



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.02.1999 Bulletin 1999/08

(51) Int Cl.⁶: **G01D 5/14, G01D 5/16,
F15B 15/28**

(21) Application number: **98306579.8**

(22) Date of filing: **18.08.1998**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(72) Inventor: **Bailey, Keith Derek
Dorset, BH19 1TY (GB)**

(74) Representative:
**Purvis, William Michael Cameron et al
D. Young & Co.,
21 New Fetter Lane
London EC4A 1DA (GB)**

(30) Priority: **19.08.1997 GB 9717547**

(71) Applicant: **Penny & Giles Position Sensors
Limited
Christchurch, Dorset BH23 3TE (GB)**

(54) **A sensing device**

(57) A sensing device comprises an axially magnetised hollow magnet 24 and means 5 for sensing magnetic field changes movable into and out of the magnet 24, the sensing means 5 being aligned to generate a first potential difference when the sensing means 5 is inside the magnet 24 and a second, different, potential

difference when the sensing means 5 is outside of the magnet 24, detection of the first and second potential differences being indicative of the position of the sensing means 5 with respect to the magnet 24. An end of travel sensor 10 employing the sensing device is also disclosed.

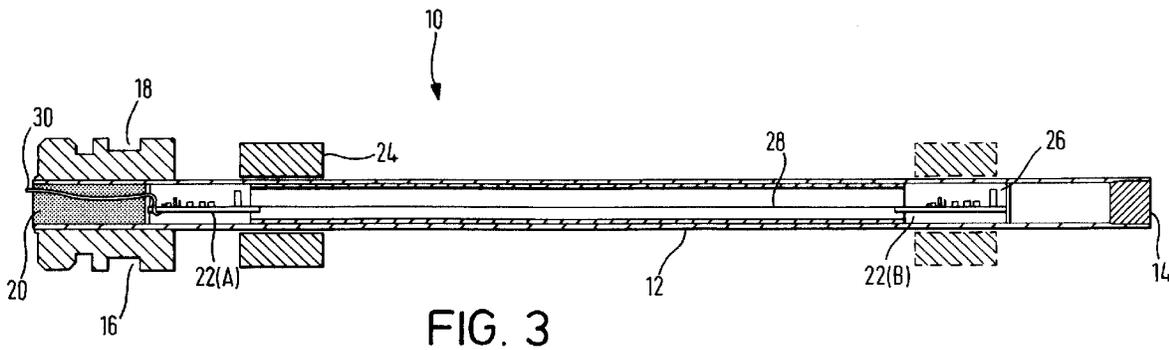


FIG. 3

Description

[0001] This invention relates to a sensing device.

[0002] A variety of sensing devices have previously been proposed. One such previously proposed sensing device employs a Hall effect sensor and is shown in Figure 1. As shown, the sensing device comprises a pair of bar magnets 1, 3 having opposite poles aligned and each having a thickness "X". Disposing the Hall effect sensor 5 in the magnetic field "B" between the bar magnets 1, 3 causes the current carriers within the sensor to be displaced to cause the generation of a potential difference across the sensor 5.

[0003] As shown in Figure 1A, the potential difference increases from a minimum value when the sensor 5 is to the left of the magnets 1, 3 to a maximum value when the sensor 5 is approximately coincident with the magnets 1, 3, and returns to a minimum as the sensor 5 moves to the right of the magnets 1, 3. The resulting potential difference profile is such that it can be difficult to determine exactly when the sensor is coincident with the magnets 1, 3. Thus, an end of travel sensor employing the previously proposed Hall effect sensor 5 typically requires complex and expensive thresholding electronics in order to determine when the sensor is coincident with the magnets 1,3. These thresholding electronics are also unduly susceptible to dithering at the "on/off" position boundary which can lead to behavioural oddities in the system employing the sensing device. It has also been noted that the accuracy of these previously proposed devices is unduly sensitive to temperature changes and to changes in magnetic field strength as a result of those temperature changes. Furthermore, these previously proposed sensing devices are also hampered by the sensitivity of the Hall effect device which can further reduce the accuracy of position determination.

[0004] In addition, the Hall effect sensor of the Figure 1 device must be carefully monitored in order to ensure that it is perpendicularly aligned to the magnetic field "B". This requires the services of trained personnel and unacceptably increases both the down time of any system employing the sensing device and the running costs of that system.

[0005] In accordance with a first aspect of the invention, there is provided a sensing device comprising an axially magnetised hollow magnet and means for sensing magnetic field changes movable into and out of the magnet, the sensing means being aligned to generate a first potential difference when the sensing means is inside the magnet and a second, different, potential difference when the sensing means is outside of the magnet, detection of the first and second potential differences being indicative of the position of the sensor with respect to the magnet.

[0006] This arrangement obviates the need for expensive monitoring and adjustment of the sensing device as, by virtue of the axially magnetised hollow magnet,

the sensor is always perpendicularly aligned to at least a portion of the magnetic field. In addition, the determination of the position of the sensor with respect to the magnet is simplified as the boundary between the first and second potential differences is clarified. Furthermore, the accuracy of the sensing device is less vulnerable to changes in temperature and magnetic field than previously proposed devices. Preferably, the magnet is a ring magnet.

[0007] Preferably, the first potential difference is larger than said second potential difference.

[0008] Preferably, said sensing means comprises a Hall effect sensor, and more preferably a unipolar Hall effect sensor. In either case, it is preferred that the sensing means outputs a logic high when said sensing means is inside of said magnet, and a logic low when said sensing means is outside of said magnet.

[0009] One popular application for a sensing devices is as an end of travel position sensor which can be used, for example, in conjunction with various pneumatic or hydraulic systems to sense end of travel positions of moving components within the system.

[0010] In a previously proposed system, two pairs of bar magnets - each arranged as in Figure 1 - are provided within, or in abutment with the outside of, a pneumatic cylinder. One pair of magnets is provided at a fully retracted position of the cylinder and the other pair is provided at a fully extended position of the cylinder. The piston of the pneumatic cylinder is provided with a Hall effect sensor so that a voltage is generated as the sensor passes through the magnetic fields generated by respective pairs of magnets. By sensing the voltage generated from the sensor, it is possible to determine the position of the sensor with respect to the magnets and thus the position of the piston with respect to the fully extended and fully retracted cylinder positions.

[0011] Whilst this previously proposed arrangement operates adequately, it has been noted that the Hall effect sensors have an unacceptably high failure rate - which rate has been postulated to be due to the action of the high pressure environment within the system on the sensitive Hall effect sensors. As a consequence of this, the sensors must be regularly inspected and replaced thereby unacceptably increasing the operating costs of the equipment employing the end of travel sensor. Furthermore, it has been noted that previously proposed sensors have a limited accuracy due to temperature variations in the system.

[0012] In accordance with a second aspect of the invention, there is provided a an end of travel sensor for a pneumatic or hydraulic system, the sensor comprising at least one of the sensing devices described herein; wherein the magnet is movable within a high pressure and/or temperature environment of the system; and the sensing means is provided in a low pressure and/or environment, the sensor comprising means for determining the position of the magnet with respect to the sensing means based upon the first and second potential differ-

ences generated by said sensing means.

[0013] In this way, it is possible to shield the relatively delicate sensing means from the high pressure and/or temperature environment thereby to improve the reliability of the sensor.

[0014] Preferably, said sensor comprises a pair of said sensing devices, a first device being positioned to sense a retracted position of a moving component and a second device being positioned to sense an extended position of the moving component. The moving component may be a piston of a pneumatic or hydraulic system. The magnet may be attached to, or formed as part of, the moving component.

[0015] Preferably, said low pressure and/or temperature environment comprises a rigid tube, sealed at at least one end to shield said sensing means from the high pressure and/or temperature environment. In which case, the magnet may be slidably receivable over said rigid tube. Preferably, said rigid tube is of stainless steel.

[0016] Preferably, said determining means determines said magnet to be coincident with said sensing means when a logic high generated by said sensing means is detected and/or determines said magnet to be away from said sensing means when a logic low generated by said sensing means is detected.

[0017] An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 schematically illustrates a previously proposed sensing device;

Figure 1A illustrates a potential difference profile of the sensor of Figure 1;

Figure 2 is a perspective view of an axially magnetised hollow magnet;

Figure 2A is a cross-sectional view along the line II--II of Figure 2, showing the magnet of Figure 2 employed in a sensing device;

Figure 2B illustrates a potential difference profile of the device of Figure 2A;

Figure 3 is a cross-sectional elevation of an end of travel sensor employing the device of Figure 2A; and

Figure 4 is a schematic representation of a position determining circuit employable with the sensor of Figure 3.

[0018] Figure 2 is a perspective view of an axially magnetised magnet 24, for example a ring magnet (although other magnetically equivalent arrangements will be apparent to persons skilled in the art), employed in embodiments of the present invention. As shown, the magnet 24 comprises a tube of suitable magnetic material magnetised to have opposite poles at opposite ends. Figure 2A shows a cross-sectional view along the line (II) -- (II) of Figure. 2. As shown in Figure 2A, the magnet 24 is capable of being moved over a sensor 5 (which is preferably a unipolar sensor) to generate a hall

effect in the sensor in a direction perpendicular to the magnetic field "B". As shown in Figure 2B, the potential difference measured in the sensor when it is to the left of the magnet (Position (i) in Figure 2A) increases suddenly from a minimum to a maximum as the sensor is coincident with an end of the magnet (Position (ii) in Figure 2A). The maximum potential continues to be sensed in the sensor until the sensor is coincident with the other end of the magnet 24, at which point the voltage again drops to the minimum (Position (iii) in Figure 2A). By comparing Figures 1A and 2B, it can be seen that the determination of when the sensor is coincident with the associated magnet is much simplified when a magnet is moved over the sensor. Accordingly, a position sensor incorporating the arrangement of Figure 2 is significantly less complex than that of Figure 1 as it requires less electronic components (in particular no thresholding components) and provides for more predictable results exhibiting less or no dithering.

[0019] Figure 3 is a schematic cross-sectional view of an end of travel sensor according to an aspect of the invention. With reference to Figure 3, the end of travel sensor 10 comprises a pressure tube 12 which is sealed at one end by an end cap 14 welded, or otherwise affixed, thereto. The pressure tube 12 is welded, or otherwise affixed, at its other end to a flanged member 16 which is provided with a groove 18, capable of receiving some form of pressure seal, such as an O-ring (not shown), to provide a pressure seal between the flanged member and a surrounding hydraulic or pneumatic system (not shown).

[0020] The flanged member 16 is receivable in a suitable opening in a hydraulic or pneumatic cylinder (not shown), for example, of a hydraulic or pneumatic system. The end of the tube affixed to the flange member 16 is preferably filled with a potting compound 20, or other like substance, so as to seal the interior of the tube 12 both from the high pressure environment within the hydraulic or pneumatic cylinder and the environment outside of the cylinder. Preferably, the tube 12 and end cap 14 are of stainless steel - although other suitable materials will be readily apparent to persons skilled in the art.

[0021] Within the tube 12 there is provided a pair of printed circuit boards (PCB's) 22, one PCB 22(a) being provided in the neighbourhood of the potting compound 20 and the flange member 16, and the other PCB 22(b) being provided in the neighbourhood of the end cap 14. The PCB's 22(a) and 22(b) are each provided in a position that approximately corresponds to a retracted position and an extended position, respectively, of a moving component (not shown), such as a piston, of the hydraulic or pneumatic system (not shown). Advantageously, the position of the PCB's may be adjusted to allow the sensor to be configured for use with a particular apparatus.

[0022] The sensor 10 is provided with an axially magnetised hollow magnet, in this example a ring magnet

24, similar to that of Figure 2. The magnet 24 has an annular shape with the aperture being slightly larger than the cross-sectional area of the pressure tube 12. The magnet 24 is connected to, or forms part of, the moving component (not shown) of the hydraulic or pneumatic system (not shown) and is capable of freely sliding over the outside of the pressure tube 12.

[0023] Each of the PCB's 22 include a Hall sensor 26 which, in accordance with the Hall effect, generates a voltage when a magnetic field is applied in a direction perpendicular to the current carriers within the sensor 26. Advantageously, the alignment of the sensor is less critical as the sensor of Figure 2 will always be perpendicular to at least a component of the magnetic field "B". Preferably, the Hall sensors are digital sensors outputting a logic high when a magnetic field is applied and a logic low when no magnetic field is applied. It is also preferred that the Hall effect sensors are unipolar sensors, although bipolar sensors could be used with less accurate results.

[0024] The two PCB's 22(a) and 22(b) are connected to one another by suitable interconnecting means 28 and the first PCB 22(a) is connected to external equipment (not shown) by input/output connection means 30 buried in and travelling through the potting compound 20.

[0025] Figure 4 illustrates an exemplary arrangement of PCB components wherein the Hall effect sensors 26 each comprise a digital output Hall effect sensor. As shown, the sensors 26 are each connected to a logic means 32 which may be a microcontroller or other suitable device. The logic means is cycled by a clock signal; the clock signal being inputted on input line 34 from a clock signal generator 36; to interrogate inputs 38 and 40 from the first hall effect sensor and the second hall effect sensor, respectively. When the logic means detects a logic low on both inputs 38 and 40, it determines that the magnet 24 and thus the piston (not shown) is between the retracted and extended end of travel positions, and thus that operation of the cylinder may safely be continued. When the logic means 32 detects a logic high on input 38, it determines that the magnet (and hence the piston) is at the retracted position, and thus the operation of the cylinder should be interrupted pending reversal of the cylinder during an extension stroke.

[0026] Similarly, when the logic means 32 detects a logic high on input 40, then it determines that the piston (not shown) is at the extended position and thus that the operation of the cylinder should be interrupted pending reversal of the cylinder during a retraction stroke. Suitable control signals are output from the control on output line 30 to control the external equipment to reverse the operating direction of the cylinder.

[0027] It will be understood that the arrangement described in Figure 4 is purely exemplary and that alternative control circuits will be immediately apparent to persons skilled in the art. For example, the digital output Hall effect sensors could be replaced with analog sen-

sors - in which case an additional electronic comparative circuit would be preferred to generate a digital output for processing by the logic means.

[0028] It will be understood that the invention has been described above by way of example only and that modifications may be made within the scope of the appended claims.

10 Claims

1. A sensing device comprising an axially magnetised hollow magnet and means for sensing magnetic field changes movable into and out of the magnet, the sensing means being aligned to generate a first potential difference when the sensing means is inside the magnet and a second, different, potential difference when the sensing means is outside of the magnet, detection of the first and second potential differences being indicative of the position of the sensor with respect to the magnet.
2. A sensing device according to Claim 1, wherein the magnet is a ring magnet.
3. A sensing device according to Claim 1 or Claim 2, wherein said first potential difference is larger than said second potential difference.
4. A sensing device according to any of Claims 1 to 3, wherein said sensing means comprises a Hall effect sensor.
5. A sensing device according to Claim 4, wherein said sensor is a unipolar Hall effect sensor.
6. A sensing device according to any of Claims 1 to 5, wherein said sensing means outputs a logic high when said sensing means is inside of said magnet, and a logic low when said sensing means is outside of said magnet.
7. An end of travel sensor for a pneumatic or hydraulic system, the sensor comprising at least one sensing device according to any preceding claim; wherein the magnet is movable within a high pressure and/or temperature environment of the system; and the sensing means is provided in a low pressure and/or environment, the sensor comprising means for determining the position of the magnet with respect to the sensing means based upon the first and second potential differences generated by said sensing means.
8. An end of travel sensor according to Claim 7, wherein said sensor comprises a pair of said sensing devices, a first device being positioned to sense a retracted position of a moving component and a

second device being positioned to sense an extended position of the moving component.

- 9. An end of travel sensor according to Claim 8, wherein the moving component is a piston of a pneumatic or hydraulic system. 5

- 10. An end of travel sensor according to Claim 8 or Claim 9, wherein the magnet is attached to, or formed as part of, the moving component. 10

- 11. An end of travel sensor according to any of Claims 7 to 10, wherein said low pressure and/or temperature environment comprises a rigid tube, sealed at at least one end to shield said sensing means from the high pressure and/or temperature environment. 15

- 12. An end of travel sensor according to Claim 11, wherein the magnet is slidably receivable over said rigid tube. 20

- 13. An end of travel sensor according to Claim 1 or Claim 12, wherein said rigid tube is of stainless steel. 25

- 14. An end of travel sensor according to any of Claims 7 to 13, wherein said determining means determines said magnet to be coincident with said sensing means when a logic high generated by said sensing means is detected. 30

- 15. An end of travel sensor according to any of Claims 7 to 14, wherein said determining means determines said magnet to be away from said sensing means when a logic low generated by said sensing means is detected. 35

40

45

50

55

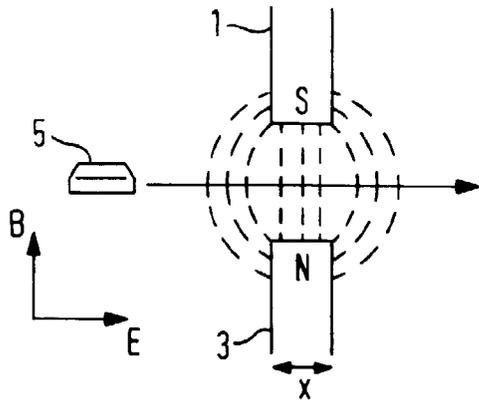


FIG. 1

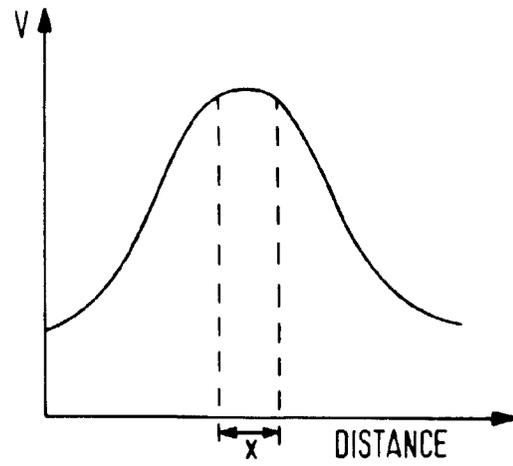


FIG. 1A

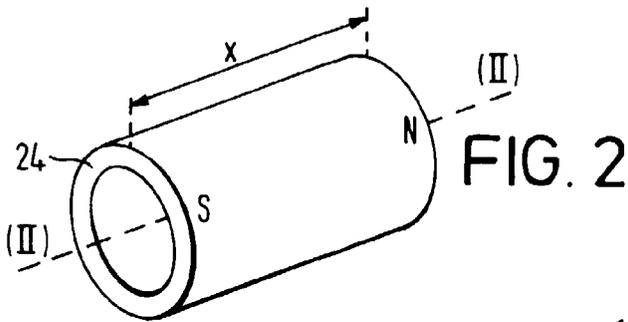


FIG. 2

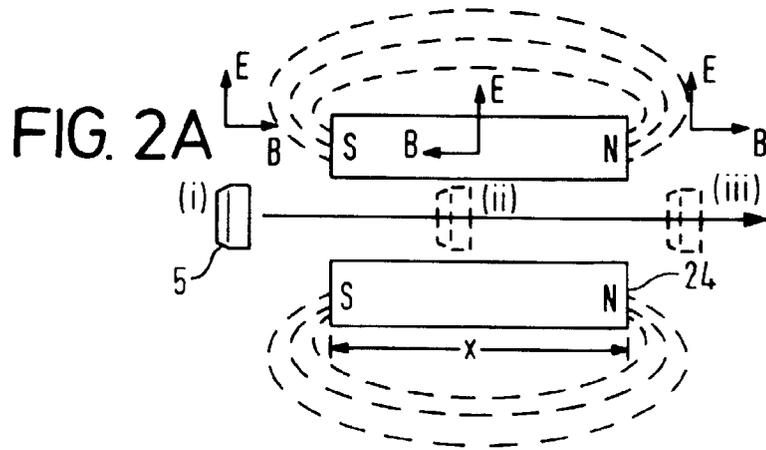


FIG. 2A

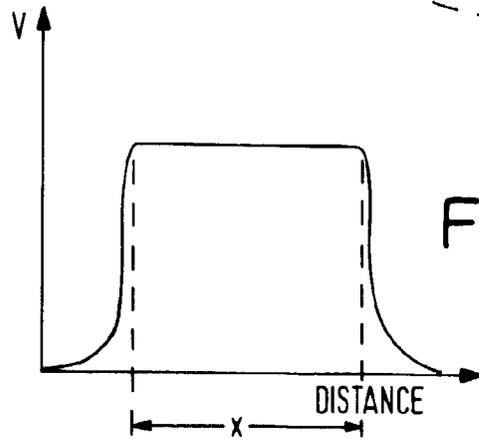


FIG. 2B

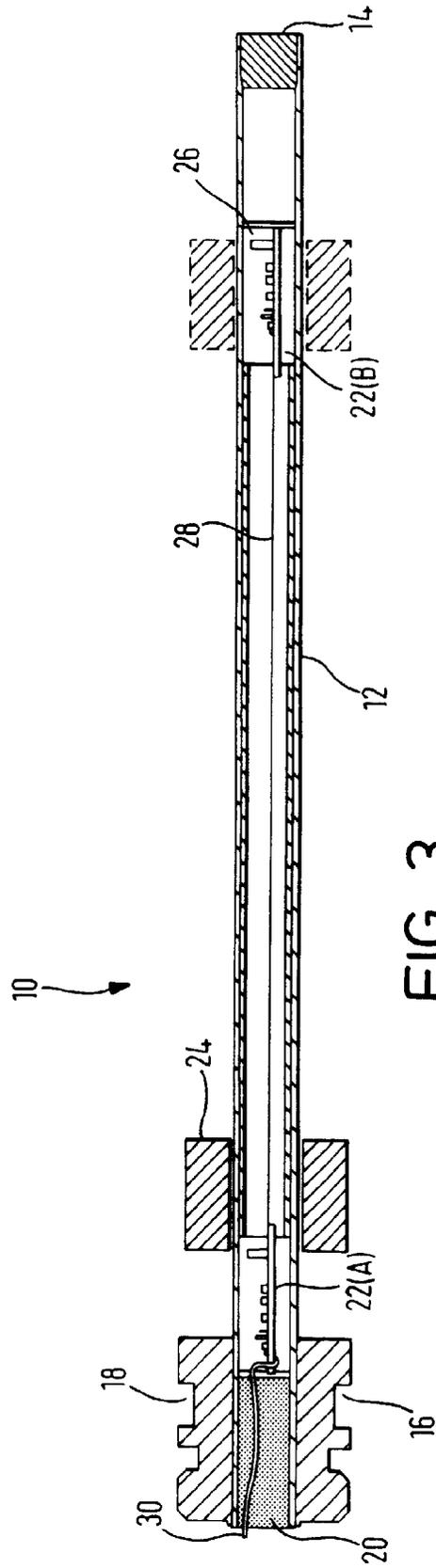


FIG. 3

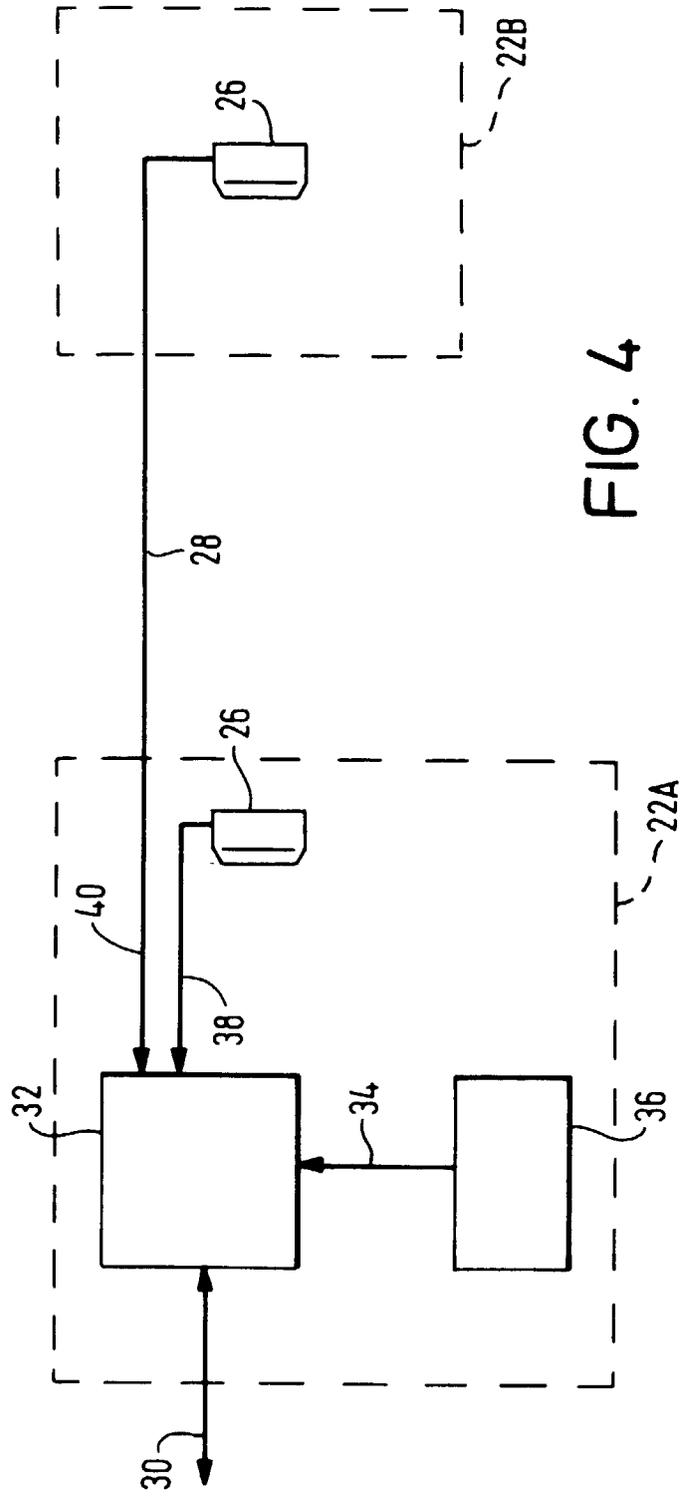


FIG. 4



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 6579

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	US 5 196 791 A (DUMAIS ARTHUR) 23 March 1993 * abstract; figure 1 *	1,2	G01D5/14 G01D5/16 F15B15/28
Y	GB 2 272 060 A (ROLLS ROYCE & ASS) 4 May 1994 * page 3, line 5 - line 19; figure 1 *	1-15	
Y	FR 2 598 219 A (SALOU ALAIN) 6 November 1987 * page 1, line 21 - page 2, line 7; figure 1 *	1-15	
Y	DE 41 35 381 A (KROLL DIETRICH ;KROLL ROLAND (DE)) 29 April 1993 * abstract; figures *	1-6	
Y	DE 44 42 019 A (INTEGRAL HYDRAULIK CO) 30 May 1996 * column 3, line 2 - line 48; figures *	1,7-15	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			G01D F15B
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	3 December 1998	Lloyd, P	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 03/82 (P04C01)