



(19)

Europäisches Patentamt

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(11)

EP 0 788 847 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
13.08.1997 Bulletin 1997/33

(51) Int. Cl.⁶: **B21C 37/04**, B21B 1/16

(21) Application number: **97100966.7**

(22) Date of filing: **22.01.1997**

(84) Designated Contracting States:
AT CH DE ES FR GR IT LI

(30) Priority: **07.02.1996 IT MI960222**

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(54) Steel rod used in the production of electrically welded mesh

(57) A method for producing highly ductile electrically welded steel nets, particularly for use as reinforcement frames in the manufacture of reinforced-concrete structures, the method consisting in subjecting a steel billet, having a composition that contains substantially between 0.16 and 0.22% carbon, to rolling after heating in a furnace up to approximately 1200°C. The wire rod (1), preferably provided with ribs (2), produced by the rolling process is then subjected to a cold-deformation treatment and to assembly in a net-like configuration by electric welding.

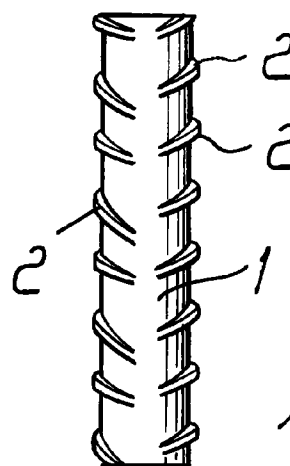


Fig. 1

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Description

The present invention relates to a method for producing highly ductile electrically welded steel nets, particularly for use as reinforcement frames in the manufacture of reinforced-concrete structures.

Electrically welded steel nets for reinforced-concrete structures are generally obtained starting from a steel wire rod which is cold-rolled, wound on reels, and then unwound, arranged in a net-like configuration, and electrically welded.

There are specific standards which prescribe specific strength and ductility characteristics for electrically welded nets for reinforced-concrete structures, so that structures produced with said nets may offer adequate safety assurances.

The law introduced by Ministerial Decree no. 1086, dated February 14, 1992, prescribes for electrically welded nets and frames an ultimate tensile strength of at least 440 N/mm², a yield strength of at least 390 N/mm², a ratio between ultimate tensile strength and yield strength of no less than 1.1, and a post-breaking elongation of at least 8%.

The same law prescribes, for weldable steels, a maximum content of carbon, phosphor, sulfur, and nitrogen and a maximum value for equivalent carbon which is expressed by the formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

where the chemical symbols indicate the content of said elements expressed as a percentage.

As far as electrically welded nets for reinforced-concrete structures are concerned, there is also a European standard (standard ENV 10080 dated November 1994) which provides for two ductility classes for electrically welded nets; more specifically, a class for nonseismic countries, which requires the ratio of ultimate tensile strength to yield strength to be at least equal to 1.03-1.05 and requires elongation under maximum stress to be at least equal to 2-2.5%, and a class for seismic countries, which requires the ratio of ultimate tensile strength to yield strength to be at least equal to 1.08 and requires elongation under maximum stress to be at least equal to 5%.

The methods currently used to produce electrically welded nets do not allow to meet these standards; in particular, they do not allow to comply with the prescription concerning the value of the ratio of ultimate tensile strength to yield strength.

The method currently used in the production of electrically welded nets starts, as mentioned, from steel wire rods with a chemical composition that provides for no more than 0.05-0.16% carbon, no more than 0.40-0.80% manganese, no more than 0.08-0.25% silicon according to the diameter of the wire rod, and no more than 0.045% phosphor, no more than 0.045% sulfur, no

more than 0.045-0.50% copper and tin, no more than 0.20% chrome and nickel, and no more than 0.05% molybdenum.

The wire rod, with this chemical composition, has ultimate tensile strengths that vary between 380 N/mm² and 530 N/mm² from the smallest diameter of 5.5 mm to the largest diameter of 14 mm, yield strengths that vary between 250 N/mm² and 350 N/mm², and a breaking elongation of more than 23-27%.

The steel wire rod is then subjected to a cold-rolling operation which is inappropriately termed "drawing". This operation has three basic purposes. A first purpose is to obtain from the wire rod a bar having the intended diameter, which is usually 1 mm smaller than the initial wire rod for smaller diameters and 2 mm smaller for larger diameters, and to obtain anchoring ribs on the bar surface. A second purpose is to improve the mechanical characteristics, i.e., to increase the ultimate tensile strength and the yield strength as a consequence of the work-hardening caused by drawing. A third purpose of the drawing operation is to perform mechanical descaling, i.e., to remove from the wire rod surface the so-called "calamine" constituted by ferrous oxide and ferric oxide, so as to allow a successful subsequent electric welding operation during the assembly of the bars to form the net.

It should be noted that the work-hardening caused by cold-rolling, in addition to positively increase the ultimate tensile strength and the yield strength, has the drawback of reducing ductility, which is expressed by the ratio between the ultimate tensile strength and the yield strength, as well as percentage elongation.

For this reason, this method, which has been used up to now, provides on the average for an electrically welded net which is unlikely to fully meet the above-mentioned standards, since it does not allow to obtain a ratio of at least 1.1 between ultimate tensile strength and yield strength.

A principal aim of the present invention is to solve the above problem by providing a method which allows to produce an electrically welded net of higher quality with respect to conventional electrically welded nets obtained by cold-rolling.

Within the scope of this aim, an object of the invention is to provide a method which allows to produce high-ductility electrically welded nets which are fully satisfactory as regards current statutory provisions covering electrically welded nets for reinforced-concrete structures.

Another object of the invention is to provide a method which can be performed with commercially available equipment and facilities.

Another object of the invention is to provide a method which allows to produce electrically welded nets at competitive costs.

This aim, these objects, and others which will become apparent hereinafter are achieved by a method for producing electrically welded steel nets, particularly for use as reinforcement frames in the manufacture of

reinforced-concrete structures, characterized in that it consists in subjecting a steel billet, having a composition containing substantially between 0.16 and 0.22% carbon, to rolling after heating in a furnace up to approximately 1200°C, and in subsequently subjecting the wire rod produced by the rolling process to a cold-deformation treatment and to assembly in a net-like configuration by electric welding.

Further characteristics and advantages of the invention will become apparent from the following detailed description of two preferred but not exclusive embodiments of the method according to the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

figure 1 is a lateral elevation view of a segment of a ribbed wire rod produced by the rolling step in the method according to the invention;

figure 2 is an enlarged-scale transverse sectional view of a detail of the wire rod;

figure 3 is a schematic axial sectional view of a straightening unit which can be used in a first embodiment of the method according to the invention;

figure 4 is a schematic view of an apparatus for performing the cold-deformation treatment whereto the wire rod is subjected after rolling;

figure 5 is a top plan view of a station of the apparatus shown in figure 4;

figure 6 is a lateral elevation view of another station of the apparatus shown in figure 4;

figure 7 is an enlarged-scale view of a detail of figure 6;

figure 8 is a lateral elevation view of a winding traction unit of the apparatus shown in figure 4.

With reference to the above figures, the method according to the invention, in both embodiments, substantially consists in starting from a steel billet, preferably having a diameter of 130 mm, which has a composition containing substantially between 0.16 and 0.22% carbon and preferably substantially between 0.80 and 0.95% manganese, substantially between 0.20 and 0.30% silicone, less than 0.045% phosphor, less than 0.045 sulfur, less than 0.55% copper, less than 0.055% tin, less than 0.25% chromium, less than 0.30% nickel, and less than 0.05% molybdenum, which in any case allow to keep the value of C_{eq} below the 0.50 value prescribed by standards, and less than 0.013% nitrogen, as prescribed by weldability standards.

This billet is first heated in a preheating furnace, preferably of the "pusher" type, i.e., a conventional furnace wherein the entire charge, in a single layer, is pushed towards the hot region and subsequently towards the discharge section. This furnace, adapted for preheating materials having a low carbon content, is capable of maintaining limited surface oxidation levels which can accordingly be easily removed in view of the

intrinsic brittleness. This fact can be explained because in this furnace the inserted billets are not struck by the hot products of combustion but are heated by the reverberatory effect of the radiating roof lying above the inserted charge of billets and contains the flat combustion chamber. The heating cycle in the "pusher" heating furnace, in the method according to the invention, includes the loading of the billets at a temperature of no more than 300°C, retention in the preheating region at a temperature substantially between 600°C and 700°C for a period substantially between 35 and 45 minutes, travel through the heating region with an initial region temperature of 800°C and a final region temperature of 1240°C, over a period between 45 and 55 minutes, retention in the equalization region at a temperature substantially between 1180°C and 1220°C, to complete heat penetration, for a further 25-35 minutes.

At this point, the billet is discharged and rolled. The temperature measurable on the billet surface is between 1070 and 1090°C and the surface layer of oxides is poorly anchored, thin, and can be easily eliminated by the first rolling stages. This allows to continue the entire rolling process by a plurality of consecutive reduction steps, maintaining a surface that is practically free from secondary oxidations on the rolled part.

It should also be noted that the ratio between the volumes of the fuel and of the comburent in the heating furnace is preferably kept between 1:8.5 and 1:9.3 so as to obtain, even in case of unwanted retentions of the billets in the heating regions, a surface oxidation layer compatible with subsequent treatments. This is possible since, in case of accidents along the subsequent rolling mill train or in case of anomalies in the discharge sequences, the billets in the furnace, which have by then reached the correct temperature, can be retained for further time without problems, the environment inside the furnace being partially reducing by the above-mentioned fuel-comburent ratios.

After heating, the billets are rolled and then cold-shaped; this is followed by assembly in a net-like configuration by electric welding.

Rolling is performed in successive steps in order to gradually reduce the diameter of the billet until a wire rod of the desired diameter, preferably between 6 and 12 mm, is obtained, with rolls preferably shaped so as to obtain anchoring ribs 2 (figure 1) on the surface of the wire rod 1.

At least the finishing rolls of the rolling mill trains are preferably made of tungsten carbide, have excellent resistance to wear when hot, and allow to obtain, for the rolled wire rod, a smooth, roughness-free surface so as to prevent the formation of an excessive anchoring base for the formation of the final oxidation layer.

Moreover, use of this material allows to obtain an intended increase in the height of the ribs 2 with respect to conventional practice, in order to compensate for a reduction in said height which arises from the subsequent cold-deformation step, obtaining a finished product with ribs having a height which fully complies with

the relevant standards.

In practice, when rolling ends, the ribbed wire rod 1 is provided with ribs having: for a diameter of 6 mm, a height that is substantially between 0.30 and 0.60 mm and preferably equal to 0.60 mm; for a diameter of 8 mm, a height which is substantially between 0.40 and 0.80 mm and preferably equal to 0.70 mm; for a diameter of 10 mm, a height which is substantially between 0.50 and 1 mm and preferably equal to 0.90 mm; for a diameter of 12 mm, a height which is substantially between 0.60 and 1.20 mm and preferably equal to 1 mm.

The wire rod produced by the rolling process has, on the average, an ultimate tensile strength of 552-620 N/mm², a yield strength of 360-400 N/mm², and a breaking elongation of more than 22%.

It should be noted that the wire rod 1, at the end of the rolling process, has a surface oxide layer with a thickness substantially between 0.010 mm and 0.045 mm, and that said thickness value is determined by the setting up of the rolling cycle.

At the end of the rolling process, the wire rod is wound in coils having preferably an inside diameter of 800-900 mm, an outside diameter of 1100-1200 mm, and a height of 800-1100 mm.

The subsequent cold-deformation treatment can be constituted by a straightening process in a first embodiment of the method according to the invention or, in a second embodiment thereof, by a further winding process.

If straightening is performed, it is preferably carried out by means of a conventional working bench comprising, in sequence, a station for unwinding the coil, a unit for the advancement of the rolled material, a rotary-drum straightening unit, for example of the type shown in figure 3 and generally designated by the reference numeral 10, and a station for cutting the straightened bars to size.

In practice, the rotary drum 10 has an axial passage for the wire rod delimited by a plurality of bushes 11 which are arranged inside the rotary drum in an eccentric alternating manner, with an eccentricity substantially between 2 and 8 mm with respect to the axis of the rotary drum, which is made to rotate about said axis. The arrangement of the bushes 11 in the drum 10, which is made to rotate, causes a plurality of alternating bendings of the wire rod, with deflections which are substantially equal to the eccentricity of the bushes 11. The straightening performed with the rotary drum 10 enhances certain mechanical characteristics of the wire rod and leads to a ratio between the ultimate tensile strength and the yield strength of the final product which fully complies with the above-mentioned standards. The straightening thus performed affects the structure of the wire rod in full, since it does not act on separate planes, which would in any case limit the regions affected by yielding, but on the entire cross-section. Since the drum 10 rotates at a rate preferably on the order of 3000 rpm, and since the linear speed of the wire rod passing there-

through is approximately 2 m/sec, the bending force produced by the eccentric arrangement of the bushes 11 is distributed uniformly over all possible planes.

By virtue of its passage within the drum 10, the wire rod also undergoes substantially complete descaling, fully eliminating the oxide layer from its surface and allowing to perform trouble-free subsequent electric welding during the production of the net.

If the wire rod is instead subjected to a further winding process, this operation is preferably performed by means of an apparatus of the type shown schematically in figure 4. Said apparatus comprises, in sequence, an unwinding device 21 which gradually unwinds the coil of wire rod, a first descaling unit 22, a lubricator 23, a yielding and pulling bench 24, and a coil winding device 25.

The descaling unit 22 is substantially constituted by a bench 30 with a plurality of pairs of rollers with a grooved profile 31, which have mutually parallel axes and are arranged so as to form a path for the wire rod having one or more S-shaped portions, so as to obtain, during the passage of the wire rod, its alternating bending with a camber of substantially 10 to 20 mm, which causes the separation of the oxide layer covering the wire rod surface.

The lubricator 23 is constituted by a conventional lubricator which delivers onto the wire rod surface a lubricant having the purpose of preventing the turns of wire rod from overlapping during the pulling and winding on a drum performed downstream.

The yielding and pulling device comprises, in sequence, a first winding traction unit 40, shown in figure 8, which is substantially constituted by a motorized drum around which the wire rod arriving from the descaling unit 23 is wound in turns and then conveyed through two yielding benches 41 and 42, which are substantially constituted by a first set of rolls with a groove-shaped profile 43 and by a second set of rolls with a groove-shaped profile 44, arranged so as to produce the S-shaped deformation of the wire rod on two mutually perpendicular planes, i.e., on a horizontal plane and on a vertical plane, as shown in particular in figure 6. The rolls 43 are arranged so as to have axes which are parallel and spaced with respect to each other so as to produce a sequence of alternating bendings of the wire rod with a maximum camber of substantially between 80 and 120 mm and with a distance between two maximum camber points of two contiguous regions bent on opposite sides that is substantially between 180 and 210 mm.

At the output of the second yielding bench there is provided another drum winder, again of the type shown in figure 8, i.e., provided with a motorized drum around which the wire rod arriving from the yielding benches 41 and 42 is wound.

The apparatus is completed by a coil winder 25, which packages the wire rod in coils.

The wire rod, by passing through the apparatus shown in figure 4, is pulled, unwound, made to yield on

a horizontal plane, made to yield on a vertical plane, wound again, pulled, and unwound again with an advancement rate varying between 3 and 9 m/s for larger-diameter wire rods and between 6 and 12 m/s for smaller-diameter wire rods. This treatment heats the wire rod up to 70-80°C, producing a work-hardening of the material which raises the ultimate tensile strength and the yield strength and allows at the same time to obtain a ratio between ultimate tensile strength and yield strength and a percentage elongation value which fully comply with the pertinent standards.

The resulting wire rod is then electrically welded in a per se known manner to obtain the electrically welded net.

Practical testing of the method according to the invention has produced, with the embodiment that provides for a cold-deformation of the wire rod which consists of straightening, an electrically welded net having a yield strength of more than 425 N/mm², an ultimate tensile strength of more than 463 N/mm², with a ratio between ultimate tensile strength and yield strength of more than 1.15, an elongation after breakage of more than 14%, and an elongation under maximum stress of approximately 8%, and an electrically welded net, obtained through a cold-deformation treatment which provides for a further winding process, as described above, having a yield strength of more than 500 N/mm², an ultimate tensile strength of more than 550 N/mm², with a ratio between ultimate tensile strength and yield strength of more than 1.10, and a breaking elongation of more than 10% and more than 5% under maximum stress.

In practice it has been observed that the method according to the invention fully achieves the intended aim and objects, since it allows to produce an electrically welded net of higher quality than electrically welded nets produced with conventional processes and fully complies with the requirements of the standards concerning electrically welded nets for the manufacture of reinforced-concrete structures.

The method thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept; all the details may furthermore be replaced with other technically equivalent elements.

Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A method for producing electrically welded steel nets, particularly for use as reinforcement frames in the manufacture of reinforced-concrete structures, characterized in that it consists in subjecting a steel

billet, having a composition that contains between 0.16 and 0.22% carbon, to rolling after heating in a furnace up to approximately 1200°C, and in subsequently subjecting the wire rod produced by the rolling process to a cold-deformation treatment and to assembly in a net-like configuration by electric welding.

2. A method according to claim 1, characterized in that said steel billet contains between 0.80 and 0.95% manganese.

3. A method according to claim 1, characterized in that said steel billet contains between 0.20 and 0.30% of silicon.

4. A method according to claim 1, characterized in that said steel billet contains less than 0.045% phosphor, less than 0.045% sulfur, less than 0.055% copper, less than 0.055% tin, less than 0.25% chromium, less than 0.30% nickel, less than 0.05% molybdenum, and less than 0.013% nitrogen.

5. A method according to claim 1, characterized in that said billet has a diameter of substantially 130 mm.

6. A method according to claim 1, characterized in that said heating is performed in a so-called "pusher" furnace.

7. A method according to claim 1, characterized in that said heating comprises a step for inserting the billets in the furnace at a temperature of no more than 300°C, a preheating step at a temperature between 600 and 700°C for approximately 35-45 minutes, a step for gradual heating from a temperature of approximately 800°C up to a temperature of approximately 1240°C over 45 to 55 minutes, and an equalization step at a temperature between 1180 and 1220°C for approximately 25-35 minutes.

8. A method according to claim 6, characterized in that in said pusher heating furnace the ratio between the volume of fuel and the volume of comburent is between 1:8.5 and 1:9.3.

9. A method according to claim 1, characterized in that during said rolling process the wire rod is provided with ribs having, at the end of the rolling process, a height that is between 0.30 and 0.60 mm for wire rods having a diameter of 6 mm, between 0.40 and 0.80 mm for wire rods having a diameter of 8 mm, between 0.50 and 1 mm for wire rods having a diameter of 10 mm, and between 0.60 and 1.20 mm for wire rods having a diameter of 12 mm.

10. A method according to claim 1, characterized in

that during said rolling process the wire rod is provided with ribs having, at the end of the rolling process, a height of 0.60 mm for wire rods having a diameter of 6 mm, 0.70 mm for wire rods having a diameter of 8 mm, 0.90 mm for wire rods having a diameter of 10 mm, and 1 mm for wire rods having a diameter of 12 mm.

11. A method according to claim 1, characterized in that the wire rod that leaves the rolling process is coated with surface oxides having a thickness between 0.010 and 0.045 mm. 10
12. A method according to claim 1, characterized in that said rolling process is performed on rolling mill trains wherein at least the finishing rolls are made of tungsten carbide. 15
13. A method according to claim 1, characterized in that the wire rod, after rolling, is wound in coils having an inside diameter of 800-900 mm and an outside diameter of 1100-1200 mm. 20
14. A method according to claim 1, characterized in that said cold-deformation treatment comprises a straightening of the wire rod. 25
15. A method according to claim 14, characterized in that said straightening is performed on a rotary-drum straightening machine having an axial passage for the wire rod, bushes crossed by the wire rod being provided along said axial passage and being arranged eccentrically with respect to the axis of the drum to produce, as a consequence of the rotation of the drum about its own axis, an alternating bending of the wire rod during its advancement along said drum. 30 35
16. A method according to claim 15, characterized in that during said straightening the alternating bending of the wire rod is performed with bending cambers substantially between 2 and 8 mm. 40
17. A method according to claim 14, characterized in that during the straightening of the wire rod said rotary drum is actuated with a rotation rate of substantially 3000 rpm, and in that the advancement rate of the wire rod along said drum is substantially 2 m/sec. 45 50
18. A method according to claim 1, characterized in that said cold-deformation treatment comprises a step for making the wire rod yield on two planes substantially perpendicular to each other. 55
19. A method according to claim 18, characterized in that the wire rod is wound on a reel before and after said step for yielding on two planes which are substantially perpendicular to each other.

20. A method according to claim 18, characterized in that the wire rod is subjected to descaling, prior to said yielding step, by passing through rolls which form a path with S-shaped portions for the wire rod.
21. A method according to claim 20, characterized in that said descaling is performed in said descaling unit by means of a plurality of alternating bendings of the wire rod with bending cambers substantially between 10 and 20 mm.
22. A method according to claim 18, characterized in that said step for making the wire rod yield on two planes substantially perpendicular to each other is performed, for each plane, by means of a plurality of alternating bendings of the wire rod with a maximum camber substantially between 80 and 120 mm and with a distance between two contiguous opposite maximum camber points that is substantially between 180 and 210 mm.
23. A method according to claim 18, characterized in that during said yielding step the wire rod has an advancement rate substantially between 3 and 12 m/s.

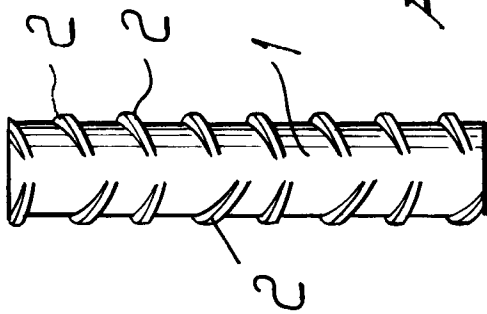


Fig. 1

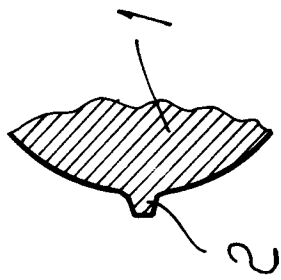


Fig. 2

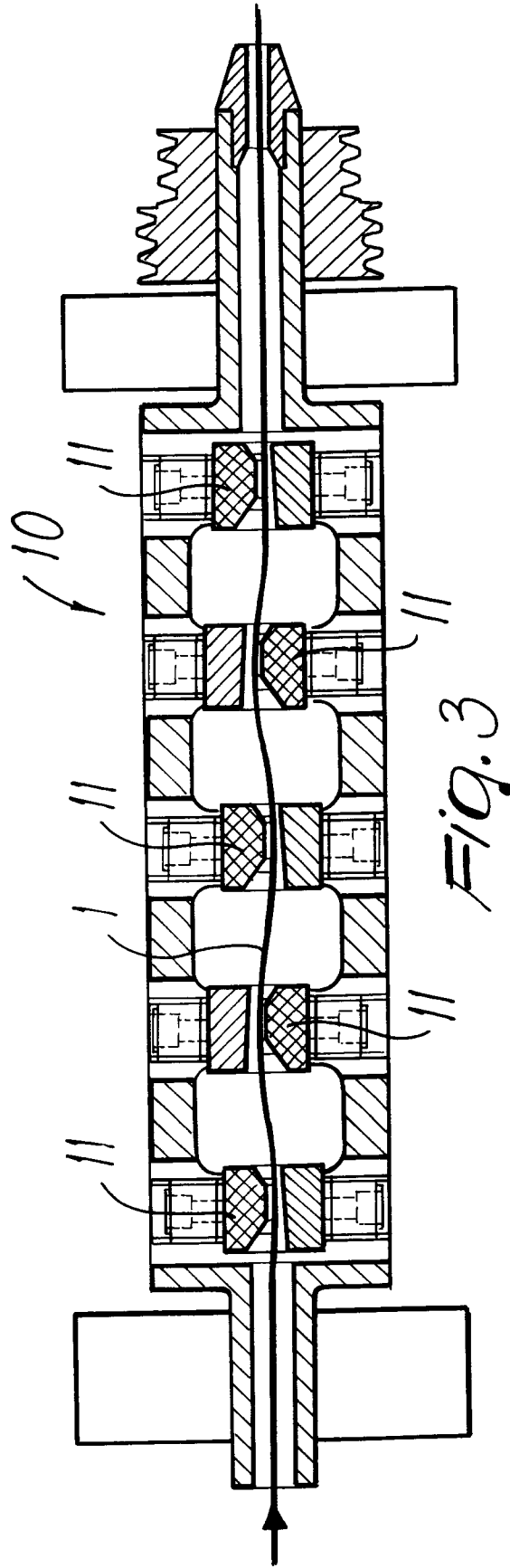
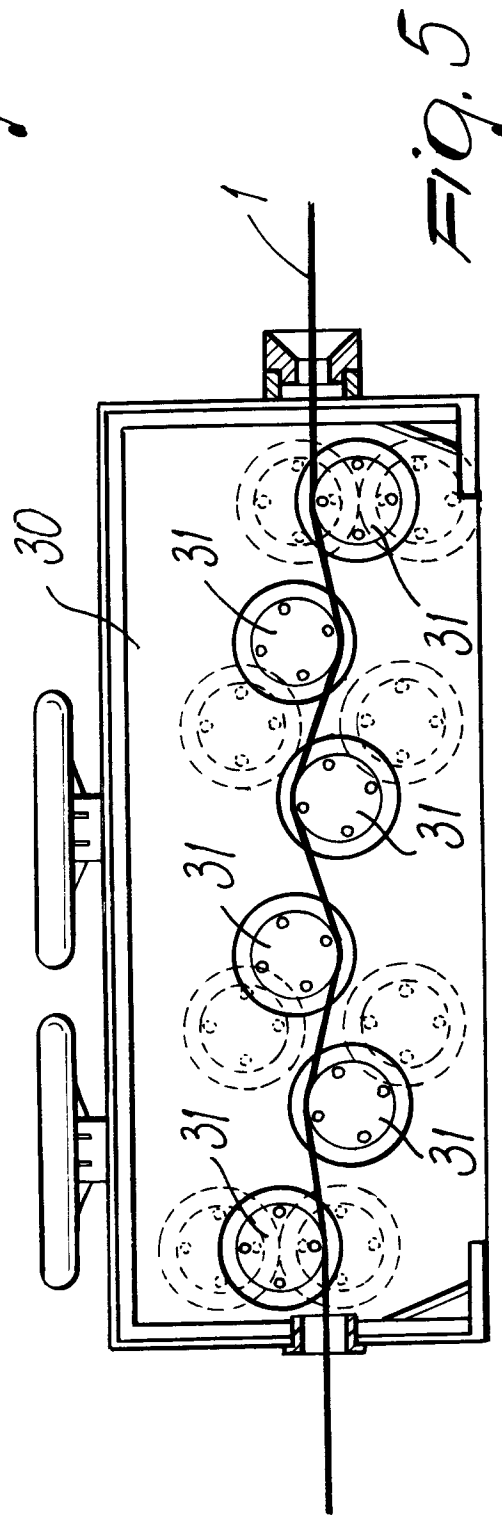
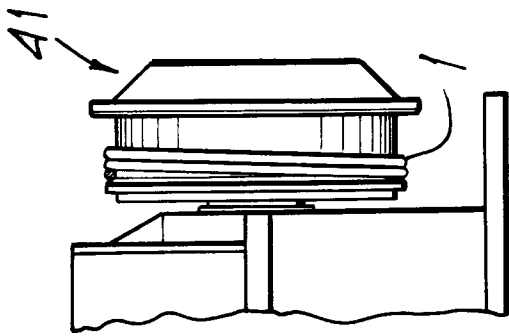
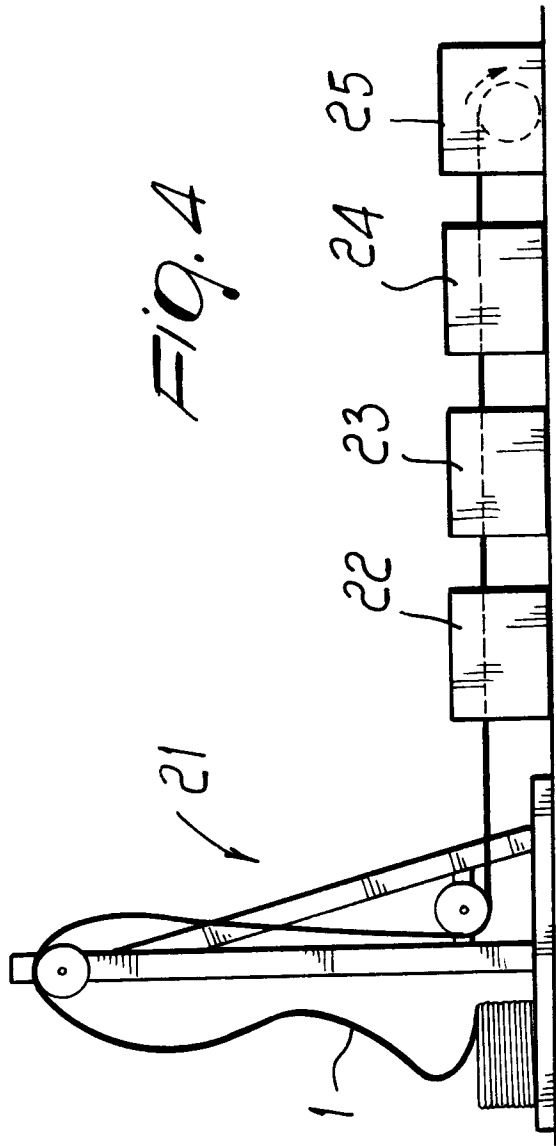


Fig. 3



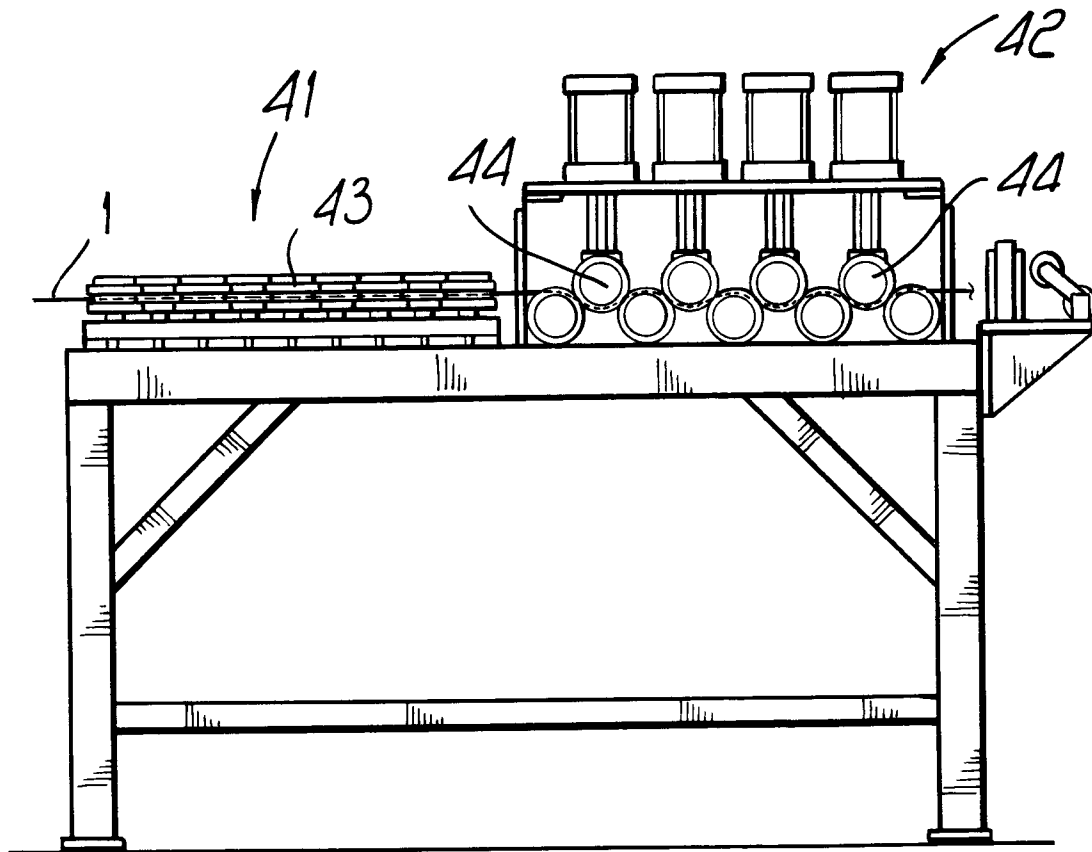


Fig. 6

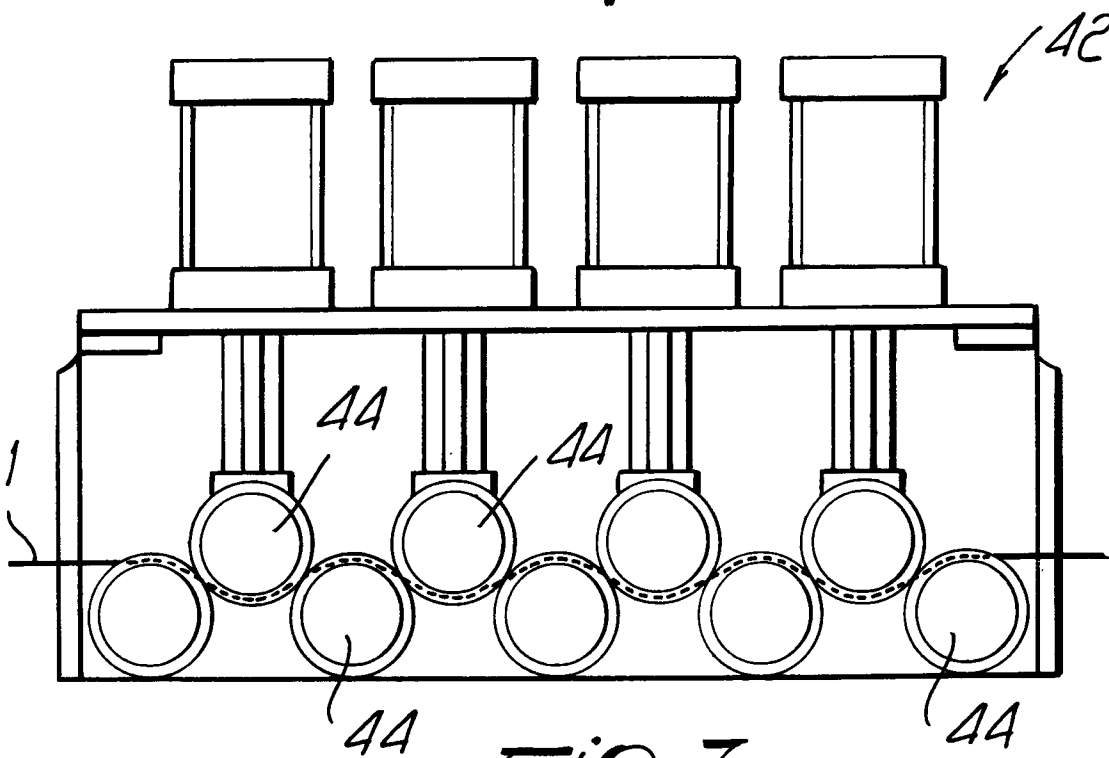


Fig. 7



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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 0966

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	GB 2 109 281 A (ALLIED STEEL WIRE LTD) 2 June 1983	1,11,14, 18-22	B21C37/04 B21B1/16
A	* page 1, line 63 - line 93 * * page 1, line 107 - page 2, line 101 * ---	9,10,13	
X	BE 635 211 A (AG DER VON MOOS'CHEN EISENWERKE LUZERN)	1,11,13, 14,18-22	
A	* page 3, paragraph 3 - page 6, paragraph 2 * ---	9,10, 15-17	
A	DE 26 21 330 A (FELS WERKE PEINE SALZGITTER) 24 November 1977 * claim 1 * ---	1-3	
A	FR 2 378 578 A (ARBED) 25 August 1978 * claim 1; figures * -----	12	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6) B21C B21B C21D
Place of search THE HAGUE		Date of completion of the search 5 June 1997	Examiner Barrow, J
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 D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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