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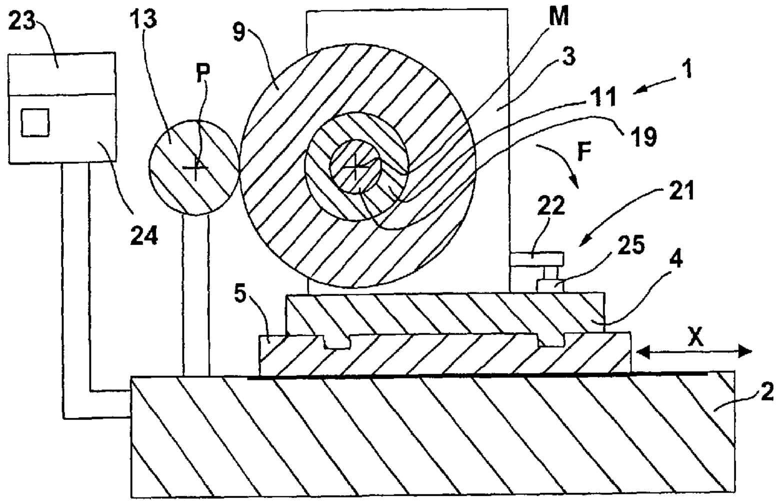
(54) Title: APPARATUS AND METHOD FOR CHECKING THE MACHINING PROCESS OF A MACHINE TOOL



(57) **Abstract:** An apparatus and a method for checking the machining process of a machine tool, for instance a grinding machine (1), to get information about the quantity of the material removed and the wear condition of the grinding wheel (9). The apparatus includes an acoustic sensor (19) adapted to detect the acoustic signals generated by contact between the grinding-wheel and the piece (13) to be machined, and a force-detecting sensor (21) adapted to detect the force applied between grinding-wheel and piece during the machining. The method includes processing signals provided by both the sensors, to define time intervals (ti-tf) on the basis of the signals (SA) of the acoustic sensor, and to monitor the signals (SF) of the force-detecting sensor in the so-defined intervals.

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«APPARATUS AND METHOD FOR CHECKING THE MACHINING PROCESS OF A MACHINE TOOL»

Technical Field

The present invention relates to an apparatus for checking the machining process of a machine tool with a base and a tool-carrier slide, movable with respect to the base and carrying a tool, the apparatus including a support and reference system for supporting and referring a piece to be checked, a first sensor, adapted for sensing the force occurring between the tool and the piece and for emitting a first output signal and a processing and control unit connected to the first sensor and adapted for processing the first output signal.

The invention also relates to a method for checking the machining process of a machine tool.

Background Art

The ever-pressing requirements to increase the productivity of machine tools, to improve the quality of the mechanical pieces that these machine tools produce, on the basis of ever-tighter tolerances, and to diminish the production costs call for minimizing the machine down-times and concurrently performing, whenever necessary, all the maintenance operations required for avoiding both the down-grade of the quality of the produced pieces and the costs deriving from scraps and re-machining of pieces.

For checking the machining process of computer numerical control ("CNC") machine tools, as lathes, grinding machines, milling machines, etc. there are utilized apparatuses provided with sensors that detect the magnitude of physical features connected to the process to be checked and indicate, to the machine numerical control, or directly to the operator, the need to perform maintenance or corrective procedures.

Similar apparatuses are those, for example, that detect the wear or the breakage of the tools and signal the need for their substitution or sharpening.

US patent US-A-5070655 discloses an apparatus for monitoring some specific working conditions of a machine tool, more particularly for detecting grinding wheel sharpness, loss of coolant or excessive vibrations.

The apparatus processes signals indicative of the power consumption, as provided by a power-detecting sensor, and signals indicative of the mechanical vibrations, as provided by an accelerometer, and emits a visual signal (in the form of a green, a yellow or a red light, the latter is associated with an acoustic signal) for indicating to the operator the condition of the process under control.

US patent US-A-5718617 discloses a system for measuring a force existing between a grinding wheel and a piece in the course of the machining of a computer numerical control ("CNC") grinding machine, by a force-detecting sensor mounted between the ball screw that activates the tool-carrier slide and the machine base. In the machine there can also be mounted accelerometers for compensating the signals arriving from the force-detecting sensor by removing components of said signals that depend on vibrations.

US patent US-A-5044125 discloses a machine tool, more specifically a grinding machine, with a force transducer that comprises piezoelectric sensors mounted adjacent the wheelhead to measure the magnitude of the force occurring between the grinding wheel and the piece. The signals output by the force transducer are sent to the numerical control that determines when there is the need to perform a grinding wheel dressing cycle.

The signal output by the force transducer is suitably processed and provides significant information relating to the machining or to the grinding wheel sharpness, but does not enable to accurately distinguish the time intervals when the grinding wheel is actually in contact with the piece. In fact, the amplitude of the signal output by the force transducer slowly increases when contact between grinding wheel and piece occurs and it slowly decreases when the grinding wheel is detached from the surface of the piece, as hereinafter described. Furthermore, immediately after the displacing of the grinding wheel away from the piece, the output signal of the force transducer has spurious components, due to the displacing of parts of the machine tool, that can have an amplitude comparable with that of the signal in the course of the machining and must not be considered during the processing.

Disclosure of Invention

An object of the present invention is to overcome the inconveniences of the known apparatuses.

This object is achieved by an apparatus for checking the machining process of a machine tool according to claim 1 and an associated checking method according to claim 10.

Brief Description of the Drawings

The invention is now described in more detail with reference to the enclosed sheets of drawings, given by way of non-limiting example, wherein:

figure 1 is a schematic cross-sectional view of a grinding machine in the course of the machining of a mechanical piece and an apparatus according to the present invention;

figure 2 is a plan view of the grinding machine and the apparatus of figure 1;

figure 3a is an enlarged scale view of a detail of the grinding machine shown in figure 2 in the course of a first machining phase of the piece;

figure 3b is an enlarged scale view of a detail of the grinding machine shown in figure 2 in the course of a second machining phase of the piece;

figure 4a shows the trend of the signal output by the acoustic sensor in the course of the two machining phases shown in figures 3a and 3b, performed in sequence;

figure 4b shows the trend of the signal output by the force-detecting sensor in the course of the two machining phases shown in figures 3a and 3b, performed in sequence;

figure 5a shows the trend of the signal output by the acoustic sensor in the course of two machinings in which the grinding wheel has different cutting capacity;

figure 5b shows the trend of the signal output by the force-detecting sensor in the course of two machinings in which the grinding wheel has different cutting capacity;

figure 6a shows the trend of the signal output by the acoustic sensor in the course of two machinings performed at different grinding wheel approach speeds;

figure 6b shows the trend of the signal output by the force-detecting sensor in the course of two machinings performed at different grinding wheel approach speeds;

figure 7 is a flow chart showing the operation of an apparatus according to the present invention, and

figure 8 is a block diagram showing the logic interconnections of the various elements that form the apparatus according to a preferred embodiment of the invention.

Best Mode for Carrying Out the Invention

Figures 1 and 2 show, in an extremely simplified form, a machine tool, in particular a computer numerical control ("CNC") grinding machine **1**, including a base **2**, a tool-carrier slide **3**, more specifically a grinding wheel-carrier coupled to a slide **4**, movable with respect to the base **2** along an axis **Y** and coupled to a slide **5** movable along an axis **X** with respect to the base **2**, in such a way that the tool-carrier slide **3** can displace with respect to the base **2** in the plane **XY**. A spindle **7** is mounted on the tool-carrier slide **3** and coupled, by means of a flange **11**, to a grinding wheel **9**. The spindle **7** is coupled to a motor, not shown in the figures, and enables the grinding wheel **9** to rotate about a longitudinal axis **M**.

The grinding machine **1** is utilized for machining a mechanical piece **13**, with rotational symmetry, for example a shaft, supported, arranged and put into rotation about a longitudinal axis **P**, parallel to the longitudinal axis **M**, by means of a support and reference system of the known type consisting, for example, of a live center **15** and a dead center **17**.

An apparatus for checking the machining process of the grinding machine **1** includes a first sensor, i.e. a force-detecting sensor **21**, of a known type, with a first portion **22**, coupled to the tool-carrier slide **3**, and a second portion **25**, coupled to the slide **4**, a second sensor, more specifically an acoustic sensor (or AE sensor) **19**, also of the known type, coupled to flange **11**, and a processing and control unit **23** electrically connected, in a way that has not been shown in the figures, to the sensors **19** and **21** and to a numeric control **24** of the grinding machine **1**. The force-detecting sensor **21** detects deformations of the tool-carrier slide **3**, with respect to the slide **4**, in the direction indicated by arrow **F** in figure 1, caused by the force applied by grinding wheel **9** on the piece **13** and provides a first output signal **SF**. The acoustic sensor **19** detects the acoustic signals generated by contact between the surfaces of the grinding wheel **9** and of the piece **13** in the course of the machining and provides a second output signal **SA**.

Figures 3a and 3b show two subsequent phases of the machining of the piece **13**, in which the extension of the contact surface between grinding wheel **9** and piece **13** differs. In the condition shown in figure 3a, there is the maximum amount of contact surface between grinding wheel **9** and piece **13**, whereas in the condition shown in figure 3b just part of the grinding wheel **9** is in contact with piece

13.

Figures 4a and 4b show, in a time sequence, the trends of signal **SA** output by the acoustic sensor **19** and of the signal **SF** output by the force-detecting sensor **21** respectively, at the two subsequent machining phases shown in figures 3a and 3b.

The instants of time tia, tfa, tib, tfb indicate the instant of start (tia, tib) and the instant of end (tfa, tfb) of contact between grinding wheel **9** and piece **13** in the machining phases shown in figures 3a and 3b.

As shown in figure 4a, the signal **SA** output by the acoustic sensor **19** has an amplitude that very rapidly varies both as a consequence of grinding wheel **9** and piece **13** coming in touch with each other (instants tia, tib) and as a consequence of the grinding wheel **9** detaching from the piece **13** (instants tfa, tfb), but does not substantially depend on the extension of the surface of contact between grinding wheel **9** and piece **13.**

In fact, the time frame in which the signal assumes a high logic value depends on the contact time between grinding wheel **9** and piece **13** (time lags tia-tfa, tib-tfb), but its amplitude does not undergo significant modifications in the course of the two different machining phases illustrated in figures 3a and 3b in which there is a different extension of contact surface between grinding wheel **9** and piece **13.**

On the contrary, the signal **SF** output by the force-detecting sensor slowly varies after grinding wheel **9** and piece **13** touch each other (instants tia, tib) and mutually detach (instants tfa, tfb), while its amplitude directly depends on the extension of the contact surface between grinding wheel **9** and piece **13** and more specifically, the larger the contact surface, the greater the amplitude of signal **SF.**

Figures 5a and 5b show the output signal **SA** of the acoustic sensor **19** and the output signal **SF** of the force-detecting sensor **21** in the course of two different machinings, that start, respectively, at instants ti1, ti2 and end, respectively, at instants tf1 and tf2, in which grinding wheel **9** has different cutting capacity. The instants ti1 and tf1 represent the instant of start and the instant of end of contact between grinding wheel **9** and piece **13** under a condition in which grinding wheel **9** has low cutting capacity. The instants ti2 and tf2 represent the instant of start and the instant of end of contact between grinding wheel **9** and piece **13** under a condition in which, at identical conditions as those of the previous case (for example with regard to the extension of the contact surface between grinding wheel and piece), the grinding wheel has high cutting capacity (for example after it has undergone dressing).

As shown in the figures, the output signal **SA** of the acoustic sensor **19** does not vary in a significant way if the grinding wheel **9** is more or less sharp, but its trend just depends on the contact time between grinding wheel **9** and piece **13**. On the contrary, the output signal **SF** of the force-detecting sensor **21** slowly increases after contact occurs between the grinding wheel and the piece, slowly decreases when the grinding wheel detaches from the piece, and has an amplitude that depends on the cutting capacity of the grinding wheel **9**, more specifically the amplitude of the signal **SF** increases as the cutting capacity of the grinding wheel **9** decreases.

Figures 6a and 6b show the output signal of the acoustic sensor **19** and the output signal of the force-detecting sensor **21** in the course of two different machinings, that start, respectively, at instants ti3 and ti4 and end, respectively, at instants tf3 and tf4, and that differ as far as the approach speed of the grinding wheel **9** is concerned. The instants ti4 and tf4 are the instant of start and the instant of end of contact between grinding wheel **9** and piece **13** under a condition in which the approach speed is relatively low whereas the instants ti3 and tf3 are the instant of start and the instant of end of contact between grinding wheel **9** and piece **13** under a condition in which the grinding wheel **9** has a faster approach speed.

From the figures it is possible to realize that the output signal **SA** of the acoustic sensor **19** does not substantially vary if the approach speed of the grinding wheel **9** varies, but its trend only depends on the amount of time in which there is contact between grinding wheel **9** and piece **13** (time intervals ti3-tf3, ti4-tf4). On the contrary, the output signal **SF** of the force-detecting sensor **21** slowly increases after contact occurs between grinding wheel **9** and piece **13** (instants ti3, ti4), slowly decreases at the end of contact between grinding wheel **9** and piece **13** and has an amplitude that directly depends on the approach speed of the grinding wheel **9.** Higher approach speeds cause signals **SF** with greater amplitudes.

In summary, the output signal **SA** of the acoustic sensor **19** rapidly increases when grinding wheel **9** contacts the piece **13** and rapidly decreases when the grinding wheel displaces away from piece **13,** and has an amplitude that substantially does not depend on the extension of the contact surface between grinding wheel **9** and piece **13,** on the cutting capacity and on the approach speed of the grinding wheel **9.** An analysis of such a signal provides information on the time frames in which the machining occurs (contact between grinding wheel and piece), regardless of the machining conditions. The force-detecting sensor **21,** instead, generates a signal **SF** that slowly increases when the grinding wheel **9** contacts the piece **13,** slowly decreases as they detach from one another, but has an amplitude that depends on the extension of the contact surface between grinding wheel **9** and piece **13,** on the sharpness condition of the grinding wheel **9** and on the approach speed of the grinding wheel **9.** Said output signal **SF** of the force-detecting sensor **21** does not enable to accurately define the time intervals in which machining occurs but it enables to obtain information on the machining process and more specifically on the contact area between piece **13** and grinding wheel **9**, and on the cutting capacity of the grinding wheel **9** and on the approach speed of the grinding wheel **9**.

A method according to the invention exploits in a synergetic way the information provided by the acoustic sensor **19** and by the force-detecting sensor **21**. More specifically, the output signal **SA** of the acoustic sensor **19**, owing to its rapid response features when contact occurs between the grinding wheel **9** and the piece **13** and to the amplitude substantially uncorrelated to the contact force, is utilized for determining the time intervals in which the output signal **SF** of the force-detecting sensor **21** provides useful information for checking the machining process, in other words the intervals in which the grinding wheel **9** is actually in contact with the piece **13**. The trend of the output signal **SF** of the force-detecting sensor **21** in said time intervals provides significant information on the quantity of material that has been removed in the course of the machining (on the basis of the approach speed of the grinding wheel **9** and on the extension of the contact surface between grinding wheel **9** and piece **13**) and on the sharpness condition of the grinding wheel **9**.

The operation of the apparatus according to the invention is now described with reference to the flow chart in figure 7.

In a first phase the numeric control **24** automatically selects, or the operator can manually select, the type of check to carry out, for example the wear condition of the grinding wheel **9** (block 40).

Subsequently the processing and control unit **23** checks the logic value of the output signal **SA** of the acoustic sensor **19** (block 50). As soon as the signal **SA** changes to a high logic value, there is detected an instant of start, with a substantially negligible delay with respect to the instant ti in which there occurs the actual contact between grinding wheel **9** and piece **13**: the processing and control unit **23** consequently starts to monitor the output signal **SF** of the force-detecting sensor **21** (block 60). The processing and control unit **23** checks the logic value of the output signal **SA** (block 70). The monitoring of the output signal **SF** of the force-detecting sensor **21** continues until the output signal **SA** of the acoustic sensor **19** maintains a high logic value and, consequently, for all the time interval in which the grinding wheel **9** is in contact with the piece **13** (block 60). When the output signal **SA** of the acoustic sensor **19** changes to low logic value, there is detected an instant of end, with a substantially negligible delay with respect to the instant tf at which there occurs the actual displacing of the grinding wheel **9** away from the piece **13**, and the monitoring of the signal **SF** by the processing and control unit **23** ends. The retrieved (and stored) output signal **SF** of the force-detecting sensor **21** undergoes a suitable processing for obtaining information relating to the monitored feature, in this case the cutting capacity of the grinding wheel **9**, such processing including, for example, the integration of the signal **SF** in a time interval that substantially corresponds to the interval ti-tf (block 80). Subsequently, the value obtained by the processing is compared with values memorized and detected in a previous setting or "learning" phase of the apparatus (block 90). If the result of this comparison indicates that the monitored feature, in this case the wear of the grinding wheel **9**, is within acceptable limits, it is possible to move on to carry out, if necessary (block 100), another type of checking (block 40). On the contrary, if the monitored feature exceeds the acceptable limits, the numeric control indicates to the operator, for example by displaying a message, the need to carry out a dressing cycle of the grinding wheel **9**, or, once the machining of the piece ends, directly controls, without the operator's attendance, the dressing cycle of the tool (block 110). The procedure ends (block 120) when the required checkings have been completed.

In a preliminary setting or "learning" phase, that follows the installation of the sensors **19** and **21** on the machine **1**, the processing and control unit **23** retrieves the output signals of the sensors **19** and **21** at different working conditions: different extensions of contact surface between grinding wheel **9** and piece **13**, different wear conditions of the grinding wheel **9** and different approach speeds of the grinding wheel **9** and processes said signals for obtaining and memorizing reference values to be compared with those that are acquired during the checkings.

As an alternative to what is described above, after having chosen the type of check to carry out, the processing and control unit **23** can simultaneously acquire the output signals **SA** and **SF** of both the sensors **19** and **21** and, on the basis of the trend of the signal **SA**, determine the instant of start and the instant of end of contact, that substantially define the time interval in which machining occurs, and process thereafter, as previously described, the signal **SF** only at said time interval.

The sensors can be arranged on the grinding machine at positions that differ from those herein described, so long as they allow the correct detecting of the signals. More specifically, the acoustic sensor can be coupled to one of the two centers, or to a grinding wheel balancing device, if applied to the grinding machine. Instead, the force-detecting sensor can be arranged between an intermediate support of the piece, or a steady rest, if included, and the base of the machine.

Variants with respect to what is herein described are feasible and more specifically the force-detecting sensor **21** can be replaced with a power-detecting sensor for detecting the electric power absorbed by the motor of the grinding wheel **9**, or with a strain gauge with high sensitivity, for example a strain gauge on a silicon film, for determining the deformations of the grinding wheel slide in the course of the machining and, consequently, the force applied by the grinding wheel **9** on piece **13**. The trends of the signals output by the power-detecting sensor and by the strain gauge are alike that of the above described signal output by the force-detecting sensor **21** and thus provide identical information on the machining process. The acoustic sensor **19** can be substituted with a sensor of another type that is able to detect, with appropriate accuracy, the time intervals in which the grinding wheel **9** is in contact with piece **13.** For this purpose there can be utilized, for example, optical sensors or proximity inductive sensors that measure the mutual position between grinding wheel **9** and piece **13.**

Furthermore, an apparatus according to the invention can include a greater number of sensors (identified as **S1…SN** in figure 8), identical or of a different type with respect to those herein described, for checking a greater number of processes. The block diagram of figure 8 shows an apparatus including **N** sensors **S1…SN**, connected with associated conditioning electronics **E1…EN**, the outputs of which meet in a processing unit **27** connected with a unit **29**, for determining the control procedure, connected with the numeric control **24** and the PLC (Programmable Logic Controller) **31** of the machine **1.**

The signals output by the sensors **S1…SN** are amplified and suitably processed by the conditioning electronics **E1…EN** before being sent to the processing unit **27.** Unit **29** for determining the control procedure, on the basis of the requests received by the numeric control **24** or by PLC **31,** sends signals to the processing unit **27** in order that it can carry out the necessary processings of the output signal of a single sensor **S1…SN** or synergetically utilize the output signals of a plurality of sensors **S1…SN,** and sends the results of said processings to the numeric control and/or to the PLC and/or to other display units as, for example, a personal computer **33.**

Many types of checkings can be carried out by an apparatus of this kind and they include automatic checkings of the various machining phases, checkings of the condition of the tools, control of their possible sharpening, in addition to checking of possible collisions and diagnosticating for preventive maintenance.

Obviously, an apparatus and a method according to the invention can be utilized for checking the machining process of other types of machine tools, as for example, lathes or milling machines.

CLAIMS

1. An apparatus for checking the machining process of a machine tool **(1)** with a base **(2)** and a tool-carrier slide **(3)**, movable with respect to the base **(2)** and carrying a tool **(9)**, the apparatus including:

- a support and reference system **(15,17)** for supporting and referring a piece **(13)** to be checked;
- a first sensor **(21)**, adapted for sensing the force occurring between the tool **(9)** and the piece **(13)** and for emitting a first output signal **(SF)**; and
- a processing and control unit **(23)** connected to the first sensor **(21)** and adapted for processing said first output signal **(SF)**,

characterized in that it includes a second sensor **(19)**, adapted for detecting the contact occurring between the tool **(9)** and the piece **(13)** and for emitting a second output signal **(SA)**, the processing and control unit **(23)** being connected to the second sensor **(19)** and being adapted for processing the first output signal **(SF)** and the second output signal **(SA)** and for providing information on the machining process of the machine tool **(1)**.

2. The apparatus according to claim 1, wherein said second output signal **(SA)** is indicative of a time interval **(ti-tf)** during which there is the contact between the tool **(9)** and the piece **(13)**, the processing and control unit **(23)** being adapted to define said time interval **(ti-tf)** on the basis of the second output signal **(SA)** and process said first output signal **(SF)** at said time interval **(ti-tf)**.

3. The apparatus according to claim 1 or claim 2, wherein said second sensor **(19)** is an acoustic sensor **(19)**.

4. The apparatus according to claim 3, wherein said tool **(9)** is a grinding wheel **(9)** coupled to said tool-carrier slide **(3)** and able to rotate with respect to it, said

acoustic sensor **(19)** being coupled to said grinding wheel **(9)**.

5. The apparatus according to one of the preceding claims, wherein said first sensor **(21)** is a force-detecting sensor **(21)**.

6. The apparatus according to claim 5, wherein said tool-carrier slide **(3)** is coupled to a slide **(4)**, movable along a transversal direction **(Y)**, said force-detecting sensor **(21)** being connected to said tool-carrier slide **(3)** and to said slide **(4)**.

7. The apparatus according to one of claims from 1 to 4, wherein said first sensor **(21)** is a power-detecting sensor.

8. The apparatus according to one of claims from 1 to 4, wherein said first sensor is a strain gauge.

9. The apparatus according to one of the preceding claims, wherein said machine tool includes a numeric control **(24)** connected to said processing and control unit **(23)**.

10. A method for checking the machining process of a machine tool **(1)** by means of an apparatus according to one of the claims from 1 to 9, including the following steps:

- checking **(50)** the logic value of the second output signal **(SA)** and detecting an instant of start, substantially corresponding to the instant **(ti)** at which there occurs the contact between the tool **(9)** and the piece **(13)**;
- monitoring **(60)**, from said instant of start on, the first output signal **(SF)**;
- checking **(70)** the logic value of the second output signal **(SA)**, and detecting an instant of end, substantially corresponding to the instant **(tf)**, at

which there occurs the detachment between tool **(9)** and piece **(13)**;

- ending the monitoring of the first output signal **(SF)** at said instant of end;
- processing **(80)** said first output signal **(SF)**;
- performing a comparison **(90)** between the results of said processing and reference values and
- deciding, on the basis of the result of said comparison, the necessary operations **(100,40;110)** to be carried out.

11. The method according to claim 10, wherein the results of the processing of the first output signal **(SF)** are indicative of the quantity of material removed in the course of the machining of the piece **(13)**.

12. The method according to claim 10, wherein the results of the processing of the first output signal **(SF)** are indicative of the sharpness condition of the tool **(9)**.

13. The method according to claim 11 or claim 12, for the checking of the machining process of a grinding machine **(1)**.

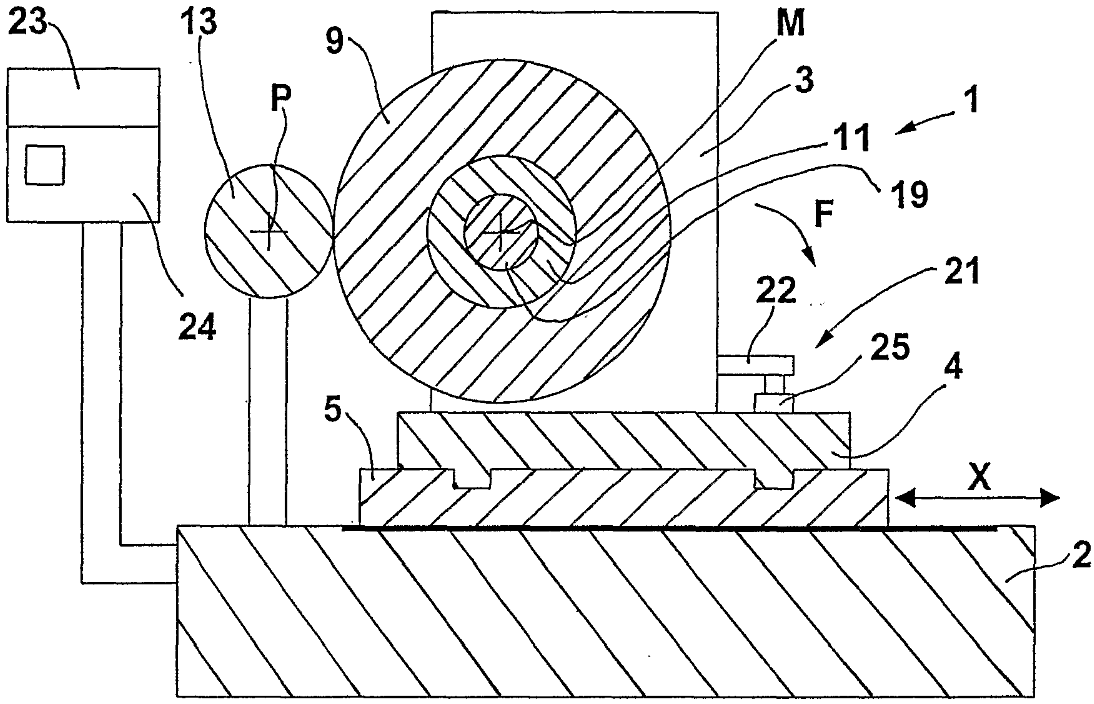
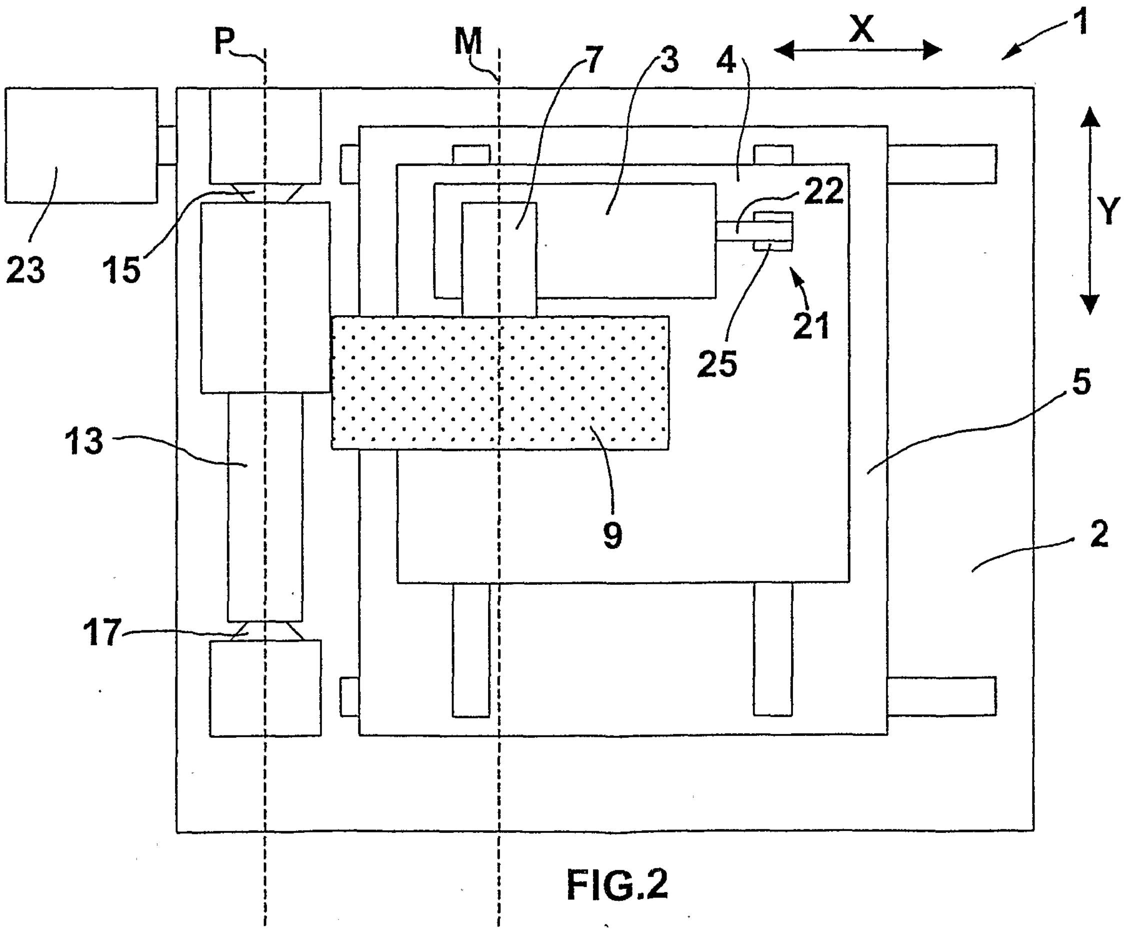

23
13
9
M
3
1
P
11
19
F
21
22
25
4
24
5
X
2

FIG.1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X
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7
3
4
22
Y
23
15
21
25
5
13
9
2
17

FIG.2

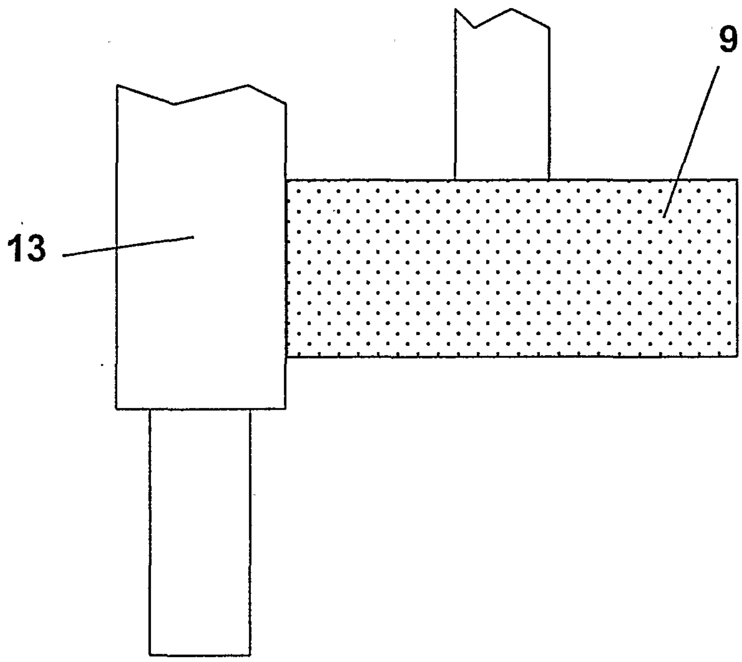

FIG.3A

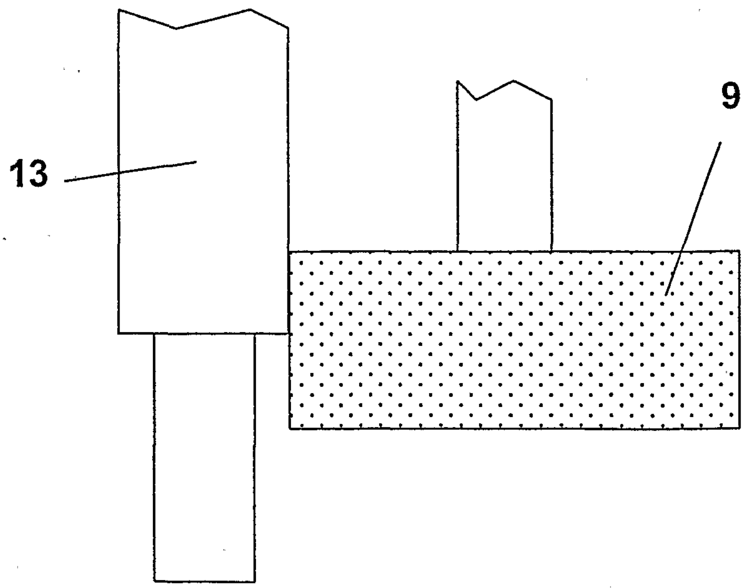

FIG.3B

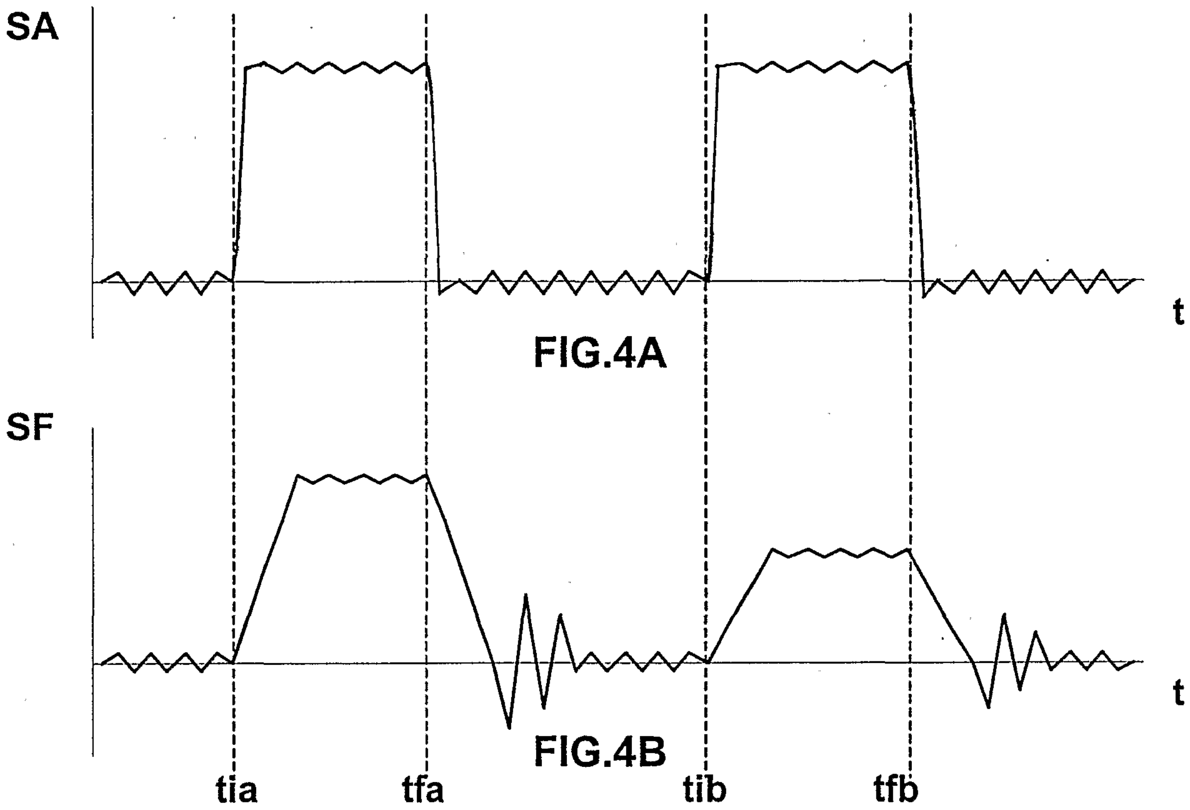

FIG.4A

FIG.4B

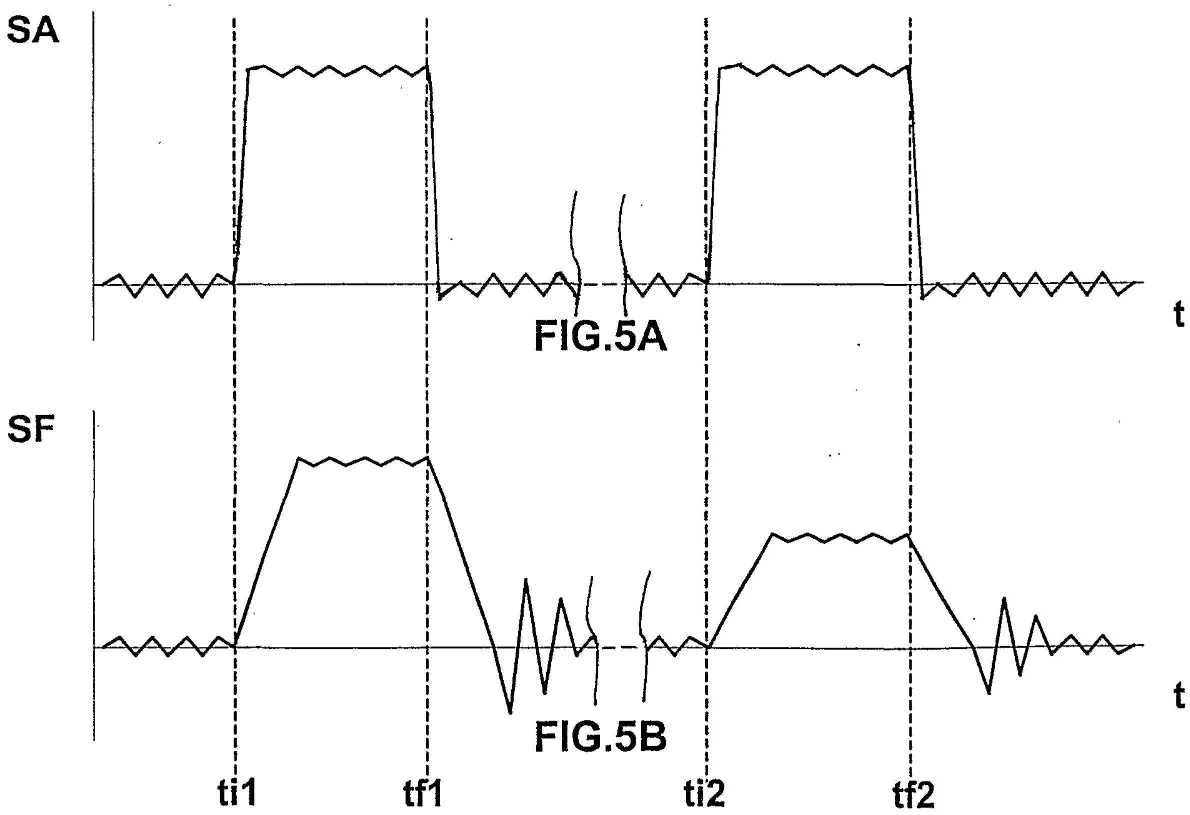

FIG.5A

FIG.5B

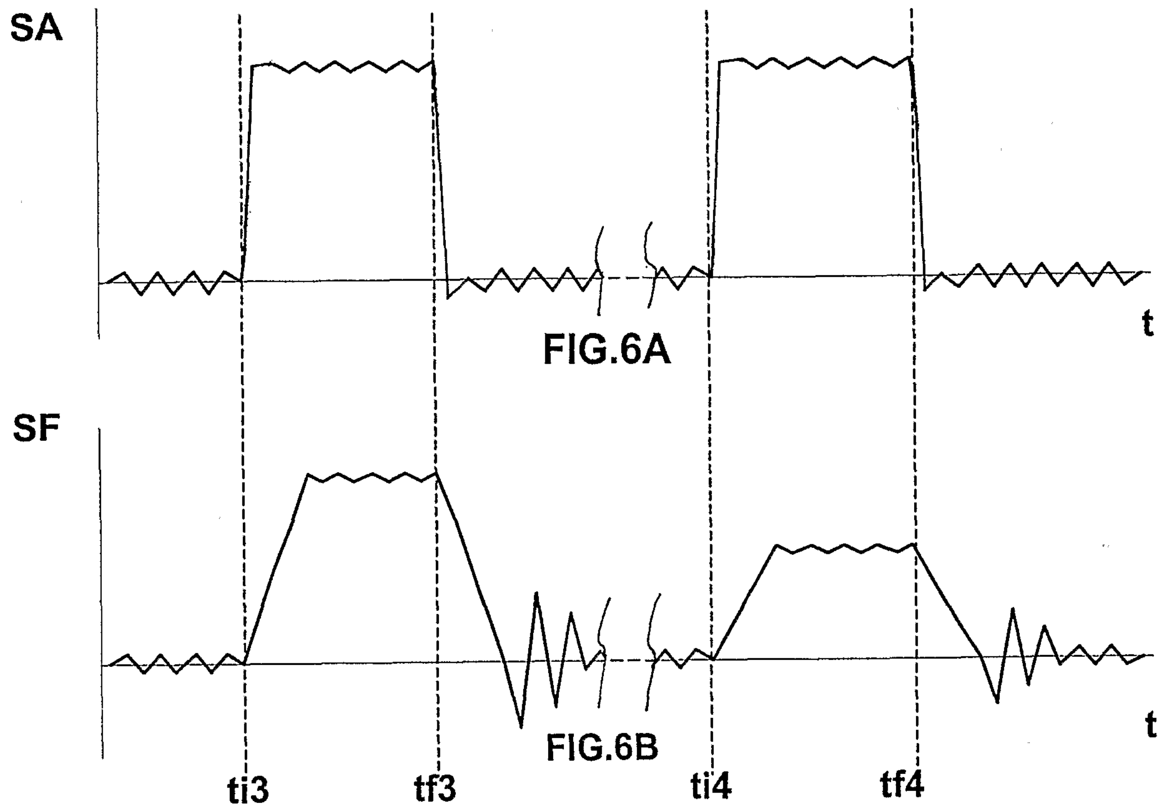

FIG.6A

FIG.6B

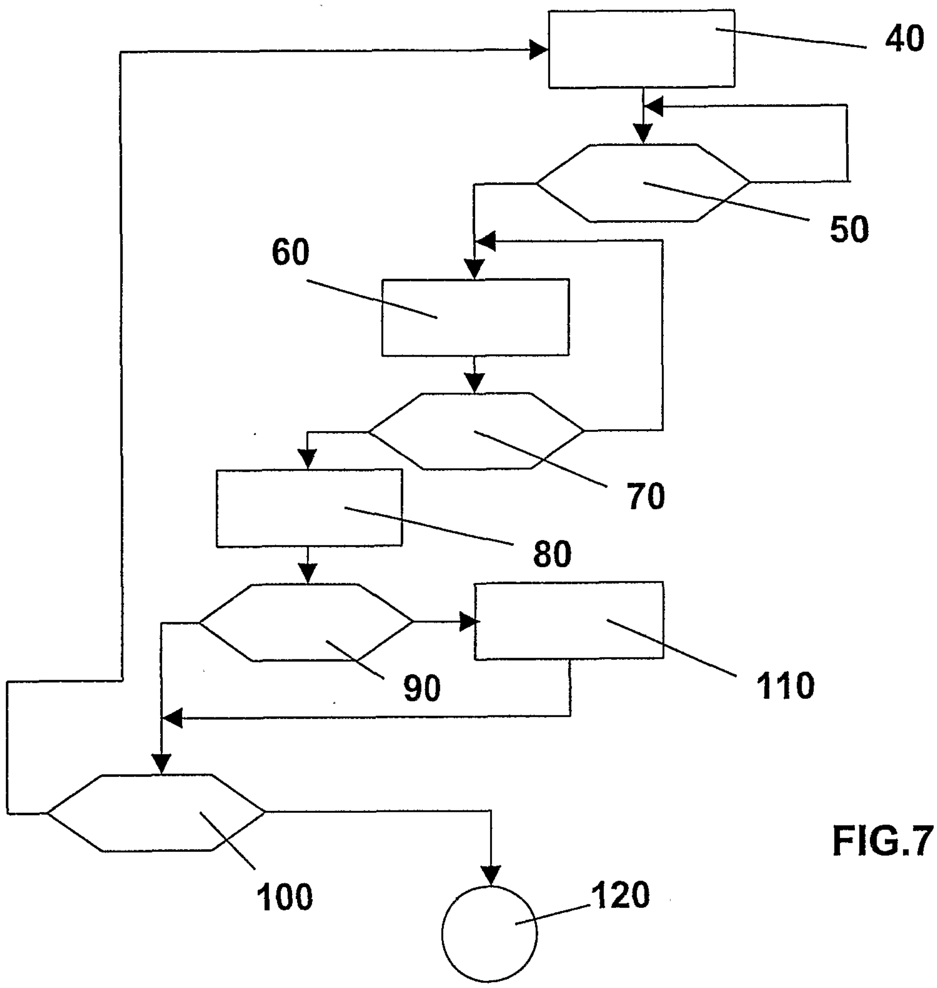

FIG.7

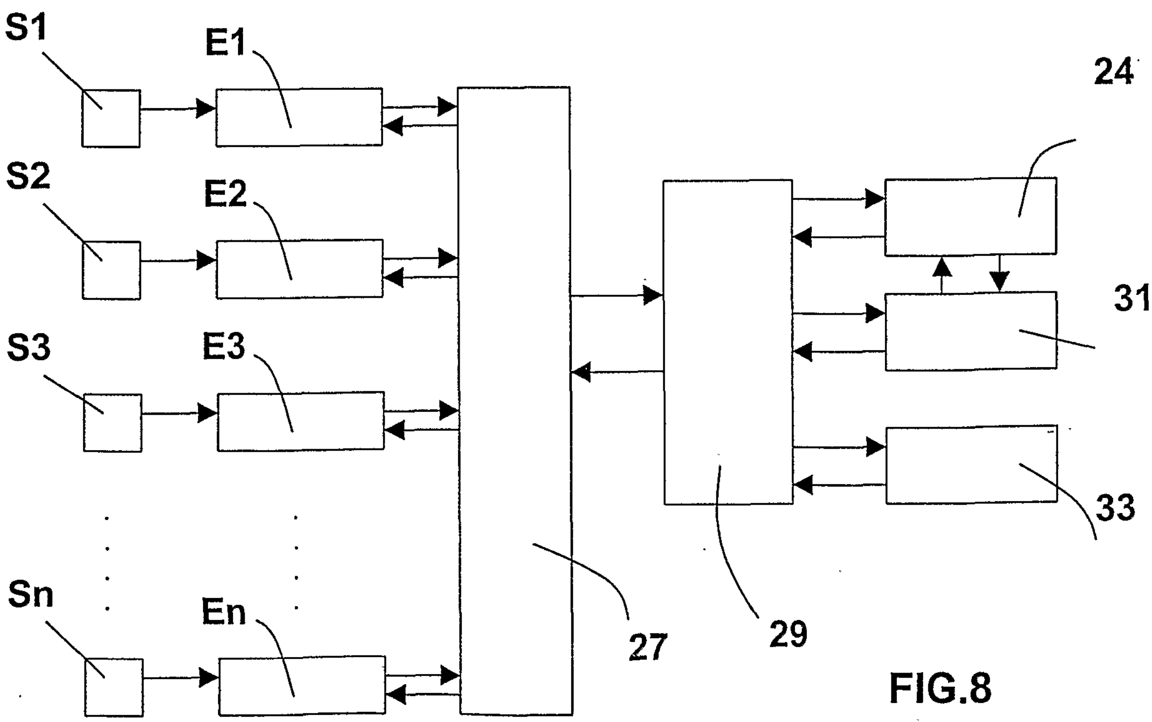

FIG.8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/07519

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B23Q17/09 B24B49/16

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)
IPC 7 B23Q B24B

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

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

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 866 429 A (GRANERE VERNE R) 12 September 1989 (1989-09-12) column 2, line 31 - line 36 column 3, line 20 - line 40 column 3, line 58 -column 4, line 8 column 4, line 26 - line 33 column 9, line 37 - line 41 ---	1,2,5, 7-12
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A	column 2, line 28 - line 36 ---	10-13
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
19 November 2002	26/11/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Carmichael, Guy

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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