

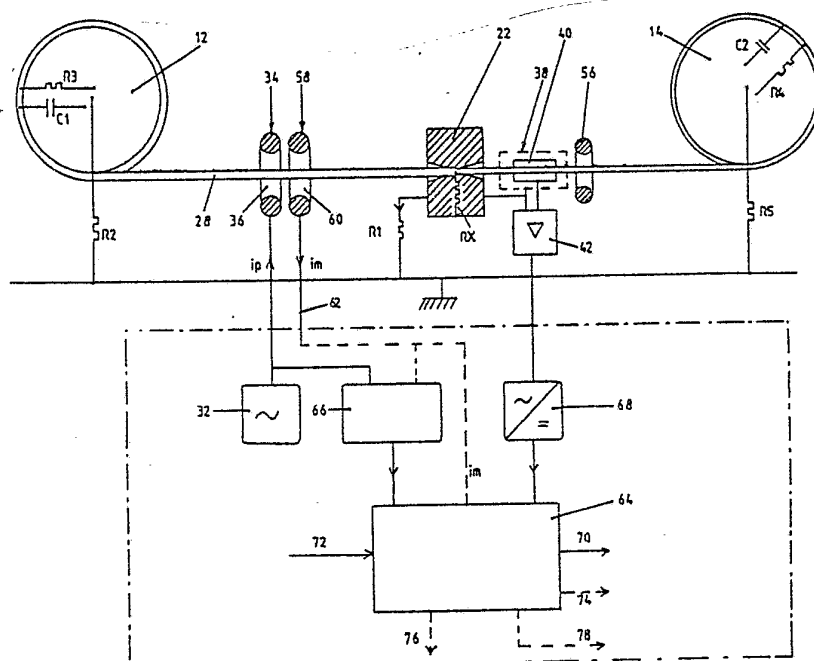


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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| <b>(51) International Patent Classification<sup>3</sup> :</b><br><br><b>F16N 29/00; B21C 9/00</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>A1</b> | <b>(11) International Publication Number:</b> <b>WO 84/ 03751</b><br><br><b>(43) International Publication Date:</b><br>27 September 1984 (27.09.84) |
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**(54) Title:** DEVICE FOR DETECTING VARIATIONS IN THICKNESS OF LUBRICATING FILM OF WIRES**(57) Abstract**

A device for detecting variations in thickness of lubricating film of wires (28) by measuring electrical contact resistance at wire drawing in a drawing bench. In a drawing bench of the intended type the wire runs between uncoiling and coiling capstans (12 and 14, respectively) or so-called pulleys, a drawing box (16) provided with lubricant and draw plate (22) being placed between the capstans and pulleys, respectively. Part of the wire, the lubricating film, the draw plate and additional members associated with the drawing bench form a closed electric circuit. The very wire (28) receives current contactless via a transformer (34), which is fed from an A. C. current source (32). A capacitive sensor (38) containing a tubular electrode (40) providing a capacitive connection between the wire and an amplifier (42) is arranged in a casing (44) galvanically connected to the draw plate for measuring the voltage across the lubricating film. An evaluating means (64) electrically connected to the measuring sensor is arranged to determine the resistance of the lubricating film according to the formula:  $R_x = k (U/i)$ , where  $i$  is the current through the wire (28) to be measured,  $U$  is the voltage measured via the sensor (38) and  $k$  is a constant. It is possible to evaluate by means of  $R_x$  so-called tearing, wear of draw plate and variation in quality of the produced wire.



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Device for detecting variations in thickness of  
lubricating film of wires

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This invention relates to a device for detecting variations in thickness of lubricating film of wires by measuring electrical contact resistance at wire drawing in a drawing bench, the wire running between uncoiling and coiling capstans or pulleys via a drawing box provided with lubricant and draw plate and located between the capstans/pulleys, a part of the wire, the lubricating film, the draw plate and additional members associated with the drawing bench forming a closed electric circuit.

The new device is based on resistance measurement according to the current/voltage method. Measurement is to be carried out contactless against the moveable measuring object, i.e. the wire, and there is only one galvanic connection with the stationary part of the system.

It is the object of the invention to provide a device making it possible to detect tearing in connection with wire drawing and to stop the wire drawing automatically. It is also intended to make it possible to predict wear of the draw plate by means of the new device and to perform quality control.

Laboratory tests have shown that it is practically possible to measure electrical contact resistance by means of the new detecting device with a resolution of down to 0.1 - 1 milliohm. The resistance at a mere metallic contact between wire and draw plate is rated at approximately 0.01 milliohm. Tests in a laboratory draw bench and in a production plant also show that the electrical contact resistance in normal operation substantially varies within the range of 10-1000 milliohm. At so-called tearing the resistance is reduced to milliohm level.

It is previously known to utilize the current/voltage method to detect correct lubrication at wire drawing. An arrangement of this kind is for instance shown in Japanese patent 56-6722. However, in the known arrangement the electrical resistance is measured with direct voltage which should bring essential additions of thermoelectrical



signal voltages. Moreover, the sum of the resistance in two draw plates as well as the intermediate wire is measured. This makes detection of local defects impossible which are shorter than the wire length between the draw plates. Thus, lubricant defects of the order of 1 mm can be allowed to pass as the normal resistance variations are so great that it is impossible to decide whether a draw plate is short-circuited or not.

The minimum detectable resistance measured by the aid of the known construction corresponds to the resistance in the wire between the draw plates, thus approximately 10 milliohm.

By using the arrangement according to the known Japanese patent it is thus impossible to record an irregular product quality with a good time/length resolution. Nor is it possible to calculate accumulated resistance distribution with good accuracy to judge plate wear on the basis thereof.

Moreover, the degree of tearing cannot be recorded as it presupposes resolution at a resistance value below 1 milliohm.

The drawbacks indicated above are eliminated according to the invention by means of a detecting means of the type mentioned above, which is primarily characterized in that an A.C. operated transformer is arranged to transmit current contactless to the wire included in the electric circuit and that a capacitive sensor is arranged in a casing galvanically connected to the draw plate for measuring the voltage across the lubricating film, an evaluating means electrically connected to the sensor being arranged to determine the resistance of the lubricating film according to the formula

$$R_x = k \cdot \frac{U}{i}$$

where  $i$  is the current through the measuring wire,  $U$  is the voltage measured via the sensor and  $k$  is a constant. The very wire is preferably included in the secondary winding of the transformer.

A detecting device of this kind can be designed for use at reaction times down to the range of 1 millisecond which



allows registration of point-like defects at drawing velocities of several meters per second.

The invention will now be described below more in detail in the form of a preferred illustrative example with reference to the enclosed drawing, wherein

Fig. 1 shows an example of the main members of a wire drawing bench, in which the resistances and capacitances to be used with the electric circuits according to the principles of the invention are drawn,

Fig. 2 shows a wire drawing plant with a detecting means which is embodied and installed according to the principles of the invention, and

Fig. 3 shows more in detail the new device according to the invention for providing current in the drawing wire and measurement of the electrical contact resistance between the wire and the draw plate.

The same reference numerals have been used for like members in the different Figures.

The drawing bench arrangement generally shown in Fig. 1 comprises a stationary support 10, on which an uncoiling capstan 12 and a coiling capstan 14 are rotatably mounted. Said capstans 12, 14 are shown only partially on the drawing. Between the capstans 12, 14 there is the so-called drawing box 16, which consists of a lubricant container 18 and a draw plate 22 arranged in a special space 20 and well sealed against the very drawing box by means of packings 24. The draw plate 22 is cooled in operation by means of water 26, which makes contact with the draw plate 22 around its periphery.

In wire drawing the wire 28 is forced in known manner through the aperture 30 of the draw plate 22, the lubricating film applied around the wire - not shown - being continuous and uniform in order to obtain the best possible result.

In Fig. 2 the drawing bench is shown schematically together with the connected detecting device according to the invention, the relative electric circuits corresponding to the construction according to Fig. 1 being indicated.

$R_x$  is the electric resistance across the lubricating film,  $R_1$  is the resistance in the draw plate 22, the



packing 24 and support 10 of the drawing bench,  $R_2$  the resistance across the bearing of the uncoiling capstan 12,  $R_3$  the contact resistance between the uncoiling capstan 12 and the wire 28,  $C_1$  being the corresponding capacitance,  $R_4$  the contact resistance between the uncoiling capstan 14 and the wire 28,  $C_2$  being the corresponding capacitance, and  $R_5$  the resistance across the bearing of the coiling capstan 14.

As current source of the disclosed detecting device an oscillator 32 is used in the indicated example, which operates a current transformer 34. The primary winding of the transformer 34 consists of a toroidal coil 36 which encloses the wire 28 which will thus be included in the secondary winding of the transformer 34. The current paths appear from the arrows in Fig. 2. The A.C. current of the measuring circuit is thus obtained contactless.  $i_p$  and  $i_x$  on the drawing indicate the currents through the primary and secondary windings of the transformer 34. A capacitive measuring sensor 38 comprising a tubular electrode 40 as well as an associated amplifier 42 capacitively connected to the wire via the tube electrode 40 is arranged in a casing 44, which is galvanically connected to the draw plate 22 for measuring the voltage  $U_x$  across the lubricating film. The casing 44 shields the measuring sensor 38 from outer electric interference fields. The galvanic connection to the draw plate 22 is arranged so that undesired voltage drops are eliminated. Thus, the casing 44 is directly connected to the draw plate 22 via an adapter 46 which is in good contact with a flange 48 projecting from the draw plate 22. The tubular adapter 46 is provided with through-passing slots 50, through which non-desired lubricant scales coming off the lubricant film can easily pass. An electric insulation 52 is arranged between the draw plate 22 and the very draw plate 16 on the side facing the measuring sensor 38. On the opposite side a good galvanic connection is, on the other hand, achieved. This is shown on the drawing with a ground lead 54. In order to attain a good function it is very important that the resistance  $r_1$  is low, which is thus ensured by a pure metallic contact.



Another toroidal coil 56 is arranged around the wire 28 in immediate connection with the casing 44 to eliminate by blocking inductance non-desired voltage drops along the wire and shunting of the contact resistance  $R_x$  which should otherwise be attained via the wire 28 across the resistance  $R_4$ , the capacitance  $C_2$  and the resistance  $R_5$ .

In the embodiment illustrated in the drawing a special current measuring transformer 58 is connected. In this a toroidal coil 60 is included which encloses the wire 28 in the same way as the toroidal coil 36. The two transformers 34, 58 are arranged in the immediate vicinity of each other. The toroidal coil 60 is to make possible an accurate current measurement in the cases when great variations in impedance are to be expected. The contact resistance  $R_x$  can then be calculated by dividing the measured voltage  $U_x$  by the measuring current  $i_m$  passing the electric conductor 62 connected to the toroidal coil 60.

The oscillator 32, the measuring sensor 38 as well as the toroidal coil 60 of the transformer 58 are connected to a signal processor 64, which makes it possible to evaluate the measuring values obtained. In the electric circuit from the oscillator there is also a detector 66 for failure of power supply.

The A.C. voltage signal received from the measuring sensor 38 is demodulated in a demodulator 68 and is then passed on to the signal processor 64. The signal processor 64 can sound the alarm via the output 70 by means of predetermined criteria fed via the adjusting means 72.

Depending on the use of the detecting device it is also possible to obtain alarm signals - at 74 - at an unsatisfactory detector function and to analyze data - at 76 - with information about calculated quality or wear of draw plate. For connection of external data registration equipment values concerning current, voltage and optionally calculated resistance can be obtained via an output 78.

In the embodiment shown the signal processor consists of a microprocessor but may in its simplest form consist



of an analogous level discriminator. A processing of signals is made by means of the described equipment after signal conversion, said processing being adapted to the primary object. In the simplest case alarm is sounded  
5 when you are below a predetermined resistance limit, optionally after a certain duration of time. In a more advanced use signal analysis is performed to obtain a rapid and safe reaction on changes or in order to correlate the result with experience as to plate wear and  
10 production quality.

Modifications of the detector means described above can of course be carried out within the scope of the invention. Thus, the transformer shown on the drawing can be embodied in many different manners. This also applies to  
15 the very measuring sensor. However, the constructive details are within the field of knowledge of one skilled in the art.

Moreover, it is also possible to utilize the inventive idea when measuring resistance of lubricating film, a  
20 rotary shaft being used instead of the wire used above. In this case the draw plate is replaced by a bearing.

## Patent Claims

1. Device for detecting variations in thickness of lubricating film of wires (28) at wire drawing in a drawing bench by measuring electrical contact resistance, the wire running between uncoiling and coiling capstans (12 and 14, respectively) or pulleys via a drawing box (16) provided with lubricant and draw plate (22) and located between the capstans/pulleys, a part of the wire (28), the lubricating film, the draw plate (22) and additional members associated with the drawing bench forming a closed electric circuit, c h a r a c t e r - i z e d in that an A.C. operated transformer (34) is arranged to transmit current contactless to the wire (28) included in the circuit and that a capacitive measuring sensor (38) is arranged in a casing (44) galvanically connected to the draw plate (22) for measuring the voltage across the lubricating film, an evaluating means (64) electrically connected to the sensor (38) being arranged to determine the resistance of the lubricating film according to the formula

$$R_x = k \cdot \frac{U}{i}$$

where  $i$  is the current through the wire (28) to be measured,  $U$  is the voltage measured via the sensor (38) and  $k$  is a constant.

2. The device of claim 1, c h a r a c t e r i z e d in that the wire (28) is included in the secondary winding of the transformer (34).

3. The device of claim 1, c h a r a c t e r i z e d in that the primary winding of the transformer (34) consists of a toroidal coil enclosing the wire (28).

4. The device of any one of claims 1-3, c h a r a c t e r - i z e d in that a signal amplifier (42) is connected in series with the sensor (38).

5. The device of claim 3 or 4, c h a r a c t e r - i z e d in that a second toroidal coil (56) is arranged around the wire (28) in connection with said casing (44) in order to eliminate non-desired voltage drops by means of a blocking inductance.



6. The device of any one of claims 3-5, characterized in that a third toroidal coil (60) is arranged around the wire (28) for measuring the current passing through the wire.

7. The device of any one of claims 1-6, characterized in that the measuring sensor (38) is electrically connected to a signal processor (64) operating as an evaluating means, preferably via a demodulator (68).

8. The device of claim 7, characterized in that the signal processor consists of a level discriminator.

9. The device of any one of claims 3-8, characterized in that the first and third coil, if any, (36 and 40 respectively) are individually connected to the signal processor (64).

10. The device of any one of claims 7-9, characterized in that the signal processor is a microprocessor.

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FIG.1

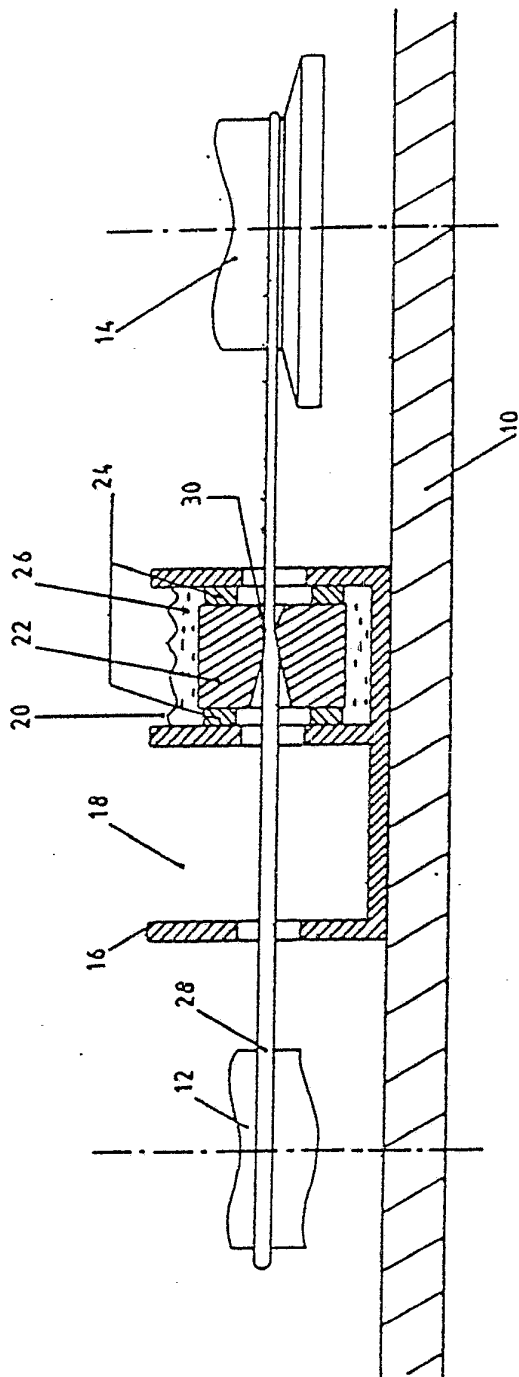


FIG.3

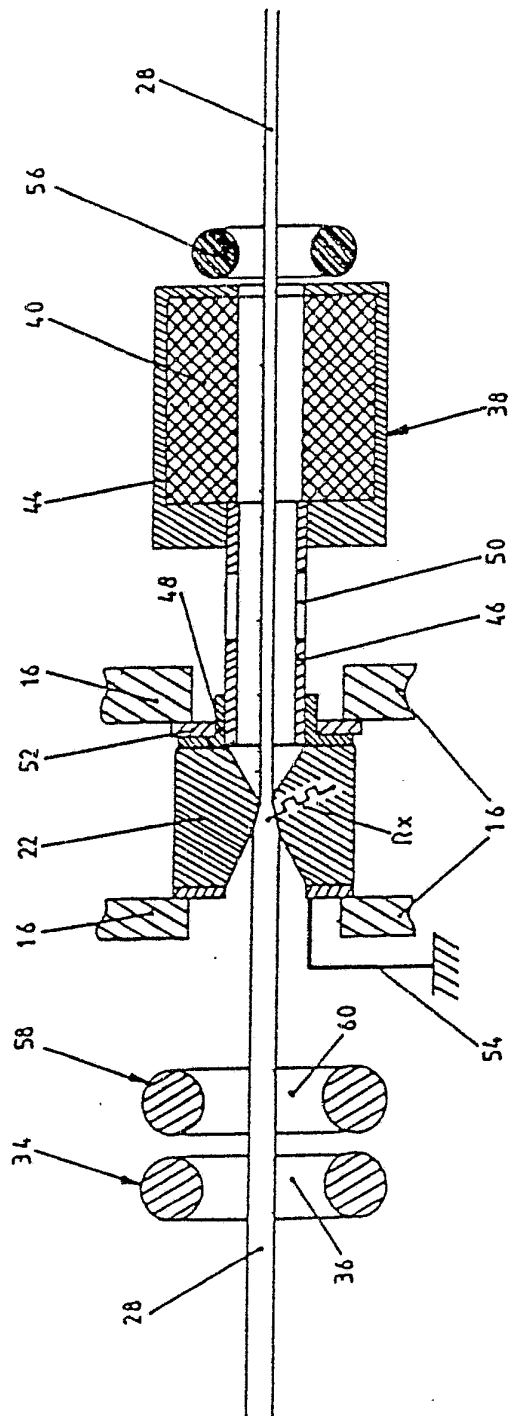
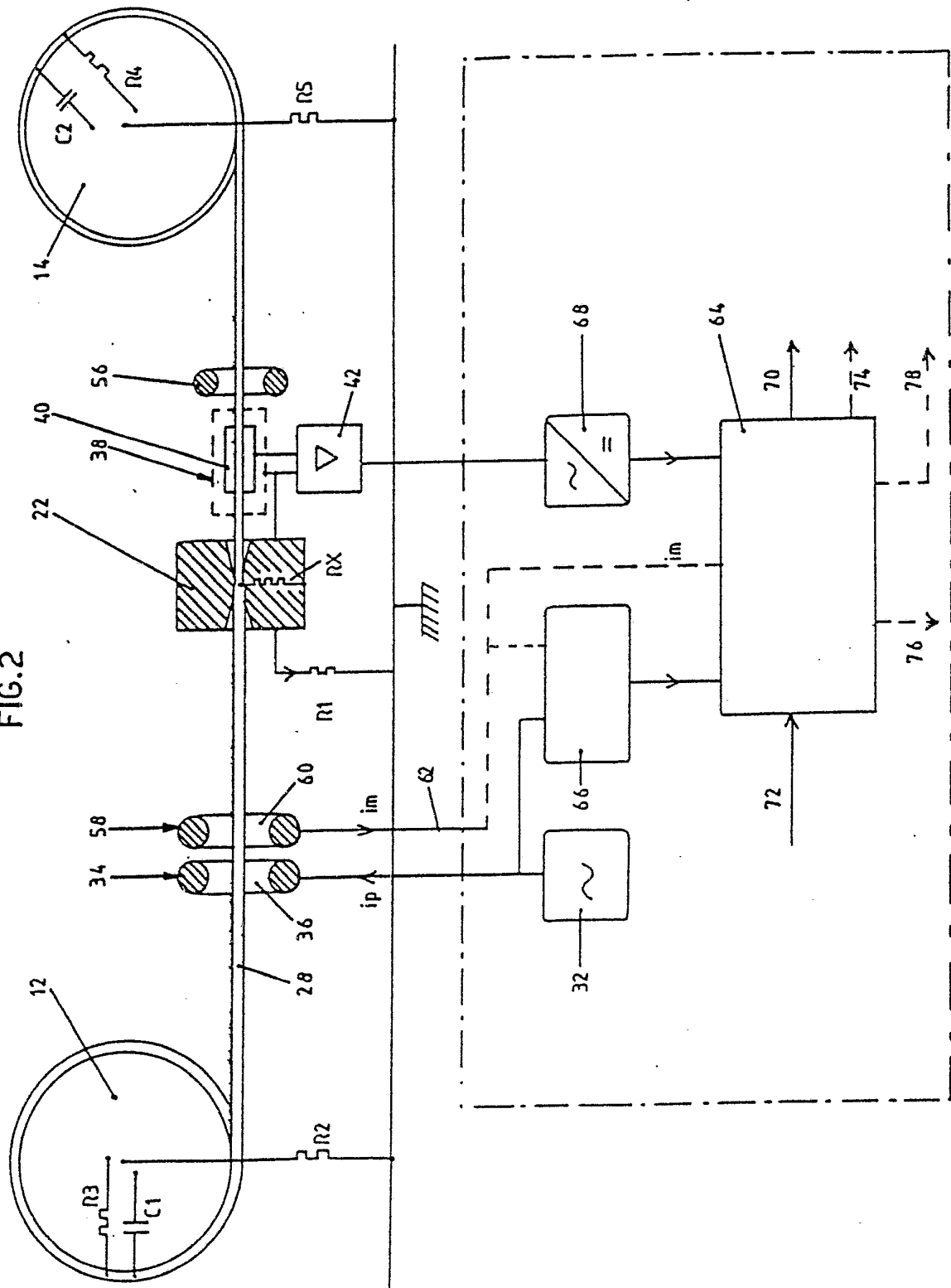


FIG.2



# INTERNATIONAL SEARCH REPORT

International Application No. PCT/SE84/00090

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                |                                     |
| According to International Patent Classification (IPC) or to both National Classification and IPC 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                |                                     |
| F 16 N 29/00; B 21 C 9/00                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                |                                     |
| <b>II. FIELDS SEARCHED</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                |                                     |
| Minimum Documentation Searched <sup>4</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                |                                     |
| Classification System                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Classification Symbols                                                                                         |                                     |
| IPC 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | F 16 N 29/00-04; F 16 C 17/24, 19/52; B 21 C 3/14, 9/00, 02; G 01 R 27/14                                      |                                     |
| National Cl                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 76: 4/50 .../...                                                                                               |                                     |
| Documentation Searched other than Minimum Documentation to the extent that such documents are included in the Fields Searched <sup>4</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                |                                     |
| SE, NO, DK, FI classes as above.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                |                                     |
| <b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>10</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                |                                     |
| Category <sup>9</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup> | Relevant to Claim No. <sup>13</sup> |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | EP, A, 0 030 694 (DJ WILKINSON)<br>24 June 1981                                                                | 1-10                                |
| <p>* Special categories of cited documents:<sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Z" document member of the same patent family</p> |                                                                                                                |                                     |
| <b>IV. CERTIFICATION</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                |                                     |
| Date of the Actual Completion of the International Search <sup>6</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Date of Mailing of this International Search Report <sup>7</sup>                                               |                                     |
| 1984-06-13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1984-06-25                                                                                                     |                                     |
| International Searching Authority <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Signature of Authorized Officer <sup>14</sup>                                                                  |                                     |
| Swedish Patent Office                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Hans Hagström                                                                                                  |                                     |

## FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II

Fields Searched (cont)

US CI

184: 1, 6.1, 6.4; 308: 1;  
72: 39, 41-45

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE <sup>10</sup>

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

1. ☐ Claim numbers ..... because they relate to subject matter <sup>12</sup> not required to be searched by this Authority, namely:

2. ☐ Claim numbers ..... 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 <sup>13</sup>, specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING <sup>11</sup>

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

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

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

3. ☐ 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 claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

## Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.