March 15, 1966 W. W. HAY 3,241,152

BLOOD PRESSURE CUFF INFLATOR

Filed Sept. 25, 1962

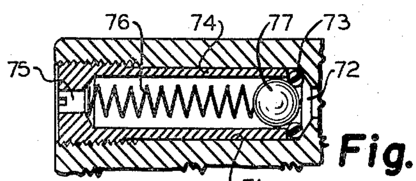

Fig. 3

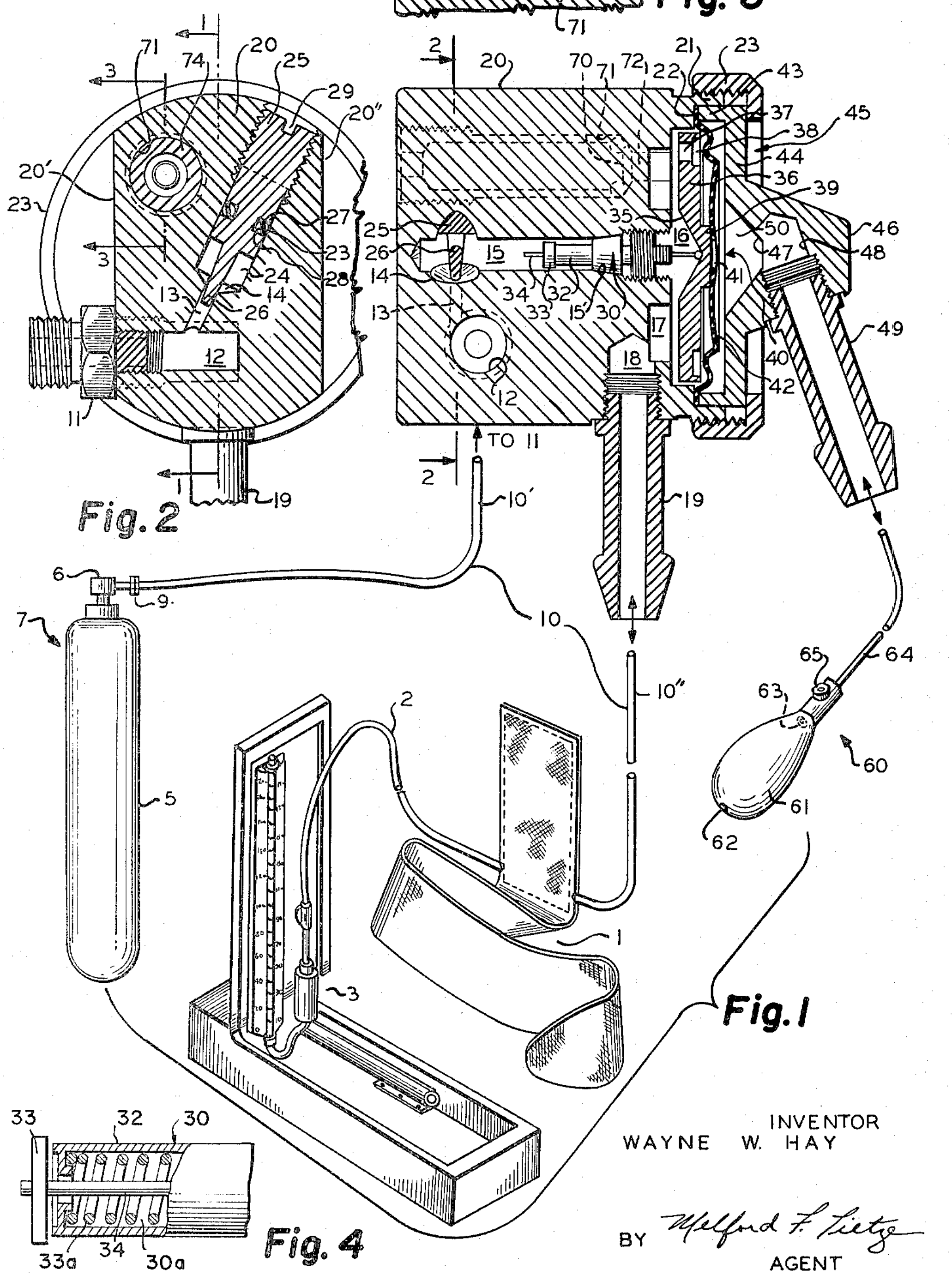

Fig. 2

Fig. 1

Fig. 4

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United States Patent Office 3,241,152
Patented Mar. 15, 1966

3,241,152
BLOOD PRESSURE CUFF INFLATOR

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Filed Sept. 25, 1962, Ser. No. 226,107
11 Claims. (Cl. 128—2.05)

This invention relates to blood pressure taking apparatus.

In the typical use of such apparatus of the ordinary variety a cuff or armlet is wrapped around the patient's arm and is then inflated by means of a hand bulb to a pressure somewhat in excess of the expected systolic value; by manipulation of a bleed valve the pressure is then dropped slowly through the systolic range, is next dropped quickly to a value somewhat in excess of the expected diastolic value, and is then dropped slowly through the diastolic range. The pressure-raising and -dropping cyle may be gone through either once or several times in rapid succession or, as in the case of use during anesthesia, many times spaced apart by appreciable intervals. After the last cycle the remaining pressure is quickly discharged and the armlet removed.

During each cycle the physician, anesthetist or other operator listens with a stethescope to the pulse of the patient, and ordinarily needs to use one of his hands to manipulate the stethescope; accordingly, only one of his hands is free to effect the raising and lowering of the pressure. It is, therefore, customary to mount the pressure-reducing or bleed valve on the hand bulb so that it may be manipulated by one or two digits of the hand which holds and has squeezed the bulb to develop the pressure.

Lowering the pressure, of course, requires negligible effort and consumes negligible time; raising it, however, requires a considerable number of repeated compressions of the bulb. This is time-consuming, and furthermore may be wearying—particularly in the case of an anesthetist, whose hand has frequently been engaged in, and consequently already tired from, repeated squeezing of the rebreathing bag of the anesthetic system.

It is an object of the present invention greatly to reduce the effort and time consumed in raising the pressure. It is an object to do in a manner which permits the use, to command the raising and lowering of the pressure, of the identical devices—typically the hand bulb and bleed valve abovementioned—conventionally used, each for commanding its usual function. It is an object to do so in a manner which is simple, reliable, safe and inexpensive. Other and allied objects will appear from the following description and the appended claims.

Briefly, the invention contemplates the use of a pressurized source of air or other gas, which may be connected through a suitable passage to the armlet; it provides valve means, controlled by a pilot pressure applied thereto, for rendering the pressure within the armlet a bidirectionally variable function of that pilot pressure; and is provides a chamber within which that pilot pressure is developed and to which the pressure-commanding means—typically the same hand bulb, with associated bleed valve, which is ordinarily used—is connected. The pilot pressure chamber may be of capacity very small relative to the operative capacity of the armlet, with the result that a single compression of the hand bulb will be all that is required to develop over-systolic pressure in the armlet. The valve means abovementioned may comprise a regulating valve interspersed in the source-to-armlet passage and a check valve operatively connecting the armlet to the pilot pressure chamber. In accordance with further features, a throttling valve, such as a needle valve, may be interposed in the source-to-armlet passage, and a relief valve may be connected with the armletward portion of that passage to limit the maximum pressure in the armlet.

In the detailed description of the invention hereinafter set forth, reference is had to the accompanying drawing, in which:

FIG. 1 is a prespective view of the armlet or cuff and the manometer of typical blood-pressure-taking apparatus and of a pressurized source of gas, together with a similar view of manual control apparatus and a relatively much enlarged cross-sectional view of a valve system and a pilot pressure chamber embodying the invention;

FIG. 2 is a cross-sectional view taken along the line **2—2** of FIG. 1 in the direction of the arrows (and indicating as **1—1** the line along which the cross-sectional portion of FIG. 1 is taken; and

FIG. 3 is a cross-sectional view taken along the line **3—3** of FIG. 2 in the direction of the arrows.

FIG. 4 is an enlarged partial sectional view of the valve mechanism seen in FIG. 1.

Reference being had to FIG. 1, there will be seen a conventional armlet or cuff **1** and a conventional manometer **3** (typically of the mercury-column type) which is connected to the armlet by tubing **2** and from which the pressure (over-atmospheric) in the armlet may be read. There will also be seen a tank **5** of gas (which may be air, oxygen or any other convenient and safe gas) under pressure; at its outlet the tank **5** may, if desired, be provided with a conventional pressure-reducing means **6** to avoid excessive pressures in the line to which it is connected, the tank and those means (if employed) constituting a typical pressurized source **7** of gas. Connected to the armlet **1**, there will be seen a line **10** constituted by suitable tubing, the source **7** being connectible (and shown connected) to the line **10** by any suitable coupling **9**. The invention is, among other things, directed to the controllable supply of gas through the line **10** to the armlet **1** and with the controllable drainage of that gas from the armlet; it accomplishes those functions by appropriate means, of which a portion is interposed in the line **10** and to which attention may now be directed.

That portion comprises a regulating valve contained within a generally cylindrical housing member **20**, which member may be and is illustrated as an integral one through which an axis-containing plane is seen in cross-section in FIG. 1. Thus, axially of the member **20**, from its forward or right-shown surface almost but not fully to its rear or left-shown surface, there may be provided a bore **15** which, near the housing member's forward surface may have a tapered portion **15′** and which forwardly of that portion may be internally threaded. Rearwardly into the bore there may be screwed a valve mechanism **30**, of the general type commonly used for the retention of air in (and its controllable release from) automobile tubes or tires, having an intermediately along its length a tapered surface which will be securely seated against the tapered portion **15′** of the bore **15**. This valve has an axially disposed and axially movable stem **34** carrying a closure member **33** near its inner or rearward extremity and biased forwardly, by internal means, such as spring *33a* seen in FIG. 4, to bring the closure member **33** normally into valve-closing abutment against the body portion **32**; when the stem **34** is moved rearwardly against its bias, however, it will carry the closure member **33** rearwardly away from the body portion **32** thereby to render terminally open an internal passage, seen at *30a* in FIG. 4, through the valve and, thus, to establish communication between the bore **15** and the space **16**, immediately in front of the forward surface of the housing member **20**.

The sourceward portion **10′** (which may be of semirigid tubing appropriate to the source pressure) of the line 10 communicates with the bore 15. Thus, transversely into the housing member 20 (see both FIGS. 1 and 2), in a position (as shown) too low itself to intersect the axial bore 15, there is provided a bore 12—the rear portion of the housing member 20 being desirably machined away to provide parallel flat surfaces 20′ and 20″ for facilitating among other things the making of this bore. The bore 12 may extend from the surface 20′ to a little beyond the transverse center of the housing; in its portion adjacent the surface 20′ it may be internally threaded, and into it may be screwed an adapter 11 to which the line portion 10′ may be secured by any suitable coupling means (not shown). On the other hand, from the periphery of the housing member 20 at an upper-shown region relatively near the surface 20″, to the axial region of that member and thus intersecting the bore 15, there is provided another bore 24 (see FIG. 2) of a substantial diameter which may terminate in a shallow conically surfaced end region 14, from which in turn a much smaller bore 13, coaxial with 24 and 14, may extend to intersect the bore 12 (see both FIGS. 1 and 2). The portion of the bore 24 adjacent the periphery of the housing member may be internally threaded and into it may be screwed a plug 25 which, by reason of an O-ring 28 inset into a groove 27 in the plug periphery, serves hermetically to seal off the innermost portion of the bore 14 from the mouth of that bore independently of the axial or angular position of the plug in the bore. The plug 25 may be provided with a very gradually tapered axial extension 26 whose inner portion enters the bore 13 to an extent determined by the axial position of the plug, and which with the shoulder between 13 and 14 constitutes a throttling or needle valve by which the rate of flow of gas from the line portion 10′ to the axial bore, if otherwise permitted, may be regulated; a screw-driver slot 29 in the outer surface of the plug 25 facilitates the adjustment of that needle valve.

The space 16, which forwardly and peripherally is bounded in a manner described immediately hereinafter communicates with the armletward portion 10″ of the line 10. Thus, in the forward or right-shown surface of the housing member 20, there may be provided an annular recess 17 with which the space 16, of course, communicates; at any suitable angular position about the housing-member axis (as shown, by way of example, at the bottom) there may be provided a radial bore 18 intersecting and, thus, communicating with the recess 17. The portion of the bore 18 adjacent the periphery of the housing member may be internally threaded and into it may be screwed an adapter 19 to which the line portion 10″ may be suitably connected. Thus, there is provided, between gas tank, 5 and armlet 1, a sequential passage whose elemental portions are identified as 10′–11–12–13–14–15–16–17–18–19–10″ and in which (between 15 and 16) the valve mechanism 30 is interposed.

The space 16 is forwardly bounded by a diaphragm 42. To provide for the clamping in place of this diaphragm, as well as peripherally to bound the space 16, the forward or right-shown surface of the housing member 20 is provided near the periphery of that member with an externally threaded annular forward (as shown in FIG. 1, rightward) extension 21, which, in turn, is provided with an internal shoulder 22. An internally threaded cap ring 23 may be screwed onto the extension 21 and then serves to urge toward the shoulder 22 an annular clamping ring 43; the marginal portion of the diaphragm 42 may be clamped between that ring and that shoulder. Between its marginal portion and its main portion, the diaphragm may be annularly corrugated, for example in a manner which disposes that main portion somewhat forwardly of that marginal portion, and the forward surface of that main portion may, for example, be slightly convex.

The diaphragm 42 is the immediate agent by which the valve mechanism 30 is caused to perform a regulating

function. Thus, in and substantially (but not quite completely) radially filling the space 16, there may be provided a moderately thick disk 36 whose rear or left-shown surface is centrally provided with a shallow conical recess 35 having an apex which may under appropriate conditions rest against the end of the valve stem 34, and whose forward surface is centrally provided with a forwardly extending slight protuberance or boss 39 against which the diaphragm may under appropriate conditions bear rearwardly. Close to its periphery, the forward surface of the disc 36 may be provided with an annular recess 38 to avoid interference with the corrugations of the diaphragm. One or more holes 37 may pass from the recess 38 to the rearward surface of the disc 36 to ensure that the disc does not subdivide the space 16 into pressure zones.

In considering the conditions just referred to, it is helpful to note that the valve stem 34 is always lightly biased forwardly both by the force of the abovementioned internal biasing means contained within the valve mechanism 30 and by the force developed by the source 7 pressure exerted on the very small closure member 33 of that mechanism; to this forward force-bias acting on the diaphragm from left to right in FIG. 1, there corresponds some forward equivalent pressure-bias on the diaphragm. Equivalent pressure-bias is a term intended to describe the imaginary pressure whose exertion on the diaphragm would produce a force equal in force and direction to that exerted on the diaphragm by the stem 34. On the other hand, by the geometry of the parts the diaphragm may be and is constrained, or prestressed, so that, in the absence of unequal fluid (i.e., air or other gas) pressures against its forward and rearward surfaces, its portion adjacent the boss 39 is biased rearwardly by a force less by at least a little than the forward bias of the valve stem. Thus in the absence of differential gas pressure acting on the diaphragm, the valve will remain closed. To this rearward force-bias, or pre-stress of the diaphragm acting from right to left, there corresponds some rearward equivalent pressure-bias on the diaphragm. The excess of the forward over the rearward equivalent pressure bias may conveniently be considered as a net equivalent pressure-bias.

The gas pressure existing within the armletward portion 16–17–18–19–10″ of the source-to-armlet passage is inherently applied to the rearward surface of the diaphragm as an actual forward fluid pressure thereon; on the other hand, by means hereinafter described, air pressure may be applied to the forward surface of the diaphragm as an actual rearward fluid pressure thereon. So long as the net difference between or resultant of those actual fluid pressures is a rearward pressure or is zero or is a forward one not in excess of the rearward equivalent pressure-bias, the diaphragm will bear against the boss 39 and the disc 36 will rest against the valve stem. These conditions subdivide into the particular case wherein a rearward net difference of actually applied fluid pressures exceeds the net equivalent pressure-bias in which case the valve mechanism 30 opens, and the remaining general case in which the valve mechanism 30 remains closed.

It will, accordingly, be understood that if in the absence of gas pressure in the armlet and of fluid pressure on the forward diaphragm surface there be initiated a rise of the latter pressure, then as soon as it exceeds the net equivalent pressure-bias the valve mechanism 30 will open and gas will flow from the source 7 through the passage abovementioned into the armlet 1—the open valve-mechanism condition and that flow persisting until, but only until, the gas pressure in the armlet has been raised to equal that pressure on the forward diaphragm surface less the net equivalent pressure-bias. Thus, the diaphragm 42 renders the valve mechanism 30 a regulating valve; that valve on increase of pressure applied to the forward diaphragm renders the pressure within the armlet a function of such applied pressure.

That valve fails, however, to perform a corresponding function on decrease of such applied pressure. To cure this deficiency there may be incorporated a one-way or check valve operatively (i.e., when open) connecting the armlet to the region adjacent the forward diaphragm surface. While such a check valve may be incorporated in any of a variety of arrangements, there is preferred an arrangement in which the check valve leads to the region just mentioned from the armletward portion **16–17–18–19–10″** of the source-to-armlet passage.

In the structure as thus far described, a check valve of such arrangement, designated as **40**, may be incorporated by the simple expedient of providing in the center of the diaphragm **42** a hole **41**, of diameter substantially smaller than that of the boss **39** so that as long as the diaphragm bears rearwardly against that boss the hole and check valve will be inoperative, but which when the diaphragm does not so bear will afford communication between the space **16** and the region adjacent the forward diaphragm surface. The diaphragm will not so bear, and the check valve **40** will be opened, whenever the net difference between the actual fluid pressures on the two sides of the diaphragm is a forward one exceeding the rearward equivalent pressure-bias abovementioned—for then the diaphragm will be subjected to a forwardly moving influence until in response thereto it has moved forwardly sufficiently for its rearward equivalent pressure-bias, which is meanwhile being increased by increasing diaphragm constraint, just to equal that net difference.

Since the valve mechanism **30** is under these conditions closed its stem **34** is incapable of forward movement and thus of exerting any forwardly moving influence on the disc **36**; it does, however, remain true that if the disc were nevertheless to be moved forwardly equally with the diaphragm, by the pressure in the space **16** or under any other possible influence, the check valve **40** would not be opened. Pressure in the space **16** is precluded from being effective thus to move the disc by its presence on the forward as well as on the rearward disc surface, resulting not only from the imperfection of radial disc fit within the housing extension **21** but also from the hole or holes **37** abovementioned, and in any event any tendency whatever of the disc to follow the forward movement of the diaphragm may be positively precluded by an early impingement of its forward peripheral shoulder against a diaphragm.

It has been seen above that increase of rearward pressure applied to the forward diaphragm surface will transiently open the regulating valve mechanism **30** to result in a prompt increase of the armlet pressure to the value of that rearward pressure less the net equivalent pressure-bias. From that state of affairs a decrease of the rearward pressure so applied will quickly reverse the net difference of actual fluid pressures on the diaphragm into an increasing forward one which will quickly reach equality with the rearward equivalent pressure-bias—and thereafter continued decrease of the rearward applied pressure will transiently open the check valve **40** to result in a prompt decrease of the armlet pressure to the value of that rearward pressure plus the rearward equivalent pressure-bias. Thus, the check valve **40** on decrease of pressure applied to the forward diaphragm surface renders the pressure within the armlet a function of such applied pressure.

It follows that the valve mechanism **30** and valve **40** form a valve system which renders the pressure within the armlet a bidirectionally variable function of the pressure applied to the forward diaphragm surface. From another point of view, the diaphragm is positionally responsive differentially to the pressure within the armletward portion of the source-to-armlet passage and the

pressure applied to the forward diaphragm surface, and the diaphragm in turn renders the two valves, severally and as a system, responsive differentially to those pressures. It is true that the function and the responsivity just stated involve some pressure "hysteresis"—i.e., on increase the armlet pressure remains less than the pressure applied to the forward diaphragm surface by the value of the net equivalent pressure-bias, and on decrease it remains more than that applied pressure by the value of the rearward equivalent pressure-bias. The magnitude of those pressure-biases and thus of the hysteresis may, however, readily be kept very small. Even when this has not been well done, the hysteresis has proven of no disturbing significance whatever in the practical use of the invention; thus, for example, at the conclusion of a use of the apparatus, when the pressure on the forward diaphragm surface will have been reduced to zero, there will be left in the armlet a pressure equal to the rearward equivalent pressure-bias—but this is so small as to be meaningless.

According to the invention, the rearward pressure applied to the forward diaphragm surface is developed within a pilot pressure chamber **50**, preferably of very small volumetric capacity. Of that chamber, the diaphragm **42** may form one wall, and the clamping ring **43** another; the remaining wall of the chamber may be formed by a generally disc-shaped cover **44** which extends across the clamping ring in that ring's forward portion, and which is conveniently made integral with that ring in the form of a unitary shallow cap **45**. In its central portion, the cover **44** may have a forwardly extending truncatedly conical boss **46** into which there may extend from the rear cover surface a conical recess **47**; from the periphery of the boss **46** a hole or bore **48** may extend diagonally into intersection with the recess **47**. The outer portion of the bore **48** may be interiorly threaded, and into it may be screwed an adapter **49** to which tubing may be connected.

To the pilot pressure chamber **50**, by means of the adapter **49**, there may be connected suitable manual control apparatus by which air pressure may be developed in the chamber and by which pressure may be discharged from the chamber at will. Such apparatus, designated in FIG. 1 as **60**, may for example comprise a hand bulb **61** of the design usual for blood-pressure-taking apparatus, and, accordingly, provided at its free end with the check valve **62** arranged to permit only ingress of ambient air into the bulb and at its other end with an internal check valve **63** arranged to permit only egress of air from the bulb into the tubing **64** by which the bulb is connected to the adapter **49**, as will be understood without detailed illustration of those check valves. Mounted to the bulb, but beyond the check valve **63** and thus in direct communication with the tubing **64**, may be a manually operable and closeable bleed valve **65**, closeable and progressively operable at will and typically of the usual needle-valve design, operatively leading from the tubing **64** to the ambient air.

It will, of course, be understood that pumping manipulation of the bulb **61** will serve controllably to develop pressure in the pilot pressure chamber **50** and that opening of the bleed valve **65** will serve controllably to discharge the chamber pressure; the pressure within the armlet being a function of the chamber pressure, it is controllably increased and decreased by that development and that discharge. Decrease of the armlet pressure, of course, takes place by a discharge of gas from the armlet through the check valve **40** into the pilot pressure chamber, from which it is in turn discharged through the bleed valve **65**. Increase of the armlet pressure, however, takes place by a transfer of gas from the source **7** into the armlet, with no need for manual pressure development excepting in the very small pilot pressure chamber; accordingly, with typical embodiments, only one gradual "squeeze" of the hand bulb will be all that is required to invoke an increase of armlet pressure from zero to over-systolic pressure.

Not only is the effort required for armlet pressure increase vastly reduced, but also the speed of that increase may be made tremendous; indeed, the practical limitation of that speed is dictated by the comfort of the subject, accommodation to which is readily made by an appropriate throttling adjustment of the needle valve formed by **26** and the shoulder between **13** and **14**. Moreover, the striking minimization of effort and increase of speed are achieved without calling on the operator to familiarize himself with new or newly positioned controls; he continues to use the controls to which he has been conventionally accustomed, each for invoking its usual function. He is unconscious of the hysteresis mentioned above, even when it is not aptly minimized; he continues to govern his control by observation of the manometer, whose readings are utterly unaffected by the hysteresis.

Unless the pressure at which the source **7** supplies gas be quite moderate, inattentive operation of the system could, of course, result in a high gas pressure in the armlet and tubing **10″** which would be uncomfortable in the former and might even be disruptive of one or the other. To guard against this, it is preferable that there be included in the system a relief valve through which needlessly excessive armlet pressure may be discharged. Such a valve, leading to the ambient from the armletward portion of the source-to-armlet passage, is conveniently provided within the housing member **20** and has been illustrated, dottedly in FIG. 1 and in full and in more detail in FIG. 3, as **70**.

Thus, at an off-axis position—for example (see FIG. 2) relatively near a portion of the surface **20′** removed from the bore **12** and adapter **11**—there may be provided a hole or bore **71** parallel to the axis of the housing member and extending from the rear of that member forwardly almost to the annular recess **17**; between its forward extremity and that annular recess there may extend a smaller hole **72**. The rearward portion of the bore **71** may be internally threaded and into that bore may be screwed a sleeve **74** which extends forwardly to hold a rubber O-ring **73** between its forward extremity and the shoulder formed between **71** and **72**. The rearward end portion of the sleeve **74** may be solid excepting for a small central hole **75**; within the sleeve, between that rearward end portion and the O-ring **73**, there may be sequentially assembled a compressed helical spring **76** and a ball **77** biased by the spring into pressure against the O-ring. The degree of compression of the spring **76** is chosen so that upon the development in the annular recess **17** (which forms part of the armletward portion of the source-to-armlet passage) of more than a predetermined pressure the ball will be forced against the bias of the spring away from the O-ring, whereupon gas may escape between ring and ball and through the sleeve and through hole **75** to the ambient thereby precluding the development in the armlet of appreciably more than that predetermined pressure.

The most convenient location and manner of mounting of the housing member **20** will vary according to the circumstances of use of the apparatus and, since those aspects form no part of the invention itself, no particular mounting or means therefor are shown.

While I have disclosed my invention in terms of a particular embodiment thereof, it will be understood that I intend thereby no unnecessary limitations. Modifications in many respects will be suggested by my disclosure to those skilled in the art, and such modifications will not necessarily constitute departures from the spirit of the invention or from its scope, which I undertake to define in the following claims.

I claim:

1. In blood pressure taking apparatus including an armlet, a passage connected to the armlet to which a pressurized source of gas may be connected, and means for controllably supplying gas from said source through said passage to the armlet and draining the same from the armlet the improvement comprising, in combination, valve means, controlled by a pilot pressure applied thereto and including a regulating-valve portion interposed in said passage, for rendering the pressure within the armlet a bidirectionally variable function of such pilot pressure; a pilot pressure chamber, of capacity small relative to the operative capacity of the armlet, means applying the pilot pressure within said pilot chamber to said valve means; manual control apparatus connected with the pilot chamber, including a compressible device for developing pilot pressure within the pilot chamber, a bleed valve closeable and openable at will to conserve or to discharge the pilot chamber pressure and a check valve responsive to the differential gas pressure between said passage and said pilot chamber for venting gas from said passage at a predetermined differential gas pressure.

2. The subject matter claimed in claim **1** further including a throttling valve interposed in said passage to control the rate at which gas is supplied to the armlet.

3. The subject matter claimed in claim **1** further including a relief valve connected with the armlet for limiting the pressure therein.

4. In blood pressure taking apparatus including an armlet, a passage connected to the armlet to which a pressurized source of gas may be connected, and means for controllably supplying gas from said source through said passage to the armlet and draining the same from the armlet, the improvement comprising, in combination, a pilot chamber; manual control apparatus, including a compressible device for developing pilot air pressure within the pilot chamber, a bleed valve closeable and openable at will to conserve or to discharge the pilot chamber pressure; and a valve system, including a regulating valve interposed in said passage and a check valve leading into the pilot chamber from the armletward portion of said passage, responsive differentially to the pressure within the armletward portion of said passage and the pilot chamber pressure whereby gas is vented from said passage through said pilot chamber at a predetermined differential gas pressure.

5. The subject matter claimed in claim **4** wherein said pilot chamber is provided with a movable wall positionally responsive differentially to the pressure within the armletward portion of said passage and the pilot chamber pressure and by which said valve system is operated.

6. The subject matter claimed in claim **5** wherein said movable wall is provided with an aperture, further including a member which with the portion of said wall surrounding said aperture forms said check valve.

7. The subject matter claimed in claim **6** wherein said member is operatively interposed between said movable wall and said regulating valve.

8. The subject matter claimed in claim **4** wherein the capacity of said pilot pressure chamber is small relative to the operative capacity of the armlet.

9. The subject matter claimed in claim **4** further including a throttling valve interposed in said passage to control the rate at which gas is supplied to the armlet.

10. The subject matter claimed in claim **4** further including a relief valve leading from the armletward portion of said passage for limiting the pressure in the armlet.

11. In apparatus including an inflatable pressure-transmitting member, a passage connected thereto to which a pressurized source of gas may be connected, and means for controllably supplying gas from said source through said passage to said member and draining the same therefrom the improvement comprising, in combination, a pilot chamber; manual control apparatus, including a compressible device for developing pilot pressure within the pilot chamber, a bleed valve closeable and openable at will to conserve or to discharge the pilot chamber pressure; and a valve system, including a regulating valve interposed in said passage and a check valve leading into the pilot chamber from the memberward portion of said passage, responsive differentially to the pressure within said portion of said passage and the pilot chamber pressure whereby gas is vented from said passage through

said pilot chamber at a predetermined differential pressure.

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RICHARD A. GAUDET, *Primary Examiner.*

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,241,152 March 15, 1966

Wayne W. Hay

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 45, for "to do" read -- to do so --; line 59, for "is" read -- it --; line 68, for "interspposed" read -- interposed --; column 2, line 17, after "taken" insert a parenthesis; line 56, after "having" strike out "an"; line 61, for "as spring" read -- as a spring --; column 5, line 1, before "renders" insert -- surface --.

Signed and sealed this 1st day of August 1967.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents