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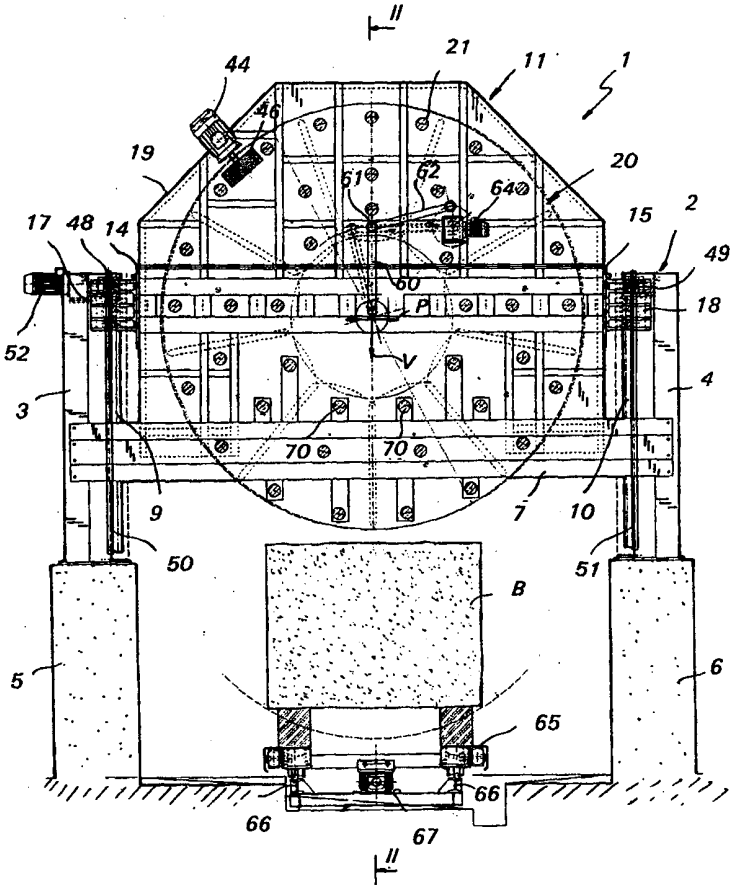
(54) Title: METHOD, TOOL AND APPARATUS FOR SAWING STONE BLOCKS

(57) Abstract

A machine for sawing blocks of marble, granite and other stony materials comprises a support frame (2) for a circular tool (20) and a carriage (65) for carrying blocks positioned below the tool. The rotary tool (20) is vertically fed into the stationary block, while an additional oscillating movement is imparted to the tool. The tool (20) comprises a circular flange core (28) provided with annular sections (27) which are connected at their centre to the core (28). Diamond cutting elements (42) are mounted onto the annular sections (27). The assembly of core (28) and sections (27) has a diameter to thickness ratio of at least 600 with a diameter (D) equal to at least 5m. The sections (27) are reciprocally coupled along their adjacent edges. Each section (27) is provided with face joining elements in the vicinity of its radial (29, 30) and internal (31) circular edges.



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METHOD, TOOL AND APPARATUS FOR SAWING STONE BLOCKS

Technical field

The present invention relates to a method for continuously sawing blocks of marble, granite and other stony material. The present invention also concerns a tool and an apparatus for carrying out such sawing method.

Background art

From the European patent n. 506533 a machine for sawing blocks of stony materials in slabs is known, which essentially comprises a tool having the shape of a circular planar ring with a diameter of at least 3 meter and a relatively small thickness, as well as a series of cutting elements, along the peripheral outer edge thereof. Motorized driving means are arranged on opposite sides of the tool, to make the tool rotate around its own axis; guiding means are further provided to keep the tool in a fixed plane perpendicular to said axis. The block of workpiece is placed on a carriage mobile with respect to the tool along a horizontal direction which is substantially parallel to a diameter of the cutting tool.

Thanks to the shape of the tool and to the driving and guiding means, said known machine allows for continuously sawing blocks of great dimensions, i. e. with a unique cutting without successive traverses along seams previously made by the cutting tool.

However such know machine suffers from the drawback that the cutting tool, that has annular shape, is relieved in correspondence of the central portion thereof and cannot be laterally guided in such position, and therefore sets

forth a limited transversal stiffness. As a consequence, the cutting tool is subject to uncontrolled deflections and distortions in its sawing plane. This results in cutting of slabs that is not plane and uneven, with big waste of raw material.

Other cutting tools having substantially the shape of a circular saw or disc are also known, e.g. from French patents n. 507980, 1319139, 2387107, UK patents n. 14031, German patents n. 3236045 and 2717935 and the European Patent n. 523260.

However, a certain number of such known tools of the background art has a diameter much smaller than 5 meters, which is insufficient to cut continuously slabs of big dimensions. Other tools have rather large diameters, but they are difficult to handle, to transport and to install and thus additionally involve high operation costs.

All the known continuous disc-shaped tools have a rather high thickness to diameter ratio and entail an excessive waste of material and consequently environmental problems of waste disposal.

The machines that use such known cutting tools have a discontinuous operating method, i.e. with successive traverses, or with low cutting speeds, which entails low efficiency and high operation costs.

Disclosure of the invention

The main purpose of the present invention is to eliminate the above mentioned drawbacks by means of a method, a tool and an apparatus for sawing blocks of marble, granite and other stone material that allows continuous cutting of large slabs with high speed and low costs.

Another purpose of the present invention is to provide a tool and machine that allow the continuous sawing of blocks of more than 2 meter height.

Another purpose of the present invention is to provide a tool and an apparatus that allows the lowest possible waste of raw material.

Yet another important purpose of the present invention is to provide a tool for continuous sawing of blocks of marble, granite and other stony materials having large dimensions that can be made with materials commonly available in the commerce at relatively low price.

The above mentioned purposes and others which will be better clarified hereafter are provided for by a method for continuously sawing blocks of marble, granite and other stony materials by means of a planar circular tool having reduced thickness which, in accordance with claim 1, has a substantially core, with a diameter of at least 5 meter and a diameter to thickness ratio at least equal to 600, in which the cutting tool rotation axis is always held above the top side of the workpiece.

The invention also provides a tool according to claim 4 and an apparatus according to claim 15.

Dependent claims disclose details of said method, tool and apparatus.

Brief description of the drawings

Further advantages and aspects of the invention will become more evident from the detailed description of a preferred, non limitative, embodiment of a method, tool and apparatus according to the invention, hereafter shown by way of non-limitative example by means of the accompanying drawings, in

which:

Fig. 1 shows a front view of an apparatus and tool according to the invention;

Fig. 2 shows a sectional side view of the apparatus of Fig 1 along the section plane II-II;

Fig. 3 shows a top view of the tool according to the invention;

Fig. 4 shows a detail of the tool of Fig 3;

Fig. 5 shows an enlarged section view of a detail of Fig 4 along plane V-V;

Fig.6 shows an enlarged section view of another detail of Fig. 4 along plane VI-VI;

Fig. 7 shows an enlarged front view of another detail of Fig. 4;

Fig. 8 shows an enlarged view of a detail of Fig. 3;

Fig. 9 shows an enlarged view with a partial section of the detail of Fig. 8;

Fig. 10 shows a section view along plane X-X of the detail of Fig. 9;

Fig. 11 shows an expanded view of the detail of Fig. 10;

Fig. 12 shows an enlarged partial section view of a detail of Fig. 2

Fig. 13 shows an enlarged partial section view of a detail of Fig. 2

Fig. 14 shows an enlarged partial section view of a detail of Fig. 1.

Description of a preferred embodiment

With reference to the figures, an apparatus for sawing blocks of marble, generally identified with the reference numeral 1, granite and other stony materials is comprised of a support frame 2, formed by a pair of solid columns 3, 4 fixed on the respective piers 5,6 respectively mounted on the floor of the room where the apparatus is located. The columns 3, 4 are fixedly connected to one another by means of a pair of horizontal crossbeams 7,8 and are provided with respective vertical guides 9,10.

A structure generally identified 11 holding a cutting tool is supported by the support frame 2, said structure 11 being essentially formed by a pair of substantially parallel and horizontal beams 12, 13, said pair of beams being connected by a pair of plates 14, 15 so as to define therebetween a space 16 suitable to accommodate a cutting tool. Two slides 17, 18, which are slidably mounted along the vertical guides 9, 10 of columns 3, 4 are anchored to plates 14, 15.

Beams 12, 13 support a guard or protecting shroud 19 for a disc-shaped cutting tool generally identified 20, hereafter described more in detail.

Tool 20 is formed by a core 21 of generally circular shape, and has on the peripheral edge thereof a series of diamond or cutting elements which are fixed in circumpherentially adjacent positions.

A central flange 23 is fixed to core 21 and supports a bearing 24 for a shaft 25 which extends along a substantially horizontal rotation axis R.

According to the invention, the cutting tool has a remarkably large diameter D, both in an absolute and in a relative sense, i.e. as a ratio to the tool thickness S. In fact, core 21 has a diameter equal to at least 5 meter and a diameter to thickness ratio equal to at least 600.

By way of non limitative example, the tool core is selected to have a diameter of 5160 mm, so as to enable the direct and continuous cutting of blocks having a dimension greater than 2000 mm, and a thickness of 8mm, so as to considerably reduce material waste during sawing.

Advantageously, core 21 is obtained by the assembly of a multiciplity of partial elements 26 of metal plate having maximum thickness S.

More particularly, such partial elements comprise a series of annular sections 27 placed side-by-side and connected to one another and to a circular-shaped inner flange 28.

Thus, it will be possible to manufacture both the flange and the annular sections from commercially available plates, which have reducer dimensions as compared with those of the tool assembly 20, are of high quality though having a relatively low cost.

With reference to Fig. 4, each annular section 27 has radial and rectilinear edges 29, 30 and a generally circular convex inner edge 31.

Face joints are arranged along edges 29,30,31, said joints being formed by a series of juts 32 made on one of the edges 29, 30 of the annular sections and which can be facingly connected in corresponding seatings 33 with a complementary shape, e.g. with ellipsoidal profiles, arranged on the adjacent side of the next annular section. In view of such complementary shape, the total joint thickness of the tool in assembled condition, will be equal to the overall maximum tool thickness S, so as to have a substantially continuous core.

In order to guarantee the stiffness of core 21, connecting elements are provided, which are formed by screws 34 with flared head and by nuts or bushes 36 having cylindrical body 37 and flared head 38. Screws 34 and bolts 36 after screwing have a total width smaller that the overall thickness S of the core plate. Both flared heads of screws and bolts are housed in respective, complementary shaped holes 39, 40 formed on opposite edges of the frontal joints.

Obviously, juts or seatings may be arranged on the lateral edges of each annular sections 27 on the same side or on opposite sides thereof, so as to connect adjacent joints.

Moreover, circumferentially shaped cuts are formed on the opposite sides of the outer circular edge 41 of the annular sections 27, so as to locally provide a reduced thickness of the element $T<S$. On these thinner edges 41, it is possible to fix cutting elements 42 having a substantially U-shaped cross section with maximum thickness S and central spacing 43 slightly greater than thickness T. By way of non-limitative example, cutting elements 42 may be fixed on the edge 41 of peripheral annular sections 27 by means of the same fixing means 34, 36 above described, or by any equivalent means.

According to the invention, the machine 1 comprises first motor means arranged for rotatively driving the cutting tool around its own rotation axis R, preferably at steady angular speed. Such first motor means may preferably consists of a pair of electrical motors 44, 45 with rubber wheels 46, 47 mounted on respective axes, in facing relationship and in frictional rolling engagements at the peripheral portion of the cutting tool 21.

Second motor means are provided to drive the cutting tool 20 along a first and substantially vertical direction of arrow V. More particularly, such second motor means may be constituted by worm gears 48, 49 mounted on slides 17, 18 and connected to respective driving screws 50, 51 which are synchronously driven by a motor reduction gear 52. Upon rotation of screws 48, 49, the tool support structure 11 will be selectively raised or lowered in a controlled manner.

Third motor means are also provided to drive the cutting tool 20, so as to promote oscillation thereof in the second horizontal direction P, substantially perpendicular to the first direction V.

To this end, the rotation shaft 25 of tool 20 is supported at the ends thereof by a pair of short arms 53, 54 fixed on respective coaxial hubs 55, 56. These latter hubs can synchronously rotate about an oscillation axis O, which is parallel and transversally staggered, with eccentricity E, with respect to the rotation axis R of the cutting tool 20. Hubs 55, 56 are journalled on respective bearings 57,58 arranged on the side wall of shroud 19.

Hub 56 is provided with an axial extension 59 to which an arm 60 is rigidly attached. A link rod 62 is connected to end 61 of arm 6, said link rod being connected to a crank-lever 63 which is in turn driven by a motor reduction gear 64. The above described connecting-rod mechanism produces a swinging motion of the cutting tool rotation axis R, so as to make the cutting tool contact the workpiece in different zones of it periphery thereby reducing unit load and thermal stress and enhancing penetration of the cutting tool in the raw material.

Fourth motor means, of known type, are also provided which are suitable to drive in translatory motion a workpiece transportation carriage 65 in steps of predetermined length in direction H, parallel to the cutting tool rotation axis R. By way of example, the carriage 65 can move along rails 66 anchored to the floor G and can be driven by a motor reduction gear 68 which engages a screw 69 connected to a nut fixed to said carriage 65. By rotating stepwise the screw 67, it is possible, at the end of each sawing cycle, to translate the carriage 65 over a distance equal to the thickness of the next slab to be cut.

In order to guarantee the stability of the cutting tool 20 on its plane, lateral support means are arranged on both sides of the core 21. Such support means may comprise a series of pads 70 having planar or slightly convex shape, evenly distributed over the core, resiliently urging the opposite sides of

the web 21 and supplied with water under high pressure to support such web with the lowest possible friction factor and to also provide cooling of the cutting surface.

Moreover, the planar pads 70 located below beams 12, 13, in the portion thereof where the cutting tool engages the workpiece B, can be mounted at the ends of linear actuators, e.g. pneumatic or hydraulic cylinders, having respective axes substantially perpendicular to the vertical plane of the cutting tool. Cylinders 71 can be fed by a control unit that controls the selective movement away or towards the core21 in the portion of the tool 20 that is in contact with the workpiece.

In use, after positioning a block B on carriage 65 and translating it under the cutting tool 20 with its rotation axis parallel to the carriage advancement direction H, the cutting tool is driven into rotation at substantially steady speed. Tool 20 is subject to a continuous feeding movement towards the workpiece B in a vertical direction V parallel to its extension plane as well as to an oscillation with respect to the block in a parallel direction to its plane and perpendicular to the feeding direction V. At the end of each slab sawing cycle, the carriage 65 is displaced shifted along direction H by a predetermined distance that amounts the thickness of the slab to be cut.

Claims

1. Method for continuously sawing blocks of marble, granite and other stony materials, comprising the following steps:

- placing a block (B) on a workpiece carriage (65) arranged for movement along a longitudinal direction (H);

- providing a tool of planar disc shape having a relatively high diameter to thickness ratio;

- positioning the tool (20) above the block to be cut with its rotation axis (R) substantially parallel to said longitudinal direction (H);

- rotating the tool (20) around its own rotation axis (R) with substantially steady speed;

- continuously advancing the tool (20) towards the block to be cut with a substantial steady speed in a first advancement direction (V) substantially parallel to the extension plane of said tool;

- oscillating the tool (20) relatively to the block in a direction (P) parallel to the extension plane of the tool and perpendicular to said advancement direction;

- translating the block workpiece carriage (65) with a step of predetermined length along said longitudinal direction (H) after complete cutting of each slab;

wherein said tool (20) is selected to have a substantially continuous core (21) and has a diameter (D) of at least 5m and a diameter to thickness ration equal to at least 600, and in which the tool rotation axis (R) is constantly kept above the top face of the block (B) to be cut.

2. Method according to claim 1, wherein said tool (20) is caused to rotate, oscillate and advance in a substantially vertical plane, while said carriage (65) is caused to translate in a substantially horizontal direction (H).

3. Method according to claim 1, wherein said tool (20) is caused to

oscillate with a continuous swinging movement around an axis (O) substantially parallel and eccentric with regard to the tool rotation axis (R).

4. A tool for continuous sawing in slabs of blocks of marble, granite and other stony materials, for carrying out the method described in any preceding claims, comprising an internal core (21) of substantially planar disc shape, provided with a plurality of diamond cutting elements (42) along its periphery, characterised in that said central core (21) is substantially continuous so as to intersect the rotation axis (R) of said tool (20) and has a diameter to thickness ratio equal at least to 600 with a diameter (D) of at least 5 m.

5. Tool according to claim 4, wherein said core-web (21) is made of metal plate having a thickness (S) lower or equal to approximately 8 mm.

6. Tool according to claim 4, wherein said diameter to thickness ratio is preferably close to 650, and said diameter is equal to approximately 5160 mm.

7. Tool according to claim 5, wherein said core-web (21) is composed of a plurality of planar elements (26) that can be reciprocally assembled along their adjacent edges.

8. Tool according to claim 7, wherein said planar elements (26) comprise annular sections (27) which are connected, at their central portion, to a circular element (28) which is keyed to said rotation axis (R).

9. Tool according to claim 8, wherein each of said annular sections (27) is provided with respective face joints (28,29) along its radial and internal circular edges.

10. Tool according to claim 8, wherein said face joints (28,29), when assembled, have a total thickness equal to the maximum thickness (S) of said core (21).

11. Tool according to claim 8, wherein said face joints (28,29, 30) comprise on one of the elements to be coupled a series of juts (32) adapted for engagement with a series of complementary shaped seatings (33) formed on the other element to be coupled, there being provided coupling means in form of screws (34) and shaped bushes (36) which have, when completely coupled, an overall maximum length smaller than the maximum thickness (S) of a core-web (21).

12. Tool according to claim 4, wherein said diamond cutting elements (42) are comprised of supports having substantially U-shaped cross section with internal recesses (43), said recesses being arranged for engagement with the outer peripheral edge (41) of reduced thickness of said annular sections (27) by means of suitable connecting means (34, 36).

13. Tool according to claim 13, wherein said connecting means (34, 36) include screws (34) with flared heads (35) arranged for engagement with internally threaded bushes (36) having a cylindrical body (37) and a flexed head (34), said screws and bushes being adapted for housing in corresponding holes (39,40) of complementary shape formed in said elements (42).

14. A sawing machine, particularly for sawing blocks of marble, granite and stony materials, comprising a support frame (2) supporting at least a substantially circular cutting tool (20) and a block carrying carriage (65) positioned underneath said cutting tool, wherein said cutting tool (20) comprises a core (21) of planar disc shape, peripherally provided with a plurality of diamond cutting elements (42), characterised in that said core (21)

is substantially continuous and is arranged for intersecting the cutting tool rotation axis (R) and has a diameter to thickness ratio equal to at least 600 and a diameter (D) equal to at least 5m.

15. Sawing machine according to claim 14, wherein it comprises first motor means (44-47) acting on said cutting tool (20) to promote continuous rotation thereof about its rotation axis (R), second motor means (48-52) acting on said cutting tool (20) to promote advancement thereof in a first direction (V), that is substantially vertical and parallel to a tool diameter, third motor means (60-64) acting on said cutting tool (20) to permits an oscillating movement in a second direction (P) perpendicular to said first direction (V) and parallel to a diameter of the cutting tool, fourth motor means (67-69) arranged for translating said block carrying carriage (65) with steps of predetermined length in a direction (H) substantially parallel to the cutting tool rotation axis (R).

16. Sawing machine according to claim 15, wherein the rotation axis (R) of said cutting tool is mounted on a pair of movable arms (53,54) adapted for oscillation with respect to a tool support structure (11) which is movable along vertical guide means (9,10).

17. Sawing machine according to claim 15, wherein said pair of oscillating arms (53, 54) is journalled to a support beam on a second axis (O) which is substantially parallel to the said rotation axis (R).

18. Sawing machine according to claim 16, wherein it comprises means (70) for laterally supporting said cutting tool (20) in correspondence of its core, said lateral support means (70) being formed by a series of pads fed with pressurized water and uniformly distributed on said core (21), with the exception of the portion of this latter that is engaging the workpiece.

19. Sawing machine according to claim 18, wherein the pads (70) which are located in the lower half of said cutting tool (20) are mounted on actuators (71) selectively movable away from the core in the portion thereof which is in contact with the workpiece.

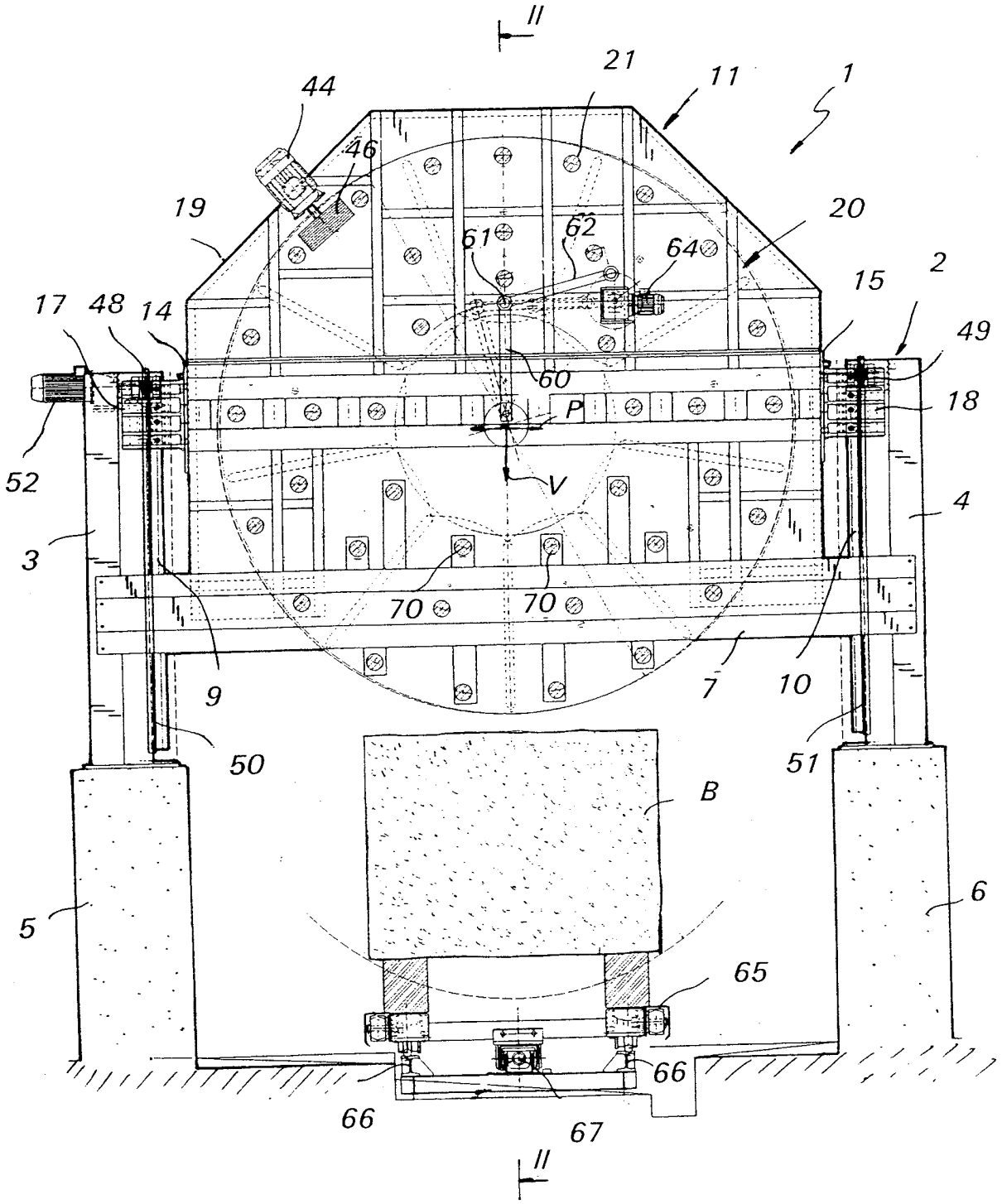
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Fig. 1

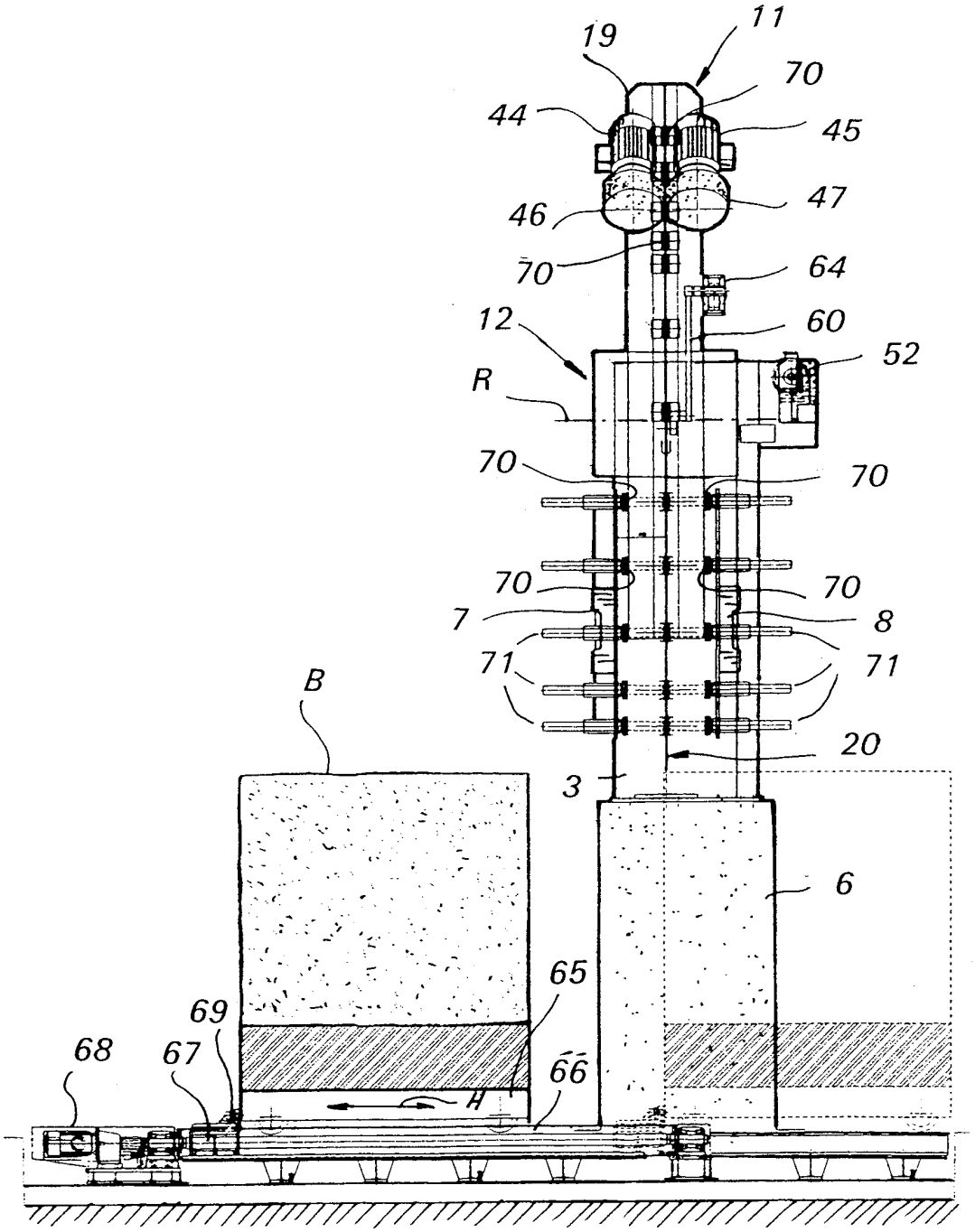
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Fig. 2

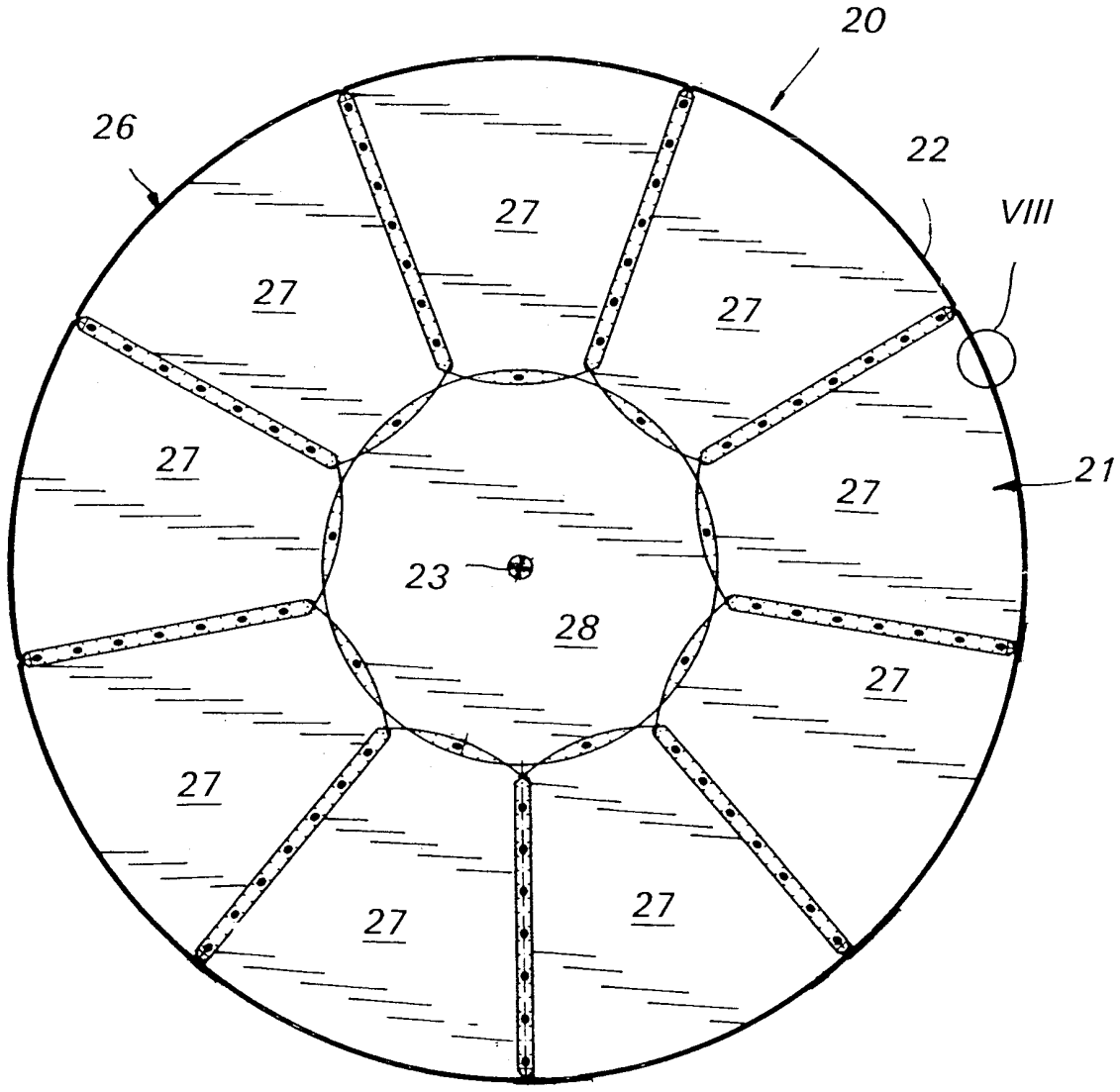


Fig. 3

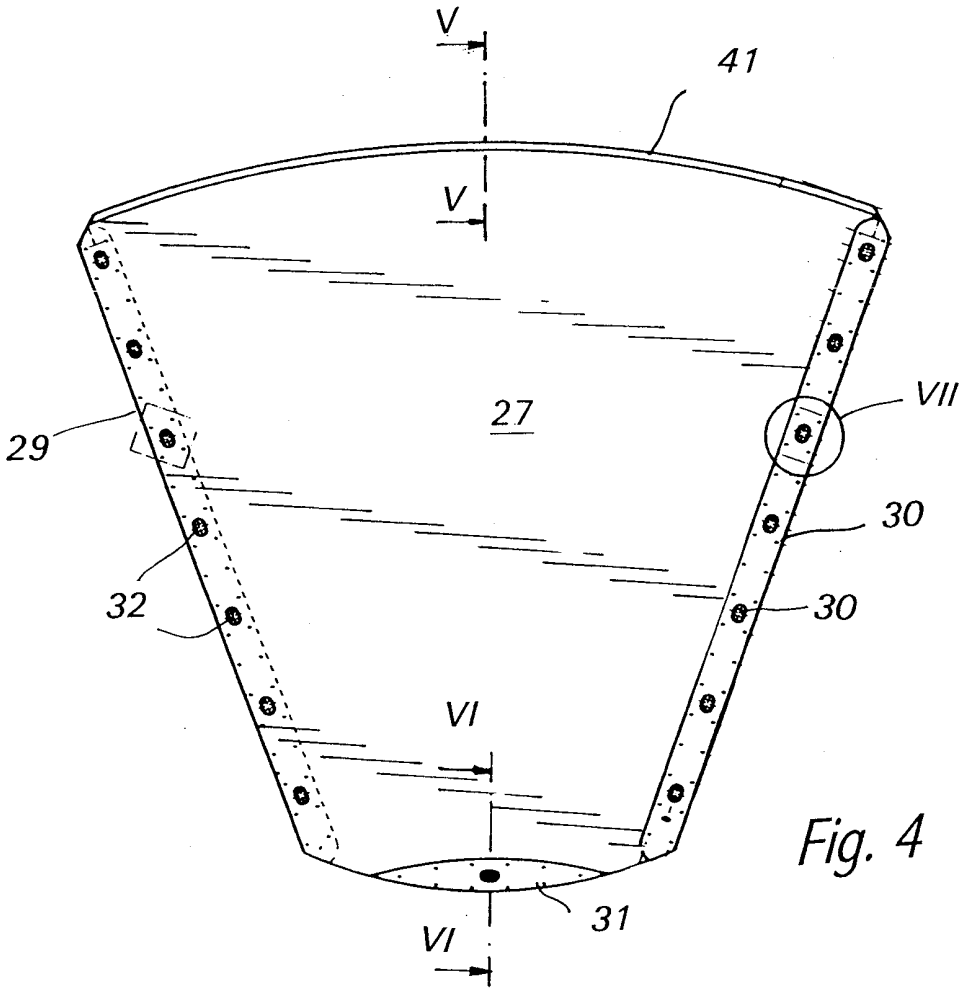


Fig. 4

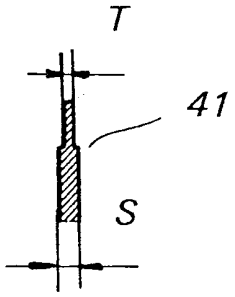
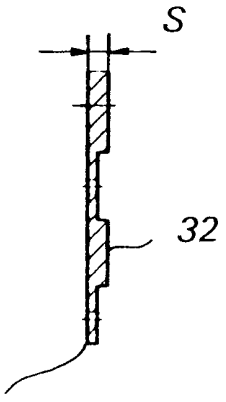


Fig. 5



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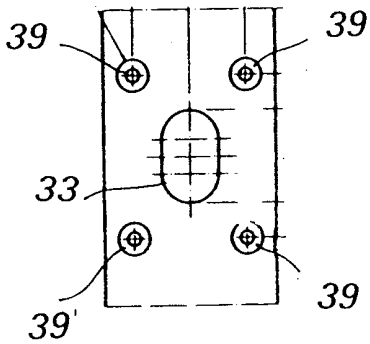

Fig. 7

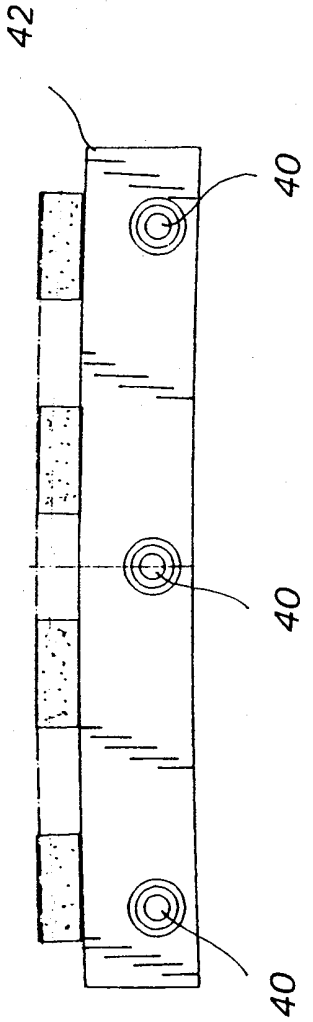

Fig. 8

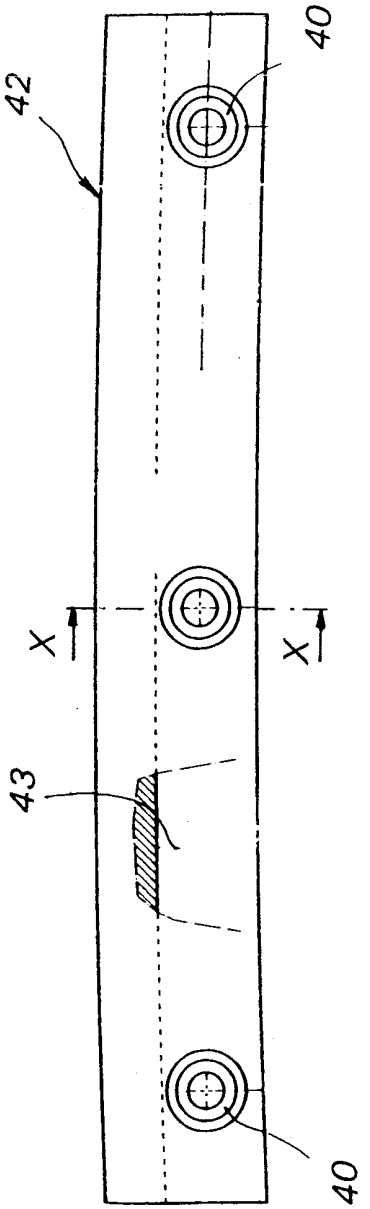

Fig. 9

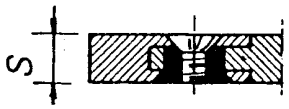

Fig. 10

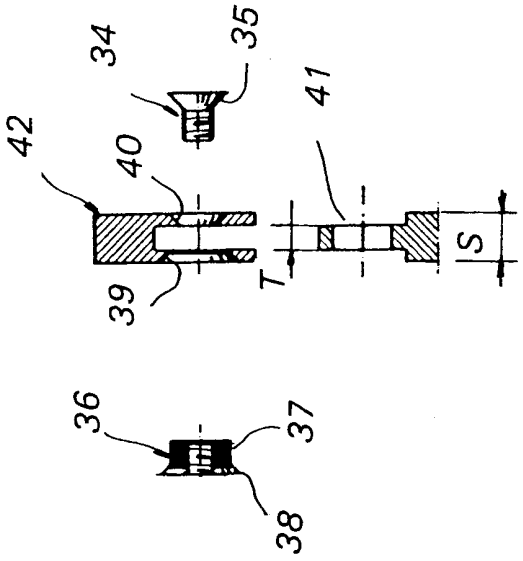

Fig. 11

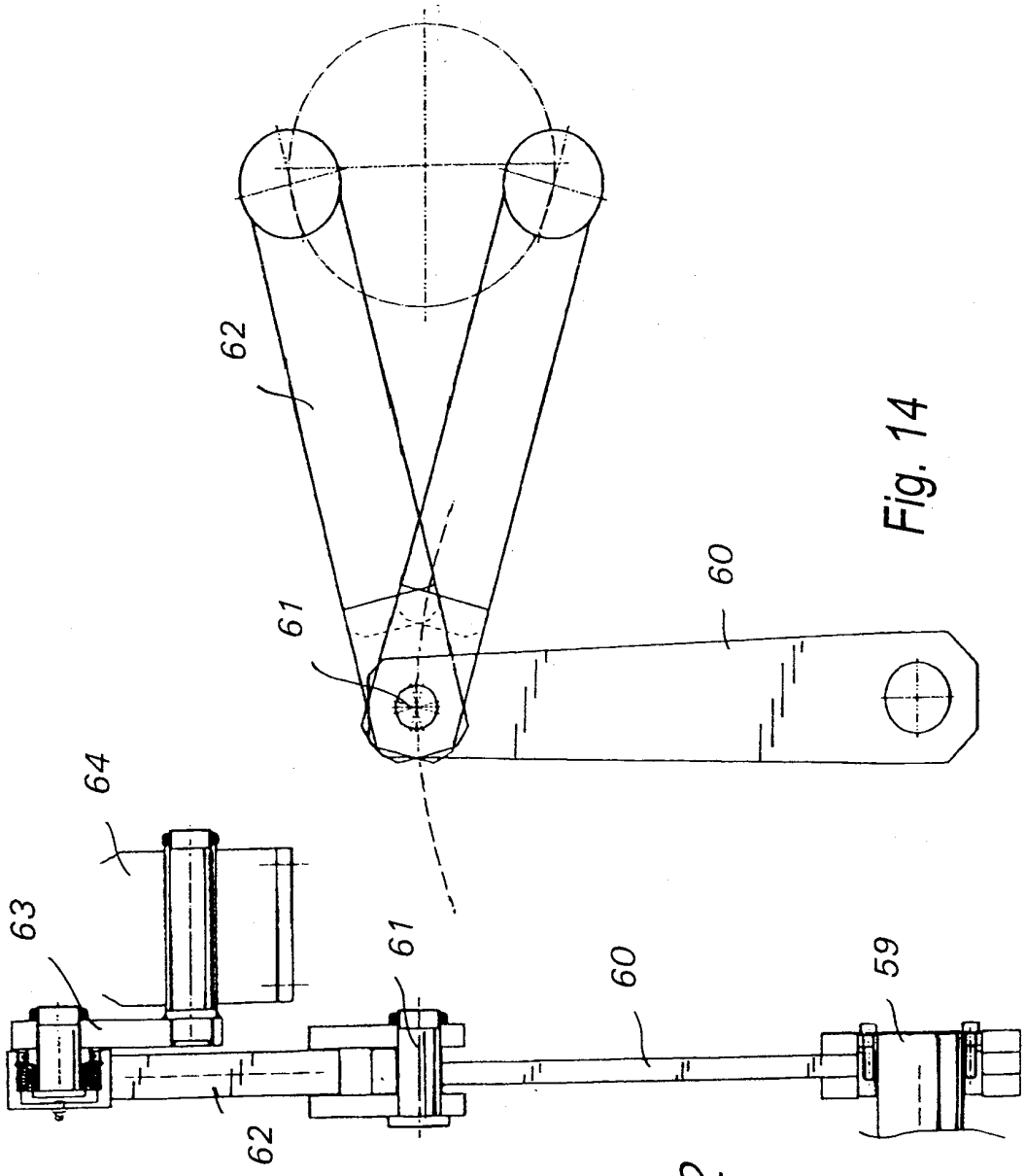

Fig. 14

Fig. 12

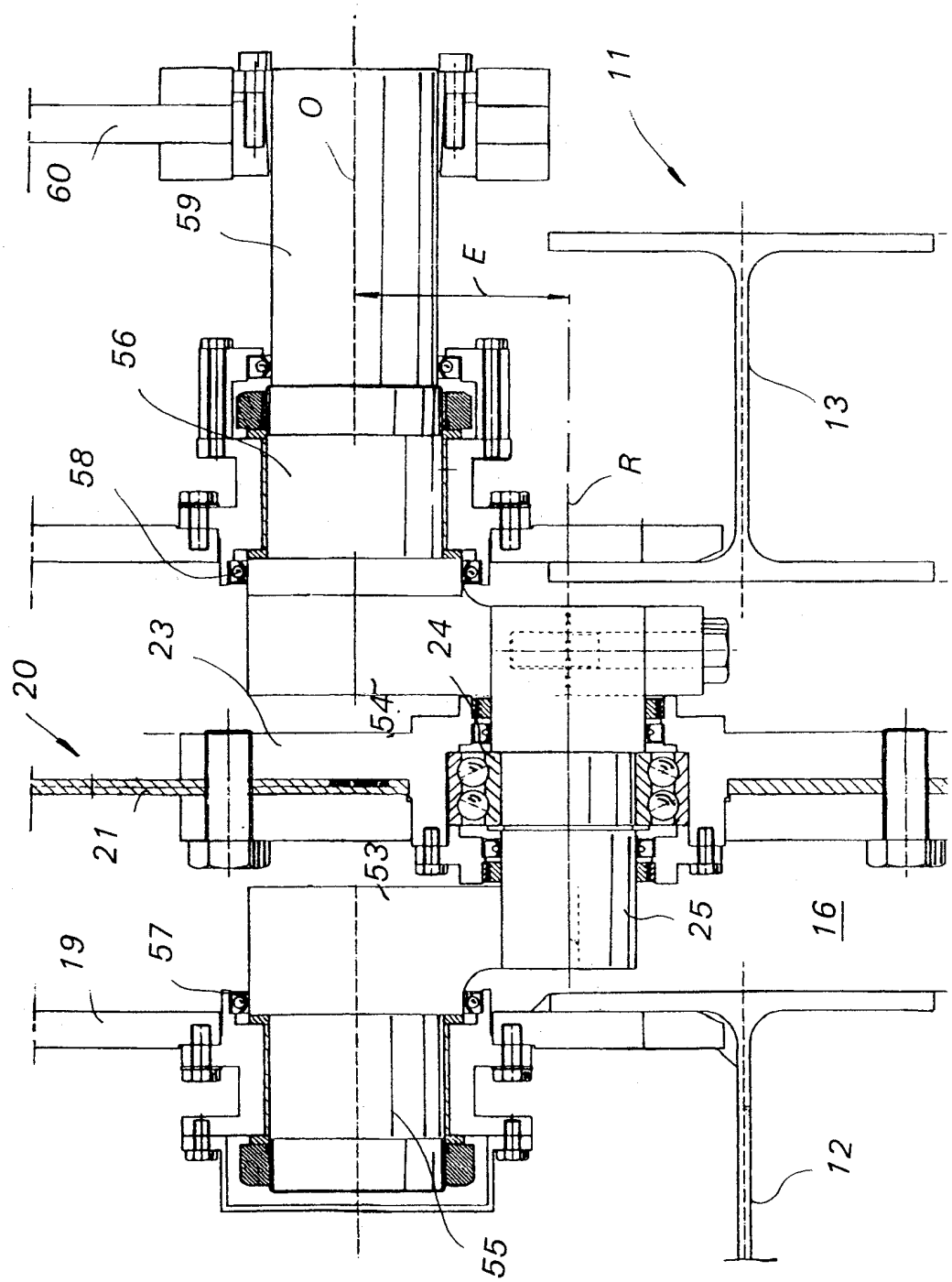

Fig.13

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/IB 98/01885

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B28D1/04 B28D1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B28D B23D

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 069 622 A (D. SWAROVSKII) 24 January 1978 see column 2, line 60 - column 3, line 19 see figures	4-6
A		12,13

X	US 3 795 078 A (L. COES) 5 March 1974 see column 3, line 32 - column 4, line 21 see column 6, line 26 - column 7, line 55 see figures	4-6
A		12,13

X	US 2 506 076 A (L.I. GARRISON) 2 May 1950 see column 2, line 2 - line 17 see column 2, line 48 - column 3, line 5 see figures 1,2	14
Y		1-3

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
1 March 1999	15/03/1999

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

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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...ormation on patent family members

Inter nal Application No
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