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(71) Applicant:
Tractor System Equipment di Villa Rag. Andrea & C. S.n.c.
29017 Fiorenzuola D'Arda (PC) (IT)

(72) Inventor: **Villa, Andrea**
29010 Alseno (PC) (IT)

(74) Representative:
Marietti, Giuseppe
MARIETTI e GISLON S.r.l.
Via Larga, 16
20122 Milano (IT)

(54) Mandrel for supporting the inside wall of a pipe during the cold-bending of said pipe in a press

(57) A device for the cold bending of pipes in a press, comprising a plurality of substantially cylindrical elastically deformable disks as a means of supporting the inside wall of the pipe to be bent and one or more substantially rigid separator elements between the disks.

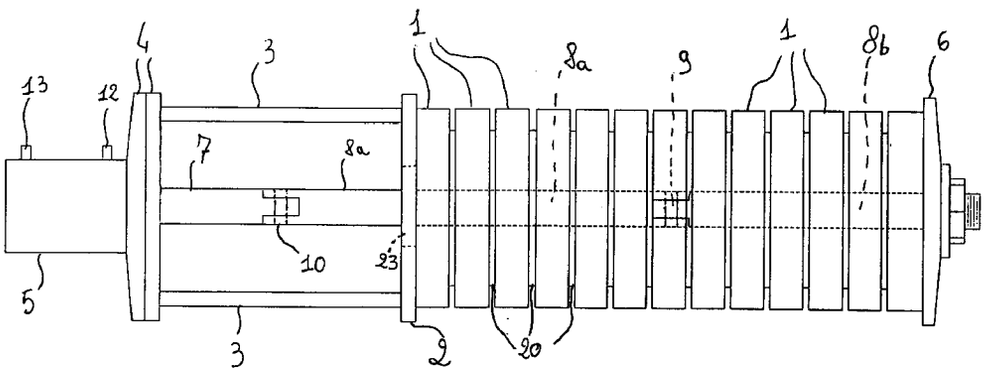

Fig. 1

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Description

[0001] The present invention relates to a device for supporting the inside wall of a pipe during the cold bending of the same pipe by means of a press.

[0002] During the processes of cold bending pipes, it is necessary to insert a structure to support the inside wall of the pipe, known generally as a bending mandrel, to avoid deformation of the inner section of the pipe and the wrinkling of the same pipe which is found prevalently on the inside curve of the bending.

[0003] Some examples of a bending mandrel already known in the art are described in the U.S. patent nr. 4493203. In one embodiment described in this U.S. patent, the device comprises essentially an hydraulic actuator which allows to compress a plurality of close-packed elastically deformable disks made of urethane and mounted freely slidable on a structure of rigid rods or tie rods. According to another embodiment, the package of disks is replaced by a single elastically deformable tubular element mounted on a hollow shaft made of spring steel. In either case, the disks or the tubular element is compressed by a piston operated by the hydraulic actuator against a fixed flange at the opposite extremity with respect to the hydraulic actuator.

[0004] However, the devices so produced, have various drawbacks. For instance, according to the first embodiment shown in the cited U.S. patent, the elastic support elements are mounted freely-slidable and operated by means of rigid rods. In this case, the stress generated by bending the pipe is therefore absorbed by the elastic material alone.

[0005] That subjects the same material, above all in the extremity sections, to very severe deformation during the pipe-bending phase. The result is therefore a reduction in the lifetime of the elastic material, which considerably effects the operating costs.

[0006] In any case, one of the main drawbacks of the device thus produced is the irregular deformation of the material of the elastic support elements.

[0007] In both the forms of embodiment described in the cited U.S. patent, the force produced by the piston against the fixed flange cannot be transmitted equally along all the section of the disks or of the tubular element, because of the elastic characteristics of the material. That makes the action of the mandrel ineffective, above all where the deformation of the material in the radial direction is not such as to exert a lot of pressure against the inside wall of the pipe subjected to bending.

[0008] This drawback becomes more marked as the size of the mandrel and/or of the pipe to be bent increases.

[0009] The object of the present invention is to propose a device, or bending mandrel, to support the inside wall of a pipe during cold bending which uniformly distributes the supporting pressure along the inside wall of the pipe for all the length involved in the bending.

[0010] Another object of the present invention is to propose a device, or bending mandrel, that requires reduced operating costs and maintenance compared with known types of mandrels.

[0011] A further object of the present invention is to propose a device, or bending mandrel, which is less cumbersome and therefore can also be used for bending small diameter pipes.

[0012] These objects are achieved by the present invention, which relates to a device for the cold bending of pipes in a bending press, of the type comprising a plurality of substantially cylindrical elastically deformable disks as a means for supporting the inside wall of the pipe to be bent, and means for causing the radial expansion of the disks, characterised in that the means for causing the radial expansion of the disks comprise one or more substantially rigid separator elements between the disks.

[0013] By using rigid separator elements between the disks, the compression pressure of the hydraulic actuator is substantially uniform on all the disks and their deformation in the radial direction is equally uniform. In other words, the principal function of the separator elements is to allow a correct and uniform radial expansion of the elastically deformable disks.

[0014] Therefore, the device according to the invention allows substantially uniform pressure to be exerted on all the inside wall of the pipe for all of the length involved in the bending.

[0015] In particular, the package comprising the elastically deformable disks and their related separator elements is contained between two substantially rigid extremity flanges which act respectively on the first and last of the elastically deformable disks.

[0016] According to a preferred aspect of the invention, the surfaces of the separator elements and of the flanges in contact with the elastically deformable disks are conical. In particular, the conical surfaces are each oriented with the vertex turned toward the surface of the disk with which they are mutually in contact. That allows the elastic disks to deform in such a way as to keep as much as possible the configuration of the cylindrical side surface of each disk in contact with the inside wall of the pipe.

[0017] The device preferably comprises a plurality of cylindrical rods inserted into a central through hole in the disks and the separator elements, and each connected at their adjacent extremities to one or more articulation elements. In this way, the articulated rods follow the bending imparted to the pipe while avoiding excessive or irregular deformations of the elastic disks.

[0018] In particular, at least one articulation element is arranged between a first and a last elastically deformable disks. Depending on the length of the mandrel, and of the package of elastic disks in particular, more inter-rod articulation elements could also be provided. A further articulation element is provided between the shaft of the hydraulic actuator and one of the rods.

[0019] The hydraulic actuator preferably comprises a

double-acting cylinder.

[0020] Such a cylinder moves a mobile, substantially rigid extremity flange, bound to the extremity of one of the rods, in order to cause the radial expansion of the disks. The mobile flange acts on the last elastically deformable disk, while at the opposite end, integral with the body of the double-acting cylinder, there is a fixed extremity flange which acts on the first elastically deformable disk.

[0021] The use of a double-acting cylinder, unlike what is provided in the known devices, also allows the disks to return more rapidly to their original size after the bending has been completed. This is particularly important in the case in which more than one phase of bending must take place. In the presses known at present, such as, for instance, that illustrated in the U.S. patent nr. 4493203, limited bending of the pipe is achieved at each step. To get a more pronounced bending, it is necessary to subject the pipe to more successive bending steps in near-by points. That could mean a large number of phases of tensioning the mandrel, of bending, of relaxing the elastic elements and then of shifting the mandrel, in which case it is particularly important to accelerate as much as possible the elastic recovery of the disks to their original form.

[0022] Preferably, the elastically deformable disks are made of elastomeric polyurethane and comprise a recess on each face to receive the separator elements in a such way as to retain the separator elements in the correct position when the mandrel is not in tensioned state.

[0023] It is evident that the particularly simple and compact embodiment of the bending mandrel according to the invention also allows its use with pipes having particularly reduced diameter.

[0024] Further advantages and characteristics of the present invention will become more evident from the following description, which is illustrative and not limitative, with particular reference to the attached drawings, in which:

- Figure 1 is a top view of a form of embodiment of the device according to the present invention;
- Figure 2 is a schematic side elevation view of the device of Figure 1 inserted into a pipe and in tensioned state;
- Figure 3 is an enlarged view, in partial section, of a detail of the device of Figure 1;
- Figure 4 is a side view of a separator element of the device according to the present invention;
- Figure 5 is a plan view of the separator element of Figure 4;
- Figure 6 is a side view of an elastically deformable disk of the device according to the present invention;
- Figure 7 is a plan view of the elastically deformable disk of Figure 6; and
- Figure 8 is a schematic view in side elevation of the device of Figure 1 inserted into a pipe and in tensioned state after a first phase of bending of the pipe.

[0025] The device shown in Figure 1 comprises a plurality of disks 1, made of an elastically deformable material, which form the means of supporting the inside wall of the pipe to be bent.

[0026] The entire package of disks 1 is held between a substantially rigid extremity flange 2, fixed to the body of a hydraulic actuator 5 by means of a series of columns 3 and a couple of rigid plates 4. The flange 2 is therefore in contact with a first one of the disks 1.

[0027] At the opposite end of the package of disks 1, the device is provided with an extremity flange 6, connected to the shaft 7 of the hydraulic actuator 5 by means of a series of cylindrical rods 8a and 8b. The flange 6 is therefore mobile with respect to the structure of the device and is in contact with a last one of the disks 1.

[0028] The cylindrical rods 8a and 8b are inserted into central through holes in the disks 1 and are mutually connected at their adjacent extremities by an articulation element 9. The latter is preferably arranged inside the package of elastically deformable disks 1.

[0029] A further articulation element 10 is preferably provided between the shaft 7 of the hydraulic actuator 5 and the extremity of the rod 8a.

[0030] Naturally, depending on the length of the support device and/or of the angle of bending imparted to the pipe in each phase, a larger number of rods and a larger number of articulation elements could be provided.

[0031] The hydraulic actuator 5 comprises preferably a double-acting cylinder, in a such way as to allow not only the drawing in of the flange 6, but also its commanded release to accelerate the elastic recovery of the disks 1 to their normal configuration.

[0032] Figure 2 shows the support device in tensioned state inside a pipe 15 before the bending of the same pipe. The device is inserted into the pipe 15 in non-tensioned state (Figure 1), and then oil under pressure is fed to the hydraulic actuator 5 by means of one of the supply lines 12 of the fluid under pressure. The piston 14 draws in the shaft 7, the rods 8a and 8b, and therefore the flange 6, to compress the package formed by the disks 1 and the separator elements 20 between the same mobile flange 6 and the fixed flange 2, thus causing the radial expansion of the same disks. In this way, choosing the appropriate dimensions for the disks 1 and the materials from which they are made, the side surfaces of the disks are pressed against the inside wall of the pipe 15 forming a substantially continuous surface of contact and exerting sufficient pressure to support the wall of the pipe during bending. At this point, the pipe 15 can be bent in the press (not shown) through a small angle β (Figure 8) without suffering wrinkling or flaws.

[0033] The articulation elements that connect the rods 8a and 8b as well as the rod 8a with the shaft 7, comprise for instance pivots 9 and 10 inserted into transversal through holes in proximity of the extremities of the rods, in such a way as to allow the relative rotation around the pivots of the rods and of the shaft.

[0034] As previously mentioned, it is advantageous to provide substantially rigid separator elements 20 between the disks 1 to transmit sufficient axial compression to each disk 1 in order to cause a substantially uniform radial expansion of the same disks.

[0035] The structure of the package of disks 1 and of the separator elements 20 is shown in more detail in Figures 3 to 5.

[0036] In Figure 3, a partial section around the articulation element 9 is shown.

[0037] As can also be seen from the view in Figure 4, the surfaces 21 of the separator elements 20 which are in contact with the disks 1 are preferably conical, with the vertex 22 of the generating cone turned toward the surface of the disk 1 with which it is respectively in contact.

[0038] The angle α between the inclination of the conical surface and a corresponding plane surface is preferably less than 5°. However, different angles can also be selected depending on the material used for the elastically deformable disks and on the external diameter of the same disks.

[0039] As shown in Figures 3 to 5, the separator elements 20 comprise substantially rigid rings, for instance made of steel, and are of external diameter less than that of the elastically deformable disks 1. The rings 20 have a central through hole 23 of diameter larger than the external diameter of the rods 8a and 8b to allow movement of the same rods with respect to the rings 20 during the bending of the pipe.

[0040] The flanges 2 and 6, also made of steel, have a conical surface on the face in contact with the respective extremity disks 1. Furthermore, the flange 2 has a central through hole 23 substantially similar in diameter to the hole of the separator elements 20.

[0041] Figures 6 and 7 show an elastically deformable disk 1 preferably made of elastomeric polyurethane, for instance that distributed under the VULKOLLAN trademark by Bayer, with a Shore hardness rating between 70 and 100. Other suitable materials are for instance those commercially distributed with the trademarks ADIPRENE and PHILAN. The disk 1 is substantially cylindrical with a pair of base surfaces on which are provided recesses 31 that retain the respective separator elements 20.

[0042] The disks 1 each have a central through hole 32 substantially identical in diameter to the external diameter of the cylindrical rods 8a and 8b. The external diameter of the disks 1 is selected depending on the diameter of the pipe to be bent and depending on the characteristics of the material of the same. In general, the external diameter of the disks 1 in their normal state is about 2-15% less than the diameter of the pipe to be bent. This value varies, however, depending on different factors, such as the type of material from which the disks 1 are made, their dimensions and the desired angle through which the pipe will be bent.

[0043] For instance, for the bending of pipes of inside diameter of 304.8 mm (12 inches) disks in VULKOLLAN of external diameter of about 295 mm and about 60 mm thick have been used successfully. The separator elements were of external diameter of 120 mm and about 6 mm thick, with a central hole of about 60 mm. The angle α (Figure 4) of the conical surfaces of the separator elements were of slightly less than about 2°.

[0044] Figure 8 shows a pipe 15 that has been subjected to bending through an angle β while using a device according to the invention. It should be noticed that the disks 101, 201, and 301 in correspondence to the point of bending are deformed in such a way as to maintain a continuous surface of contact between the same disks and the inside wall of the pipe 15. The rods 8a and 8b have been clearly rotated around the pivot of articulation 9 and there has also been a slight rotation (not shown in Figure 8 for the sake of simplicity) around the articulation pivot 10 between the rod 8a and the shaft 7 of the hydraulic actuator 5. The rotation around the pivot 10 would be more evident, however, for more pronounced angles of bending than that indicated in figure, or for bending in more distant points from that represented in Figure 8.

[0045] At the end of the bending, the hydraulic actuator 5 is operated by sending fluid under pressure to the supply line 13, in such a way as to facilitate the rapid return of the disks 1 to their normal shape. At this point, the device could be moved in correspondence of a new point of bending.

[0046] To facilitate the movement of the device inside the pipe, suitable means to allow the movement of the device to be commanded, can also be provided, for instance, hydraulic motors or the like.

[0047] Some tests carried out on pipes of inside diameter of 406.4 mm (16 inches) have given results surprisingly superior to those obtainable with the devices of the known art. In particular, using a device according to the invention, it has been possible to bend the above cited pipe through an angle of about 8° in a single step without causing surface wrinkling.

[0048] With the known mandrels, it was only possible to bend a similar pipe in a single step through a maximum angle of about 1.5°.

[0049] It is worth mentioning that the particularly simple construction and reduced bulk of the device according to the invention also allows its use with pipes of particularly reduced internal diameter, i.e. internal diameter between 152.4 mm (6 inches) and 304.8 mm (12 inches).

Claims

1. Device for the cold bending of pipes in a bending press, of the type comprising a plurality of substantially cylindrical elastically deformable disks as a means for supporting the inside wall of a pipe to be bent, and means for causing the radial expansion of said disks, characterised in that said means for causing the radial expansion of said disks comprise one or more substantially rigid separator elements between said disks.

2. Device according to Claim 1, characterised by comprising a substantially rigid fixed extremity flange, acting on the first of said disks.

3. Device according to Claim 1 or 2, characterised by comprising a substantially rigid mobile extremity flange, acting on the last of said disks.

4. Device according to any of the preceding Claims, characterised in that the surfaces of said separator elements and of said flanges in contact with said elastically deformable disks are conical.

5. Device according to Claim 4, characterised by said conical surfaces being oriented each with the vertex turned toward the surface of the disk with which it is mutually in contact.

6. Device according to any of the preceding Claims, characterised by the said separator elements being substantially rigid rings of outside diameter less than that of said elastically deformable disks and having a central through hole of larger diameter than the external diameter of said rods.

7. Device according to any of the preceding Claims, characterised by said elastically deformable disks comprising a suitable recess on each face to receive said separator elements.

8. Device according to Claim 1, characterised by comprising a plurality of cylindrical rods inserted into a central through hole in said disks and in said separator elements, and connected to their adjacent extremities by one or more articulation elements.

9. Device according to Claim 8, characterised by at least one articulation element being arranged between the first and the last of said elastically deformable disks.

10. Device according to any of the preceding Claims, characterised by said mobile extremity flange being bound to at least one of said rods.

11. Device according to any of the preceding Claims, characterised by said means of causing the radial expansion of said elastically deformable disks comprising a hydraulic actuator whose shaft is connected to one of the extremities of at least one of said rods by means of one of said articulation elements.

12. Device according to Claim 11, characterised by said hydraulic actuator comprising a double-acting cylinder.

13. Device according to any of the preceding Claims, characterised by said cylindrical rods having external diameter substantially equal to the inside diameter of the central through holes in said disks.

14. Device according to an any of the preceding Claims, characterised by said elastically deformable disks being made of elastomeric polyurethane.

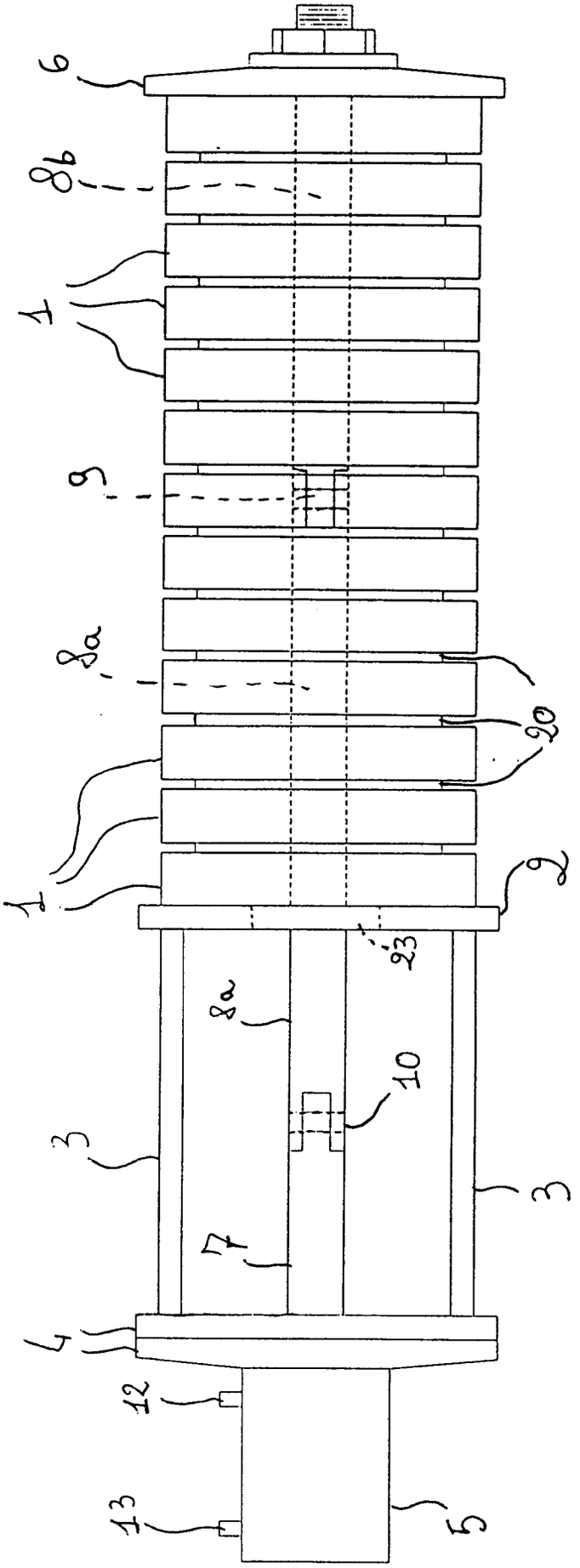

Fig. 1

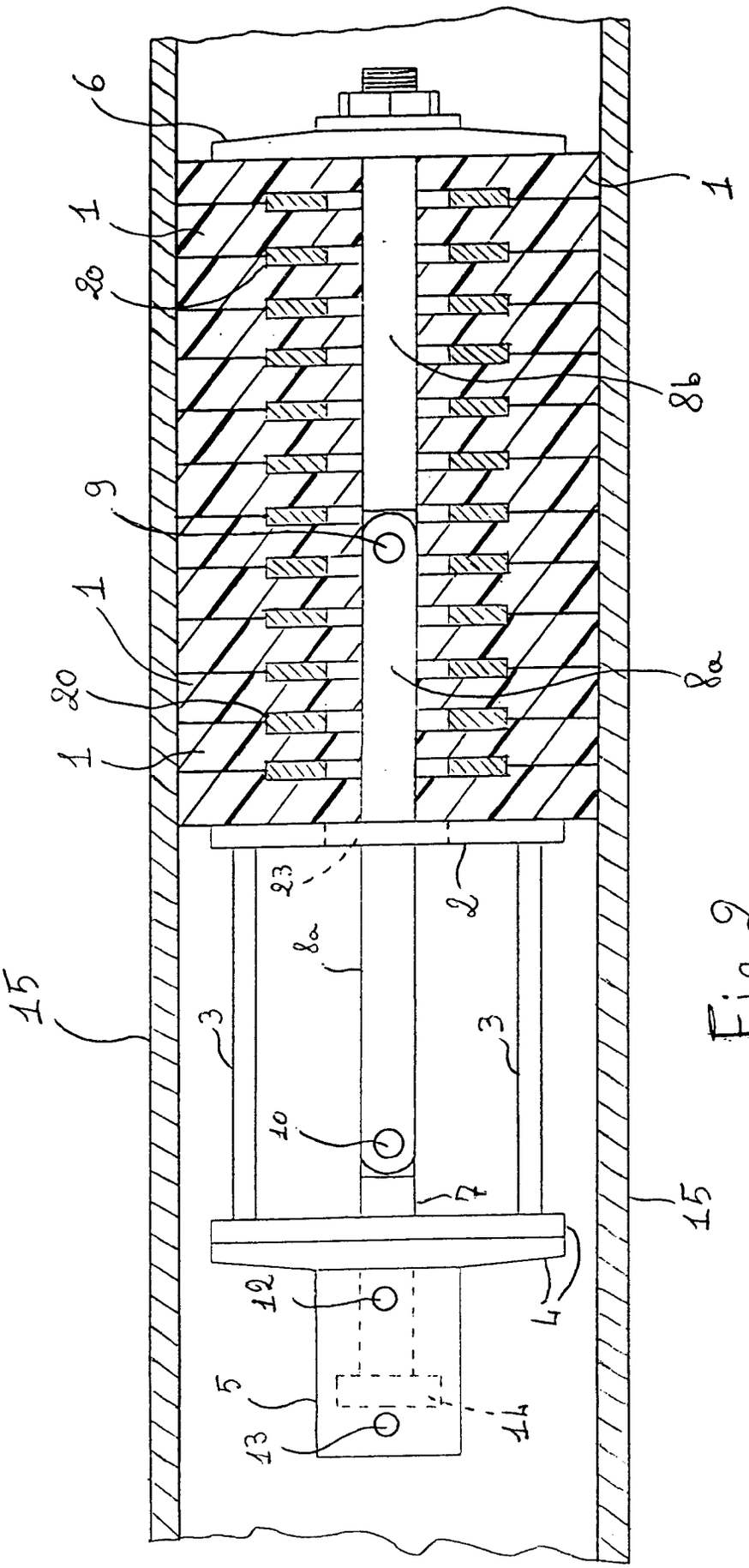

Fig 2

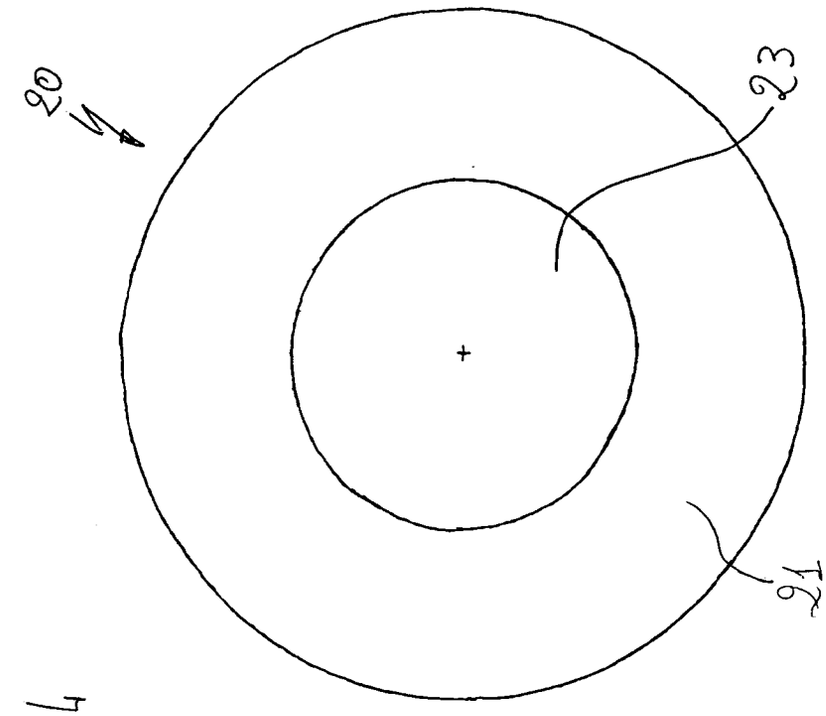

Fig. 5

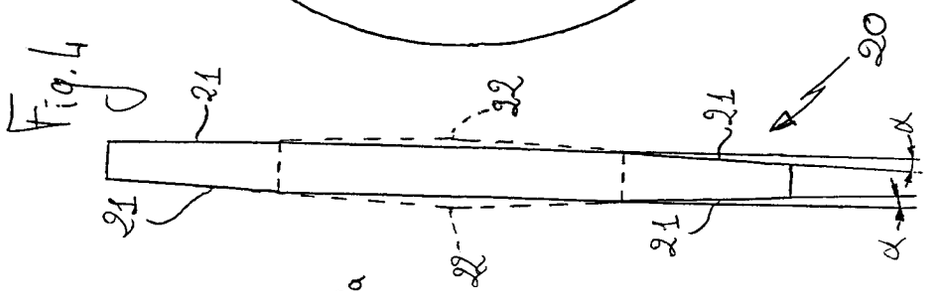

Fig. 4

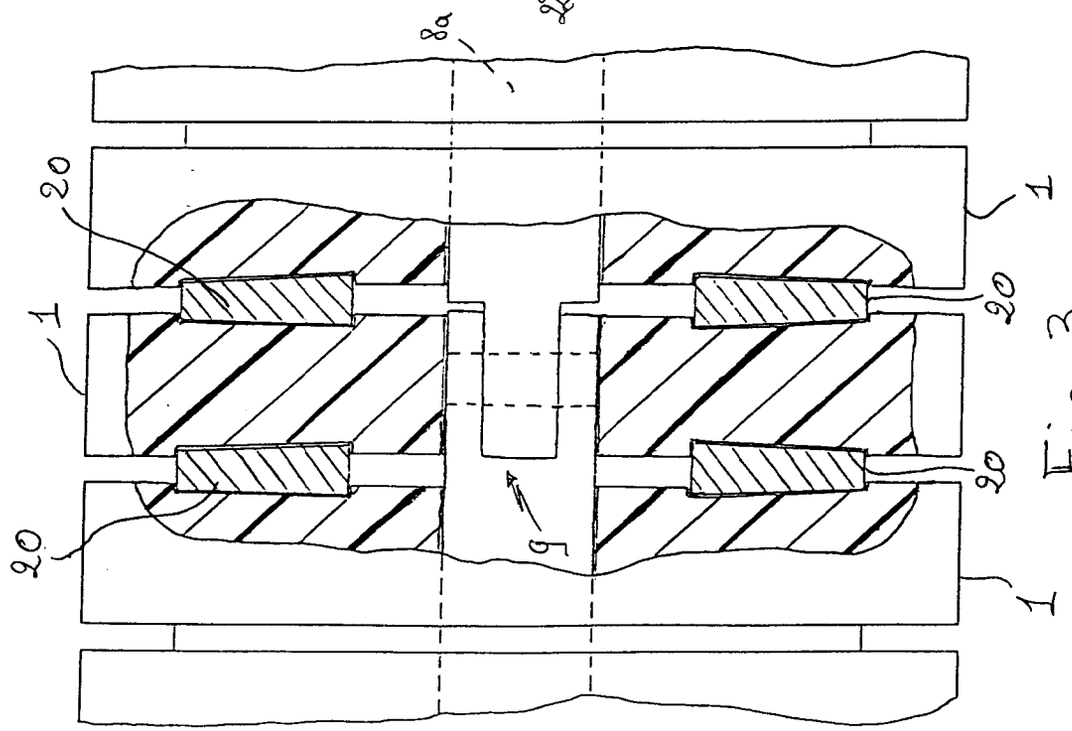

Fig. 3

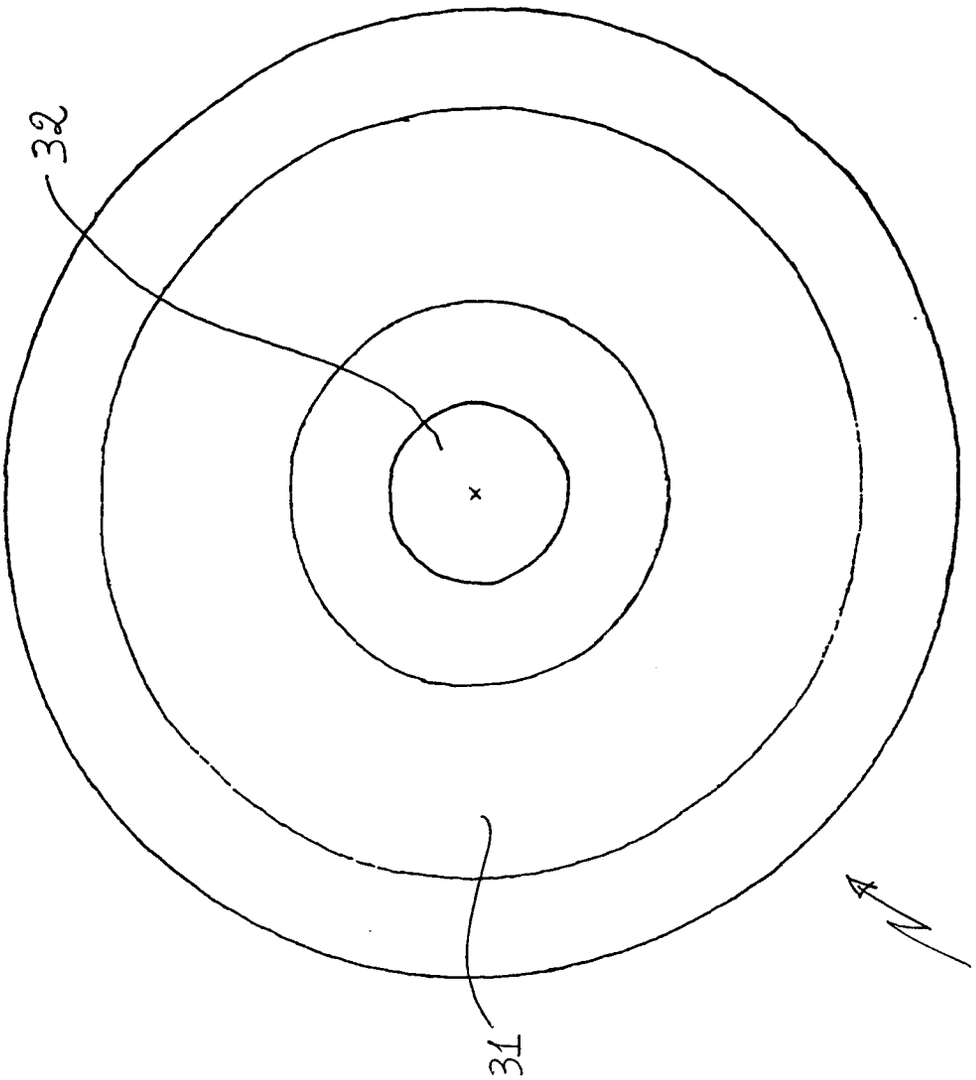

Fig. 7

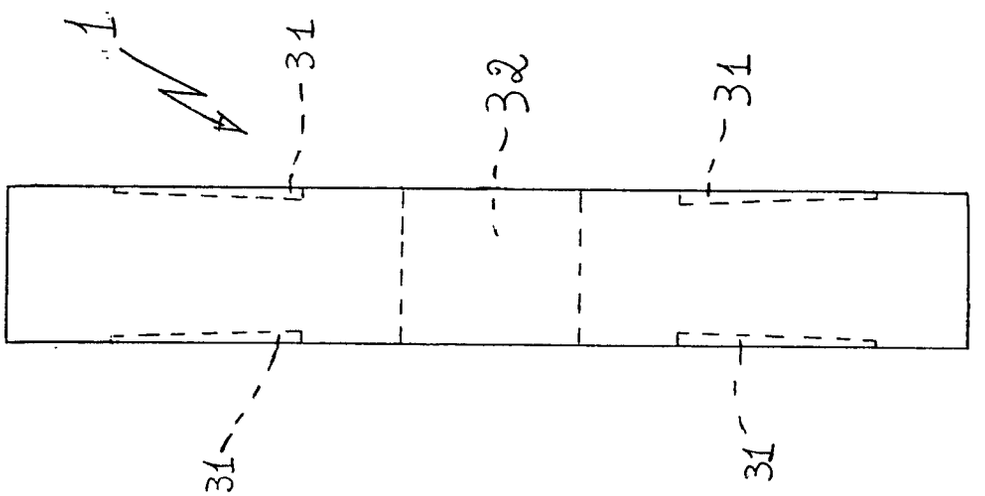

Fig. 6

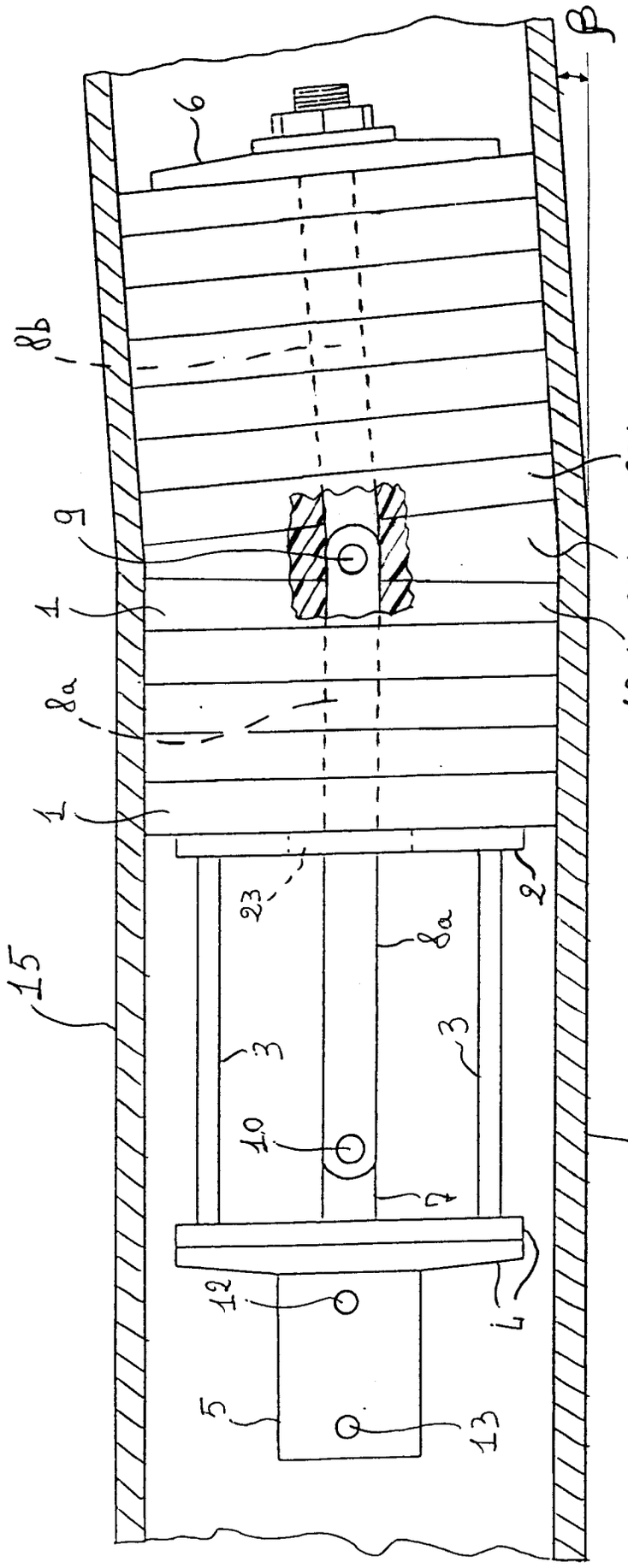

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 97 83 0447

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.6)
X	US 4 378 689 A (W. ECKOLD AG) * column 2, line 6-16; claim 1; figures 2-5 *	1-10	B21D1/00 B21D9/01 B21D9/03
Y	---	11-14	
Y	US 4 493 203 A (CRUTCHER RESOURCES CORP) * figure 2 *	11-14	

A	US 4 671 096 A (LOCKHEED CORPORATION) * claims 1,3,10; figures 1-4 *	1	

A	US 5 564 303 A (BUCHANAN ET AL) * figures 1,2 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	18 December 1997	Ash, R

CATEGORY OF CITED DOCUMENTS

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