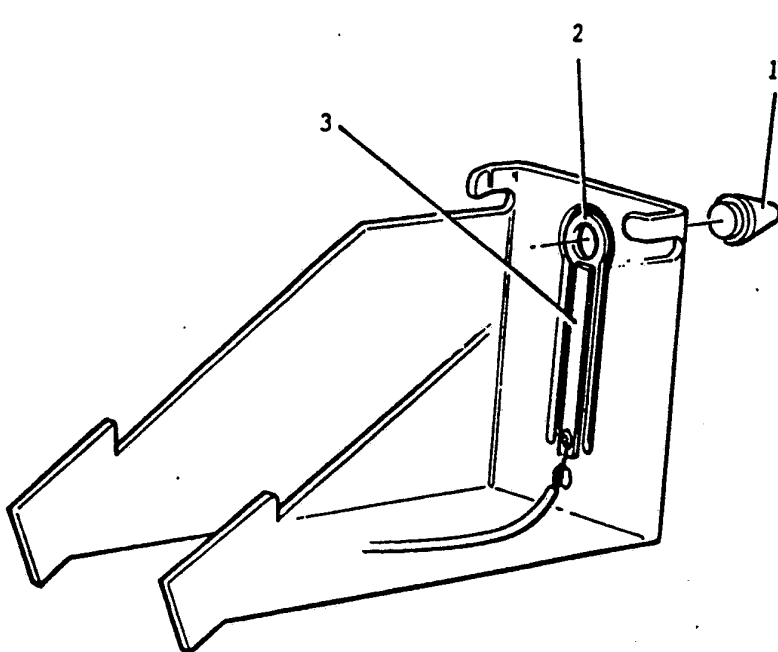




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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| <b>(54) Title:</b> MOVEMENT SENSOR USING MECHANICAL VIBRATIONS<br><br><div style="text-align: center;">  </div><br><b>(57) Abstract</b><br><br><p>A movement sensor (40) for a process device has a sensor tip (42); means (41) for transmitting the vibrations from the sensor tip to a transducer means (43), the transducer means electrically detecting the resulting vibrations as movement occurs and producing an output signal. Means (70) can be provided for filtering the output signal below and above respective predetermined frequencies and producing a movement detection signal when the output signal lies between the predetermined frequencies.</p> |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

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Movement Sensor Using Mechanical Vibrations

5 This invention relates to a method of detecting the movement of an active device relative to a surface, in order to control the operation of the device to process the surface in some way. A particular field of application is for controlling a range of hand held devices used for writing, scanning, coating, spraying, heating, etc..

10 There are many applications where it is necessary to bring some device up to a surface, which cannot be prepared in any way beforehand, and to move the device over the surface whilst treating or sensing the surface in some way. Examples are:

- 15 - writing or printing on the surface by depositing ink
- spraying some material onto the surface
- using an optical sensor to read existing marks on the surface, such as bar codes or letters
- 20 - heating the surface with a focused beam of infra-red radiation
- writing or reading a magnetic pattern with an electromagnetic head.

A particular example is in the context of hand held printers.

25 In the general applications it is necessary to generate a signal to control the process to treat the desired region of the surface in the correct way.

30 The basic control function that is required is to turn the process on when the device is moving across the surface, and in contact with it. In some cases, as in a writing instrument, it may be necessary to signal that contact has been made, even if there is no transverse movement.

35 In the prior art various techniques have been used to generate the control signal. The simplest approach in a hand-held device is to provide a finger operated switch, as in the ink jet pen described in US-A-4 746 936. The user

has to decide exactly when to turn the device on and off. In practice this is inconvenient to use, and does not provide accurate enough control.

Many existing devices, e.g. as described in  
5 US-A-4 168 533 have a wheel or belt which is moved by friction as the device travels across the surface. The movement of the wheel or belt is then detected by some additional sensor system. This approach can provide good results in many applications, but has a number of  
10 disadvantages:

- the low reliability of a moving parts mechanism
- high component and assembly costs
- large size and inconvenient shape
- single direction operation.

15 The object of the current invention is to provide a sensor which overcomes the disadvantages of the prior art to offer the following:

- solid state operation, and reliability
- small size
- 20 - low cost
- omni-directional operation
- convenient shapes and formats.

The present invention provides a sensor device which is sensitive to the vibrations generated by the movement of  
25 one surface, that of the part of the process device touching the surface being treated, in contact with another surface, that being treated.

According to the present invention there is provided a movement sensor for a process device, comprising

30 a sensor tip;

means for transmitting the vibrations from the sensor tip to a transducer means, the transducer means electrically detecting the resulting vibrations as movement occurs and producing an output signal.

35 Preferably, the movement sensor comprises means for filtering the output signal below and above respective predetermined frequencies and producing a movement

detection signal when the output signal lies between the predetermined frequencies.

Although in the presently preferred embodiments of the invention, the transducer is a piezoelectric device, it is envisaged that the vibrations may alternatively be detected by a microphone constituting the transducer, and in which case, an acoustic waveguide may be used to direct the air vibrations to the microphone from the supporting means.

The device finds particular application in a hand-held writing instrument as described in our co-pending application, reference 90/4361/03, but may also be used in a wide range of other devices where movement sensing is important. For example, the device may be used to sense movement of a pen across the paper surface in an X-Y plotter used for preparing drawings and the like, or may be used to detect paper movement in devices such as printers, fax machines, photocopiers or the like, in order to provide a fast way of sensing paper jamming.

Three examples of sensors according to the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is an exploded view of a first example;

Figure 2 is a side view of a modification of the first example;

Figure 3 is a side view of a second example.

Figure 4 is a plan view of a third sensor assembly;

Figure 5 is a diagrammatic partial side view of the third sensor assembly;

Figures 6A & 6B are diagrammatic side views of part of the third sensor shown engaged with a sheet of paper, figure 6B being on a much enlarged scale;

Figure 7 is are block circuit diagrams of the electronic components for operating the third sensor; and,

Figure 8 is a waveform diagram showing filtering of the sensor signal.

In the first example, a stylus or sensor tip 1 is mounted on a cantilever 2 mounted on a laser writing

device. A piezoelectric strain gauge 3 is mounted on the cantilever 2 and detects vibrations generated by movement of the stylus 1 over the writing surface.

The principle of operation is as follows:

5        When the process device is not in contact with the surface the transducer receives no vibrations, and as a result, the process device can be controlled to be off.

         When the stylus 1 touches a writing surface, a vibration impulse is transmitted to the transducer. This  
10       provides a signal that contact has been made. This can be used to turn on the process device instantaneously.

         If there is no transverse movement, no further vibrations are generated, and the process device is controlled off.

15       When there is transverse movement, in any direction, vibrations are generated and detected, thus controlling the process device on, to process the surface over which the device is moving.

         The example of figures 1 and 2 shows a sensor applied  
20       to a hand held marker pen being operated in the way described below in connection with the third example (see also our copending application, reference 90/4361/03).

         The tip of the sensor consists of a stylus 1 connected to a cantilever and makes contact with the writing surface  
25       10, so that vibrations are produced when there is relative movement. The vibration is a result of factors such as the roughness of the writing surface and the friction between the surface and the stylus. The vibration signal can be enhanced by the choice of stylus material, its surface  
30       finish, and its geometry.

         The strain gauge, preferably a piezo-electric ceramic transducer 3, monitors the compliant region of the stylus assembly. The associated electronic signal processing is arranged to distinguish between sensor signals caused by  
35       writing, and spurious signals due to other causes such as airborne noise, and vibrations generated in the body of the marker, e.g. by tapping it. The level and frequency

content of the vibrations can be used as discriminating features.

It is also possible to derive a velocity signal from the vibration signal. For example, as the velocity of the pen increases, so does the mean frequency of the vibrations and the total vibration energy. Suitable signal processing and calibration allows the marking process to be controlled to take account of velocity variations. When marks are made by pulses of laser energy, the pulse repetition rate can be increased at high velocities, to keep the distance between pulses, and the marks, more consistent.

In a second example, shown in figure 3, the stylus 1 is mounted on a shaft 5 which, in turn is connected to a cantilever 2, on which is mounted a transducer 3 as in the first example.

In a further example (not shown) there is no specific component to provide the support and vibration generation means, but rather, the process device is designed so that if its active element is in a suitable position to process the surface, any part of the casing of the process device will function to support the device and generate vibrations.

The transducer may be a conventional audio microphone mounted where there is an adequate pathway for transmission of sound to it from the working surface.

When vibrations are generated by movement of the casing over the surface, some of this vibrational energy can travel through the air to the transducer.

There are many other possible embodiments of this invention, not restricted to the above fields of application.

The third example described with reference to and illustrated in Figures 4 to 8 is an example as used in a marker pen described and claimed in our copending application reference 90/4361/03.

It is worthwhile considering the theory before describing the sensor actually used in the third embodiment.

The speed of sound in steel is roughly 6000m/s. At  
5 the current maximum sensor operating frequency of 20kHz, therefore the wavelength is 250mm, much longer than the sensor (10mm).

This means that in modelling the behaviour of the device, we can assume static behaviour.

10 The calculated "tuning fork" resonance frequency of a steel beam is:

$$f = \frac{1}{2\pi} \cdot \frac{6EI}{(M_1 + \frac{M_2}{2})^3}$$

where  $M_1$  is the tip mass  $M_2$  the beam mass and  $I$  the cross-sectional area moment. For the current sensor this  
15 resonance frequency is  $f = 68\text{kHz}$

The design must not change in such a way as to bring the resonance frequency within the sensor passband, otherwise the sensor will be very sensitive to stray vibration.

20 The position of the neutral surface in relation to the glue line in a piezo-steel beam is given by the equation:

$$y = \frac{E_s d_s^2 - E_p d_p^2}{2(E_p d_p + E_s d_s)}$$

where  $d_s$  is the steel thickness and  $d_p$  the piezo thickness.

For a fixed maximum writing force,  $F$ , the energy  
25 stored within the piezo is maximised if the neutral surface is at the glue boundary. This also reduces the stress on the glue (in this case only shear forces act on the glue line). In this case  $y = 0$  so

$$d_p = d_s \cdot E_s / E_p$$

30 The Young's modulus of steel is 200GPa and that of PZT5 70GPa. Therefore

$$d_p = 1.7 \times d_s$$

The piezo thickness should therefore be around 850 $\mu$ m for a 500 $\mu$ m thick steel beam.

5 The maximum stress within the beam as at the support point, since the bending moment  $G$ , is maximum there for a force  $F$  applied at the tip. The piezo should therefore cover the support end of the beam.

10 It is reasonable to expect that a beam which is very flexible will detect large signals, for two reasons. Firstly, a stiff beam will crush paper height variations more readily, and secondly, since the work done on the piezo is the writing force (which is externally fixed) multiplied by the beam deflection, the energy transfer will be greater for a beam which gives greater deflection.  
15 Therefore the beam should be as narrow as possible. Practically, a 1mm thick beam is at the limit of ready manufacture.

The beam will fail for maximum writing pressure if the shear force on the glue line exceeds the specified shear  
20 limit. The shear stress for a fixed load is constant down the length of the beam and is given by:

$$\text{Shear Stress} = \frac{3F}{4d_s w}$$

where  $d_s$  is the steel thickness and  $w$  the beam width. Typical fail shear stress for most adhesives is around  
25 50MPa, hence for safe operation

$$\frac{3F}{4d_s w} < 50 \times 10^6$$

The maximum force is  $F = 3N$ , the width is  $w = 1mm$  and  $d_s = 500\mu m$ , so

$$\frac{3F}{4d_s w} = 4.5 \times 10^{-6}$$

i.e. the applied shear stress is 1/10 the shear stress limit at maximum specified writing force.

The proposed beam structure is shown in Figure 5.

5 The sensor tip has to be constructed of a hard material to prevent excessive wear/alumina or sintered steel are the most probable materials. Given the material the surface structure may be tuned to alter the sensor characteristics. There are two critical parameters:

10 The 'feel' of the pen is important for market acceptance. The sensor must not feel rough as it runs over the paper.

The tip should have a surface structure which maximises the output signal.

15 The surface of paper consists of a mat of bound fibres. The typical fibre width is around  $10\mu\text{m}$  and this defines the maximum feature size. However, it is the gaps between fibres which the tip detects: in this case the typical feature size is around 5 fibre diameters ( $50\mu\text{m}$ ).

20 A MathCad model suggests that with a smooth tip, the output frequency spectrum will be:

$$P(f) = Af^2e^{-2f/\ell}$$

where  $\ell$  is the typical fibre to fibre distance.

Where the typical tip feature size is less than or much larger than the figure size, this spectrum is independent of tip surface.

25 Only using a tip with monodisperse roughness similar to the fibre size increases the high frequency content of the spectrum.

30 For a  $30\mu$  typical feature size the bulk of the spectral power is in the 1-3Hz region. There is no useful spectral power above 5kHz.

Experimental results can be summarised as follows:

The signal frequency and power response is optimised for a  $30\mu$  typical surface feature size. In this case the original power is around 16dBV higher

than that produced by a smooth tip (an increase of 40 times).

A coarse ( $30\mu$ ) tip gives larger higher frequency components.

5       The rms signal power rises by a factor of 3.2 for an increase in speed by factor 3.7 i.e. the rms power is roughly proportional to writing speed.

10       The drag remains roughly constant regardless of writing speed. The work done against the drag is drag multiplied by velocity, so we would expect the sensor output power to rise linearly with velocity).

15       The signal power is non-linear with applied load. An increase in load of 1.3x resulted in 3.2x increase in rms sensor output power. This exponential rise may be due to the tip pressing further into the paper surface (according to the model the fibre density increases exponentially with depth into the paper). This suggest that a sharper tip, giving higher pressure for the some writing load, will give higher signal output power.

20       The tip should therefore be as sharp and rough as possible without excessive degradation in 'feel'. A reduction of dip radius to around  $100\mu\text{m}$  (similar to the ball in a Pentel) should be achievable, although such a tip would have to life tested for increased wear.

25       The "feel" of the sensor as it moves across the paper, whilst of no technical interest, could be of much commercial importance, since it adds towards the market acceptability of the pen. "Feel" may be split down into three subjective judgements made about the sensor:

Vibration - do the fingers detect vibration in the pen as it moves?

35       Scratching - is the sensor tearing the paper fibres?

Noise - does the sensor sound as though it is rough?

Scratching is the worst effect and it occurs when small radii of curvature are present on the sensor tip. In these areas the applied writing force is translated into a large pressure which punctures the paper surface and causes a harsh stick-slip motion, as might be expected when a needle is moved across paper. (The worst case is when the radius of curvature is less than or equal to the typical surface fibre - to fibre distance (c.  $15\mu\text{m}$  typically), so that the tip digs into the surface). Subjectively the effect is the combination of stick-slip motion detected by the fingers with the scratching noise. Thus, overall tip radii must be greater than  $50\mu\text{m}$  to avoid tearing.

The frequency limit due to reaction times in generalised nerve cells is around 1000 pulses per second; it is therefore not unreasonable to expect the vibration of frequency in excess of 1kHz will not be detected as vibration by generalised nerve cells (of course the cells within the ear show substantially different frequency response, since they are specialised for this purpose). Tests on two 'typical' individuals show that subjective roughness is related to the typical feature size of the tip. Sizes less than  $15\mu\text{m}$  on this scale appear to give an acceptable 'silky' feel whereas particle sizes greater than may give a stick-slip motion.

Grains less than  $15\mu\text{m}$  diameter should give acceptable 'feel', but there is clearly a compromise necessary and therefore the tip employed has grains of approximately  $30\mu\text{m}$  size and the tip has a diameter of around  $500\mu\text{m}$  (see figures 6A & 6B).

The detailed construction of the sensor will now be discussed with regard to figures 4 to 8.

The sensor 40 provides for a natural control of ink delivery during writing, causing the ink to flow when the user wants to write. This thus gives an acceptable "feel" when writing. The sensor has to be sufficiently robust to resist damage, for example, when the instrument is dropped accidentally, and must be capable of operating over a wide

range of papers, hand pressures, writing speeds, writing angles, etc. Further commercial requirements are: low cost, small size, immunity to electrical and mechanical interference, and low power consumption.

5       A writing speed of  $30\text{-}150\text{mm.s}^{-1}$  is a typical range of speeds which needs to be accommodated together with a writing force of 30-300g. The sensor should provide an perceived stiffness comparable with a ballpoint pen.

10       The essential function of the sensor is to provide a signal to the pen's control electronics to switch on the ink jet mechanism when 'writing' is taking place. 'Writing' consists of certain specific conditions and so the ink jet must be switched on only when they are met as follows:

15       the pen is in contact with the paper and moving across it in any direction;

the pen comes into contact with the paper without moving across it (as in a full stop).

20       If the pen is in contact with the paper but not moving the ink jet must be switched off, otherwise the result would be continual ink supply to a single point.

A vibration sensor was identified as the best method of achieving these requirements in a unit with relatively simple signal processing.

25       If a stylus is drawn across paper (which on a microscopic scale is a rough surface) vibration is produced in three mutually perpendicular directions, two of which are parallel to the paper and at  $90^\circ$  to each other, the third is the vertical component, perpendicular to the paper. The sensor of this invention responds to the vibration component in the vertical direction which has two specific advantages:

30       it responds equally to vibrations produced by travel in any direction across the paper;

35       it allows a very compact sensor design.

The sensor 40 was designed to occupy the otherwise unused space below the substrate 21 and between the contact areas.

5 The sensor mechanism consists of a metal beam 41 (supported at one end, with a stylus or tip 42 at the other end) with a piezoelectric strip 43 bonded to it. The beam and piezoelectric strip bend in response to the vibration signals from the paper.

10 The size and shape of the elements of the sensor are governed by the following:

- the space in the available volume, described above;
- the need to provide sufficient signal strength for the electronic control system to process it without unreasonable need for very high sensitivity;
- 15 to be sufficiently stiff to give the pen the correct 'feel'. This should not feel in any way soft and so require an awkward writing action. The following graph shows the measured load/deflection characteristic of the beam/piezo.
- 20 to be sufficiently robust to withstand heavy writing pressure or inadvertent impact (within reasonable limits).

As a force is applied at the stylus 42, a bending moment is produced in the beam 41 and increases linearly  
25 along its length. The bending moment produces strain in the beam and piezoelectric strip. The piezo 43 is manufactured with characteristics such that, when it is subjected to strain of this type, an electrical signal (voltage) is generated across its faces. These two faces  
30 have electrodes on them allowing electrical connection, via a coaxial cable, to the control electronics.

The steel beam 41 is an integral part of a larger steel plate 44 in order to facilitate mounting in the pen and making electrical connections. The plate 44 has a  
35 rectrangular aperture 45 through which the ink jets pass from the nozzles in use. The details of sensor

construction and electrical connection are described further below.

The stylus or tip 42 is the part of the pen which makes contact with the paper writing surface and has to exhibit the following characteristics:

shape and surface texture to provide the best combination of electrical signal (strength and frequency range) and quality of feel to the user. (ie it is detrimental if the sensor is excessively noisy or scratchy).

durability to withstand the very high distance it must travel throughout its life without excessive wear.

The choice of material for the stylus 42 was determined by identifying a material with good wear characteristics without incurring high component cost. Alumina from was chosen to provide a stylus which can be manufactured very cost effectively.

It was determined by testing that the human hand is sensitive to vibrations of less than 1000 Hz and so one objective of the stylus design work was to maximise the energy above 1000 Hz, in order to make the writing action of the pen feel as smooth as possible. A benefit of ceramic tips is that they tend to exhibit more energy above 1000 Hz than say a steel stylus would.

The sensor assembly plate 44, on which the sensor is situated, is a small rectangular plate that is located between the two halves of the casework (see later section on casework). The piezoelectric transducer is of a simple arrangement with electrodes on both faces. One face of the piezoelectric strip is bonded to the beam with a low viscosity epoxy in such a way that there is electrical contact through the adhesive layer via asperities in the surface roughness of the plate and piezoelectric material. With this arrangement the plate forms part of the electrical circuit to the piezoelectric strip.

The stylus or tip 42 consists of an alumina tip 42' bonded into a brass body 42" which is rivetted into the end of the beam (see figures 6A & 6B).

5 The piezoelectric strip is of dimensions and arrangement shown earlier in Figure 4 and is manufactured in a lead zirconate titanate grade similar to PZT5A. The sensor beam is manufactured by blanking from sheet metal such as nickel plated spring steel (400 - 450 VPN). The stylus or sensor tip has a main body which is a small  
10 turned component and could be manufactured in a variety of materials. Brass is preferred for its low cost, ease of machining and suitability for rivetting. The stylus or sensor tip has an end formed of alumina in order to provide the necessary wear characteristic as described earlier. It  
15 should be possible to manufacture it by pressing and firing in such a way that its shape and surface roughness are as required.

Figure 7 shows an ASIC which forms part of an electronic control system for a marker pen (as described in  
20 more detail in our copending application mentioned above). The ASIC has a signal conditioning circuit 70 which consists of an input buffer 71, an amplifier 72 with external components 73, a comparator 74 and a monostable block 75.

25 A high impedance input buffer 71 is necessary as the vibration sensor is itself a high impedance capacitive source of the order of 1nF. When combined with the input impedance of 480 k $\Omega$  the sensor gives a high pass filter with a 3dB frequency of 330kHz. The signal of interest  
30 produced by the vibration sensor is between 1kHz and 5kHz of approximately 1.5V peak to peak amplitude.

The buffered and referenced signal is then amplified by a factor of approximately 3. The amplifier 72 has some further low pass filtering and a high pass filter to limit  
35 the signal bandwidth to the frequency of interest. The low 3dB frequency is at 1kHz which suppresses the phenomenon of "bounce" at the start and end of a line or pattern. It is

believed that bounce is caused by the very large offset voltage produced when the user first contacts the paper and finally lifts off. This voltage consists of low frequency components and can be attenuated by the high pass filtering mentioned above. The high frequency cut-off frequency of 5kHz is present to minimise the effects of any spurious signals or interference from electrical noise, which may cause the pen to eject ink inadvertently. The filter characteristics of the amplifier 72 are shown in Figure 8.

The output of the amplifier 72 is fed to a comparator 74 with hysteresis of 100mV. This relatively high hysteresis is used to reduce the possibility of false triggering. The signal which is by now digital, is presented to a monostable block 75 which is implemented digitally. The monostable 75 is retriggerable and maintains an active output for 10ms upon each trigger which prevents the output signal from "dropping out" if the vibration sensor signal is not present for short periods. This usually occurs when the stylus moves slowly across the writing surface. The time must not be too long otherwise the pen will continue to deposit ink after the stylus has stopped moving or is no longer in contact with the surface. Setting the monostable time delay too long is manifested by "tails" appearing at the end of words when writing. The output of the monostable is connected directly to the microcontroller 57 which controls the ink jetting process during use.

CLAIMS

1. A movement sensor for a process device, comprising  
a sensor tip;  
5 means for transmitting the vibrations from the sensor  
tip to a transducer means, the transducer means  
electrically detecting the resulting vibrations as movement  
occurs and producing an output signal.
- 10 2. A movement sensor according to claim 1, further  
comprising  
means for filtering the output signal below and above  
respective predetermined frequencies and producing a  
movement detection signal when the output signal lies  
15 between the predetermined frequencies.
3. A movement sensor according to claim 1, further  
comprising  
means for filtering the output signal below 1000Hz and  
20 producing a movement detection signal when the output  
signal lies above 1000Hz.
4. A sensor according to any of claims 1 to 3, wherein  
the transducer means includes a piezoelectric transducer.  
25
5. A sensor according to claim 4, wherein the transducer  
means includes an arm on one end of which is mounted the  
sensor tip, the piezoelectric transducer being mounted on  
the arm so as to sense changes in strain on the arm and  
30 thus vibration of the sensor tip.
6. A sensor according to claim 5, wherein the  
piezoelectric transducer is elongate and extends along the  
arm.

7. A sensor according to any of claims 1 to 6, adapted to sense contact between the device and the surface, before movement of the device over the surface.
- 5 8. A sensor according to any of claims 1 to 7, which includes means for detecting the speed of movement of the sensor over the surface.
- 10 9. A sensor according to any of claims 1 to 3, wherein the vibrations are detected by a microphone constituting the transducer.
- 15 10. A sensor according to claim 9, wherein an accoustic waveguide is used to direct the air vibrations to the microphone from a means for supporting the process device in contact with a surface relative to which the device is to be moved;
- 20 11. A sensor according to any of claims 1 to 10, wherein the tip has a surface comprising particles of an average grain size of between 15 and 40  $\mu\text{m}$ .
- 25 12. A sensor according to claim 11, wherein the tip has a curved surface having a radius of about 250 $\mu\text{m}$ .

1/6

Figure 1

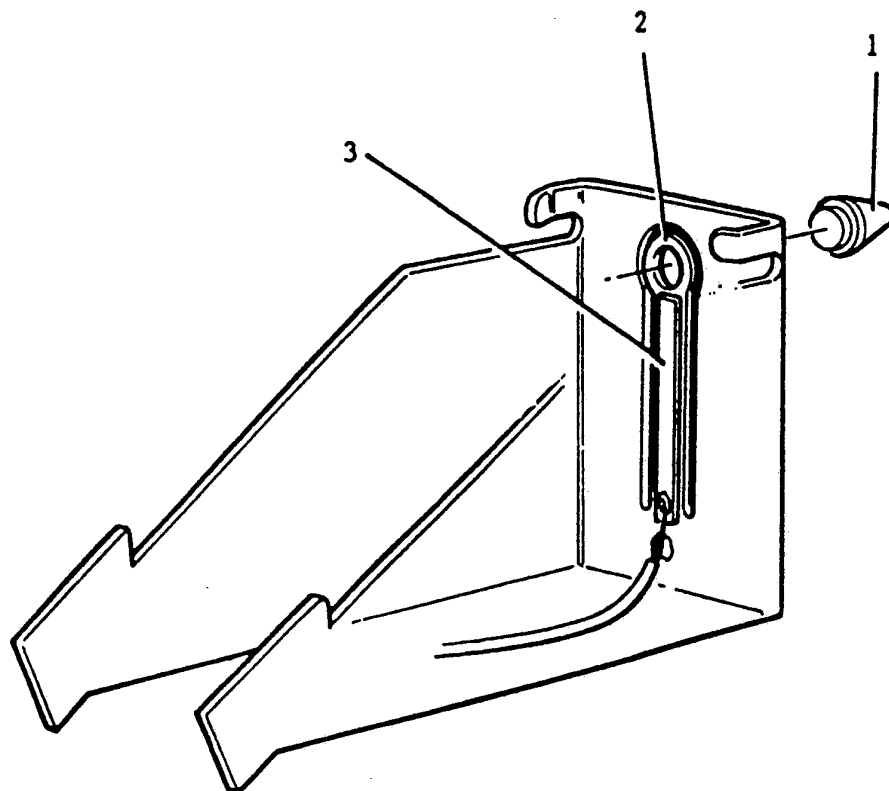
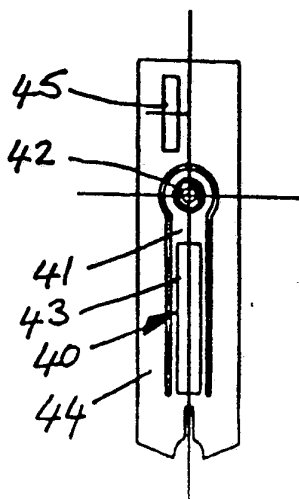


Figure 4



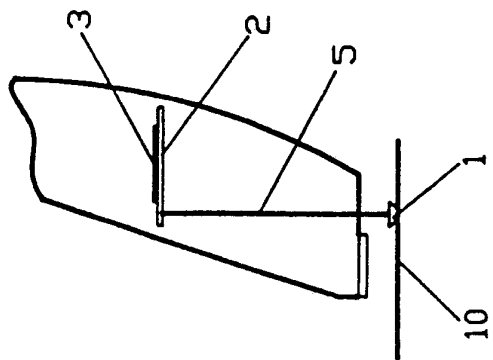


Figure 3

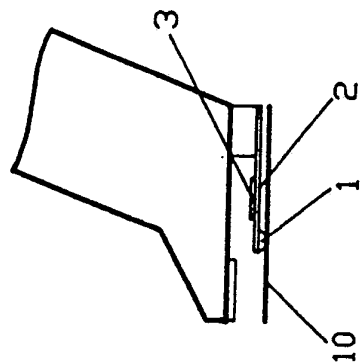
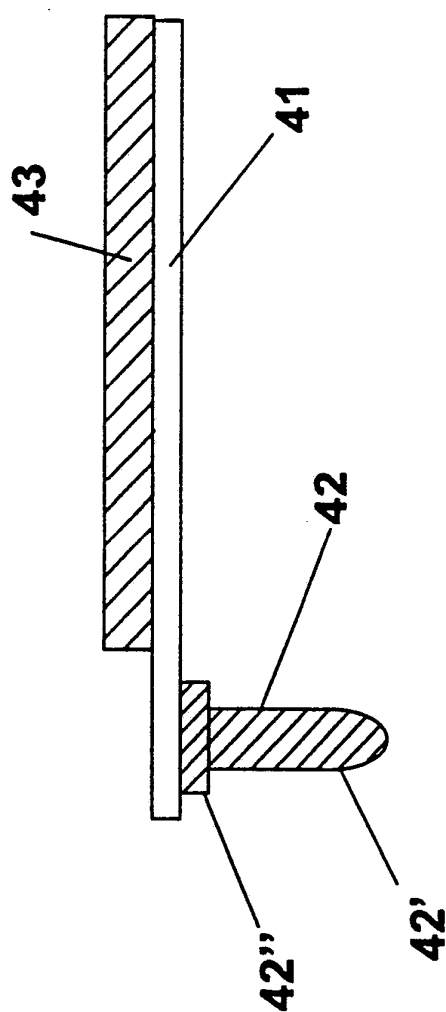


Figure 2

Figure 5



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Figure 6B

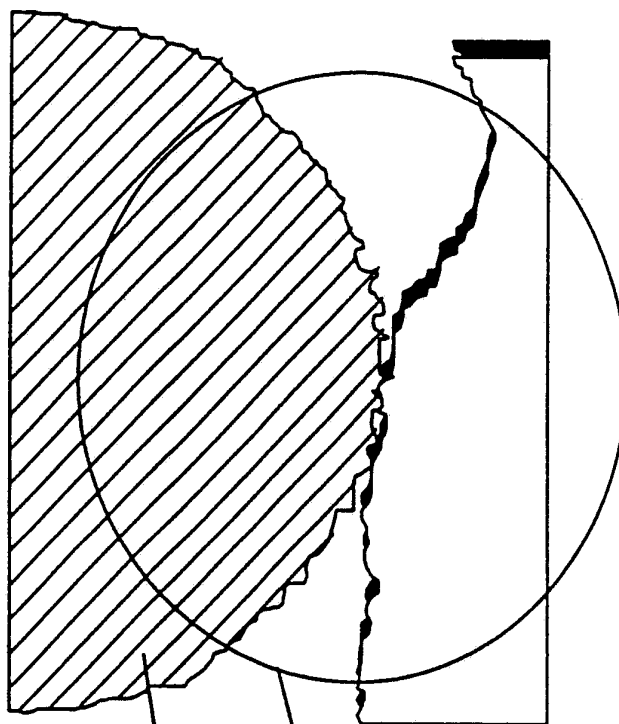
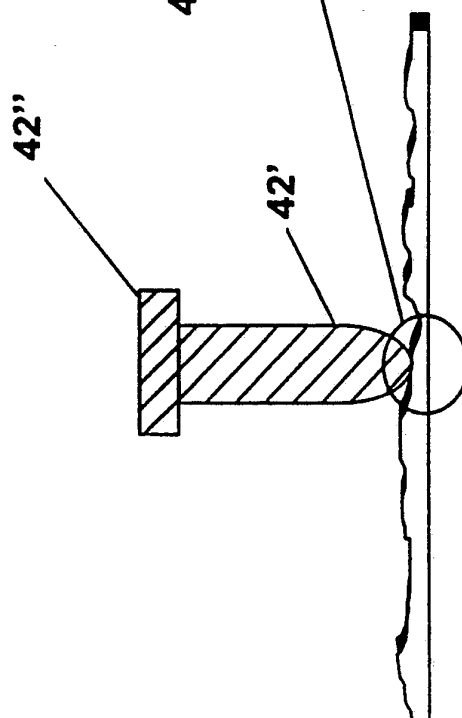


Figure 6A



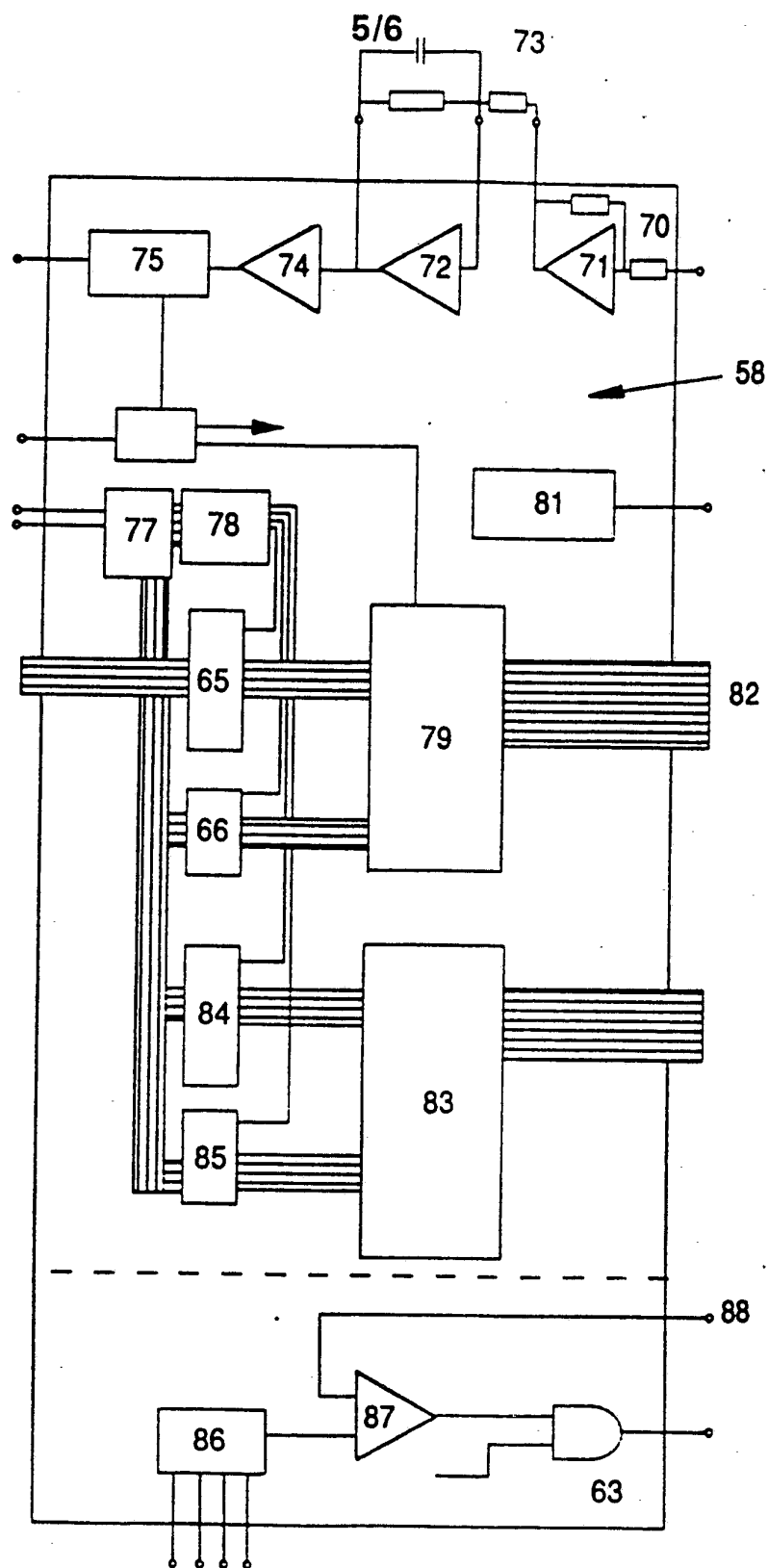
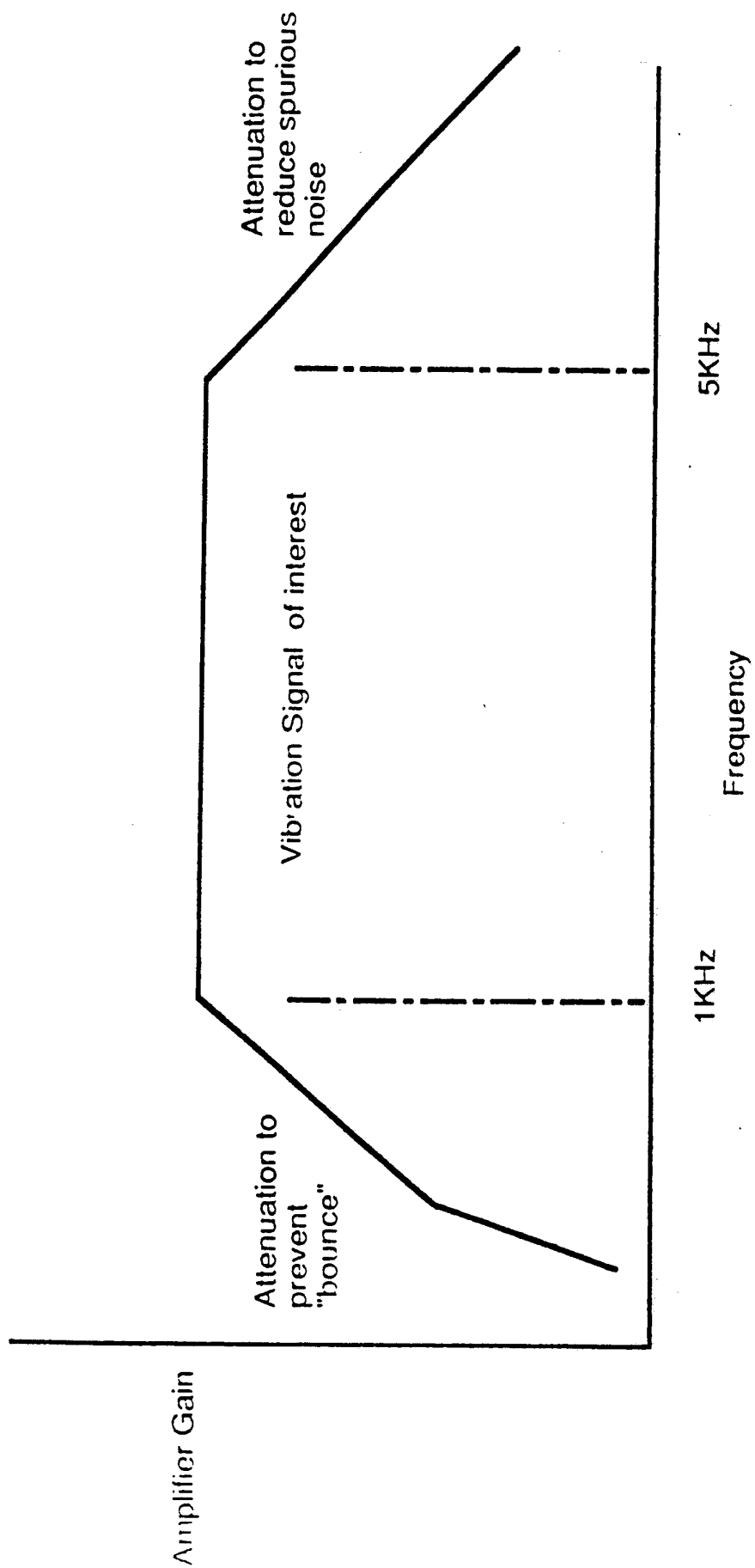


Figure 7

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Figure 8



## INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 93/00439

**I. CLASSIFICATION OF SUBJECT MATTER** (if several classification symbols apply, indicate all)<sup>6</sup>

According to International Patent Classification (IPC) or to both National Classification and IPC  
Int.Cl. 5 B41J3/36

**II. FIELDS SEARCHED**Minimum Documentation Searched<sup>7</sup>

| Classification System | Classification Symbols |
|-----------------------|------------------------|
| Int.Cl. 5             | B41J ; G01P ; G01N     |

Documentation Searched other than Minimum Documentation  
to the Extent that such Documents are Included in the Fields Searched<sup>8</sup>

**III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup>**

| Category <sup>o</sup> | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>                                                            | Relevant to Claim No. <sup>13</sup> |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| X                     | PATENT ABSTRACTS OF JAPAN<br>vol. 6, no. 229 (P-155) 16 November 1982<br>& JP,A,57 132 005 ( MATSUSHITA DENKI<br>SANGYO K.K. ) 16 August 1982                             | 1,4,7                               |
| Y                     | see abstract                                                                                                                                                              | 9,10                                |
| Y                     | ---<br>Section EI, 15 December 1991<br>Derwent Publications Ltd., London, GB;<br>Class S03,<br>& SU,A,1 698 749 (KIEV CIVIL ENG INST) 15<br>December 1991<br>see abstract | 9,10                                |
| A                     | ---<br>FR,A,2 535 060 (ANTIVOLS SIMPLEX FR)<br>27 April 1984<br>see page 1, line 1 - line 3; claim 1<br>---<br>-/--                                                       | 1-12                                |

<sup>o</sup> Special categories of cited documents : <sup>10</sup>

- "A" document defining the general state of the art which is not considered to be of particular relevance  
 "E" earlier document but published on or after the international filing date  
 "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  
 "O" document referring to an oral disclosure, use, exhibition or other means  
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

**IV. CERTIFICATION**

|                                                                          |                                                                 |
|--------------------------------------------------------------------------|-----------------------------------------------------------------|
| Date of the Actual Completion of the International Search<br>18 MAY 1993 | Date of Mailing of this International Search Report<br>08.06.93 |
| International Searching Authority<br>EUROPEAN PATENT OFFICE              | Signature of Authorized Officer<br>JOOSTING T.E.                |

| III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET) |                                                                                                               |                       |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|-----------------------|
| Category °                                                                 | Citation of Document, with indication, where appropriate, of the relevant passages                            | Relevant to Claim No. |
| A                                                                          | US,A,3 973 111 (WASHIZUKA ET AL.)<br>3 August 1976<br>see column 2, line 53 - line 64; figure 3<br>---        | 8                     |
| A                                                                          | US,A,4 523 235 (RAJCHMAN)<br>11 June 1985<br>see column 5, line 2 - line 45; claim 1;<br>figures 1,3<br>----- | 1-12                  |

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9300439  
SA 70721

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18/05/93

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