuff or bandage and 2 is a hose connecting said cuff with a nozzle 3 extending into a hermetically closed chamber 4, in which is supported a two-armed lever 5, 6 on an axle 7 in the manner of an electric instrument with rotary spools. The arm 5 of said lever bears a cap 8 which normally keeps the orifice of the nozzle 3 closed; the arm 6 of the said lever bears a contact piece 9 which when the lever is turned

in clock-wise direction pushes upon an adjustable contact screw 10 extending from the outside into the chamber 4. The lever 5, 6 is held by a spring 11 normally in that position in which the cap 8 keeps the nozzle 3 closed.

The chamber 4 is connected by a pipe 12 with a bottle or the like 13 containing compressed air or any other suitable gas under pressure. 14 is a pressure-reducing valve inserted into said bottle or the like 13.

The pipe 12 is partly subdivided into two branches 12^1 and 12^2, of which 12^1 contains an electrically controlled valve 15 and a throttle orifice 16. Another throttle orifice 17 is arranged in the pipe 12 just in front of the chamber 4, and a third throttle orifice 18 is provided in a branch 19 of the pipe 12, this branch connecting the pipe 12 with the body member 19^1 of the nozzle 3, said latter member establishing the connection between said nozzle and the hose 2.

When the valve 15 provided in the branch 12^1 of the pipe 12, as stated, is opened, air streams from the bottle 13 into the chamber 4, as well as into the pneumatic cuff 1. The several throttle orifices are so adjusted that the relations between the pressures in the chamber 4 and in the cuff 1 remain unchanged.

When the pressure in the cuff has attained a certain height, the oscillations of the pulse commence in known manner, as indicated at I in Fig. 7. The respective height of the pressure is considered to constitute the diastolic limit of the blood pressure. The amplitudes of these oscillations have various values. When the pressure in the cuff is further rising, owing to the continued supply of air, the oscillations will cease at a certain distinct height of the pressure, as indicated at II in Fig. 7. This point is considered to constitute the systolic limit of the blood pressure.

Filling the cuff 1 and the chamber 4 up to the lower limit of the blood pressure is effected by opening a valve 20 arranged in the branch 12^2 of the pipe 12, at which time the valve 15 remains closed. I wish it, however, to be understood that said branch 12^2 is not indispensably requisite, but may be dispensed with, in which case the valve 15 must, however, be open so as to permit the rise of the pressure.

Now, in order to make in a given case the state of the blood pressure continuously visible at the indicating and writing manometer 21 that is connected by tube 21^1 with the chamber 4, or to attain the same result with the aid of a recording instrument of any suitable known type and also connected to chamber 4, the following arrangement and combination of parts has been devised:

The contact screw 10 and a conducting member 22 provided at the outer end of the spring 11 are located in a circuit serving for controlling a relay 23 acting upon the valve 15. The oscillations of the pulse produce air shocks in the cuff 1 which then proceed forward and outwardly through the nozzle 3 and move the lever 5, 6. At every oscillation of this lever a contact is established between the contact members 9 and 10, and a rush of current passes through the controlling relay 23 across a highly sensitive auxiliary relay constituted, for instance, by a suitable known electronic tube 24, the air valve 15 being then opened by the action of the relay 23. and an intermediate relay 31 which is operated by the anode current of the electron tube 24 and shown more clearly in Fig. 2. The valve 20 is closed at this time. As the opening of the valve 15 is only very short, in that it has been produced by a rush of current, as stated, and as, therefore, the amount of air necessary to increase the pressure in the cuff 1 and in the chamber 4 would require correspondingly high speed, there is inserted into the circuit a delaying system 25 of any known type, comprising, for instance, a condenser and a resistance, the action being such that the contact for the circuit of the controlling relay 23 is kept closed for about one second. If after the first impulse a second impulse should follow owing to an insufficient height of pressure in the cuff, the retarding relay 25 would still retain its energization and therefore be effective in maintaining the circuit closed before the contact members in the circuit of relay 23 become separated from each other. Only when an impulse has passed by, that is to say, when the point II of the diagram (Fig. 7) has actually been attained and no further oscillations of the pulse take place, is the circuit interrupted and the valve 15 closed. By reason of the thus attained continuous supply of air to the cuff 1 and to the chamber 4 the speed of the air can be kept so low that the air supply cannot affect detrimentally the result and indication of the measurement in any way.

The throttling members 17 and 18 and the air pipes are arranged and adjusted relatively to one another in such a manner that the supplied air gets solely into the chamber 4 and into the cuff 1, but cannot escape through the nozzle 3.

In a branch 12^3 of the air pipe 12 is provided a throttling member 26 through which air escapes continually into the atmosphere in order to enable the apparatus to follow a decrease of the blood pressure.

When the pressure in the cuff 1 and in the chamber 4 decreases owing to the escape of the air through the throttling member 26, the oscillations of the pulse arise again and entail opening of the air-supply valve 15. This procedure is continually repeated, and by appropriately adjusting the contact screw 10 it is rendered possible to make the point II (indicated in Fig. 7), that is to say, the point on the gauge corresponding to the upper blood pressure limit, continually visible at the gauge 21, or to register this pressure continually on a suitable recording apparatus (not shown).

In order to interrupt the measurement after a certain length of time a branch pipe 28 of the pipe 12 and in this branch pipe an outlet valve 27 may be provided, this valve serving for emptying the chamber 4 and the cuff 1.

The electrically controlled air valve may consist of a piece of tube 41 enclosing a piece of rubber hose 42 and having a lateral hole 43 through which extends an iron pin 44 into said tube and is pressed against said hose by a spring 44^1. The pin 44 is, in fact, the core of a solenoid, of which the coil 43^1 forms the other part. When current is flowing through this coil, the pin or core 44 is drawn into the coil and the sectional area of the hose 42 is increased so that a correspondingly large amount of air can flow therethrough. I wish it, however, to be understood that the piece of tube 41 may be dispensed with if instead thereof an abutment member for the piece of hose just counter to the end of the pin or core is provided, as will be clear without further details. And I wish it further to be understood that the air valve in question may be

designed also in a variety of other manners without affecting the effect of the same.

Concerning the constructional form shown in Fig. 1 and dealt with on the preceding pages it has been assumed that the bandage or cuff 1 contains an inflatable member which is connected with the nozzle 3 by the hose 2 and from which escape the rushes of air produced by the oscillations of the pulse. In particular cases it may, however, be desirable to withdraw the air not from the damming cuff proper, but from a separate inflatable member which is provided at a certain distance from said damming cuff and is not acted on by impulses arising outside of said cuff as soon as the pressure in the other cuff has reached the height of the blood pressure. A thus modified cuff 1^1 is shown in Fig. 6 in which 52 denotes a pneumatic cushion that forms the damming cup proper and with which the air pipe 19 is connected, whereas 53 is another pneumatic cushion which is connected with the nozzle 3 (Figs. 2 and 3) by means of the hose 2.

Referring now to Figs. 2, 3 and 4, this constructional form is so designed as to enable the operator to measure the lower and the upper limit of the blood pressure. Those reference numerals which correspond with the same reference numerals in Fig. 1 denote the same parts as in Fig. 1.

The filament cathode of the thermionic tube 24 is heated by a battery 45. A current, therefore, flows continually from the battery 52 for the anode through the winding of the relay 31, which relay thereby maintains the contact 46 in the closed position indicated in Fig. 2. When the switch lever 47 also assumes the position shown in Fig. 2, alternating current will flow then from the source of alternating current indicated at 53 through the levers 46, 47 and through the winding of the control relay 23 for the valve 15. The valve 15 thereby is being opened and the air from the receptacle 13 escapes through the conduit 12 to the hermetically sealed casing 4, a portion of this air also entering through a branch 19 and flexible tube 2 to the arm cuff 1. When a certain pressure is thereby produced in the cuff, the oscillations due to the pulse beat will be transmitted through the same tube 2 and nozzle 3 to the lever 5, 6 in the casing 4, this lever being thereby rocked to establish contact between the contact elements 9 and 10 in the casing. A negative voltage from the battery 56 is thereby placed upon the grid of tube 24. The current having up to then come from this tube 24 is thus interrupted and the relay 31 opens the contact 46 whereby the circuit of the air-controlling-relay 23 is interrupted and the valve 15 is consequently closed. The lower blood pressure limit has now been attained and can continually be measured at the manometer 21 or recorded with the aid of a recording instrument connected, for instance, to the tube 21^1, but not shown in the drawings.

As soon as, owing to the continual discharge of the air from the throttling valve 26, the pressure in the cuff 1^1 has decreased and the rushes of air from the nozzle 3 have ceased, the contact lever 5, 6 swings back into its former position and opens the contact 10. Now current commences again to flow from out of the electronic tube 24, and the contact 46 is again closed by means of the relay 31 whereby the air-supply valve 15 is again opened and the phases described are repeated. By an appropriate adjustment of the contact screw 10, the writing member of a recording instrument can be caused to oscillate so slightly that the line it produces is nearly straight.

In order to ascertain the upper blood pressure limit, or to record the same, the switch lever 47 is turned downwardly so as to contact with the contact 48. Air from the bottle 13 is being led to the hermetically closed chamber 4 and to the cushions 52 and 53 of the cuff 1^1 through the filling valve 20 or through the valve 15, this air-supply being maintained until the oscillations of the pulse arise again. The valve 20 is now being closed. As soon as rushes of air escape from the nozzle 3, the lever 5, 6 thereupon again closes the contact 10. Thus, the grid of the tube 24 is loaded and the current coming continually from the electronic tube 24 across the relay 31 is interrupted, as is, therefore, also the contact 46, and as now the contact 49 is closed, the current flows from the source 53 for the alternating current across the parts 46, 49, 48 and 47 to the control relay 23, so that now the air valve 15 is being opened. The air supply through the valve 15 proceeds as long as rushes of air escape from the nozzle 3 owing to the existence of the pulse oscillations. When these cease, the contact 10 is being opened and the current from the electronic tube 24 can again act in the already described manner. The relay 31 opens the contact 46, 49 and the air valve 15 is being closed, as the circuit of the control relay 23 has been interrupted.

When measuring the upper blood pressure limit the writing member of a recording instrument may be caused to oscillate only very slightly and to draw a nearly straight line by suitably adjusting the contact screw 10.

In order to attain a quiet and continuous supply of the air to the chamber 4 and to the cushions 52, 53 of the cuff 1^1 in spite of the short duration of the contacts, a delaying system 25 comprising a condenser 50 and a resistance 51 is provided also in connection with the modification in question. This delaying system operates by charging the condenser 50 intermittently upon closure of the contact 9, 10 in the casing 4. When this contact is open, as indicated in Figs. 1, 2 or 3, a gradual discharge of the condenser 50 takes place through the high resistance 51. Owing to the insertion of this high ohmic resistance, the negative grid voltage of the tube 24 slowly decreases. It is possible to select a resistance of such values that this voltage on the grid has become low enough only after the expiration of about one second to permit current from the anode of the tube to flow through the winding 31. This current will then suffice to actuate the contact 46.

By a suitable adjustment of the contact screw 10 it is also rendered possible to ascertain the amplitudes of the oscillations produced by the pulse oscillations, or to trace the greatest thereof.

I wish it to be understood that I do not limit myself merely to the details of the arrangements and combinations of parts shown solely by way of example. Many departures in the details are possible without constituting departures from the gist of the invention.

I claim:

1. A hemadynamometer operative according to the compensation method, comprising, in combination, an arm cuff and a hermetically closed chamber connected therewith, a pressure gauge in communication with said chamber; means adapted to supply air to said cuff and said chamber, and means responsive to the shock-like varia-

tions of pressure between the cuff and the chamber caused by oscillations of the pulse, for regulating the air supply to said chamber.

2. A hemadynamometer operative according to the compensation method, comprising, in combination, an arm cuff and a hermetically closed chamber connected therewith, a pressure gauge in communication with said chamber; means adapted to supply air to said cuff and said chamber, means responsive to the shock-like variations of pressure between the cuff and the chamber caused by oscillations of the pulse for regulating the air supply to said chamber, and means to retard the regulating movements of said regulating device.

3. A hemadynamometer operative according to the compensation method, comprising in combination an arm cuff, a hermetically closed chamber connected with the cuff, a source of fluid pressure, conduits extending from said source to said cuff and to said chamber, a contact device in said chamber, and means under control of said contact device for obstructing one of said conduits from said source upon initiation and upon cessation of pulse oscillations transmitted by the arm cuff, whereby the pressure conditions in such chamber are varied in dependence upon pulse oscillations and a pressure gauge in communication with said chamber.

4. A hemadynamometer operative according to the compensation method, comprising in combination an arm cuff adapted to respond to pulse oscillations, a hermetically closed chamber connected with the cuff, a source of fluid pressure, conduits extending from said source to said cuff and to said chamber, a contact lever oscillatably supported in said chamber, one arm of said lever being subjected to the flow of air entering through the communicating conduit between the cuff and the chamber, the other end of the lever carrying a contact element, a companion contact element stationary in said chamber, and means under control of said contact elements for obstructing one of said conduits from said source upon initiation and upon cessation of pulse oscillations transmitted by the cuff, whereby the pressure conditions in said chamber are varied in dependence upon the pulse oscillations and a pressure gauge in communication with said chamber.

5. A hemadynamometer operating according to the compensation method comprising in combination an arm cuff adapted to respond to pulse oscillations, a hermetically closed chamber in communication with the cuff, a source of fluid pressure, conduits extending from said source to said cuff and to said chamber, a two-armed lever pivoted in said chamber, a switch contact piece on one end of the lever, the other end of the lever overlying the end of the conduit between the arm cuff and the chamber, a companion contact stationed in the chamber whereby a circuit is closed upon oscillation of said lever in response to shock-like variations of pressure in the chamber caused by the pulse oscillations transmitted from the arm cuff, another circuit containing a relay, a valve in the conduit extending from the source of pressure fluid to the arm cuff, said valve being under control of said relay, the circuit containing the relay being controlled by the circuit established upon closure of the said contacts, whereby the pressure conditions in the chamber are varied in dependence upon the pulse oscillations, and a pressure gauge in communication with said chamber.

6. A hemadynamometer operative according to the compensation method, comprising in combination an arm cuff adapted to respond to pulse oscillations, a hermetically closed chamber connected with the cuff, a source of fluid pressure, conduits extending from said source to said cuff and to said chamber, air throttling and air outlet valves located in said conduits between the pressure supply and said cuff and chamber, said valves in the conduit being adapted to weaken shock-like movements of air through the conduits and to regulate the supply of air of higher pressure in different chambers, whereby the pressure increases uniformly in such different chambers, a contact device in the chamber, means under control of the contact device for influencing the air throttling members, whereby the pressure conditions in the chamber are varied in dependence upon the pulse oscillations and a pressure gauge in communication with said chamber.

7. A hemadynamometer comprising an arm cuff, a source of pressure, a hermetically sealed chamber, a nozzle leading into said chamber, a conduit connecting said nozzle and arm cuff, a two armed lever pivoted in said chamber, a cap on one arm of said lever which normally keeps the orifice of the nozzle closed, a switch contact piece on the other arm of said lever, means providing communication between the source of pressure and said chamber and cuff, an electrically operative valve for controlling said communicating means, an electric circuit for operating said valve, said circuit including a switch contact extending into said chamber for cooperation with the switch contact piece on said arm, whereby the circuit is closed upon oscillation of said lever in response to shock-like variations of pressure in said nozzle caused by the pulse beat for regulating the air supply to said chamber and cuff, and pressure measuring means in communication with said chamber.

8. A hemadynamometer operative according to the compensation method, comprising in combination an arm cuff adapted to respond to pulse oscillations, a hermetically closed chamber in communication with the cuff, a source of fluid pressure, conduits extending from said source to said cuff and to said chamber, a contact device in said chamber actuated by intermittent gusts of air flowing from the arm cuff to said chamber and corresponding to the pulse oscillations to which the arm cuff is responsive, a valve in a conduit leading from the source of pressure fluid to the cuff, and the chamber, said valve comprising a flexible tubular member, a pressure element adapted to compress said member to close the same, and electric means for actuating the pressure member of the valve, said electric means being under control of the contact device in the chamber, whereby the pressure conditions in the chamber are varied in dependence upon the pulse oscillations, and a pressure gauge in communication with the chamber.

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