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(71) **Applicant**: **TITAN ENTERPRISES LIMITED** [GB/GB]; Unit 2A, 5A Coldharbour Business Park, Sherborne Dorset DT9 4JW (GB).

(72) **Inventor**: **FORSTER, Trevor**; c/o Unit 2A, 5A Coldharbour Business Park, Sherborne Dorset DT9 4JW (GB).

(74) **Agents**: **BEATSON, Matthew** et al.; Bryers LLP, 7 Gay Street, Bath Bath and North East Somerset, BA1 2PH (GB).

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(54) **Title**: ACOUSTIC FLOW METER

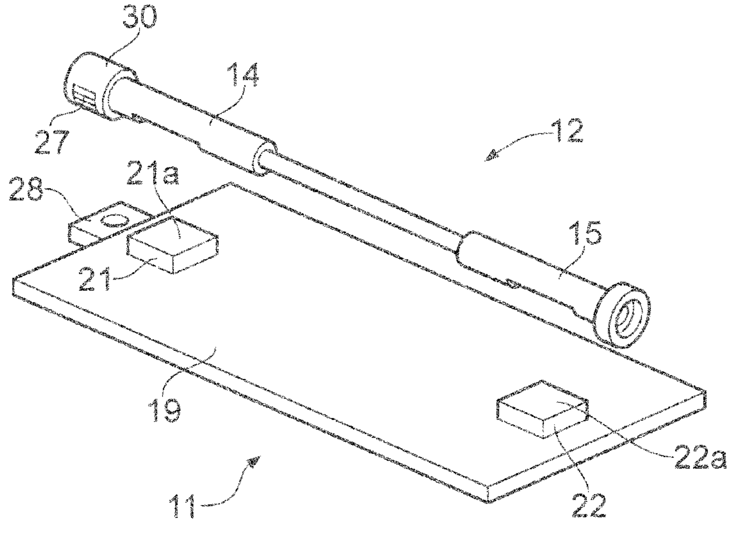

FIG. 1

(57) **Abstract**: A transit-time-differential acoustic flowmeter having transducers acoustically coupled to the outside of the flow tube and in contact therewith over a fractional part of the circumference of the side wall thereof.

ACOUSTIC FLOW METER

The present invention relates generally to an acoustic flowmeter. Acoustic flowmeters have gained wide acceptance in recent years upon the adoption of the transit time differential technique in place of the previously-used, but rather unreliable Doppler technique. Whereas the Doppler technique relied on reflections from entrained particulates the transit time differential technique employs two acoustic transducers, one for transmitting and one for receiving the acoustic signal. Transmissions are made by each transducer alternately so that the transit time with the flow of fluid in the flow tube, and the transit time against the flow can be compared to establish the flow rate of the fluid medium through which the acoustic signal is travelling. Such flowmeters may be formed in a variety of structural or mechanical arrangements. All have the common feature, however, that sonic energy, at ultrasonic frequencies, is transmitted through a fluid and received by a detector. Ultrasonic flowmeters have been used industrially to measure the flow rates of potable water, service water, acids, oils and many other freely flowing fluids, including gases, at a range of temperatures and pressures.

Many of the known industrial ultrasonic flowmeters function by transmitting the acoustic energy into the flow of the fluid being measured at an angle to the direction of travel of the fluid. This is convenient for large tubes, but there are particular advantages in creating a plane wave front travelling substantially parallel to the direction of fluid flow, especially for the smaller diameter flow tubes of medical appliances. One attempt to achieve this is made in the device described in UK patent GB 2 400 439 in which a plane wave is generated by annular acoustic transducers which form part of the flow path defined by a flow tube. For this purpose the transducers have inner surfaces which define part of the flow channel along which fluid the flow rate of which is to be measured can flow. Each annular transducer is so constructed and arranged that an electric drive signal applied to the transducer causes the inner face of the transducer to oscillate perpendicular to the axis of the tube so as to generate and propagate acoustic waves inwardly into the fluid. Because the oscillating surface surrounds the entirety of the fluid flow this generates an axisymmetric acoustic wave in the fluid which behaves substantially as a plane wave travelling along the length of the tube.

One of the advantages of using radiation with a planar wavefront is that the flowmeter is capable of providing a substantially linear performance throughout both the laminar and turbulent flow regimes.

The use of acoustic flowmeters is becoming increasingly adopted in therapeutic and medical applications where measurement of the rate of flow of body fluids, especially blood, is of increasing importance. The quantity of fluid flowing, and the flow rates, however, are rather small and there is continuing pressure to use small bore flow tubes for such purposes. Typically, the smallest useful diameter for a flow tube of a conventional known flowmeter is in the region of 6mm, whereas a flow tube having a diameter of 1mm would be more appropriate for the conditions met in medical applications. This, however, is difficult to achieve, partly because of the difficulty in coupling the acoustic signal in to a fluid in a flow tube having such small transverse dimensions, and partly because of the signal-to-noise ratio which in small tubes is much greater than in flow tubes of larger dimensions as a result of the multiple reflections which take place in the smaller tube. The present invention seeks to provide a flowmeter in which these requirements can be met, in particular by providing, according to one aspect of the invention, an axial transit-time-differential acoustic flowmeter having transducers acoustically coupled to the outside of the flow tube and in contact therewith over a fractional part of the circumference of the side wall thereof.

In one embodiment the flowmeter has means for generating an excitation signal such as to cause the generation of an acoustic wave by a transmitting transducer the frequency of which lies within a range at which, in relation to the spacing of the transducers, the said acoustic wave propagates along the flow tube as a substantially plane wave, at least over that part of its path approaching the receiving transducer.

Although the plane wave has certain advantages it is not essential for the wavefront to be planar. However, by arranging for a substantially plane wavefront for be propagated along the tube the signal-to-noise ratio remains within tolerable limits despite the fact that the flow tube may have small dimensions, and the transducers are coupled through the side wall.

One feature of the acoustic flowmeter according the present invention is that the acoustic impedance of the flow measurement section of the flow tube may be significantly higher than that of the liquid being monitored. This may be achieved, for example, by using a material such as stainless steel.

Preferably the transducers have substantially flat faces from which the acoustic signal is transmitted and there are provided acoustic coupling means between the active face of the transducer and the outer surface of the flow tube.

The use of acoustic transducers coupled to the fluid through the wall of the flow tube itself, as opposed to being coupled through an opening in the flow tube wall as in known flowmeters, means that ready removability of the transducers can be achieved. For this purpose the acoustic transducers may be fixedly mounted on the body of the flowmeter and a releasable connection provided between the acoustic transducers and the acoustic coupling mean or the flow tube. This is economic, although there is some additional costs associated with the fact that the calibration of a flowmeter having a flow tube which is not in contact with its acoustic transducers upon manufacture (at which time the flow tube itself would be calibrated) involves a more careful and possibly more complex calibration technique in order to ensure adequate accuracy.

In any event there may be provided means for recording calibration data on the flow tube, either marked thereon or on a part of the acoustic coupling means. Alternatively means for recording the calibration data may comprise an element carrying a machine-readable code, which may be fixed to the flow tube or the acoustic coupling means.

Such means for recording calibration data may alternatively comprise a machine-readable code marked or otherwise applied directly to the flow tube or to the said acoustic coupling means. Such machine-readable code may be an optical or magnetic record, although, of course, any suitable form of information storage medium may be utilised.

The form of the transducers in such a flowmeter has to be chosen carefully. It has been found, however, that transducers having an active face which matches the shape of the side wall of the flow tube works very well. Alternatively, however, the transducers may have a parallelepiped shape with a substantially flat face in contact with the said acoustic coupling means. These are capable of providing a suitable acoustic signal for transmission into a narrow flow tube, so that it is unnecessary to provide an encircling transducer in order to achieve a substantially planar wave front. The factors to take into account for this are the choice of the frequency of the ultrasonic signal and the spacing between the two transducers as well as the diameter of the flow tube. In a preferred embodiment, the two transducers act alternately as transmitters and receivers in a time-shift multiplex mode of operation. A parallelepiped acoustic transducer may be stimulated to resonate in one of three modes, namely lengthwise oscillation (length mode), transverse oscillation in the direction of the width of the transducer (width mode) or oscillation within the thickness of the material (thickness mode). By making the dimensions of the parallelepiped sufficiently different from one another the resonant frequencies at which these three modes of oscillation can be stimulated are sufficiently different from one another that the acoustic energy transmitted into the fluid flow is suitable for use with different ranges of flow rate, thereby making a single flowmeter capable of determining a wider range of flow rates than might otherwise be the case if only a single mode of oscillation were available.

In an alternative embodiment the transducers may have a concavely curved face in contact with the acoustic coupling means or the flow tube. Such transducers may have a part-annular, that is arcuate, shape and the driving circuitry may be connected to the or each such transducer in such a way as to stimulate its oscillation in a radial mode. Thickness mode oscillation is also available although, with a partially annular configuration the length mode is not practicable.

The frequency of the acoustic wave generated upon energisation of the driving circuit is determined in relation to the length, the diameter and the wall thickness of the flow tube in such a way that, in use, a substantially planar acoustic wave is propagated through the fluid along the length of the tube. Although this may not be a strictly axisymmetric wave front, the off-axis components of the wave are sufficiently attenuated during transmission along the length of the flow tube between the transmitting and receiving transducer that a reliable transit-time determination of the flow rate may be made.

The flow tube may have a generally circular cross section. Tthe transducers may have an arcuate or a substantially parallelpiped shape, the latter with a flat active face. It is of course, not essential for the flow tube to have a circular cross section, although this is particularly convenient. Alternatively the flow tube may have a triangular, square or, indeed any polygonal cross section.

Further, the flow tube may be substantially straight along its entire length between the acoustic coupling means, but again this is not essential and curved flow tubes may be utilised if the circumstances require it. Preferably, however, there are no singularities between the acoustic coupling means and the flow tube which might cause a disruption in the fluid flow. For this reason the flow tube preferably has a constant flow cross section along its length between the acoustic coupling means, although the flow cross section of the tube at or to either side of the region between the acoustic coupling means may be different from that of the portion of the flow tube between the acoustic coupling means.

The acoustic coupling means and the acoustic transducers are preferably held in contact with one another (if separable) by connection means operable to apply a mechanical force to the interface between the transducer and the coupling means. In the case of a parallelepiped transducer such interface will be substantially flat.

Preferably, a single driving circuit is connected to both transducers and is arranged to deliver energising signals thereto and, likewise, a single detection circuit is preferably connected to both transducers and is operable to process electrical signals generated by both transducers. This may be done in a time-shift multiplex mode, or may be done simultaneously. Likewise, it is possible to determine the phase shift or time difference upon transit upstream and downstream.

As mentioned above, in embodiments of the invention in which the flow tube itself is separable from the transducers (the transducers being permanently mounted on the flowmeter body) it is necessary to ensure that accurate calibration of the assembled instrument is effected once the flow tube has been mounted in position. Although, upon manufacture, a preliminary calibration of the flow tube may be made, the precise separation of the transducers on any one transducer body cannot be determined in advance and accordingly a subsequent recalibration (or initial calibration if a preliminary calibration has not been undertaken) is necessary to establish the parameters of the flowmeter prior to use.

Various embodiments of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view of the major components of a first embodiment of the invention shown partially assembled;

Figure 2 is an axial sectional view through an assembled flowmeter as in the embodiment of Figure 1;

Figure 3 is a schematic perspective view of an inverted flow tube of the embodiment of Figures 1 and 2, showing how the transducers engage the acoustic coupling means;

Figure 4 is a schematic perspective view of the major components of a flowmeter formed as a second embodiment of the invention;

Figure 5 is a schematic perspective view illustrating the major components of an alternative embodiment of the invention;

Figure 6 is a partially assembled perspective view of a further alternative embodiment;

Figure 7 is a perspective view of the embodiment of Figure 6, showing it assembled; and

Figure 8 is an enlarged detail of the embodiment of Figures 6 and 7.

Referring now to the drawings, and particularly to Figures 1, 2 and 3 thereof, there is shown a flowmeter generally indicated 11 having an elongate flow tube generally indicated 12 which comprises a stainless steel tube forming a central section 13 having respective acoustic couplers means 14, 15 at each end. The acoustic couplers 14, 15 are substantially identical polymer mouldings which are connected to the ends of the stainless steel tube 13 and have an internal passage 16, 17 respectively (see Figure 2) which is of the same internal diameter as the internal bore 18 within the stainless steel tube 13 so that fluid flowing therethrough experiences no discontinuities or disturbances in the flow path, thereby avoiding (as far as this is possible) the introduction of turbulence into the stream.

The flowmeter 11 has a body 19 incorporating the control circuitry generally indicated 20 in Figure 2 and shown schematically. Two piezoelectric transducers 21, 22 are mounted on the body 19 of the flowmeter 11, and are held in contact with respective acoustic couplers 14, 15. As can be seen particularly in Figures 1 and 3 each acoustic coupler 14, 15 is generally cylindrical and has a flat-faced recess or cavity 23, 24 respectively in its curved surface, the flat face of the recess or cavity lying on a chord of the circular profile of the coupler. Each transducer 21, 22 is generally of cylindrical form with a flat face 21a, 22a respectively. Upon assembly, as shown in Figure 2, the transducers 21, 22 are located in respective recesses 23, 24 in the acoustic couplers 14, 15 with their flat faces 21a, 22a in intimate contact with the flat faces of the recesses 23, 24.

The transducers 21, 22 are permanently fixed to the body 19 of the flowmeter 11, and the connection between the transducers 21, 22 and the acoustic couplers 14, 15 is releasable. This is achieved, in this embodiment, by pressure members 25, 26, held in place by straps or other means (not shown). It is important that the acoustic couplers 14, 15 are held in firm engagement with the transducers 21, 22, preferably with a reactive force between them such as would be achieved by locating the couplers 14, 15 in place with a spring clip or screw connection, clamp or the like.

The dimensions of the transducers 21, 22 are chosen in such a way as to maximise the capacitance of the piezoelectric plate whilst remaining consistent with the requirement to provide the overall system with sufficient mechanical strength.

Because the flow tube 12 having its associated acoustic couplers 14, 15 is interchangeable with other such flow tubes it is important that appropriate calibration is undertaken in order to ensure accurate readings. The flow tube 12 may be subject to a preliminary calibration step during manufacture, and the information concerning the calibration recorded, for example on a barcode 27 on one of the couplers, in the example illustrated in Figures 1 to 3 the coupler 14. Alternatively, of course, the barcode 27 may be printed directly on to the tube 13 itself. This barcode comprises information relating to the serial number of the flow tube, the date of calibration of the flow tube and the calibration constants which are specific to that flow tube. A barcode reader 28, for example a camera or other such sensitive device, is located on the body 19 of the flowmeter 11, and is able to read the barcode 27 on the coupler 14 during installation of the interchangeable flow tube 12. For this purpose it is necessary that the barcode 27 be displaced with respect to the reader 28, for which purpose a sleeve 30 of the coupler 14 may be so formed that relative turning of this can achieve an appropriate relative displacement between the barcode 27 and the reader 28. On initialisation of the flow measurement process the barcode reader then reads the flowmeter batch data and the calibration factors which are then used in the subsequent flow measurement.

The flowmeter is a transit-time ultrasonic flowmeter in which the piezoelectric transducers act both to transmit and to receive acoustic signals used to measure the flow rate of the liquid by using the transit time difference between signals transmitted in opposite directions along the length of the flow tube. Methods for measuring time difference and converting these to a flow velocity or flow volume are well known to those skilled in the art.

Figure 4 illustrates an alternative embodiment having a different configuration. It will be noted that, throughout the drawings, and in the different embodiments, those components which are the same as, similar to, or fulfil the same function as, corresponding components described in relation to Figures 1 to 3, have been identified with the same reference numerals. In the embodiment of Figure 4 the flow tube 12 differs from that in the embodiment of Figures 1 to 3 in that the acoustic couplers 14, 15 at each end of the central tube 13 have respective permanently-fixed piezoelectric transducers 21, 22 secured thereto.

In this embodiment the piezoelectric transducers 21, 22 are shaped differently from those in the embodiment of Figures 1-3, being quadrantal elements having radially inner and outer curved surfaces the radially inner of which is securely connected, for example by adhesive or other acoustic coupling material, to the respective acoustic coupler 14, 15. For this purpose each acoustic coupler 14, 15 has a circumferential groove 33, 34 in to which the radially inner curved face of the respective piezoelectric transducer 21, 22 is fitted. Opposite flat faces 31, 32 of the quadrantal transducers 21, 22 are silvered to provide electrical contact surfaces, and these engage with respective spring contacts, 35, 36 carried by the body 19 of the flowmeter 11. Both transducers act to radiate acoustic signal through the side wall of the flow passage from the same side thereof, and the choice of operating frequency is made in relation to the flow tube diameter, the wall thickness and the transducer separations to achieve a plane wave front travelling along the tube by the time the acoustic wave reaches the receiving transducer. This increases the signal-to-noise ratio and ensures that the flowmeter provides an adequate accurate output signal.

In the embodiment of Figure 5 the transducers 21, 22 are again quadrantal in shape (or more accurately arcuate as they may not extend fully over 90°, but in this case they are fixedly secured, possibly even embedded, in the body 19 of the flowmeter 11. The radially inner curved surfaces 37, 38 of the transducers 21, 22 engage in circumferential grooves 33, 34 of the acoustic couplers 14, 15. Unlike the embodiment of Figure 4 the transducers 21, 22 are not secured fixedly to the acoustic couplers 14, 15, but rather are simply held in place by suitable releasable connectors (not shown) which may be for example, spring clips, surrounding straps or other clamping means capable of providing suitable contact pressure between the transducers 21, 22 and the acoustic couplers 14,15. This embodiment, like the embodiment of Figures 1 to 3, is more economical to produce since the disposable flow tube 12 is simpler and does not have the piezoelectric transducers incorporated in it. For this reason, as discussed in relation to Figures 1 to 3, greater measures must be taken to achieve calibration, and a similar calibration technique to that described in relation to the embodiment of Figures 1 to 3, utilising a barcode or other record of preliminary calibration data on the tube 13 or one of the acoustic couplers 14, 15 may likewise be provided.

A further alternative embodiment is illustrated in Figures 6, 7 and 8. In this embodiment the acoustic couplers 14, 15 at each end of the central tube 13 of the disposable flow tube 12 have a different cross sectional shape from that of the flow tube 13 itself. In detail, considering the acoustic coupler 15, this comprises a flat rectangular central section 60 bounded by two opposite flat faces 61, 62 and joined to the circular section of the tube 13 by flattened conical or tapering horn-like interconnection sections 63, 64 having a circular cross section at one end where they join the circular flow tube 13 and a generally rectangular cross section where they join the flattened rectangular coupler 15.

The acoustic couplers 14, 15 fit snugly into respective slots 65, 66 between the piezoelectric transducers 21, 22 and respective reaction blocks 71, 71 made of a material such as to enhance the resonance of the transducers 21, 22. In this embodiment the transducers 21, 22 are parallelepiped in shape. As will be appreciated, parallelepiped transducers such as the transducers 21, 22 illustrated in Figures 6, 7 and 8 of the drawings, have three resonant frequencies corresponding to resonances of the structure between the main faces (thickness mode) along its length (length mode) and across its width (width mode).

By exciting the piezoelectric electric transducer across its thickness at a frequency corresponding to the length resonance an ultrasonic wave at a suitable frequency is launched into the fluid in the flow tube. The thickness of the material (being a suitable polymer) of which the acoustic coupler 14, 15 is made is chosen such that matching of the impedance between the fluid intended to pass through the tube 13 and the piezoelectric material of the transducers 21, 22 is optimised. The thickness of the acoustic coupler (that is the dimension between the internal bore 17 and outer cylindrical surface can be determined by reference to the intended frequency of the acoustic wave and the speed of sound in the material from which the coupler is made. Although described as being energised in the length mode, it is to be understood that the resonant frequency in any of the moulds may be used to generate a plane wave in the conduit providing the frequency of energisation is selected appropriately. For example, the piezoelectric transducer may be energised at the 250kHz resonance condition for anticipated high flow rate in the tube 13, whereas by switching to 1Mhz resonance it may be adapted for lower flows. This allows the greater relative phase shift of the higher frequency signal (for a given tube length) to give a better resolution at the lower flow rate. In this way the operating range of the flowmeter 11 can be extended.

In the embodiment of Figures 5, 6, 7 and 8, the transducers 21, 22 may be excited in the thickness mode to resonate in the length mode.

The transducers 21, 22 in the embodiment of Figures 6 to 8 are carried on respective transducer mounts 77, 78 which are themselves carried by the body 19 (not shown in Figures 6 to 9) at a determined spacing D which is known for a given transducer body. By utilising flattened rectangular coupler bodies 14, 15, however, any variations in the length of the disposable flow tube 12 can be easily accommodated providing, as discussed above, appropriate measures are taken to calibrate the instruments once the flow tube has been fitted.

There may be circumstances where the available distance for a separation of the transducers 21, 22 equivalent to the distance D in Figure 7, is less than the required length of the flow tube 12, in which case an embodiment such as that illustrated in Figure 9 may be utilised. Here, the central metal tubular part 13 of the flow tube 12 is formed into a circle so that its ends joining the acoustic couplers 14, 15 are relatively closely spaced. In this embodiment arcuate piezoelectric transducers 21, 22 are permanently connected to the couplers 14, 15. Other components of this embodiment, such as the flow meter body 19 and the physical connections of the couplers 14, 15 to this body are not illustrated. The advantage of utilising a part-annular or arcuate transducer lies in the significant reduction in the amount of piezoelectric material used in the construction of a flow tube which is intended to be disposable.

CLAIMS

1. A transit-time-differential acoustic flowmeter having transducers acoustically coupled to the outside of the flow tube and in contact therewith over a fractional part of the circumference of the side wall thereof.

2. A transit time differential acoustic flowmeter as claimed in claim 1, in which there are provided means for generating an excitation signal such as to cause the generation of an acoustic wave having a plane wavefront by a transmitting transducer.

3. An acoustic flowmeter a claimed in Claim 2, in which the transducers have substantially flat faces from which the acoustic signal is transmitted, and there are provided acoustic coupling means between the active face of the transducer and the outer surface of the flow tube.

4. An acoustic flowmeter as claimed in any of Claims 1 to 3, in which the active face of the transducer matches the shape of the side wall of the flow tube.

5. An acoustic flowmeter as claimed in claim 4, in which the flow tube has a generally circular cross-section and the transducers have an arcuately curved active surface.

6. An acoustic flowmeter as claimed in claim 3, in which the flow tube has a generally circular cross-section.

7. An acoustic flowmeter as claimed in claim 3, in which the flow tube has a triangular, square or polygonall cross-section.

8. An acoustic flowmeter as claimed in any preceding claim, in which there are provide acoustic coupling means between each transducer and the flow tube or the fluid therein.

9. An acoustic flowmeter as claimed in any of Claims 8, in which the acoustic coupling means comprise a plastic material mouldable to the shape of the interface between the flow tube and a transducer.

10. An acoustic flowmeter as claimed in claim 8, in which the acoustic coupling means comprise or include a rigid plastics element.

11. An acoustic flowmeter as claimed in any preceding claim, in which the transducers are spaced by a distance such that, in relation to the wall thickness of the flow tube and the intended frequency of the acoustic signals, acoustic energy is, in use, propagated along the flow tube from the transmitting transducer with a substantially plane wavefront, at least in the vicinity of the receiving transducer.

12. An acoustic flowmeter as claimed in any preceding claim, in which the or each transducer is generally parallelpiped in shape and is connected for excitation to resonate in the length mode.

13. An acoustic flowmeter as claimed in any preceding claim, in which the or each transducer is generally parallelpiped in shape and is connected for excitation to resonate in the width mode.

14. An acoustic flowmeter as claimed in any preceding claim, in which the or each transducer is generally parallelpiped in shape and is connected for excitation to resonate in the thickness mode.

15. An acoustic flowmeter as claimed in any preceding claim, in which the acoustic coupling means and the acoustic transducers are held in contact with one another by connection means operable to apply a force to the interface between the transducer and the coupling.

16. An acoustic flowmeter as claimed in any preceding claim, in which the flow tube is substantially straight along its entire length between the acoustic coupling means, with no singularities between the said acoustic coupling means and the flow tube.

17. An acoustic flowmeter as claimed in Claim 16, in which a single detection circuit is connected to both transducers, and operable to process electrical signals generated by both transducers.

18. An acoustic flowmeter as claimed in any preceding claim, in which the driving circuitry and the connection to the acoustic transducers are such that the transducers can be stimulated selectively to resonate at one of a number of different frequencies whereby to extend the range of flow rates measurable by the flowmeter.

19. An acoustic flowmeter as claimed in any preceding claim, in which the flow tube is substantially straight along its entire length between the acoustic coupling means, with no singularities between the said acoustic coupling means.

20. An acoustic flowmeter as claimed in any of claims 1 to 19, in which the flow tube is curved along at least part of its length.

21. An acoustic flowmeter as claimed in any preceding claim, in which the flow tube has a constant transverse dimension along its length.

22. An acoustic transducer as claimed in any of claim 11 to 20, in which the flow tube has an intermediate section of different transverse dimension from the ends.

23. An acoustic flowmeter substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

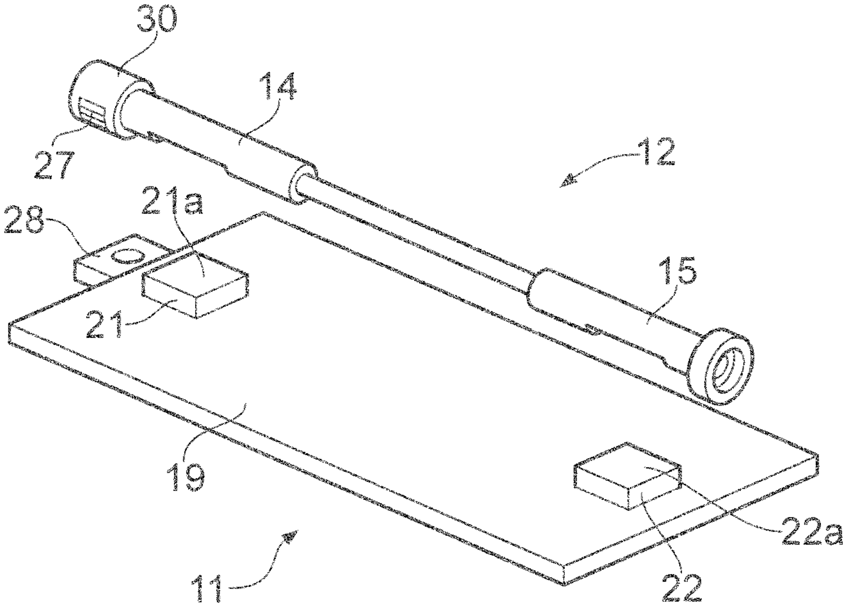

FIG. 1

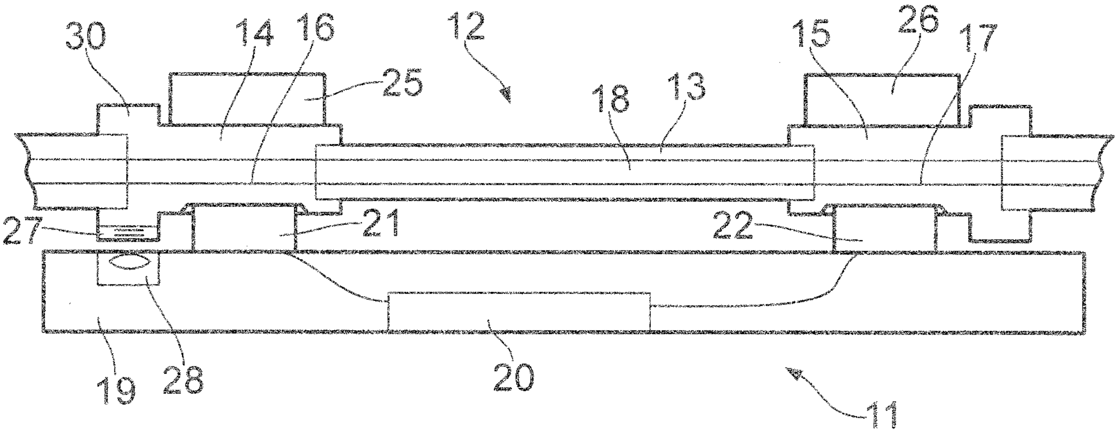

FIG. 2

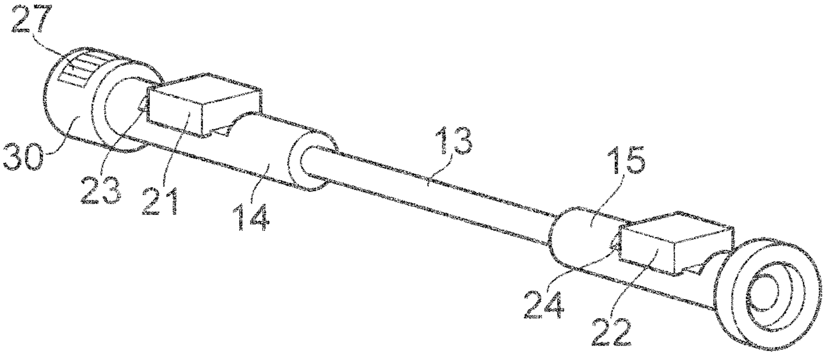

FIG. 3

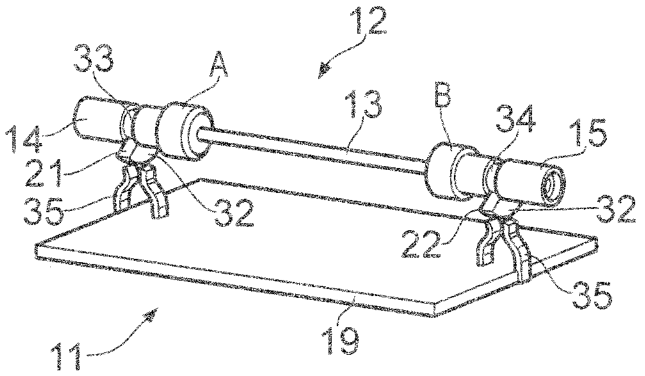

FIG. 4

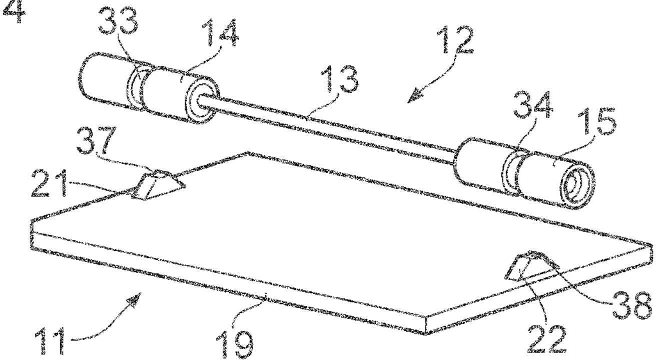

FIG. 5

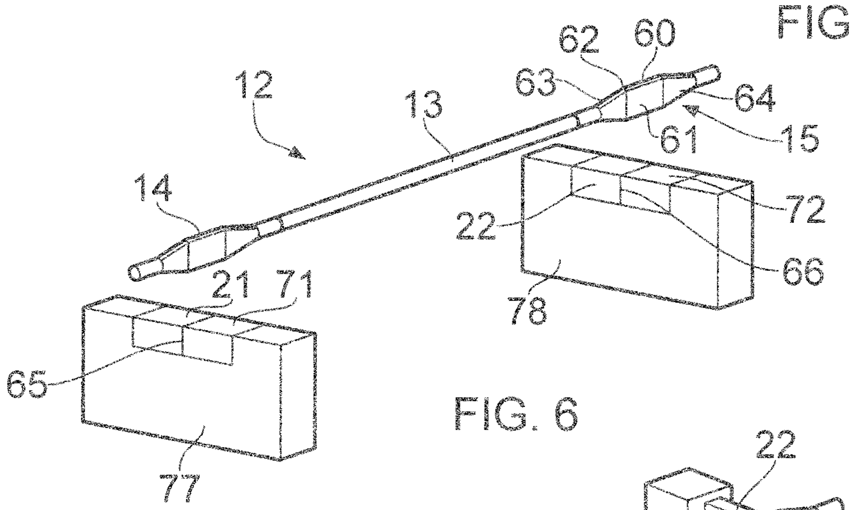

FIG. 6

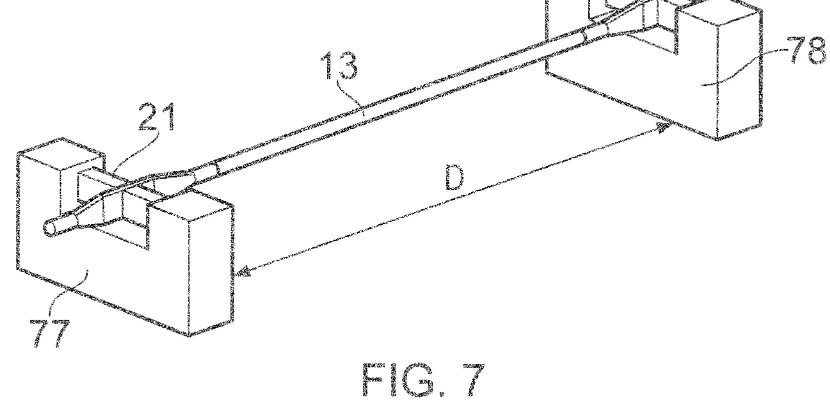

FIG. 7

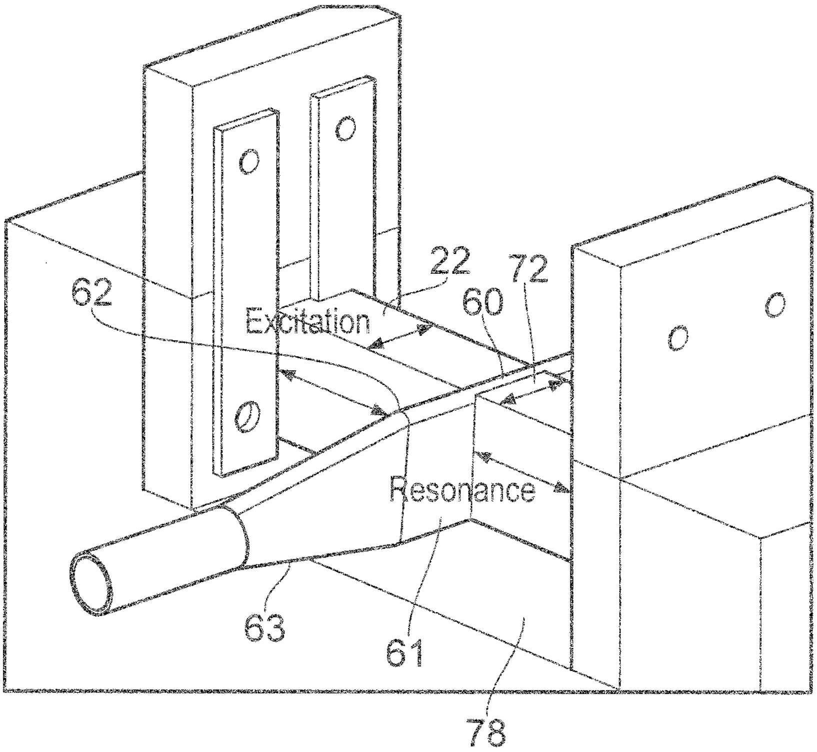

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/065555

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01F1/66
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/033055 A1 (OHKAWA MICHIO [JP]) 21 March 2002 (2002-03-21) paragraphs [0009] - [0015], [0036] - [0051]; figures 1-10 -----	1-6,8,9, 12-16, 18,19, 21,23
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search 28 November 2013	Date of mailing of the international search report 06/12/2013
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Rambaud, Dilek

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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