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Datasheet for the decision of 22 March 2011

Case Number: T 1985/07 - 3.4.01

Application Number: 03704131.6

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IPC: G01S 5/28, G01S 13/86, G01S 5/18

Language of the proceedings: EN

Title of invention:
Identification and location of an object via passive acoustic detection

Applicant:
HER MAJESTY THE QUEEN IN RIGHT OF CANADA AS REPRESENTED BY THE MINISTER OF NATIONAL DEFENCE OF HER MAJESTY'S CANADIAN GOVERNMENT

Headword:
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Relevant legal provisions:
-

Relevant legal provisions (EPC 1973):
EPC Art. 83, 54, 56

Keyword:
"Sufficiency of disclosure (no - main request)"
"Novelty (yes - first auxiliary request)"
"Inventive step (yes - first auxiliary request)"

Decisions cited:
G 0010/93, T 0226/85

Catchword:
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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 1985/07 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 22 March 2011

Appellant: HER MAJESTY THE QUEEN IN RIGHT OF CANADA AS REPRESENTED BY THE MINISTER OF NATIONAL DEFENCE OF HER MAJESTY'S CANADIAN GOVERNMENT
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 26 July 2007 refusing European patent application No. 03704131.6 pursuant to Article 97(1) EPC 1973.**

Composition of the Board:

Chairman: B. Schachenmann
Members: P. Fontenay
F. Neumann

Summary of Facts and Submissions

I. The appeal lies from the decision of the examining division to refuse European patent application No. EP 03 704 131.6 on the ground of lack of inventive step (Article 56 EPC 1973) of claims 1 to 15 then on file. The examining division also held *obiter* that the application contained added subject-matter (Article 123(2) EPC) and that the description was not consistent with the claims. The decision was dispatched on 26 July 2007.

II. The appellant (applicant) filed an appeal against the decision by notice received on 20 September 2007 and paid the prescribed appeal fee on the same day. A written statement setting out the grounds of appeal was filed on 4 December 2007. The appellant requested that the contested decision be set aside and a patent be granted on the basis of claims 1 to 17 annexed to the statement of grounds.

III. At the appellant's request, a summons to attend oral proceedings was issued.

On 5 October 2010, in preparation of these proceedings, the Board issued a communication pursuant to Article 15(1) Rules of Procedure of the Boards of Appeal (RPBA), expressing its provisional opinion with regard to the sole request then on file. Particular concern was expressed with regard to the requirements of sufficiency of disclosure under Article 83 EPC 1973 in relation with the subject-matter of independent claims 1, 7 and 14, although this aspect had not been addressed in the proceedings before the examining

division. The Board's doubts resulted from the fact that claims 1, 7 and 14 defined, respectively, a method, a system and a computer program for locating a moving object producing an acoustic wave in 3-dimensional space which relied on the identification of at least three signals. It was, more specifically, stressed that only two independent Time Difference Of Arrival (TDOA) measurements could be obtained in the case that only three signals were detected. As a consequence, the independent claims appeared to include subject-matter for which the information provided in the application was not sufficient to identify a position in 3-dimensional space. The provision of a minimum of three independent TDOA measurements (i.e. four signals) was considered indispensable. It was further observed that the method defined in claim 1 always identified, when relying on three signals only, an intersection point within the plane defined by the three sensors which, most probably, did not correspond to the actual physical position of the object to be located.

The Board further questioned whether the reference to an acoustic wave having an unknown waveform was sufficiently supported by the application as filed (Article 123(2) EPC). It was also pointed out that the independent claims' wording did not establish that the process on which the invention relied to determine the location of an object was iterative (Article 84 EPC), although this aspect appeared to be essential in the light of the description. Insofar as the issues of novelty and inventive step were concerned, the Board indicated that it was not convinced by the reasoning

carried out by the examining division with regard to the prior art.

IV. Under cover of a letter dated 22 February 2011, the appellant filed a new main request and a new auxiliary request, taking due account of the Board's comments with regard to the issues of added subject-matter and clarity.

Concerning the issue of sufficiency of disclosure, no evidence was provided to show that the principle on which the claimed invention relied was feasible with only three signals. Instead, the appellant posed the following question: "*Is the assumption that only two independent Time Difference Of Arrival (TDOA) measurements can be obtained from three detection times/three sensors correct. I would assume that it is possible to detect 3 TDOA signals with three sensors S1, S2 and S3, namely a) S1-S2, b) S2-S3 and c) S1-S2 [sic]? Please check [...]!*"

The appellant further emphasized that it was, in effect, the association of TDOA measurements in combination with acoustic reciprocity which made it possible to identify the location of the object. He also indicated that the independent claims of the main request and auxiliary request had been amended so as to render this aspect clear.

V. Oral proceedings before the Board took place on 22 March 2011 in the presence of the appellant's representative. During the proceedings, a document reproducing a statement of the inventor with regard to the issue of sufficiency of disclosure was filed. The

appellant requested that the decision under appeal be set aside and a patent be granted on the basis of claims 1 to 16 as filed on 22 February 2011 as main request or, alternatively, on the basis of claims 1-16 and description pages 1, 1a, 2-22, filed during the oral proceedings as first auxiliary request and drawing sheets 1/8 - 8/8 as originally filed, i.e. as published under the PCT.

Claim 1 of the main request reads:

"1. A method of locating a moving object producing an acoustic wave, the acoustic wave being detected by a plurality of passive acoustic detectors formed in an array to produce at least three signals, characterized in that the method comprises the steps of:

(a) determining a wavelet that correlates with each of the at least three signals, said wavelet being a Doppler-shifted version of a wavelet derived from an acoustic wave of a known form;

(b) determining time difference of arrival (TDOA) measurements between the at least three signals using correlation intensity with said wavelet;

(c) performing acoustic reciprocity at a pre-determined time interval from each of the plurality of detectors based on said TDOA measurements resulting in a hemisphere centered around each of the plurality of detectors, wherein a first detector is determined from the array having the earliest time of detection of the acoustic wave and hemispheres are generated centered over each detector in the array that detected the acoustic wave according to the TDOA measurements;

(d) examining hemispheres produced from step (c) to determine an intersection point of all hemispheres; and

(e) repeating (c) and (d) in an iterative process with a further time interval to increase the size of said hemispheres in an hemisphere expansion mechanism expanding hemispheres centered over each detector at a predetermined time interval if said intersection point is not determined by an intersection determination mechanism, whereby the iterative process between the hemisphere expansion mechanism and the intersection determination mechanism continues until an intersection between all hemispheres is located with the earliest time being the first detection time and iteratively decreasing the earliest time until the intersection between the hemispheres from each sensor is found;

wherein said intersection point represents a location of the object."

Independent claim 7 of the main request refers to the corresponding system for locating a moving object. It reads:

"7. A system for locating a moving object producing an acoustic wave by passive detection of the acoustic wave, wherein at least three signals are produced by detection of the acoustic wave at a plurality of detection points, characterized in that the system comprises:

an object characteristic library containing wavelets that are Doppler-shifted versions of wavelets derived from acoustic waves of known form;

a correlation mechanism for determining a wavelet from said object characteristic library that correlates with the at least three signals;

a time difference mechanism for determining time difference of arrival (TDOA) measurements between each of the at least three signals using correlation intensity with said wavelet from said correlation mechanism;

an acoustic reciprocity mechanism for performing acoustic reciprocity at time intervals forming hemispheres centered around each of the plurality of detection points based on said TDOA measurements from said time difference mechanism to determine an intersection point of all hemispheres in an intersection determination mechanism, wherein a first detection point is determined from the plurality of detection points having the earliest time of detection of the acoustic wave; and

a controller for coordinating said correlation mechanism, said time difference mechanism and said acoustic reciprocity mechanism and for repeating the acoustic reciprocity mechanism and the intersection determination mechanism in an iterative process with a further time interval to increase the size of said hemispheres in an hemisphere expansion mechanism if said intersection point is not determined by the intersection determination mechanism,

whereby the iterative process between the hemisphere expansion mechanism and the intersection determination mechanism continues until an intersection between all hemispheres is located with the earliest time being the first detection time and iteratively decreasing the earliest time until the intersection

between the hemispheres from each detection point is found;

wherein said intersection point represents a location of the object."

Claims 2 to 6 and 8 to 16 of the main request depend, respectively, on independent claims 1 and 7.

Independent claim 1 according to the auxiliary request differs from claim 1 of the main request, essentially, in that the preamble of the claim has been amended to read: "*1. A method of locating a moving object producing an acoustic wave, the acoustic wave being detected by* ***at least four*** *passive acoustic detectors (104) formed in an array (102) to produce at least* ***four*** *signals, characterized in that ...*" and in that the reference to the "at least three signals" in the charactering portion of the claim has been replaced by a reference to "the signals". In step (e), the reference to "the intersection between the hemispheres from each sensor" has been replaced by the wording "the intersection between the hemispheres from the detectors (104)".

Similarly, independent claim 7 of the auxiliary request differs from independent claim 7 of the main request, essentially, in that the claim's preamble has been amended to read "*7. A system (100) for locating a moving object producing an acoustic wave by passive detection of the acoustic wave, wherein at least* ***four*** *signals are produced by detection of the acoustic wave at* ***at least four*** *detection points, characterized in that...*" and in that the reference to "at least three

signals" in the rest of the claim has been amended so as to refer to "the signals".

Claims 2 to 6 and 8 to 16 of the auxiliary request differ from the corresponding claims of the main request in minor amendments intended to reflect the amendments in the independent claims and to avoid possible redundancies.

VI. This decision is issued after the entry into force of the EPC 2000 on 13 December 2007. Reference is thus made to the relevant transitional provisions for the amended and new provisions of the EPC, from which it may be derived which Articles of the EPC 1973 are still applicable to the present application and which Articles of the EPC 2000 are to apply. When Articles or Rules of the former version of the EPC are cited, their citations are followed by the indication "1973".

Reasons for the Decision

1. The appeal is admissible.

2. *Main request - Sufficiency of disclosure*

2.1 In its decision G 10/93, the Enlarged Board of Appeal ruled that the boards of appeal are not restricted, in ex parte proceedings, to examination of the grounds on which the decision of the first instance was based. More specifically, the boards of appeal have the power to examine whether an application meets requirements of the EPC that have not been considered during the

examination proceedings or have been regarded as fulfilled by the examining division.

In the present case, the Board raised the issues of sufficiency of the disclosure under Article 83 EPC 1973 with regard to the subject-matter of independent claims 1 and 7 of the main request.

2.2 While it is acknowledged that three TDOA measurements may be obtained from three signals only, the Board notes that, contrary to the view expressed by the applicant, these three measurements are not independent of each other since any of them can be defined as a combination of the two others.
If it is assumed that three sensors S_1, S_2 and S_3 located at different locations M_1, M_2 and M_3, each receive a signal corresponding to an acoustic wave which has previously been generated at a point (P) in 3-dimensional space, each time difference of arrival ΔT_{ij} defined as: $\Delta T_{ij} = T_j - T_i$ may also be expressed in the form:

$$\begin{aligned} \Delta T_{ij} &= T_j \mathbf{- T_k + T_k} - T_i, \\ &= (T_j \mathbf{- T_k}) + (\mathbf{T_k} - T_i), \\ &= \Delta T_{kj} + \Delta T_{ik} \end{aligned}$$

wherein i, j, k, $\in$ (1, 2, 3);
T_i, T_j and T_k define the time of arrival of the signal, as measured by the corresponding sensor S_i, S_j and S_k by reference to any arbitrary time origin.

Similarly, the same result can be obtained when expressing each TDOA measurement as the time required for the acoustic wave to travel over a distance

corresponding to the difference between the radii separating two detectors S_i, S_j from the source P of the acoustic wave :

$$\Delta T_{ij} = 1/v * (R_j - R_i)$$
$$= 1/v * (R_j \mathbf{- R_k + R_k} - R_i)$$
$$= 1/v * ((R_j - \mathbf{R_k}) + (\mathbf{R_k} - R_i))$$
$$= \Delta T_{kj} + \Delta T_{ik}$$

wherein v defines the velocity of the acoustic signal and R_i, R_j and R_k define the radii or distances separating the source of the acoustic signal (P) from the corresponding sensor located at point M_i, M_j or M_k.

Consequently, contrary to the appellant's view, the determination of three signals emanating from a source can only provide two independent TDOA measurements and is, thus, in the absence of any complementary information as to the possible location of said source, not sufficient for determining its three coordinates.

2.3 The statement provided by the inventor contains an illustration of three hemispheres of different radii crossing at an intersection point positioned at a certain height above the surface defined by the centres of the hemispheres. This illustration was provided to show that the intersection point of the three hemispheres can be defined by a 3-dimensional position. The Board does not contest this issue. However, the Board does contend that the steps set out in claim 1 will necessarily lead to the unique point representing the location of the object which produces the acoustic wave. Indeed the Board notes that the illustration does not, in fact, correspond to the situation actually defined by the claimed method. In the method of claim 1,

a hemisphere expansion mechanism is repeated in an iterative process until an intersection point between the hemispheres is found. The expansion routine is interrupted once it has identified a **first** intersection point common to all the hemispheres. The figure provided by the inventor appears, on the contrary, to illustrate a situation corresponding to a further expansion of the hemispheres following the determination of the first intersection point. Indeed, as the hemispheres are expanded further, the locus of corresponding intersection points will describe a curve and the situation illustrated by the inventor depicts one point of this curve.

The hemispheres illustrated in the inventor's statement may be defined by their respective centres (O_1, O_2 and O_3) and radii (R_1, R_2 and R_3). It is immediately apparent from the figure that hemispheres defined by the same centres but slightly smaller radii ($R_1-\delta R$, $R_2-\delta R$ and $R_3-\delta R$) would also have a common intersection point, thus demonstrating the fact that the illustrated configuration does not actually correspond to the situation referred to in claim 1 according to which the expansion process is halted as soon as a first intersection point has been identified.

This analysis also appears to reflect the view of the inventor in section "d" of her statement, as filed during the oral proceedings, which reads: "*d. There is a caution however. The expanding hemisphere approach will provide a location based on three sensors but not the only possible location. What three signals provide initially in our system is the closest location to the sensor array from which the signal could emanate from.*

As the hemispheres are expanded iteratively, it looks for a location which is common on the surface of each hemisphere and once it finds that location it stops there." The Board is indeed of the opinion that there is an infinite number of "possible locations", i.e. locations at which a source of acoustic waves would emit a signal which would then be received by the three detectors in an order which would correspond to the sequence actually recorded. The Board further concurs with the inventor that the claimed method and system provide an intersection point corresponding to the location closest to the sensor array from which the signal could possibly emanate from, but notes that the purpose of the claimed invention is not to identify this closest location from which a signal could originate, but rather the point representing the actual location of the object. The application does not contain any indication of how this point may be unambiguously determined using only the signals from three sensors.

2.4 Although the content of the present application has been substantially modified with regard to the application from which a priority right is claimed, it still relies on the same principle as the one disclosed in the priority document, namely, the identification of an intersection point based on near field assumptions and on acoustic reciprocity. It is worth observing, in this context, that the former application explicitly recites on page 2, lines 13 and 14, that "*A minimum of three TDOAs are required and therefore four microphones*", or on page 5, lines 12, 13: "*... m is the microphone number (i.e., 1 to 4 in the test case but*

this could be increased to any number of microphones desired, four is the minimum required for TDOA)... " . The present application does not contain any other indication or additional source of information which would compensate for the absence of a fourth microphone and hence justify the deletion of these statements.

2.5 In the appellant's view, the mere fact that some variants of a claimed invention could not be carried out did not justify the rejection of an application under Article 83 EPC 1973, insofar as the application disclosed at least one way enabling the skilled person to reproduce the claimed process and system. This latter condition was clearly met in the present case, since the provision of an array of four or more detectors was obviously capable of locating an object in the 3-dimensional space, as had been acknowledged by the Board.

The Board, however, rejected this argumentation which focuses exclusively on one of the requirements identified by the jurisprudence of the boards of appeal with regard to the condition of sufficiency of disclosure, namely, the necessity for the application to indicate at least "one way" of carrying out the invention. By doing so, the appellant ignores a further condition according to which the application should allow the invention to be performed over the whole range claimed (cf. Case Law of the Boards of Appeal, 6th edition, II-A-3 (b),(c)). While it is indeed established jurisprudence of the boards of appeal that the inclusion of non-working embodiments is immaterial to the question of sufficiency as long as there are suitable variants known to the skilled person through

the disclosure or common general knowledge, it has also been repeatedly emphasised that substantially any embodiment of the invention, as defined in the broadest claim, must be capable of being realised on the basis of the disclosure (cf. T 226/85, OJ 1988, 336). As has been shown above, this is not the case for a sensor array producing only three signals.

2.6 Consequently, the present application does not meet the requirements of Article 83 EPC 1973 since it does not contain sufficient information to enable the skilled person to reproduce the subject-matter of independent claims 1 and 7, i.e. to locate a moving object, in the case of only three signals being detected.

3. *Auxiliary request*

3.1 *Added subject-matter*

In the following, references to the original disclosure apply to the published PCT application WO-A-03/067281.

Claim 1 of the auxiliary request differs from claim 1 as originally filed, primarily, in that the reference to a plurality of passive acoustic detectors has been replaced by a reference to at least four passive acoustic detectors, wherein the mention of the "three signals" or "three hemispheres", in original claim 1, has been amended accordingly. Furthermore, additional details of the method have been specified in steps (a), (c) and (e) of claim 1.

A specific reference to four sensors or more than four sensors may be found on page 7, line 31 to page 8,

line 4, and page 12, lines 11-14, of the original disclosure. Feature (a) of claim 1 now includes the further limitation, originally recited in claim 13, according to which the wavelet is a Doppler-shifted version of a wavelet of an acoustic wave of a known form. Step (c) of performing acoustic reciprocity has been amended on the basis of page 14, lines 29-33, page 16, lines 9-13 and page 22, lines 4-10. Finally, step (e) has been amended so as to clearly establish that the claimed method is iterative and relies on a repetition of steps (c) and (d) until an intersection between all the spheres has been identified. A basis for this latter definition may be found on page 14, lines 20-23 and page 15, lines 2-22. The various passages referred to above all relate to the embodiment concerning the location of an object in near field conditions.

Original claim 14 constitutes the main basis for the system of independent claim 7. The passages referred to above, in relation to independent claim 1, similarly, constitute a valid basis for the amendments carried out in relation to the claimed system.

Dependent claims 2 to 6 are based, primarily, on original claims 2 to 6 and have been further adapted so as to take into account the amendments made in relation with claim 1. Similarly, dependent claims 8 to 12 derive from original claims 15 to 19. A support for claim 13 may be found on page 16, lines 27-29, and page 17, lines 8-24. The passage on page 7, line 31 to page 8, line 4, was considered to constitute a sufficient basis for dependent claims 14 to 16.

The conditions of Article 123(2) EPC are therefore met by the auxiliary request.

3.2 *Novelty - Inventive step*

3.2.1 In the course of the appeal proceedings, the following documents, referred to by the examining division in their decision to refuse the application (D1, D2) or cited in the international search report (D4), have been considered to be of particular relevance:

D1: US-A-3466753;
D2: D. Garreau, Conference Proceedings; "Multiscale Inverse Filtering"; 3 April 1990, pages 2495 - 2498, XP010004157;
D4: A. Graps; "An Introduction to Wavelets" IEEE Computational Science & Engineering, Vol. 2, No. 2; 21 June 1995; pages 50-61; XP000560561.

3.2.2 Document D1 discloses a method and system for displaying the location of schools of fish making use of three under-water listening devices (16, 17 , 18) arranged to pick up under-water sounds. According to the method and system disclosed in document D1, three signals are generated by the listening devices (16, 17, 18). Changes or breaks in the pattern of the received signals are identified for the determination of time difference of arrival (TDOA) measurements (cf. column 3, lines 66-74).

According to the principle put into practice in the method and system of D1, acoustic reciprocity is performed at a pre-determined time interval from each of the plurality of detectors (16, 17, 18) making use

of said TDOA measurements. This results in a circle being defined around each of the plurality of detectors with a radius directly proportional to the measured TDOA measurement. Concretely, a first detector is identified which has the earliest time of detection of the acoustic wave. Three circles, each centered over the respective detector that detected the acoustic wave, are then generated having radii representative of the TDOA measurements whereby the radius of the circle around the first detector will be zero (cf. column 3, line 74 - column 4, line 6). The radii of these circles are progressively increased by the same amount representative of a fixed time interval. At each extension it is checked whether an intersection point common to all circles may be found. This iterative process is repeated until all three of the circles intersect (cf. column 4, lines 6-16).

The method of claim 1 according to the auxiliary request is thus distinguished from the method of locating schools of fish disclosed in D1 in that:
(i) at least four signals are produced by the acoustic detectors;
(ii) a wavelet is determined that correlates with each of the at least four signals, wherein said wavelet is a Doppler-shifted version of a wavelet derived from an acoustic wave of a known form;
(iii) TDOA measurements are obtained between the at least four signals using correlation intensity between said recorded signals and said wavelet, and in that
(iv) hemispheres are used in the determination of the intersection point, instead of circles.

The system of claim 7 according to the auxiliary request differs from the system disclosed in D1 in that it incorporates the corresponding functional units.

Documents D2 and D4 relate to general aspects regarding the use of wavelet transformations in signal analysis and do not address the issue of locating a moving object producing an acoustic wave.

The subject-matter of independent claims 1 and 7 of the auxiliary request is, hence, new in view of the available prior art (Article 54 EPC 1973).

3.2.3 Document D1 shares a common purpose with the claimed method and system, namely, to locate a source of acoustic signals. Moreover, it also makes use of an iterative process relying on acoustic reciprocity, the principle of which is identical to the one recited in claim 1. For these reasons, document D1 is considered to illustrate the closest prior art.

The claimed invention is distinguished from the known locating method by features (i) to (iv) identified above. The use of at least four detectors combined with the elaboration of hemispheres permits the determination of the location of a source of acoustic waves in 3-dimensional space, whereas the features relating to the use of wavelets and correlation techniques permit automatic TDOA measurements.

The objective problems solved by the claimed method in relation with document D1 may thus be defined as:

(a) to determine the location of an object in 3-dimensional space and

(b) to automate said process.

In the Board's judgement, each of the solutions set out in claim 1 to these two distinct problems defines an inventive contribution to the prior art.

The two location determination processes discussed in D1 rely, respectively, on the drawing of circles or, in a more elaborated locating method (cf. US-A-3388373, referred to by reference in document D1) on the association of a manually controlled bridge, for a more convenient record of TDOAs, and an associated oscilloscope. In this respect, both methods require the visual inspection of a two-dimensional display thus allowing a direct identification of an intersection point. Even if the necessity to determine the location of a moving object in the 3-dimensional space may exist with regard to schools of fish, the Board considers that adapting the method of D1 to allow such a 3-dimensional determination would imply departing from an essential concept underlying document D1, namely, the direct visual perception of the sought location. Consequently, the modification of the process disclosed in D1 to the 3-dimensional space would imply sacrificing an essential feature of this process and would thus amount to ex-post facto analysis.

Moreover, it is considered that identification processes relying on wavelets cannot be directly integrated in the process for locating schools of fish, as disclosed in document D1. According to the present invention, the implementation of wavelets is justified by the fact that the expected signals have reproducible characteristics. The changes or breaks which affect the

sound signals recorded by the microphones in document D1 may result from a plurality of causes such as a change in speed, or course or another action affecting the source of acoustic waves (cf. column 3, lines 53-55). In general, the resulting signals will have waveforms without clearly recognisable features. The variety of patterns which may result makes it, therefore, impossible to identify a specific wavelet which would be able to correlate with such breaks in the recorded signals. Consequently, even if documents D2 and D4 emphasize that wavelets are adapted to identify transient signals or signals with sharp discontinuities, (cf. D2, abstract; D4, page 50, third paragraph), it is unlikely that wavelets derived from acoustic waves of known form will enable breaks in recorded signals to be identified. For these reasons, the skilled person would have never considered implementing this technique in the process of document D1.

The same analysis applies *mutatis mutandis* to independent claim 7 of the auxiliary request. For these reasons, the claimed inventions meet the requirements of Article 56 EPC 1973 since they involve an inventive step.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the examining division with the order to grant a patent with claims 1 to 16 according to the first auxiliary request and description pages 1, 1a, 2 to 22, both filed at the oral proceedings, and the drawings as originally filed, i.e. as published under the PCT.

The Registrar: The Chairman:

R. Schumacher B. Schachenmann