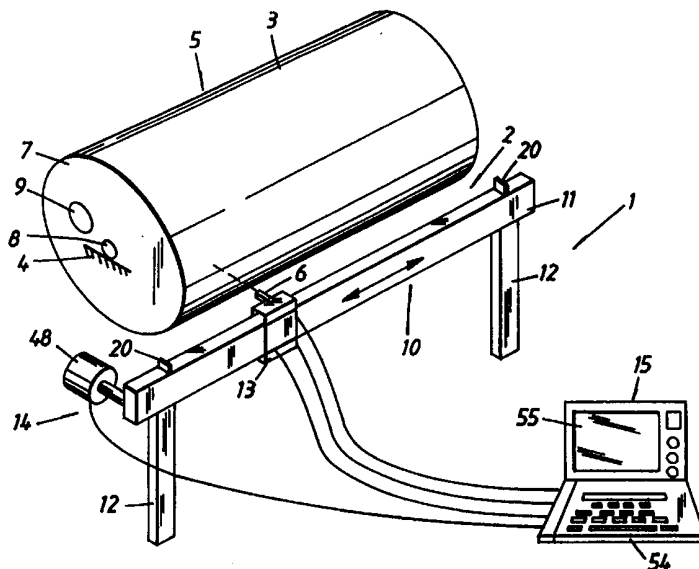




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(54) Title: METHOD AND MEASURING DEVICE FOR MEASURING AT AN ENVELOPE SURFACE



(57) Abstract

Method and device for measuring an envelope surface (3) of a measuring object (5) with respect to cylindricity or straightness relative to a straightness reference (16) arranged parallel to the axis of rotation of the object, said device comprising said straightness reference, a measuring stand (10) and a measuring carriage (13) at which a measuring means (6) is arranged, said carriage being traversed along a support member (11). According to the invention a first measurement is performed for a starting position for the measuring means relative the straightness reference and the measuring object being determined. The measuring means is then moved to further positions, which are determined in relation to each other or the starting position by measurements. A laser beam (58), protected by a protective device (17), is used as straightness reference.

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Method and measuring device for measuring at an envelope surface

5 The present invention relates to a method for, without
contact and with the aid of a measuring device, measuring
in a predetermined measuring area in connection to an
envelope surface of at least one measuring object
journalled rotatably in a machine stand of a paper
10 machine, with respect to its cylindricity and/or its
straightness relative to a straightness reference
arranged substantially parallel with the axis of rotation
of the measuring object, which measuring device comprises
said straightness reference, a measuring stand and a
15 linearly movably journalled measuring carriage on which
at least one measuring means is arranged, said measuring
carriage during said measurement is traversed along an
elongate form-stable support member forming a part of the
measuring stand, and running substantially parallel to
20 the axis of rotation of the measuring object, whereby
said measuring means is moved to one or more desired
positions for the measurement, and the measuring means is
caused to perform a measurement of the present
measurement values at each such position selected in said
measuring area.

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The invention also relates to a measuring device for,
without contact, measuring in a predetermined measuring
area in connection to an envelope surface of at least one
measuring object journalled rotatably in a machine stand
30 of a paper machine, with respect to its cylindricity
and/or its straightness relative to a straightness
reference, said straightness reference being arranged
substantially parallel with the axis of rotation of the
measuring object, which measuring device comprises said
35 straightness reference, a measuring stand and a linearly
movably journalled measuring carriage on which at least
one measuring means is arranged, said measuring carriage

during said measurement is traversed along an elongate form-stable support member forming a part of the measuring stand, and running substantially parallel to the axis of rotation of the measuring object.

5

Substantially all machines include a larger or smaller number of machine elements which are in the shape of cylindrical bodies that rotate about an axis of rotation during operation. In a paper machine, for instance, such machine elements consist primarily of either rolls or drying cylinders such as Yankee cylinders, the rolls usually being used to influence a continuous material web in one or more roll nips through which the web runs, to transfer some form of liquid, mixture or the like to said material web and also to support, guide and propel the web, whereas the drying cylinders are used to dry the moving web before it is finally reeled to a finished reel of paper. The drying cylinder has a hollow, thin-walled drum, heated by steam, which has a polished envelope surface over and around which the moist material web is moved in contact with the surface so that considerable heat can be transferred to the web. In view of this heat transfer the drum has relatively large diameter in order to facilitate the necessary drying.

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Common to said machine elements is that, due to their function and because they shall not influence the properties of the moving paper web in an uncontrolled and thus negative manner, they should normally be either as long as is technically possible, perfectly straight in their longitudinal extension, i.e. the envelope surface is parallel to said axis of rotation or cambered as in the specific case of a Yankee cylinder where instead of the actual cylinder being perfectly straight a carefully adjusted curvature is sought, a camber, which achieves the best possible uniformity in linear loading of the material web, and also perfectly cylindrical, i.e. that

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their physical cross section coincides exactly with the rotationally symmetrical cross section of the relevant machine element having one and the same radius around the axis of rotation for any imagined cross section along this axis. Any deviation, such as an incorrect or discontinuous camber and/or out of roundness, thus always affects the pressing, operability and, in the case of Yankee cylinders, the creping. Depending on how and where these deviations appear, the paper produced in the paper machine will not achieve the uniform paper properties striven for as far as possible.

Measurement and inspection of the envelope surface of a measuring object, e.g. a Yankee cylinder, are relatively simple to perform when it is not in operation and a great deal of information can therefore be obtained. The shape of the envelope surface can be compared, for instance, with the rotationally symmetrical cross section described above in order to determine the size and any variation in the cylindricity or the straightness profile of the measuring object. For the sake of simplicity the word "straightness" is used instead of the expression "straightness profile". Furthermore deposits, corrosion, wear patterns and the magnitude of this wear can be observed or measured. However, the shape of the Yankee cylinder's envelope surface, and thus the properties of said cylinder, are very different during operation from when it is stationary, because of the unavoidable deformations that occur during operation. Said deformations are caused primarily by three different loads, viz. linear pressure or loading from press rollers, an internal steam pressure and temperature forces.

If the measuring object consists of a drying cylinder, the temperature forces mentioned above are caused by heating from the water vapour used for the drying

process, which affects the shape and dimensions of the drying cylinder.

These stresses arise because the construction can never
5 be completely homogeneous and the measuring object,
particularly in the case of a thin, hollow drum which is
also subjected to many other forces such as centrifugal
force, linear pressure, steam pressure, vibration forces,
etc., is always deformed to a greater or lesser extent
10 during operation. Even extremely slight changes in the
parts of the machine element give rise to friction, wear
and, in the worst case, even an increased risk of rupture
in the moving material web, which always entails
extremely high costs. It is therefore vital to arrive at
15 a satisfactory method of correctly measuring the envelope
surface even during full operation of the paper machine.

In a previously suggested measuring device, e.g. "Tissue
Making '89: Creping and Drying", October 5-6, 1989 in
20 Karlstad, Sweden, VALMET Paper Machinery, Uddeholm Strip,
pages 75-78, a distance transducer stated to be a "non
contact eddy-current type displacement transducer" is
used for measuring the envelope surface of a Yankee
cylinder. This "displacement transducer" is supposed to
25 enable measurement of the distance between the envelope
surface and the transducer with an accuracy of $\pm 1/100$ mm
when the cylinder is in full operation which, as
established below, is not the case. Carried by a movable
measuring carriage, the transducer is moved along a
30 device travelling longitudinally along the Yankee
cylinder and included in said measuring means which is
suitably secured to the stand of the doctor blade, the
doctor-blade beam, transverse to the paper machine.
Situated at a specific first position along and close to
35 the envelope surface of the Yankee cylinder, the
transducer emits an extremely accurate signal which is
thus proportional to the distance to said envelope

surface. After one complete turn of the drying cylinder, therefore, the cylindricity of the envelope surface for this first position can be determined with relatively great precision.

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However, it is in practice impossible to subsequently move the transducer along the envelope surface of the cylinder to a specific second, third, and so on position absolutely in line with the first position, and at the same time completely parallel with the axis of rotation of the cylinder with an accuracy equal to or better than the resolving power of the transducer mentioned above. When measuring straightness profile, therefore, the measurement performed for a specific first position must in some way be related to corresponding measured values for every other position along the cylinder. In said measuring device, therefore, a taut metal wire, e.g. a piano wire, is used as straightness reference, this reference wire being arranged as best possible between two attachment devices in a measuring stand arranged in said measuring device parallel to the envelope surface of the cylinder and extending from the drive side of the paper machine across the entire length of the cylinder close to its downstream side.

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Due to the unavoidable physical properties of the straightness reference, however, the measured values obtained acquire a number of unavoidable measuring errors. One of the reasons is the fact that a certain apparently slight, but due to the accuracy of the measurements still not negligible, sag occurs which is greatest at the middle of the wire and the measured value in the measuring direction of the transducer with thus naturally also be incorrect. The magnitude of this sag varies greatly depending on the tension to which the wire is subjected and also on the stretch and creep occurring in the wire as a result of this tension.

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In said measuring device an attempt to solve this problem has been made by applying a specific tension in the wire firmly anchored to the measuring device by one end, with
5 the aid of a weight attached at the other, free end of the wire. Since it is arranged to extend over and round a rotatable member arranged at the opposite end of the measuring device from the fixed attachment, the wire will always be kept taut. How much this weight weighs has thus
10 been calculated and chosen so that the wire tension obtained will be very close to the yield point of the wire used so that its suspension and curvature are minimized maximally without risking a break in the wire.

15 The measuring means can thereafter be adjusted laterally to a fix position in relation to the reference wire for each selected measuring position along the envelope surface of the Yankee cylinder. Since the length of the reference wire must at least be equal to the length of
20 the object being measured which in paper mills used nowadays may be more than 8 meter, as well as the measuring accuracy being $\pm 1/100$ mm, it will be understood that the unavoidable sag in the wire constitutes an extremely considerable problem which must
25 be determined, despite maximum wire tension having been applied for the reference wire, and the measured values obtained by the transducer for each new measuring position along the measuring object must be corrected in accordance with the change in position that has thus
30 occurred in the measuring direction of the transducer.

In the described measuring device the measured values may be reported in isometric form, for example, so that a topographic map of the envelope surface is drawn showing
35 the irregularities thus ascertained in the longitudinal and transverse directions on said envelope surface.

Due to the proximity of the measuring device to the paper machine other error sources arise with the use of a straightness reference consisting of a reference wire, such as air turbulence caused by the rotating cylinder and by the moving material web, vibrations, collections of dust and paper fluff, liquid spray, etc. Thus, to reduce the influence of the above-mentioned error sources, the straightness reference must be checked, and possibly cleaned, and re-adjusted prior to each measurement and even during each measurement if said measurement comprises extended measurement sequences.

Furthermore, in the known measuring device the measuring carriage on which the measuring means is fitted must be pushed manually along the measuring beam and it is therefore extremely complicated to obtain any exact measuring positions in the cramped and hazardous space for the operator in the area around the doctor blade. This results in relatively long measuring times for each measurement sequence and the measurements can therefore really only be performed in a more or less efficient and safe manner on a paper machine which is temporarily out of operation, e.g. during repairs or service of the drying cylinder which, as ascertained above, gives a completely different and poorer measurement result - exactly the problem the known device was intended to remedy.

The main object of the present invention is to provide an improved method and an improved device for measuring at the envelope surface of at least one object to be measured with respect to its cylindricity and/or straightness so that the above problems are eliminated or at least greatly reduced.

A second object of the present invention is to provide a method and a device for completely automatically and

while simultaneously performing measurements, pass a transducer or measuring means, without contact, along a measuring stand substantially parallel with the cylindrical body or measuring object to be measured and
5 at the same time automatically collect, process and visually present the result of said measurement.

A third object of the invention is to provide a method and a device for, as far as possible, obtaining an
10 improved straightness reference which lacks or at least minimizes the errors and deficiencies that were unavoidable in the straightness references used hitherto.

A fourth object of the invention is to provide a method
15 and a device for protecting said improved straightness reference from substantially all external influence.

A further object of the invention is to provide a method and a device for performing said measurement of the
20 envelope surface of a measuring object during full operation of the machine in which said measuring object is included.

The method according to the invention is characterized in
25 that the measuring commences with a starting position for the measuring means relative the straightness reference and the measuring object being determined, which starting position comprises an initial position for the rotating measuring object, a current position along the support
30 member and a position in radial direction from the envelope surface of the measuring object, that a first measurement is performed for this starting position, that the measuring means is thereafter moved to at least one more position along the support member while this or
35 these new positions are continuously determined in relation to each other or said starting position, whereupon a measurement occurs in said measuring area at

each position, that a laser beam is used as straightness reference, said laser beam being generated by a laser unit, and that the laser beam is protected from external influence by being arranged along at least a part of its length in the shelter of an elongate protective device arranged substantially parallel with said support member.

The device according to the invention is characterized in that said straightness reference comprises a laser beam which is generated by a laser unit comprising a laser transmitter and a receiver detector, which laser beam is protected from external influence by being arranged along at least a part of its length in the shelter of an elongate protective device arranged substantially parallel with said support member.

The invention will be described in more detail in the following with reference to the accompanying drawings.

Figure 1 is a schematic perspective view of parts of a measuring device according to the present invention, seen from one long side of the measuring device and situated close to a cylindrical body to be measured, said measuring device comprising an electronic measuring and control unit, a measuring stand, a measuring carriage including a measuring means and a traversing device for said measuring carriage.

Figure 2 is a schematic top view of parts of a measuring device according to Figure 1 seen from above, showing a measuring beam included in said measuring stand comprising a schematic straightness reference and protective device and the measuring carriage running on the measuring beam.

Figure 3 is a front view of parts of the measuring device according to Figure 1 seen from the front, showing said

measuring beam and measuring carriage, respectively and the traversing device.

5 Figure 4 is a schematic top view of parts of the traversing device according to Figure 3.

Figure 5 is a top view of parts of a motor included in the traversing device according to Figure 3, seen straight from above.

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Figure 6 is a top view of parts of a retaining and adjustment member seen straight from above, included in the measuring device shown in Figure 1 comprising a setting member and an adjustment device.

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Figure 7 is a front view of parts of the retaining and adjustment member according to Figure 6 seen from the front, showing a number of non-contact measuring means with protective members and spacers.

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Figure 8 is a side view of parts of the retaining and adjustment member according to Figure 6, seen from one side.

25

Figure 9 is a cross section through parts of the measuring device according to Figure 1 showing a non-contact measuring means or a protective member and spacer in its position close to the cylindrical body arranged for measurement.

30

35 Figures 1 and 2 show schematically in perspective parts of the measuring device 1 according to the invention for measuring without contact in a predetermined measuring area 2 at, on, around and along an envelope surface 3 of at least one measuring object 5 rotatably journalled in a machine stand 4, preferably the machine stand 4 of a paper machine, to determine the cylindricity and/or

straightness of said object, as well as any other desired property or determination of or at said measuring object 5, such as corrosion, wear, temperature or velocity, and also suitable properties of a material web running over and around said measuring object 5 deemed advantageous to determine with the aid of said measuring device 1 comprising at least one measuring means 6 suitable for the purpose.

10 In the embodiment shown in Figure 1 the measuring object 5 comprises a substantially cylindrical body, e.g. a roll or a cylinder, rotating about an axis of rotation 8, such as a drive shaft. At least one suitable revolution pulse device 9 is arranged close to the measuring object 5, suitably at one end wall 7 or one drive shaft extension 8 so that it can be determined when the measuring object 5 is at its zero or starting position, when it has rotated part of a revolution, one complete revolution or several complete revolutions. In the embodiment shown said 15 revolution pulse device 9 may comprise an inductive transducer, suitably placed a few millimetres from said end wall 7, which reacts to a metal object arranged on the end wall, the transducer then having the advantage of an extremely short reaction time, a photocell detector comprising a reflector arranged at the axis of rotation 8 20 of the measuring object 5 and a transmitter which may be placed at a relatively much greater distance, approximately 0.5-1.0 m, from the rotating body 5 than the inductive transducer. The transmitter is therefore comparatively better protected than said inductive 25 transducer but the reaction time of the photocell detector is somewhat longer than that of said inductive transducer.

35 The measuring device 1 according to the invention also comprises a measuring stand 10 consisting of an elongate, rigid, i.e. form-stable, support member 11 arranged

substantially parallel with the axis of rotation 8 of the measuring object 5, e.g. a linear unit or a measuring beam, at each end of which measuring beam 11 an attachment means 12 is arranged. The measuring stand 10 is also provided with a linearly movably journalled measuring carriage 13 on which the measuring means 6 is arranged and which is arranged to be moved substantially parallel with said measuring beam 11, as well as a traversing device 14 to move said measuring carriage 13 to preferably predetermined, optional positions along said measuring beam 11 where measurement is desired, and an electronic measuring and control unit 15. Said measurement is performed with the aid of the non-contact measuring means 6 and a straightness reference 16 cooperating with this measuring means 6 (see Figure 2), which straightness reference is protected and screened from external influence by an elongate protective device 17, described in more detail below, arranged substantially parallel to said measuring beam 11.

By "substantially parallel with the axis of rotation 8 of the measuring object 5" is meant that the support member 11 is arranged so that said measurements will always be performed within the measuring area of respective measuring means 6.

In the embodiment shown each of said attachment means 12 may comprise at least one leg, a support or an attachment to the machine stand 4 mentioned above, in which the cylindrical body/bodies 5 to be measured are rotatably arranged, or else to some other permanent member able to give the requisite stability for the measuring device 1, e.g. the foundation of the machine.

When using the measuring device 1 according to the invention with a Yankee cylinder 5 in a paper machine, a space is required for assembly and manipulation of the

measuring carriage 13 of said measuring device 1 which is more or less accessible close to and between the Yankee cylinder 5 and the moving web. The normal placing of the measuring device in this specific case, not shown, is
5 suitably between the creping doctor and the cleaning doctor.

In order to reduce and as far as possible eliminate the vibrations transmitted to the measuring device 1 through
10 the air, for instance, or through the attachment means 12 of the measuring device 1, construction elements are used in or designed for the measuring device 1 that have or achieve considerable rigidity and/or a vibration
suppressing effect.

15 For this reason the measuring beam 11, see Figures 3-5, comprises a member, or if necessary several substantially identical sections 18, form-stable in all directions and rigidly joined together coaxially and/or in parallel,
20 which sections are suitably made of composite material or metal, preferably steel or aluminium sections, see Figure 9. When several of the identical sections 18 must be joined together to form a coherent measuring beam 11 in order to obtain a total length corresponding to at least
25 the length of the desired measuring area 2, generally equivalent to the extension of the measuring object 5, this is suitably achieved by means of detachable joints 19, e.g. screw or bolt joints, recessed in the sides of the sections 18, see Figure 3 so that the measuring
30 device 1 can easily be taken apart and thus transported in an easily managed form, and also so that said detachable joints 19 shall not impede the linear travelling movement of the measuring carriage 13, for instance. Some form of stop member is arranged at each
35 end of said measuring beam 11, adjustable to optional positions along the beam, see Figures 1-2, suitably consisting of a part of one or more non-contact

end-sensing devices comprising transducers such as photocells, inductive transducers or the like for recording the current position of said measuring carriage 13 relative a start or end position as described in more detail below. Said stop member 20 may consist of any other known type of position-recording means, e.g. electric breakers, but non-contact stop members 20 are preferable since they do not cause unfavourable influence in the form of impact jolts. One or more linear journalling means 21, such as linear bearings or guides, are arranged along the measuring beam 11, substantially parallel thereto and at one or more of its sides. In the embodiment shown in Figure 9 two journalling members 21 are situated, one at the upper side 22 and the other at the lower side 23 of the measuring beam 11, which journalling members 21 comprise one or more parallel guides constituting a shaped bar, slide or rail along which some form of journalling member 24 arranged on the measuring carriage 13 runs in cooperation therewith. The journalling member may consist, for instance, of a number of bogie wheels, slide, ball or roller bearings. One or more sliding surfaces 25 of some type of self-lubricating material, e.g. Teflon plastic, may be arranged between said measuring carriage 13 and measuring beam 11, suitably along the entire extension of said guides mentioned above, beside at least one or between several of these guides.

According to Figures 3-5 said measuring carriage 13 comprises a positioning unit 26 on which the coupling 27 for the traversing means 14 is arranged, enabling positioning of the measuring carriage 13 in a to and fro linear movement to each desired and predetermined position along one or more of the linear journalling means 21 of the measuring beam 11, suitably along one or more of the journalling means 21 arranged at the sides of the measuring beam 11 facing the measuring object 5. In

the embodiment shown the positioning unit 26 comprises a slide or carriage 28 in which one each of said couplings 27 for the traversing device 14 is arranged at its two opposite ends seen in the direction of travel, and also a sleeve or frame 29 surrounding the support beam 11 and connecting said carriage 28 with the other journalling means 21 described above.

In the embodiment shown in Figure 3 a tensioning device 30 is arranged on the measuring carriage 13, at the lower edge of the frame 29, the function of the tensioning device 30 being to suitably hold and clamp the measuring carriage 13 against the measuring beam 11 during its linear movements to and fro. The tensioning device 30, which in the device shown, comprises a link arm 31 arranged pivotably at one end of the frame 29, with a suitable journalling means 32 such as a bogie wheel at its free, opposite end, which tensioning device 30 is clamped against and cooperates with the support member 11, suitably one of the linear journalling means 21 described above, of the support member 11. Said link arm 31 can then either be fixed at a specific angle by means of a screw member 33 arranged at its pivot point, or a suitable tension force can be obtained by means of a spring member, not shown, arranged together with said link arm 31.

The other, movable part of the above-mentioned non-contact end-sensing device(s) 20 is also fitted on the measuring carriage 13, which end-sensing devices 20 record the current position of the measuring carriage 13 in relation to its start or end position travelling along the measuring beam 11, so that the traversing movement can always commence and finish at a known position in relation to said end position. The measured values obtained can thus easily be compared within the same measuring sequence and also with equivalent measured

values obtained during previous measurements performed on the same or other similar measuring objects 5.

An adjustment member 35 is also arranged at the
5 positioning unit 26 of the measuring carriage 13, see
Figures 6, 8 and 9, and comprises a shaft 36 arranged in
suitable manner in the longitudinal direction of the
support beam 11, and at least one hinge member 37
pivotal about this shaft 36. Said hinge member 37 can
10 be secured to the shaft 36, e.g. by a screw member 38, so
that a retaining and adjustment member 39, e.g.
consisting of a platform of bent sheet metal, arranged at
this hinge member(s) 37, on which platform 39 the
measuring means 6 is/are mounted, can be set at a desired
15 angle to the envelope surface 3 of the measuring object
5.

In order to adjust said platform 39 to a suitable
distance for these measuring means 6 from said envelope
20 surface 3 in radial direction also, a manual or automatic
adjustment member 40 is arranged, in the embodiment
illustrated in Figure 9, at the lower side of said
platform 39. The adjustment member 40 then comprises a
spring member 41, which in the embodiment illustrated
25 consists of a rod 42 attached to the hinge member 37
perpendicularly to the measuring object 5 and parallel
with said platform 39 and a forward control element 43
and a rear control element 44, both displaceable along
the rod 42, which control elements 43, 44 are permanently
30 mounted on the platform 39, the latter thus being
adjustable along said rod 42, and also a spring 45 coiled
around said rod 42 so that a force is obtained on the
platform 39 directed against the measuring object 5, and
also a manual or automatic actuator 46, in the embodiment
35 shown in Figure 6 extending between said hinge 37 and the
rear control element 44 and acting parallel to this
spring member 41, e.g. consisting of a micrometer screw

or an electric motor, so that said distance from the envelope surface 3 of the measuring object 5 can be controlled, in the latter case automatically, by the measuring and control unit 15 in cooperation with said
5 spring member 41.

One or more protective spacers 47 are fitted on the front of the platform 39, facing the measuring object 5, suitably shaped as blocks of plastic, ceramic, composite
10 or some other suitable material that does not damage the envelope surface 3 of said measuring object 5 in the event of contact between them, during adjustment of said platform 39, for instance.

15 Said traversing device 14 comprises a motor 48, see Figure 5, such as a stepping or servo motor, suitably arranged at one end of the measuring beam 11 for propelling said measuring carriage 13, a coupling 49 which may comprise a planetary gear, a drive shaft 50
20 from the motor 48 connected to one wheel, in this case constituting a driving wheel, of at least two journalling members such as wheels 51, 52, between and around which wheels 51, 52 at least one synchronous transmission belt 53 runs in a loop in a completely or partially sheltered
25 position inside the support member 11, and each of the above-mentioned coupling 27 between the ends of the transmission belt 53 and the positioning unit 26 of said measuring carriage 13. Said coupling 27 is suitably designed with some form of means to regulate the tension
30 in the transmission belt 53.

The described motor 48, with all movable parts carefully enclosed to protect them from external influence of dust, fluff, etc., is controlled so that it automatically
35 adjusts the measuring carriage 13 with the aid of the transmission belt 53 to any desired position along the measuring beam 11, instead of the previous complicated

and in some cases dangerous method of pushing the measuring carriage 13 manually.

The electronic measuring and control unit 15 used in the measuring device 1 for controlling said motor 48, collecting the measured values obtained by the measuring means 6 and presenting the calculated results, comprises a computer 54 with a pre-programmed measurement collection card suitably in the form of an insert card for the computer. The computer 54 is specially designed for recording measurement data from different forms and types of transducers, including the requisite data processing of said measured values, and suitably presents the result either visually on a display screen 55 or in the form of a data print-out. The computer 54 may also include a calibrating unit for the straightness reference 16. In the embodiment shown the straightness reference 16 comprises a laser beam 58 generated by at least one laser unit comprising a laser transmitter 56 and a receiver detector 57, see Figure 2, said laser unit also including a correction and control device, not shown, enabling adjustment of the direction of the laser beam 58 to be performed with the aid of two differential micrometer screws. This fine adjustment allows an accuracy of adjustment of 0.001 mm per meter. In the embodiment shown the laser detector 57 comprises a 2-axis, position-sensitive receiver with a detector surface of 20x20 mm, said receiver having a display box with two display windows showing the x and y values, respectively, of the detector 57 in digital form with a resolution of 0.01 mm.

To enable the whole straightness reference 16 or a part of it, as well as preferably also the laser unit with one, several or all its parts, to be screened off from all external influence such as air turbulence, temperature fluctuations, collected dust, paper fluff and

liquid sprayed from the paper web, etc. an elongate protective device 17, mentioned above, is arranged below at least a part of the length of the laser beam 58 substantially parallel with the measuring beam 11. In the
5 embodiment described this protective device 17, which may be telescopic, comprises a laser path 59 constituting some form of an extended member 60 inside which, or sheltered by which, the laser beam 58 extends, such as a screen, hollow beam, pipe or boom at least partially
10 surrounding or in some other way protecting the laser beam 58. Alternatively the protective device may comprise a resilient bellows, suitably of plastic or rubber, which laser path 59 thus forms an undisturbed light channel for the laser beam 58 between its transmitter 56 and receiver
15 57, said extended member 60 having at least one gap, sector or groove, not shown, running horizontally along one side and extending at least along the part(s) of the member 60 located between the end positions applicable for traversing of the measuring carriage 13, said gap
20 suitably being screened from the outer of two or more coaxial brush members arranged preferably parallel to each other on each side of said gap thereby forming a soft, flexible curtain which screens and closes the gap in a plastic and yielding manner. The purpose and
25 function of said brush members is to protect the straightness reference 16 arranged in the shelter of, or inside the protective device 17, the elongate protective device 17 thus forming a space constituting said light channel in the centre of which the detector 57 or laser
30 transmitter 56 are arranged or operate. Either the laser transmitter 56 or the receiver detector 57 is mounted on the measuring carriage 13 and the remaining either receiver detector 57 or laser transmitter 56 is mounted on the measuring beam 11, protected from external
35 influence, after having been accurately adjusted with the aid of said correcting and control devices.

When measuring the cylindricity or, if preferred, the non-cylindricity, the differences are thus measured in the distance between the envelope surface 3 of the measuring object 5 and the measuring means 6, the measuring means 6 being maintained in one and the same stationary position on the measuring beam 11 throughout a complete rotation of the measuring object 5. Measuring is suitably performed in such a way that a measured value is obtained both for each degree of rotation during a revolution so that the mentioned non-cylindricity can be obtained, and also for a number of positions along the measuring beam 11 where the location of the measuring means 6 in relation to the straightness reference 16 is determined, so that the straightness profile of the measuring object 5 can also be obtained. The number of measuring positions is determined by the length of the measuring object 5 and the required accuracy of the measuring result.

The measuring results thus automatically collected, analyzed and suitably processed may be reported both in real time, in the embodiment shown on said display screen 55 included in the control and measuring unit 15, graphically in the isometric form described above for instance, or in tabular form, and also on a unit, e.g. a printer, connected thereto. If appropriate, said measurement and reporting may be performed for different operating conditions such as web speed, temperature or some other parameter of significance to operation.

The measuring device 1 according to the embodiment illustrated is dismountable and can therefore be packed up and simply moved when necessary between different measuring objects 5 or machines, and installed at the measuring object 5 selected, e.g. a Yankee cylinder, where said measurement can be performed during manufacture, in connection with service and repair or

even during operation of the finished and installed cylindrical body 5.

5 Since sufficient and relatively accessible space for mounting and handling the measuring device 1 and measuring carriage 13 is required close to and between the Yankee cylinder and the web draw, the measuring device 1 is normally placed between the creping and cleaning doctors. If necessary it is also possible to
10 measure through the web and a position both before and after the pickup doctor may therefore be used.

All transducers or similar measuring means used in the measuring device 1 are suitably non-contacting
15 transducers, e.g. optical, photo-electric or inductive eddy-current transducers of known type, but may of course be entirely or partially replaced with electric, mechanical or pneumatic contact means if deemed sufficient.

20 If the above-mentioned revolution pulse device 9 is placed on the axis of rotation 8 of the measuring object 5, in this case suitably said photocell detector, it can suitably be attached to said shaft 8 by means of a
25 belt-like attachment member to facilitate mounting and dismantling of said revolution pulse device 9.

The measurement of the cylindricity and/or straightness of a measuring object 5 can of course also include
30 simultaneous recording of any other required parameter possible and desirable for measuring objects 5 of this type, using one of the measuring devices now commercially available. Such parameters are mentioned above and include deposits, corrosion, wear patterns, magnitude of
35 wear, etc. The described invention is particularly suitable for measuring at a Yankee cylinder.

C L A I M S

1. A method for, without contact and with the aid of a measuring device (1), measuring in a predetermined
5 measuring area (2) in connection to an envelope surface (3) of at least one measuring object (5) journalled rotatably in a machine stand of a paper machine, with respect to its cylindricity and/or its straightness relative to a straightness reference (16) arranged
10 substantially parallel with the axis of rotation (8) of the measuring object (5), which measuring device (1) comprises said straightness reference (16), a measuring stand (10) and a linearly movably journalled measuring carriage (13) on which at least one measuring means (6)
15 is arranged, said measuring carriage (13) during said measurement travels along an elongate form-stable support member (11) forming a part of the measuring stand (10), and running substantially parallel to the axis of rotation (8) of the measuring object (5), whereby said
20 measuring means (6) is moved to one or more desired positions for the measurement and the measuring means (6) is caused to perform a measurement of the present measurement values at each such position selected in said measuring area (2), characterized in that the measuring
25 commences with a starting position for the measuring means (6) relative the straightness reference (16) and the measuring object (5) being determined, which starting position comprises an initial position for the rotating measuring object (5), a current position along the
30 support member (11) and a position in radial direction from the envelope surface (3) of the measuring object (5), that a first measurement is performed for this starting position, that the measuring means (6) is thereafter moved to at least one more position along the
35 support member (11) while this or these new positions are continuously determined in relation to each other or said starting position, whereupon a measurement occurs in said

measuring area (2) at each position, that a laser beam (58) is used as straightness reference (16), said laser beam being generated by a laser unit, and that the laser beam (58) is protected from external influence by being
5 arranged along at least a part of its length in the shelter of an elongate protective device (17) arranged substantially parallel with said support member (11).

2. A method as claimed in claim 1, characterized in
10 that at least one revolution pulse device (9) is arranged at the measuring object (5), that said initial position is determined with the aid of the revolution pulse device (9), and that said current position along the support member (11) is determined with the aid of stop members
15 (20) arranged at each end of the support member (11).

3. A method as claimed in claim 1 or claim 2,
characterized in that the laser beam (58) is protected from external influence by the laser unit and the laser
20 beam (58) generated thereby being arranged inside the elongate protective device (17) arranged parallel with said support member (11).

4. A method as claimed in any of the preceding claims,
25 characterized in that the measured values obtained are processed and reported by means of an electronic measuring and control unit (15).

5. A method as claimed in claim 4, characterized in
30 that traversing of the measuring carriage (13) along the support member (11) occurs automatically with the aid of a traversing device (14) comprising a motor (48), a coupling (49), a drive shaft (50), at least two wheels (51, 52), one of which comprises a driving wheel (51),
35 between and around which wheels (51, 52) at least one synchronous transmission belt (53) runs in a loop secured to said measuring carriage (13), the synchronous

transmission belt (53) being located in a completely or partially sheltered position inside the support member (11), and that the traversing device (14) is controlled by the electronic measuring and control unit (15) which
5 has been pre-programmed to place the measuring carriage (13) in optional, predetermined positions along the support member (11).

6. A method as claimed in one or more of the preceding
10 claims, characterized in that a retaining and adjustment member (39) arranged on said measuring carriage (13) is set at a desired angle relative the envelope surface (3) of the measuring object (5) with the aid of an adjustment member (35) arranged at a positioning unit (26) arranged
15 on the measuring carriage (13) and comprising a shaft (36) arranged in the longitudinal direction of the support member (11), that at least one hinge member (37) is turned about this shaft (36), and that the hinge member (37) is thereafter secured to the shaft (36) so
20 that the retaining and adjustment member (39) arranged at these hinge members (37) acquires said desired angle to the envelope surface (3) of the measuring object (5).

7. A method as claimed in claim 6, characterized in
25 that said retaining and adjustment member (39) is also set in radial direction at a distance from the envelope surface (3) of the measuring object (5) suitable for said measuring means (6), with the aid of a manual or
automatic adjustment device (40), thereby enabling said
30 distance to be regulated at the automatic adjustment device (40) with the aid of the measuring and control unit (15).

8. A method as claimed in any of the preceding claims,
35 characterized in that measurement occurs in the predetermined measuring area (2) of every other desired property or parameter of or at said measuring object (5),

and also of a material web running over and around said measuring object (5) which it is considered advantageous to determine with the aid of said measuring device (1), such as corrosion, wear, temperature or velocity, and
5 that at least one additional suitable measuring means (6) is therefore arranged on the measuring device (1).

9. A measuring device (1) for, without contact, measuring in a predetermined measuring area (2) in
10 connection to an envelope surface (3) of at least one measuring object (5) journalled rotatably in a machine stand of a paper machine, with respect to its cylindricity and/or its straightness relative to a straightness reference (16), said straightness reference
15 (16) being arranged substantially parallel with the axis of rotation (8) of the measuring object (5), which measuring device (1) comprises said straightness reference (16), a measuring stand (10) and a linearly movably journalled measuring carriage (13) on which at
20 least one measuring means (6) is arranged, said measuring carriage (13) during said measurement is traversed along an elongate form-stable support member (11) forming a part of the measuring stand (10), and running substantially parallel to the axis of rotation (8) of the
25 measuring object (5), characterized in that said straightness reference (16) comprises a laser beam (58) which is generated by a laser unit comprising a laser transmitter (56) and a receiver detector (57), which laser beam (58) is protected from external influence by
30 being arranged along at least a part of its length in the shelter of an elongate protective device (17) arranged substantially parallel with said support member (11).

10. A measuring device as claimed in claim 9,
35 characterized in that the laser unit and thus its laser transmitter (56) and receiver detector (57) are arranged

inside the elongate protective device (17) arranged substantially parallel to said support member (11).

11. A measuring device as claimed in claim 9 or claim
5 10, characterized in that the measuring device (1) also includes an electronic measuring and control unit (15).

12. A measuring device as claimed in any of claims 9 to
10 11, characterized in that the measuring device (1) also includes an automatic traversing device (14) to set said measuring carriage (13) in desired measuring positions along said support member (11), said traversing device (14) comprising a motor (48) suitably arranged at one end of the support member (11) and comprising a coupling (49)
15 and a drive shaft (50) connected to one of at least two wheels (51, 52) provided as journalling members, one of which comprises a driving wheel (51), between and around which wheels (51, 52) at least one synchronous transmission belt (53) runs in a loop in a completely or
20 partially sheltered position inside the support member (11), and each one a coupling (27) between the ends of each transmission belt (53) and a positioning unit (26) arranged at the measuring carriage (13).

25 13. A measuring device as claimed in any of claims 9 to 12, characterized in that said support member (11) comprises one or more form-stable, substantially identical sections (18) joined together by means of suitable joints (19) to form a coherent length
30 corresponding to at least the length of the desired measuring area (2), which joints (19) are recessed in the sides of the sections (18), a stop member (20) arranged at each end of said support member (11), suitably consisting of one part of one or more contact-free
35 end-sensing devices comprising transducers such as photocells, inductive transducers or the like for recording the current position of said measuring carriage

- (13) relative a start or end position along the support member (11), one or more linear journalling means (21) arranged substantially parallel with and close to one or more of the sides of the support member (11), which
- 5 journalling members (21) comprise one or more parallel guides constituting a shaped bar, slide or rail along which some form of journalling member (24) arranged on the measuring carriage (13) runs in cooperation.
- 10 14. A measuring device as claimed in claim 13 in combination with claim 12, characterized in that the positioning unit (26) comprises a slide or carriage (28) in which one each of said couplings (27) for the
- 15 traversing means (14) is arranged at its two opposite ends seen in the direction of travel, and also a sleeve or frame (29) surrounding the support member (11) and connecting said carriage (28) with the other journalling means (21) described above.
- 20 15. A measuring device as claimed in claim 13 or 14, characterized in that a tensioning device (30) is arranged at the measuring carriage (13), said tensioning device comprising a link arm (31) arranged pivotably at one end of the measuring carriage (13), with a
- 25 journalling means (32) at its free, opposite end, which tensioning device (30) is clamped against and cooperates with the support member (11), suitably one of the linear journalling means (21) of the support member (11).
- 30 16. A measuring device as claimed in claim 12, or in claim 13 in combination with claim 12, or in claim 14, characterized in that an adjustment member (35) is also arranged at the positioning unit (26) of the measuring carriage (13), which adjustment member comprises a shaft
- 35 (36) arranged in the longitudinal direction of the support member (11) and at least one hinge member (37) pivotable about this shaft (36), which can be secured to

the shaft (36) so that a retaining and adjustment member (39) arranged at this or these hinge member(s) (37), on which member (39) said measuring means (6) is/are mounted, can be set at a desired angle to the envelope surface (3) of the measuring object (5).

17. A measuring device as claimed in claim 16, characterized in that a manual or automatic adjustment member (40) is arranged at said retaining and adjustment member (39) to adjust this also in radial direction to a suitable distance for said measuring means (6) from said envelope surface (3), which adjustment member (40) comprises a spring member (41) so that a force is obtained directed on the retaining and adjustment member (39) and against the measuring object (5), and also a manual or automatic actuator (46) acting parallel to this spring member (41), so that said distance from the envelope surface (3) of the measuring object (5) can be controlled, in the latter case automatically, by the measuring and control unit (15) in cooperation with said spring member (41).

18. A measuring device as claimed in claims 16 and 17, characterized in that one or more protective spacers (47) are fitted on the front of the retaining and adjustment member (39), facing the measuring object (5), suitably shaped as blocks of plastic, ceramic, composite or some other suitable material that does not damage the envelope surface (3) of said measuring object (5) in the event of contact between them.

19. A measuring device as claimed in any of claims 16 to 18, characterized in that the retaining and adjustment member (39) comprises a platform of bent sheet metal.

20. A measuring device as claimed in any of claims 9 to 19, characterized in that an elongate protective device

(17) is arranged below at least a part of the length of the laser beam (58), substantially parallel with the support member (11), which protective device (17) comprises a laser path (59) comprising some form of elongate member (60) within which, or in the shelter of which, the laser beam (58) extends, which laser path (59) thus forms a light channel for the laser beam (58) between its transmitter (56) and its receiver (57), which elongate means (60) comprises at least one gap, sector or track running horizontally and extending at least along the part(s) of the means (60) situated between the end positions applicable to the traversing of the measuring carriage (13), in which light channel the detector (57) and the laser transmitter (56) are arranged or operate, of which either the laser transmitter (56) or the receiver detector (57) is mounted on the measuring carriage (13) and the remaining either receiver detector (57) or laser transmitter (56) is mounted on the support member (11).

20

21. A measuring device as claimed in claim 20, characterized in that the protective device (17) is telescopic.

25

22. A measuring device as claimed in claim 20 or 21, characterized in that the elongate means (60) comprises a screen, hollow beam or pipe, or even resilient bellows, for instance, the bellows then suitably being of plastic or rubber, said member at least partially surrounding or otherwise protecting the laser beam (58).

30

23. A measuring device as claimed in any of claims 20 to 22, characterized in that the gap is screened from the outer of two or more coaxial brush members.

35

24. A measuring device as claimed in any of claims 9 to 23, characterized in that the measuring device (1) can be

removed and transported between different measuring
objects (5) or machines and thus installed at a measuring
object (5) selected on a particular occasion so that
measuring can be performed during manufacture of the
5 measuring object (5), and also during operation of the
finished and installed object.

1 / 3

Fig. 1

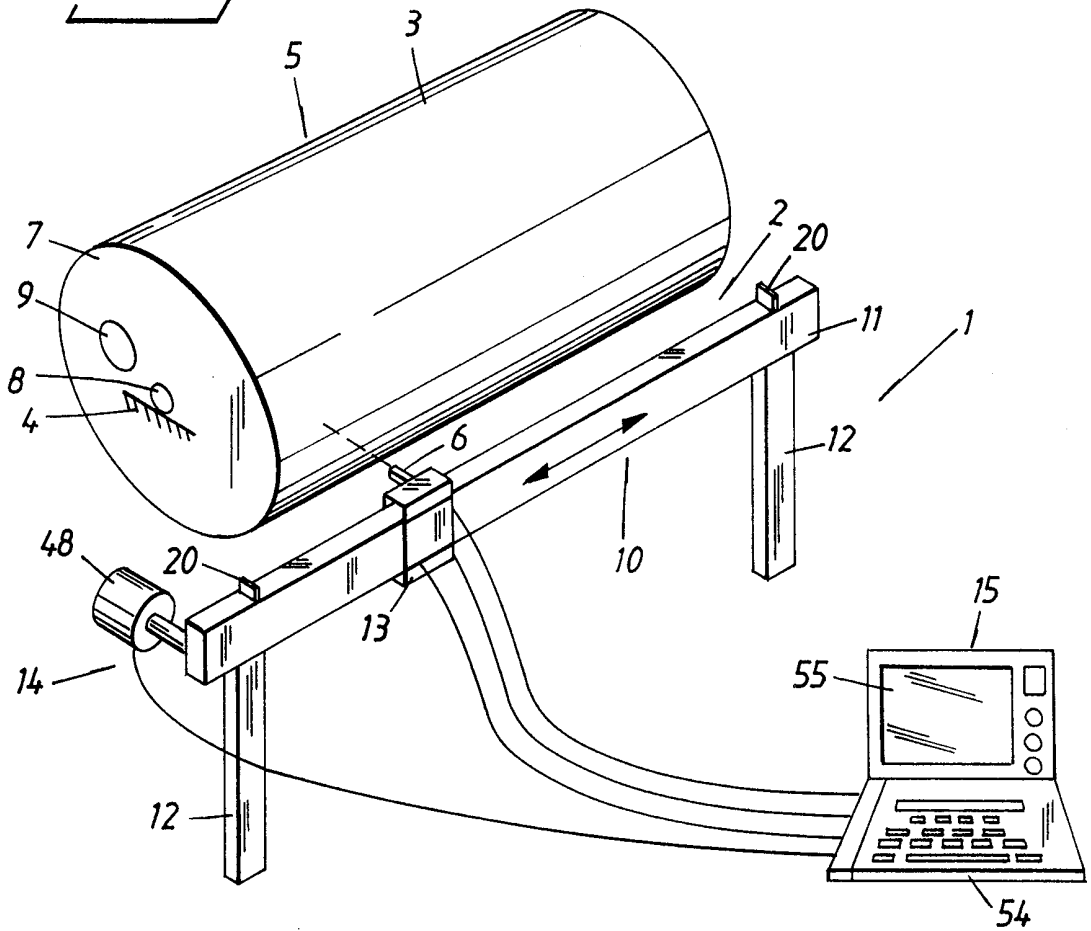


Fig. 2

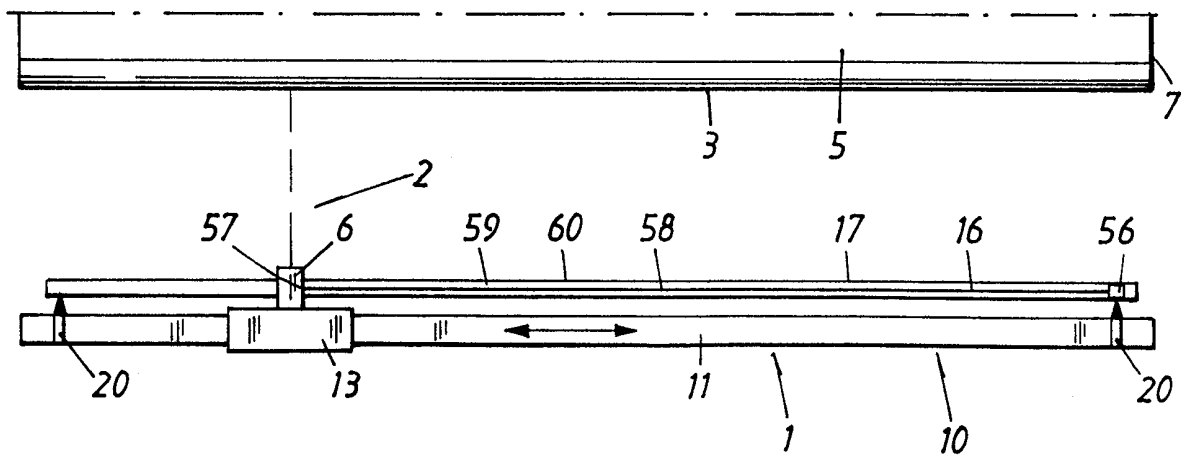


Fig. 3

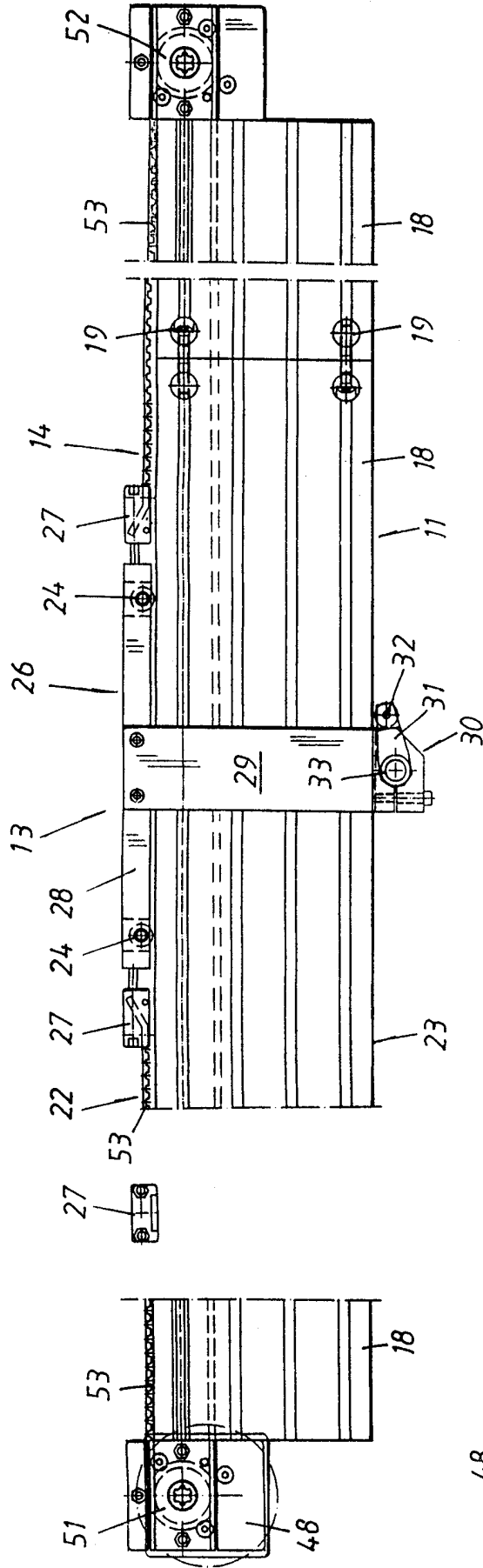


Fig. 4

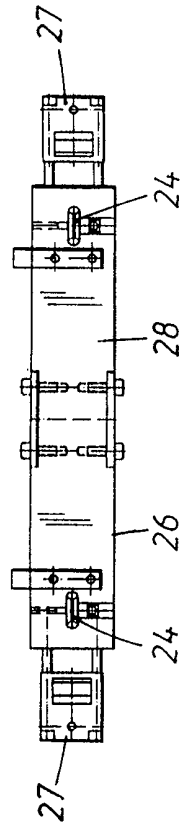
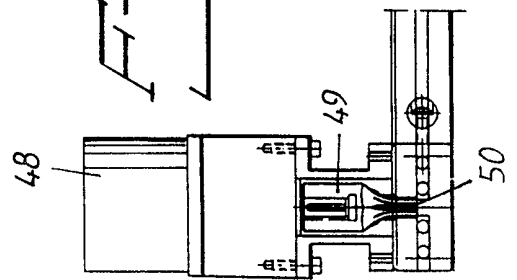
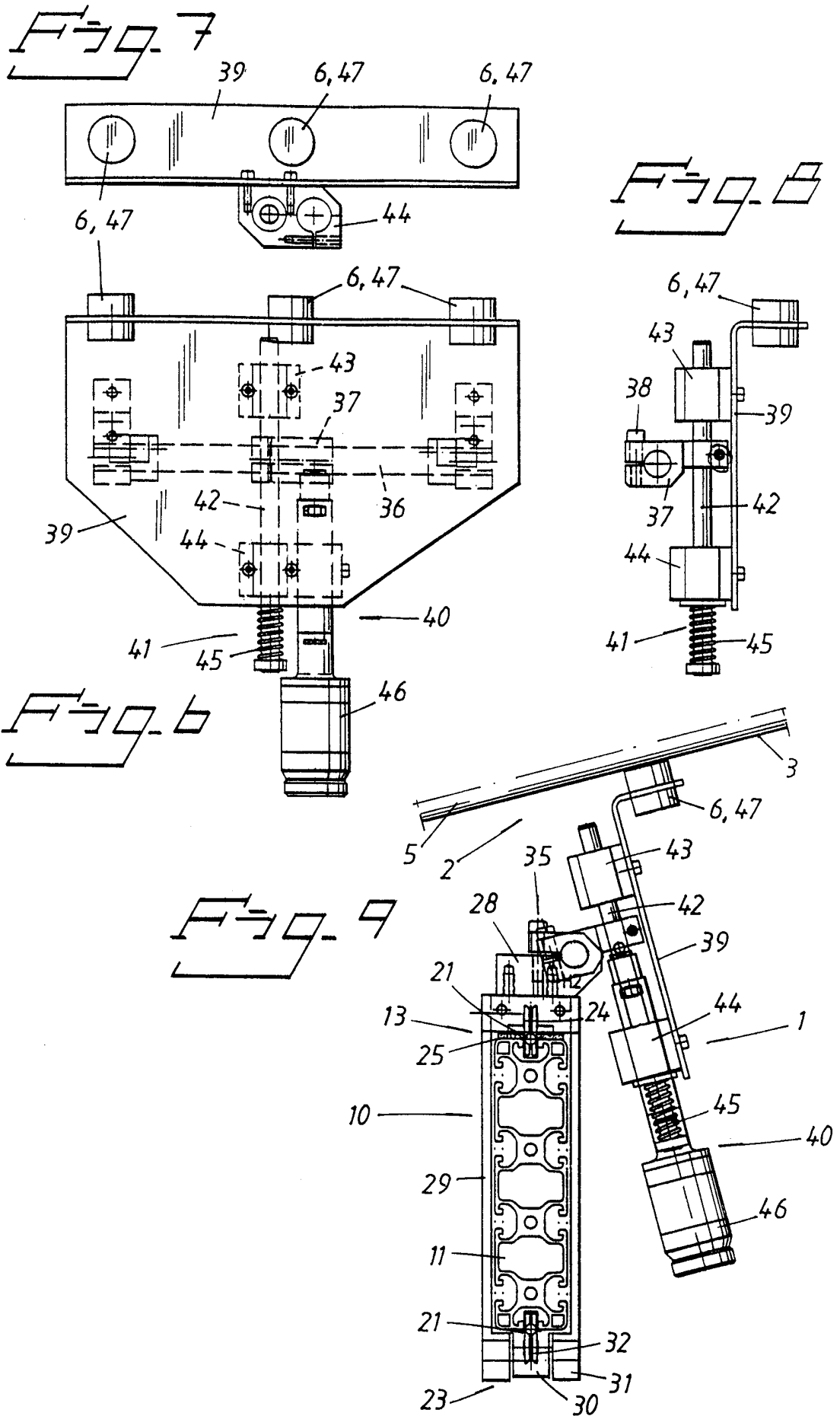


Fig. 5





INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/01465

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: G01B 11/24, G01B 11/30 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)		
IPC6: G01B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3923402 A (P. TURCOTTE), 2 December 1975 (02.12.75), see the whole document --	1-24
A	US 5605097 A (S. RUCKL ET AL.), 25 February 1997 (25.02.97), abstract --	1-24
A	WO 9604423 A1 (WANGNER SYSTEMS CORPORATION), 15 February 1996 (15.02.96), abstract --	1-24
A	US 5587051 A (V. OSTERMAYER ET AL.), 24 December 1996 (24.12.96), abstract --	1-24
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "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 "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
18 January 1999		20 -01- 1999
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer Pernilla Hall Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/01465

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4725738 A (H. LYSEN), 16 February 1988 (16.02.88), abstract -- -----	1-24

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Information on patent family members

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01/12/98

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US 5605097 A	25/02/97	AT 150365 T CN 1115877 A DE 59402148 D EP 0679510 A,B ES 2102094 T JP 8039754 A US 5781224 A	15/04/97 31/01/96 00/00/00 02/11/95 16/07/97 13/02/96 14/07/98
WO 9604423 A1	15/02/96	EP 0724662 A FI 962197 A US 5492601 A US 5587051 A	07/08/96 24/05/96 20/02/96 24/12/96
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US 4725738 A	16/02/88	DE 3419059 A EP 0183811 A,B SE 0183811 T3 JP 4031323 B JP 61502218 T WO 8505443 A	28/11/85 11/06/86 26/05/92 02/10/86 05/12/85