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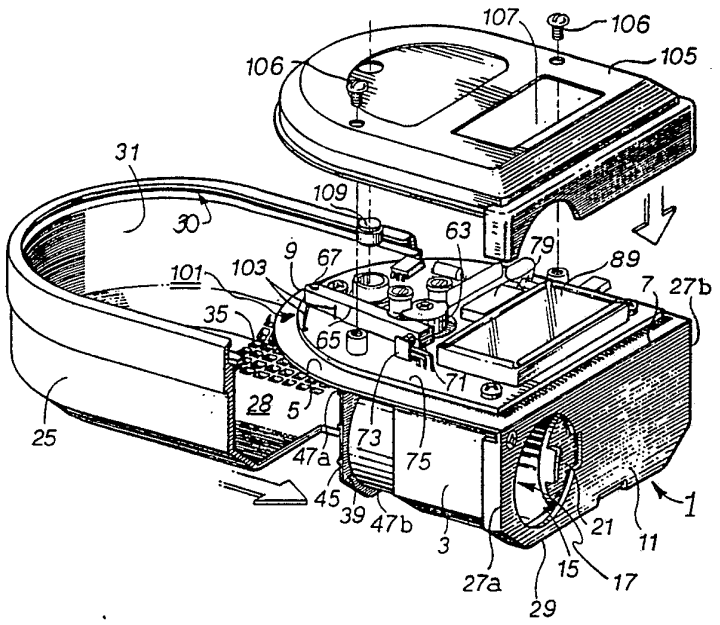

(57) Abstract

A spirometer includes a chassis (3) with an enclosed curved passageway (33). The passageway (33) has an inlet (17), for receiving the forced expiration of the user, and an outlet (35), through which the expiration may be exhausted from the passageway (33). A vane (37) is eccentrically and pivotally mounted in the passageway, between the inlet (17) and the outlet (35) and is moved by the user's forced expiration. The vane (37) pivots from a first position closing off the passageway to a succession of other open positions forming a widening gap between the vane and part of the passageway as the vane moves therethrough. The vane (37) is eccentrically positioned in the passageway. A vane position measuring system preferably using a Hall Effect device (73) measures the position of the vane over time, during the interval when the user blows into the spirometer. A microprocessor (79) converts the signal from the vane position measuring system into various diagnostic parameters applicable to the user's lung condition.

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DESCRIPTION

PORTABLE SPIROMETER

The field of the present invention is spirometers, or devices for measuring pulmonary function.

A spirometer is an instrument for measuring breathing capacity and other bronchial activity of the lungs. Spirometers find wide utilization in the diagnosis of lung and breathing difficulties such as emphysema, asthma and chronic bronchitis. More particularly, they have found use in monitoring the progress of recipients of lung transplants. Ordinarily, spirometers involve large equipment located in laboratories or doctors' offices. The testing requires the patient to breath into the equipment with a forced expiration.

The parameters obtained through the use of spirometers are reported in well-accepted formats such as "forced vital capacity" (FVC) which is the volume of air that is exhaled following a maximum single breath regardless of the time taken; "peak expiratory flow" (PEF) which is a measure of the highest flow rate of air from the lungs during a single forced expiration; "forced expired volume during the first second" (FEV_1) which represents the volume of air that can be exhaled in the first second: "$FEF_{25/75}$" which is the average expiratory flow for the middle 50% of the expiration; and, other combinations of these values as FEV_1 expressed as a percentage of the FVC. Depending upon the particular lung condition, the physician or physiotherapist may choose to look at one, some, all of these parameters, or other ones.

Large electronic spirometers situated in a laboratory or doctor's office are often large and quite expensive. These spirometers are therefore not installed at many locations. Patients may therefore travel substantial distances to undergo testing. Small, hand-held, portable meters presently available measure only peak flow. Portable electronic spirometers presently available

measure only a few parameters of lung function. These devices are costly and few, if any, individuals can afford them for home monitoring. Further, because of the lack of multiple parameter reporting, the treating physician is often left with only partial results, and a more complete analysis of the patient's lung condition cannot readily be made. In addition, these portable spirometers are generally inadequate for measuring the very low flow rates associated with highly impaired lung conditions.

Some of these spirometers require the patient to record the results of the tests and bring them to the physician's office for later analysis. This practice can result in errors in recording and evaluating the data. Accordingly, there remains a need for a portable spirometer that measures many or all of the desired parameters, designed to be economically affordable by most patients, and that would automatically record the results for reporting to the user or to the physician's office for analysis.

SUMMARY OF THE INVENTION

The present invention is directed to a portable spirometer for measuring a variety of pulmonary functions or parameters. To this end, a vane is pivotally supported in a curved passageway. A detector detects movement of the vane over time. Preferably a processor is linked to the detector and determines pulmonary functions based on the detected movement of the vane. The processor is ad advantageously connected to a display on the spirometer for reporting or displaying pulmonary functions.

Accordingly, it is an object of the present invention to provide an improved spirometer for measuring pulmonary functions. Other objects and advantages will appear hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein similar reference characters denote similar elements throughout the several views:

Fig. 1 is an exploded perspective view of the present spirometer showing the chassis and top and bottom covers;

Fig. 2 is a perspective view of the underside of the chassis of Fig. 1;

Fig. 3 is a bottom plan view of the chassis showing travel of the vane through the curved air passageway;

Fig. 4 is a top plan view of the chassis;

Fig. 5 is a perspective view of the present spirometer fully assembled including a blowing tube inserted therein;

Fig. 6 is a schematic illustration of the electronic components of the spirometer;

Fig. 7 is top plan view of a second preferred embodiment of the present spirometer;

Fig. 8 is a side elevation view in part section of the chassis of the embodiment of Fig. 7;

Fig. 9 is an enlarged plan view of the Hall Effect device and magnet of the embodiment of Fig. 7; and

Fig. 10 is an exploded partial side elevation view of the chassis of Fig. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to the drawings, as shown in Figs. 1, 2 and 3 the spirometer **1** has chassis **3** comprising a top plate **5** with a straight front edge **7** and a U-shaped edge **9** extending rearward from the front edge. A front wall **11** extends down from front edge **7**. A battery box **13** is nested behind front wall **11** and under top plate **5**.

An aperture **15** at one side of front wall **11** opens into a bore **17** that extends rearwardly into the spirometer. A short tube **19** either of disposable cardboard or reusable plastic is provided for insertion into bore **17** to facilitate blowing into the spirometer. A door **21** is slidably mounted in front wall **11** and can be moved by a handle or projection **23** back and forth to open and close aperture **15**

to keep dust and dirt out of the interior of the spirometer when it is not in use.

A bottom cover **25** is provided for attachment about chassis edge **9**, and the spaced-apart sides **27a** and **27b** and bottom edge **29** of the front wall **11**. Cover **25** has a flat bottom **28** and an upwardly extending U-shaped rear wall **31** with a slot **30** for receiving U-shaped chassis rear edge **9**. Bottom cover **25** and chassis plate **5** thus form a curved passageway **33**, of generally rectangular cross-section, within the spirometer. A plurality of exhaust apertures **35** are formed in bottom cover **25** and are closely spaced together, on the opposite side of cover **25** from where aperture **15** is located in front wall **11**.

A vane **37** is pivotally mounted in passageway **33**. Referring to Figs. 2 and 3, vane **37** is formed by a flat plate **39**, reinforced with cross-ribs **41**, extending outwardly from a pivotal edge **43** to an outer edge **45** and joined together through spaced-apart top and bottom edges **47a** and **47b**, respectively. Vane **37** is arranged to swing from a first position **49** at the inner end **51** of bore **17** and across passageway **33** through a succession of other positions further into curved passageway **33**, urged by the forced expiration of the user's breath into bore **17**. Top and bottom vane edges **47a** and **47b** are arranged to swing in the arch in close proximity with the under surface of top plate **5** and the top surface of bottom cover **25** that formed the top and bottom of passageway **33**. The term "close proximity" is meant to indicate a gap therebetween of a few thousandths of an inch. The outer edge **45** of vane **37** is made straight and aligned such that it too moves into close contact, i.e., within a few thousandths of an inch of the inside surface of cover rear wall **31** when vane **37** is in its first position at the inner end **51** of bore **17**. Vane **37** essentially closes off bore **17** when in the first position, such that even a very slight air flow through the bore will cause an immediate movement of the vane.

Preferably, curved passageway **33** is of a fixed radius and vane **37** is mounted off-center from the center of curvature thereof by a shaft **53** built into or made a part of vane pivotal edge **43**. Vane shaft **53** extends upward through an aperture **55** formed in chassis plate **5** and extends downward into a short cylinder **57** formed on chassis **3**.

As vane **37** pivots about pivotal edge **43** away from inner bore end **51** or first position **49**, an ever-increasing gap **59** is created, as shown in dotted line in Fig. 3, between vane outer edge **45** and the inside surface of rear wall **31**, thereby allowing more and more forced air to pass through passageway **33** and out exhaust apertures **35**. This construction allows spirometer **1** to sense flows of air from a minimum of about 2 liters per minute to a maximum of about 800 liters per minute and therefore covers a far wider range of air flows than is currently possible with known portable units. The spirometer **1** is therefore usable by a wide range of individuals whose lung size and condition may vary widely.

A vane position measuring system **61** is provided for rapidly and accurately measuring the incremental change of positions of vane **37** as it rotates through its arch in air passage **33** under the positive pressure of the forced expiration of air by the user, flowing into aperture **15** and out exhaust apertures **35**. It is through these incremental measurements over time of the different positions of vane **37**, that FVC, PEF, FEV, and other particular lung function parameters are calculated.

As shown more particularly in Figs. 1, 4 and 6, in the first embodiment, vane position measuring system **61** includes a cam lobe **63** attached to vane shaft **53**. Preferably the cam lobe **63** is mounted with the plane of the cam lobe perpendicular or normal to the axis of pivotal edge **43**. Cam lobe **63** is attached to vane pivotal edge **43** by shaft **53** so that it is rotated by the pivotal movement of vane **37**. A sensor arm **65** is pivotally mounted at one end

67 and extends toward cam lobe 63. A cam following surface 69 is formed on sensor arm 65 and slidably contacts the cam lobe 63.

A small permanent magnet 71 is attached to sensor arm 65. A Hall Effect device 73 is mounted independently of permanent magnet 71, preferably on a circuit board 75 that is mounted atop and parallel to chassis plate 5. The Hall Effect device 73 is positioned near magnet 71 to measure the magnetic flux variations generated by the movement of magnet 71.

As shown in Figs. 1, 4 and 6, as vane 37 is rotated by the forced expiration of air traveling through passageway 33, cam lobe 63 rotates and shifts the position of sensor arm 65. This causes magnet 71 to move closer to or further away from Hall Effect device 73. Such movement causes a change in the magnetic lines of flux passing through Hall Effect device 73. The changing magnetic flux causes the Hall Effect device 73 to generate analog data input to a position detector 76, the data corresponding to the position of vane 37 at any particular point in air passageway 33.

A microprocessor 79 which contains an A/D converter 81 is linked to an operational amplifier 76 and converts the analog data generated by relative movement between Hall Effect device 73 and magnet 71 into digital data for determining the various diagnostic parameters applicable to the user's lung condition as determined by the forced expiration into spirometer 1 to move vane 37.

As shown in Fig. 6, the microprocessor 79 includes a clock 83 to provide a plurality of time segments over which the analog measurements may be made to create the digital information. It is preferred that clock 83 be arranged to provide a multiplicity of time units, such as 150 separate time frames per second, in which the vane position is measured throughout the forced expiration by the user.

The vane position information from the operational amplifier **76** is converted to digital information by the analog-to-digital converter **81**. A memory integrated circuit **85** stores known lung parameter information. Based upon digital information and programming parameters, microprocessor **79** computes forced vital capacity (FVC), forced expired volume during the first second (FEV_1), FEV_1 expressed as a percentage of FVC, and FEF_{25-75}, which is the average flow rate during the middle 50% of the expiration. A display drive **87** of the microprocessor is linked to a display, such as a liquid crystal display **89**. The display **89** is preferably mounted on circuit board **75**, over the microprocessor; and displays the computed lung parameters. The details of the design and operation of the operational amplifier **76**, microprocessor **79** and display **89** are well known in the art.

A bias adjuster **91**, as shown in Figs. 2 and 3, is provided along with vane **37** to provide an adjustable bias to vane **37** in either direction. As shown in Fig. 2, the bias adjuster preferably includes a coil spring **93**, positioned near vane pivotal edge **43**. One end of coil spring **93** is attached to vane shaft **53** and the other end attached to a cap **97** that fits tightly by friction down into cylinder **57**. A small slot **99** is formed in cap **97** to receive the blade of a standard screwdriver to twist or reposition cap **97** and spring **93** one way or the other to increase or decrease the bias on vane **37**. This is useful in calibrating the spirometer.

A sensor arm tensioner **101** shown in Fig. 4, is also provided, preferably in the form of a spring **103** bearing against sensor arm **65** near its pivotal mounting **67**. The spring **103** biases sensor arm **65** against cam lobe **63** to effect more accurate movement of permanent magnet **71** through the rotation of cam lobe **63**. A top cover **105**, front wall **11** and bottom cover **105** over liquid crystal display **89** to allow observation of the readouts as they occur.

A tactile button start and sequence switch **109** is provided to start a testing sequence. Various user friendly directions are programmed to appear in display **89** such as "PLEASE BLOW", "READY", "BLOW AGAIN" or a symbol denoting low battery or other information. The results of the test are preferably programmed to appear on liquid crystal display **89** in a sequence of readings that each remain the display for approximately five seconds. Advancing the readouts can be accomplished more rapidly by pressing switch **109**. Holding the switch down for longer than five second will re-set the device for another blow. As the readouts are made to appear in display **89**, they are also recorded in memory unit **85** for later viewing or transfer via a modem to the physician's office for analysis.

As shown in Figs. 3 and 6, a dip switch (dual in-line package switch) **111** is preferably located under bottom cover **25** for use by the physician or other monitoring person to select specific lung parameters that are to be viewed.

Chassis **3**, top plate **5**, front wall **11**, bottom cover **25**, top cover **105** and many of the various components therein are most conveniently made from plastics, both for light weight and for ease of manufacturing. Battery box **13** holds one or a plurality of batteries to power the computer and other electronic hardware. Bottom cover **25** is preferably made removable from chassis **3** for ease in changing the batteries, cleaning the air passageways, and selecting various positions in dip switch **111** to isolate certain parameters apart from one another.

The spirometer is prepared for use by using tactile button **109**, inserting air tube **19** in bore **17**, and blowing in one continuous blow into tube **19**. The forced air will move vane **37** from its first position across passageway **33**, near the inner end of bore **17**, through an arch about its pivot shaft **53** and through a succession of other open positions while forming ever-widening gap **59**. The air is

exhausted through exhaust apertures **35** while the microprocessor **79** measures the changing positions of vane **37**.

In an alternate preferred embodiment, shown in Figs. 7-10, an improved vane position measuring system is provided to decrease the at rest sensitivity of the Hall Effect device measurements to, e.g., tolerance errors, temperature changes, strain on the body of spirometer, calibration errors, etc. Referring to Figs. 7, 8 and 9, the cam **63** is replaced with a magnet holder **120** attached at the top end of the vane shaft **53** which is preferably an integral part of the vane. A cylindrical magnet **72** extends through a bore and is bonded to the holder **120**. The Hall Effect device **73** is positioned on the circuit board adjacent to the holder **120**. As the vane pivots through the curved passageway, the north and south poles of the cylindrical magnet **72** change positions 180 degrees, with respect to the Hall Effect device **73**. Consequently, the output signal from the Hall Effect device is much greater than in the first embodiment shown, e.g., in Fig. 4. As a result, the Hall Effect device **73** may be positioned much farther away from the magnet, in comparison to the embodiment shown in Fig. 4. As a result, errors arising from a change in the separation of the Hall Effect device and the magnet are greatly reduced. In its other design aspects, the second embodiment may be substantially identical to the first embodiment.

While the invention has been described with reference to a particular embodiment thereof, those skilled in the art will be able to make various modifications to the described embodiment of the invention without departing from the true spirit and scope thereof. It is intended that all combinations of elements and steps which perform substantially the same function in substantially the way to achieve substantially the same result are within the scope of this invention.

WHAT IS CLAIMED IS:

1. A portable, hand-held spirometer comprising:

a) a chassis;

b) an enclosed curved passageway including an inlet for receiving the expiration of the user, and an outlet through which the expiration may be exhausted;

c) a vane pivotally mounted in said passageway, between said inlet and said outlet, for moving under the influence of the user's expiration from a first position substantially closing off said passageway to a succession of other positions forming a widening gap between said vane and part of said passageway as said vane moves therethrough;

d) a measurer for measuring positions of said vane, as a function of time;

e) a measurement converter for converting measured positions of said vane to diagnostic parameters; and,

f) a communicator for communicating the diagnostic parameters.

2. A spirometer comprising:

a housing containing a curved passageway having a center of curvature;

a vane pivotally mounted within the housing at a location offset from the center of curvature of the curved passageway;

a biaser for biasing the vane to a first position against an inner end of a bore extending into the housing, the vane positioned substantially perpendicular to the bore when in the first position; and

a measurer for measuring over time the position of the vane within the housing.

3. The spirometer of Claim 1 or 2 wherein the measurer includes:

a) a cam including a cam surface attached to and movable with said vane;

b) a sensor arm pivotally mounted at one end to the chassis including a cam following surface in contact with said cam;

c) a magnet attached to said sensor arm for moving through a path as a function of vane movement; and,

d) a Hall Effect device mounted apart from said magnet.

4. The spirometer of Claim 2 wherein said biaser comprises:

a) a cylinder attached to said chassis;

b) a spring in said cylinder for applying a tension to said vane and having a first end connected to said vane;

c) a cap positioned in said cylinder and connected to a second end of said spring; and

d) a receptacle in said cap for receiving a tool to rotate said cap to a new position increasing or decreasing the tension of said spring on said vane.

5. The spirometer of Claim 1 wherein said measurement converter comprises:

a) a microprocessor including a clock for computing the position of said vane, as a function of time, and producing analog data therefrom; and,

b) an analog-to-digital converter linked to said microprocessor and including a memory unit to produce digital diagnostic parameter values from the analog data.

6. The spirometer of Claim 1 wherein said communicator comprises a liquid crystal display, connected to the measurement converter to display said digital diagnostic parameter values.

7. The spirometer of Claim 1 or 2 further including at least one cover that is removable to permit cleaning of the curved passageway.

8. The spirometer of Claim 1 or 2 further including a battery box for containing at least one battery.

9. The spirometer of Claim 1 or 2 further including a moveable door for closing off said curved passageway when said spirometer is not in use.

10. The spirometer of Claim 2 further comprising a measurement converter linked to the measurer and including:

a) a microprocessor including a clock for computing the position of said vane, as a function of time, and producing analog data therefrom; and

b) an analog-to-digital converter attached to said microprocessor including a memory unit to produce digital diagnostic parameter values from the analog data.

11. The spirometer of Claim 1 or 10 further including a dual in-line package switch (DIPS) linked to the measurement converter for pre-selecting the diagnostic parameters desired to be computed and reported.

12. The spirometer of Claim 1 or 2 wherein the measurer comprises a cam movable with said vane, a sensor arm engaged against said cam, a magnet on the sensor arm, and a Hall Effect device adjacent to the sensor arm.

13. The spirometer of Claim 1 wherein said outlet comprises a plurality of closely spaced apertures extending from the curved passageway through the housing.

14. The spirometer of Claim 10 further comprising a display or sound speaker linked to the measurement converter for reporting a diagnostic parameter to the user.

15. The spirometer of Claim 1 or 2 wherein the measurement converter includes a microprocessor and a clock for computing the position of the vane, as a function of time, and producing a corresponding analog output; and

an analog-to-digital converter and a memory linked to the microprocessor for producing a digital diagnostic parameter from the analog output.

16. The spirometer of Claim 1 or 2 wherein said enclosed curved passageway has a fixed radius and said vane is pivotally mounted offset from the radius of curvature thereof.

17. The spirometer of Claim 1 or 2 further including a bore spanning said air inlet and said passageway, wherein said air passageway has a generally rectangular cross-section and said vane is of a size and shape to fit transversely therein at the intersection of said passageway and said bore.

18. The spirometer of Claim 1 or 2 wherein said measurer includes:

a) a cam lobe including a cam surface attached to said vane, normal to the axis of said shaft, and arranged to rotate as a function of vane movement;

b) a sensor arm including a cam following surface extending into contact with said cam lobe;

c) a magnet attached to said sensor arm for moving through a path as a function of vane movement; and

d) a Hall Effect device mounted apart from said magnet for receiving a variable pattern of lines of flux from said magnet as a function of vane position.

19. The spirometer of Claim 18 further comprising means for tensioning said sensor arm against said cam.

20. The spirometer of Claim 19 wherein said means for tensioning includes a spring bearing against said sensor arm to bias it into contact with said cam.

21. A portable, hand-held spirometer comprising:

a) a chassis;

b) an enclosed curved passageway including an inlet and an outlet;

c) a vane positioned in said passageway, between said inlet and said outlet, and pivotable from a first position substantially closing off said passageway to a succession of other positions forming a widening gap between said vane and said passageway;

d) a magnet linked to and moveable with the vane;

e) a Hall Effect device adjacent the magnet and fixed in position on the chassis;

f) measurement electronics connected to the Hall Effect device; and

g) a display connected to the measurement electronics.

22. A spirometer comprising:

a housing containing a curved passageway having a center of curvature;

a vane pivotally mounted within the housing at a location offset from the center of curvature of the curved passageway;

a biaser for biasing the vane to a first position against an inner end of a bore extending into the housing, the vane positioned substantially perpendicular to the bore when in the first position;

a magnet moveable with the vane; and

a Hall Effect device adjacent the magnet for generating a signal indicative of the position of the vane.

23. The spirometer of Claim 22 wherein said biaser comprises:

a) a cylinder attached to said chassis;

b) a spring in said cylinder for applying a tension to said vane and having a first end connected to said vane;

c) a cap positioned in said cylinder and connected to a second end of said spring; and

d) a receptacle in said cap for receiving a tool to rotate said cap to a new position increasing or decreasing the tension of said spring on said vane.

24. The spirometer of Claim 21 wherein said measurement electronics comprise:

a) a microprocessor including an analog-to-digital converter and a clock for computing the position of said vane, as a function of time, and producing digital data therefrom; and,

b) a memory unit linked to said microprocessor.

25. The spirometer of Claim 21 wherein said display comprises a liquid crystal display, connected to the measurement electronics to display said digital diagnostic parameter values.

26. The spirometer of Claim 22 further including at least one cover that is removable to permit cleaning of the curved passageway.

27. The spirometer of Claim 22 further including a moveable door for closing off said curved passageway when said spirometer is not in use.

28. The spirometer of Claim 22 further comprising measurement electronics linked to the Hall Effect device and including:

a) a microprocessor including an A/D converter and a clock for computing the position of said vane, as a function of time, and producing digital data therefrom; and

b) an analog-to-digital converter linked to said microprocessor including a random access memory.

29. The spirometer of Claim 22 further including a dual in-line package switch (DIPS) linked to the measurement electronics for pre-selecting the diagnostic parameters desired to be computed and reported.

30. The spirometer of Claim 21 wherein said outlet comprises a plurality of closely spaced apertures extending from the curved passageway through the housing.

31. The spirometer of Claim 21 further comprising a display or sound speaker linked to the measurement electronics for reporting a diagnostic parameter to the user.

32. The spirometer of Claim 22 wherein said enclosed curved passageway has a fixed radius and said vane is pivotally mounted offset from the radius of curvature thereof.

33. The spirometer of Claim 22 further including a bore spanning said air inlet and said passageway, wherein said air passageway has a generally rectangular cross-section and said vane is of a size and shape to fit transversely therein at the intersection of said passageway and said bore.

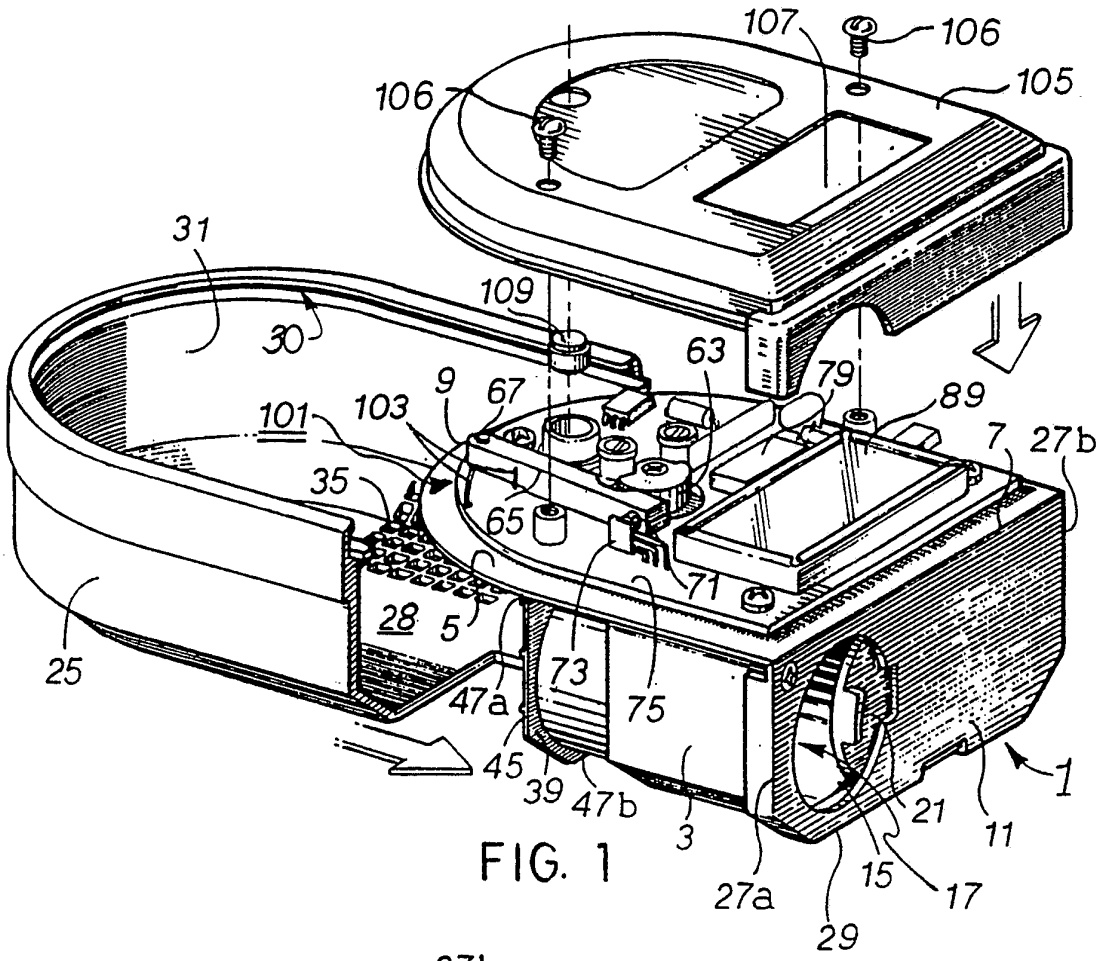
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FIG. 1

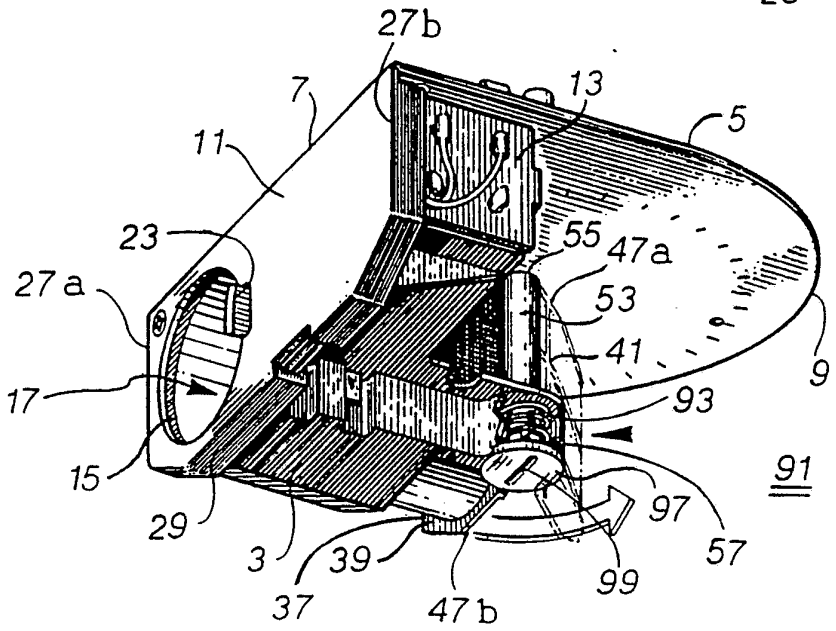
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FIG. 2

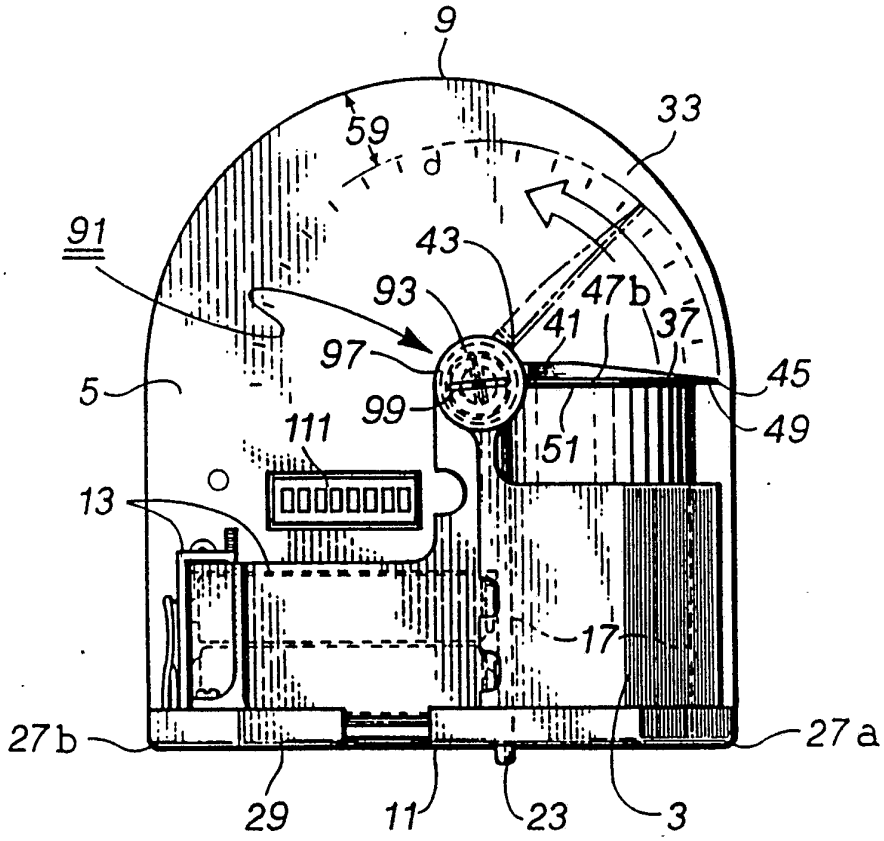
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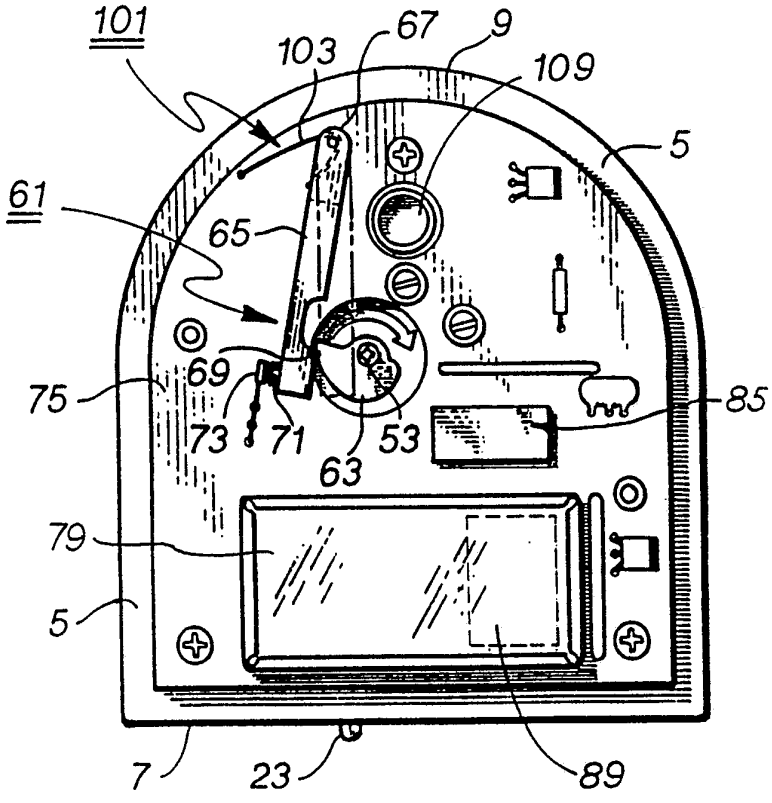
FIG. 3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89

FIG. 4

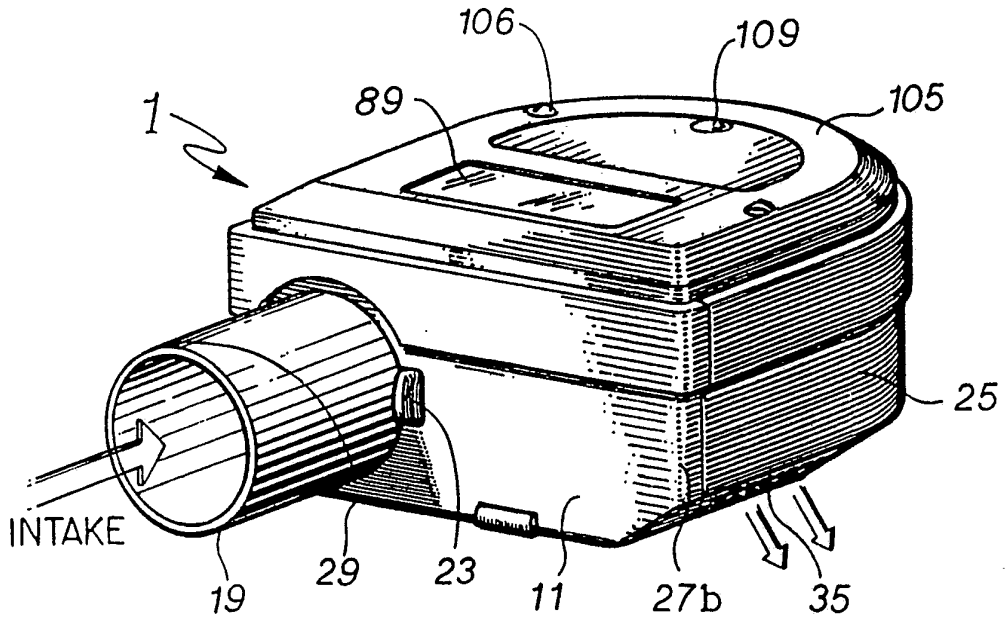

106
109
89
105
1
25
INTAKE
19
29
23
11
27b
35

FIG. 5

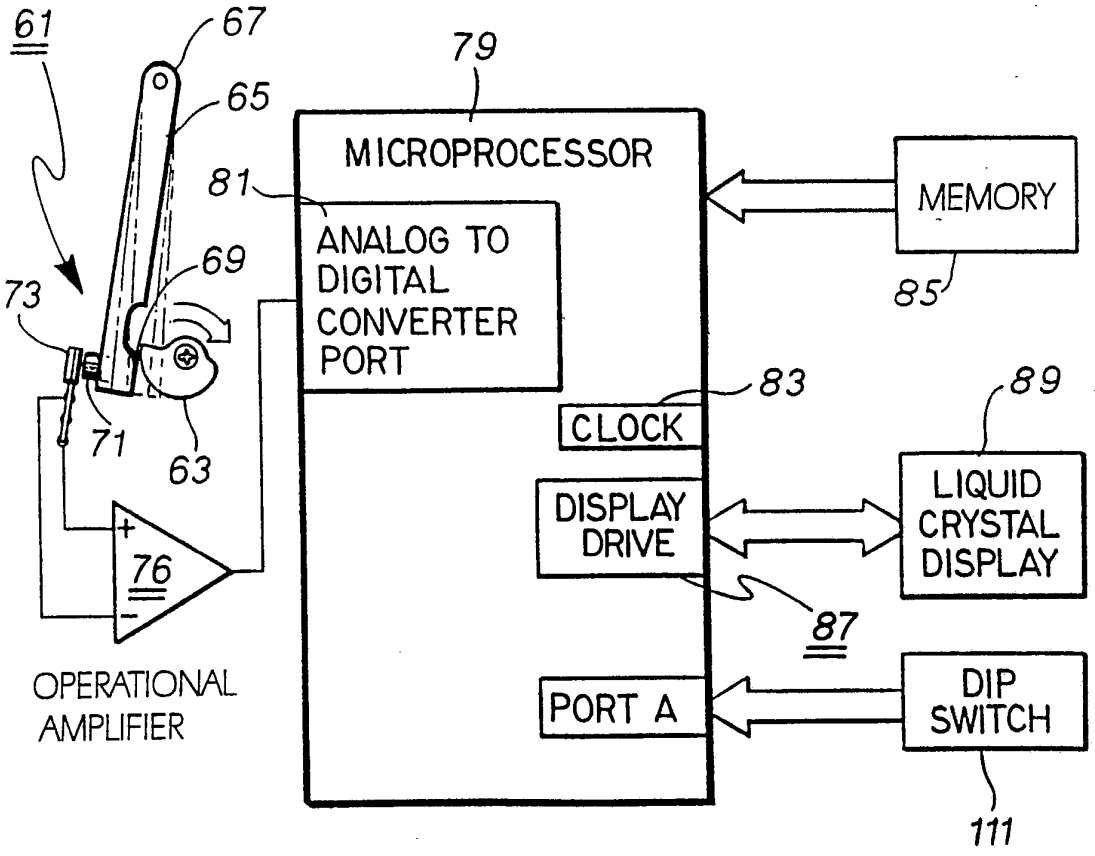
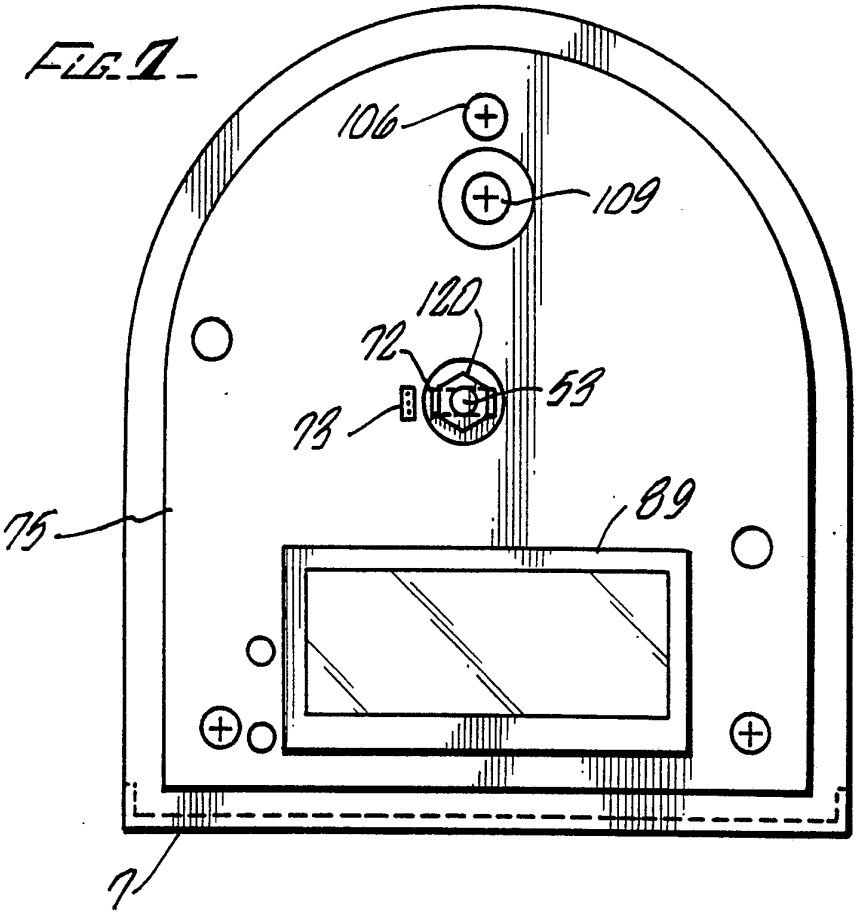

61
67
65
79
MICROPROCESSOR
81
ANALOG TO DIGITAL CONVERTER PORT
MEMORY
85
69
73
71
63
83
CLOCK
89
DISPLAY DRIVE
LIQUID CRYSTAL DISPLAY
87
76
OPERATIONAL AMPLIFIER
PORT A
DIP SWITCH
111

FIG. 6

FIG. 7



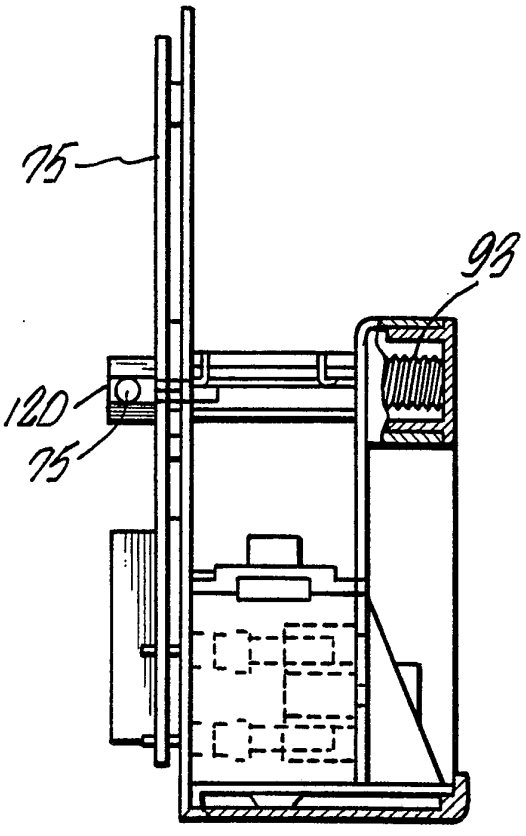


FIG. 8

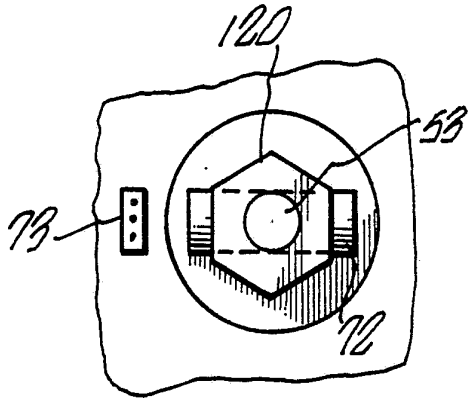


FIG. 9

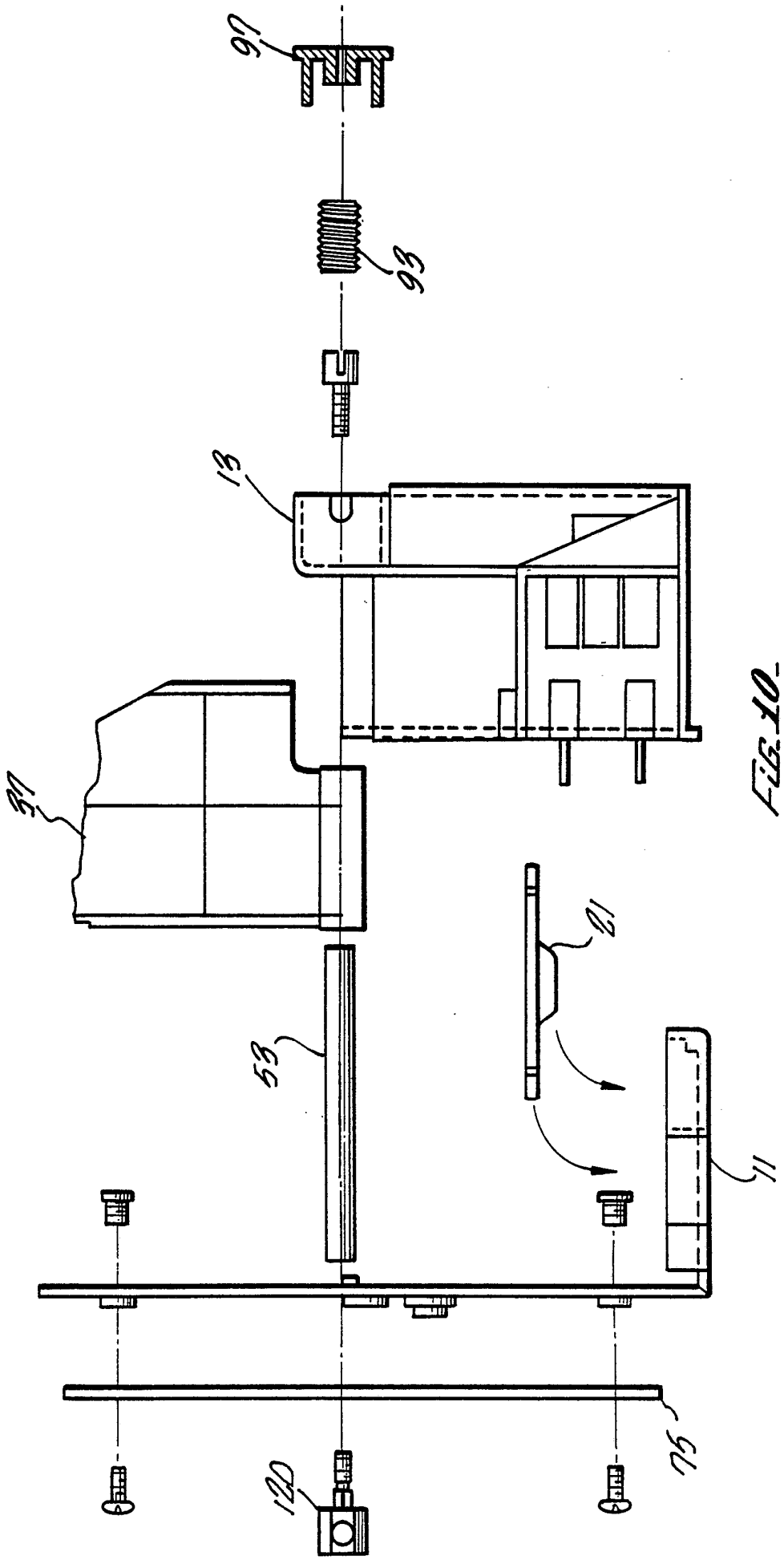


FIG 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/00820

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61B 5/087
US CL :128/725
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 128/720,726; 73/861.75,861.76 482/13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	"Wright's Peak Flow Meter" Brochure (1989) Ferraris Medical LTD. See entire document.	9,13
Y	"Wright's Pocket Peak Flow Meter" Brochure Ferraris Medical LTD. See entire document.	1,2,9,10, 16,17
Y	US,A, 2,724,969 (Bloser) 29 November 1955 See entire document.	9-16
Y	US,A, 4,991,591 (Jones et al.) 12 February 1991 See entire document.	10
Y	GB,A, 2,236,395 (Chowienczyk et al.) 03 April 1991 see entire document.	9
A	US,A, 4,073,189 (Draper) 14 February 1978.	1-33

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 23 MARCH 1993	Date of mailing of the international search report 21 MAY 1993
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer BRIAN CASLER Telephone No. (703) 308-0858

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/00820

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A, 4,294,262 (Williams et. al.) 13 October 1981	1-33