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(71) Applicant: **HOOGOVENS GROEP B.V.**
P.O. Box 10.000
NL-1970 CA IJmuiden(NL)

(72) Inventor: **Middel, Jan**
Meerstraat 84a
NL-1941 JD Beverwijk(NL)
Inventor: **Rademaker, Lodevicus Mattheus**
Esdoornlaan 52
NL-1702 SK Heerhugowaard(NL)

(74) Representative: **Van Breda, Jacobus, Mr. Ir. et al**
HOOGOVENS GROEP BV P.O. Box 10.000
NL-1970 CA IJmuiden(NL)

(54) Trace grinding apparatus.

(57) A trace grinding apparatus for grinding an inspection trace on a workpiece which is moved along a path relative to the trace grinding apparatus, has a grinding device (4) including a grinding element (5) which in use contacts the workpiece, a carrier frame (3) carrying said grinding device and a support frame (2) supporting the carrier frame. To provide good control of position of the grinding device (4) and the force which it applies, mounting means mounting the carrier frame (3) movably on said support frame (2) comprise two bellows (6,7) containing pressurized fluid interposed side-by-side between said support frame and said carrier frame. There are means (9) for adjusting pressure of the fluid in at least one of the bellows (6,7).

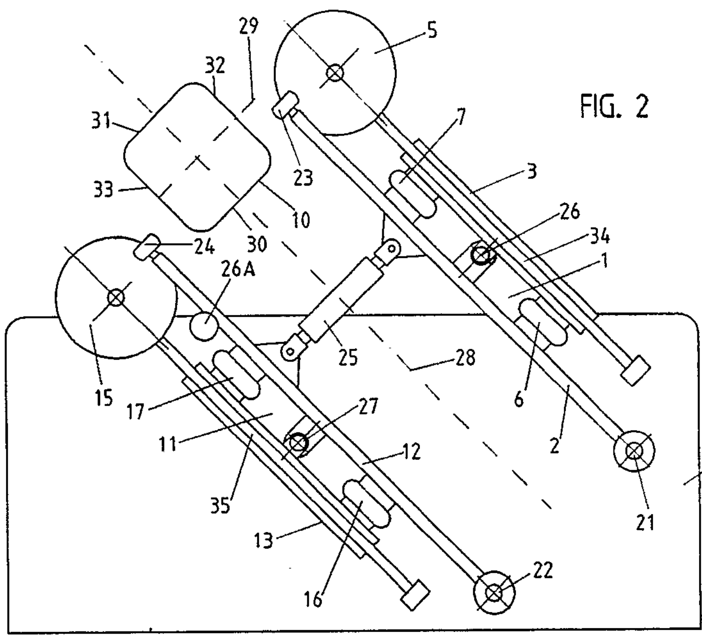

FIG. 2

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TRACE GRINDING APPARATUS

The invention relates to a trace grinding apparatus for grinding an inspection trace onto a workpiece moved relatively to the trace grinding apparatus. The workpiece is for example a metallurgical product.

Inspection traces are made on a workpiece such as a steel billet from which parts such as shaft journals, lifting eyes and crane hooks are forged. Such parts must be of very high quality. An inspection trace must have just enough depth, that is to say beneath the outer surface, that it breaks through any mill scale present on the surface. In practice a depth of a few tenths of a millimetre has been found sufficient. The clean inspection trace revealed makes it possible by means of visual inspection to observe any cracks in the surface of the workpiece.

It is usual to make the inspection trace using a repair grinding machine, that is a grinding machine which is designed to grind away flaws in the surface at a high rate of removal and at high speed. An inconvenience of the repair grinding machine is that the depth of the repair trace cannot be controlled well and that the machine has too high a speed of travel of the workpiece. On the other hand for making an inspection trace on each of the side faces of a rectangular workpiece of polygonal section, the workpiece often has to be fed through the repair grinding machine as many times as there are side faces.

GB-A-874300 discloses a machine specifically designed to grind two inspection traces on opposite sides of a billet simultaneously. Grinding units are mounted on a pair of pivoting carrier frames which are moved by pneumatic cylinders against counterweights, to bring the grinding wheels into contact with the billet. The force applied to the billet by the grinding wheels varies according to the position of the carrier frames, which can cause non-uniformity of the inspection traces.

An object of the invention is to provide a trace grinding machine with which these inconveniences are remedied, and in particular in which uniform force may be applied to the article being treated.

Another object of the invention is to provide a trace grinding machine which may be extensively mechanized or automated.

Yet another object of the invention is to provide a trace grinding machine which can make an inspection trace over the full length of a workpiece.

A further object of the invention is to provide a trace grinding machine which may be incorporated in a conventional production line for steel billets.

The trace grinding machine in accordance with the invention has at least one grinding assembly comprising a support frame and carrier frame for a grinding unit and between support frame and carrier frame two bellows operated by fluid under pressure mounted side by side. Control means are provided for adjusting the pressure of the fluid in at least one of the bellows. The fluid is preferably gas, but any suitable means for providing resilient fluid force in the bellows may be employed.

As a result of a change in the pressure of the fluid in a first one of said bellows, the bellows deform so that the second bellows exercise a varying reactive force on the first bellows through intervention of the supporting frame and the carrier frame. The deformation of the first bellows continues until a fresh equilibrium of forces between the two bellows is reached at a new position of the carrier frame relative to the supporting frame.

For example, the pressure in the first bellows is adjustable using the control means to a value whereby the first and the second bellows have a shape such that the grinding element on the carrier frame just makes contact with the workpiece. The force with which the grinding element presses onto the workpiece, i.e. the grinding force, may then be set to a chosen value by further changing the pressure of the fluid in one bellows.

This achieves the advantage that, within certain limits influenced by the dimensions of the bellows, it is possible to adjust accurately the setting of the grinding force and the depth of the inspection trace.

In principle the position of the carrier frame relative to the support frame is position-controlled and not force-controlled by the joint action of the two bellows. Consequently the trace grinding machine in accordance with the invention also has the advantage that at the end of the workpiece the carrier frame is not sent uncontrolled into the empty space behind the workpiece, but that the carrier frame is sent to a new, known and controlled position.

Preferably the support frame is provided with a guide member, e.g. a roller, for tracking the position of the workpiece in the trace grinding machine. The guide member determines the position of the workpiece and then adopts a desired position relative to the workpiece. Because the guide member and support frame are joined together, the position of the support frame relative to the workpiece is consequently also determined. This achieves the advantage that the starting position of the carrier frame relative to the workpiece is likewise known and that the deflection of each of the bellows is independent of the dimensions of the workpiece.

The relationship between pressure in each of the bellows on the one hand, and the grinding force and grinding depth on the other is consequently determined in an easily reproducible way.

Another advantage of this embodiment is that the guide member follows the face to be worked directly or indirectly, and that through intervention of the two bellows and the carrier frame the grinding element also follows the face to be worked without occurrence of any appreciable acceleration forces and grinding force variations associated with them.

When the trace grinding machine is incorporated in the production line of the workpiece, in particular in the case of steel billets, it is desirable that the workpiece travels through the trace grinding machine at a speed matching that of the production line. Here it is an advantage to use a roller as the guide member and to provide a roller drive for rotating the roller to apply driving force to the workpiece. The roller then also helps move the workpiece through the trace grinding machine. Driving of the roller may be desirable in cases where transport means for the workpiece already present in a production line are not sufficiently powerful to transport the workpiece against the force exercised by the grinding device.

Preferably in accordance with the invention the trace grinding machine is provided with means for displacement of the grinding element reciprocatingly back and forth in a direction transverse to the movement of the workpiece, for example perpendicular thereto. Practical trials have shown that a crack to be inspected in the surface can be observed well if the inspection trace is a serpentine or wavy line over the surface to be inspected. In some cases a crack is then found to be even easier to observe than with a fully ground surface. At the same time it has been found that for the majority of applications an inspection trace extending as a serpentine or wavy line enables adequate inspection.

The wave length of the wavy line may be chosen by matching the speed of longitudinal movement of the workpiece and the speed of transverse displacement of the grinding unit. In particular under that circumstance it is an advantage if the trace grinding machine has its own means of drive for the workpiece such as a powered roller. The wave length may then be chosen, within any limits which might be imposed by a production line.

The trace grinding machine may be provided with means for controlling the stroke of the transverse displacement in dependence on the size of the workpiece, e.g. on the displacement of the guide member as it tracks the position of the workpiece in the trace grinding machine.

For the sake of mechanization or automation it is important that the trace grinding machine is able to work a large variety of workpiece sizes with a minimum of human intervention. The guide member determines the position of the surface to be inspected in the trace grinding machine. With rectangular workpieces there is a fixed relationship between the position of the surface to be inspected and the width in its transverse direction. From the position determined the width may be derived and thereby also the desired stroke of the reciprocating transverse movement for making an inspection trace over a chosen part of the surface.

In many cases there is a typical direction for cracks occurring in the surface. Therefore, depending on the production method being used, in steel billets there is a typical direction for longitudinal or transverse cracks.

With a trace grinding machine which is provided with a grinding element rotating about an axis preferably the grinding axis makes an angle different from zero degrees to the direction of movement of the workpiece and to the perpendicular direction to the direction of movement. Preferably this angle is 10 to 20°, particularly approx. 15°. Choosing the angle of the grinding axis as stated prevents cracks present in the surface from being filled in as a result of the grinding action by the grinding movement of a grinding element, such as a grinding wheel.

In this preferred arrangement the direction of the grinding movement intersects the typical direction of a crack. In practice an angle of about 15°, as stated, has been found to be a good compromise between the requirement that on the one hand a crack must be intersected by the direction of the grinding movement, and on the other hand the space taken up by the obliquely positioned grinding elements.

The invention can also provide apparatus for grinding inspection traces onto a plurality of faces of a workpiece of rectangular section, such as a rectangular steel billet, simultaneously.

A particularly compact and fast acting apparatus system provided with at least two grinding assemblies as described above and means acting on the two support frames for moving the two grinding assemblies towards opposite sides of the workpiece. The two grinding assemblies are moved simultaneously or directly following one another towards the workpiece. If desired a second set of two grinding assemblies may be positioned at 90° to the first set, for simultaneously grinding an inspection trace on each of the four side faces of a rectangular billet.

Embodiments of the invention will now be illustrated by way of non-limitative example with reference to the accompanying drawings. In the drawings:-

Fig. 1a and 1b are schematic representations of a first trace grinding apparatus in accordance with the invention;

Fig. 2 is a schematic representation of a second trace grinding apparatus in accordance with the invention;

Fig. 3 is a schematic representation of a further embodiment of a trace grinding apparatus in accordance with the invention, and

Fig. 4 is a schematic representation of a feature applicable to the trace grinding apparatus in accordance with the invention.

In the several figures, the same reference numbers indicate corresponding parts with corresponding functions.

Fig. 1a shows a trace grinding machine 1 embodying the invention which comprises a support frame 2 and a carrier frame 3. On one end the carrier frame 3 carries a grinding unit 4 with a grinding element 5. The grinding unit 4 has an electric motor with a right-angled transmission and the grinding element 5 is a grinding wheel rotated by the motor.

Two air-filled bellows 6 and 7 are mounted side by side between the supporting frame 2 and the carrier frame 3. The bellows 7 are filled with a fixed amount of air and the bellows 6 are coupled by means of a line 8 and control valve 9 to a source, not shown in the drawing, of pressurising fluid, such as a compressed air system. Control valve 9 may be made as a proportional valve.

The two bellows 6,7 thus provide adjustable resilient forces between the support frame 2 and carrier frame 3. In this case there is essentially no other support of the carrier frame 3.

In the position drawn in Fig. 1a, which may be a condition of rest, the distribution of pressure between the bellows 6 and 7 is selected in such a way that the raised grinding unit 4 and the grinding element 5 do not touch the workpiece 10 to be worked on. By increasing the pressure in the bellows 6, for example by adjusting control valve 9, the bellows 6 expand and the bellows 7 are compressed through the relative movement of the support frame 2 and carrier frame 3. A certain pressure in the bellows 6 relates to a certain position of carrier frame 3 relative to support frame 2. By increasing the pressure in the bellows 6 far enough, the position as drawn in Fig. 1b is reached, in which the grinding element 5 just touches the workpiece 10. By increasing the pressure in the bellows 6 further a desired grinding force may be set. It will be appreciated that, since an equilibrium can be established at any position, the grinding force can be set independently of position of the carrier frame.

Fig. 2 shows a grinding apparatus which is provided with two trace grinding units which are mounted on a sub-frame 20. A first trace grinding unit 1 is mounted to rotate on the sub-frame 20 around a pivot axis 21, and a second trace grinding unit 11 is mounted rotatably on the sub-frame 20 by a pivot 22. In each case, the support frame 2,12 is pivotally mounted on the sub-frame 20 and the carrier frames 3,13 and mounted by pivots 26,27 on the respective carrier frames 2,12. Support frame 2 is provided at an outer end with a guide roller 23; support frame 12 is provided at an outer end with a guide roller 24. The guide roller 24 is coupled to means of drive, not shown in the drawing, while the guide roller 23 is freely rotatable.

As in Fig. 1, two bellows 6,7,16,17 act between each support frame 2,12 and the respective carrier frame 3,13, to apply resilient force to the carrier frame 3,13. In this case, the two bellows are on opposite sides of the pivot 26 or 27, urging the carrier frame oppositely.

In its position of rest, the trace grinding unit 11 rests on a stop 26a and the trace grinding unit 1 is supported on the trace grinding unit 11 by an intervening fluid-operated piston-and-cylinder 25. The two support frames 2,12 may be pulled towards each other by the piston-and-cylinder unit 25 acting between them. The piston-and-cylinder unit 25 can be controlled hydraulically or pneumatically. As Fig. 2 shows, the two grinding units act to clamp a workpiece 10 between them.

When the rollers 23 and 24 rest on the workpiece 20, the pressure in the bellows 6 and 16 is increased so that the carrier frames 3 and 13 tilt around the axes 26 and 27 respectively until the grinding elements 5 and 15 respectively touch the opposite sides 32,33 of the workpiece 10. As described above, by further increasing the pressure in the bellows 6 and 16 the desired grinding force may be set.

A desired reciprocating transverse displacement of the grinding units 1,11 is provided by grinding unit drives 34 and 35, in the form of linear piston- and-cylinder combinations (not shown in detail).

The grinding system shown in Fig. 2 possesses a certain degree of symmetry relative to the line 28. A second, similar pair of trace grinding units may be positioned with a symmetry relative to the line 29. The second ser is then suitable for providing the other two faces 30 and 31 of the workpiece with an inspection trace. For reasons of space, the second set may be positioned in a plane that extends parallel to yet outside the plane of the drawing of Fig. 2.

Fig. 3 shows schematically a top view of an arrangement of such a trace grinding apparatus in accordance with the invention. Only some parts are shown, diagrammatically. The grinding elements 5 and 15 with the rollers 23 and 24 together are parts of the first pair of grinding units. The elements 40,41,42,43 are parts of the second set of grinding units. In this embodiment, the four longitudinal faces of a steel billet 10 may each be provided with an inspection trace in one single pass. In order to prevent longitudinal or transverse cracks from being filled in by the grinding movement of the grinding elements, the grinding axis, that is the axis around which the grinding element is rotated, and which is indicated by line 44 for grinding element 5, is positioned obliquely relative to the longitudinal direction of the billet indicated by line 45. In practice an angle a of 15° between the direction of the grinding shaft and the longitudinal direction has been found to be a good compromise between the quality of observation of surface cracks and the overall end-to-end length of the grinding system.

Fig. 4 shows diagrammatically a feature which may be included in trace grinding apparatus of Fig. 2. There is joined to the two support frames 2 and 12 a system of rods which adopts a position dependent on the mutual position of the two rollers 23 and 24 respectively mounted on the support frames. Rods 50,52,54 are connected as shown to support brackets 51 and 53 which are positioned in the centre of the support frames 12 and 2; the length of the rod 54 is twice the length of the rod 52. As the two diaphragm-rollers 23 and 24 move apart, a flag 55 on the rod 54 tilts forward. Because of the dimensioning described above, the stroke of the flag gives a faithful representation of the movement of the two rollers 23,24. The flag is a suitable means of detection for limiting the stroke of the transverse reciprocating movement of the grinding devices relative to the support frames 2 and 12. Through detection and control means, not shown, the position of the rod 54 can be used to control directly the length of this reciprocating stroke, in dependence on the sensed spacing of the rollers 23,24, i.e. on the size of the workpiece.

Claims

1. A trace grinding apparatus for grinding an inspection trace on a workpiece (10) moving relatively thereto, said apparatus having at least one trace grinding assembly comprising a grinding device (4,5;15) mounted on a carrier frame (3,15) which is movably supported on a support frame (2,12), characterised in that two bellows (6,7,16,17) containing pressurized fluid are interposed between said support frame (2,12) and said carrier frame (3,13) so as independently to apply force between said support frame (2,12) and said carrier frame (3,13), and in that means (8,9) are provided for adjusting fluid pressure in at least one of said bellows (6,7,16,17).

2. A trace grinding apparatus according to claim 1 wherein said pressurized fluid is a gas.

3. A trace grinding apparatus according to claim 1 or claim 2 wherein said carrier frame (3,13) is provided with a guide member (23,24) arranged to contact a said workpiece (10), so as to locate said carrier frame relative to said workpiece.

4. A trace grinding apparatus according to claim 3 wherein said guide member (23,24) is a roller, said apparatus being provided with drive means for rotating said roller so as to apply driving force to said workpiece.

5. A trace grinding apparatus according to any one of claims 1 to 4 wherein said carrier frame (3) is above said support frame (2) and is supported thereon essentially only by said two bellows (6,7).

6. A trace grinding apparatus according to any one of claims 1 to 4 wherein a pivot mount (26,27) supports said carrier frame (3,13) rotatably about a pivot axis on said support frame (2,12), said two bellows (6,7,16,17) being mounted respectively on different sides of said pivot axis so as to urge said carrier frame (3,13) in respectively opposite directions around said pivot axis.

7. A trace grinding apparatus according to any one of claims 1 to 6 further including means for moving said grinding device (4,5,15) reciprocatingly in a direction transverse to the path of movement of said workpiece (10).

8. A trace grinding apparatus according to claim 7 including means for controlling the stroke length of the reciprocation of said grinding device in dependence on the size of the workpiece.

9. A trace grinding apparatus according to any one of claims 1 to 8 wherein said grinding device has a grinding element (5) which is rotated about an axis at a non-zero angle to the path of movement of said workpiece.

10. A trace grinding apparatus according to claim 9 wherein said non-zero angle is in the range 10 to 20°.

11. A trace grinding apparatus according to any one of claims 1 to 10 having two said trace grinding assemblies arranged oppositely to each other, and having means (25) for moving the respective support frames (2,12) of said assemblies towards each other, so that the respective grinding devices (5,15) engage opposite sides of said workpiece.

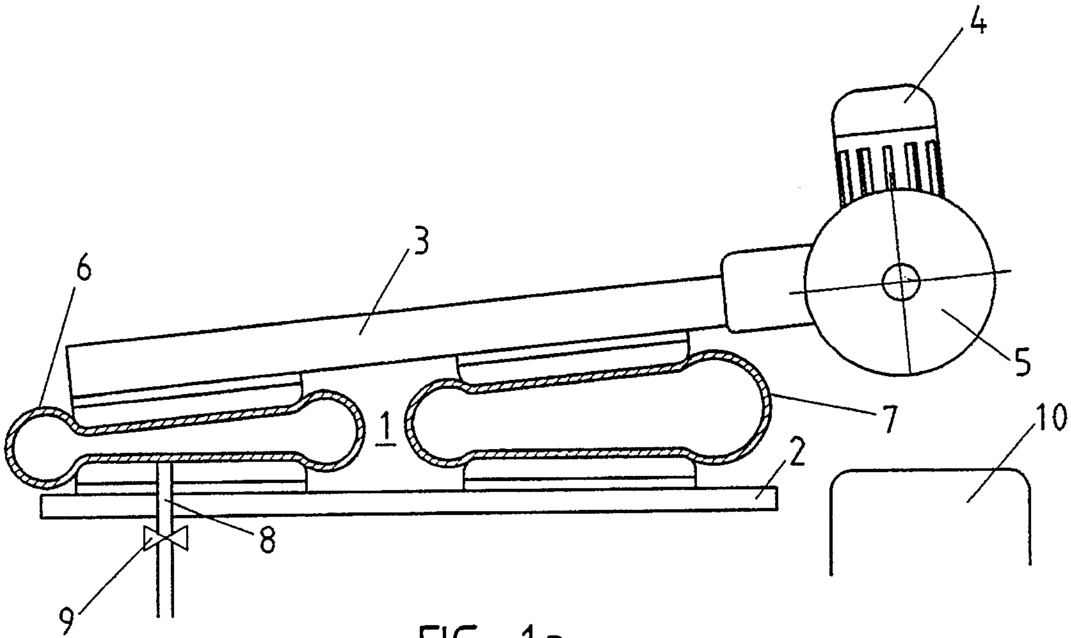

FIG. 1a

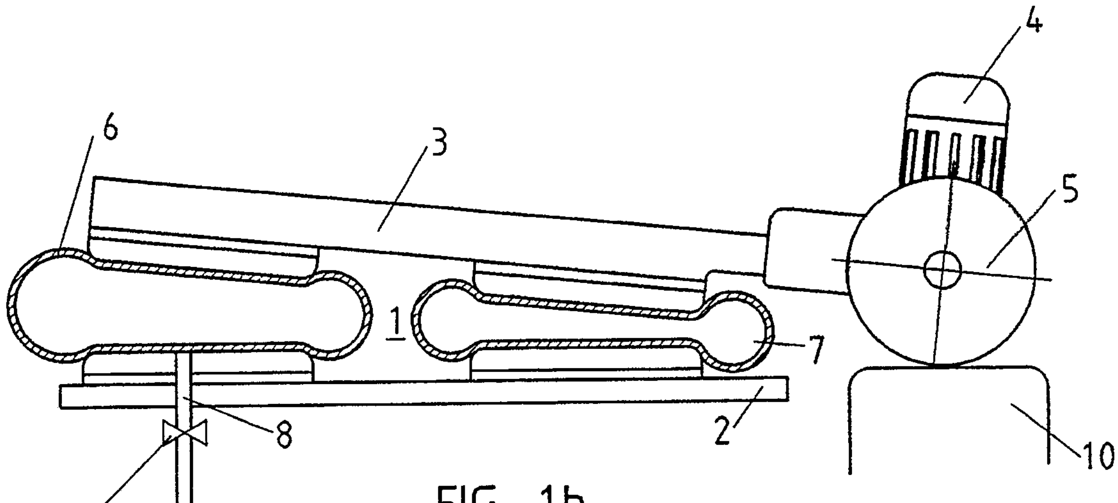

FIG. 1b

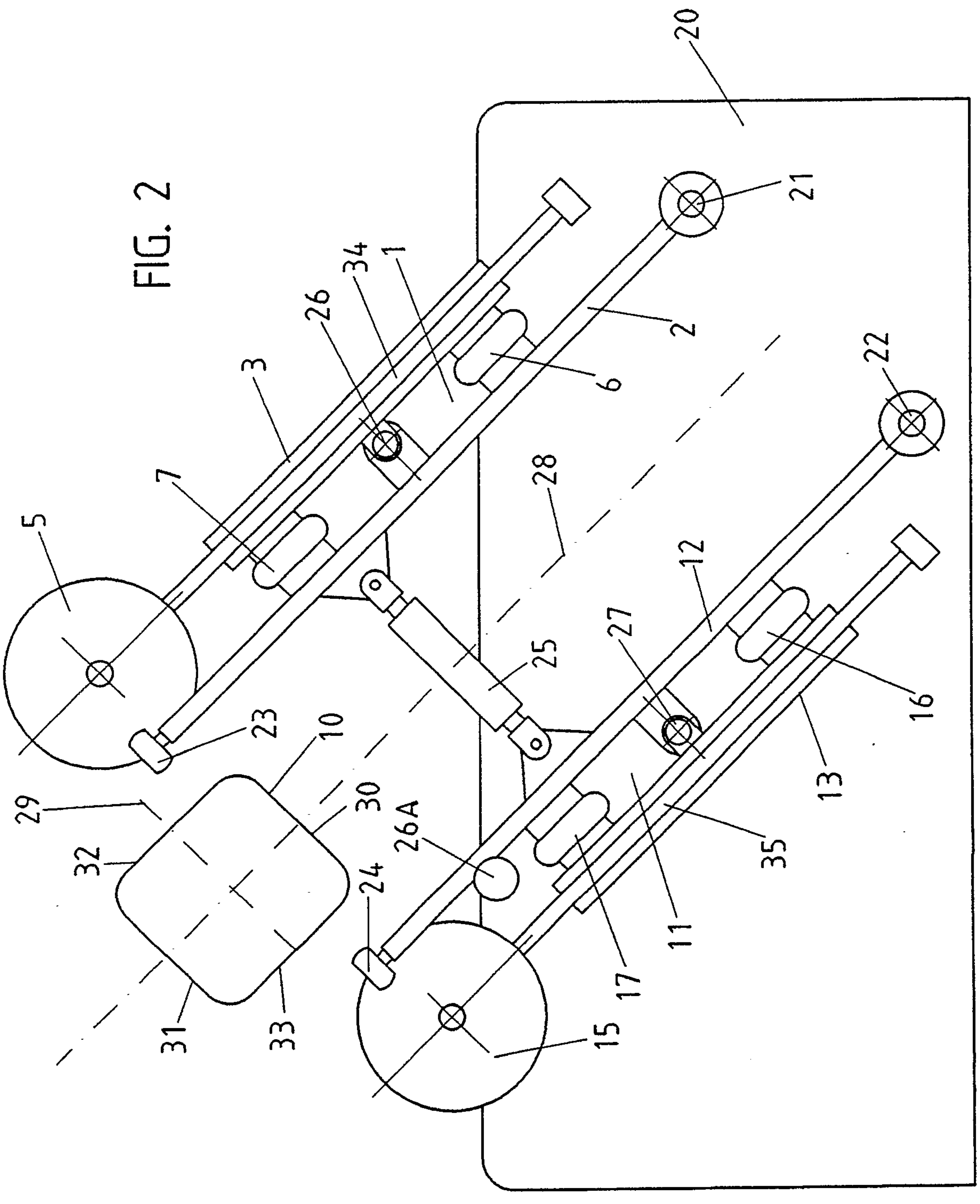
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FIG. 2

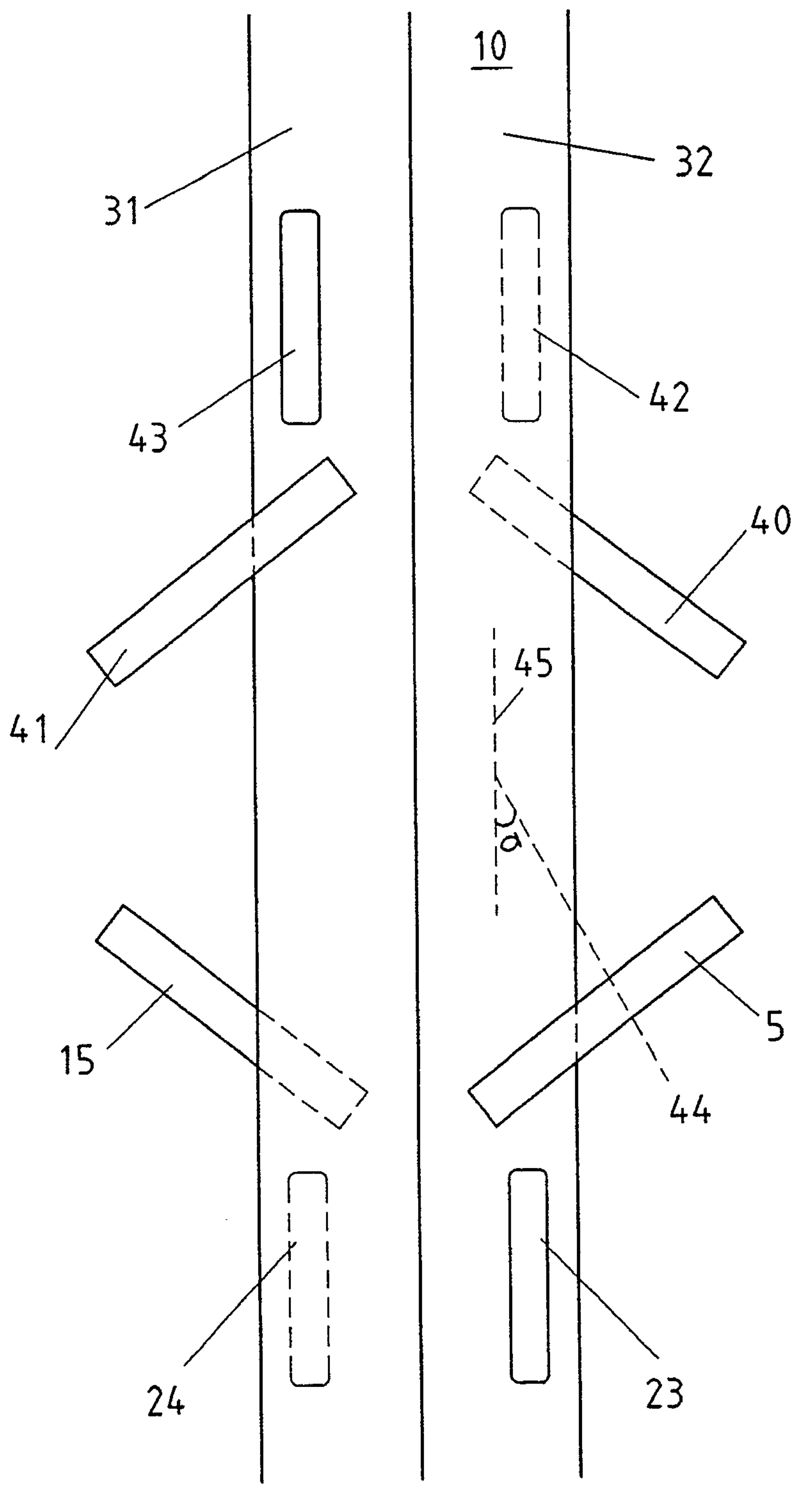

FIG. 3

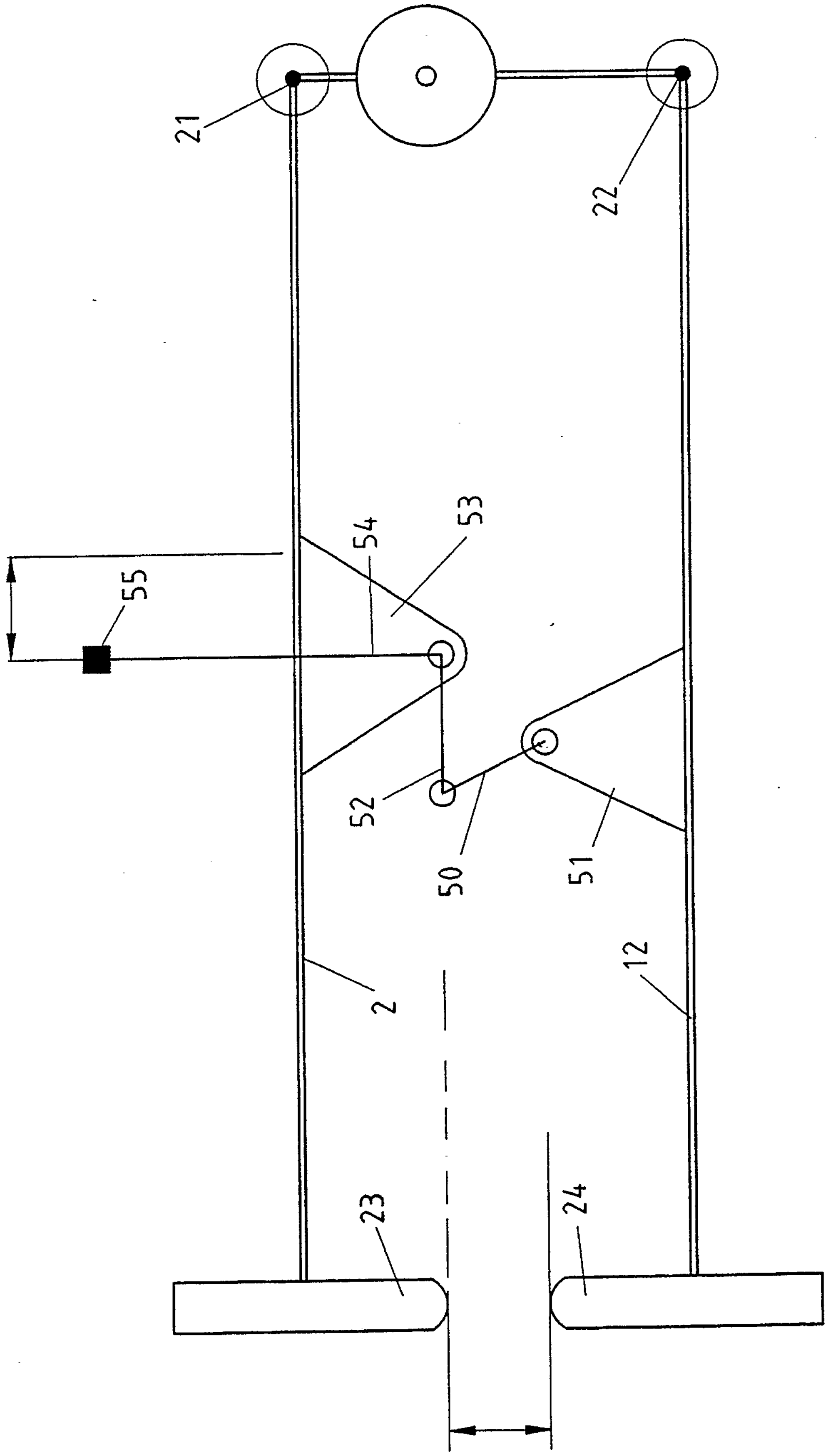

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 20 2630

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	GB-A-8 743 00 (SHEPPARD & SONS LTD) * Page 6, line 19 - page 7, line 26; fig. * - - -	1,7,11	B 24 B 27/033
A	FR-A-2 619 043 (EdF) * Page 4, lines 23-30; fig. * - - -	1,2	
A	DE-A-3 524 561 (E. EVERTZ) * Claim 1 * - - -	9,10	
A	BE-A-5 425 43 (F.H. LOYD & CO., LTD) * Claims 1,3; fig. * - - - - -	3	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 24 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	11 December 90	ESCHBACH D.P.M.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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