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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3 :		(11) International Publication Number: WO 83/ 02052
A61B 5/10	A1	(43) International Publication Date: 23 June 1983 (23.06.83)

(21) International Application Number: PCT/US81/01641

(22) International Filing Date: 7 December 1981 (07.12.81)

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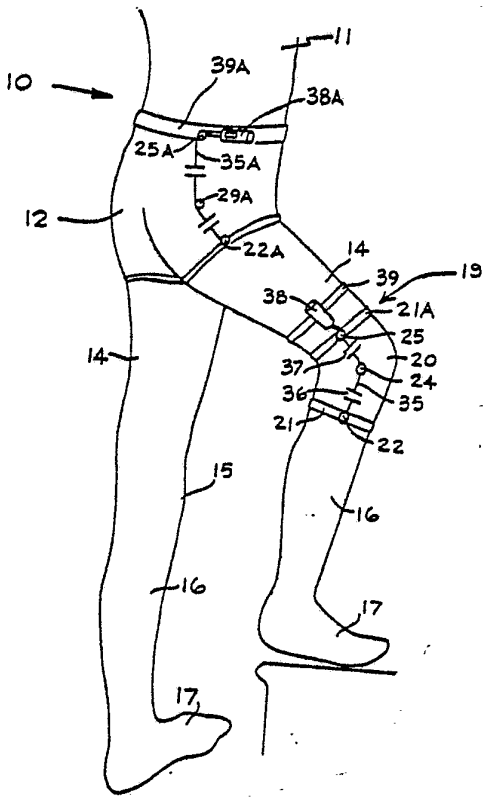
(81) Designated States: CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, US.

Published
With international search report.
With amended claims.

(54) Title: BODY MOVEMENT SENSOR

(57) Abstract

Apparatus to be worn on the body for measuring the degree of flexion of a joint comprising a harness (19) with means for attachment to a joint and a flexible member (35) held by the harness so as to be moved or flexed when the joint is flexed. A warning device (38) attached to the flexible member sounds an alarm when the flexible member is flexed beyond a predetermined amount.



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Title: Body Movement Sensor

Field of the Invention

A sensor for detecting and warning the wearer when a body joint is being flexed or extended more than a predetermined amount. The sensor connects with a harness worn to be normally flexed with the joint. When preselected flexing limits are exceeded, a warning device such as a bell, vibrator or light is energized to inform the wearer.

Background of the Invention

As a result of certain pathological conditions, the normal flexibility of various joints of the human body may be impaired. Such impairment might result from disease, injury, fractures, sprains, a chronic misuse of the body mechanics and the like. Treatment of the joint usually requires limiting the flexion of the joint for a period of time. At the present time the joint normally is placed in a cast or restrictive binder to prevent all flexing. However, preventing all flexing has the disadvantage of allowing the joint and surrounding musculature to weaken thereby increasing the risk of reinjury. Therefore, limiting the flexing or movement of the joint is preferred in most treatment schedules.

Additionally the patient might be required to become permanently accustomed to limiting the flexing of the joint. For instance in many back ailments, the only non-surgical treatment is to limit the bending or flexing of the back. Harnesses have been devised to provide stops for preventing flexion beyond a predetermined limit but such harnesses have been only partially effective due primarily to poor compliance by the wearer and most frequently are uncomfortable because they must withstand the force of stopping the flexion. A better approach is to educate the patient

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to limit the flexion of the joint without the use of prosthetic devices.

In other medical situations, the patient might be required to bend a joint further and further in order to work towards a complete recovery. For instance if an elbow was injured and the patient could only partially straighten the arm, it might be prescribed that the patient repeatedly attempt such straightening to stretch and lengthen the ligaments and muscles to regain complete arm usage. However, it might be difficult for the patient to detect when such attempted straightening was exceeding the previous limits so as to be affecting full recovery.

It is the purpose of the present invention to provide a system for informing the wearer when a joint is being flexed beyond a preset limit.

Summary of the Invention

A method and apparatus for measuring and sensing the degree of flexion of a joint of the human body comprising a harness which can be attached to the joint to be measured. A flexible member is fixed to the harness so as to move as the joint is flexed or extended, with the movement of the flexible member indicating the degree the joint is moved. Attached to the flexible member is an alarm which indicates to the wearer when the flexible member has moved beyond a predetermined limit, which limit is determined by adjustment of the alarm.

Description of the Drawings

FIG. 1 shows the invention attached to the knee and the hip of a human body;

FIGS. 2A and 2B show a guide for the harness;

FIG. 3 shows another guide for a harness;

FIG. 4 is an enlarged view and partial schematic of one type of sensor which can be used with the

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subject invention;

FIGS. 5 and 6 are back and front views of a back movement sensing device incorporating the subject invention;

FIG. 7 is a schematic of another embodiment of the sensor; and

FIGS. 8 and 9 are front and back views of another embodiment of the sensor harness.

Description of the Invention

In FIG. 1 is shown a portion of a human torso comprising the upper body 11, the hip region 12, thighs 14, knee 15, lower leg 16 and feet 17. Frequently it is desirable to limit the flexing of a joint such as the knee to allow healing or to prevent further injury. For this purpose there is provided the subject invention which in this embodiment comprises a harness 19 having a mesh or fabric portion 20 terminated below and above the knee by the reinforced collars 21 and 21A. Preferably this harness is made of a stretch material that is very durable yet will permit movement of the joint with little hindrance.

Fixed to the harness, preferably on the outside of the knee, are three guides 22, 24 and 25. Guides 22 and 24 are similar in design to the guides shown in FIGS. 2A and 2B. The guide comprises a center shaft 26 on which are positioned three flat annular discs 27, 28 and 29. The discs 28 and 29 are permanently fixed to the shaft while the disc 27 is releasably attached. The disc 27 is removed and the shaft portion 26A is inserted through the harness material at the appropriate location. Thereafter the disc 27 is replaced on the inside of the fabric to hold the guide in place. In this manner the guides 22 and 24 are fixed in place. The guide 25 comprises a center shaft 30 having a disc 31 fixed to the end and a disc

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32 supporting a semicircular eyelet 34. After removal of the disc 31, the shaft 30 is inserted through the harness fabric and with replacement of the disc 31 the guide is fixed in place.

One end of a flexible member 35 comprising a metallic or nylon rope or cable is fixed to the guide 22 and then passed through a loop 36 in the fabric and around the guide 24 by passage between the discs 28 and 29. Thereafter the member is passed through a second loop 37 and the eyelet of the guide 25 with the second end being fixed to a warning device 38. The warning device is fixed to the leg by an elastic collar 39. The flexible member is at least partially enclosed in a tubing 35A. At times the warning device will be worn on the waist to permit easy access and adjustment of the limits.

With flexing of the knee, the cable 35 will be bent around the guide 24 in the manner illustrated in the drawing. Such knee flexing will also cause a slight elongation of the distances between the guides 22, 24 and 25, which elongations will be detected by an increased tension on the flexible member, a condition detected by the warning device 38. The warning device can be of any general type such as a vibrator, a buzzer or other audible device, or a light which will be activated when the cable moves or pulls on the warning device a predetermined amount. Also the flexible member can have other configurations so as to change shape or increase or decrease in tension with flexing of the joint and the warning device attached to detect such changes.

One embodiment of such a warning device is shown in FIG. 4 and comprises a housing 41 to which is attached a threaded stud 42 having an axial extending opening through which the cable extends. Threaded onto

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this stud is a collar 44 fixed to the flexible member tubing 35A. With the warning device fixed in position, the tension on the cable can be adjusted by screwing the collar 44 toward or away from the warning device. A locknut 45 holds the collar in the position selected. The cable 35 extends through a center opening in the collar and the stud 42 and is attached to a slide member 46 slideably mounted within an insulating support 47. The slide member 46 includes a threaded end 48 extending out the other side of the insulating support. Threaded onto this threaded end is an adjusting nut 49 and a locknut 50 adjustable through an opening (not shown) in the housing 41. A spring 51 anchored on an insulating cap 53 biases the slide 46 to the lefthand position while a cap 52 around the right end of the slide prevents the slide from being pulled from the bushing under the influence of the spring.

The object of the switch mechanism described above is to sense when the flexible member 35 has been moved a predetermined limit and in response to that movement, close the switch to energize a communicating device 54. As previously stated, the communicating device can be a light, vibrator, bell or other means for warning the wearer that predetermined limits of flexing have been exceeded. For this purpose the communicating device will include a battery (not shown) and a pair of conductors 55 and 56 connected through the battery to the switch. With closing of the switch, a circuit is closed to allow the battery to energize the communicating device. The communicating device can be incorporated in the housing 41 if desired.

The conductor 55 is connected directly to the conductive housing 41 of the switch. The conductor 56 is connected to the stationary sleeve 47A which is made of conducting material and includes an insulating

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threaded liner 47B. The support 47 insulates this sleeve from the housing 41 which is made of conducting material. Thus when the shaft 46 is pulled to the right in the drawing against the force of the spring 51 the locknut 49 is caused to contact the conducting sleeve 47A and complete the circuit through the communicating device thereby allowing the communicating device to be energized by the self-contained battery. Thus by adjusting the position of the nut 49, the degree of travel of the slide member necessary for energizing the communicating device is set. For instance the further the locknut 49 is moved to the left, the more movement necessary before the locknut contacts the conductive sleeve 47A. A locking nut 50 holds the locknut 49 in place once the position is determined.

Thus a switch has been described which can be adjusted to both vary the tension on the flexible member 35 and vary the amount of cable travel necessary before the communicating device is energized. The warning device is quite small and can be incorporated in a sheath which is worn on a belt or strap extending around a portion of the torso of the wearer. While it is normally expected that the initial adjustment of this switch is accomplished by a medical doctor or paramedic, subsequent adjustments can be made if discomfort is encountered because of under or overflexing of a joint. Additionally the communicating device can be worn on any part of the body so long as the manner of communicating with the wearer is satisfactory to alert the wearer of the overflexing condition.

As illustrated in FIG. 1, the communicating system can be used to detect the overflexing of the knee joint of the wearer. Additionally a similar communicating device 38A can be mounted on a strap of a pair of snug briefs (worn by the user). The strap

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extends around the waist of the wearer and the flexible member 35A extends around similar guides 25A, 24A and 22A and down along the hip of the wearer to sense over-flexing of the hip joint. The operation of the device works in the same manner as previously described relative to the knee joint. In FIGS. 5 and 6 are shown yet another embodiment of the invention wherein the communicating device 38B is positioned on a belt 39B extending around the waist of the wearer and part of a pair of briefs 33A. Shoulder straps 58 and 59 extend from the midpoint of the back, over the shoulders of the wearer and crossover and down vertically along the chest to be fixed to a front portion of the briefs. A pair of flexible members 60 and 61 are fixed at the extending ends to guides 62 and 64. The lower ends of each flexible member come together at the guide 63 and form a Y juncture 65 and thereafter are continued side-by-side around the guide 66 to the switching assembly 38B. Stops 63 prevent these flexible members from entangling near the guides.

Thus it can be seen that if the individual wearing this harness bends forward, a tension will be established in the flexible members which ultimately will cause energization of the communicating device. Additionally if the individual bends to one side or the other, one flexible member will be placed in greater tension while the other flexible member will be relaxed. However the tensioned flexible member will serve to pull on the communicating device and, depending upon the setting of the communicating device, will cause energization by closing the switch if a predetermined limit of movement is reached.

In FIG. 7 is shown a warning device 38C representing a second embodiment of the device shown in FIG. 4. In this device a circuit is caused to oscillate to

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generate an audible sound. A differential amplifier 70 is supplied the voltages V_1 and V_2 at the terminals 5 and 4, respectively. The voltages are generated by current flow from the battery 71 through the resistors R4, R5, R3, R2 and R1, respectively. The resistor R4 is manually adjustable and the resistor R2 is set by the flexible cable 35C pulling against the spring 72 to set the position of the contact 74.

With sufficient pull on the cable 35C as would occur with the bending of a joint as explained previously, the voltage V_2 will exceed the voltage V_1 and the output signal at terminal 2 of the amplifier 70 will switch to a logic one or 9 volts. The base of the transistor Q1 will be biased positive to cause the oscillator 75 to oscillate and make an audible sound. The sound informs the wearer that the flexing is out of the predetermined range set by the adjustment of the resistor R4.

In FIGS. 8 and 9 are shown a further embodiment of the invention for detecting back flexing. Herein the harness shorts 76 are attached to an elastic waistband 77 to which is attached a vest 78. The vest includes laces 79 in the front and shoulder straps 80. Non-elastic strips 81 extend from the shorts to the vest to assure a firm connection therebetween and also to limit movement of the patient if desired.

The sensor 82 is supported from the waistband or in a suitable means and functions as previously described to detect a change in tension of the cables 84. The cables are held in cable guides 85 formed in the back of the vest and extending up to the top of the shoulder straps 80.

In this embodiment the cables are held more firmly in place by the vest and a more precise movement of the back can be detected. Also by use of the

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waistband and shorts, the tension of the cables can be increased to improve the sensitivity of the device.

It should also be understood that the subject invention can be used to inform the wearer of progress in the further flexing of a joint as well as informing the wearer that a joint is being flexed too much. For instance in a rehabilitation program in which partial flexing of a joint has been temporarily lost and it is desired to encourage and infrom the patient when greater flexing is being achieved, the device can be set to render a signal when the joint is being flexed to a greater degree. In this manner the wearer is encouraged to flex the joint sufficiently to cause a signal to be generated and is thereby informed that previously set limits are being exceeded. By increasing the warning level periodically, the wearer is caused to increase the flexing action and rehabilitation is enhanced.

In another mode of usage, the harness can be placed over the joint of the wearer and the alarm set as described previously. While not shown, a timer is incorporated in the alarm to cause the alarm to sound if the actions of the wearer have not activated the alarm within a preset period. The activation of the alarm by the timer reminds the wearer that the joint should be flexed thereby causing the wearer to flex the joint periodically.

As another modification of the subject invention, the flexible member has been described as a flexible cable, but could also be a bendable rod. In this embodiment (not shown) the rod is fixed to the harness in a manner to be bent with the bending of the joint. The alarm is fixed to a portion of the rod so as to detect the change in tension on the rod resulting from the bending.

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Thus it can be seen that the subject sensing device can be incorporated on many parts of the body, i.e. the neck, arms, legs, back, feet or so forth, to alert the wearer when flexion of that body part has exceeded a preset limit. The device is made to be used universally since only the harness need be changed for attachment to various body parts. Also, the manner of warning the wearer can be selected to match the needs of the wearer.

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Claims

1. Apparatus to be worn on the human body for measuring the degree of flexion of a joint of the body comprising:

a harness;

means for attaching said harness to the body at a position to encompass at least a portion of the joint to be measured;

a flexible member;

means for attaching said flexible member to said harness such that said flexible member will be moved an amount proportional to the flexing of the joint; and

a warning device attached to said flexible member to generate a warning signal in response to movement of said flexible member a predetermined amount and alert the wearer of such movement.

2. Apparatus as defined in Claim 1 wherein said flexible member is a cable having one end attached to said warning device and including a portion extending past the joint in position to be bent as the joint is flexed.

3. Apparatus as defined in Claim 2 wherein said means for attaching is a plurality of guides fixed to the harness along said joint.

4. Apparatus as defined in Claim 2 wherein said warning device includes means to adjust said flexible member to change the amount the flexible member must be moved to cause the warning device to sound a warning.

5. Apparatus as defined in Claim 4 wherein said warning device emits an audible sound as the warning signal.

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6. Apparatus as defined in Claim 4 wherein said warning device vibrates to generate a warning signal to warn the wearer.

7. Apparatus as defined in Claim 3 wherein said attaching means fits around a limb of the wearer's body.

8. Apparatus as defined in Claim 3 wherein said attaching means fits around the torso of the wearer's body.

9. Apparatus as defined in Claim 1 wherein said warning device is adjustable to permit the adjustment of the amount said flexible member must be moved to cause said warning device to generate a warning signal.

10. The method of detecting the flexing of a joint of a body, comprising the steps of:

attaching a flexible member to the outside of the body at points spaced along the joint to cause the tension on the flexible member to change in an amount proportional to the degree of flexing of the joint; and

fixing to the flexible member a warning device which will generate a warning signal and alert the wearer when the tension on the flexible member changes beyond a predetermined limit due to a change in tension of the flexible member as the joint is flexed.

11. The method as defined in Claim 10 including the step of mounting the flexible member on a body-fitting harness which is fitted on the body to attach the flexible member thereto.

12. The method as defined in Claim 10 including the step of fixing to the flexible member a warning device that makes an audible sound as a signal when the tension of the flexible member changes beyond a predetermined limit.

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13. The method as defined in Claim 10 including the step of providing a warning device wherein the predetermined limit is adjustable and adjusting the warning device to generate a warning signal when the joint is flexed past a predetermined amount.

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AMENDED CLAIMS
(received by the International Bureau on 09 June 1983 (09.06.83))

1. (cancelled)
2. (cancelled)
3. (cancelled)
4. (cancelled)
5. (cancelled)
6. (cancelled)
7. (cancelled)
8. (cancelled)
9. (cancelled)
10. (cancelled)
11. (cancelled)
12. (cancelled)
13. (cancelled)
14. (new) Apparatus to be worn on the human body for measuring the degree of flexion of a joint of the body, comprising:

a harness.

means for attaching said harness to the body in a position to encompass at least a portion of the back;

characterized by a pair of flexible members;

means for attaching said pair of flexible members to said harness such that said members are spaced apart across said back and are drawn sufficiently taut that the tension thereof will be changed as the back is moved; and

a warning device attached to said flexible members to generate a warning signal in response to one or both flexible members changing in tension beyond a predetermined limit thereby to signal the movement of the back in the forward and back, side to side or twisting direction beyond a predetermined amount.

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15. (new) Apparatus as defined in Claim 14 wherein said means for attaching said harness includes suspenders extending from the waist of the wearer and over the shoulders.

16. (new) Apparatus as defined in Claim 15 including means to adjust the tension on said flexible members thereby to adjust the predetermined limit beyond which a warning signal will be generated.

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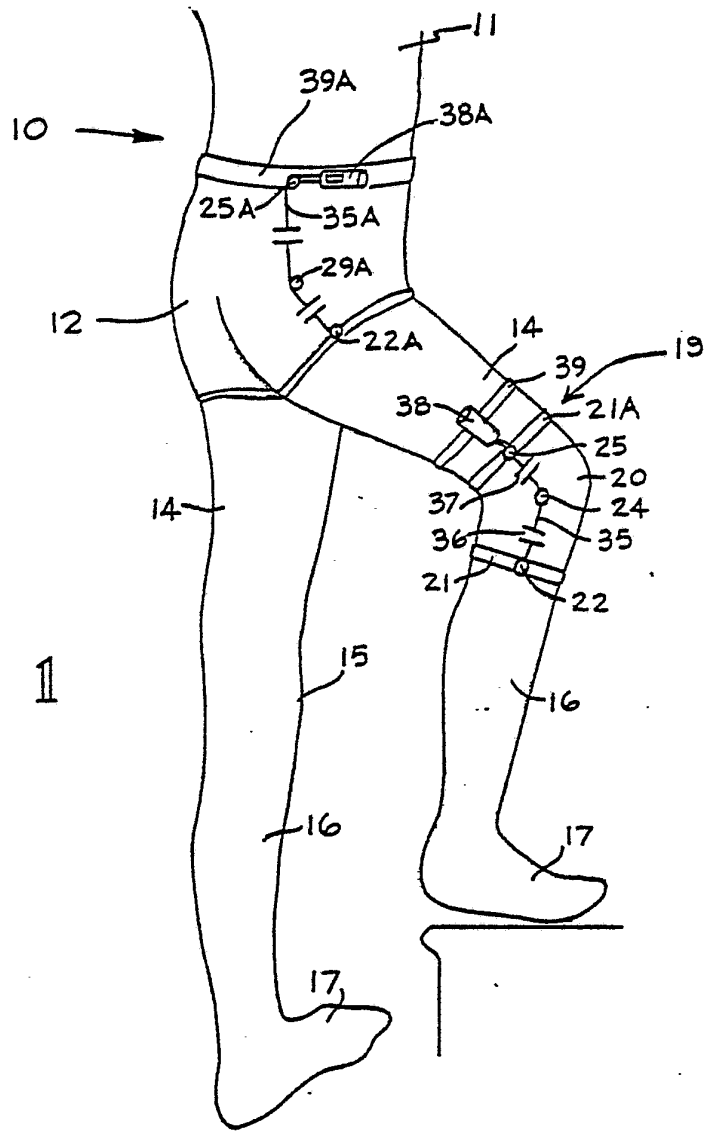


FIG 1

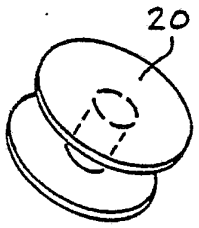


FIG 2A

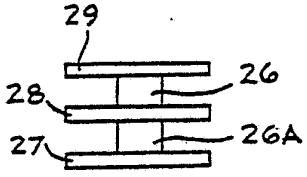


FIG 2B

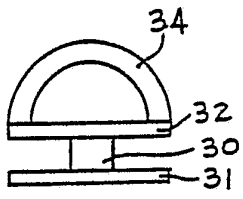


FIG 3

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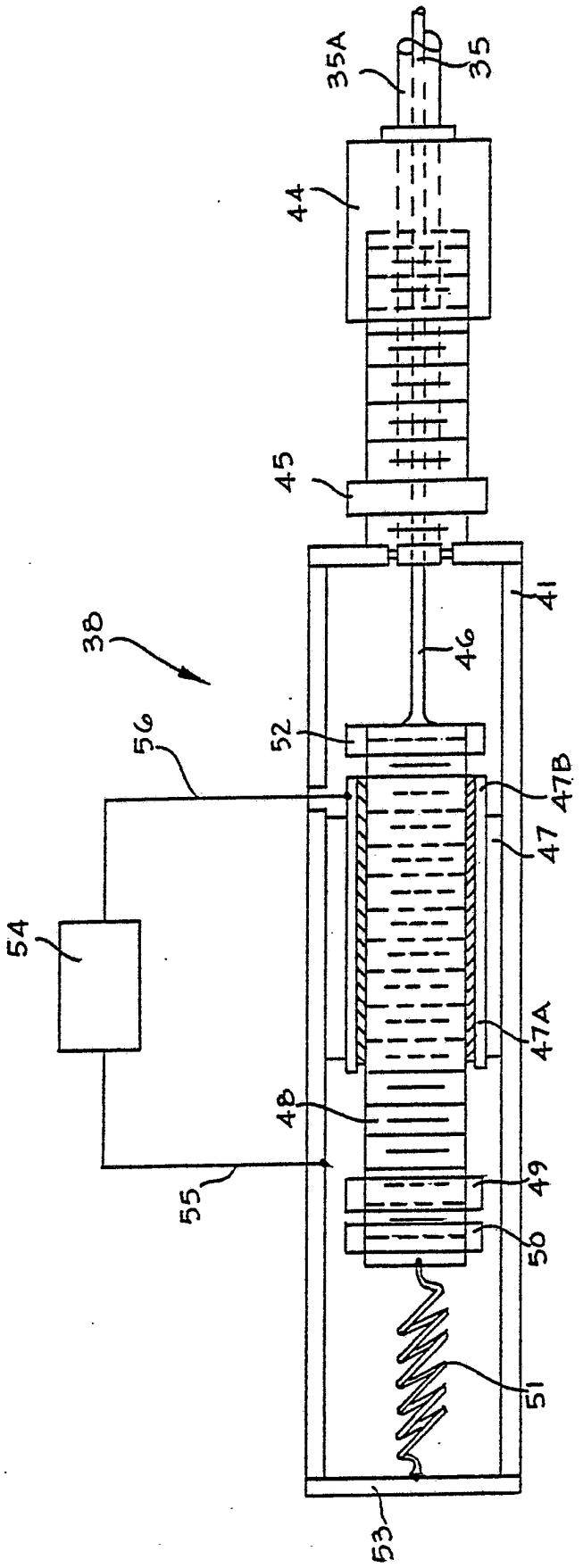


FIG 4

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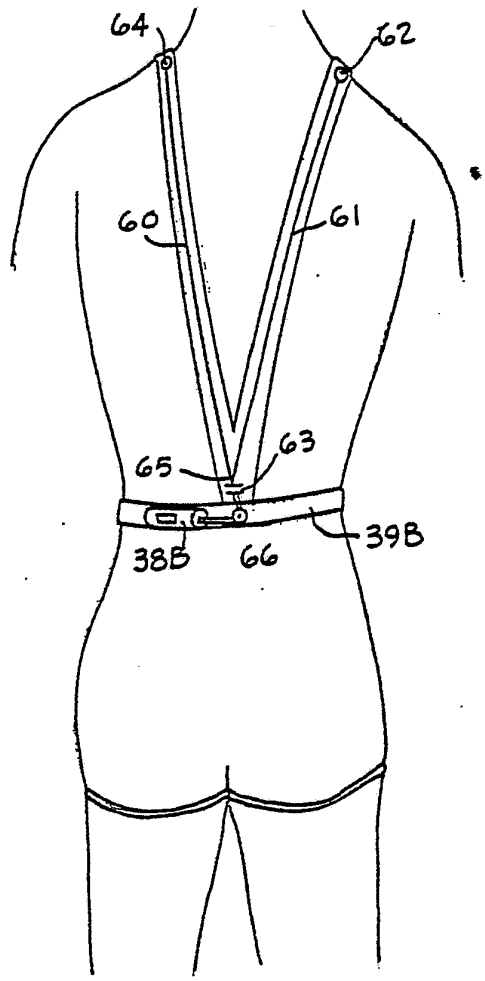


FIG 5

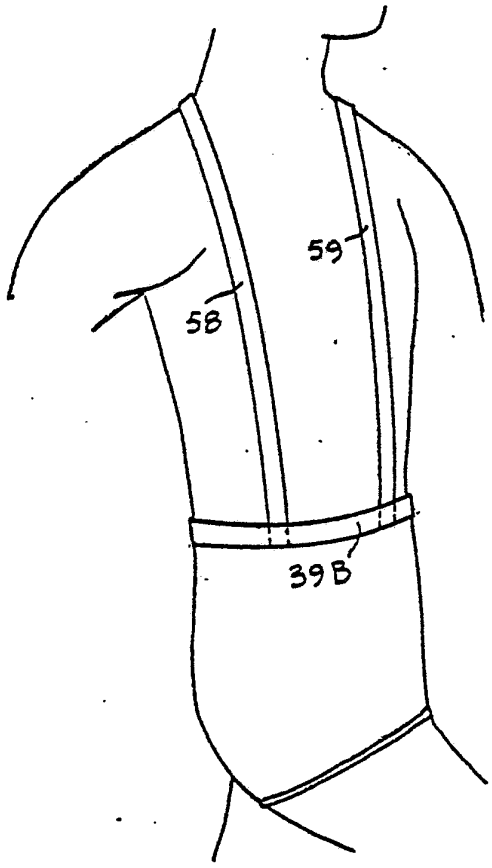


FIG 6

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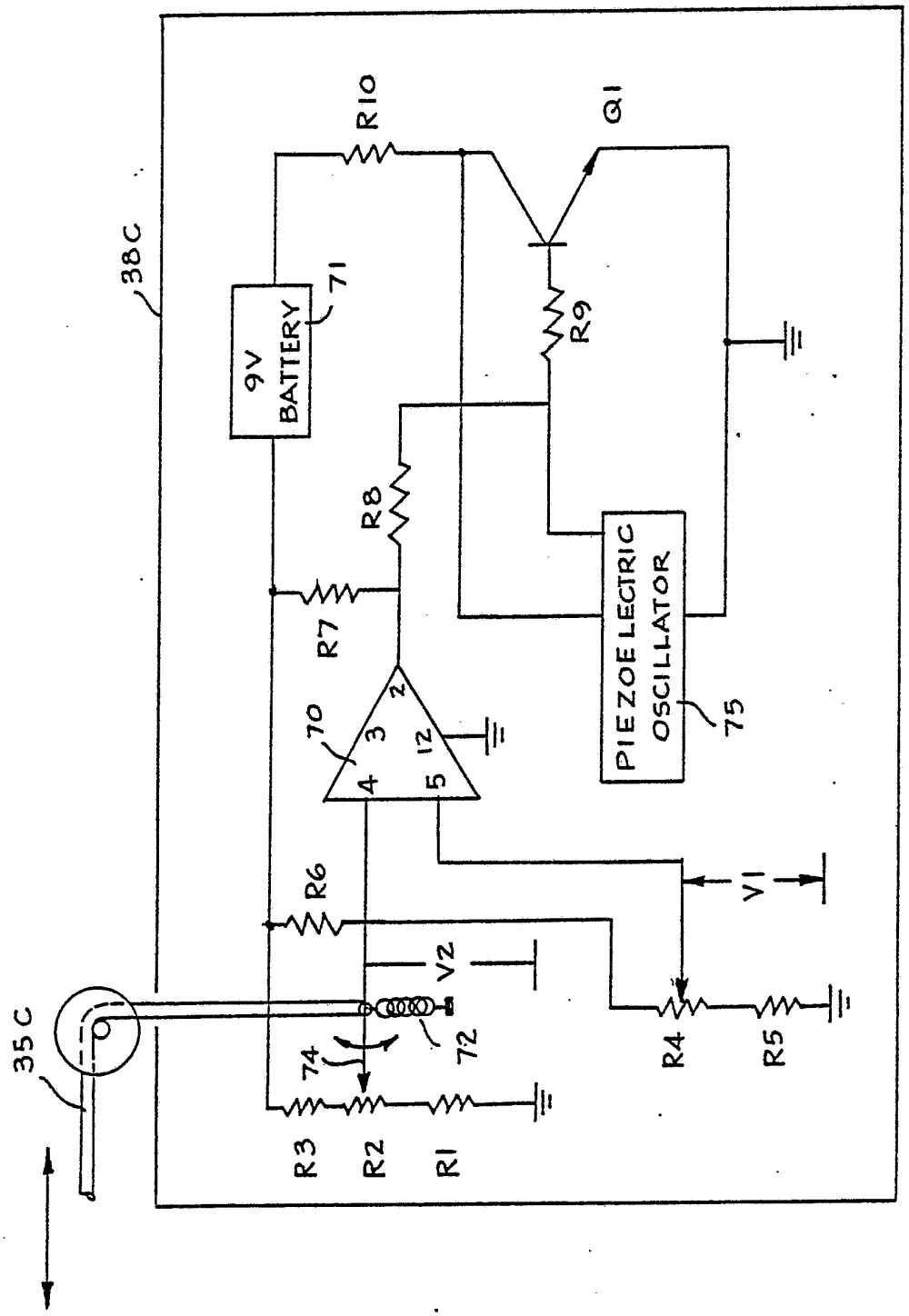


FIG 7

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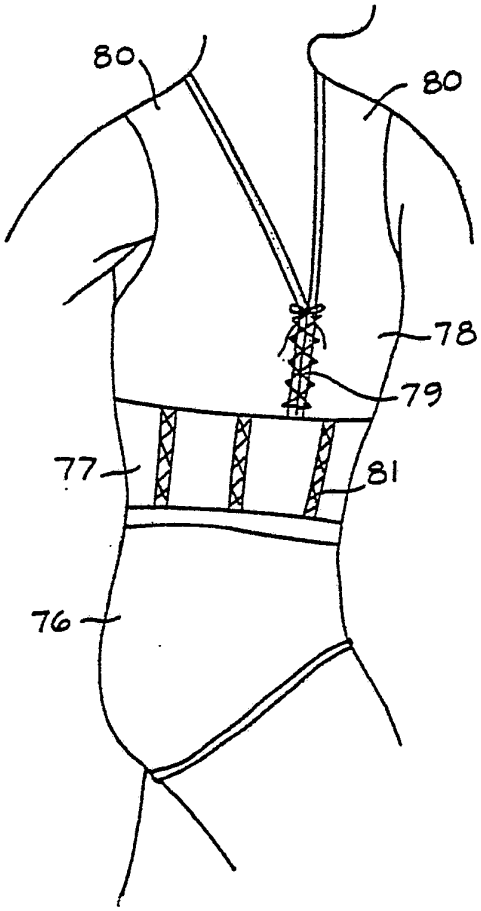


FIG 8

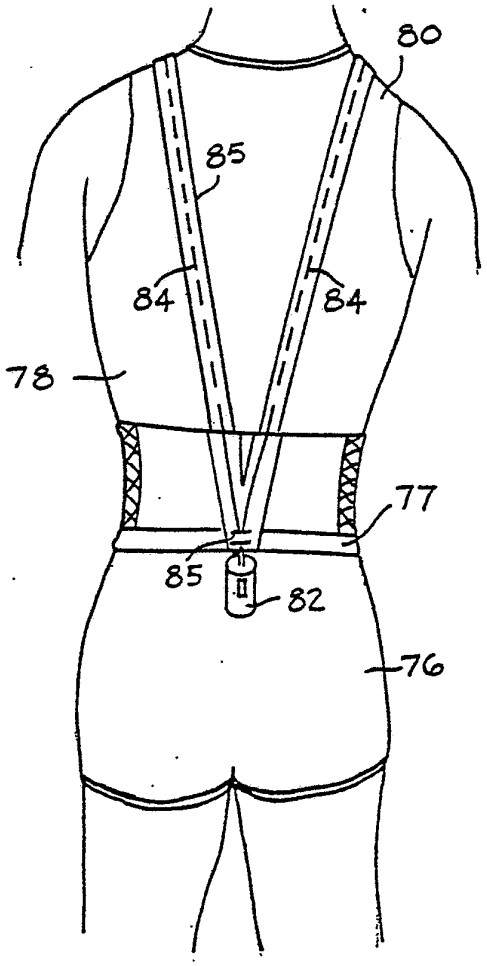


FIG 9

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INTERNATIONAL SEARCH REPORT

International Application No PCT/US81/01641

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC 3 A61B 5/10
U.S. Cl: 128/781

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
US	128/776,777,779,781,782 340/573,574,575,576

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US,A, 3,608,541, Published 28 September 1971, HALL	1-6,8-13
X	US,A, 3,642,276, Published 15 Feb 1972, KROPF	1,9
X	US,A, 3,908,279, Published 30 September 1975, YOSLOW ET AL	1-2,6,9
X	US,A, 4,007,733, Published 15 February 1977, CELESTE ET AL	1,9-13
X	US,A, 4,055,168, Published 25 October 1977, MILLER ET AL	1-6,8-13
X	US,A, 4,108,164, Published 22 August 1978, HALL, SR.	1-13
X	US,A, 4,149,445, Published 17 April 1979 WIS	1-4,9-13
T	US,A, 4,306,571, Published 27 De ember 1981, MCLEAD, JR.	1,9-13
X	SU,A, 231,711, Published 28 November 1968, SYSIN ET AL	1-4,7,9-13

* Special categories of cited documents: [15]

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"T" later document published on or 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

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
24 February 1981	01 APR 1982
International Searching Authority [1]	Signature of Authorized Officer [20]
ISA/US	Francis J. Jaworski