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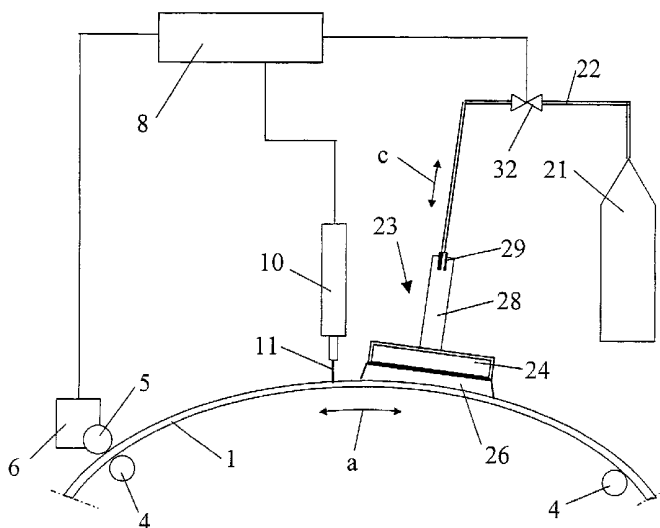
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(54) Title: A DEVICE FOR COOLING A WORKPIECE



(57) Abstract: The invention relates to a device and a method for cooling a workpiece (1) in connection with machining the workpiece with a laser beam. The device comprises a source (21) for providing a cooling medium, a member (22) for supplying the cooling medium and an application member (23) which is positionable in the vicinity of or against the workpiece. The supply member is arranged to supply the cooling medium to the application member. The application member (23) forms an essentially closed space together with the workpiece for receiving the cooling medium. The space is arranged to allow application of the cooling medium against the workpiece (1). The invention also relates to a plant for machining a workpiece.

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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A device for cooling a workpiece

BACKGROUND OF THE INVENTION AND PRIOR ART

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The present invention relates to a device for cooling a workpiece in connection with machining the workpiece with a laser beam, the device comprising a source for providing a cooling medium, a member for supplying the cooling medium, and an application member arranged to be positionable in the vicinity of or against the workpiece, the supplying member being arranged to supply the cooling medium to the application member. The invention also relates to a plant for machining a workpiece comprising a laser apparatus arranged to direct a laser beam towards the workpiece and a device for cooling the workpiece, the device comprising a source for providing a cooling medium, a member for supplying the cooling medium, and an application member arranged to be positionable in the vicinity of or against the workpiece, the supplying member being arranged to supply the cooling medium to the application member. The invention further relates to a method for cooling a workpiece in connection with machining the workpiece with a laser beam.

30 More and more, laser is used to machine metal, partly for cutting metal workpieces and partly for welding metal workpieces to each other. A very high accuracy can be obtained when laser cutting metal workpieces. The cut surfaces have a very high surface finish. Cutting with laser is thus suitable for precision working of workpieces usable in a range of applications, such as, for example, machine

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components. A specific component that advantageously can be machined by laser cutting is the holding ring which is arranged between the roller races of a roller or ball bearing and which is intended to keep the rollers or the balls in place. As a starting material, a ring is manufactured which is then machined by a laser beam to cut out openings in the ring in which the rollers or balls are to be located in the completed bearing. One problem in connection with the manufacturing of such rings is that heat will be added because of the laser cutting. If one wishes to increase the machining speed, the efficiency of the laser beam must be increased, meaning that the amount of heat added to the workpiece will be increased further. If the temperature increase in the ring or in another workpiece becomes too high, the ring might be deformed, i.e. it obtains another shape than the shape the ring had before the laser cutting. Even if the deformation is very small, the problem can be of major importance for precision components, such as holding rings for roller or ball bearings. The problem also increases with the size of the workpieces to be machined.

It should be noted that this problem is general during laser machining of precision components and not solely associated with laser cutting of holding rings. It is, of course, also a general desire to be able to increase the machining speed as much as possible in order to improve the efficiency of the machining process.

In order to solve this problem, it is possible to cool the workpiece. There are a number of different methods and devices for cooling workpieces that have been machined in different ways.

JP 61119393 shows a method for cutting with laser, the workpiece being cooled from above and from underneath by

supplying carbon dioxide in the vicinity of the laser beam. Nozzles are thus arranged in the vicinity of the workpiece and carbon dioxide is added directly towards the workpiece. Such a method however has the drawback that it is difficult
5 to obtain a sufficient cooling efficiency. Another problem in connection with the laser cutting is that the carbon dioxide is not allowed to reach the laser beam, since laser light is absorbed by carbon dioxide and since the carbon can contaminate the machined metal.

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US 4,125,757 shows cutting of a workpiece with laser, wherein the workpiece is submerged in a cooling liquid, for example water, during the cutting operation.

15 WO 95/23669 shows a welding of metal workpieces using conventional welding. The workpieces are cooled during the welding operation by carbon dioxide being sprayed towards the workpieces on the opposite side of the welding seam.

20 US 4,152,568 also shows a conventional method for arc welding in combination with cooling the workpiece with carbon dioxide. In this case, carbon dioxide is also sprayed on the workpiece at the opposite side of the welding seam.

25 SUMMARY OF THE INVENTION

The purpose of the present invention is to improve the efficiency and/or the accuracy during machining of a workpiece with laser machining. More specifically, it is
30 aimed at an efficient cooling of a workpiece in connection with laser machining.

This object is achieved with the device initially mentioned, which is characterised in that the member application is
35 arranged to form an essentially closed space together with the workpiece for receiving the cooling medium, the space

being arranged to allow application of the cooling medium against the workpiece. Thanks to such an essentially closed space, the cooling medium can be used in an efficient way and can achieve a very efficient cooling of the part of the workpiece upon which the cooling medium is applied. In such a way, it is possible to lower the temperature of the workpiece and thus the maximum temperature that the workpiece reaches in connection with the laser working can be reduced in comparison to if the workpiece was not cooled initially. Thanks to such a reduced maximum temperature of the workpiece, the risk for deformation of the workpiece during the laser machining is reduced. At the same time, the invention makes it possible to apply a higher power by the laser beam without reaching a maximally allowed highest temperature in the workpiece. Subsequently, the working speed, for example the cutting speed, can be increased.

According to a preferred embodiment of the invention, the application member comprises a box-like element with an opening arranged to be turned towards the workpiece. With such a box-like element it is ensured that a sufficient amount of cooling medium can be contained in the application member. Further, the application member can comprise a sealing member arranged to sealingly bear against the workpiece and to extend at least around a part of the opening. With such a sealing member which can comprise a strip of an elastic material, the cooling medium can, in an efficient way, be kept within the space. It is especially important that the sealing member seals the space at least in the direction which is directed towards the laser beam in order to avoid the cooling medium to reach the laser beam.

According to a further embodiment of the invention, the application member is arranged to apply the cooling medium against one part of the workpiece at the same time as the laser beam hits another part of the workpiece. In such a

way, the workpiece can be given an initial temperature decrease with respect to a part of the workpiece and this part can at a later occasion be machined with the laser beam. The application member can thus be arranged to be
5 positioned in such a way that the cooling medium cools at least a part of the workpiece before the laser beam hits that part of the workpiece. At the same time, it is secured according to these embodiments that cooling and laser machining can be carried out at the same time.

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According to a further embodiment of the invention, the cooling medium comprises carbon dioxide. Carbon dioxide is a very efficient and relatively inexpensive cooling medium. Advantageously, the application member is arranged to supply
15 carbon dioxide in such a way that it is present in essentially solid state within the space.

According to a further embodiment of the invention, the cooling medium comprises nitrogen. Liquid nitrogen is also a
20 very efficient cooling medium.

According to a further embodiment of the invention, the application member comprises at least one nozzle arranged to allow passage of the cooling medium being supplied to the
25 space. Thanks to such a nozzle, the cooling medium can be allowed to expand after passage through the nozzle. In such a way, carbon dioxide supplied in liquid state from the source can turn into a solid state after passage through the nozzle. Thus, the application member can comprise at least
30 one tube having a first end opening into the space and a second end in which the nozzle is arranged for passage of liquid carbon dioxide, the tube forming an expansion chamber for the carbon dioxide supplied through the nozzle.

35 According to a further embodiment of the invention, the application member is arranged to allow the cooling medium

in the space to be forced against the workpiece. As an alternative or complement, the device can comprise means arranged to increase the transfer of heat between the cooling medium and the workpiece. Said means can also
5 comprise a piston member arranged in the space and arranged to force the cooling medium against the workpiece. Said means can further be arranged to provide a movement in the cooling medium in the space. Such a movement can, for example, be achieved if the cooling medium is supplied
10 intermittently. There may also be some kind of mechanical stirrer in the space.

The object is also achieved with the plant initially described, which is characterised in that the application
15 member is arranged to form an essentially closed space together with the workpiece for receiving the cooling medium, the space being arranged to allow application of the cooling medium against the workpiece. Advantageously, the plant comprises a feeding member arranged to provide a
20 relative movement between the laser beam and the workpiece, the application member being arranged to be positioned in such a way that the cooling medium cools at least a part of the workpiece before the laser beam hits that part of the workpiece.

25 The object is also achieved with the method initially described, which comprises the steps of:
providing a cooling medium,
positioning of an application member in the vicinity of or
30 against the workpiece, wherein the application member together with the workpiece are arranged to form an essentially closed space,
supplying the cooling medium to the space and
cooling the workpiece through application of the cooling
35 medium in the space against the workpiece.

Preferred embodiments of the method are defined in the claims 19 - 25.

SHORT DESCRIPTION OF THE DRAWINGS

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The present invention is now to be explained more closely through different embodiments, shown such as examples, and with reference to the attached drawings.

10 Fig. 1 schematically shows a plant with a device for cooling a workpiece.

Fig. 2 shows a view from above of the workpiece.

15 Fig. 3 shows a view from underneath of a component of the device in Fig. 1.

Fig. 4 shows a sectional side view of another embodiment of the component in Fig. 3.

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DETAILED DESCRIPTION OF DIFFERENT EMBODIMENTS OF THE INVENTION

Fig. 1 shows a plant for machining a workpiece 1. In the example shown the workpiece 1 is an essentially circular holding ring for rollers in a roller bearing. The holding ring 1 is shown more closely in Fig. 2 in a schematic view from above. The machining intended in the present application is to cut out holes 2 from the holding ring 1 with a laser beam. These holes 2 are intended to receive the rollers of the bearing which is to be manufactured. Fig. 2 shows a holding ring 1 in which the holes have been made. It shall be noted that the invention also is applicable on holding rings 1 with some other appearance, for example with round holes 2 for reception of balls of a ball bearing. The invention is further applicable to other workpieces than

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holding rings 1 for bearings, for example different types of precision components for machines.

The plant comprises a support arrangement to support and
5 hold the workpiece 1 during the machining. In the shown
embodiment the support arrangement has been exemplified with
two supporting wheels 4 on which the workpiece 1 rests. On
the outside of the workpiece 1 opposite to one of the
supporting wheels 4 there is a feeding member with a driving
10 wheel 5 which can be rotated continuously or intermittently
with the help of a driving member 6 for example in the form
of an electric drive motor. The driving member 6 is
connected to a control unit 8 of the plant. With the help of
the driving wheel 5 the workpiece 1 can thus be moved in the
15 direction of the arrow a in relation to the two rotatable
supporting wheels 4 that are preferably mounted on a
stationary foundation (not shown) of the plant.

The plant further comprises a laser machining apparatus 10
20 which in itself is known and arranged to provide a laser
beam 11 that is directed towards the workpiece 1. In the
embodiment shown, the laser machining apparatus 10 is also
connected to the common control unit. The workpiece 1 can
thus be machined with help of the laser beam 11 and working
25 gas being supplied against the workpiece 1 in a conventional
way around the laser beam 11. In the embodiment shown the
laser machining apparatus 10 is essentially stationary in
the direction of the arrow a in relation to the workpiece 1
which is thus moved intermittently or continuously in the
30 direction of the arrow a in relation to the laser beam 11.
It shall however be noted that within the framework of the
invention the workpiece can be held stationary in relation
to the supporting arrangements and instead the laser
machining apparatus can be moved in the direction of the
35 arrow a in relation to the workpiece 1. Furthermore, the
laser machining apparatus 10 and/or the workpiece 1 can be

movable forwards and backwards in a direction transversely to the direction of the arrow a and transversely to the workpiece 1 along the direction of the arrow b, see Fig. 2.

5 Furthermore, the plant comprises a device 20 for cooling the workpiece 1. The cooling device 20 comprises a source for supplying a cooling medium. In the embodiment shown the source comprises a container 21 for liquid carbon dioxide. The cooling device 20 also comprises a member for supplying
10 a cooling medium, which in the embodiment shown comprises a conduit 22 arranged to transport liquid carbon dioxide from the container 21 to an application member 23 for application of carbon dioxide against the workpiece 1. The application member 23 is arranged to be positionable in the vicinity of
15 or against the workpiece 1. Advantageously the application member 23 can thus be displaceable in a direction extending essentially perpendicularly relative the surface of the workpiece 1 and in the example shown thus essentially radially in relation to the circular holding ring. The
20 application member 23 is in the embodiment shown essentially stationary in relation to the direction of the movement of the workpiece 1, that is the application member 23 and the laser machining apparatus 10 are fixed in relation to the moveable workpiece 1 during the machining proper. Of course
25 it is also possible to let the application member 23 be moved together with the laser machining apparatus 10 if the workpiece 1 is stationary instead.

The application member 23 comprises a box-like element 24
30 which has an opening arranged to be turned towards the workpiece 1 and enclosing a space 25, see Fig. 3 and 4. When the box-like element 24 of the application member 23 is positioned against the workpiece 1 the space 25 will thus be essentially closed. Advantageously the application member 23
35 comprises a sealing member 26 arranged to sealingly bear against the workpiece 1 when the application member 23 is in

an active position of use against the workpiece 1. The sealing member 26 extends around the opening of the boxlike element 24. It is not necessary for the sealing member 26 to extend around the whole opening but it is advantageous if it at least extends along that side of the boxlike element 24 which is facing the laser beam 11. The sealing member 26 can comprise a strip of an elastic material, for example plastics, natural or synthetic rubber.

Moreover, the application member 23 comprises at least one tube 28 and in the example shown three tubes 28, see Fig. 3. Each such tube 28 has a first end which opens in the space 25 and a second end which is connected to the conduit 22. The application member 23 also comprises a nozzle 29 arranged to allow passage of the cooling medium supplied to the space 25. In the embodiment shown such a nozzle 29 is arranged at the second end of each of the pipes 28. Each such nozzle 29 comprises a throttling. In the shown embodiment carbon dioxide will thus be led from the container 21 through the conduit 22 and the nozzle 29, after which the carbon dioxide is expanded in the tube 28 which forms an expansion chamber. Because of this expansion the liquid carbon dioxide will turn into a solid state and thus be supplied to the space 25 in a solid state as carbon dioxide snow.

Carbon dioxide can thus be supplied in such a way that the closed space 25 is essentially filled with carbon dioxide snow. Thus solid carbon dioxide will bear against the workpiece 1 and cool the same. Only with the arrangement shown in Fig. 1 the carbon dioxide will be forced against the workpiece thanks to gravity. Carbon dioxide snow that is heated and transforms into a gaseous state will rise in the space 25, thus a slight surpressure can be formed in an upper gas volume in the space 25. This gas volume will press the solid carbon dioxide against the workpiece 1. The heat

transfer between the carbon dioxide and the workpiece 1 can also be increased in other ways, for example through intermittent feeding of the carbon dioxide to the closed space 25. In such a way a stirring will take place in the solid carbon dioxide in the space 25 leading to a better cooling efficiency. In Fig. 4 another embodiment of the invention is shown according to which a piston member 30 has been arranged in the space 25. The piston member 30 is displaceable upwards and downwards in the direction of the arrow c essentially and perpendicularly to the surface of the workpiece 1 and thus the carbon dioxide snow underneath the piston member 30 can be forced against the workpiece 1. In the embodiment shown the piston member 30 is fixedly mounted on the tube 28 which is displaceable in the direction of the arrow c with the help of a schematically indicated driving member 31. The first end of the tube 28 opens in the space 25 is thus arranged underneath the piston member 30.

As is apparent from Fig. 1 the application member 23 is arranged to apply the cooling medium against a part of the workpiece 1 at the same time as the laser beam 11 hits another part of the workpiece 1. The workpiece 1 in the embodiment shown moves in the direction of the arrow a and the workpiece 1 will therefore be cooled to a lower temperature than its original temperature before the laser beam 11 hits the workpiece 1. In such a way the part of the workpiece 1 machined by the laser beam 11 will have a reduced temperature and thus it will be possible to limit the maximum temperature reached during the machining.

The cooling device 20 further comprises a control valve 32 arranged on the conduit 22. With the control valve 32 the supply of liquid carbon dioxide can be controlled. The control valve 32 is also connected to the control unit 8. The control unit 8 can thus control the feeding of the

workpiece 1, the laser beam 11 and the supply of cooling medium in such a way that these three functions are adapted to each other. For example the workpiece 1 can be fed intermittently, wherein the liquid carbon dioxide is supplied to the space 25 during a time period when the workpiece 1 is essentially not moving.

The container 21 can also be arranged to comprise other cooling mediums than liquid carbon dioxide, for example liquid nitrogen. In this case liquid nitrogen will be supplied to the space 25 through the nozzle 29. In this case the expansion chamber formed by the tubes 28 can be omitted. The supplying member, that is the conduit 22 and the application member 23 can, furthermore, comprise a heat insulation (not shown) preventing the cooling medium from being heated too much during the transport from the container 21 to the inner space 25. Such a heat insulation is particularly essential if nitrogen is used as a cooling medium.

The invention is not limited to the embodiments shown but can be varied and modified within the scope of the following claims. For example the tubes 28 can also be omitted when carbon dioxide is used as cooling medium, wherein one or several nozzles 29 can be arranged in the space 25 forming an expansion chamber. Carbon dioxide snow can also be produced at a distance from the application member 23 and supplied to the space 25 in a solid state through a conduit.

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Claims

1. A device for cooling a workpiece (1) in connection with
5 machining of the workpiece (1) with a laser beam (11), the
device comprising a source (21) for providing a cooling
medium, a member (22) for supplying the cooling medium and
an application member (23) arranged to be positionable in
the vicinity of or against the workpiece (1), the supplying
10 member (22) being arranged to supply the cooling medium to
the application member (23), characterised in that the
application member (23) is arranged to form an essentially
closed space (25) together with the workpiece (1) for
receiving the cooling medium, wherein the space (25) is
15 arranged to allow application of the cooling medium against
the workpiece (1).

2. A device according to claim 1, characterised in that
the application member (23) comprises a box-like element
20 (24) with an opening arranged to be turned towards the
workpiece (1).

3. A device according to claim 2, characterised in that
the application member (23) comprises a sealing member (26)
25 arranged to bear sealingly against the workpiece (1) and
extend around at least a part of the opening.

4. A device according to claim 3, characterised in that
the sealing member (26) comprises a strip of an elastic
30 material.

5. A device according to any of the previous claims,
characterised in that the application member (23) is
arranged to apply a cooling medium against a part of the
35 workpiece (1) at the same time as the laser beam (11) hits
another part of the workpiece (1).

6. A device according to any of the previous claims,
characterised in that the application member (23) is
arranged to be positioned in such a way that the cooling
5 medium cools at least one part of the workpiece (1) before
the laser beam hits that part of the workpiece (1).

7. A device according to any of the previous claims,
characterised in that the cooling medium comprises carbon
10 dioxide.

8. A device according to claim 7, characterised in that
the application member (23) is arranged to supply carbon
dioxide in such a way that it exists in an essentially solid
15 state in the space (25).

9. A device according to any of the previous claims,
characterised in that the cooling medium comprises nitrogen.

20 10. A device according to any of the previous claims,
characterised in that the application member (23) comprises
at least one nozzle (29) arranged to allow passage of the
cooling medium supplied to the space (25).

25 11. A device according to claim 8 and 10, characterised in
that the application member (23) comprises at least one tube
(28) having a first end which opens in the space (25) and a
second end at which the nozzle (29) is arranged for passage
of liquid carbon dioxide, the tube (28) forming an expansion
30 chamber for the carbon dioxide supplied through the nozzle
(29).

12. A device according to any of the previous claims,
characterised in that the application member (23) is
35 arranged to allow the cooling medium in the space (25) to be
forced against the workpiece (1).

13. A device according to any of the previous claims, characterised in that the device comprises means (30, 32, 8) arranged to increase the transfer of heat between the cooling medium and the workpiece (1).

14. A device according to claim 12 and 13, characterised in that said means comprises a piston member (30) arranged in the space (25) and arranged to force the cooling medium against the workpiece (1).

15. A device according to any of the claims 13 and 14 characterised in that said means (32, 8) are arranged to provide a movement in the cooling medium in the space (25).

16. A plant for machining a workpiece (1) comprising a laser apparatus (10) arranged to direct a laser beam (11) towards the workpiece (1) and a device (20) for cooling the workpiece (1), the device comprising a source (21) for providing a cooling medium, a member (22) for supplying the cooling medium and an application member (23) arranged to be positionable in the vicinity of or against the workpiece (1), the supply member being arranged to supply the cooling medium to the application member (23), characterised in that the application member (23) is arranged to form an essentially closed space (25) together with the workpiece (1) for receiving the cooling medium, wherein the space (25) is arranged to allow application of the cooling medium against the workpiece (1).

17. A plant according to claim 16, characterised in that the plant comprises a feeding member (5, 6) arranged to provide a relative movement between the laser beam (11) and the workpiece, wherein the application member (23) is arranged to be positioned in such a way that the cooling

medium cools at least a part of the workpiece (1) before the laser beam (11) hits that part of the workpiece (1).

5 18. A method for cooling a workpiece in connection with machining the workpiece with a laser beam, comprising the steps of:
providing a cooling medium,
positioning of an application member in the vicinity of or against the workpiece, the application member being arranged
10 to form an essentially closed space together with the workpiece,
supplying the cooling medium to the space and
cooling the workpiece through application of the cooling medium in the space against the workpiece.

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19. A method according to claim 18, comprising the step of:
displacing of the workpiece or the laser beam in order to achieve a relative movement of the workpiece in relation to the laser beam in a direction, wherein the cooling of the
20 workpiece comprises application of the cooling medium against at least a part of the workpiece before the laser beam hits that part of the workpiece.

20. A method according to any of the claims 18 and 19,
25 wherein the cooling medium comprises carbon dioxide.

21. A method according to claim 20, wherein the carbon dioxide is supplied in such a way that it exists in an essentially solid state in the space.

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22. A method according to any of the claims 18 to 21, wherein the cooling medium comprises nitrogen.

23. A method according to any of the claims 18 to 22,
35 wherein the cooling medium is supplied to the space through at least one nozzle.

24. A method according to claim 23, wherein the cooling medium is allowed to expand downstream of the nozzle.

5 25. A method according to any of the claims 18 to 24, wherein the cooling medium in the space is forced against the workpiece.

Fig 1

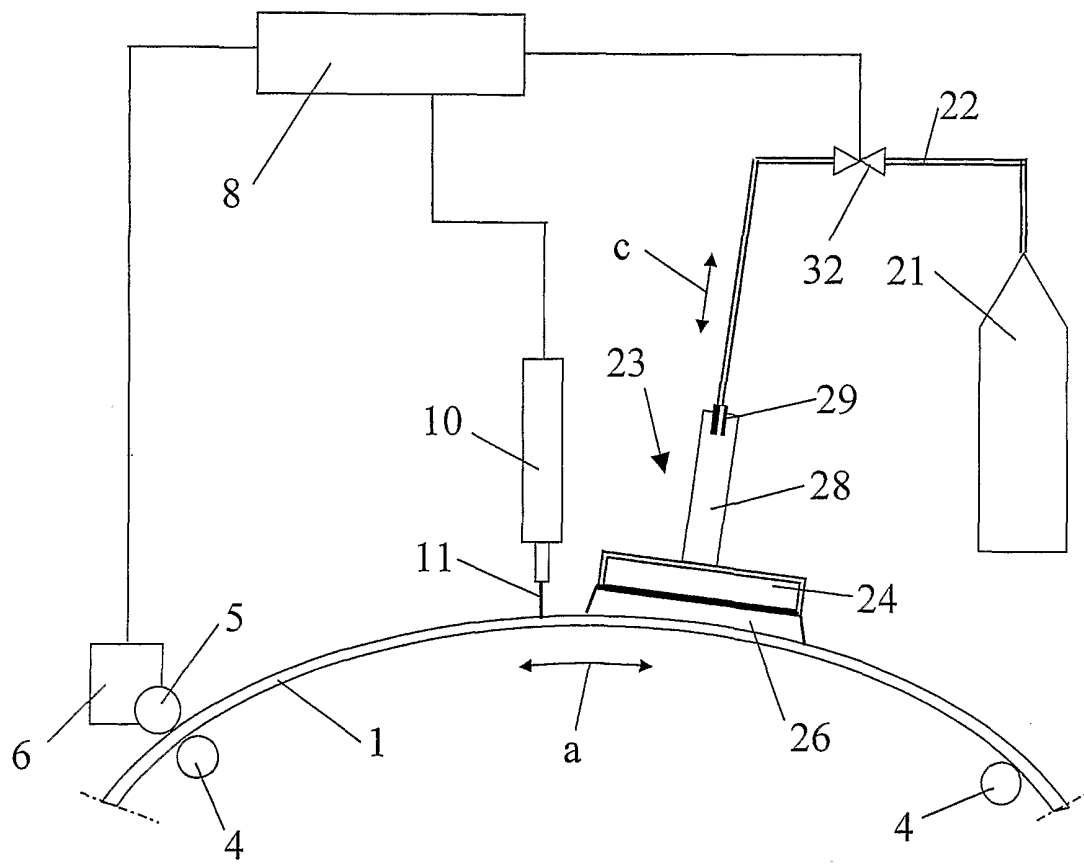


Fig 2

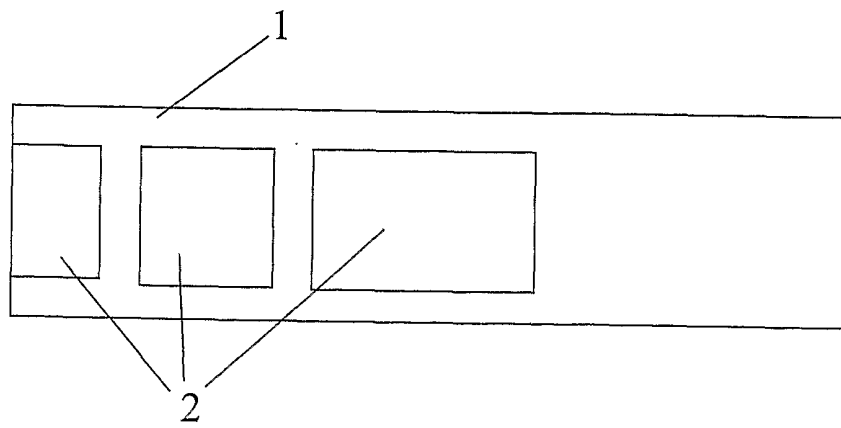


Fig 3

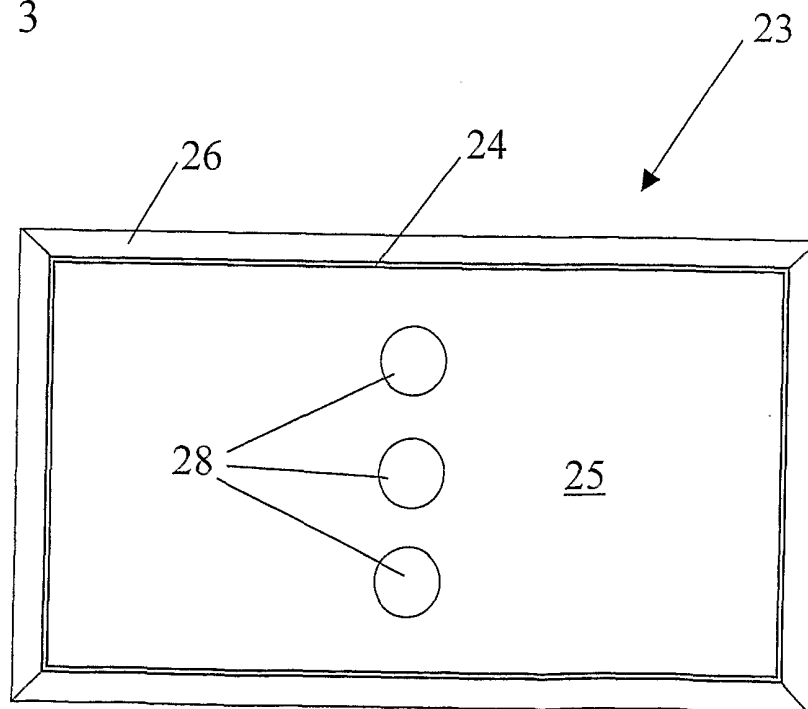
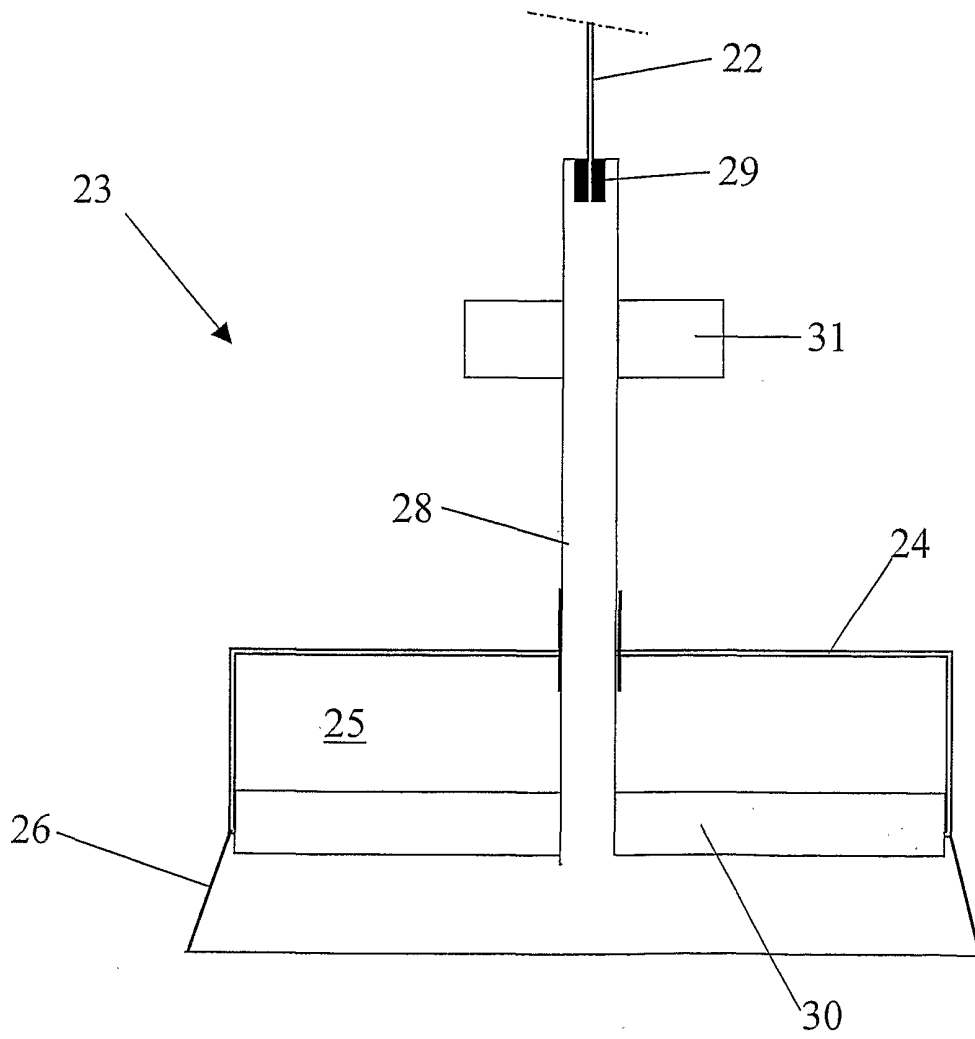


Fig 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 02/00234

A. CLASSIFICATION OF SUBJECT MATTER		
IPC7: B23K 26/42 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC7: B23K		
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)		
EPO-INTERNAL, WPI DATA, PAJ		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4125757 A (WILLIAM A. ROSS), 14 November 1978 (14.11.78) --	1,16,18
A	US 5073694 A (JEFF M. TESSIER ET AL), 17 December 1991 (17.12.91) --	1,16,18
A	JP 61119393 A (HITACHI LTD) 1986-06-06 (abstract), (online) (retrieved on 2001-12-04). Retrieved from EPO PAJ Database -- -----	1,16,18
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

01/05/02

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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