(12) UK Patent Application (19) GB (11) 2 111 196 A

(21) Application No **8227670**
(22) Date of filing **28 Sep 1982**
(30) Priority data
(31) **8129247**
(32) **28 Sep 1981**
(33) **United Kingdom (GB)**
(43) Application published
29 Jun 1983
(51) **INT CL³**
G01B 11/02 17/00
(52) Domestic classification
G1A A3 C11 C12 C13 C5 D10 D4 D5 EE EF G10 G7 P14 P16 P17 R1 R6 R7 T15 T23 T25 T3 T8
U1S 2146 2150 2289 G1A
(56) Documents cited
GB 1569360
GB 1557441
GB 1169440
GB 1159164
GB 1061239
GB 0804424
GB 0679114
GB 0637456
(58) Field of search
G1A
(71) Applicant
G. A. Platon Limited, (Great Britain), Wella Road, Basingstoke, Hampshire, RG22 4AQ
(72) Inventor
Peter Norgate
(74) Agent and/or address for service
Marks and Clerk, 57—60 Lincoln's Inn Fields, London, WC2A 3LS

(54) Indicating or measuring instruments

(57) An indicating or measuring instrument such as fluid flowmeter is characterised by the provision of means (C, B Figure 6) for directing radiation energy across the path of movement of an indicator element (2) onto an electrically resistive element (V) which may taper in a direction substantially parallel to that path and of, which the electrical resistance varies as a function of the magnitude or position of the energy shadow thereon due to the intervening indicator element. This varying resistance is preferably measured by a Wheatstone Bridge circuit which may be connected to a resistance-to frequency converter to yield a digital read-out of the parameter causing positional alteration of the element. Instead of tapering the resistive element may have a tapering mask in front of it.

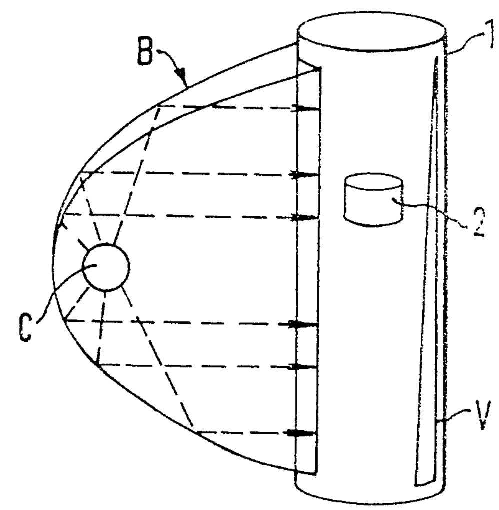


FIG.6.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

GB 2 111 196 A

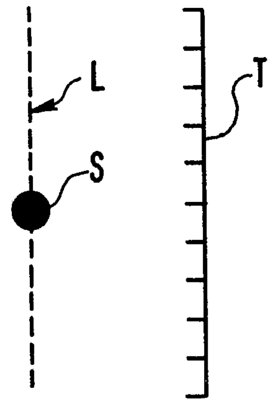


FIG.1.

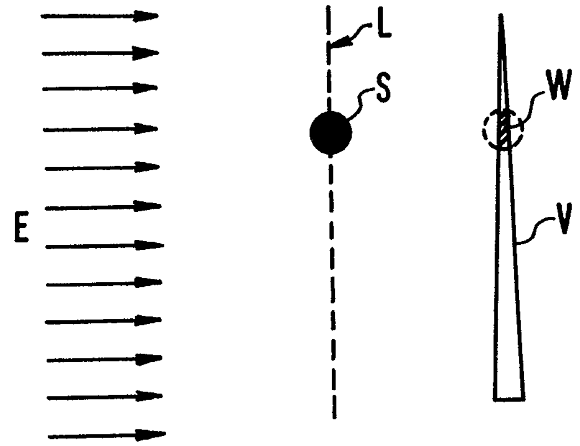


FIG.2.

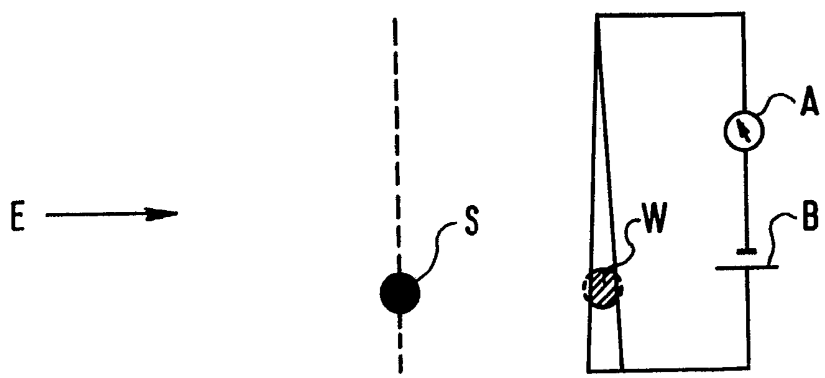


FIG.3.

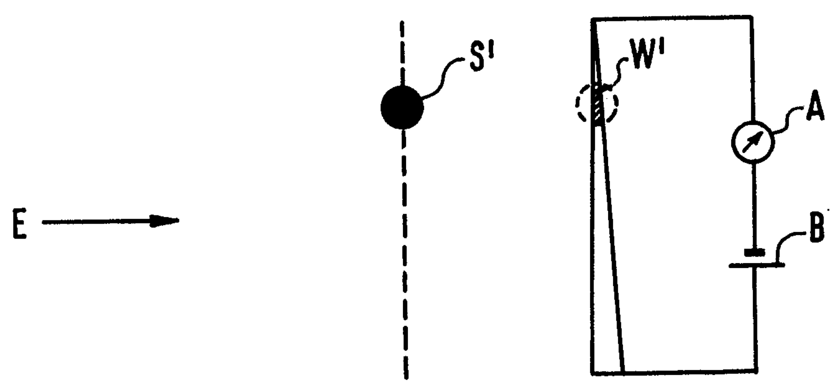


FIG.3A.

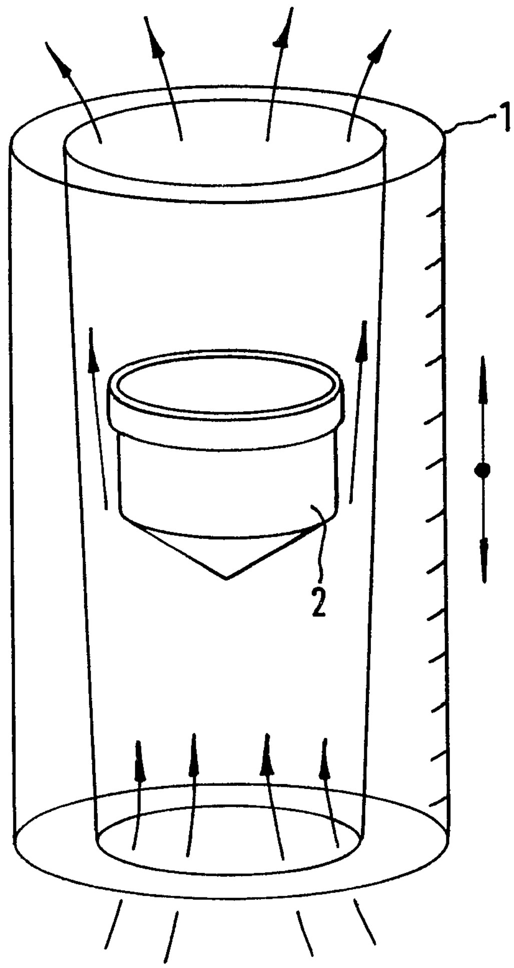


FIG. 4.

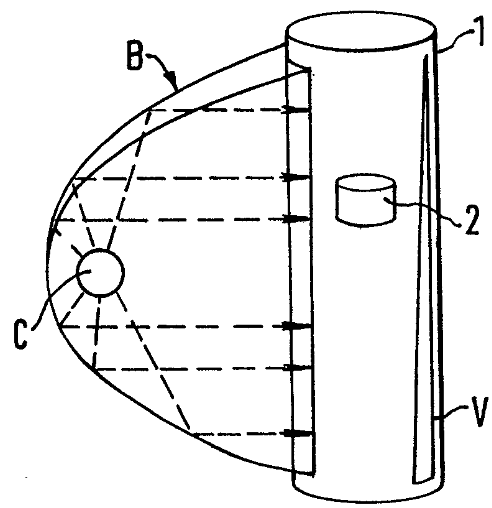


FIG. 6.

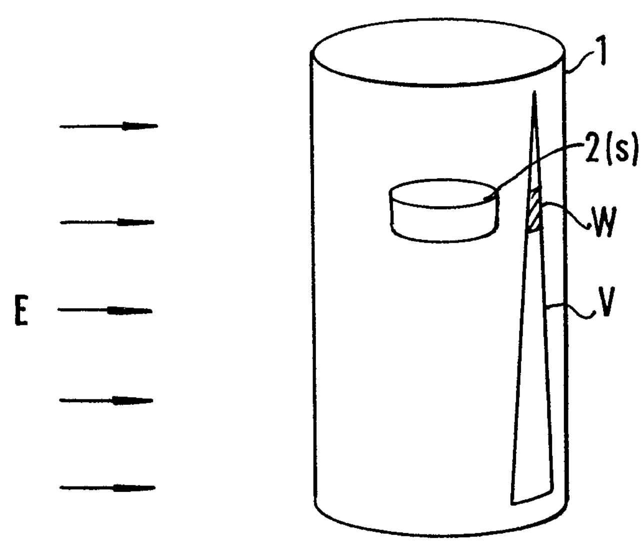
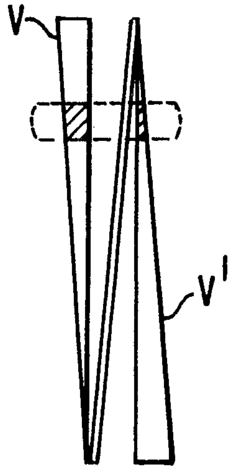


FIG. 5.



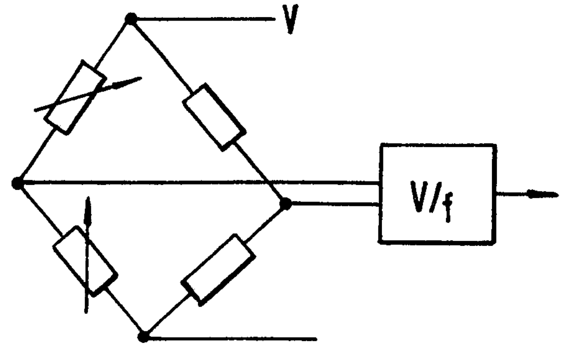


FIG.7A.

FIG.7.

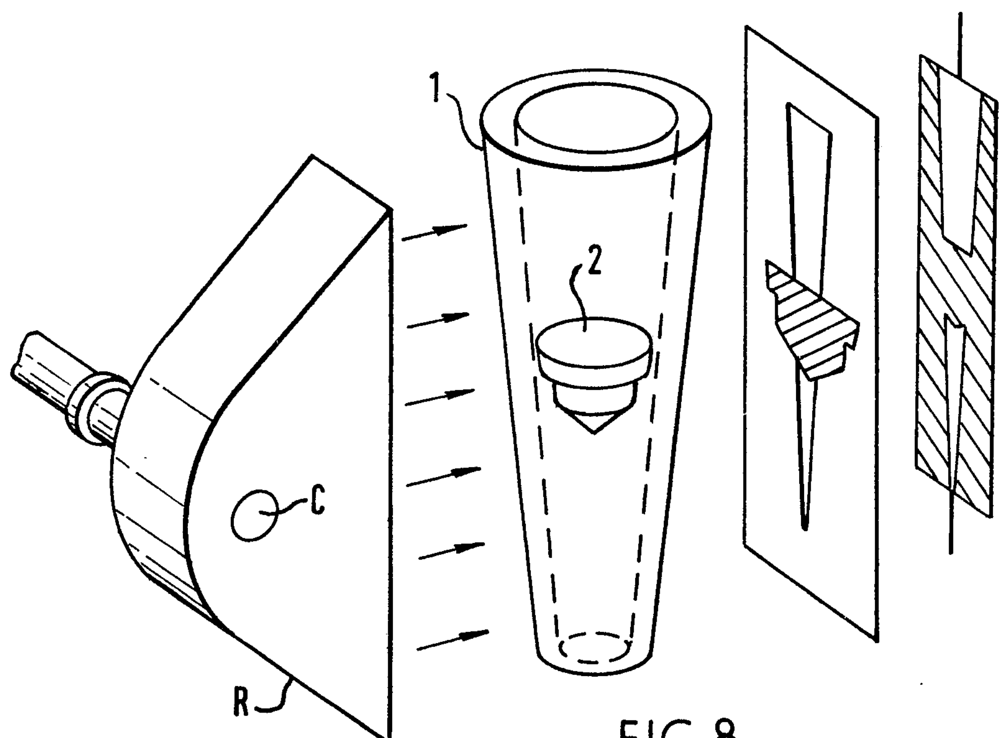


FIG.8.

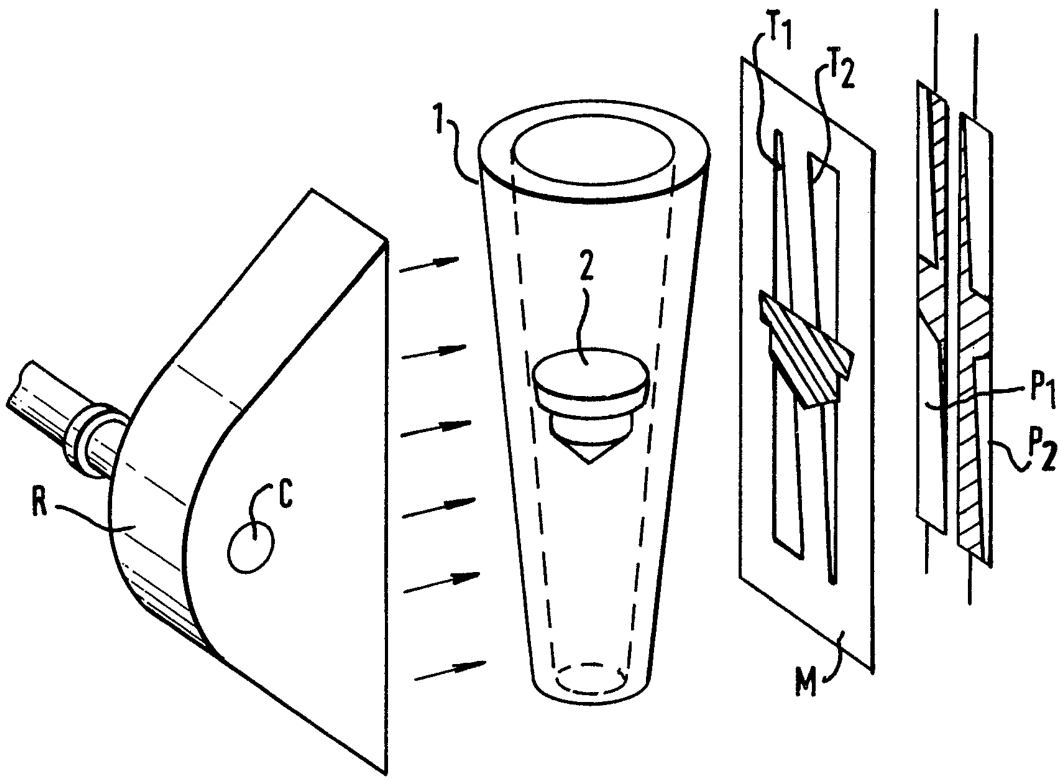
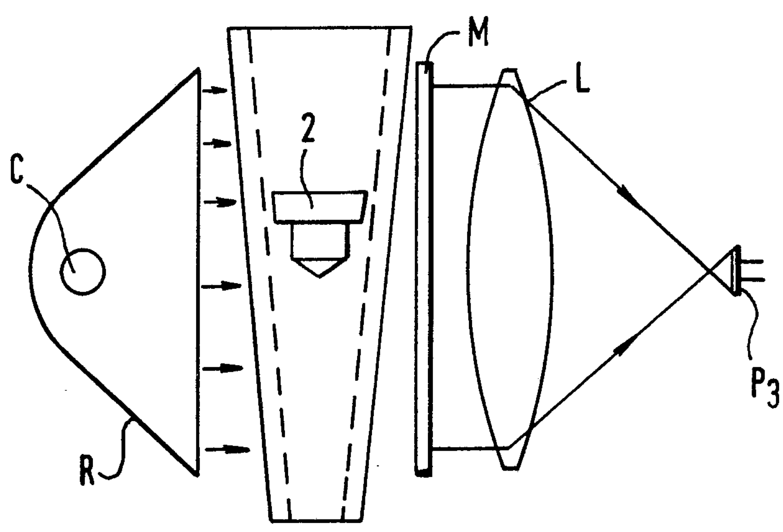


FIG. 9.

FIG. 10.



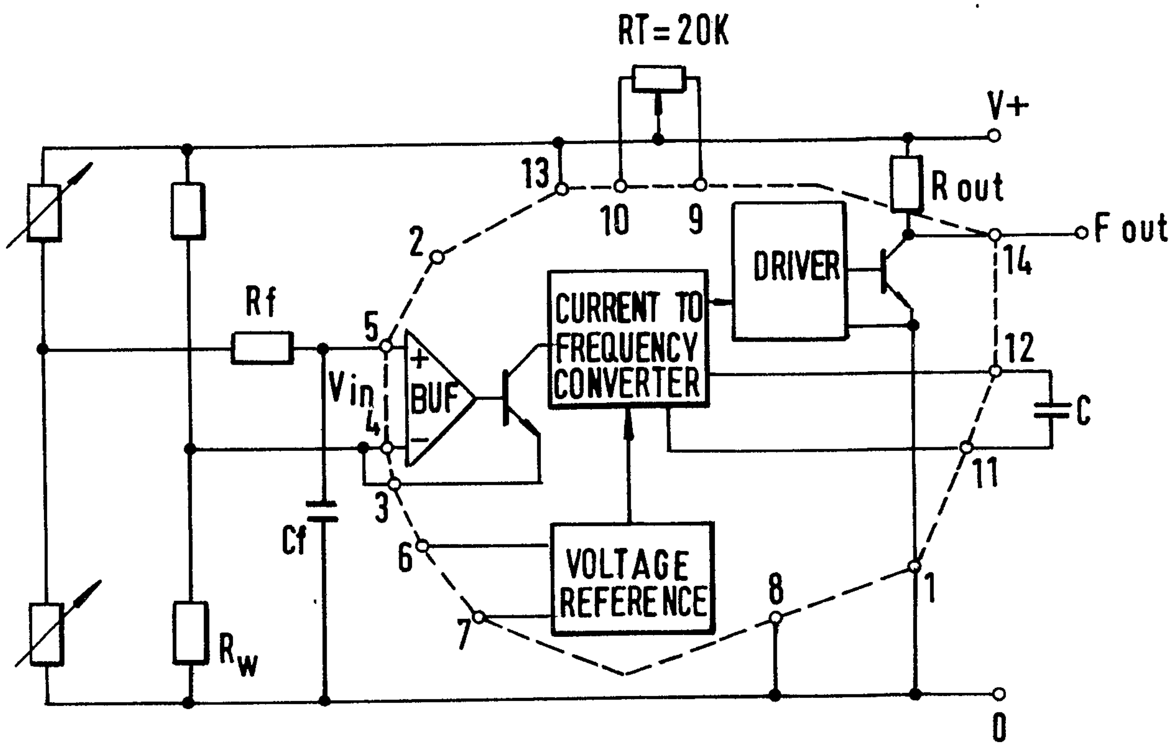

RT=20K
V+
13
10
9
R out
F out
14
2
DRIVER
Rf
5
CURRENT TO
FREQUENCY
CONVERTER
12
Vin
BUF
4
C
11
3
Cf
6
VOLTAGE
REFERENCE
8
1
7
R_w
0

FIG. 11.

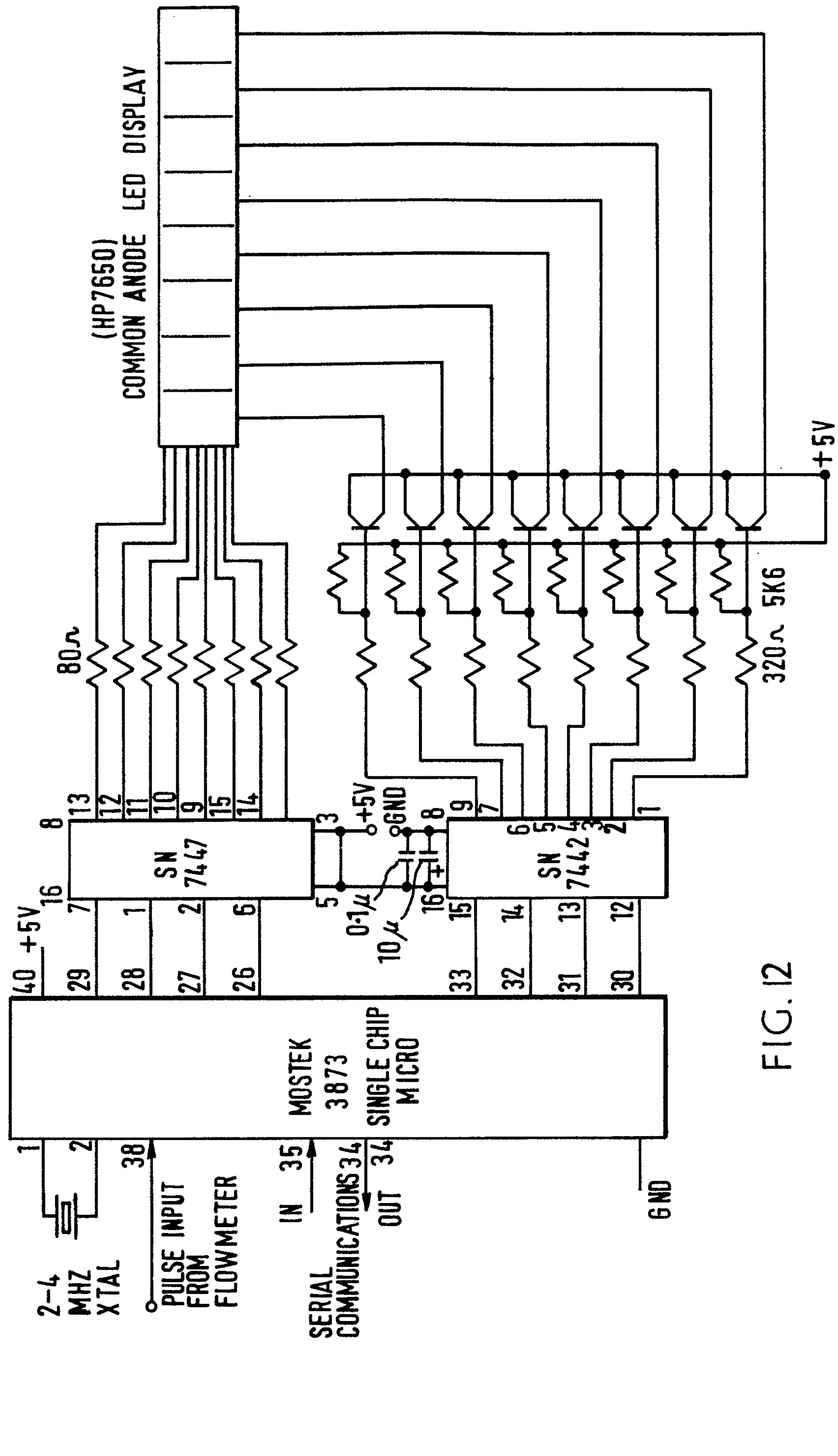

(HP7650)
COMMON ANODE LED DISPLAY
80Ω
5K6
320Ω
+5V
SN 7447
SN 7442
+5V
GND
0·1μ
10μ
MOSTEK 3873 SINGLE CHIP MICRO
2–4 MHZ XTAL
PULSE INPUT FROM FLOWMETER
IN
OUT
SERIAL COMMUNICATIONS
GND

FIG. 12

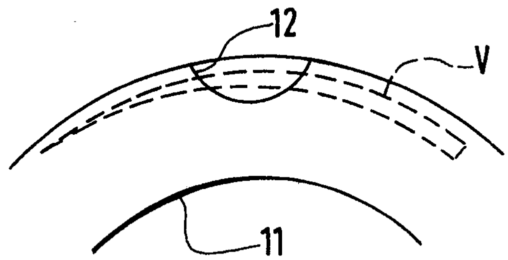


FIG.13.

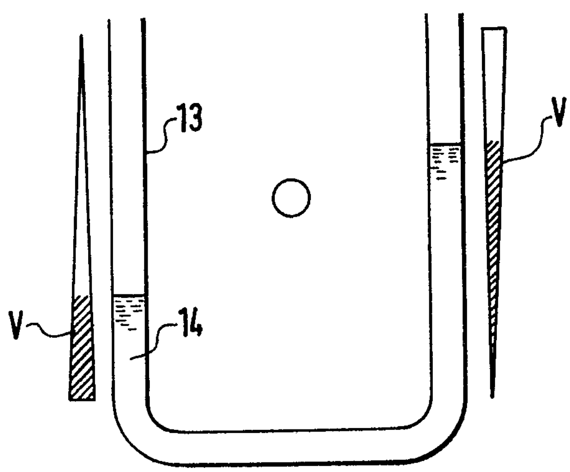


FIG.14.

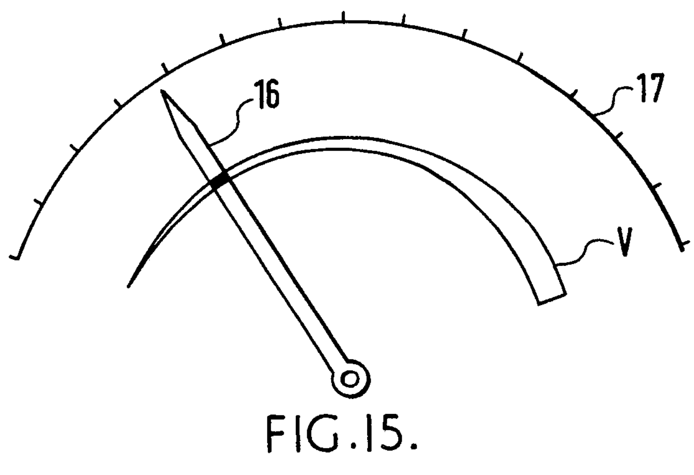


FIG.15.

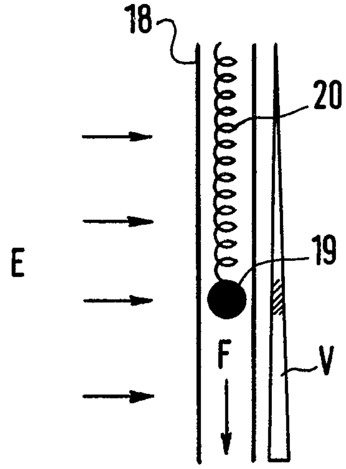


FIG.16.

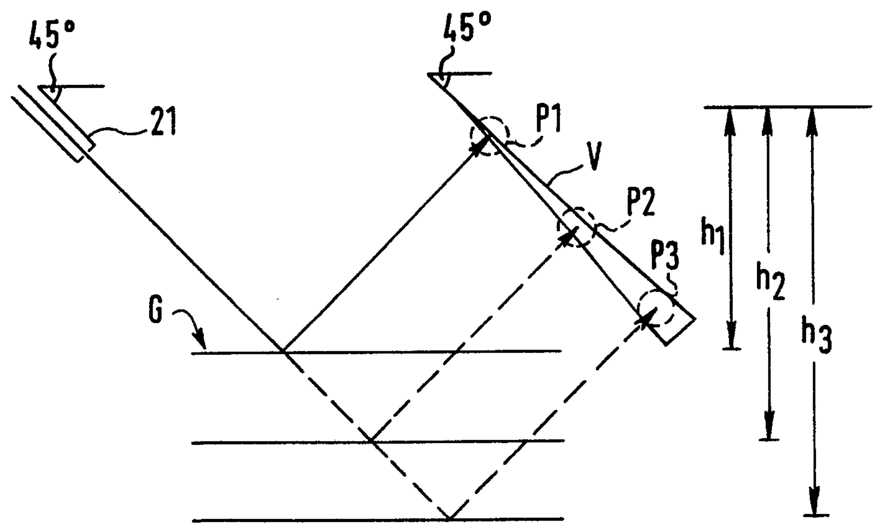


FIG.17.

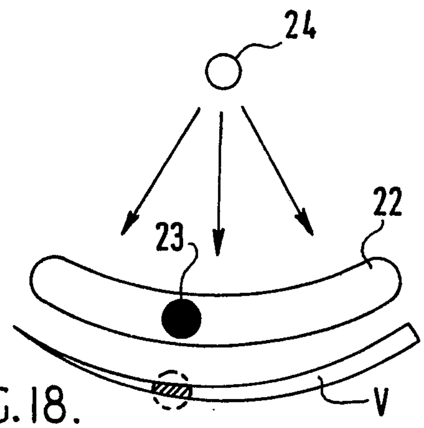


FIG.18.

SPECIFICATION

Improvements relating to indicating or measuring instruments

This invention relates to indicating or measuring instruments of the kind in which variations in a parameter cause positional alterations of an indicator element and these positional alterations have to be related to a scale of magnitude. The underlying principle of the invention is that the position of such an indicator element should be represented by a change in an electrical resistance, and that there should be no physical contact between the indicator element and the means by which its change of position is indicated or recorded.

This has obvious advantages in conditions where contact between the indicator element and such means would be impossible or hazardous.

In accordance with the invention therefore an indicating or measuring instrument of the kind referred to is characterized by the provision of means for directing a radiation energy beam across the path of movement of the indicator element onto an electrically resistive member which extends in a direction substantially parallel to that path and of which the electrical resistance varies as a function of the magnitude or position of the energy shadow incident thereon due to the intervening indicator element.

The nature of the invention should become more clearly apparent from the following description with reference to the accompanying drawings, in which:

Figure is a diagram of a basically known measurement scheme;

Figure 2 is a diagram of the underlying principle of the present invention;

Figures 3 and 3A are diagrams developed from Figure 2;

Figure 4 shows a variable area flowmeter;

Figure 5 is a diagram to illustrate the mode of application of the invention to the flowmeter of Figure 4;

Figure 6 shows a lens and wedge device;

Figure 7 shows a double wedge and Figure 7A a Wheatstone Bridge arrangement as used therewith;

Figures 8, 9 and 10 schematically illustrate three alternative arrangements which involve the use of masks for controlling output of light to a photocell;

Figure 11 is a diagram of a preferred circuit to be used with a device according to the invention;

Figure 12 is a diagram showing the use of a microprocessor with the circuit of Figure 8; and

Figures 13 to 18 diagrammatically illustrate modes of adaptation of the invention to various different measuring or indicating instruments.

Referring firstly to Figure 1, there is shown a displaceable indicator element S of a measuring instrument. This indicator element S is constrained to move in a straight line path L and its position has to be judged visually by reference to an adjacent scale T having its axis parallel to the line path L. The requirement underlying the invention is to obtain an electrical representation of the displacement of the indicator element S without any physical connection thereto for fear of interfering with the actual position of the indicator element, e.g. because that would be impossible, undesirable or dangerous. The path L need not necessarily be straight and one-dimensional but may be curved and extend in two or three dimensions.

Figure 2 illustrates the principle of the invention and shows a wide beam of energy E directed at an indicator element S displaceable along a straight line path L. Beyond the path L is a tapered strip V made of a material sensitive to the energy beam in such a way that its electrical impedance is effected in dependence upon the position along its axis of the energy shadow W caused by the intervention of the indicator element S.

The energy beam and the material of the strip could for instance alternatively be visible light and photoconductive film, infra-red radiation and infra-red photoconductive film, or sound or ultrasound radiation and material electrically sensitive to sound.

A typical strip to be used in conjunction with a visible light radiation source would embody a photoconductive paste such as cadmium sulphide, cadmium sulpho-selenide, cadmium selenide or any other photoconductive material.

Figures 3 and 3A show the tapered strip V in circuit with a current source B and an ammeter A whereby a change in the resistance of strip V caused by movement of the energy shadow W to a position W′ as the indicator element S moves to a position S′ causes a proportional alteration in the current flowing in the circuit so that the change in the ammeter reading is a quantitative indication of the change in the parameter which has caused movement of the indicator element.

A typical instrument to which the invention can be applied is a so-called variable area flowmeter of which a typical example is illustrated in Figure 4. It comprises a glass tube 1 with a tapered bore through which the fluid to be metered flows from its narrower end to its wider end past an indicator element in the form of a specially shaped slug 2.

The slug 2 is so shaped in relation to the taper of the bore that its position in the tube 1 is dependent upon the velocity of fluid flow through the tube balanced by gravitational force in the opposite direction. The configuration of the slug 2 and the tube 1 are critical to the accurate operation of the flowmeter and these are manufactured to fine tolerances.

Normally the flowmeter would carry graduations 1A on the outer surface of the tube 1 so that the height of the slug could be viewed and hence the fluid flow rate measured. The 'aerodynamic' shape of the slug 2 causes it to spin as a result of the flow of fluid which helps to stabilise the slug by gyroscopic action and affords an indication to a human observer that the slug is 'flying' and not adhered to the side of the glass.

The fact that the slug is finely machined to fly properly and to spin means that any method to represent the slug position electrically must not rely on any sort of physical contact with the slug.

Figure 5 shows diagrammatically how in accordance with the invention means would be provided for directing a beam of light energy through the glass tube 1 past the slug 2 (S) and onto a tapered strip of photoconductive film on the glass tube surface behind the slug 2. This strip would be connected in series in a circuit as for instance the one above described, which would indicate variations in its resistance proportional to the position of the float in the tube.

The tapered strip of film made of a photoconductive paste of any of the already mentioned substances would be applied to the glass tube 1 using a standard screen printing process involving successive stages as follows:

1) Preparation of surfaces and electrode substrates.
2) Screen printing.
3) Firing to achieve optimum temperature profile by using proprietary furnace.
4) Washing with clean water followed by methanol.
5) Dark bake, 24 hours at 75°—80°C in dark.
6) Light bake, 2 hours at 190°—200°C followed by 16 hours at 115°C under 25—50 foot candle incandescent light.
7) Quality control and test.

Preliminary experimental work using a triangular strip 1.25 inches in length with a maximum width of .25 inches yielded the following results:—

Shadowless resistance	500 ohms
Shadow at thin end	560 ohms.
Shadow at centre	680 ohms
Shadow at thick end	865 ohms

The above were obtained with an incandescent lamp held approximately two inches from the photoconductive surface.

In a practical embodiment of the flowmeter various refinements would be incorporated as follows:

a) The light source would be of non-incandescent type to minimise heat and power problems.

b) As shown in Figure 6 there would be provided a plastics material lens B with an encapsulated light source C so as to illuminate the photoconductive surface uniformly, minimise mechanical problems and to reduce the effect of ambient light.

c) The pattern of photoconductive material would be modified to constitute two tapered strips V, V′ as shown in Figure 7 so that the resistive surfaces can be connected to form two arms of a Wheatstone Bridge as shown in Figure 7A.

The advantages of this are as follows:

(i) Any temperature change which might have affected the value of the photoconductive resistance will affect both sides of the Wheatstone Bridge and therefore not affect the measured value.

(ii) A similar argument applies for changes in light intensity falling on the photoconductive surface.

(iii) The bridge arrangement automatically balances out the standing resistance of the photoconductive tapered strips, and bridge output is thus proportional only to incremental resistance alterations.

(iv) By using two arms of the bridge together, the voltage swing for change of energy shadow position is further enhanced.

Although the above is sufficient to provide a practical transducer output, variation of bridge output voltage will flow, it is likely that the production unit will incorporate a voltage-to-frequency converter as shown in Figure 7A in order to provide digital pulses out. The advantages of this are as follows:—

(i) A digital pulse stream is easily counted by modern electronic digital circuitry, and thus the finished flowmeter will enjoy wide utility.

(ii) A pulse-stream lends itself readily for transmission *via* a number of media, e.g. fibre-optics, ultrasound, microwave and so forth.

In the preferred embodiment Wheatstone Bridge and voltage/frequency converter circuit shown in Figure 11, Rf Cf are optional filter components and:

$$F\,out = \frac{Vin}{10.CRw.}$$

The dashed line encloses the components of a voltage/frequency converter unit known as AD 537 and marketed by Analog Devices Limited.

In Figure 9 there is shown a variant of the device which is illustrated in Figure 6. In this variant light from an encapsulated light source C is projected by a collimating reflector R through the glass tube 1 of a variable area flowmeter as previously described containing a specially shaped float or slug 2. Beyond the flowmeter is a photocell strip P and between the flowmeter and the strip P there is interposed a mask M with a narrow inverted triangular aperture T therein. The photocell strip may comprise cadmium selenide or preferably a diffused metal oxide silicon substrate. As is evident the slug 2 throws a shadow of varying size on the mask M depending upon its vertical position in the flowmeter housing and alters its resistance which is measurable as already described.

In Figure 9 there is shown a variant of the Figure 8 arrangement wherein the mask M has two oppositely directed vertical narrow triangular apertures T_1, T_2 which control the light falling on two photocell strips P_1, P_2 which are connected in a bridge circuit as shown in Figure 7A in order to compensate for temperature and ambient light variations.

Figure 10 illustrates a variant of Figure 9 wherein the light after passing through the double apertured mask M is focussed by a lens or lens assembly L onto a pair of small photoelectric cells P3 mounted side by side, such cells being readily available commercially.

Alternatively a photo-voltaic device could be used instead of a photoconductive device using a beta light source.

In Figure 12 there is illustrated the mode of use of a single chip microprocessor unit which receives a pulse input from the circuit of Figure 8 and which affords the facilities of pulse counting, display and serial line communications.

The invention is believed to be capable of application to many instruments other than flowmeters as is hereafter explained.

Figure 13 is thus a fragmentary side elevation of a spirit level with electrical read-out. It shows the spirit level sealed glass tube 11 which contains an opaque liquid with an air bubble 12. Extending along one side of the tube 11 with its axis concentric with the arcuate path of travel of the bubble 12 is a curved tapered strip V of photoconductive material as aforesaid. The light source is not shown but obviously would be located above the plane of the drawing paper.

Figure 14 is a fragmentary side view of a manometer comprising a U-tube 13 containing an opaque fluid 14. A light source 15 is disposed between the limbs of the U-tube 13 and alongside the limbs are respectively oppositely directed tapered strips V of photoconductive material as aforesaid so that as the liquid column is displaced by a fluid pressure change there will be a corresponding electrical resistance change.

Figure 15 is a fragmentary side view of measuring instrument having an indicating element in the form of a rotatable needle 16 of which the free end moves over a scale 17. Instead of or in addition to this scale there would be provided an arcuate tapered photoconductive strip V with a light source (not shown since it is above the plane of the drawing paper) which evenly illuminates it except where the needle casts a shadow to vary the electrical resistance of the strip as the needle moves.

Figure 16 shows a mode of application of the invention to a viscosity meter comprising a glass tube 18 and an indicating element in the form of a ball 19 fixed to the movable end of a spring 20 with the fluid flowing in the direction indicated by arrow F. The tapered photoconductive resistance strip extends along one side of the tube 18. As viscosity increases the spring 20 stretches and the ball 19 causes an energy shadow and resistance change as previously explained.

Figure 17 shows an instrument for measuring the height or change of height of a horizontal component G with a reflective top surface. It comprises a fixed light source 21 which projects a downward beam inclined at 45° to the horizontal and a fixed straight photoconductive tapered strip V having its axis parallel with that of the light beam. At different levels h_1, h_2, h_3 of the component G the light spot is reflected to different locations p_1, p_2, p_3 along the strip V with consequential and measurable alterations in its electrical resistance.

Figure 18 shows an aircraft slip indicator comprising an arcuate sealed tube 22 which contains a liquid and a ball 23. On one side of the tube 22 is a light source 24 and on the other side is the by now familiar arcuate tapered photoconductive strip V. The ball 23 moves sideways in an unco-ordinated aircraft turn and varies the resistance of the strip V in a measurable manner as already explained, whereby an electric read-out of the angle of slip can be obtained.

Claims

1. An indicating or measuring instrument of the kind referred to, characterised by the provision of means for directing a radiation energy beam across the path of movement of the indicator element onto an electrically resistive member which extends in a direction substantially parallel to that path and of which the electrical resistance varies as a function of the magnitude or position of the energy shadow incident thereon due to the intervening indicator element.

2. An instrument in accordance with claim 1 in which the electrically resistive member is at least one photoelectric cell.

3. An instrument in accordance with claim 2 in which the photoelectric cell or cells tapers in said direction.

4. An instrument in accordance with claim 1 and further comprising between the indicator and the electrically resistive member a mask having at least one aperture which tapers in said direction so as to vary the size of the energy shadow of said indicator of said electrically resistive member.

5. An instrument in accordance with claim 4 in which the mask has two apertures which are side by side and taper in opposite directions.

6. An instrument in accordance with claim 4 or 5 which further includes a lens or lens assembly which focusses light from the or each mask aperture onto a pair of adjacent photo cells.

7. An instrument in accordance with any of claims 1 to 6, in which a said electrically resistive member is connected into a Wheatstone Bridge circuit for the purpose of movement.

8. An instrument in accordance with any of claims 1 to 7, in which there are two said electrically resistive members which are connected to form two arms of a Wheatstone Bridge circuit.

9. An instrument in accordance with claim 7 or claim 8, in which the Wheatstone Bridge circuit is connected to a voltage-to-frequency converter.

10. An instrument in accordance with claim 9, in which the voltage-to-frequency converter output is fed to a microprocessor unit.

11. An instrument in accordance with any of the preceding claims, in which the energy radiation means comprises an incandescent lamp.

12. An instrument in accordance with any of claims 1 to 10, in which the energy radiation means comprises a non-incandescent lamp.

13. An instrument in accordance with claim 11 or 12, in which the lamp is encapsulated in a lens which directs an energy beam over the whole path of movement of the indicator element.

14. An indicating or measuring instrument as claimed in any of claims 1 to 13 and constructed substantially as hereinbefore described with reference to, and as shown in, any of the Figures of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained