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(54) Rock bolt.

(57) A method of making a rock bolt with a thread (4) on a section (3) thereof comprising the steps of providing a metal bar (1) of circular or near circular cross-section having a diameter which is substantially equal to the pitch diameter of the thread (4) to be provided thereon, forming a series of protrusions (2) on a first selected section of the bar, straightening the bar, and, forming a thread (4) with the said pitch diameter on a further selected section (3) of the bar (1).

FIG 1a

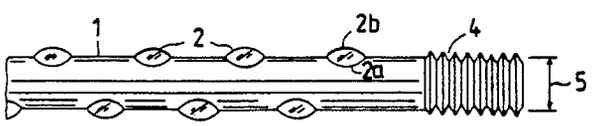

FIG 1c

EP 0 351 465 A1

ROCK BOLT

This invention relates to a rock bolt and more particularly, but not exclusively, to a rock bolt for use in underground mining operations.

Many different kinds of rock bolts are used to secure rock strata underground. One kind comprises a length of reinforcing bar having ribs along its length. The ribs enhance the anchoring ability of the bolt. In the case where a settable material with a catalyst is used to secure the bolt in a hole in the rock matrix, the bolt is usually rotated in the hole to mix the settable material and the ribs also serve the purpose of assisting the mixing of the settable material. However, known ribbed formations on rock bolts do not provide good mixing characteristics.

The end of the bolt which is intended to project from the rock face has a rolled thread thereon which receives a nut used to tension the bolt. The bar from which such a prior art rock bolt is made is manufactured in a steel mill and is supplied with the ribs formed on the whole length of the bar. Thus, in order to provide the rolled thread on the bolt, the bolt has to be machined to remove the ribs on a section thereof and to ensure that such section has a circular cross-section. Such a machining operation adds to the cost of the prior art rock bolt.

It is an object of the invention to lessen the problems associated with prior art rock bolts.

In this specification, the term "pitch diameter", in relation to a straight thread, means the diameter of an imaginary co-axial cylinder, the surface of which passes through the thread profiles at such points as to make the width of the groove equal to one half of the basic pitch of the thread. On a perfect thread this occurs at the point where the width of the thread and groove are equal.

The term "bar" when used in this specification includes a pipe and a bar with an axial bore.

According to the invention, a method of making a rock bolt with a thread on a section thereof, comprises the steps of providing a metal bar of circular or near circular cross-section having a diameter which is substantially equal to the pitch diameter of the thread to be provided thereon, forming a series of protrusions on a selected section of the bar, straightening the bar, and, forming a thread with the said pitch diameter on a further selected section of the bar.

This method obviates the need for machining the bar before forming the thread thereon. As will become evident in the subsequent description, the method also results in a saving of material without reducing the yield or tensile load-carrying ability of the rock bolt.

In one form the metal bar is first cut to a discrete length, is then advanced through means forming the series of protrusions on the selected section of the bar, and is thereafter advanced through straightening means to straighten it, whereafter thread is formed on the further selected section of the bar.

In another form a continuous length of the metal bar is first advanced through means forming the series of protrusions on selected sections of the bar, the continuous length is thereafter advanced through straightening means to straighten it, whereafter the bar is cut to required lengths and thread is formed on a selected section of each length.

The protrusions may be formed in the metal bar in a single pass through a pair of rolls in the cold condition of the bar.

The protrusions may be formed on the bar by pinching the metal of the bar at intervals along the length of the selected section of the bar. The protrusions which are thus formed may be in the form of flat lobes provided in staggered formation along opposite sides of the bar. The sides of each lobe nearest and furthest the axis of the bar may be arcuate so that each lobe has a generally elliptical outline.

The protrusions may be formed on substantially the entire length of the bar, save for the selected section on which the thread is formed.

The thread formed on the further selected section of the bar may be formed by cold rolling.

According to a further aspect of the invention there is provided a method of making a rock bolt from a metal bar comprising the steps of providing a pair of rolls defining a nip between them and having formations provided at selected positions along their peripheries, rotating the rolls in opposite directions so that a formation on one roll coincides periodically with a formation on the other roll in the nip of the rolls, and, feeding the bar lengthwise through the nip of the rolls so that the formations pinch the metal of the bar at selected positions along its length.

The metal bar may be straightened in two planes, preferably by passing it sequentially through two sets of opposed, staggered rollers.

The invention also provides apparatus for making a rock bolt from a metal bar comprising a pair of rolls, means for driving the rolls about their axes in opposite directions, each roll having a channel formed in its surface facing the other roll, the channels defining a passage for receiving the bar in lengthwise fashion, each roll having formations provided along its periphery which align periodi-

cally with similar formations on the other roll in the nip of the rolls when they are rotated in opposite directions.

The apparatus may include means for straightening the bar after it has been passed between the rolls.

The means for straightening the bar may comprise two sets of opposed staggered rollers through which the bar is passed, the rollers of one set being located at right angles to those of the other set.

The formations on the rolls may be in the form of pegs mounted on the rolls.

According to a further aspect of the invention there is provided a rock bolt comprising a metal bar having a circular or near circular cross-section of a selected uniform diameter, the bar having a thread with a selected pitch diameter formed on a selected section thereof located at at least one end of the bar, the pitch diameter of the thread on the bar being substantially equal to the diameter of the bar, and a series of protrusions pinched from the bar formed on a further selected section of the bar.

The rock bolt of the invention can be of any required length and the selected section carrying the protrusions will normally be longer than 1 metre.

The invention also extends to a rock bolt when made according to the method of the invention described above.

A preferred embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which;

Figures A to C illustrate a prior art method of making a rock bolt;

Figures 1a to 1c illustrate steps in making a rock bolt according to the method of the invention;

Figures 2a and 2b are a schematic elevation and plan view respectively of apparatus used to carry out the method of the invention;

Figures 3a to 3e are enlarged views of parts of the apparatus of Figures 2a and 2b; and

Figures 4a and 4b show two different kinds of rock bolts made according to the invention;

With reference to Figure A, a prior art steel bar (a) is provided, and is cut to the required length. The bar (a) carries a series of diametrically opposed inclined ribs (b) separated by a pair of longitudinal ribs (c) of which only one is shown. The ribs (b), (c) are formed conventionally by hot rolling during manufacture of the bar (a) in a steel mill. The next step in making the prior art rock bolt is to machine or shave the bar (a) as shown in Figure B along a section (d) of its length to remove the ribs (b), (c) and to provide the section (d) with a circular cross-section of diamater (e). Thereafter a thread (f) is rolled onto the section (d) of the bar as shown in Figure C to complete the rock bolt. It will be appreciated that the tensile strength of the bolt is determined by the minimum diameter of the thread (f) of the bolt, since that is its smallest diameter.

With reference to Figures 1a to 1c, a rock bolt according to the invention is formed from a steel bar 1 of circular or near circular cross-section. The first step in making a rock bolt from the bar 1 is to form a series of protrusions in the form of flat lobes 2 in the bar by a method which will be more fully described hereunder. A section 3 of the bar which is to be threaded is left free of lobes 2. After the lobes 2 have been formed in the bar and after the bar has been passed through a straightening station to straighten it, a thread 4 is cold rolled on to the section 3 of the bar. The pitch diameter of the thread 4 is indicated by numeral 5 and is substantially equal to the diameter of the bar.

In this embodiment of the invention, as most clearly shown in Figures 1b and 1c, the lobes 2 are arranged in staggered formation along the length of the bar 1. The sides 2a, 2b of each lobe respectively nearest and furthest the axis of the bar are arcuate so that each lobe has a generally elliptical outline in plan view.

In an alternative method the thread 4 may first be rolled onto the section 3 of the bar after which the lobes 2 may be formed on the remainder of the bar. Thereafter the bar may be straightened.

The manner of forming the lobes 2 on the bar and the apparatus used for this purpose is illustrated in Figures 2 and 3. The apparatus, indicated generally by numeral 6, comprises a frame 7 having a pair of rolls 8, 9 mounted thereon for rotation about horizontal axes. An electric motor 10 is provided to drive the rolls about their respective axes in opposite directions. The drive is effected through a pulley 11 and a suitable gear train (not shown).

The rolls 8, 9 are mounted in such a manner that they can selectively be displaced towards and away from one another. This may conveniently be effected by hydraulic means (not shown).

The rolls 8, 9 have grooves 12, 13 formed respectively in their edges facing one another, which grooves define a passage for receiving the bar 1 in lengthwise fashion (Figure 3a). Each roll has a plurality of pegs 14 mounted thereon along its periphery. The pegs 14 are arranged in such a manner that corresponding pegs on the rolls periodically align in the nip of the rolls when they are rotated. The pegs 14 are preferably of cirular cross-section but they may be of any required cross-section depending on the shape of the lobes 2 required on the bar 1.

Alongside the rolls 8, 9 there is a set of driven rollers 15 followed by a set of straightening rollers 16 which are arranged in opposed, staggered formation (Figures 2a, 2b). Alongside the straightening

rollers 16 there is a further set of driven rollers 17. The sets of rollers 15, 16 and 17 are mounted for rotation about horizontal axes. Alongside the driven rollers 17 there is a further set of straightening rollers 18 arranged in opposed, staggered formation and mounted for rotation about vertical axes. Finally, alongside the straightening rollers 18 there is a set of driven rollers 19 mounted for rotation about horizontal axes. The sets of driven rollers 15, 17 and 19 are driven by an electric motor 20.

In use, the bar 1 is cut to a discrete length and is fed through a pair of guide rollers 21 into the nip of the rolls 8, 9 while the rolls are driven in opposite directions. As the bar 1 passes through the nip of the rolls the pegs 9 periodically pinch the metal of the bar 1 to form the lobes 2 therein. This is achieved in a single pass of the bar 1 through the rolls 8, 9 in the cold condition of the bar. (Owing to the size of the drawings, the lobes 2 are not shown on the bar 1 in Figures 2a and 2b. They are, however, shown in Figures 3a and 3d.)

The rolls 8, 9 are controlled to ensure that the lobes 2 are formed only on a selected section of the bar. In this embodiment of the invention this is achieved by means of a pair of sensing devices 22, 23 mounted ahead of and behind the rolls 8, 9.

The sensing device 23 mounted behind the rolls 8, 9 comprises a support 24 carrying a retractable stop member 25 and a sensor 26 (Figure 3b). The support 24 also carries two pairs of dependent guides 27, 28 through which the bar 1 moves. The sensing device 22 mounted ahead of the rolls 8, 9 may be the same as the sensing device 2, 3 but the retractable stop member 25 may be omitted.

With the rolls 8, 9 in an open position, the bar 1 is advanced freely therebetween. As the leading end of the bar enters the sensing device 23 located behind the rolls 8, 9 the sensor 26 of the device 23 causes the stop member 25 to retract and causes the rolls 8, 9 to close and to commence rotating. The bar 1 advances further through the rolls 8, 9 as the lobes 2 are formed thereon and as the trailing end of the bar leaves the sensing device 22, the rolls 8, 9 are caused by the sensor of the device 22 to open and to cease rotation. The sensing devices 22, 23 are adjustable in the direction of the path of the bar 1 and hence the sections of the bar which are free of lobes 2 and which carry lobes 2 can be selected by forward and rearward adjustment of the sensing devices 22, 23.

The driven rollers 15, 17 and 19 serve to advance the bar 1 along its path through the apparatus 6. To maintain pressure between opposing sets of driven rollers 15, 17 and 19, pneumatic heads 29 are provided which carry the upper rollers in the sets. Each head 29 has a dependant rod 30 which connects to a mounting 31 which carries the associated roller 16 and which is slidable in a guide 32 (Figure 3c).

As the bar passes between the straightening rollers 16 it is straightened in a vertical plane and as it passes between the straightening rollers 18 it is straightened in a horizontal plane. The rollers 18 have central channels 33 formed therein to accommodate the lobes 2 on the bar as it passes between the rollers (Figure 3d).

Each of the straightening rollers 16, 18 is adjustable towards and away from its opposing rollers to enable its effect on the bar 1 to be varied. For this purpose each straightening roller 16, 18 is mounted on a slide 34 which is slidable in a guide 35 and is adjustable by means of a setting bolt 36 (Figure 3e). The slide 34 is secured by lock nuts 37, 38. In a preferred form, the rollers, 16, 18 will be so adjusted that a flexing of the bar 1 takes place as it passes between the rollers.

Once the bar 1 has passed through the apparatus 7, the thread 4 is rolled onto a selected section of the bar in conventional manner.

A chute 39 is positioned beneath the rolls 8, 9 to collect scale generated by the action of the rolls on the bar 1.

The manner of forming the lobes 2 on the bar 1 described above is relatively simple and inexpensive and the apparatus 7 can maintain speeds of the bar 1 passing therethrough of at least 35m/min.

In this embodiment of the invention the lobes 2 are formed in a single plane but if desired they can be formed in two or more planes.

In an alternative form, a continuous length of the bar 1 may be fed through the apparatus shown in Figures 2a to 2b. In such a case the rolls 8, 9 are periodically displaced away from and towards one another to ensure that the lobes 2 are formed only on consecutive selected sections of the bar. Once the bar has passed through the apparatus, it is cut into the required lengths and threads are rolled onto the individual lengths in conventional manner.

In Figures 4a and 4b two rock bolts made according to the invention are shown. The rock bolt 40 shown in Figure 4a is intended for embedding in a settable resinous material mixed with a catalyst. It has thread 4 formed at one end thereof to receive a nut (not shown). At its other end it has a chamfered point 41 which is used to rupture a capsule of the settable material (not shown) located in the hole in the rock matrix in which the bolt is to be embedded.

The rock bolt 42 shown in Figure 4b is similar to the one shown in Figure 4a but instead of the point 41 it has a thread 43. The thread 43 is used to connect the rock bolt to a conventional mechanical anchor (not shown) which expands when the rock bolt is tensioned to anchor it in a hole. In addition to the mechanical anchor, settable resin-

ous material or concrete can be used to grout the rock bolt 42 in the hole.

Where a rock bolt made according to the invention is to be embedded in a settable material mixed with a catalyst, the rock bolt will, in use, be rotated about its axis to assist in mixing of the settable material. The lobes 2 on the bolt will in such a case assist considerably in mixing the settable material by causing lateral displacement of the settable material during rotation of the bolt. In this regard, any particle situated adjacent the bolt between two lobes 2 will be displaced by the lobe on the opposite side of the bolt when it is rotated. The improved mixing ability of the bolt arises from the fact that with the use of the lobes 2, the diameter of the bolt at the apices of opposed lobes can be as much as 1,5 times the diameter of the bolt. It will also be appreciated that the rock bolt described above provides a continuously changing perimeter along its length and this in itself enhances its mixing ability in use. The lobes 2 will also assist in the anchoring of the bolt in settable material.

Whilst the rock bolt of the invention provides a continuously changing perimeter along its length, the provision of the lobes 2 thereon does not materially alter its cross-section along its length. This means that the provision of the lobes does not result in a sacrifice of cross-section and hence does not affect the tensile strength of the rock bolt.

With the method of making a rock bolt in accordance with the invention the machining or shaving step in the prior art method described above, is dispensed with. In addition, a substantial saving of material can be obtained with a rock bolt made according to the invention, when regard is had to the following. The diameter of the ribbed section of the prior art rock bolt is larger than the diameter (e) thereof. Yet this larger diameter does not increase the tensile strength of the prior art bolt, since the tensile strength is determined by the minimum diameter of the thread (f). The prior art rock bolt therefore carries excess material over the length of its ribbed section. In the rock bolt made according to the invention, such excess material is limited since the diameter of the bar 1 is in the first place chosen to equal the pitch diameter of the thread 4. In this way a saving of material of up to 25% can be achieved compared with a prior art rock bolt, which results in a less expensive rock bolt when made according to the method of the invention.

It is well known that the load capacity of the anchorage provided by a rock bolt embedded in a settable material such as concrete is proportional to the perimeter of the bolt. To ensure that a rock bolt according to the invention does not have a lesser anchorage capacity compared with a conventional rock bolt, the perimeter of the bar 1 may be increased before, during or after the operation in which the lobes 2 are formed in the bar. This may be done, for example, by changing the cross-section of the bar in the lobe forming operation from a circular to an elliptical shape.

Thus, the rock bolt of the invention formed in this way from a bar of smaller cross-section than that of a conventional rock bolt, can provide the same anchorage capacity as the conventional rock bolt.

The rock bolt of the invention can also be made from pipe or metal bar with an axial bore, for use in applications where settable material is injected through the rock bolt itself. Also, any part of the rock bolt of the invention may be left free of lobes 2, if required.

The invention has particular application to rock bolts which are provided in lengths in which the lobed section is longer than 1 metre.

Other embodiments of the invention may be made without departing from the scope of the invention as defined in the appended claims.

Claims

1. A method of making a rock bolt with a thread on a section thereof comprising the steps of providing a metal bar of circular or near circular cross-section having a diameter which is substantially equal to the pitch diameter of the thread to be provided thereon, forming a series of protrusions on a selected section of the bar, straightening the bar, and, forming a thread with the said pitch diameter on a further selected section of the bar.

2. A method according to claim 1 in which the protrusions are formed on the bar by pinching the metal of the bar at intervals along the length of the selected section of the bar.

3. A method according to claim 2 in which the protrusions are flat lobes provided in staggered formation along opposite sides of the bar.

4. A method according to claim 2 or claim 3 in which the protrusions are formed on the metal bar in a single pass through a pair of rolls in the cold condition of the bar.

5. A method according to claim 4 in which the rolls define a nip between them and have formations provided at predetermined positions along their peripheries, the rolls being rotated in opposite directions so that a formation on one roll coincides periodically with a formation on the other roll in the nip of the rolls, the bar being fed lengthwise through the nip of the rolls so that the formations pinch the metal of the bar at selected positions along its length.

6. A method according to any one of the pre-

ceding claims in which the protrusions are formed on substantially the entire length of the bar, save for the selected section on which the thread is formed.

7. A method according to any one of the preceding claims in which the metal bar is straightened in two planes.

8. A method according to claim 7 in which the metal bar is straightened by passing it sequentially through two sets of opposed, staggered rollers.

9. A method of making a rock bolt substantially as herein described with reference to Figures 1-3 of the accompanying drawings.

10. A method of making a rock bolt from a metal bar comprising the steps of providing a pair of rolls defining a nip between them and having formations provided at predetermined positions along their peripheries, rotating the rolls in opposite directions so that a formation on one roll coincides periodically with a formation on the other roll in the nip of the rolls, and, feeding the bar lengthwise through the nip of the rolls so that the formations pinch the metal of the bar at selected positions along its length.

11. A method of making a rock bolt from a metal bar, substantially as herein described with reference to Figures 1-3 of the accompanying drawings.

12. Apparatus for making a rock bolt from a metal bar comprising a pair of rolls, means for driving the rolls about their axes in opposite directions, each roll having a channel formed in its surface facing the other roll, the channels defining a passage for receiving the bar in lengthwise fashion, each roll having formations provided along its periphery which align periodically with similar formations on the other roll in the nip of the rolls when they are rotated in opposite directions.

13. Apparatus according to claim 12 including means for straightening the bar after it has been passed between the rolls.

14. Apparatus according to claim 13 in which the means for straightening the bar comprise two sets of opposed staggered rollers through which the bar is passed, the rollers of one set being located at right angles to those of the other set.

15. Apparatus according to claim 12 in which the formations on the rolls are in the form of pegs mounted on the rolls.

16. Apparatus for making a rock bolt from a metal bar, substantially as herein described with reference to Figures 1-3 of the accompanying drawings.

17. A rock bolt comprising a metal bar having a circular or near circular cross-section of a selected uniform diameter, the bar having a thread with a selected pitch diameter formed on a selected section thereof located at at least one end of the bar, the pitch diameter of the thread on the bar being substantially equal to the diameter of the bar, and a series of protrusions pinched from the bar formed on a further selected section of the bar.

18. A rock bolt according to claim 17 in which the protrusions on the bar are flat lobes provided in staggered formation along opposite sides of the bar.

19. A rock bolt according to claim 18 in which the sides of each lobe nearest and furthest the axis of the bar are arcuate so that each lobe has a generally elliptical outline.

20. A rock bolt according to any one of claims 17-19 in which the length of the selected section of the bar carrying the protrusions is greater than 1 metre.

21. A rock bolt when made according to the method of any one of claims 1-9.

22. A rock bolt substantially as herein described with reference to Figures 1 and 4 of the accompanying drawings.

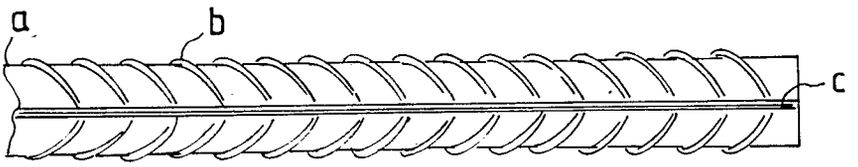

FIG A

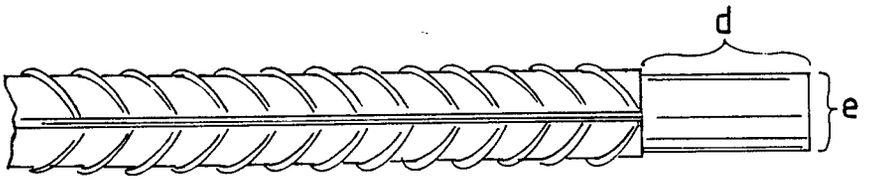

FIG B

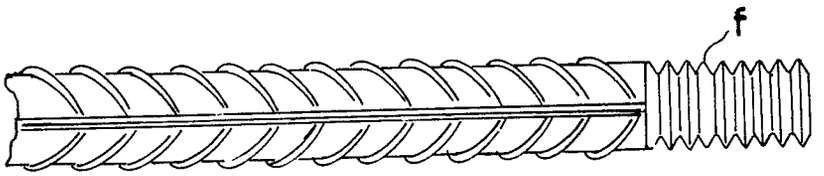

FIG C

PRIOR ART

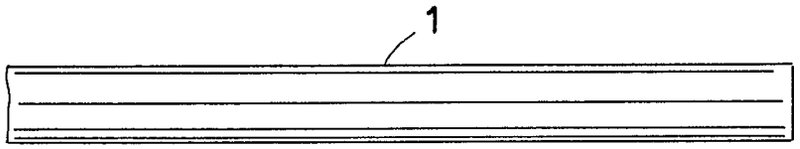

FIG 1a

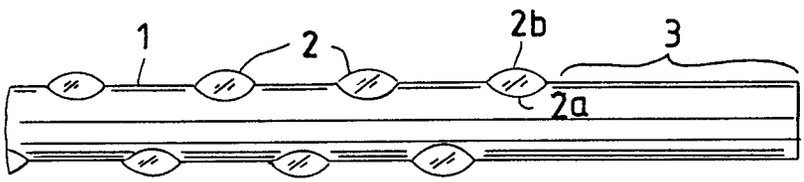

FIG 1b

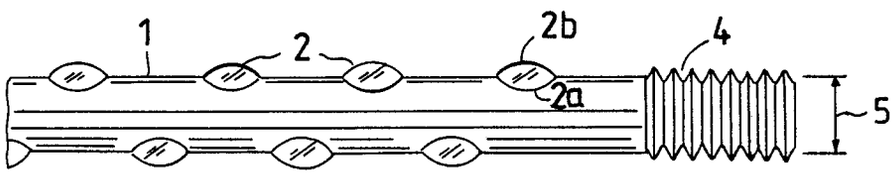

FIG 1c

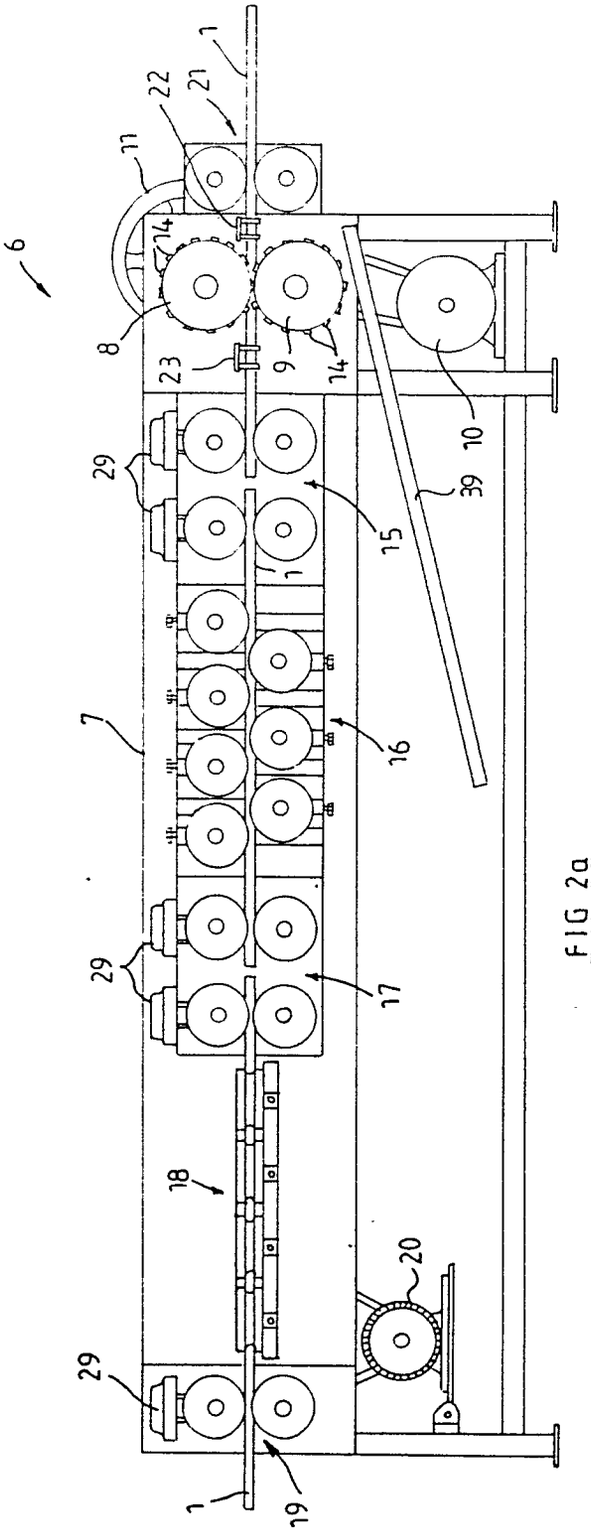
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FIG 2a

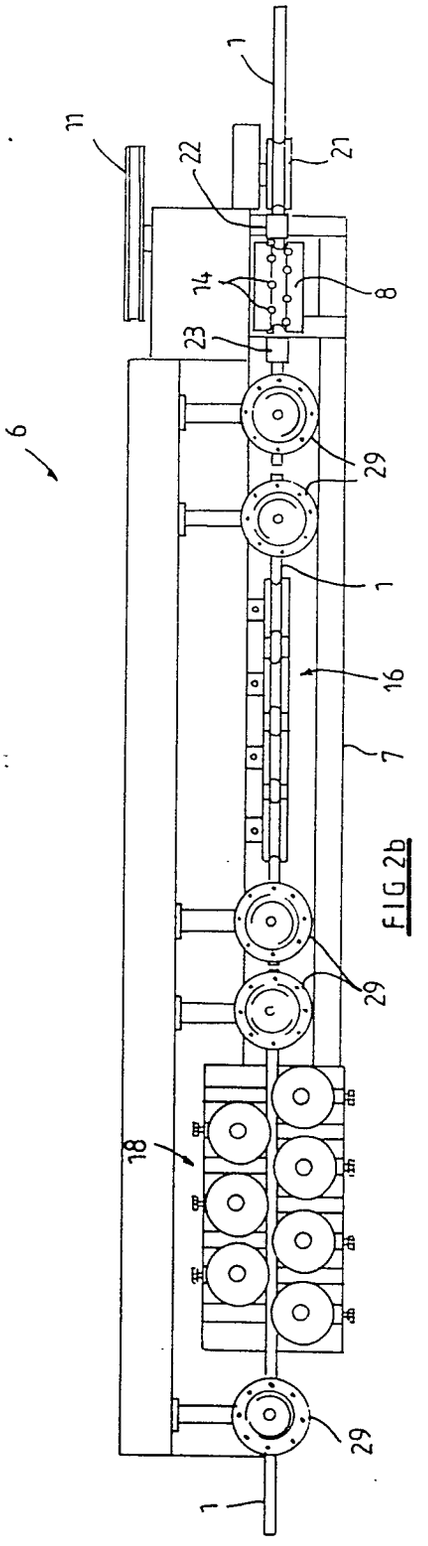
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FIG 2b

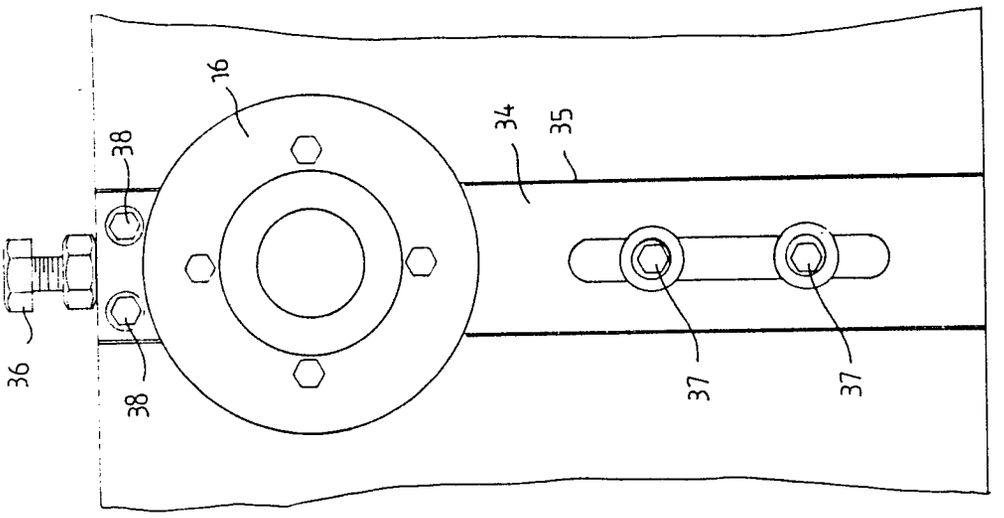

FIG 3e

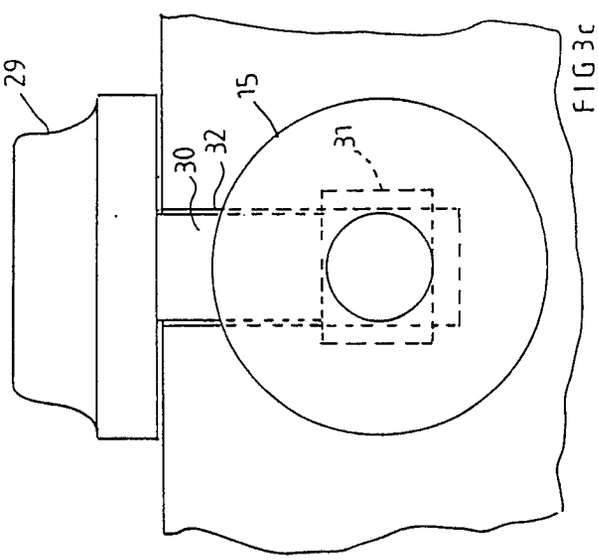

FIG 3c

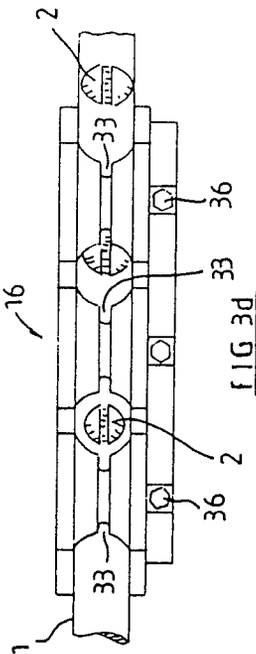

FIG 3d

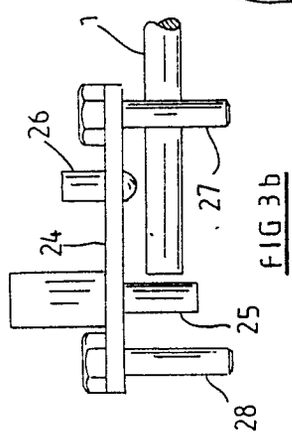

FIG 3b

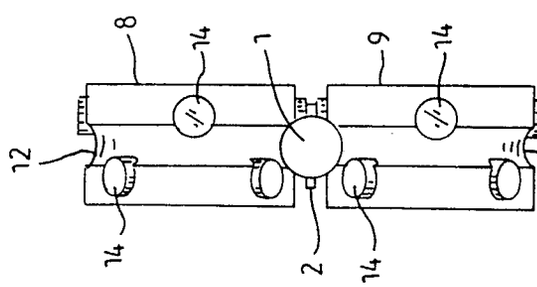

FIG 3a

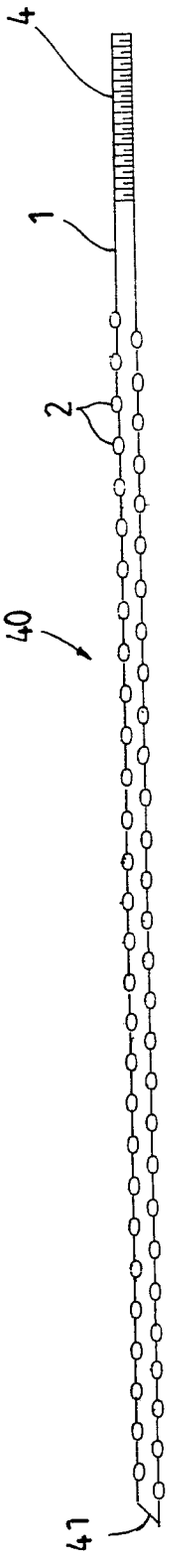

FIG 4a

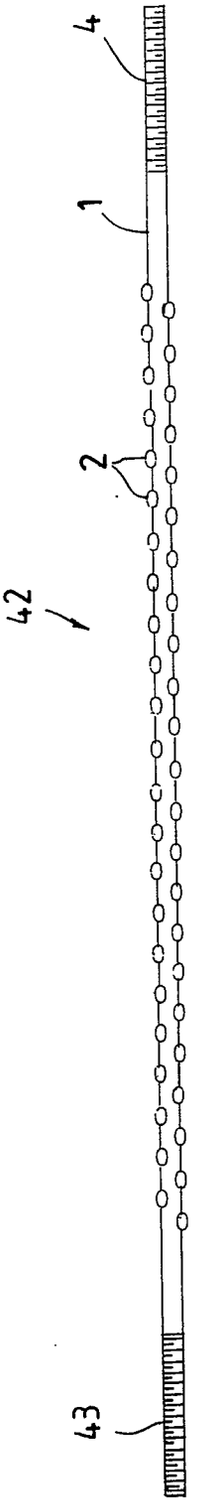

FIG 4b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 30 6706

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.4)
X	US-A-4 649 729 (FLORIDA STEEL) * Column 3, lines 19-44; column 4, lines 1-60; column 5, lines 1-19 *	1-22	B 21 H 8/00 B 21 H 3/02 // E 04 C 5/12 E 21 D 21/00
X	AU-B- 523 376 (TITAN MANUFACTURING) * Page 3, lines 4-10 *	1,2,4, 10,17, 20,21	
X	PATENT ABSTRACTS OF JAPAN, vol. 8, no. 234 (M-334)[1671], 26th October 1984; & JP-A-59 113 948 (NIHON BIYOURATEI SEISAKUSHO K.K.) 30-06-1984 * Abstract *	1,2,4, 10,17, 20,21	
A	US-A-2 911 865 (BRICKMAN) * Figures 1-4; columns 1,2 *	12-16	
A	US-A-4 064 729 (HOMERY) * Figure 1; abstract *	10-16	
A	US-A-2 347 904 (GREULICH) * Figures 1-4; claim 1 *	7,8,13, 14	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	US-A-3 742 747 (NIPPON CONCRETE) * Figures 1-6; column 2 *	7,8,13, 14	B 21 H E 04 C
A	GB-A-2 045 836 (PEABODY COAL) * Abstract; figures 1,2 *	17-22	
A	CH-A- 604 951 (FERRIERE BELLOLI) * Figure 2 *	17-22	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21-03-1989	VERMEESCH,P.J.C.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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