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[54] **OPHTHALMODYNAMOMETER**

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[52] **U.S. Cl.** ..... **128/2 T**; 73/80; 128/2.05 R; 128/2.05 N; 351/6

[51] **Int. Cl.²** **A61B 3/00**; A61B 5/02

[58] **Field of Search** .. 128/2 T, 2 R, 2.05 N, 2.05 R, 128/2.05 P; 73/80; 351/6, 7

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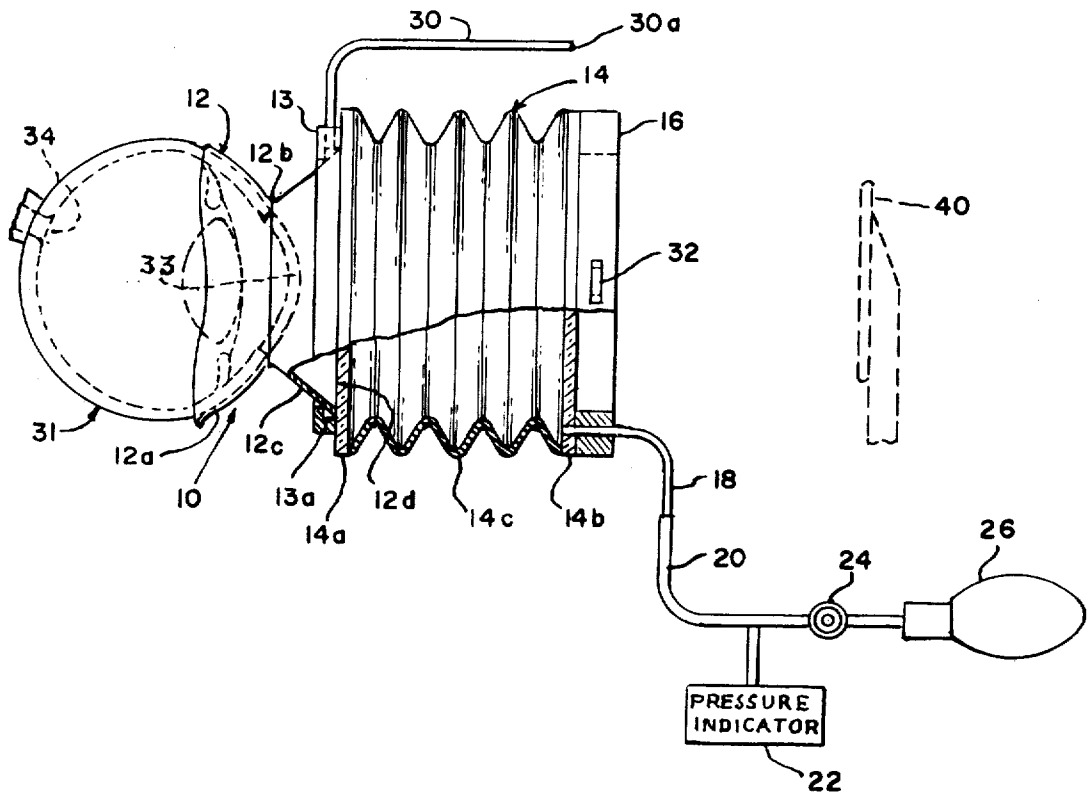
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[57] **ABSTRACT**

A portable ophthalmodynamometer, which operates in the active compression mode, includes a transparent plastic eyecup or speculum attached to a bellows-like bladder having glass endwalls. The eyecup fits under the eyelids and is seated against the sclera by a headstrap attached to the bladder structure and secured around the head. An integral adjustment gauge facilitates correct positioning of the ophthalmodynamometer on the eyeball. An air duct extends from the interior of the bladder structure to a hand squeeze bulb whereby manipulation of the bulb increases the internal pressure of the bladder structure. Increasing bladder pressure is transmitted to the eyeball via the eyecup to thereby raise intra-ocular pressure. Bladder pressure is related to retinal artery blood pressure. Means are provided to ascertain the bladder pressure so that retinal artery blood pressure may be determined.

12 Claims, 4 Drawing Figures



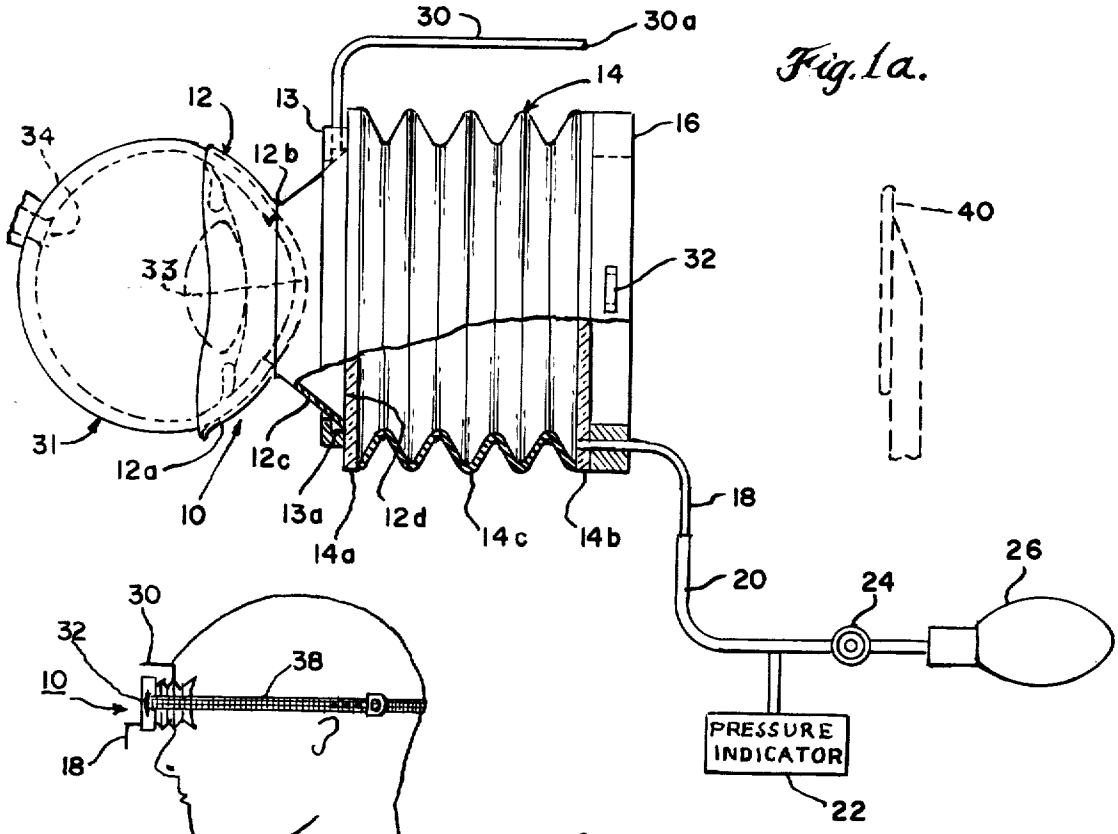


Fig. 1a.

Fig. 3.

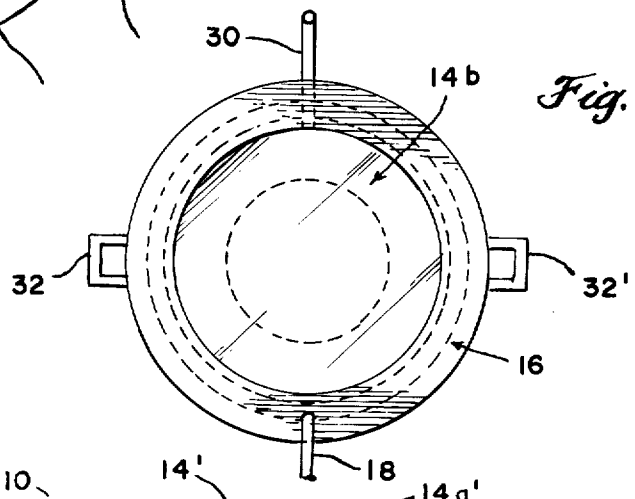


Fig. 1b.

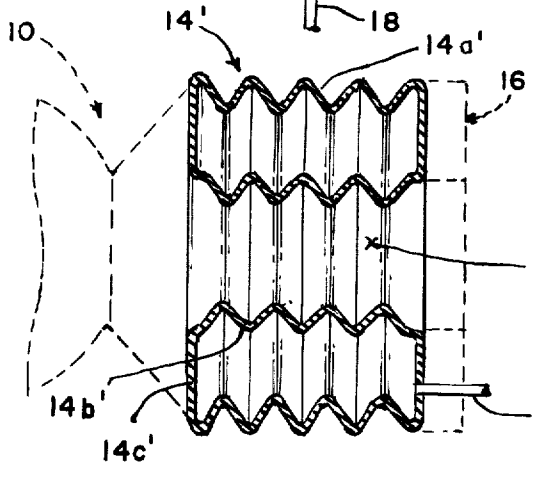


Fig. 2.

OPHTHALMODYNAMOMETER

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to ophthalmodynamometers and in particular to ophthalmodynamometers which employ the active compression principle.

An ophthalmodynamometer is an instrument which measures retinal artery pressures by applying a variable but calibrated force over a known area of the eye to induce systole, i.e., pulsations at the peak of the blood pressure cycle, and diastole, i.e., pulsations at the minimum of the blood pressure cycle, of the central retinal artery. With the ophthalmodynamometer the intra-ocular pressure is artificially elevated by means of mechanically applied pressure or suction. A separate apparatus, e.g., a hand held ophthalmoscope, is then employed to observe or detect the pulsations. (The essential function of the ophthalmoscope is to provide illumination through the pupil of the eye so that the examiner may view the fundus of the eye.) Measurement of retinal artery pressure can be used to detect several important body conditions, e.g., increased intracranial pressure, partial or complete carotid artery blockage, and carotid vascular blockage.

Present day ophthalmodynamometers increase intra-ocular pressure by using either a suction device or a compression device. The compression device employs a small flat disc which is pressed against the sclera of the eye with a calibrated force applicator. The suction device employs a small cup and a calibrated vacuum device to apply suction to a portion of the sclera. The compression and suction ophthalmodynamometer devices both distort the globe of the eye. This distortion tends to raise the pressure of the relatively incompressible vitreous fluid within the eye. The increased pressure of the vitreous fluid is then exerted against the central retinal area of the eye.

Conventional ophthalmodynamometers have several drawbacks. In both the compression type and the suction type, the actual increase in intra-ocular pressure is nonlinearly related to the external force applied to sclera. Hence it is difficult to establish an exact relationship between the force applied to the sclera and the actual retinal artery pressure. In the compression type, the axis of pressure application is sometimes non-normal to the sclera giving rise to lateral forces which can cause slippage of the disc on the sclera. In the suction type, measurement errors are sometimes introduced when there is a partial loss of vacuum around the periphery of the suction cup or the pneumatic tube providing the vacuum partially collapses. Both types of conventional ophthalmodynamometers are uncomfortable for the patient, difficult to properly and conveniently employ and generally give uncertain results. In addition, conventional ophthalmodynamometers cannot be used under field or combat conditions since they employ cumbersome equipment and normally require the patient to be in a upright position.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a compression ophthalmodynamometer which is convenient to employ and which reliably determines retinal artery pressure without unduly discomfiting the patient. It is a further object of this invention to provide an ophthalmodynamometer which is portable, atraumatic to the eye, and which can be used under field or combat conditions even where the patient is in a prone position. These and other objects of the invention are achieved as follows:

A portable ophthalmodynamometer, which operates in an active compression mode, is provided with a transparent plastic eyecup and a fluid impermeable bladder structure. The bladder structure is substantially cylindrical with glass endwalls and a sidewall fabricated from a pleated but distensible material. The eyecup is removably secured to the bladder structure by means of a grooved retaining clip. A fixed length attachment gauge secured to the retaining clip ensures correct seating of the eyecup on the sclera. An air duct extends from the interior of the bladder structure to a squeeze bulb and pressure indicator means. After the ophthalmodynamometer has been properly placed on the eyeball with the aid of head straps the bladder structure is pressurized by means of the squeeze bulb. As the bladder pressure increases a force is transmitted to the sclera via the eyecup and the intra-ocular pressure is thereby increased. With an ophthalmoscope, systole and diastole are observed and the corresponding bladder pressure is ascertained from the pressure indicator means. Since internal bladder pressure is related to intra-ocular pressure, a measurement of retinal artery pressure is obtained.

Other objects, advantages, and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1*a* shows an ophthalmodynamometer according to the invention partially in section;

FIG. 1*b* shows an end view of the ophthalmodynamometer of FIG. 1; and

FIG. 2 shows a modification of a portion of the ophthalmodynamometer shown in FIG. 1; and

FIG. 3 shows the ophthalmodynamometer of the present invention positioned on the eye and held in place with a head strap.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1*a* the ophthalmodynamometer **10** of the present invention includes a transparent plastic eyecup or speculum **12** attached to a bladder **14** having a bellows-like structure. The eyecup **12** has a flared or virtually semi-spherical portion **12***a* which fits under the eyelids (not shown) and rests against the sclera **31** just outside the periphery of the cornea **33**. The flared portion **12***a* tapers to a viewing port or orifice **12***b* having a circumference slightly larger than a cornea. (The flared portion **12***a* prevents the eyelids from closing when the ophthalmodynamometer is used and also exerts pressure on the sclera as will be described more fully hereinbelow). Thereafter the eyecup **12** extends as a substantially frusto-conical portion **12***c* having a planar rim **12***d* which is removably retained within a circular groove **13***a* provided on a plastic retaining clip or keeper **13**. (A suitable eyecup **12** that may be used

in the present invention may be the eyecup employed to hold the Burian Allen ERG Electrode manufactured by the Hansen Ophthalmodynamometer Development Laboratory of Iowa City, Iowa). The sidewall **14***c* of the bladder structure **14** is fabricated from any suitable material which is both distensible and fluid impermeable such as silicone rubber. The bladder **14** is generally cylindrical in form and has a sidewall **14***c* constructed in a pleated or corrugated fashion much like a bellows. Both endwalls **14***a*, 14*b* of the bladder **14** are fabricated from anti-reflection coated glass or scratch resistant plastic formed in the shape of a disc.

One endwall **14***b* of the bladder structure **14** is provided with a plastic circular mounting ring **16** having head strap lugs **32**, **32'** as can be seen best in FIG. **1***b*. The circular ring **16** occupies the outer periphery of the glass endwall **14***b* and is attached thereto by an adhesive such as permaband **101** contact cement or any other suitable means. The circular ring **16** has a thickness sufficient to provide a secure base or support for head strap lugs **32**, **32'**. A head strap **38** is attached to each head strap lug **32**, **32'** and brought behind the patient's head where it can be incrementally tightened.

A second endwall **14***a* of the bladder structure **14** is provided with a grooved circular retaining clip or keeper **13** which is securely attached to the glass endwall **14***a* by an adhesive such a permaband **101** contact cement or any other suitable means. The plastic retaining clip or keeper **13** occupies the outer periphery of glass **14***a* and is used to removably secure the speculum or eye cup **12** to the bladder structure **14** by means of a groove **13***a*.

A fixed length plastic adjustment gauge **30** is attached to the retaining clip **13** and extends above and along the upper portion of the bladder structure **14**. The gauge **30** is slightly smaller than the undistended length of the bladder structure **14**; within this constraint the exact length of the adjustment gauge is not critical but its optimum length will depend on the actual dimensions of a finally and fully fabricated ophthalmodynamometer **10**. The gauge **30** is used by the examiner to properly position the ophthalmodynamometer **10** on the patient's eye as will be explained more fully hereinbelow. A duct **18**, of any suitable material, extends through the lower portion of ring **16** to at least the interior surface of the glass endwall **14***b*. The duct **18** is suitably connected to a pneumatic tube **20** which extends to a normally closed exhaust valve **24** and a squeeze-bulb **26** such as those used with a conventional cuff-type sphygmomanometer. (To those skilled in the art the exhaust valve **14** is also known as sphygmomanometer inflation bulb). The exhaust valve **24** and squeeze-bulb **26** are shunted by a conventional pressure indicator **22** which transduces applied pressures to a readable numerical value.

Referring to FIGS. **1** and **3**, the operation of the ophthalmodynamometer **10** is as follows. The ophthalmodynamometer **10** is placed on the eyeball so that the eyecup **12** fits under the eyelids and rests against the sclera **31** just outside the periphery of the cornea **33**. The Headstraps **38** (FIG. **3**) attached to the lugs **32** and **32'** on the mounting ring **16** are brought behind the patient's head and thereafter incrementally tightened. The head straps **38** are tightened only until the outer surface of the ring **16** is aligned with the distal end **30***a* of the adjustment gauge **30** as shown in FIG. **3**. When such alignment occurs the eyecup **12** is correctly seated on the sclera **30** and presses against the sclera with enough force to minimize slippage but not enough force to introduce a significant pressure increment to the eyeball prior to pressurization of the bladder structure.

After the ophthalmodynamometer has been positioned on the eyeball, the pressure within the bladder structure **14** is increased by squeezing bulb **26**. As the pressure increases, the bladder structure tends to distend and exerts a pressure against the eyeball via the eyecup **12**. With an opthalmoscope **40** the examiner views the fundus **34** of the eye and continues to increase the pressure until he observes the characteristic collapse of the retinal artery. Thereafter the exhaust valve **24** is opened and the pressure decreases. As the pressure decreases the examiner observes the characteristic first blood pulse at the high point of the blood pressure cycle, i.e., systole. As the pressure continues to decrease, the examiner notes the last blood pulse at the low point of the blood pressure cycle, i.e., diastole. The corresponding readings from pressure indicator **22** represent the retinal artery blood pressure at systole and diastole respectively.

It is apparent from the description of the ophthalmodynamometer's operation set forth above, that it operates in an active compression mode as opposed to a passive compression mode. In the active mode, the bladder sructure **14** is in a semi-flaccid or substantially undistended state when the ophthalmodynamometer is initially positioned on the eyeball. Thereafter, the bladder structure **14** is pressurized by squeeze-bulb **26** and caused to expand or distend to thereby transmit an increased pressure to the eyeball via the eyecup **12**. If the ophthalmodynamometer **10** were operated in a passive mode, there would be no need for the squeeze-bulb **26** and the exhaust valve **24**. That is, the bladder structure **14** is pressurized before it is placed on the eyeball and the internal pressure of the bladder structure **14** is increased by exerting an internal force against an endwall of the bladder structure **14** after the ophthalmodynamometer is positioned on the eyeball. The increased internal pressure within the bladder structure **14** under the influence of the external force is registered on the pressure indicator **22**.

Referring to FIG. **2**, wherein like numerals refer to parts already illustrated, a modification of the bladder structure shown in FIG. **1***a* is portrayed. The single walled bladder structure **14** of FIG. **1** is replaced by a double walled bladder structure **14'** shaped substantially in the form of a toroid having pleated or corrugated sidewalls **14***a'* and **14***b'* much like a bellows. The entire double walled bladder **1**1' maybe fabricated from a fluid impermeable but distensible material such as silicone rubber. The double walled bladder **14'** is secured to the eyecup **12** by an adhesive such as permabond **101** contact cement or by any other suitable means at endwall **14***c'*. And air duct **18'** extends from the interior of the double walled bladder to the parallel connected pressure indicator **22**, exhaust valve **24** and squeeze bulb **26** as before. An advantage of the double walled bladder structure **14'** over the single walled structure is that glass endwalls are made unnecessary since the fundus **34** may be observed through the toroid hole **14***d'*. Operation of an ophthalmodynamometer equipped with the double walled bladder **14'** is the same as that set forth hereinabove for the single walled bladder structure **14**.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

We claim:

1. An ophthalmodynamometer comprsiing:

a speculum member having an opening formed by two oppositely flaring surfaces of revolution, one of said surfaces being formed to fit against the sclera of the eye beneath the upper and lower eyelids;

a bladder member attached to the other of said surfaces for transmitting a force to said speculum member, said bladder member having a transparent portion concentric with said speculum opening;

first means attached to said bladder member for securing said one surface against the sclera;

second means operatively connected to said bladder member for varying the internal pressure of said bladder member; and

third means operatively connected to said bladder member for monitoring the internal pressure of said bladder member.

2. An ophthalmodynamometer according to claim **1** wherein said bladder member includes:

a closed tube having a corrugated sidewall attached to first and second transparent endwalls.

3. An ophthalmodynamometer according to claim **2** further including:

at least one head strap;

means attached to said first endwall for securing said head strap to said bladder member;

an adjustment gage;

retaining means attached to said second endwall for securing said adjustment gage to said bladder member, said retaining means including means integral therewith for securing said speculum member to said bladder member.

4. An ophthalmodynamometer comprising:

a substantially cylindrical bladder having a pleated sidewall attached to first and second transparent disc-shaped endwalls;

a keeper attached to said first endwall;

a mounting ring attached to said second endwall;

an eyecup member attached to said keeper, said eyecup member having a viewing port concentric with said transparent disc-shaped endwalls;

an adjustment gauge attached to said keeper; and

a tube having a first end portion extending through said mounting ring and said second endwall, and a second end portion serially connected to a normally closed exhaust valve, a squeeze bulb and a pressure indicator means connected in parallel with respect to each other.

5. An ophthalmodynamometer comprising:

first means for applying force over a predetermined area of an eyeball;

a bladder member attached to said first means, said bladder member having a transparent portion through which said eyeball may be observed;

second means operatively connected to said bladder member for varying the internal pressure of said bladder member;

third means operatively connected to said bladder member for monitoring the internal pressure of said bladder member;

at least one head strap attached to said bladder member; and

an adjustment gage attached to said bladder member.

6. An ophthalmodynamometer according to claim **5** wherein said bladder member includes:

a hollow substantially cylindrical bladder having a corrugated sidewall attached to first and second transparent disc shaped endwalls;

a mounting ring attached to said first endwall and having at least one head strap lug thereon for receiving said head strap; and

a keeper attached to said endwall for supporting said adjustment gage, said keeper including attachment means integral therewith for securing said first means to said keeper.

7. An ophthalmodynamometer according to clain **6** wherein said second means comprsies:

a tube member extending from the interior of said hollow cylindrical bladder through said first transparent endwall and said mounting ring to a squeeze bulb shunted by a normally closed exhaust valve.

8. An ophthalmodynamometer according to claim **7** wherein said third means comprises:

a pressure indicator shunt connected to said tube member.

9. An ophthalmodynamometer according to claim **8** wherein said first means comprises a transparent eyecup having:

a flared portion shaped to subatantially conform to the contour of a sclera and operative to prevent eyelid closure as well as exert force against the sclera; and

a frusto-conical portion terminating in a planar rim; wherein

said fursto-conical portion and said flared portion abut at their respective smallest diameters to form a viewing port having a diameter slightly larger than a cornea.

10. An ophthalmodynamometer according to claim **9** wherein said disc shaped endwalls and said viewing port are concentric.

11. An ophthalmodynamometer according to claim **10** wherein said bladder is substantially composed of a fluid impermeable, distensible material.

12. An ophthalmodynamometer according to claim **11** wherein said material is silicone rubber.

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