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(54) **Apparatus and methods for rolling and stress relaxing a metal strip**

(57) A metal strip (10) of predetermined initial thickness is fed from an input drum (22) between two rollers (12,14) whose separation is less than the initial thickness of the strip, thereby effecting a predetermined thickness reduction. The strip is thereafter passed around three guide rollers (24,26,28) which subject it to successive changes in direction in opposite angular sense, the strip then being coiled up on an output drum (30). The longitudinal speed of movement of the strip and the extents and rates of changes in angular direc-

tion of the strip as it passes around the guide rollers (24,26,28) causes the strip to become heated to a temperature sufficient to relax its structure and offset any adverse effect on its subsequent elongation capability caused by the thickness reduction carried out by the initial rollers (12,14). The guide rollers (24,26,28) cause opposite surface portions of the strip to be subjected to alternate tension and compression.

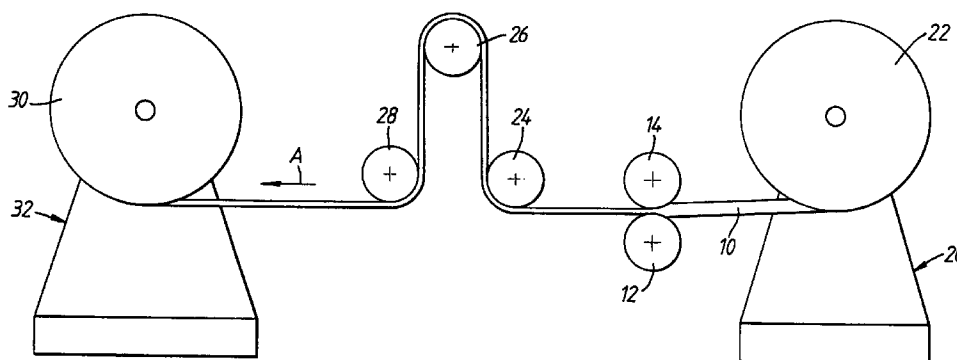


Fig.4

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Description

The invention relates to a method of processing elongate metal strips to reduce work-hardening of the strip, comprising the step of increasing the temperature of the strip by a predetermined amount to relax its structure.

The invention also relates to a method for producing elongate metal strip of a predetermined thickness, comprising the step of passing metal strips of initial thickness greater than the predetermined thickness longitudinally through the bight between two rollers which is less than the initial thickness whereby to thin-down the initial thickness of the strip to the predetermined thickness, and increasing the temperature of the strip by a predetermined amount to reduce work-hardening of the strip.

The invention further relates to apparatus for processing an elongate metal strip to reduce work-hardening of the strip, comprising transporting means for transporting the metal strip along a predetermined path, and temperature-increasing means for increasing the temperature of the strip by a predetermined amount to relax the structure of the strip and thereby to reduce work-hardening of the strip.

In such known methods and apparatus, the reduction of work-hardening of the metal strip is obtained by heating a coil of the metal strip to a predetermined temperature in an enclosure free of oxygen (to eliminate oxidation effects). However, such a heating process is expensive and time-consuming and therefore has significant economic defects. In particular, where work-hardening of the metal strip has been caused by the thinning-down process, the strip thereafter has to be coiled up and transported to the heating means, and thereafter transported back to the apparatus for carrying out such further mechanical operations on the strip as may be required.

The invention aims to overcome these problems.

According to the invention, therefore, the method as first set forth above is characterised in that the temperature increasing step comprises the step of transporting the metal strip longitudinally while subjecting it to successive changes in angular direction in opposite senses.

According to the invention, also, the method as secondly set forth above is characterised in that the temperature increasing step comprises the step of subjecting the thinned-down strip to successive changes in direction of opposite angular senses at such rates of change and with such extent of change as to heat the metal of the strip sufficiently to offset the effect of the thickness reduction of the strip on its elongation capability.

Further according to the invention, the known apparatus is characterised in that the temperature-increasing means comprises change of direction means in the predetermined path defining at least first and second successive changes in angular direction in opposite

senses, the changes in direction being of such rate and of such extent as to increase the temperature of the metal of the strip by the predetermined amount.

Apparatus and methods according to the invention for use in processing metal tape or strip will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a perspective view of a metal core or carrier for used in vehicle construction;

Figure 2 is a plan view of elongate metal tape for use in producing the carrier of Figure 1;

Figure 3 is a side view of the tape of Figure 2 showing how its thickness is reduced;

Figure 4 is a side view of one form of the apparatus;

Figure 5 is an enlarged view of part of the apparatus of Figure 4 for explaining its operation;

Figure 6 is a side view of a modified form of the apparatus of Figure 4; and

Figure 7 is a side view of a further modified form of the apparatus of Figure 4.

The metal carrier 5 (Figure 1) is of channel-shape and in this example is made up of U-shaped elements 6 joined integrally together by short connecting links 8. Using a known cross-head extrusion process, this channel-shaped carrier is incorporated into extruded flexible material such as plastics or rubber material to form a channel-shaped sealing, trimming or guiding strip for use in motor vehicle body construction. The metal carrier is formed by producing transverse slits at controlled positions in elongate metal strip or tape and then stretching the slit metal tape longitudinally so as to expand the slits into slots 9 (see Figure 1), these slots thus producing the U-shaped elements and the integral connecting links shown in Figure 1. Such a slitting and stretching process may be carried out continuously using a rotary machine. The metal carrier is then covered with extruded flexible material (plastics or rubber material, normally) using a cross-head extrusion process, either before or after the metal carrier has been formed into channel-shape. The metal tape used to produce the carrier in this way may be 0.5mm thick and 25mm wide, for example.

It will be understood that the process of slitting and stretching the metal tape to produce the carrier requires the metal tape to have certain characteristics. In particular, it must be capable of being stretched by the required amount, in order to convert the slits into slots, without fracturing. This in turn means that the process for producing the metal tape must not have work-hardened it, or otherwise affected it, so that the required stretching cannot be carried out easily and effectively. It

is found that it must be possible to stretch the metal tape (during the process of making the carrier) by at least 3%.

The process of making the metal tape involves the selection of metal tape having an initial width (w) and thickness (t) of, say 25mm and 3mm respectively (Figures 2 and 3). The metal tape manufacturer then subjects this tape to a thinning process which reduces its thickness from 3mm to 0.5mm (for example), as required by the sealing strip manufacturer. Figure 3 shows how this thinning process is carried out by the metal tape manufacturer. The metal tape 10 is passed longitudinally in the direction of the arrow A through two rollers 12 and 14 whose spacing is accurately controlled so as to reduce the thickness of the tape 10 as it passes through the bight of the rollers. The bight between the rollers is adjusted to reduce the thickness from 3mm to some lesser value between 3mm and the required final value of 0.5mm. The spacing between the rollers 10, 12 is then reduced further and the tape re-passed between them to effect a further reduction in thickness. This process is repeated again until the required final thickness of 0.5mm (in this example) is achieved.

This process of thinning the metal tape by passing it between the rollers 10, 12 tends to work-harden the metal. Unless steps are taken to rectify this, the resultant metal tape will be unsatisfactory for the sealing strip manufacturer; the work-hardening of the tape will make it impossible for it to be longitudinally stretched sufficiently and effectively - it will tend to break or rupture.

In order to reduce the effect of this work-hardening of the thinned metal tape, it is known to heat the thinned metal tape so as to relax its structure and eliminate or substantially reduce the work-hardening effect. Thus, a coil of the thinned metal tape may be heated to a predetermined temperature in an enclosure free of oxygen (to eliminate oxidation effects) However, such a heating process is expensive and time-consuming and therefore uneconomic.

Figure 4 illustrates one form of the apparatus and method according to the invention for thinning-down metal tape.

The apparatus comprises a support 20 for rotatably supporting a drum 22 of the metal tape 10. The metal tape is drawn from the drum 22 and passes through the thinning rollers 12, 14 (see Figure 3). Thence it passes partially around guide rollers 24, 26 and 28 to a receiving drum 30 which is rotatably mounted on a further support 32. The drum 30 is rotated by means of a suitable motor (not shown) and thus draws the tape in the direction of the arrow A. As already explained in connection with Figure 3, the spacing between the rollers 12 and 14 is adjusted to produce the required thinning-down of the metal of the tape. The metal tape may be passed one or more times through the apparatus. Thus, on completion of a first pass, the filled drum 30 is then removed from support 32 and placed on support 22 and the process repeated. This is carried on until the required final thickness is achieved.

Figure 5 explains the purpose and action of the additional guide rollers 24, 26 and 28. In Figure 5, rollers 24 and 26 are shown with the metal tape 10 passing around them, the thickness of the metal tape being exaggerated for explanatory purposes. As the metal tape passes around the rollers, the portion of the metal on the outside of the bends thus produced will be subjected to tension while the portion of the metal on the inside of the bends will be subjected to compression. In more detail, tension will take place over the regions indicated at 33 and 34, while compression will take place over the regions indicated at 36 and 38. Obviously, a similar effect will take place as the tape 10 passes around roller 28 (not shown in Figure 5). Because of the high speed with which the tape is passed around the rollers, this alternate tension and compression will warm the metal and thus relax its structure and eliminate or reduce any work-hardening effect caused by the thinning rollers 12, 14. In this way, the work-hardening is eliminated or reduced continuously as part of the thinning down process and without any need to carry out a separate heating step as explained above. A substantial economic improvement is thus produced.

In a modification shown in Figure 6 (in which the supports 20 and 32 and the drums 22 and 30 are omitted for clarity), the apparatus of Figure 4 is provided with a further set of guide rollers (24A, 26A, 28A) corresponding to the rollers 24, 26 and 28 but on the opposite side of the pair of thinning rollers 12, 14. The roller 26, 26A in each set of such guide rollers is made vertically movable in the directions of the arrows B. Thus each set of guide rollers can be brought into or out of operation by raising or lowering its respective guide roller 26, 26A. Thus, guide roller 26A is lowered substantially towards the rollers 24A and 28A (as shown in the Figure) while the tape passes in the direction of arrow A so that the tension and compression effects described with reference to Figure 5 are produced only by the set of guide rollers 24, 26, 28. After the tape 10 has completed its movement in the direction of the arrow A, the set of guide rollers 24, 26 and 28 shown in that Figure is put out of operation (by lowering the roller 26). The other set of guide rollers is then brought into operation by raising its guide roller 26A. The tape is then passed in the opposite direction back to the drum 22 (by means of an appropriate drive motor not shown). In this way, therefore, the apparatus of Figure 4 is made reversible.

Figure 7 illustrates how the apparatus of Figure 4 can be modified so as to be incorporated as part of the apparatus for producing the sealing strip. Parts in Figure 7 corresponding to parts in Figure 4 are correspondingly referenced. In this case, the set of guide rollers 24, 26, 28 is augmented by two further guide rollers 40, 42 to provide an increased relaxation effect on the metal of the tape after it has been passed through the thinning rollers 12, 14. The metal tape is then passed directly into the apparatus (indicated diagrammatically at 44) for slitting and stretching the tape to produce the metal carrier and then embedding it in the extruded

material. In this way, the metal tape with its initial thickness (of, say, 3mm) is thinned down to the required final thickness (of 0.5mm, say), converted into a metal carrier and covered with the extruded material, all in a continuous process.

The apparatus of Figure 4 or Figure 6 can be modified by incorporating the additional rollers 40,42, in the or each set of guide rollers.

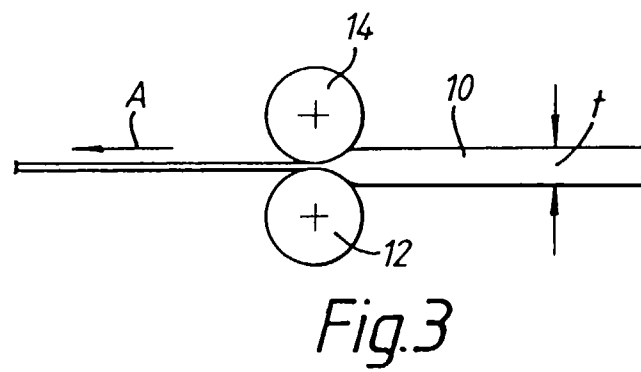
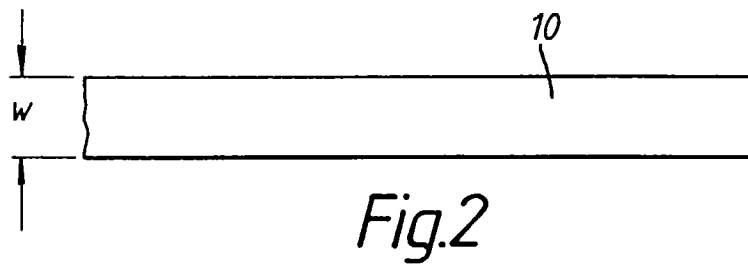
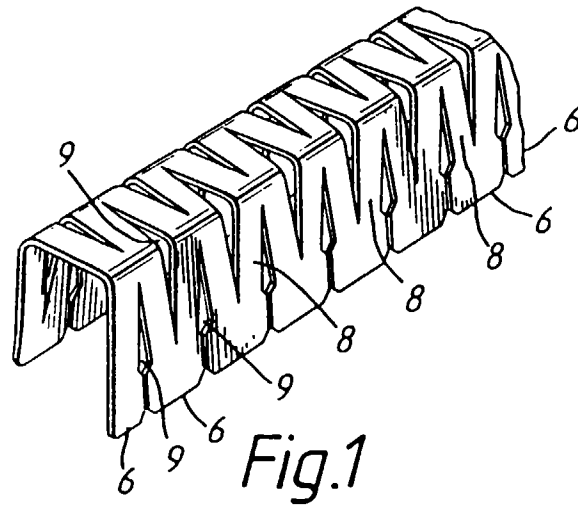
Tests have shown that passing the metal tape around the guide rollers in the manner explained with reference to Figures 4 to 7 can increase by as much as 40% the extent to which the metal tape can be elongated or stretched during the process of manufacturing the metal carrier.

However, although the apparatus and methods described above have been described with reference to producing metal tape for use in manufacturing metal carriers for sealing, trimming or guiding strips, the apparatus and methods are not of course limited to such an application. The apparatus and methods can be used for producing elongate metal strip for any other desired application.

Claims

1. A method of processing elongate metal strips (10) to reduce work-hardening of the strip (10), comprising the step of increasing the temperature of the strip by a predetermined amount to relax its structure, characterised in that the temperature increasing step comprises the step of transporting the metal strip (10) longitudinally while subjecting it to successive changes in angular direction in opposite senses.
2. A method according to claim 1, characterised in that the step of subjecting the strip (10) to the said changes in angular direction comprises the steps of feeding the strip (10) longitudinally in a first predetermined direction, changing the first direction by a predetermined angular extent (24) and in a first predetermined angular sense into a second direction and then changing the second direction by a predetermined angular extent (26) and in a second predetermined angular sense opposite to the first predetermined angular sense into a third direction, the angular extents and the rate of change of angular sense being such that the required increase in temperature is achieved.
3. A method according to claim 2, characterised by the step of receiving the strip (10) in the third direction and changing its direction by a predetermined angular extent (28) and in the first angular sense into a fourth direction.
4. A method according to claim 3, characterised in that the first and fourth directions are substantially the same.
5. A method according to any preceding claim, characterised in that the said step of transporting the metal strip (10) longitudinally includes the step of passing the metal strip (10) longitudinally through the bight between two rollers (12,14) to reduce the thickness of the metal strip (10) from an initial thickness to a predetermined lesser thickness, and in that the said step of subjecting the tape to successive changes in angular direction in the opposite senses increases the temperature of the strip sufficiently to offset the effects of the thickness reduction of the strip on the elongation capability of the strip.
6. A method for producing elongate metal strip (10) of a predetermined thickness, comprising the step of passing metal strips (10) of initial thickness greater than the predetermined thickness longitudinally through the bight between two rollers (12,14) which is less than the initial thickness whereby to thin-down the initial thickness of the strip to the predetermined thickness, and increasing the temperature of the strip by a predetermined amount to reduce work-hardening of the strip characterised in that the temperature increasing step comprises the step of subjecting the thinned-down strip (10) to successive changes in direction of opposite angular senses at such rates of change and with such extent of change as to heat the metal of the strip (10) sufficiently to offset the effect of the thickness reduction of the strip (10) on its elongation capability.
7. A method according to any preceding claim, characterised by the further step of producing predetermined transverse slits in the strip (10) and thereafter elongating the strip (10) to convert the slits into slots (9), whereby to produce a longitudinal metal reinforcement for a sealing, trimming or guiding strip.
8. Apparatus for processing an elongate metal strip (10) to reduce work-hardening of the strip (10), comprising transporting means (12,14,24,26,28) for transporting the metal strip (10) along a predetermined path, and temperature-increasing means (24,26,28) for increasing the temperature of the strip by a predetermined amount to relax the structure of the strip (10) and thereby to reduce work-hardening of the strip (10), characterised in that the temperature-increasing means comprises change of direction means (24,26) in the predetermined path defining at least first and second successive changes in angular direction in opposite senses, the changes in direction being of such rate and of such extent as to increase the temperature of the metal of the strip (10) by the predetermined amount.

9. Apparatus according to claim 8, characterised in that the change of direction means (24,26,28) also defines a third change of angular direction of opposite sense to the second change of angular direction.
10. Apparatus according to claim 8 or 9, characterised in that each change of direction means comprises a respective guide roller (24,26,28).
11. Apparatus according to any one of claims 8 to 10, characterised by a pair of processing rollers (12,14) mounted in the predetermined path upstream of the change of direction means (24,26,28) with reference to the first predetermined direction, the processing rollers (12,14) being mounted on opposite sides of the path so that the path passes through the bight between them, the spacing between the pair of rollers (12,14) being less than the thickness of the strip (10) upstream of the processing rollers (12,14) so that the thickness of the strip (10) is reduced in passing between them, the said predetermined amount of increase in temperature being sufficient to offset the effect of the thickness reduction on the elongation capability of the metal strip (10).
12. Apparatus according to any one of claims 8 to 10, characterised by further change of direction means (24A,26A,28A) corresponding to the first-mentioned change of direction means (24,26,28), the further change of direction means (24A,26A,28A) being mounted in the predetermined path, with the pair of processing rollers (12,14) between them, each change of direction means (24,26,28;24A,26A,28A) including control means for selectively bringing it into and out of operation, and means for transporting the metal strip (10) along the predetermined path in the direction opposite to the first predetermined direction, the control means comprising means bringing only the first-mentioned change of direction means (24,26,28) into operation when the strip is moving in the first predetermined direction and bringing only the second change of direction means (24A,26A,28A) into operation only when the strip (10) is moving in the opposite direction.
13. Apparatus according to claim 12, characterised by a pair of processing rollers (12,14) mounted in the predetermined path between the two change of direction means (24,26,28;24A,26A,28A), the processing rollers (12,14) being mounted on opposite sides of the path so that the path passes through the bight between them, the spacing between the pair of rollers (12,14) being less than the thickness of the strip (10) upstream of the processing rollers (12,14) according to the direction of movement of the strip (10) so that the thickness of the strip (10) is reduced in passing between them, the said predetermined amount of increase in temperature being sufficient to offset the effect of the thickness reduction on the elongation capability of the metal strip (10).
14. Apparatus according to any one of claims 8 to 11, characterised by forming means (44) positioned downstream of the change of direction means (24,26,28) for forming the strip (10) to convert it into a metal carrier for a sealing, trimming or guiding strip.
15. Apparatus according to claim 14, characterised in that the forming means (44) comprises means for producing predetermined transverse slits in the metal strip (10) and then stretching the strip (10) to convert the slits into slots (9).



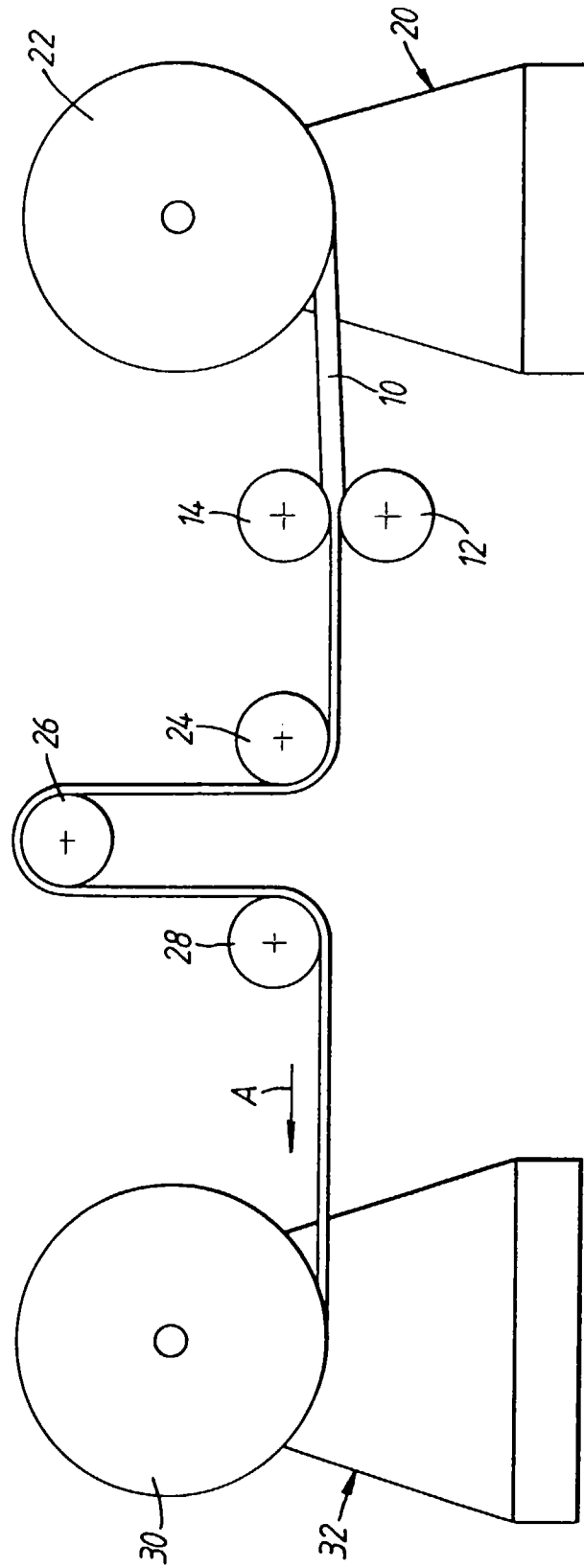


Fig.4

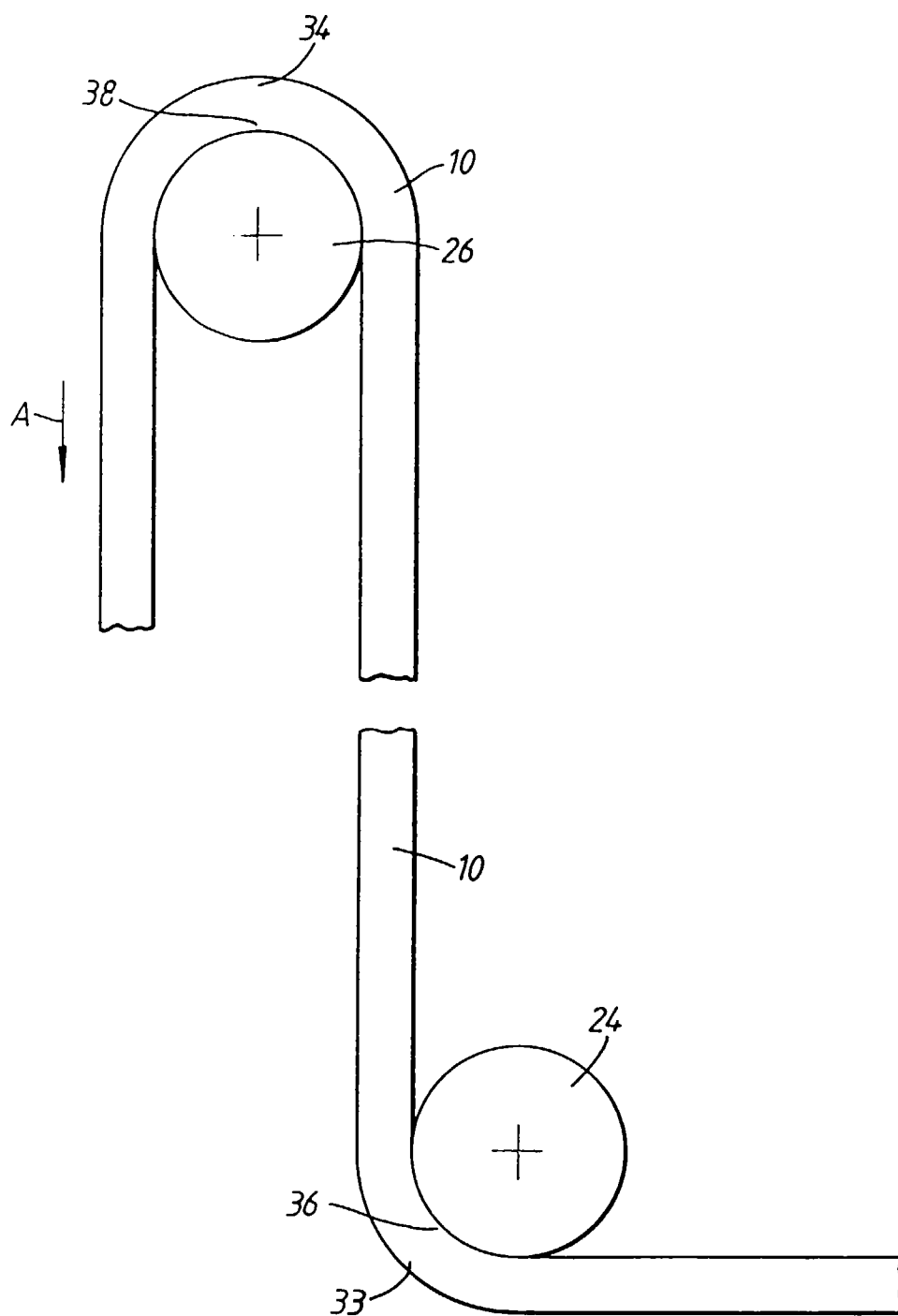
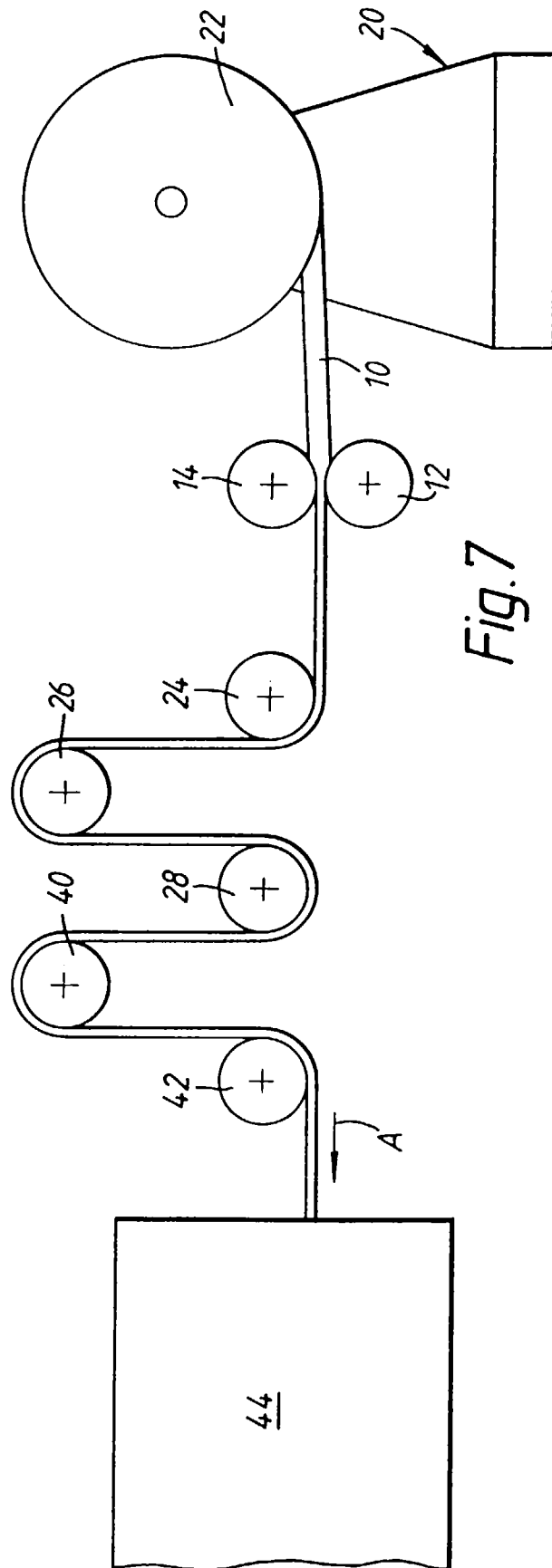
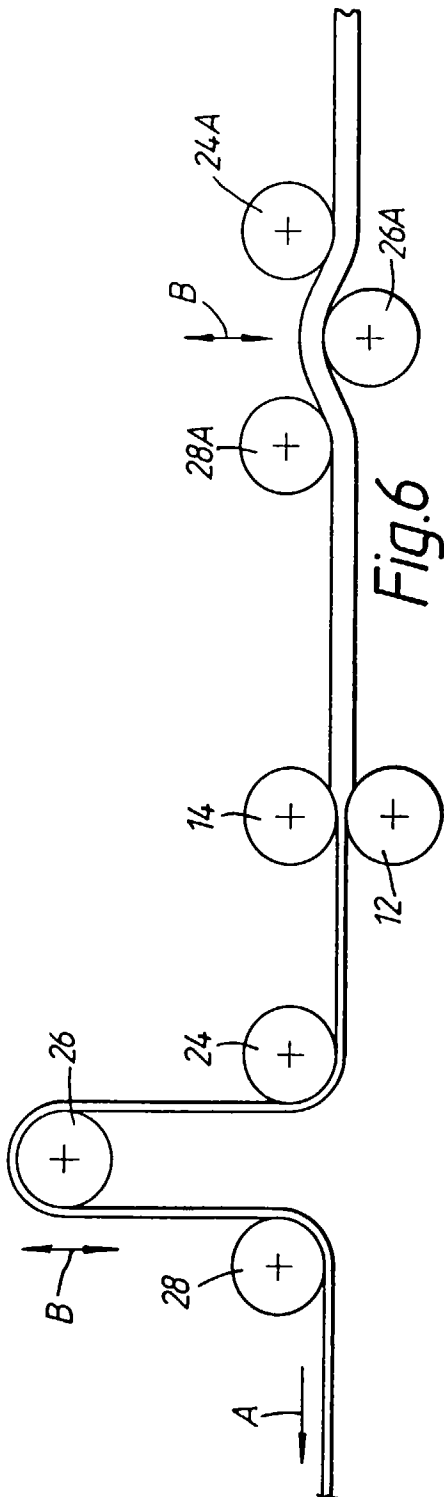


Fig.5





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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 7976

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 3 958 439 A (KAWAGUCHI KIYOSHI ET AL) 25 May 1976 * the whole document *	1-6,8-11	C21D8/02 B21B45/00 B21B41/08
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A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 207 (M-327), 21 September 1984 & JP 59 094504 A (HITACHI SEISAKUSHO KK), 31 May 1984, * abstract *	12,13	TECHNICAL FIELDS SEARCHED (Int.Cl.6) C21D B21B B21D
A	---		
A	US 3 429 164 A (OGANOWSKI KASIMIR ET AL) 25 February 1969 -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14 April 1997	Examiner Gerard, O
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