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(56) Documents cited
GB 1520432
GB 1439598
GB 1306577
GB 1224387
GB 0909139
GB 0881444
GB 0807157
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(54) Flow sensor for breath and other gas analysers

(57) A resilient, deflectable reed or leaf spring 10 is mounted in a body 14 such that its free end region 18 is in a gas flow passage 20, 22 and can be impinged upon by gas flowing in either direction. A strain gauge 12 is mounted on one or both faces of the spring 10 and resistance changes with deflection are measured, e.g. in a bridge circuit, connected to an amplifier and comparators for producing a direction of flow signal, or to a function generator to produce an output which varies proportionately to the gas flow. The sensor is used in breath or gas testing apparatus, for determining the validity of samples, particularly for alcohol measurement, which is improved with regard to devices relying only a simple timer device. A pressure differential sensitive diaphragm may be used in the place of the spring 10.

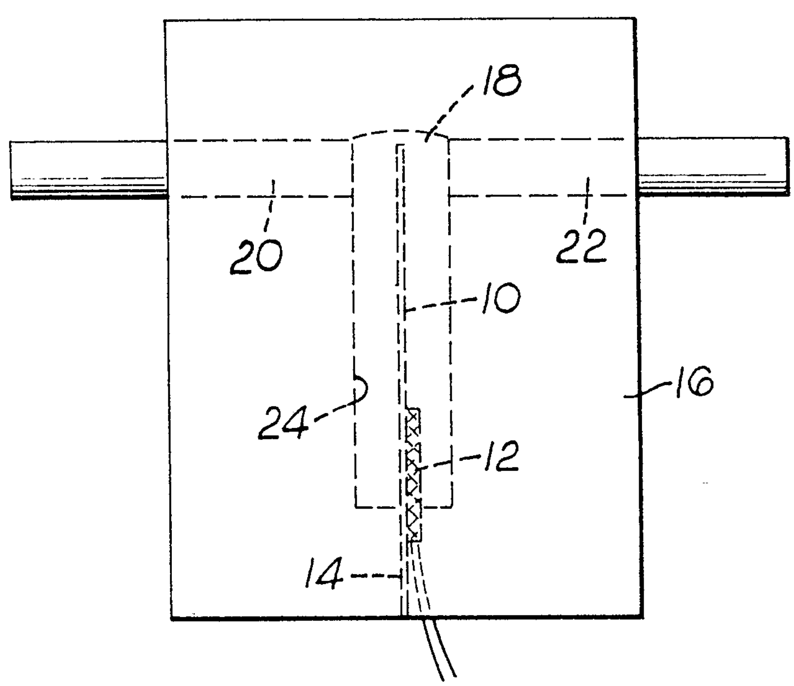

Fig. 1

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

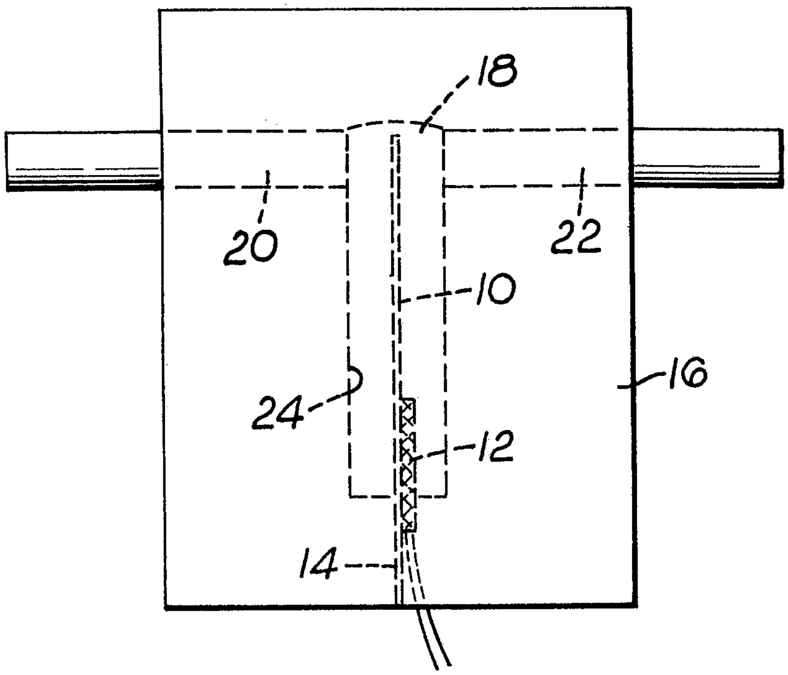

Fig. 1

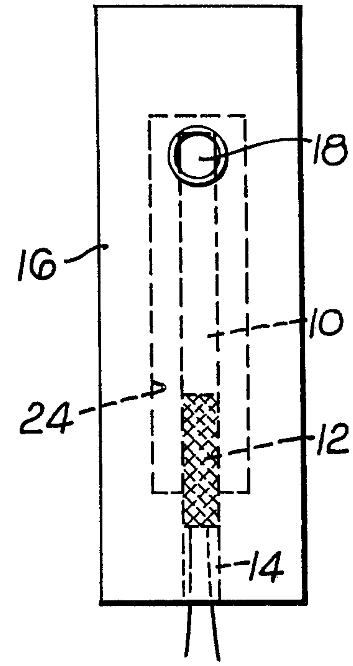

Fig. 2

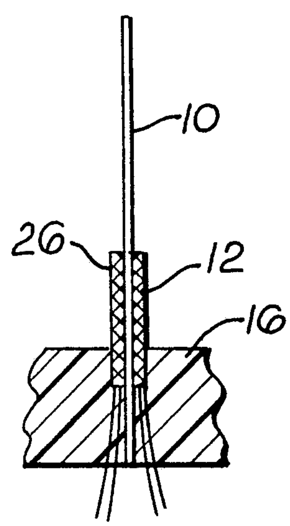

Fig. 3

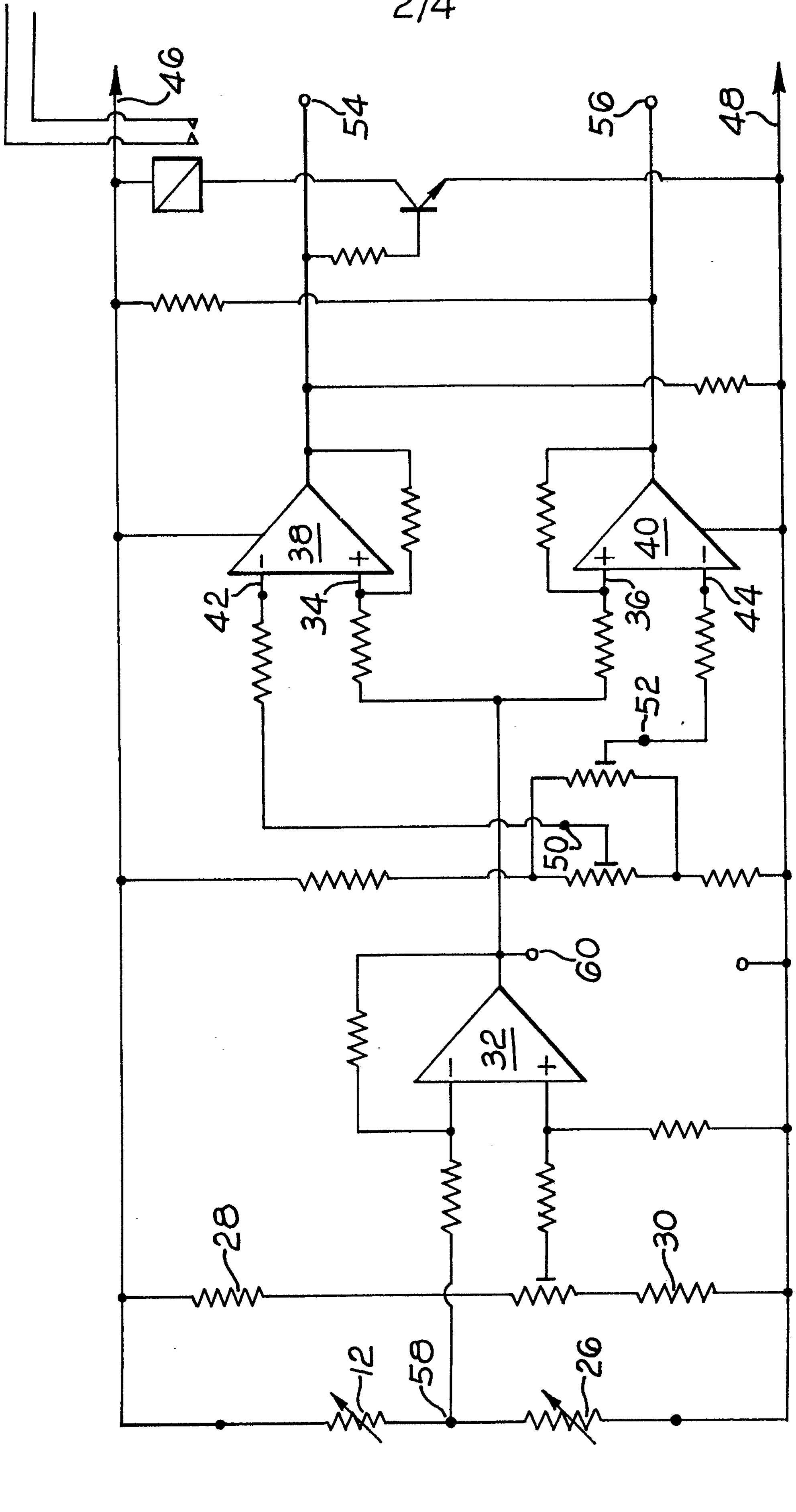

Fig. 4

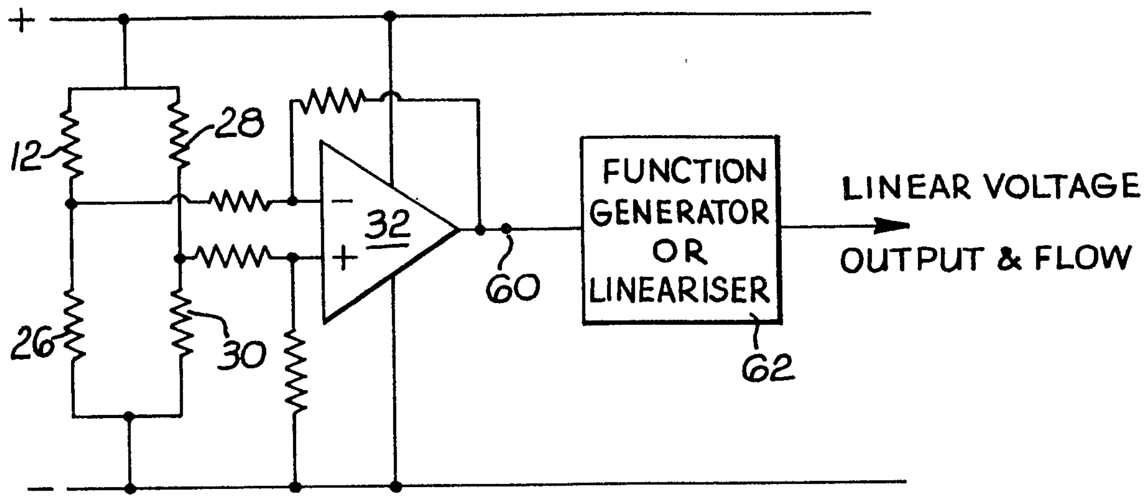
+
12
28
26
30
32
60
FUNCTION GENERATOR OR LINEARISER
62
LINEAR VOLTAGE
OUTPUT & FLOW
–

Fig. 5

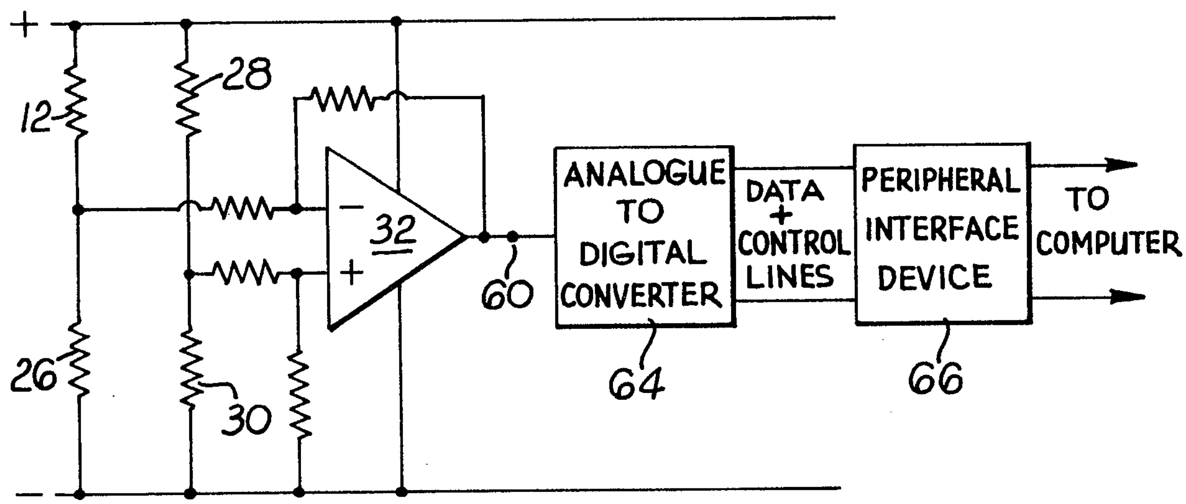
+
12
28
26
30
32
60
ANALOGUE TO DIGITAL CONVERTER
64
DATA + CONTROL LINES
PERIPHERAL INTERFACE DEVICE
66
TO COMPUTER
–

Fig. 6

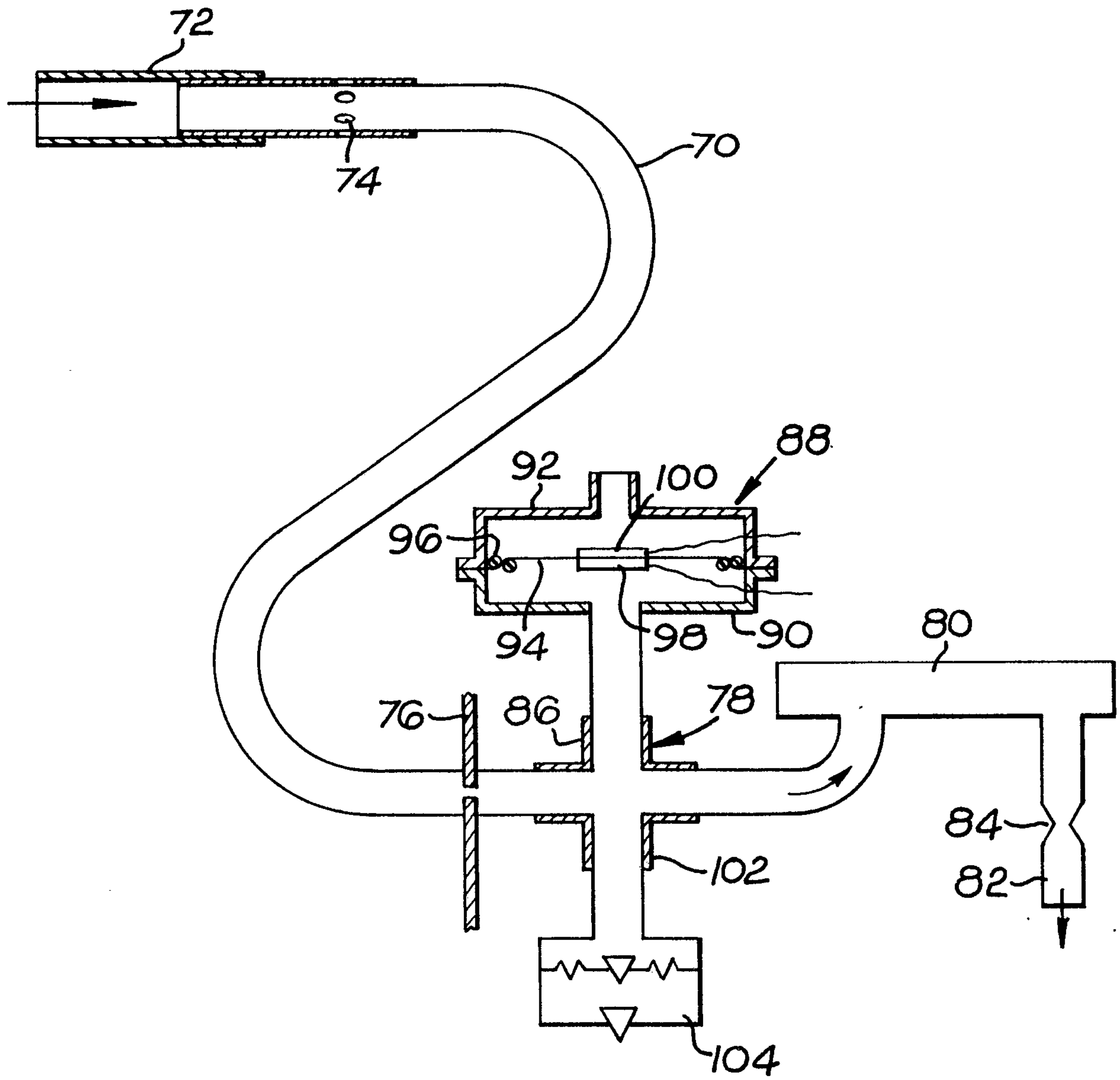

Fig. 7

SPECIFICATION

Gas flow sensor

This invention relates to a gas flow sensor, for use for sensing the validity of a gas sample supplied to a gas analysis instrument.

The invention is more particularly, but not exclusively suitable for use with an inebriate breath analyser but could be used for sensing a valid sample of gas in other gas analysers. In the case of breath analysis, where it is desired to analyse, for example, the amount of alcohol present in a sample, it is important, in the interests of accuracy, to use only deep lung breath for the analysis. It has already been proposed (e.g. in British Patent Specifications Nos. 1374143 and 1374141) to provide devices which rely upon a simple pair of electrical contacts to sense gas pressure by displacing a movable element which is coupled to said contacts thus completing an electrical circuit. This pressure sensing device is used in conjunction with a timing device such that if a preset pressure is maintained for a given time then, by implication, it is assumed that the last part of the sample taken is deep lung breath.

With the known proposal, it is, for example, possible to blow shallow breath for five seconds, or with deep exhalation to blow a valid sample in less time but the known apparatus would not recognise it as valid. Also, the application of suction to draw in air will falsify the sample completely by dilution, even if there is subsequent blowing for the predetermined time so as to give the impression of, and register, a valid sample.

An object of this invention is to provide a gas flow sensor which will enable the validity of a gas sample or breath sample to be judged on more accurate criteria than simple time lapse.

According to the invention, a gas flow sensor comprises a gas flow passage having a resilient member associated therewith so as to be deflectable by the pressure of gas flowing through the passage, at least one sensing element being provided for sensing such deflection and producing a signal indicative of the sense and magnitude of such deflection.

The resilient member may be a reed or leaf spring, fixed at one end and free at the other and arranged with its free end region in the gas flow passage so that its major surfaces may be impinged upon by gas flowing through the passage, the reed or leaf spring being mounted in such a way as to permit significant deflection by bending of the reed or leaf spring by the pressure of gas flowing through the passage.

The sensing element or elements may be strain gauges of which one is preferably mounted on each face of the deflectable resilient member, these gauges being, for example, of the kind that vary in resistance with bending so as to be effective to modify a current passed across them, in dependance on the degree of bending experienced.

As an alternative, the resilient member may be a diaphragm. This may be connected on one side to the flow passage so as to be deformable by variations in the pressure differential between its sides and preferably mounted in a bleed passage. In such an arrangement, strain gauges may be mounted one on each side of the diaphragm.

In a preferred embodiment of the invention variations in an electrical voltage are generated, as a function of gas flow, by the sensing element and this voltage is compared with a reference voltage in a comparator circuit. The comparator output is for example high (Logical "1") when the variable voltage exceeds the reference voltage and low (Logical "0") when it is less than the reference voltage. This can, of course, be reversed simply by reversing the comparator input connections. In one typical application two comparators are used, one of these comparators are used, one of these comparators serving to sense flow in one direction through the flow transducer and the other of said comparators serving to sense flow in the opposite direction. This arrangement is useful in determining the validity of a sample in breath testing or analysing equipment, that is in determining if a subject has blown or sucked at a mouthpiece of the equipment. In this embodiment of the invention the comparator outputs may be connected to a microcomputer which, if suitably programmed, can:—

a) sense if a positive breath sample has been given;

b) determine the volume of breath sample passed into the equipment;

c) select only a deep lung sample, by discarding readings obtained from an early part of the sample; and

d) sense if the subject has sucked during the process of delivering a sample.

In other words the microcomputer can be programmed to ensure that only a completely valid sample is used in the breath analysis.

The invention will be described further, by way of example, with reference to the accompanying drawings wherein:—

Fig. 1 is a diagrammatic elevation illustrating a preferred embodiment of the gas flow sensor of the invention, this sensor being particularly suitable for use in breath testing or analysing apparatus;

Fig. 2 is a side view corresponding to Fig. 1;

Fig. 3 is a part-sectional elevation illustrating part of a sensor, being a modification of that shown in Figs. 1 and 2;

Fig. 4 is a circuit diagram illustrating a suitable circuit in which the sensor of the Figs. 1 and 2 or Fig. 3 is incorporated in sample assessment equipment, such as a breath testing or analysing equipment.

Fig. 5 is a block diagram illustrating an alternative circuit to that of Fig. 4;

Fig. 6 is a block diagram illustrating another alternative circuit; and

Fig. 7 is a part-sectional diagrammatic illustration of an embodiment of breath test apparatus incorporating another embodiment of the flow sensor of the invention.

Throughout the various figures, similar reference numerals have been allocated to similar parts.

Referring firstly to Figs. 1 and 2 of the drawings, these figures illustrate a first embodiment of the gas flow sensor of the invention. This comprises a transducer which comprises a leaf spring 10 having a resistance strain gauge element 12 bonded to it. One end 14 of the spring 10 is fixed by being clamped within a diagrammatically-illustrated housing 16 whilst the other end 18 is free to be moved by the pressure of gas flow which is directed towards the spring end 18 by passages 20 and 22. The housing 16 may comprise a machined plastics block composed of two similar halves (not specifically illustrated) which can be bolted or cemented together to hold the spring 10 and strain gauge element 12. Flexure of the spring 10 to one side (e.g. to the right in Fig. 1) causes compression of the strain gauge 12 whilst flexure to the other side causes extension of the gauge element 12. The spring 10 (which may be replaced by a reed) is, of course, accommodated in a cavity 24 in the housing 16.

Compression of the strain gauge 12 causes a reduction in the resistance of the gauge 12 and extension causes an increase in its resistance. This enables gas flow direction can be sensed.

In a modification of the gas flow sensor, as shown in Fig. 3, a second strain gauge 26 is bonded to the surface of the spring 10 opposite to the strain gauge 12. By connecting the two resistance strain gauges 12 and 26 in a bridge circuit good practical sensitivity can be achieved, since as one gauge is compressed the other is extended and vice versa. Also by use of an appropriate circuit, changes in resistance due to temperature changes can be compensated.

Fig. 3 shows a suitable electrical circuit. The strain gauges 12 and 26 are connected with resistors 28 and 30 form a bridge circuit. Any out of balance voltage in the bridge, caused by gas flow bending the spring 10 is fed to inputs of a differential amplifier 32 whose amplified output is connected to one input of each 34, 36 respectively of two voltage comparators 38 and 40. The other input terminals 42, 44 respectively of the two comparators 38, 40 are connected individually to each of two independantly adjustable reference voltages as at 42, 44 by way of terminals 50, 52, such that, when the amplified out-of-balance voltage, fed for example to the positive terminal 34 of the comparator 38 is greater than the reference voltage on the negative terminal 42 on that comparator output 54 of that comparator goes high (Logic "1"). Similarly when the out-of-balance voltage fed to the positive terminal 36 of the other comparator 40 falls below the reference voltage applied to its negative terminal 44 (as is the case in reversed gas flow), output 56 of that comparator goes low (Logic "0").

In order to understand the operation of the gas flow sensor as described with reference to Figs. 3 and 4 above, let it be supposed that gas flow in the sensor is directed so that the resistance of the strain gauge 12 increases and the resistance of the strain gauge 26 decreases. This causes the voltage at point 58 in the circuit to decrease and the voltage at point 60 to increase by a greater amount, due to the gain of the amplifier 32. When the voltage at the point 60 exceeds the reference voltage at terminal 50 applied to the negative input 42 of the comparator 38, the output at 54 of the comparator 38 goes high (Logic "1"). Voltage changes at the point 60 similarly affect the comparator 40 which in this example is connected in the same way as the comparator 38.

If now the gas flow is reversed (e.g. by application of suction at a mouthpiece by which gas flow is induced through the passages 20 and 22), the resistance of the gauge 12 decreases and that of the gauge 26 increases. Correspondingly, the voltage at point 58 increases and the voltage at the point 60 decreases and when this latter value is less than that at each of the comparator negative input terminals 42, 44 the comparator output goes low (Logic "0").

These logic states are used to signal the following information to the computer:—

a) a preset flow of breath in one direction, for example into an analyser to which the gas flow sensor is connected; and/or

b) a preset flow of breath in the opposite direction (suction).

This is of particular importance in testing the breath of inebriates as suction at the end of a breath sampling period will draw air into the system and thus dilute the sample.

A further use of the sensor is as follows. Referring to Fig. 4, it will be appreciated that the voltage appearing at the point 60 varies as a function of the flow of gas through the sensor. This is normally a non-linear relationship. The output voltage at the point 60 can more conveniently be used to indicate flow if its relationship to the flow rate is linear. This can be achieved, as shown in Fig. 5, by connecting a function generator or linearising device 62 between the point 60 and a meter (not shown) used to indicate flow rate.

In another alternative as is illustrated in Fig. 6, the voltage at the point 60 is fed into an analogue to digital converter 64, the digital output of which is fed to a computer (not shown) via a suitable peripheral interface device 66. By use of an appropriate linearising programme the computer can be set up to provide a readout proportioned to the gas flow. In this case, the comparator functions could easily be implemented by means of the computer programme.

The embodiment of the gas flow sensor of the invention shown in Fig. 6 is embodied in a breath test apparatus which is illustrated only diagrammatically and comprises a flexible breath input tube 70 having a cardboard cylindrical mouthpiece 72 which is disposable and replaceable after each test for reasons of hygiene. Adjacent the mouthpiece 72 the tube 70 has a series of bleed holes 74 which allow the major part of an air sample blown into the tube 70 by way of the mouthpiece 72, to escape. The residual part of the air sample is delivered by the tube 70 through a throttle, indicated diagrammatically at 76 having an aperture of radius less than the radius of the tube 70. The throttle 76 being in the form of a heated bulkhead, which serves to create a back pressure in the tube 70 to ensure the escape of most of the breath by way of the holes 74, the residual part then passing via a four-way connection 78 to a sample cell 80 the outlet of which is a vent 82 having a flow restrictor 84.

Detector means (not shown) are provided in the sample cell 80. These may comprise a pair of infra-red sensitive diodes connected in a bridge circuit and which vary in resistance according to the amount or radiation they receive from an infra-red source. As is well known, such radiation will be diminished by the presence of alcohol in the cell 80 between the infra-red sensitive diodes and the radiation source, e.g. by absorbtion by the alcohol.

The fourway connection 78 has an arm 86 leading to a gas flow sensor in the form of a differential pressure sensor 88 comprising a pair of plastics casing halves 90, 92 and a diaphragm 94 stretched across the casing halves and sealed around its edge by staggered O-ring seals 96 and by being clamped between the casing halves 90, 92. The diaphragm 94 carries a pair of strain gauges 98, 100, which are mounted one on each face of the diaphragm 94 to sense deflection of the diaphragm 94 under the pressure exerted by the residual part of the air blown into the apparatus, which air, of course, has substantially the same pressure as the delivery pressure at which air is blown into the mouthpiece 72, and enters the sample cell 80. The gauges 98, 100 thus provide a measure of the flow of the gas. This is a measure of virtual gas flow since it is an indirect measure taken from the pressure of a residue from the main gas flow which passes out through the holes 74. Fourth arm 102 of the connection 78 is connected to a purge pump 104 which enables the apparatus to be purged after each test.

The strain gauges 98, 100 are connected into a bridge circuit as already described in connection with the previous embodiments. The apparatus is preferably used in conjunction with circuitry similar to that illustrated in Fig. 6.

The apparatus, with its circuitry and computer may be adapted to enable its operating cycle to be as follows:—

(a) Operate the purge pump 104 for thirty seconds;

(b) "Blow Now" indicator lamp is lit;

(c) A predetermined period, e.g. one minute, is allowed to blow sample. Then, if no sample delivered, the apparatus resets to be ready for restart of the cycle;

(d) The occurrence of blowing is indicated to the computer by a preset minimum signal as an equivalent digital flow rate reading at the output of the analogue/digital convertor 64;

(e) Provided this minimum signal is exceeded, the computer starts integrating the gas flow rate, so as to give a volume reading;

(f) When a predetermined volume reading is reached, a "Stop Blowing" indicator light is lit;

(g) After a fifteen second settling time, the output of the detectors of the sample cell 80 is read into the microcomputer;

(h) After a number of successive readings have indicated that conditions have settled, the analysis value derived therefrom is stored in a memory;

(i) The purge pump 104 is operated for thirty seconds; and

(j) The apparatus is reset for the next sample.

Sucking during, or at the end of, a breath sample is sensed as a negative flow rate, and serves immediately to reset the microcomputer and invalidate the sample.

The apparatus can provide a continuous series of readings from the sample cell 80 and indicate to an operator when the conditions for a valid sample have been fulfilled so that the operator knows what reading to record.

The embodiment of Fig. 7 is designed to reduce the problems arising from condensation of moisture and alcohol in the input tube 70. The input tube bleed holes 74 dump most of the sample, and the part of the sample arriving at the sample cell 80 is proportional to the total flow, so that where the apparatus is breath testing apparatus, the time when deep lung breath is delivered can still be estimated. However, a sensitive flow sensor is required because only a proportion of the breath sample is being analysed; in practice the use of a pressure-deformable diaphragm in a bleed passage, as in this embodiment, meets this requirement.

Claims

1. A gas flow sensor comprising a gas flow passage having a resilient member associated therewith so as to be deflectable by the pressure of gas flowing through the passage, at least one sensing element being provided for sensing such deflection and producing a signal indicative of the sense and magnitude of such deflection.

2. A gas flow sensor as claimed in claim 1 wherein said resilient member comprises a reed or leaf spring fixed at one end and free at the other, and arranged with its free end region in the gas flow passage so that its major surfaces may be impinged upon by gas flowing through the passage with clearances permitting significant deflection by bending of the reed or leaf spring by the pressure of gas flowing through the passage.

3. A gas flow sensor as claimed in claim 2 wherein the sensing element is a strain gauge mounted on one face of the reed or leaf spring and adapted to vary in resistance in accordance with the sense and magnitude of bending of the reed or leaf spring.

4. A gas flow sensor as claimed in claim 3 wherein a second strain gauge is mounted on the other face of the reed or leaf spring and adapted to produce a matching opposite change in resistance.

5. A gas flow sensor as claimed in claim 1 wherein the resilient member comprises a diaphragm connected on one side to the flow passage so as to be deformable by variations in the pressure differential between the sides of the diaphragm, strain gauges being provided on the diaphragm to measure the deformation of the diaphragm and thus provide a measure of pressure and thus gas flow in the passage.

6. A gas flow sensor as claimed in claim 4 or 5 wherein the strain gauges form two resistance elements of a bridge circuit which comprises two further resistance elements of fixed resistance.

7. A gas flow sensor as claimed in claim 6 wherein the outputs of the bridge circuit are connected to comparator circuits which establish an output according to the sense of deflection of the resilient member and thus the direction of gas flow through the passage.

8. A gas flow sensor as claimed in claim 7 further including an amplifier connected between the bridge and the comparators for amplifying the bridge outputs.

9. A gas flow sensor as claimed in claim 6 wherein the bridge outputs are connected via an amplifier to a functions generator or lineariser to produce a linear output voltage varying in direct proportion to the gas flow.

10. A gas flow sensor as claimed in claim 6 wherein the bridge outputs are connected via an amplifier to an analogue to digital convertor and thence to a peripheral interface device, the latter being connected to a computer input.

11. A gas flow sensor substantially as hereinbefore described with reference to and as illustrated in Figs. 1, 2 and 3 or in Fig. 7 of the accompanying drawings.

12. A gas flow sensor as claimed in claim 11 and further including circuitry as claimed in claim 4, 5 or 6 of the accompanying drawings.

13. A breath or gas analyser or test apparatus including a gas flow sensor as claimed in any preceding claim.

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