Title: ACTUATOR DEVICE

Abstract: The present invention relates to an actuator arrangement for exciting longitudinal displacement pulses, or waves, in an optical fibre. The arrangement comprises a bracket, a washer element, a piezo member arranged between the bracket and the washer element, and an optical fibre that is engaged with an extending through a passage in the washer element. The piezo member is operable, responsive to an applied voltage, to displace the washer element and the fibre engaged therewith, in the longitudinal direction of the fibre, with respect to the bracket. Thereby, a longitudinal displacement pulse may be excited in the optical fibre. The actuator arrangement may also operate as a sensor for sensing longitudinal displacements in optical fibres. A set-up and a method for repeatedly sending longitudinal displacement pulses through a length of optical fibre is also disclosed.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
ACTUATOR DEVICE

Technical field

The present invention relates to acoustic actuators and acoustic sensors, and more particularly to acoustic actuators and sensors arranged to send and detect longitudinal displacement pulses in an optical fibre. The actuators and sensors according to the invention can be employed in a set-up for sending longitudinal displacement pulses along a length of optical fibre between a first reflection point and a second reflection point.

Technical background

It is known in the prior art to alter the reflectivity of fibre Bragg gratings in optical fibres by means of longitudinal acoustic waves, i.e. longitudinal displacement waves.

One way of coupling an acoustic wave into an optical fibre is presented in the article "100% efficient narrow-band acoustooptic tunable reflector using fiber Bragg grating", Liu et al., Journal of Lightwave Technology, Vol. 16, No. 11, November 1998. According to said journal article, an acoustic wave was coupled into an optical fibre by a tapered horn made from fused silica. The horn was tapered in diameter from 3 mm at a first end to 125 μm at a second end, over a length of 12 cm. A planar piezo-electric transducer was bonded to the first end surface of the silica horn, in order to launch an acoustic wave into the horn. The second end of the horn was fusion-spliced to an end of the optical fibre. Consequently, a longitudinal displacement excited by the piezo-electric transducer was transferred into the optical fibre through said silica horn.

However, the optical fibre must be terminated at the transducer. Consequently, the above-described arrangement
does not allow light to propagate from one side of the transducer to the other side.

In many cases, it is desirable to launch acoustic waves into an optical fibre without terminating the light propagation path. This, however, not being allowed by the arrangement described above. Thus, there is a need for new and improved arrangements for sending longitudinal acoustic waves, or longitudinal displacement waves or pulses, into an optical fibre.

Summary of the invention

It is an object of the present invention to provide a new and improved arrangement for sending longitudinal displacement waves, or pulses, into an optical fibre and the like, by which arrangement at least the above-identified problem of the prior art is eliminated. This object is achieved by an arrangement according to the accompanying claims.

The present invention has several further advantageous features, which will be apparent from the detailed description of some preferred embodiments presented below.

Surprisingly, it has been found that a longitudinal displacement pulse, or wave, can be excited in an optical fibre by quickly moving the fibre at one point even when the fibre is not pre-strained. The inertia of the fibre itself is sufficient for a displacement pulse to be excited by said quick movement of the fibre.

By longitudinal displacement wave, it is meant a compression/elongation propagating along the fibre. Sometimes, such a wave or pulse is referred to as a longitudinal acoustic pulse.

In one aspect, the present invention provides an actuator arrangement for exciting a longitudinal displacement wave, or pulse, in an optical fibre. The arrangement comprises a washer element, or a collar, with which the optical fibre is engaged. Furthermore, the arrangement
comprises a piezo member, which is responsive to an applied voltage to displace said washer element with respect to a (comparatively heavy) bracket. By virtue of the fibre being engaged with said washer element, said displacement is transferred to the engaged portion of the fibre and propagated along the fibre.

In another aspect, the present invention provides a sensor arrangement for sensing longitudinal displacements in an optical fibre.

In some embodiments of the actuator or sensor arrangement above, the washer element is not present. Instead of using a washer element, the fibre rests directly onto the piezo member. In such a case, it is preferred to have the fibre pre-strained towards the piezo member by a pulling force.

The actuators and sensors according to the present invention can advantageously be employed in an arrangement, or a set-up, for sending a longitudinal displacement pulse through a length of optical fibre. In said length of optical fibre, the longitudinal displacement pulse is repeatedly reflected back and forth between two reflection points. The arrangement comprises an actuator arrangement and a sensor arrangement. The actuator arrangement is adapted to actuate and amplify the longitudinal displacement pulse, and the sensor arrangement is adapted to directly or indirectly measure the timing of said pulse in order to provide actuation of the actuator arrangement resonantly with the pulse reflected back and forth between said reflection points. One advantage of the inventive set-up is that a longitudinal displacement pulse can be repeatedly sent along a length of optical fibre without terminating the light guiding path in the fibre.

In a preferred mode of operation of the above-described set-up, the sensor arrangement is operative to provide an output signal indicative of the amplitude of the displacement pulse propagating between the two re-
flection points. Feedback is provided from the sensor arrangement to the actuator arrangement, and actuation of said actuator is adjusted so that the amplitude of the longitudinal displacement pulse, as detected by the sensor arrangement, is maximised. Maximum amplitude of the displacement pulse is obtained when the actuator is operated resonantly with the displacement pulse, i.e. when the actuator arrangement is actuated at the same instant as the longitudinal pulse passes said actuator. Therefore, maximising of the pulse amplitude is a sufficient means for operating the actuator resonantly with the longitudinal displacement pulse.

In another mode of operation, the timing of the displacement pulses is measured, and the time of passage between the two reflection points is determined. Feedback is then provided to the actuator arrangement in order to actuate said actuator arrangement at the time when the displacement pulse passes said actuator.

Furthermore, the present invention provides a method for repeatedly sending longitudinal displacement waves, or pulses, along a length of optical fibre between a first reflection point and a second reflection point.

It is envisioned that the present invention will have its primary field of use in connection with systems in which the reflective properties of fibre Bragg gratings are altered by means of longitudinal displacement waves, or pulses. Such a system is disclosed in the Swedish patent application number 0002415-8, which is incorporated herein by reference.

Brief description of the drawings

In the detailed description presented below of some preferred embodiments of the present invention, reference is made to the accompanying drawings, on which:

Fig. 1 schematically shows a first embodiment of the present invention;

Fig. 2 schematically shows a piezo member comprised
of two semi-circular parts;

Fig. 3 schematically shows a second embodiment of the present invention;

Fig. 4 schematically shows a third embodiment of the present invention; and

Fig. 5 schematically shows a set-up for sending longitudinal displacement pulses, or waves, into a length of optical fibre.

On the drawings, like parts are indicated by like reference numerals.

Detailed description of preferred embodiments

A first preferred embodiment of an actuator arrangement according to the present invention is schematically shown in figure 1.

In figure 1, a cross-section of an actuator arrangement 10 is shown. As will be explained below, the same structural arrangement can also operate as a sensor. The arrangement comprises a bracket 11, or support, which is comparatively heavy with respect to other parts of the arrangement. Further, the arrangement comprises a washer element 12 and a piezo member 13. The piezo member 13 is arranged between the bracket 11 and the washer element 12, and is operative, responsive to an applied voltage, to displace said washer element 12 with respect to the bracket 11, i.e. to change the separation of the washer from the bracket. A predefined portion of an optical fibre 14 is engaged with the washer element 12 in such a way that said portion of the optical fibre follows any movement of the washer element. In the embodiment illustrated in figure 1, the fibre 14 is engaged with the washer element 12 by means of a girdle 15, or bulb, on the fibre, said girdle being jammed to a passage in the washer element. However, it is to be understood that the fibre can be attached to or engaged with the washer in any suitable way, as long as the requirement that the en-
gaged portion of the fibre follows the movement of the washer is fulfilled.

The bracket 11, the piezo member 13 and the washer element 12 each have a through passage that allows introduction of the fibre 14 therein. The fibre 14 is engaged with the washer element 12 and extends, in its longitudinal direction, through said passage. Consequently, any movement of the washer 12 will cause a longitudinal displacement of the portion of the fibre that is engaged therewith.

In the shown embodiment, the piezo member is comprised of two separate parts 13a, 13b, each of which has a generally semi-circular shape. It has been found that by having a piezo member comprised of two parts, internal stress and other deteriorating circumstances can be avoided, thereby facilitating excitation of a "clean" and well-defined longitudinal displacement pulse in the fibre. A section through the piezo member comprised of two parts 13a and 13b, with the fibre 14 there between, is schematically shown in figure 2.

In the preferred embodiment, both the bracket 11 (or support) and the washer element 12 is made from brass. The piezo member 13 is preferably made from PZT (Lead Zirconate Titanate), which is a commercially available piezo-electric ceramic material. The optical fibre 14 engaged with the washer element 12 has a typical outer diameter of 125 μm, and the bulb 15 formed thereon has a typical outer diameter of about 160 μm. The outer diameter of the washer element 12 and of the piezo member 13 transverse to the longitudinal direction of the fibre 14 is about 1 mm. The washer element 12 has a thickness, in the longitudinal direction of the optical fibre 14, of about 0.3 mm, and the piezo member 13 (each of the semi-circular discs 13a, 13b) has a thickness in the same direction of about 0.51 mm.

In order to provide further stability of the actuator arrangement 10, a sleeve 16 could be fitted between
the bracket 11 and the piezo member 13, as schematically shown in figure 3.

Although it is preferred to have a washer element resting on the piezo member, and to have the fibre engaged with the washer element, it is conceivable to have the fibre itself resting directly on the piezo member. In case the washer element is omitted, it is preferred to have the fibre pre-strained against the piezo member, as will be further described in connection with figure 4.

Having described the basic structural features of the actuator arrangement according to the present invention, the operation thereof will now be described in more detail.

It is well known to the man skilled in the art that a piezo-electric material can alter its dimensions responsive to an applied voltage. Likewise, it is well known that a change of the dimensions of a piezo-electric material can produce an output voltage if electrical connections are applied appropriately. Hence, the piezo member of the actuator arrangement is electrically connected to an external voltage supply. By applying a voltage to the piezo member, its dimensions parallel to the longitudinal dimension of the fibre can be altered. Consequently, the separation between the bracket and the washer element can be altered. It is to be understood that, due to the relatively large inertia of the bracket 11, a sudden change of the separation between the bracket 11 and the washer element 12 caused by the piezo member 13, causes a displacement only of the washer element 12 and of the portion of the fibre engaged therewith. Furthermore, the bracket 11 may be firmly attached to an external housing.

If the change in separation between the bracket and the washer is sufficiently quick, the inertia of the optical fibre will, at least to some extent, counteract the displacement. This lead to a longitudinal displacement pulse being excited in the fibre.
The structural arrangement described above can also operate as a sensor for sensing longitudinal displacements in the optical fibre. A longitudinal displacement, propagating along the fibre and subsequently reaching the washer element, will induce a change of the dimension of the piezo member in the dimension parallel to the longitudinal direction of the fibre. By virtue thereof, a voltage is produced by the piezo member. This voltage is indicative of the level of compression or elongation of the piezo member, and can serve as a sensor output corresponding to the amplitude of the longitudinal displacement pulse, or wave, in the fibre.

Hence, not only does the structural arrangement described above provide an actuator for exciting a longitudinal displacement pulse, but also a sensor for sensing longitudinal displacement pulses in a fibre. In fact, the arrangement is a transducer that can be operated in either of said modes.

In figure 4, another embodiment of the present invention is schematically shown. In this case, the girdle 15 (or bulb) of the optical fibre 14 is engaged with the washer element 12 by resting against the same. In order to provide good transfer of displacements between the optical fibre 14 and the washer element 12, the fibre is preferably pre-strained by a pulling force F, pulling the fibre 14 towards the washer element 12. In other respects, the embodiment shown in figure 4 operates in the same way as the embodiment shown in figures 1 and 3. When the fibre is pre-strained as in figure 4, it is also possible to omit the washer element and to have the fibre resting directly upon the piezo member. Sometimes, such a configuration can be preferred by virtue of its simplicity.

In the following, an arrangement (a set-up) is described in which both the actuator arrangement and the sensor arrangement described above are utilised. The set-up is schematically shown in figure 5. A typical situa-
tion where the set-up of figure 5 is employed is when longitudinal displacement waves, or pulses, are used in order to alter the reflectivity of a fibre Bragg grating. A fibre Bragg grating that reflects light in an unper-
turbed state can be made to pass, temporarily and for a narrow wavelength range only, light when a localised and temporary compression and/or elongation is present in the grating.

The set-up shown in figure 5 comprises a bracket 11, an actuator arrangement 50 and a sensor arrangement 51, the bracket 11 acting as a common support for said actuator 50 and said sensor 51. Furthermore, the set-up includes a length of optical fibre 52 having a fibre Bragg grating incorporated in its core. Typically, the Bragg grating is a chirped grating constituting, in an unperturbed state, a continuous broadband reflector. Said length of fibre 52 is engaged with a washer element of the actuator arrangement 50 and with a washer element of the sensor arrangement 51, for exciting longitudinal displacement waves in the fibre and for sensing longitudinal displacement waves in the fibre, respectively. The length of fibre 52 comprising the Bragg grating is arranged between said actuator 50 and said sensor 51.

An input end of said length of fibre is connected, by means of a first fibre connector 61, to a first piece of standard fibre 53. In turn, said first piece of standard fibre 53 is provided with an input fibre connector 54 to which an external input fibre is to be connected. Similarly, an output end of said length of fibre is connected, by means of a second fibre connector 62, to a second piece of standard fibre 55. In turn, said second piece of standard fibre is provided with an output fibre connector 56 to which an external output fibre is to be connected. It is to be noted that there is a continuous light path through the optical fibre between said input fibre connector 54 and said output fibre connector 56.
The entire set-up is enclosed within a protective housing, in which the fibre is arranged within recesses formed in the housing material. Preferably, the housing is filled with a protective gas, e.g. nitrogen. In order to provide further protection of the fibre inside the housing, particularly during transport or in case of mechanical impact, cushions 57 can be provided that support the fibre. One preferred material for such cushions is so-called airglass. An important purpose of the protective housing is to provide temperature stability, although general mechanical protection is certainly important.

Inside the housing, the length of fibre 52 between the actuator arrangement 50 and the sensor arrangement 51 is preferably bent in a semi-circle. The radius of curvature of said bend should be large enough for light in the optical fibre not to leak out. However, such a bend can have favourable effects on the longitudinal displacement wave propagating along the fibre, as will be further elucidated below.

A preferred mode of operation of the above set-up will now be described.

The sensor arrangement 51 to which the fibre is connected does not have the only function of a sensor, but also acts as a reflection point for longitudinal displacement pulses in the fibre. Thus, whenever a longitudinal displacement pulse reaches the sensor 51, said pulse will, at least to some extent, be reflected back through the fibre towards the actuator arrangement 50. Likewise, the actuator arrangement 50 acts as another reflection point. Consequently, once a longitudinal displacement pulse (an acoustic pulse) has been excited in the fibre, it will be reflected back and forth between the sensor 51 and the actuator 50 through the length of fibre 52 comprising the Bragg grating. In other words, multiple passes of the displacement pulse through the Bragg grating will be provided.
However, at each reflection point (i.e. at the sensor 51 and at the actuator 50), some amplitude of said pulse is lost. The pulse will therefore gradually fade away unless it is amplified at some point. To this end, it is preferred that the longitudinal displacement pulse is given some additional energy, i.e. increased amplitude, every time said pulse is reflected at the actuator 50. By sensing the pulse at the sensor 51, feedback can be provided in order to drive the actuator 50 in resonance with the propagating displacement pulse.

Alternatively, the sensor can be interchanged with a passive reflector. In that case, the mode of operation of the actuator arrangement is intermittently switched from an actuating mode to a sensing mode. When the actuator is in sensing mode, the timing of the displacement pulses is measured, and feedback and calibration is thereby provided for subsequent operation in the actuating mode.

Two different ways of utilising the output signal from the sensor arrangement will now be briefly described.

In a first mode of operation, the sensor arrangement provides timing information regarding the displacement pulses propagating between the two reflection points. From said timing information, a time of passage between the two reflection points can be determined. Feedback is then provided to the actuator arrangement, in order to actuate said actuator at the time when the longitudinal displacement pulse reaches the actuator after reflection.

In a second mode of operation, regarded as the currently best known mode of operation, the sensor arrangement detects the amplitude of the longitudinal displacement pulse propagating between the reflection points. The amplitude is monitored, and the timing of the pulses sent into the length of fibre from the actuator arrangement is adjusted in fine steps until the measured amplitude is maximised. When maximum amplitude is obtained, pulses are excited by the actuator in concert with the propagating
displacement pulse between the reflectors. Any other timing of the actuator would give the displacement pulse lower amplitude. Thus, by tuning the actuation of the actuator arrangement so that the pulse amplitude, as detected by the sensor arrangement, is maximised, said actuation will be in resonance with the displacement pulse. Preferably, the amplitude of the longitudinal displacement pulse is monitored continuously during operation, and the output of the monitoring is utilised for adjusting the actuator so that the actuator is actuated at a rate that gives maximum amplitude of the displacement pulse propagating in the length of fibre, i.e. at a rate that is in concert with the roundtrip rate of the displacement pulse between the two reflectors.

As mentioned above, favourable effects may be achieved by providing the fibre with a bend between the two reflection points (i.e. between the actuator and the sensor). If the fibre is straight between the reflection points, there is a risk of standing waves building up therein. By providing the fibre with a bend between the reflection points, the risk of standing waves evolving is reduced. However, the propagation of a longitudinal displacement pulse along the length of fibre is virtually unaffected by said bend. Consequently, by providing the length of optical fibre between the actuator 50 and the sensor 51 with a bend, noise due to build-up of standing waves is reduced. The curvature of the bend should, of course, be sufficiently large in order for light not to leak out from the fibre core.

The invention has been described above by means of some preferred embodiments, schematically shown on the accompanying drawings. However, it is to be understood that various alterations and modifications are conceivable within the scope of the invention, as defined in the appended claims.
CLAIMS

1. An actuator arrangement for exciting a longitudinal displacement pulse in an optical fibre, comprising
   a bracket,
   a piezo member, and
   an optical fibre extending through a passage in said piezo member,
   wherein said piezo member is operative, responsive to an applied voltage, to rapidly displace a portion of the fibre, in the longitudinal direction of said fibre, with respect to the bracket, such that a longitudinal displacement pulse is excited in said optical fibre.

2. An actuator arrangement as claimed in claim 1, further comprising a washer element with which the fibre is engaged, the washer element having a passage through which the fibre extends in its longitudinal direction, wherein the piezo member is arranged between the bracket and said washer element, the piezo member being operative, responsive to an applied voltage, to rapidly displace the washer element and the portion of the fibre engaged therewith, in the longitudinal direction of said fibre, with respect to the bracket, such that a longitudinal displacement pulse is excited in said optical fibre.

3. An actuator arrangement as claimed in claim 1 or 2, wherein the piezo member comprises two separate parts, each of said parts having the general shape of a semicircular disc.

4. An actuator arrangement as claimed in any one of the claims 1 to 3, wherein the fibre extends through a passage in the bracket, the washer element and the piezo member, respectively.
5. An actuator arrangement as claimed in any one of the preceding claims, wherein the optical fibre is engaged with the washer element by means of a bulb on said fibre being clamped thereto.

6. An actuator arrangement as claimed in any one of the claims 1 to 4, wherein the optical fibre is engaged with the washer element by a pulling force pulling a bulb on said fibre against said washer element.

7. A sensor arrangement for sensing longitudinal displacement pulses in an optical fibre, comprising a bracket, a piezo member, and an optical fibre extending through a passage in said piezo member, wherein said piezo member is operative, responsive to a displacement pulse with respect to said bracket of said fibre in the longitudinal direction thereof, to provide an output voltage indicative of said displacement pulse.

8. A sensor arrangement as claimed in claim 7, further comprising a washer element with which the fibre is engaged, the washer element having a passage through which the fibre extends in its longitudinal direction, wherein the piezo member is arranged between the bracket and said washer element, the piezo member being operative, responsive to a displacement pulse of said washer element in the longitudinal direction of said fibre with respect to the bracket, to provide an output voltage indicative of said displacement pulse.

9. A sensor arrangement as claimed in claim 7 or 8, wherein the piezo member comprises two separate parts, each of said parts having the general shape of a semi-circular disc.
10. A sensor arrangement as claimed in any one of the claims 7 to 9, wherein the fibre extends through a passage in the bracket, the washer element and the piezo member, respectively.

11. A sensor arrangement as claimed in any one of the claims 7 to 10, wherein the optical fibre is engaged with the washer element by means of a bulb on said fibre being clamped thereto.

12. A sensor arrangement as claimed in any one of the claims 7 to 10, wherein the optical fibre is engaged with the washer element by a pulling force pulling a bulb on said fibre against said washer element.

13. An arrangement for sending a longitudinal displacement pulse along a length of optical fibre between a first reflection point and a second reflection point, the arrangement comprising

   an actuator operative to excite a longitudinal displacement pulse in said length of fibre; and

   a sensor for sensing longitudinal displacements in said length of fibre,

   wherein said first reflection point and said second reflection point are arranged to reflect said pulse excited by said actuator, the actuator further being operative to amplify said pulse as it passes the actuator based on feedback provided by said sensor, said optical fibre being engaged with and extending through a respective passage in said actuator and said sensor.

14. An arrangement as claimed in claim 13, wherein the actuator constitutes the first reflection point, and the sensor constitutes the second reflection point.
15. An arrangement as claimed in claim 14, further comprising a feedback loop from the sensor to the actuator, a sensor output signal in said feedback loop causing the actuator to amplify the longitudinal displacement pulse at the time when said actuator is reached by a previous displacement pulse, reflected from the sensor.

16. An arrangement as claimed in any one of the claims 13 to 15, wherein the optical fibre is engaged with the actuator and the sensor by means of a bulb on said fibre being clamped to a respective washer element of the actuator and the sensor.

17. An arrangement as claimed in claim 16, wherein the actuator comprises a piezo member operative, responsive to an applied voltage, to displace the washer element and the optical fibre engaged therewith.

18. An arrangement as claimed in claim 17, wherein the piezo member comprises two separate parts, each of said parts having the general shape of a semi-circular disc.

19. An arrangement as claimed in claim 16, wherein the sensor comprises a piezo member operative, responsive to a longitudinal displacement pulse in the optical fibre, to provide an output voltage indicative of the amplitude of said displacement pulse.

20. An arrangement as claimed in claim 19, wherein the piezo member comprises two separate parts, each of said parts having the general shape of a semi-circular disc.

21. An arrangement as claimed in any one of the claims 13 to 20, wherein the optical fibre is provided with a bend between the actuator and the sensor.
22. A method for repeatedly sending longitudinal displacement pulses through a length of optical fibre between a first reflection point and a second reflection point, said length of fibre being engaged with and extending through a respective passage in an actuator and a sensor, the method comprising the steps of:
   sending, by means of said actuator, a longitudinal displacement pulse into said length of optical fibre;
   detecting, by means of said sensor, the amplitude of said displacement pulse; and
   amplifying, by means of said actuator, the displacement pulse in said length of optical fibre at a time when it reaches said actuator, after one or several reflections, the timing being based on feedback from said sensor.

23. A method as claimed in claim 22, further comprising the step of adjusting the timing of longitudinal pulses sent into the length of optical fibre, based on the detected amplitude of said displacement pulse.

24. A method as claimed in claim 23, wherein the step of adjusting the timing is performed in fine increments until the detected amplitude is maximised.

25. A method as claimed in claim 24, wherein the step of adjusting the timing is performed repeatedly.

26. A method as claimed in any one of the claims 22 to 25, wherein the step of sending a longitudinal pulse into the length of optical fibre is performed by means of an actuator arrangement as defined in any one of the claims 1 to 6.

27. A method as claimed in any one of the claims 22 to 26, wherein the step of detecting the amplitude of the displacement pulse includes detecting said pulse by means
of a sensor arrangement as defined in any one of the claims 7 to 12.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G02B 6/34, G02F 1/125
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)

IPC7: G02B, G02F, G01H

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

SE,DK,FI,NO classes as above

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

Date of the actual completion of the international search: 13 June 2002

Date of mailing of the international search report: 25 June 2002

Authorized officer: Magnus Westöö/MN
Telephone No.: +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)
INTERNATIONAL SEARCH REPORT

Box I  Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II  Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. An actuator/sensor arrangement according to claims 1-12.
2. An arrangement and a method for sending a longitudinal displacement pulse along an optical fibre according to claims 13-27.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest  ☐ The additional search fees were accompanied by the applicant’s protest.
☐ No protest accompanied the payment of additional search fees.
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