

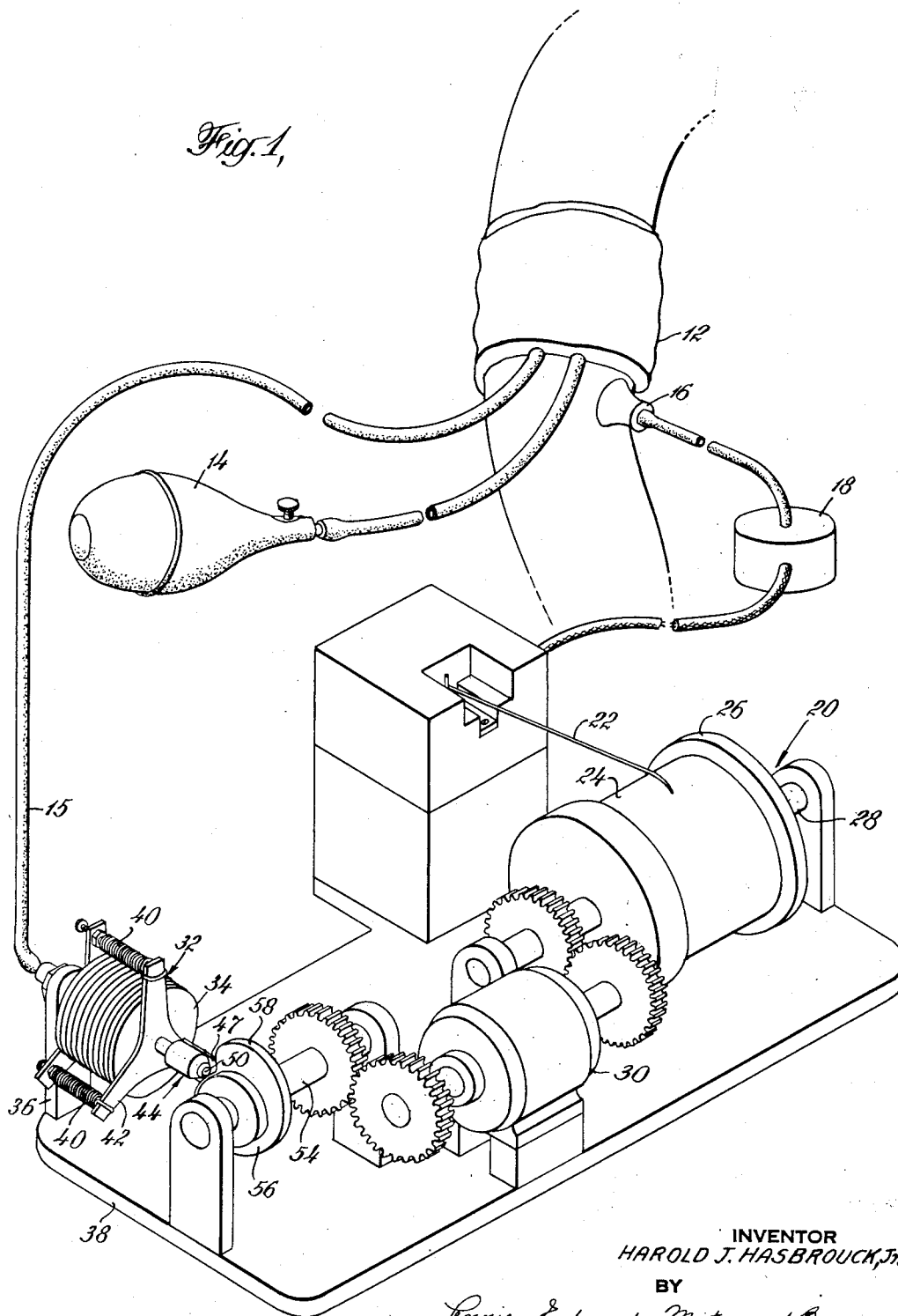
Nov. 24, 1953

H. J. HASBROUCK, JR  
SPHYGMOMANOMETER

2,660,164

Filed Jan. 27, 1948

3 Sheets-Sheet 1



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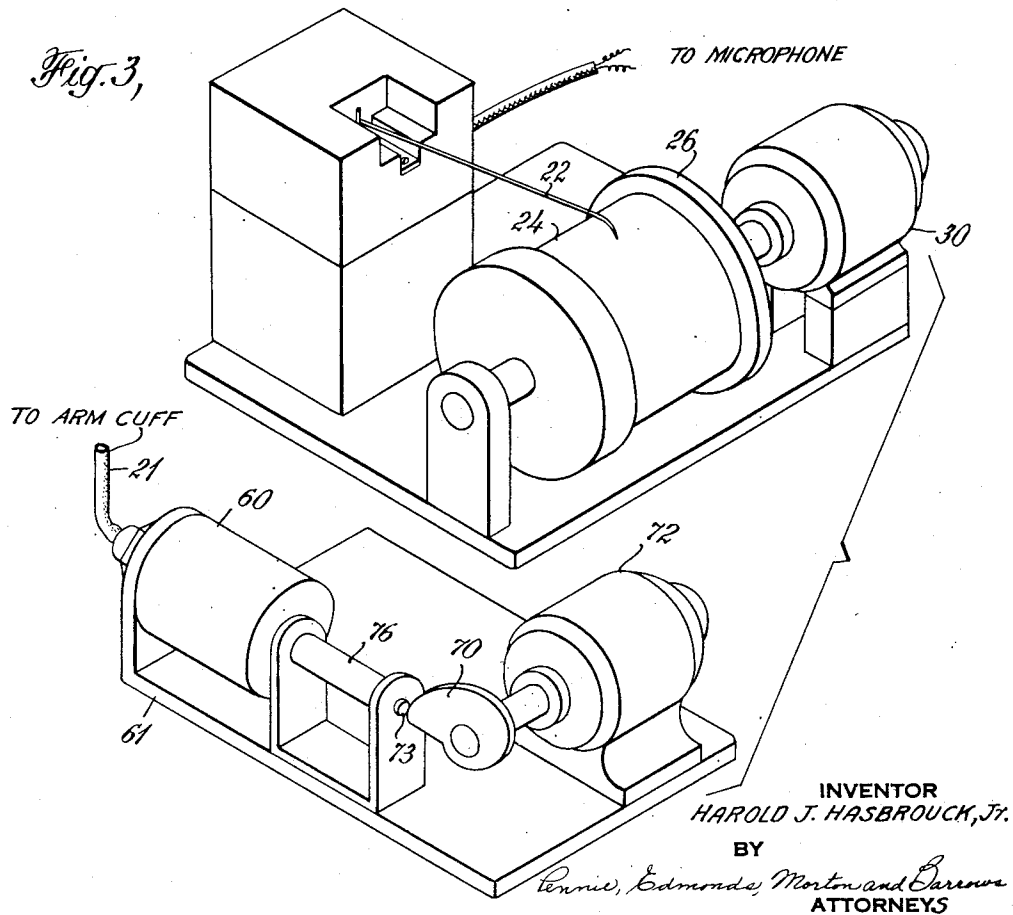
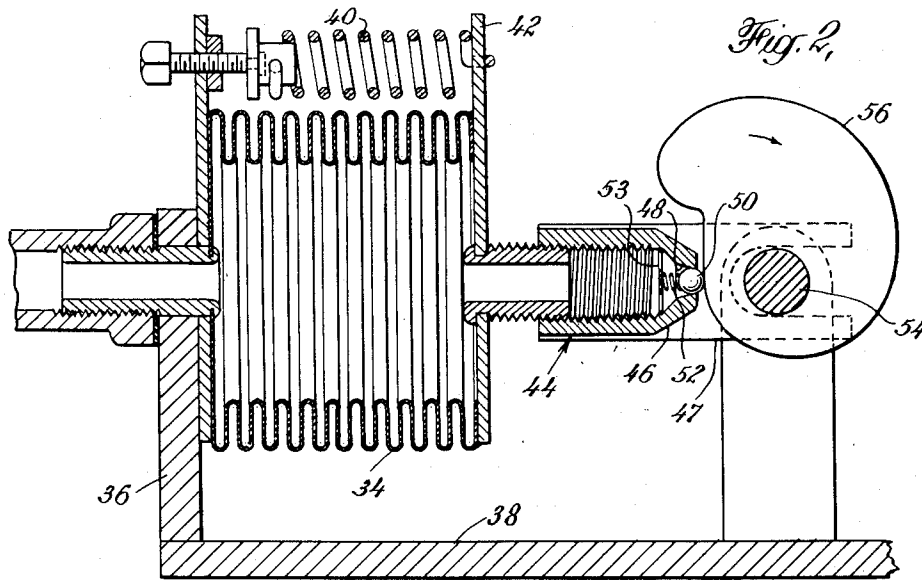
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

*Fig. 4,*

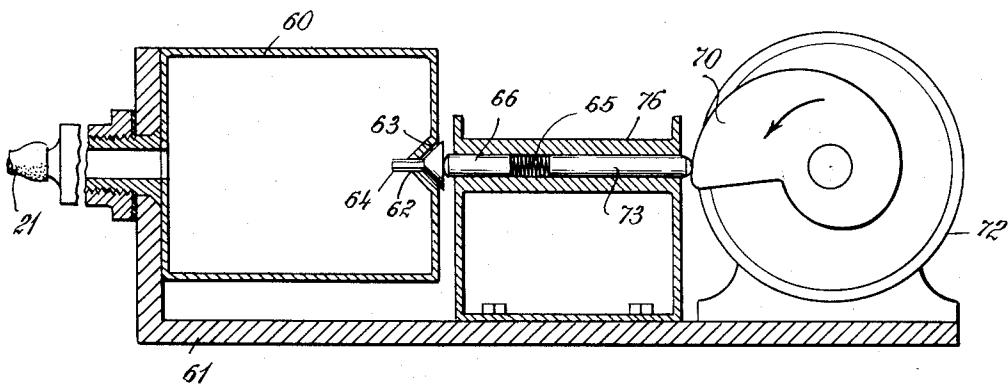
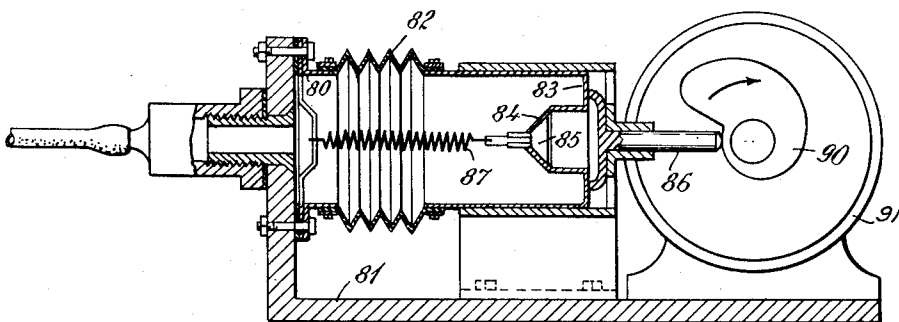


*Fig. 5,*



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## UNITED STATES PATENT OFFICE

2,660,164

## SPHYGMOMANOMETER

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Application January 27, 1948, Serial No. 4,509

12 Claims. (Cl. 128—2.05)

1

This invention relates to a recording sphygmomanometer in which both the reduction of pressure in the inflatable member or cuff which is applied over an artery of the patient and the relative movement between a recording stylus and a record medium in a recorder employed to record the auscultatory sounds produced in the artery under compression may be automatically controlled in timed relation. The invention represents a simplification and an improvement of that disclosed in the application of Clair L. Farrand, Serial No. 700,742, filed October 2, 1946, now Patent No. 2,571,124 and assigned to the assignee hereof.

The present invention is at once a simplification and improvement over the sphygmomanometer of that patent in that it provides a relatively simple mechanically operated valve for controlling the reduction of cuff pressure and eliminates the necessity for use of a mercurial manometer and a resistance wire therewithin, and the Wheatstone bridge with its associated electrical circuits. In fact it eliminates the need for any manometer of either the mercurial or aneroid type.

In accordance with the present invention the reduction of pressure in the inflatable member or cuff and the recording of the auscultatory sounds are controllably and automatically effected as either independent or interdependent function of time.

In the case of the process of pressure reduction the function of interest is that relating cuff pressure and time. In the case of the recording process the function of interest is that relating with time the progress of the recording instrument, which may be a stylus for example, along the time axis of a record medium such as a chart. If the relative motion of the stylus and chart may be controlled independently of the reduction in pressure, the two functions are independent. If they may not be controlled independently the two functions are interdependent. In either case however both functions are known so that cuff pressure is a single-valued function of the position of the recording stylus relative to the time axis of the chart. My invention permits a complete separation of the two processes and provides a method and means for accomplishing the two either independently or interdependently.

In the mechanically operated pressure reducing valve of my invention a closed chamber is provided which is pneumatically connected to the inflatable cuff by a tube and which com-

2

municates with the atmosphere through a valve. The valve includes a stem designed to seat against the periphery of an aperture in the chamber which forms a valve seat. The pressure within the chamber (the excess of absolute chamber pressure above atmospheric pressure) applies a pneumatic stress between the valve seat and valve stem.

The pressure within the chamber, and hence the pressure within the arm cuff, is controllably reduced according to the desired function of time by the provision between the valve stem and seat of an elastic mechanical stress opposed to that exerted by the chamber pressure. When the pneumatic and mechanical stresses are equal the valve will remain closed. In order to reduce the pressure within the chamber, and hence the pressure within the inflatable cuff, according to a known function of time, I provide means for varying this counteracting mechanical stress according to a known function of time, thus establishing a unique relation between chamber pressure and time. In this way the cuff pressures existing at the various instants during the recording process are known. A pressure axis may be substituted for the time axis along the time dimension of the record and the pressures of interest may be read from the record by noting thereon the indications of the sounds which are known to be characteristic of those pressures and by reading the pressures at which those characteristic sounds occurred.

Usually the variation in counterbalancing elastic mechanical stress and the advance of the record medium relative to the recording stylus will be effected from a common energy source, such as a single ordinary domestic electric lighting circuit. To insure however that the recording and pressure reducing processes do not get out of step, in a preferred embodiment I link the two processes together mechanically and drive them both from a common source of mechanical power such as an electric motor. In this way the functions relating time with cuff pressure and time with advance of stylus along the time axis of the record chart are made interdependent. The invention will now be described in terms of a number of preferred embodiments with reference to the accompanying drawings.

Fig. 1 shows a recording sphygmomanometer according to a preferred embodiment of my invention.

Fig. 2 is a sectional view in elevation of the

3

pressure-reducing valve and associated mechanism of the sphygmomanometer of Fig. 1.

Fig. 3 shows a recording sphygmomanometer according to another embodiment of my invention.

Fig. 4 is a section in elevation of the pressure-reducing mechanism of the sphygmomanometer of Fig. 3.

Fig. 5 is a section in elevation of a third form of pressure-reducing mechanism according to the invention.

In the embodiment of Fig. 1 the recording and pressure-reducing processes are driven from a common source of mechanical power and the counterbalancing elastic mechanical stress is applied between the seat and stem of the pressure-reducing valve by a stressed elastically distensible bellows forming part of a chamber in whose wall the valve proper is located.

The counterbalancing stress is varied according to a known function of time by providing for the valve stem an inelastic abutment which is movable according to a known function of time by reference to a rigid support or base to which one end of the elastically distensible bellows is connected.

In Fig. 1 an inflatable member or arm cuff 12 is shown bound around the upper arm of a patient. The cuff may be inflated by means of a bulb 14 in order to shut off the blood flow in the brachial artery of the patient's arm in accordance with the usual blood pressure measuring technique. The manometer, which in the customary sphygmomanometer of the prior art provides the pressure indications, is dispensed with and the systolic and diastolic pressures are read from a permanent record of the auscultatory sounds produced in the artery. The auscultatory sounds are picked up by a pick-up tube 16 similar to the pick-up tube of a stethoscope, which is applied to the patient's arm below the cuff. The auscultatory sounds are then conveyed to a recorder 20 by means of a transducer such as a microphone 18 which transforms the sounds into corresponding electrical signals. These signals are then conducted to amplifying mechanism in the recorder 20 which transforms them into transverse vibrations of a recording stylus 22. A record chart 24 is moved longitudinally past the stylus at an appropriate constant rate of speed by rotation of a recording drum 26 carried on a shaft 28 and driven by a motor 30.

The chart 24 is calibrated in units of pressure along its lengthwise axis, i. e. around the periphery of the drum. From this record the sounds characteristic of the systolic and diastolic pressures may be read because of the peculiarities of these sounds. The pressures which existed within the cuff at the times when the systolic and diastolic sounds occurred may also be read from the record because the cuff pressure is brought during the blood pressure measurement through a predetermined set of values in a known time sequence by an automatic pressure-reducing unit 32.

In the pressure-reducing unit shown in Figs. 1 and 2 an extensible bellows 34 is supported at one end by means of a bracket 35 affixed to a base plate 38 which also carries the drum 26. The bellows communicates by means of a tube 15 with the arm cuff 12 and is therefore subjected in its interior to the pressure existing within the cuff.

The bellows 34 is extensible along its own axis under the influence of the cuff pressure but is restrained in its distention by three calibrated

4

springs 40 strung between a spider 42 and the bracket 36. The springs 40, in conjunction with the elastic properties of the bellows, provide a linear relation between the pressure within the bellows and its distention. Mounted in and carried by the free end of the bellows is an air release or escape valve, generally indicated at 44, which communicates with the atmosphere. Referring now particularly to Fig. 2, the valve 44 comprises a body 46 with an aperture in the end thereof. The aperture has a conical wall 48 forming a valve seat. A valve stem in the form of a ball 50 seats against the wall 48 to seal the bellows by the action of the internal pressure. A light retaining-spring 52 holds the ball in its seat when the arm cuff is uninflated. The valve stem or ball 50 protrudes from the valve body 46 along the axis of the bellows so that the air pressure within the bellows may be released by pressure exerted from outside the bellows on the protruding part of the ball.

A shaft 54 is mounted on the base plate 38 for rotation about an axis perpendicular to the axis of the bellows. The shaft 54 carries a cam 56 whose cam surface 58 is presented to the valve stem 50. The shaft 54 is rotated by means of a conventional linkage connecting with the motor 30. The valve 44 with its stem is carried along the axis of the bellows as the bellows distends and contracts. The cam limits the advance of the valve along this axis to a set of diminishing values established by the rotation of the cam.

By providing the cam with a desired motion in time, and with a given relation between cuff pressure and valve position, the cuff pressure can be made to diminish according to any desired function of time. Usually of course the relation between cuff pressure and valve position will be linear. This will be the case if the distention of the bellows is kept within its elastic limit. Then if a linear relation between cuff pressure and time is desired, this may be achieved by advancing the cam according to a linear function of time. A cam having the profile of an Archimedes spiral may be used and the cam rotated at constant angular velocity.

In operation the shaft 54 is rotated by the motor in such a direction as to increase the height of the cam surface presented to the valve stem, thus steadily unseating the valve stem and effecting a continual reduction in cuff pressure, measured by the contraction of the bellows which keeps pace with the motion of the valve stem. Because the cam 56 and recording drum 26 are both linked to the motor 30, there is a point for point correspondence between the angular positions of the drum and cam. This means a similar correspondence between cuff pressure and position of the stylus 22 along the lengthwise or time axis of the chart 24.

To avoid chattering of the valve 44 a friction damper 47 may be provided. The damper is fastened to the valve body 46 and bears against the side face of the cam.

The construction of the bellows and valve and their relation to the cam are shown in detail in Fig. 2. In Fig. 2 the shaft 54 is seen to be disposed at right angles to the axis of the bellows. The valve stem 50 is shown having the form of a ball seated against a conical surface 48 in the valve and at the same time making contact with the cam 56. A small spring 52, lightly compressed between a perforated plate 53 and the ball 50, prevents the ball from falling out of its seat when the cuff is deflated. The cam shown is provided

5

with a profile in the form of an Archimedes spiral. The height of the cam surface from the axis of rotation will therefore be a linear function of the angular position of the shaft 54.

To take a blood pressure measurement the shaft 54 is first rotated to the position shown in Fig. 2, allowing the maximum distention of the bellows. The distance from the shaft 54 to the bracket 36 is made such that a convenient pressure for the beginning of a blood pressure measurement, such as 260 mm. of mercury, distends the bellows to exactly the extent required to bring the ball 50 into contact with the cam 56 without unseating the ball. Rotation of the shaft 54 to this position brings a section of a record chart 24 onto the drum 26 so that the recording stylus makes contact therewith at the point of the 260 mm. mark on the lengthwise or time axis calibration of the chart.

The arm cuff 12 is inflated with the bulb 14 until air is heard to escape from the valve. When the valve closes and air is heard no more to escape the pressure within the bellows and the arm cuff is at 260 mm. of mercury. The cam 56 is then set into rotation by means of the motor 30. As the cam rotates, the ball 50 is unseated by the increasing height of the cam surface in contact therewith above the axis of rotation. This causes air to escape from the bellows and the pressure within the cuff begins to fall. Correspondingly, the bellows contracts against the reduced internal pressure and draws the valve away from the cam so as to permit the ball to seat itself. Continued rotation of the cam, however, further reduces the pressure in the cuff and this pressure is reduced as a linear function of time until the pressure has been brought to a level below diastolic. Such a pressure corresponds to a minimum distention of the bellows and a maximum height of the cam surface in contact with the valve stem or ball above the axis of rotation of the cam. With the cam in this position the motor is de-energized and the record of blood pressure is complete. Fig. 3 illustrates another embodiment of my invention in which the recording and pressure-reducing processes are driven from separate sources of mechanical power so that the pressure may be reduced and the record made according to separate and independent functions of time. In the pressure-reducing mechanism of Fig. 3 the counterbalancing mechanical stress is applied between an inelastic support, to which the valve seat is rigidly connected, and the valve stem by means of a stressed mechanical member applied to the valve stem. The counterbalancing stress is varied according to a known function of time by altering the strain of the stressed member directly.

In the sphygmomanometer of Fig. 3 the inflatable cuff, transducer and recorder may be identical with those of the embodiment of Fig. 1. In the sphygmomanometer of Fig. 3 however the motor 30 drives only the recording drum of the recorder.

The pressure within the cuff is reduced by means of a pressure-reducing device similar in basic principle, but different in detail from that of Fig. 1. This pressure-reducing device is shown in sectional elevation in Fig. 4. The pneumatic tube 21 of Fig. 3 communicates with a chamber 60 mounted on a support 61. The chamber 60 is provided in one end thereof with an aperture 62 having a conical wall open outwards. The conical wall forms a valve seat 63. A valve stem

6

64 fits in this seat. The chamber 60 is rigid so that the valve seat 63 may not move relative to the support 61. An elastic mechanical restoring force is applied to the stem 64 by means of a spring 65 which bears on the stem through a push rod 66. The spring 65 is compressed or strained in a succession of varying amounts by a cam 70 which is mounted for rotation about an axis fixed with reference to the support 61. The cam is driven by means of a motor 72. A cam follower 73 transmits the motion of the cam to one end of the spring 65 and guides 76 are provided to keep the cam follower, spring and push rod collinear.

With the sphygmomanometer of Fig. 3 the blood pressure measurement is begun with the cam 70 rotated to a position providing maximum compression to the spring 65. The cam and spring are so dimensioned and calibrated with reference to the size of the valve stem 64 that maximum compression of the spring 65 will just keep the valve stem 64 seated on the valve seat 63 against a cuff pressure of 260 mm. To take a blood pressure measurement the cuff is inflated as usual and the recording drum is set with a record chart having its 260 mm. mark under the stylus. The motors 30 and 72 are then energized, initiating the recording process simultaneously with the pressure-reducing process. The cam 70 is rotated so as to reduce its elevation and the consequent compression of the spring 65. As the cam 70 rotates the elastic stress exerted against the stem 64 declines and the pressure within the chamber 60 and the cuff falls accordingly. Continued rotation of the cam further reduces the pressure within the cuff until the pressure has been brought to a level below diastolic. Such a pressure corresponds to maximum distention of the spring 65 and minimum height of the cam surface in contact with the follower 73 about the axis of rotation of the cam. With the cam in this position the motor is de-energized, and the record of blood pressure is complete. The rotational speeds of the cam 70 and drum 26 must be properly related to the pressure calibration of the chart, although so long as the two speeds are proportional it is not necessary that their absolute values be kept constant. Variation therein will distort the wave form of the recorded sound indications, although it will not falsify the correspondence between cuff pressure and sound records along the pressure calibration of the chart. Fig. 5 illustrates a third form of pressure-reducing mechanism according to the invention in which the valve seat is formed as part of a distensible but inelastic chamber, and in which the counterbalancing stress is applied by means of a stressed elastic member applied between the valve stem and the support for the chamber, the free end of the chamber following inelastically under its internal pressure the motion of an element inelastically connected to the support.

Fig. 5 shows a third form of pressure-reducing mechanism which may be used with the sphygmomanometers of the previous figures, whether or not mechanically linked to the recording process. In Fig. 5 a chamber 80 is connected by means of a tube (not shown) to an inflatable cuff bound around the limb of the patient. The chamber 80 is rigidly supported at one end on a base 81 which also supports a cam 90 for rotation about an axis fixed with reference to the base. The chamber 80 includes a flexible portion 82 which permits motion of a free end 83

with reference to the rigidly supported portion 80. The flexible portion 82 need have no elastic characteristics. An aperture provided in the end 83 provides a conical seat 84 for a valve stem 85 adapted to close this aperture. The chamber 80 is maintained distended by the internal pressure to the limit permitted by the instantaneous angular position of the cam 90 which bears against a guide piece 86 mounted over the free end 83 of the chamber. An elastic mechanical stress tending to close the valve against the chamber pressure is provided by means of a spring 87 connected between the stem 85 and the base 81. The spring 87 is dimensioned and calibrated by reference to the end area of the stem 85 so as to provide, over a range of strains limited by the maximum and minimum altitudes of the cam 90, stresses sufficient to keep the valve closed over the range of cuff pressures through which blood pressure measurements are to be taken. Thus in order to take a blood pressure measurement the cam 90 is rotated to present its minimum altitude to the guide piece 86 and to permit maximum distention of the chamber 80 under the influence of cuff pressure. Inflation of the cuff to the pressure at which the blood pressure measurement is begun, commonly 260 mm. of mercury, will distend the chamber 80 against the stress of the spring 87 just enough to bring the guide piece 86 into contact with the cam 90. The stress exerted by the spring 87 under the strain imposed by this distention of the chamber is just enough to close the valve against the 260 mm. pressure applied over the base of the valve stem 85, any further increase of pressure being sufficient to open the valve. The recording and pressure-reducing processes are then initiated by energizing the means which drive the recorder drum and the cam 90. As stated in connection with Fig. 1 it is preferable that the two be driven by means of a single motor. The cam 90 is rotated in such a direction as to increase the altitude of the cam surface presented to the guide piece 86. This forces a contraction of the chamber 80, driving the valve seat 84 back towards the point of suspension of the spring 87 and reducing the stress exerted by the spring 87 on the stem 85. The valve accordingly opens and permits the escape of air from the chamber 80 and from the connected arm cuff, reducing the pressure in the arm cuff through a known set of values according to a known function of time.

The embodiments described are illustrative of my invention. Variations, for example in the form of the cam, in the linkage between the cam and the recording equipment and in the type of recorder used readily suggest themselves. All such variations are intended to be included within the scope of the following claims.

I claim:

1. An automatic recording sphygmomanometer for producing a graphical representation of auscultatory sounds in terms of blood pressure, comprising an inflatable member adapted to be applied in restraining relation over an artery, means to inflate the member, an elastic extensible bellows communicating with the member and adapted to be distended by the pressure of inflation therewithin, a rigid support for supporting and fixing an end of the bellows, a valve in the bellows having a stem adapted to release to the atmosphere the pressure within the bellows, a rotating cam arranged for rotation about an axis fixed in relation to the fixed end of the

bellows, the said cam being adapted to engage the stem to open the valve, a transducer adapted to be actuated by the auscultatory sounds produced in the artery, a recorder adapted to graphically present said sounds on a record medium having a dimension representative of time, and means for establishing an interdependent relation between the cam and the recorder whereby the position along the time dimension of the record medium at which recording instantaneously takes place is a single-valued function of the position of the cam.

2. An automatic recording sphygmomanometer for producing a graphical representation of auscultatory sounds in terms of blood pressure, comprising an inflatable member adapted to be applied in restraining relation over an artery, means to inflate the member, an elastic extensible bellows communicating with the member and adapted to be distended by the pressure of inflation therewithin, a rigid support for supporting and fixing an end of the bellows, a valve in the bellows having a stem adapted to release to the atmosphere the pressure within the bellows, a rotating cam arranged for rotation about an axis fixed in relation to the fixed end of the bellows, the said cam being adapted to engage the stem to open the valve at a plurality of pressures within the bellows according to the angular position of the cam, a transducer adapted to be actuated by the auscultatory sounds produced in the artery, a recorder adapted to be actuated by the said transducer, a record medium having a dimension representative of time and a recording element arranged in the said recorder for relative movement, and a linkage between the cam and the recorder whereby the relative position of the recording element and record medium, as regards the time dimension of the medium, is a single-valued function of the angular position of the cam.

3. An automatic recording sphygmomanometer for producing a graphical representation of auscultatory sounds in terms of blood pressure, comprising an inflatable member adapted to be applied in restraining relation over an artery, means to inflate the member, an elastic extensible bellows communicating with the member and adapted to be distended by the pressure of inflation therewithin, a rigid support for supporting and fixing an end of the bellows, a valve in the bellows having a stem adapted to release to the atmosphere the pressure within the bellows, a rotating cam arranged for rotation about an axis fixed in relation to the fixed end of the bellows, the said cam being adapted to engage the stem to open the valve at a plurality of angular positions of the cam according to the pressure existing within the bellows, a transducer adapted to be actuated by the auscultatory sounds produced in the artery, a recorder adapted to produce upon a record medium having a dimension representative of time a graphical record of the auscultatory sounds by the relative movement of the record medium and a recording element in the recorder, and means for establishing an interdependent relation between the cam and the recorder whereby the progress of the record medium along its time dimension past the recording element is a single-valued function of the angular position of the cam.

4. A recording sphygmomanometer comprising an inflatable member adapted to be applied over an artery, means to inflate the member, a bellows communicating with said member rigidly sup-

ported at one end thereof and elastically distensible under the pressure existing in the member, a valve communicating between the bellows and the atmosphere, a cam arranged for rotation about an axis fixed relative to the rigidly supported end of the bellows and adapted to engage the stem of the valve upon distention of the bellows, a transducer adapted to pick up energy from the auscultatory sounds produced in the artery during a course of blood pressure measurements, a recorder adapted to record the auscultatory sounds on a record medium having a dimension representative of time, and a linkage between the cam and the recorder whereby the position of record medium with respect to its time dimension is a single-valued function of the position of the cam.

5. In a recording sphygmomanometer including an inflatable cuff adapted to be applied to a human limb, means to inflate the said cuff, a transducer for picking up the auscultatory sounds produced in the said limb during a source of blood pressure measurements, and a recorder adapted to produce by means of a stylus moving relative to a record medium a record of the auscultatory sounds produced in said limb during the course of the blood pressure measurements, a pressure-reducing valve comprising an elastic extensible bellows rigidly mounted at one end and communicating with said cuff, an escape valve mounted in the movable end of said bellows, and a cam bearing against the stem of said valve, said cam being linked in its rotation to the advancement of said record medium relative to the stylus of said recorder.

6. A sphygmomanometer comprising an inflatable cuff adapted to be applied to a human limb, means to inflate said cuff, an elastic distensible bellows rigidly mounted at one end and communicating with the said cuff, a valve in the movable end of said bellows communicating with the atmosphere, a stem in said valve, a cam mounted for rotation about an axis fixed with reference to the rigidly supported end of said bellows and adapted to engage the stem of said valve at various distentions of said bellows according to the angular position of said cam, a transducer adapted to pick up the auscultatory sounds produced in the said limb in the course of a blood pressure measurement, a recorder adapted to produce a record of the said sounds by the motion of a stylus relative to a record medium, and common means to rotate said cam and to advance said stylus relative to said record medium.

7. In a recording sphygmomanometer including an inflatable cuff adapted to be applied to a human limb, means to inflate the said cuff, a transducer adapted to pick up the auscultatory sounds produced in the said limb during a course of blood pressure measurements and a recorder adapted to produce a record of the auscultatory sounds by means of a stylus moving at a known rate relative to a record medium having an axis representative of time, means to reduce the pressure in the said cuff according to a known and predetermined function of time, said means comprising an elastically distensible chamber rigidly supported at one end and communicating with the said cuff, a valve in the free end of said chamber communicating with the atmosphere, a stem in the valve, and a cam mounted for rotation about an axis fixed with reference to the rigidly supported end of said elastically distensible chamber and positioned to engage the said valve stem upon distention of the bellows at suc-

sively varying distentions of the bellows according to the angular position of the cam.

8. In a recording sphygmomanometer including an inflatable cuff adapted to be applied to a human limb, means to inflate the cuff, a transducer adapted to pick up the auscultatory sounds produced in the limb during a course of blood pressure measurements and a recorder adapted to record said sounds on a record medium having a dimension representative of time, means to deflate the said cuff according to a known and reproducible function of time, said means comprising a support, an elastic chamber pneumatically connected with the cuff and affixed at one end to the support and susceptible of distention under the pressure of the cuff, a valve mounted in the free end of the chamber and adapted to be carried along a specified line of motion by the distention of the chamber, a stem in the valve protruding from the chamber and adapted to engage interfering objects interposed in the said line of motion, a cam mounted on the support for rotation about a fixed axis and encroaching upon the said line of motion according to its angular position, and means to rotate the said cam according to a known and reproducible function of time.

9. A recording sphygmomanometer comprising an inflatable cuff adapted to be applied to a human limb, means to inflate the cuff, an elastic distensible bellows rigidly mounted at one end and communicating with the cuff, a valve in the movable end of the bellows communicating with the atmosphere, a ball in the said valve, a cam mounted for rotation about an axis fixed with reference to the rigidly supported end of the bellows and adapted to engage the ball of the said valve at various distentions of the bellows according to the angular position of the cam, means to rotate the cam according to a known and reproducible function of time, a transducer adapted to pick up the auscultatory sounds produced in the limb in the course of a blood pressure measurement, and a recorder adapted to produce a record of the auscultatory sounds by the motion according to a known and reproducible function of time of a stylus relative to a record medium.

10. A recording sphygmomanometer comprising an inflatable member adapted to be applied in restraining relation to an artery, means to inflate the inflatable member, a transducer adapted to be actuated by the auscultatory sounds produced in the artery upon inflation of the inflatable member, a recorder coupled to the transducer adapted to record the auscultatory sounds on a record medium having a dimension representative of time by motion of the record medium relative to a recording stylus in the recorder along the said dimension, and a pressure-reducing mechanism adapted to reduce the pressure in the inflatable member according to a known function of time during the recording of the said sounds, said mechanism including a rigid support, an elastically distensible bellows pneumatically connected with the inflatable member and rigidly supported at one end, an aperture in the free end of the bellows having a periphery adapted to function as a valve seat, a valve stem adapted to seat against the said periphery so as to close the aperture, a rotating cam mounted for rotation about an axis fixed in relation to the support and adapted to unseat the stem of the said valve at successively changing distentions of the said bellows upon rotation of the cam, and means adapted to rotate the said

## 11

cam and to advance the record medium relative to the stylus in coupled relation, whereby the angular position of the said cam is a single-valued function of the relative position of the stylus and record medium along the time dimension of the record medium.

11. A recording sphygmomanometer comprising an inflatable member adapted to be applied in restraining relation to an artery, means to inflate the inflatable member, a transducer adapted to be actuated by the auscultatory sounds produced in the artery upon inflation of the inflatable member, a recorder coupled to the transducer and including a recording stylus and a record medium having a dimension representative of time, said recorder being adapted to record the auscultatory sounds on the record medium by relative motion between the stylus and medium along the time dimension of the latter according to a known function of time, and a pressure reducing mechanism adapted to reduce the pressure in the inflatable member according to a known function of time during the recording of the said sounds, said mechanism including a rigid support, an elastically distensible bellows pneumatically connected with the inflatable member and rigidly fixed at one end on the support and adapted to describe with its free end a line of motion under the influence of the pressure within the inflatable member, a valve mounted in the free end of the bellows communicating with the atmosphere, a rotating cam arranged for rotation about an axis fixed in relation to the fixed end of the bellows, the said cam being adapted to open the valve at a plurality of bellows pressures according to the angular position of the cam, and means for rotating the cam according to a known function of time.

12. A recording sphygmomanometer comprising an inflatable member adapted to be applied in

## 12

restraining relation to an artery, means to inflate the inflatable member, a transducer adapted to be actuated by the auscultatory sounds produced in the artery upon inflation of the inflatable member, a recorder coupled to the transducer adapted to record the auscultatory sounds on a record medium having a dimension representative of time by motion of the record medium relative to a recording stylus in the recorder according to a known function of time along the said dimension, and a pressure-reducing mechanism adapted to reduce the pressure in the inflatable member according to a known function of time during the recording of the said sounds, said mechanism including a rigid support, an elastically distensible bellows pneumatically connected with the inflatable member and rigidly supported at one end thereof, an aperture in the free end of the bellows having a periphery adapted to function as a valve seat, a valve stem adapted to seat against the said periphery so as to close the aperture, a rotating cam mounted for rotation about an axis fixed in relation to the support and adapted to unseat the stem of the said valve at successively changing distentions of the said bellows upon rotation of the cam, and means to rotate the said cam according to a known and reproducible function of time.

HAROLD J. HASBROUCK, JR.

## References Cited in the file of this patent

## UNITED STATES PATENTS

| Number    | Name    | Date          |
|-----------|---------|---------------|
| 2,272,836 | Gardien | Feb. 10, 1942 |
| 2,379,573 | Gilson  | July 3, 1945  |

## FOREIGN PATENTS

| Number  | Country | Date          |
|---------|---------|---------------|
| 509,638 | Germany | Oct. 10, 1930 |
| 574,873 | Germany | Apr. 21, 1933 |