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(54) Rotary movement transducer

(57) A rotary movement transducer has a shaft with a user rotatable knob and a cam with a spiraled helical cam surface. The helical cam loads and unloads a spring loaded plunger. The plunger compresses a bias spring which reacts against an actuator to provide a variable compression force on a force/pressure responsive resistor. An elastomeric pad distributes the actuator force on the force pressure responsive resistor. The force pressure responsive resistor is mounted on a circuit board with terminal strips for external electrical circuit connection to a detector circuit such as a Wheatstone bridge.

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

MICROFICHE APPENDIX

[0003] Not Applicable

BACKGROUND OF THE INVENTION

[0004] The present invention relates to devices known as transducers which provide an electrical signal output or indication, when connected in a circuit, of a mechanical or other physical non-electrical input such as motion or force to provide an interface between a physical or mechanical system and an electrical circuit.

[0005] Devices of this type are employed where it is desired to provide an electrical indication of a physical quantity to be monitored or measured on a continuous or running basis without the need to record values and reset or restart the measuring device. In particular, transducers are employed to provide an indication of motion or continuously varying displacement, particularly rotary movement of a shaft, where an electrical signal has the characteristics thereof varied or changed so as to provide a discrete electrical indication of different rotary positions of the shaft.

[0006] Known rotary movement or displacement transducers have utilized potentiometers and variable resistors employing wipers moved over stationary resistance material to vary the overall resistance of the device. Typically, the variable resistance device is connected in one leg or arm of a Wheatstone bridge. This electrical bridge arrangement provides the desired electrical sensitivity to small changes in resistance representative of a small angular displacement of the shaft to thereby provide the desired accuracy of measurement. Alternatively, a microcomputer can be used with a lookup table of predetermined relationships between the property measured and the electrical resistance.

[0007] However, variable wiper type potentiometers have inherent disadvantages in that they are expensive to fabricate and subject to variation in the electrical resistance due to changes in the wiping surfaces and degradation over time in service. Accordingly, it has been desired to provide a rotary motion or displacement transducer which has a high degree of sensitivity to small angular displacements and which provides a reliable and repeatable electrical signal and which is low in manufacturing cost.

BRIEF SUMMARY OF THE INVENTION

[0008] The present invention provides a rotary motion or displacement transducer which yields, upon connection to an external circuit, an electrical indication which is proportional to the rotary position of a shaft provided on the device in response to user rotation of the shaft. The device of the present invention utilizes a variable resistance of the type which is force/pressure sensitive to surface contact and eliminates the need for a wiper.

[0009] It is an object of the present invention to provide a transducer which provides a variable electrical resistance signal in response to user rotation of an input shaft on the device.

[0010] It is another object of the present invention to provide a rotary position or movement transducer which utilizes a force/pressure sensitive electrical device to provide a variable electrical signal proportional to user rotation of an input shaft.

[0011] It is a further object of the present invention to provide a rotary position transducer which outputs an electrical variable resistance signal responsive to user rotation of an input shaft and which employs a force/pressure responsive resistor providing a variable electrical resistance in response to rotation of the shaft.

[0012] The transducer of the present invention employs a force/pressure responsive resistive strip subjected to a variable force by a plunger which is biased against the strip with a normal force proportional to the angular rotation or movement of the input shaft. The normal force is generated by a cam on the input shaft; and, in the preferred form of the invention, the cam surfaces are configured such that the bias force is varied proportional to the input shaft rotary position. Optionally the cam surfaces are configured such that a generally constant user input torque to the shaft is experienced for movement over the desired range of rotary movement. The device may be configured with detent means at selected rotary positions of the input shaft to enable the user to rotate the shaft to a pre-selected position which is tactilely discernible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 is a front elevation view of the transducer of the present invention with portions broken away to show the internal components;

FIG. 2 is a top view of the device of FIG. 1;

FIG. 3 is a bottom view of the device of FIG. 1;

FIG. 4 is an enlarged view of the lower portion of FIG. 1 with portions broken away to show the interior components; and,

FIG. 5 is a section view taken along section indicating lines 5-5 of FIG. 4.

DETAILED DESCRIPTION OF THE INVENTION

[0014] Referring to FIGS. 1, 2 and 3, the transducer assembly of the present invention is indicated generally at 10 and includes housing means including an upper body member 12, a lower body member 14, attached thereto by suitable fasteners such as screws 18, and a capsule, indicated generally at 20, attached to the lower body 14. A rotatable shaft 22 has one end thereof journalled in aperture 24 provided in upper body 12 and the lower end of shaft 22 is journalled in an aperture 26 formed in the lower body 14.

[0015] It will be understood that bore shaft 22 has a reduced diameter portion 25 which is journalled in the aperture 24 at its upper end; and, another reduced diameter portion 23 is provided at the lower end of shaft 22 and is journalled in the aperture 26.

[0016] Shaft 22 has formed thereon an enlarged diameter cam portion 28 which has formed thereon a first or upper cam surface 30 on an axial face thereof; and, a second or lower cam surface 32 is formed on an axial face opposite the cam surface 30.

[0017] Shaft 22 has the upper end thereof extending externally of the housing 10 with a knob 34 received thereon in a torque transmitting manner. It will be understood that knob 34 is intended to be manually grasped by a user and rotated to any one of a plurality of rotary positions through an angular displacement denoted by the Greek character Theta in FIG. 2. In the present practice of the invention the angle Theta has a value of 90 degrees and is subdivided into three segments which are denoted by the four reference indicia provided on the upper surface of the body 12 as denoted by reference numerals 36 through 42 which in the present practice are spaced at an angular separation of 30 degrees.

[0018] A detent plunger 44 is slidably mounted in a bore 46 formed in the upper body 12 and is biased toward the cam 28 by a spring 48 received in the bore 46; and, the end of the detent plunger 44 engages individual detent depressions one of which is illustrated at 45 provided on the surface of cam 28 at the aforesaid angular spaced intervals for detenting the rotor in each of the desired positions corresponding to the indicia 36 through 42.

[0019] A first cam follower comprising a spherical member 50 is retained and biased into contact with upper cam surface 30 by a spring 52 received in a bore 54 provided in the upper body portion 12. The bias force of the spherical member 50 contacting the helical cam 30 is proportional to the deflection of the spring 52 in an axial direction with respect to the rotor 22 as determined by the force versus deflection constant of spring 52.

[0020] In the present practice of the invention, the cam 30 and cam 32 have equal but axially oppositely directed pitches. Preferably each cam surface 30, 32 is configured to provide an axial advance of about 2.25 millimeters for a 90 degree rotation of the shaft 22 or a helix angle of about 8 degrees measured with respect to a plane normal to the axis of rotor 22.

[0021] Referring to FIGS. 1, 3, 4 and 5 the capsule 20 of the assembly 10 is shown as having an outer shell 56 which has an enlarged diameter flange 58 provided around the upper portion thereof adjacent the upper end which flange serves to register the capsule against the undersurface of body shell 14. The capsule shell is retained in the lower body 14 by any convenient expedient, as for example, via twist locking tabs 60, 62 extending outwardly from the upper end of the shell 56.

[0022] The body shell 56 of capsule 20 has attached to the lower surface thereof a circuit board assembly indicated generally at 64 which is secured to the lower surface of the body shell 56 by suitable fastening expedients such as screws 66. It will be understood however, the capsule body shell 56 may alternatively be formed integrally with lower body 14, if desired.

[0023] Referring to FIG. 4, the capsule 20 is shown in detail as having a plunger member 68 slidably received in a bore 70 provided in the shell 56; and, the plunger 68 has a reduced diameter hollow cylindrical portion 72 extending axially downwardly from the upper portion 68. The cylindrical portion 72 of plunger 68 serves as a pilot or guide and has a spring 74 received thereover with the upper end of the spring registered against the undersurface of portion 68; and, the opposite reaction end or lower end of spring 74 is registered against the upper surface of the circuit board assembly 64. The spring 74 biases the plunger 68 upwardly to its limit of travel against the undersurface 76 of the upper wall of shell 56. In the present practice of the invention, the spring constant or spring rate of the spring 74 is quite low with respect to the other springs of the assembly and serves only to return the plunger to the upward limit of its travel.

[0024] The plunger 68 has an upwardly extending projection or post 78 which extends exteriorly of the shell 56 through an aperture 80 formed in the upper wall 76. It will be understood that the post 78 is formed integrally with the plunger 76 in the presently preferred practice; and, post 78 has a preferably hemispherical surface 82 formed on the upper end thereof which contacts and follows the lower helical cam 32 provided on the cam 28 (see FIG. 1).

[0025] Referring to FIG. 4, the hollow cylindrical portion 72 of plunger 68 has slidably received therein a generally cup-shaped actuator 84 which is limited in its downward or outward travel with respect to plunger 68 by a barbed annular surface 86 provided on the outer surface thereof, which barbed surface 86 registers against a shoulder 88 formed in the interior of the cylindrical portion 72 of plunger 68. It will be understood that the actuator 84 is slotted as denoted by reference numeral 90 about its periphery to permit radial compression of the cylindrical wall thereof to permit assembly of the barbed surface 86 into the interior of the cylindrical portion 72 of the plunger 68.

[0026] A force bias spring 94 is disposed interiorly of

the plunger and actuator 84 and has its upper end registered against the undersurface 92 of the upper portion of plunger 68. The opposite reaction end or lower end of spring 94 is registered against the interior of the closed end of actuator 84 to bias the actuator downwardly or in an outward direction with respect to plunger 68.

[0027] The lower surface of the closed end of the actuator 84 has provided thereon an elastomeric pad 96 which is secured thereto by any suitable expedient, as for example, adhesive bonding or double-sided tape.

[0028] In the present practice of the invention the pad 96 has a thickness of about one millimeter and is formed of preferably silicone elastomer and preferably has a hardness of about 65 as measured on a shore "A" scale. The pad 96 serves to provide a resilient load distributing surface for contacting the printed circuit board assembly 64.

[0029] Referring to FIG. 5, the circuit board assembly 64 includes a printed circuit board 98 which has a pair of spaced generally parallel conductive strips 100, 102 provided thereon, each of which terminates in a loop denoted respectively 104, 106. Each of the loops 104, 106 has disposed therein, through an aperture in the board 98, an electrical connector pin denoted respectively 108, 110 which is electrically connected to the loop by a suitable expedient such as, for example, soldering. The pins 108, 110 each extend downwardly through the circuit board 98 and are formed at right angles to extend through an electrical receptacle 112 which is retained on the undersurface of the circuit board by screws 114 passing through the board, and illustrated as having their heads on the upper surface of the board 98.

[0030] Referring to FIG. 5, a force/pressure responsive resistive device 116 in the form of a thin strip which bridges the contacts 100, 102 and is electrically connected therewith. In the present practice of the invention, the device 116 comprises a thin layer or strip of conductive material separated from another thin layer or strip of conductive material with a superposed layer of resistive material thereover such that increased surface contact pressure thereon causes a conductive layer to be pressed thereon and effects decrease in the resistance measured between the strips 100, 102. Such devices are well known in the art and are formed of pressure transducer ink screened on dielectric material to form a thin strip-like resistive device.

[0031] Referring to FIG. 4, the force generating means comprises a sub-assembly indicated generally at 85 formed by assembling spring 94 into hollow cylindrical portion 72 of plunger 68 and inserting the barbed end of actuator 84 therein and snapping the actuator therein in telescoped arrangement. The sub-assembly 85 is then assembled into shell bore 70 and circuit board assembly 64, with device 116 thereon, assembled over bore 70 with screws 60. It will be understood that the extended length of sub-assembly 85 is such that no pressure is provided by pad 96 on device 116 as assembled without user rotation of knob 34.

[0032] Referring to FIGS. 1 and 4 in operation, rotation of the knob 34 causes the upper helical cam surface 30 on cam 28 to raise ball 50 to compress spring 52; and, simultaneously the lower cam surface 32 on cam 28 allows the cam follower post 78 and plunger 68 to move upwardly extending spring 94 and reducing the bias of the elastomeric pad 96 against the force/pressure sensitive resistive device 116. Rotation of the knob 34 in an opposite direction permits ball 50 to move downwardly releasing the load on spring 52 and increasing the load on post 78 and compressing spring 94 to increase pressure of pad 96 on the device 116. In the presently preferred practice of the invention the spring rates or constants of the springs 52 and 94 are chosen to be equal such that the user experiences a substantially constant torque in rotating knob 34, inasmuch as one of the springs 52, 94 is unloaded at the same rate the other is loaded with either direction of rotation of knob 34.

[0033] The present invention thus provides a reliable, simple to manufacture and relatively low cost rotary position transducer which utilizes a force/pressure sensitive resistive device and eliminates the need for wiping contact.

[0034] The invention has been described and illustrated with respect to a resistive force/pressure responsive device; however, it will be understood that a capacitive force/pressure responsive device could be substituted for the device 116 to achieve the same results where an alternating current electrical signal is employed.

[0035] Although the invention has hereinabove been described with respect to the illustrated embodiments, it will be understood that the invention is capable of modification and variation and is limited only by the following claims.

Claims

1. A rotary movement transducer comprising:

(a) a housing having a force/pressure-sensitive strip associated therewith, said strip including means operative, upon application of a force thereto, to change its electrical effect in a circuit;

(b) a rotor mounted for user rotation with respect to said housing, said rotor including a cam surface;

(c) a cam follower operative to contact said cam surface and means for maintaining a bias on said follower against said cam surface;

(d) means responsive to said following of said cam follower for generating a force on said strip proportional to said following movement, wherein said force on said strip effects a variation in said electrical effect upon circuit connec-

tions thereto.

2. The transducer defined in claim 1, wherein said cam surface has a generally helical configuration.

3. The transducer defined in claim 1, further comprising first cam surface and a first cam follower resiliently biased thereagainst, and a second cam surface having a second follower biased thereagainst, wherein said first and second cam surfaces are arranged such that a constant torque input to said rotor effects an increase in said generated force with rotation of said rotor.

4. The transducer defined in claim 1, wherein said cam follower applies an increasing generated force on said strip with a substantially constant torque applied to said rotor by the user.

5. The transducer defined in claim 1, wherein said means for generating a force includes a telescoping plunger having a spring biasing the plunger to an extended position.

6. The transducer defined in claim 1, wherein said means operative to change its electrical properties is a resistive and force-sensitive device.

7. The transducer defined in claim 1, wherein said means for generating a force includes a first member contacting said cam surface and a second member disposed for limited relative movement with respect to said first member, said second member having portions thereof contacting said strip, and means operative to provide a bias force on said second member, said force proportional to said relative movement of said first member with respect to said second member.

8. The transducer defined in claim 7, wherein said means for generating a force includes a capsule housing said first and second members.

9. The transducer defined in claim 1, wherein said means for generating a force includes a spring biasing a first member against said cam surface and a second member against said strip.

10. The transducer defined in claim 1, wherein said housing includes means detenting said rotor in selected positions.

11. A method of making a rotary movement transducer comprising:

(a) disposing a force/pressure-sensitive strip on a housing;
(b) disposing a rotor for movement on said housing and forming a cam surface on said rotor;
(c) biasing a cam follower against said cam surface;
(d) moving said rotor and sequentially varying said bias and reacting said bias on said strip and varying the electrical effect of said strip in a circuit.

12. The method defined in claim 11, wherein said step of varying the electrical effect in a circuit includes varying one of the group consisting of impedance and resistance.

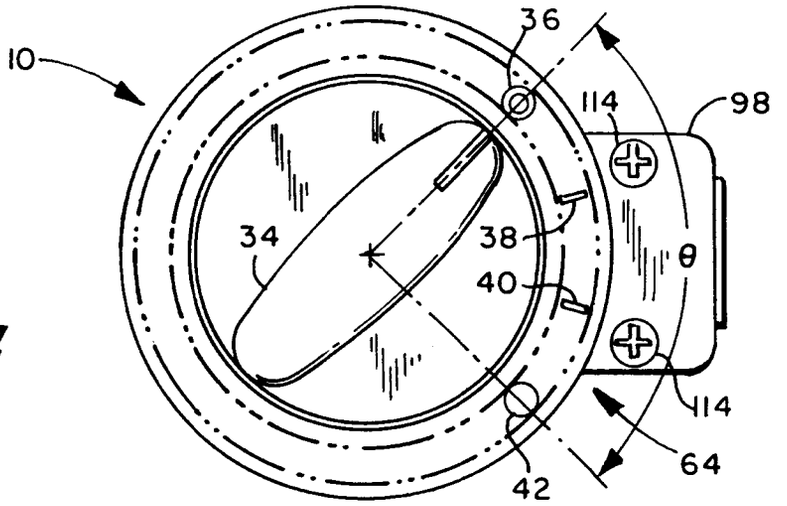

Fig. 2

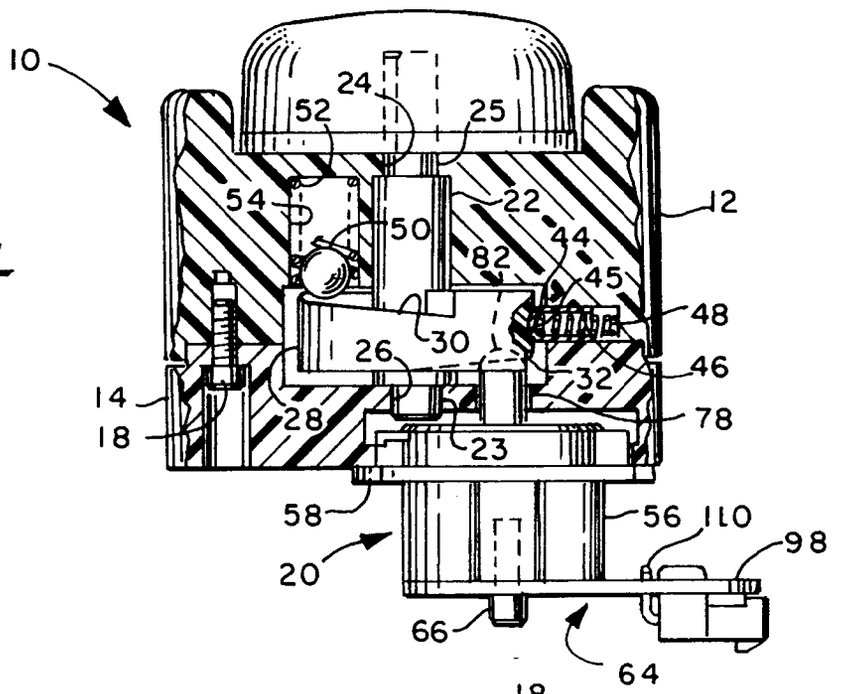

Fig. 1

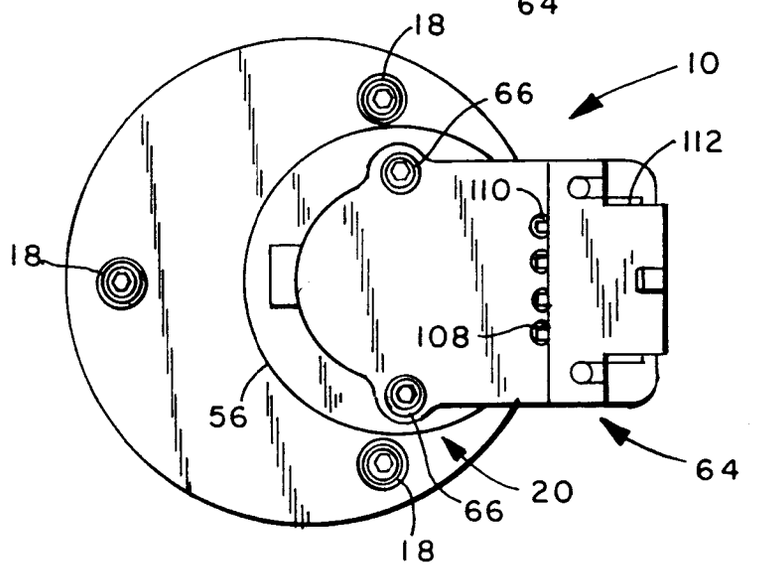

Fig. 3

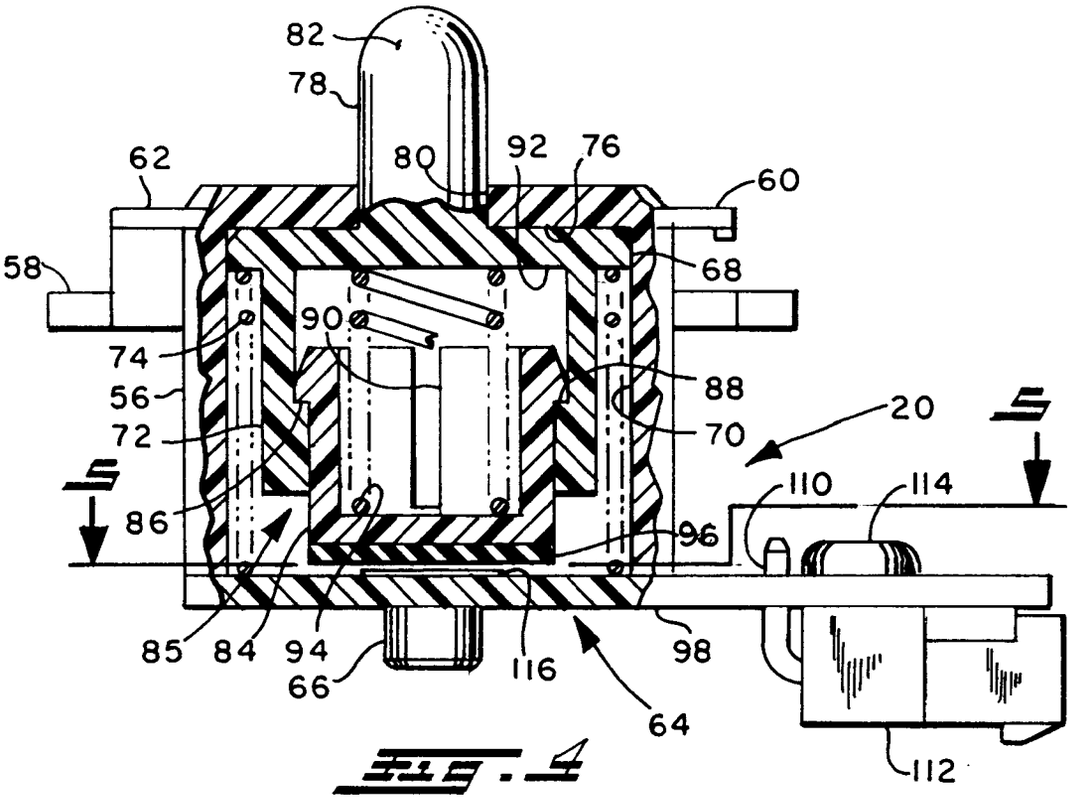
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Fig. 4

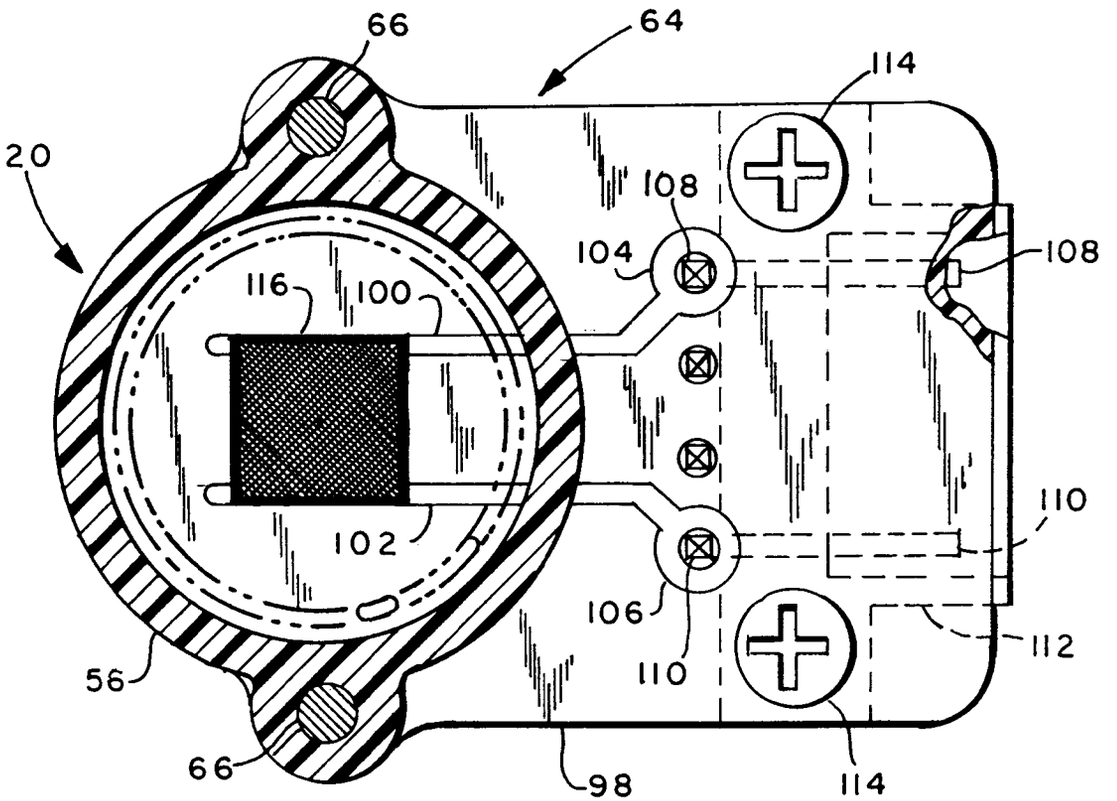
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Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 11 6001

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	GB 2 159 953 A (STC PLC) 11 December 1985 * the whole document *	1,3,6,7, 9,11,12 2,4,5,8, 10	H01C10/10 H01H1/02
A	US 4 655 091 A (GREENWOOD JOHN C) 7 April 1987 * claim 1; figure 1 *	1-12	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H01C
H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	25 November 1998	Mausser, T

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 11 6001

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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25-11-1998

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For more details about this annex : see Official Journal of the European Patent Office. No. 12/82