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(54) CONVEYOR BELT WITH CORRUGATED SIDEWALLS

(71) I, KARL HARTMANN, a citizen of the Federal Republic of Germany, of Baerler Strasse 17, 4130 Moers, Federal Republic of Germany, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement.

The present invention relates to an endless flexible conveyor belt of the type which is of channel-shaped cross-section, having a bottom wall and side walls which project from one side of the bottom wall along its opposite edges.

Conventional endless conveyor belts are, in their simplest execution, endless strips of flexible material which are trained about reversing rollers. There are many types of materials which can not be conveyed on these belts, because they drop off the lateral edges of the belt.

To avoid this problem it has been proposed to utilize an endless conveyor belt of channel-shaped cross-section, having the usual strip-like load-supporting bottom wall which is usually smooth and is trained about smooth drum-shaped reversing rollers, and sidewalls which project perpendicularly or obliquely to the face of the bottom wall. This type of belt, called herein a box belt, is especially advantageous for applications where material is to be transported between two or more levels, e.g. a higher level and a lower level. In cases where bulk material has to be transported up inclines of more than about 25°, it is known to provide the belts additionally with profiled surfaces within their cross-sectional interiors. For inclines of more than about 27°, the smooth supporting surface of the bottom wall of the belt must be provided with cleats which in known manner extend at right angles to the running direction of the belt, in order to prevent the bulk material from falling backwards.

However, when a box belt is deflected from one level to another level, it is necessary that the sidewalls be able to accommodate themselves to the change of direction which takes place at each point of deflection, i.e. depending upon the direction of deflection the sidewalls must be able to longitudinally extend or undergo compression. To facilitate this it has been proposed to corrugate the sidewalls transversely to their lengths, so that the resulting folds are either pulled apart (i.e. extended) or squeezed together (i.e. compressed) by deflection of the belt, depending upon the direction of the deflection. It will be evident that the degree of extension or compression is the greater the higher the sidewalls are; the reason for this is that an increase in the height of the sidewalls also results in increased spacing of the free outer edges of the sidewalls from the neutral bending zone of the belt which in known conveyor box belts lies within the bottom wall of the belt.

This, in turn, dictates the deflection radius required for deflecting the belt where the belt changes direction. For example, a known conveyor box belt of the type under discussion, having sidewalls of about 300 mm height, requires a deflection radius of about 750 mm to be deflected from the horizontal into the vertical. This translates into a need for deflecting drums having a diameter of 1500 mm. When this belt is deflected in one direction around these drums the sidewalls are longitudinally compressed; the limit of possible compression is evidently reached when the adjacent folds of the corrugations moves into surface-to-surface abutment with one another. This is of course, generally true of all corrugated sidewalls, whether high or low, which are required to continue to project substantially perpendicular to the bottom wall at all times, i.e. even during deflection. The use of sidewalls which are so profiled that they fold over laterally during deflection of the conveyor belt has been proposed, but has been almost completely discontinued in the industry because of their susceptibility to damage and their low ability to retain conveyed materials against spilling.

Conversely, during deflection of the belt from the upper run to the lower run or vice versa a longitudinal extension of the sidewalls takes place. The folds forming the corrugations open up, but this is of course limited to the degree of extension achieved by the time the sidewalls have become completely flat at their free outer edges, i.e. until the folds have there been unfolded fully. The degree of extension is therefore limited by the amount of sidewall material which is "stored" in the folds. Evidently, additional material could be "stored" in this manner by increasing the depth of the corrugations, i.e. the depth of the folds in the widthwise direction of the belt. This, however, results in a corresponding decrease of the available load-carrying space of the belt; if one seeks to maintain that space unchanged, then the only alternative solution is to make the overall width of the belt correspondingly greater. A decrease in the load-carrying space is evidently undesirable whereas an increase in belt width is often unacceptable because of space limitations at the point of use; also, belt widths are generally fixed by industrial and/or government norms.

The corrugating of sidewalls is also governed by other considerations. Thus, if the corrugated sidewall projects from the bottom wall by a distance greater than about 160 mm, it must be made specially resistant to folding-over in the lateral direction. Until now this was achieved by simply widening the corrugations in longitudinal direction of the sidewall, i.e. by making them wider in that direction than would otherwise be the case. However, this leads to deeper folds and a concomitant loss of carrying capacity. Moreover, conveyed matter tends to settle in such deep folds and, after unloading of the belt, travels along in the return run and becomes scattered during such travel.

In my prior British Patent No. 1,124,550 I have attempted to counteract the above problem by filling the sidewall folds at least partially with an elastic material to obtain improved stability and a better self-cleaning effect of the folds. However, I have found it to be a disadvantage of that construction that greater amounts of material are required to construct the belt and that the overall belt weight is increased. Moreover, the lateral sidewall stability can be economically improved only up to a sidewall height of about 200 mm in that manner.

The ability of a corrugated conveyor sidewall to undergo compression and extension in respect of the deflection radius for the belt, is largely a function of the geometry of the corrugation. The known solutions are not satisfactory, especially in the case of conveyor belts intended for large-volume conveying applications.

Also, known box belts of the corrugated sidewall type exhibit markedly poor roll performance, which is defined as the ability of the sidewalls to be supported and roll on supporting rollers located beneath the return run of the conveyor. Conventionally, the free edges of the folds of the sidewalls are supported on cylindrical rollers as they travel in the return run but, because of the too great distance from one fold to the next and the too great depth of the folds, the sidewalls tend to flex in the direction opposite to the movement of the return run. This results from the point contact pressure transmission and leads to increasing destruction of the originally smooth contact surfaces on the sidewalls. As the damage proceeds the contact surfaces become progressively more uneven and this, in turn, leads to increasing damage to the support rollers. Ultimately this causes vibrations which are transmitted to the entire conveying installation. Short of using very expensive auxiliary equipment to counter these problems, there is nothing that can be done with these known belts to avoid them.

Another disadvantage of these known belts is that the construction principles employed often make it impossible to produce corrugated-sidewall conveyors for special conveying applications. Yet, the increasing use of corrugated-sidewall conveyors has opened up many new fields of applications and industry is constantly asking the belt manufacturers to provide such belts for new conveying applications. For example, it is currently being requested that corrugated-sidewall belts be furnished which have a width of 4000 mm and a sidewall height of 1000 mm; these belts are, however, required for use in situations where little vertical space is available so that the large 1200 mm-diameter reversing drums ordinarily required cannot be used. The only possible compromise is to use smaller reversing drums having a diameter of only about 400 mm. Moreover, such belts have a high inherent weight which makes it impossible to support the return run on rollers, requiring instead separate supporting belts for the return run. These, in turn, require additional vertical space for their installation.

It can be concluded, then, that the ability of the corrugated sidewalls to be compressed and to extend is the factor which governs the diameter of deflecting drums that can be used, the deflection radius required for deflection of the belt from one level to another, and the amount of vertical space required for installation and operation of the belt. The service life of the belt is largely dependent on the corrugation profile of the sidewalls and the ability of the corrugated sidewalls to resist deformation resulting from pressures acting upon them from various directions.

It is a general object of the invention to overcome these disadvantages of these known corrugated-sidewall box belts.

According to the present invention in an endless flexible conveyor belt comprising an elongate flexible bottom wall and a pair of transversely-corrugated elongate flexible side walls projecting from the bottom wall on one side thereof, the bottom wall and the side walls together defining a material- accommodating channel extending lengthwise of the belt, each side wall has a series of transverse corrugations distributed along its length, whereof each complete corrugation comprises a pair of oppositely-directed major wave formations, referred to as major folds, at least one of which major folds has one or a maximum of two minor wave formations, referred to as minor folds, incorporated in it in the region of its peak, each of the major and minor folds in those portions of the belt which are longitudinally-straight at any given time being of substantially-uniform cross-sectional shape and size over that part of the respective side wall which extends from the free outer edge of the side wall towards the bottom wall over the greater part of the full height of the side wall.

The minor folds may have their peaks directed either inwardly towards or outwardly away from the material-accomodating channel of the belt, or some in the one direction and some in the other direction.

A belt whose side walls have minor folds incorporated in the major folds in accordance with the present invention, may have improved capability for extension (stretching) of its side walls, and this makes it possible to deflect the belt through small deflection radii and about small-diameter reversing drums.

Due to the provision in the present invention of both major and minor folds, it is possible to store in each complete corrugation a sidewall length corresponding to the length which in the prior art is stored in a single complete corrugation whilst at the same time, with appropriately arranged major-minor fold combinations, the maximum lateral (i.e. widthwise of the belt) depth of corrugation may be made substantially smaller than would be the case with corrugations having only major folds, as in the known belts referred to. Further, the sidewalls can be so constructed that, depending on their height, their compressibility is improved by up to 30% over such known belts. This permits the use of rather high sidewalls but yet makes possible the use of small deflecting radii when the belt is deflected from one level to another level.

Insofar as the return run on the belt is concerned, the provision of the uniform-section minor folds substantially improves the roll behaviour of the sidewalls over supporting rolls; it also increases the wear resistance of the sidewalls. The number of areas where flexing occurs in the sidewalls may be increased by the invention, and this may result in an improved self-cleaning ability of the belt, and this without the disadvantageous expedient, referred to previously, of filling up the wave troughs of the corrugations, neither those within the major folds nor those within the minor folds. If desired with respect to the behaviour during travel in the return run, the sidewalls may be made wider than previously customary so as to improve their stability in all directions, increase their resistance to deformation at the head of the corrugations, and improve their roll behaviour.

The invention may be carried into practice in various ways, but certain specific embodiments thereof will now be described by way of example only and with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic top-plan view showing part of one corrugated sidewall of a known form of the conveyor box belt not embodying the present invention;

Figure 2 is a fragmentary side view, showing a portion of a return run of the known conveyor belt of Figure 1;

Figure 3 is a fragmentary side view, illustrating the behaviour of a sidewall of the belt of Figures 1 and 2 in the region where the belt is deflected;

Figure 4 is a fragmentary perspective of a conveyor belt embodying the invention;

Figure 5 is a diagrammatic top plan view showing a part of one sidewall of the belt of Figure 4, and illustrating a currently preferred type of corrugation, as seen in the portion of the belt which is straight and flat;

Figure 6 is a view similar to Figure 5, but showing the corrugation in longitudinally compressed condition, corresponding to a deflection of the belt;

Figure 7 is a view similar to Figure 5 but showing a second embodiment of the invention;

Figure 8 id a diagrammatic top plan view showing a part of one side wall of a third embodiment of the invention;

Figure 9 is a view similar to Figure 8 but illustrating a fourth embodiment;

Figure 10 is a schematic top-plan view showing one side wall of a belt incorporating a modification of the embodiment of Figure 5;

Figure 11 is a view similar to Figure 10 but illustrating a further modification; and

Figure 12 is a view similar to Figure 11 but illustrating a modification of the embodiment shown in Figure 7.

In Figure 1 there is illustrated a top view of the outer edge of a corrugated sidewall of a known type of belt, in which all of the corrugation folds are uniform, both relative to one another and also as to their depth relative to a centre line M. That centre line M, it should be understood, extends parallel to the longitudinal centre line of the conveyor belt. This construction has disadvantages which have been outlined hereinbefore.

Figure 2 shows the known conveyor belt 1 in side view. In particular, it illustrates a portion of the return run where the sidewalls 3 (one shown) extend downwardly from the bottom wall 2 (i.e. the actual load-supporting portion of the belt) and the free edges 300 of the corrugated sidewalls are rollingly supported on idler rollers 40 (one shown). The direction of movement of the return run is indicated by the arrow, and the undesirable deflection of the sidewall corrugations in direction counter to the advancement is clearly evident.

Figure 3 shows, for purposes of further explanation, a portion of the conveyor belt 1 where the bottom wall 2 is deflected out of the horizontal plane of movement X into an inclined plane of movement Z so that the conveyor 1 can bridge two operating levels. The height of the corrugated sidewalls 3 (one shown) is identified by the reference character Y.

The deflection radius R, through which the belt 1 is deflected from the plane X into the plane Z, is determined by the height Y of the sidewalls 3 as well as -- and this is important -- the degree to which the corrugations of the sidewalls can be compressed during deflection. The compression which takes place is clearly illustrated in the Figure. Of course, if the deflection were the reverse of that illustrated, that is to say if the belt 1 were to be deflected from the plane X downwardly into an inclined plane Z, then it would be the degree of extensibility (stretch) of the corrugations of sidewalls 3 that would be important.

Conveyor belts constructed according to the invention, as for example explained below with reference to Figures 4 - 12, permit a smaller than normal deflection radius R to be employed -- and hence require deflecting or reversing drums of smaller diameter -- than those required for the prior art.

Figure 4 illustrates the general appearance of one construction of a conveyor belt 1 embodying the present invention. It has a bottom wall 2 (i.e. a strip-shaped material-supporting portion) which as a rule is smooth and from the material-supporting surface 2*a* of which there rise two sidewalls 3 which are secured at their lower edges to the surface 2*a* near the edge portions 2*b*, 2*c* thereof. There is a local thickening of the material of each side wall in the region of its lower edge. As shown in Figure 4, the local thickening advantageously starts from zero at a region whose distance from the bottom of the side wall is approximately 20% to 30% of the total height of the side wall, and broadens downwardly towards the bottom wall, merging smoothly into an integral flange 4 by which the side wall is secured to the bottom wall 2, and thereby avoiding the formation of a sharp-edge cavity in which bulk material might stick. The securing can be effected by adhesive bonding, cross-linking, vulcanizing or by mechanical means.

The sidewalls 3 are corrugated in a particular manner, in accordance with the present invention. The corrugations are identified by the reference numeral 3*a* in Figure 4 and the free outer edges of the sidewalls 3 are designated by the reference numeral 300.

Figures 5 and 6 show a currently preferred form of the sidewall corrugations of the belt of Figure 4. One sidewall 3 is here identified with reference numeral 31 and its longitudinal direction indicated by the arrow L. Character I identifies the interior of the belt, i.e. the load-receiving space between the two sidewalls, and character 0 refers to the outside. However, insofar as the deflection of the folds towards the inside and the outside is concerned, this relationship could also be reversed, i.e. the advantages of the invention would obtain even if the locations of the inside and the outside were reversed.

Each sidewall 3 (only one shown at 31) has a series of cylindrical-repeated transverse corrugations MC distributed along its length; each of these corrugations MC is composed of two half-wave portions 5 and 6 called major folds of which the portions 5 is directed outwardly from the interior I of the belt and the portion 6 is directed inwardly into the interior I. The depth (in direction normal to the elongation L, i.e. widthwise of the belt) of the main corrugations MC is determined by the distance *a* between the peaks of the outer major folds 5 and the peaks of the inner major folds 6. In this embodiment each of the major folds 5 and 6 of each of the corrugations MC is augmented in its peak region by an auxiliary or minor fold 7 which is deflected in direction towards the longitudinal centre line M of the main corrugation MC. The depth of the minor folds is designated as *b* and corresponds to approximately one-half of the depth *a*.

As is clearly shown in Figure 4, in the portion of the belt where the bottom wall 2 is straight and flat, each of the major folds 5 and 6, and also each of the minor folds 7, is of substantially uniform cross-sectional shape and size over the majority of its height from its free edge 300, down to the local thickening above the flange 4.

Due to the presence of the minor folds 7 each corrugation MC stores a length of sidewall 31 which corresponds to the fully extended length of the two major folds 5 and 6 and the two minor folds 7. In other words, a greater length of sidewall 31 is stored than would be possible without the presence of minor folds 7, assuming that the depth of the corrugations MC were to remain unchanged. The type of corrugation shown in Figure 5 makes it possible to store a substantial length of sidewall 31 in each corrugation MC but yet to have only a relatively small transverse depth *a* while obtaining full ability of the sidewalls to extend and compress.

The compression state is shown in Figure 6 for explanation. It will be noted that the flanks 5*a* of the outer major folds 5, and also the flanks 6*a* of the inner major folds 6, can be moved into abutment to one side of the space taken up by the respective minor fold 7, so that less space is required despite the greater storage capability. Also, the folds 7 substantially improve the stability of the walls 31 against pressures from any and all directions, due to the increased number of abutment points per corrugation, and this is especially advantageous in the case of pressures acting on the flanks of corrugations in high sidewalls.

Further, due to the presence of the minor folds 7 the number of flexing points of the sidewalls is increased, and this enhances the self-cleaning ability of these walls. A deflection of the (more resistant) sidewalls in or opposite to the direction of travel, especially in the return run (see Figure 2), is less readily possible than with the known belts, and the resistance of the sidewalls to deformation is increased.

Figure 7 shows an embodiment which is similar to that of Figures 4 to 6, except that only the outer major fold portion 5 of each of the corrugations MC of the sidewall 32 is provided with a minor fold 7 which is deflected in the direction towards the centre line M. The inner major folds 6 do not have minor folds. This configuration is especially suitable for applications where it is the longitudinal extensibility (rather than compressibility) of the sidewalls 32 which is of particular importance, and where a very good self-cleaning effect is required. With a view to this improved self-cleaning effect it is advantageous that the convex side 8*a* of each inner major fold 6 faces the inside I whereas the concave side 8*b* of the fold faces outwardly and does not come in contact with the conveyed material.

In Figure 8 there is illustrated an embodiment wherein the sidewall 33 again has corrugations MC (part of one shown) whose major folds 5 and 6 are each formed with a minor fold 7. Here, the thickness of the wall 33 is reduced at the peak region 71 of each of the minor folds 7. If for example, the wall thickness is about 6 mm elsewhere, the thickness in region 71 would be about 4 mm, e.g. about one-third less, although this ratio is not to be considered binding but is exemplary only. The depth *b*' of the folds 7 is equal to only about one-fourth of the depth *a*' of the corrugation MC.

The reason for the reduced wall thickness will be evident. The force required to fully stretch (i.e. extend) the wall 33 to flat or substantially flat condition must be greater in the region of the minor folds 7 than elsewhere. Therefore, if the wall thickness is reduced as described, then the stretching (as the belt passes about a deflecting or reversing drum) will be more uniform.

The embodiment of Figure 9 is a modification of the one in Figure 8, from which it differs in that the major folds 5 and 6 of each corrugation MC (part of one shown) of the sidewall 34 are both provided with two minor folds 7 each, the wall thickness of sidewall 34 being reduced throughout the area in which the folds 7 are formed.

Figure 10 shows an embodiment for special applications. For example, belts which have a width of 3 or 4 metres and sidewalls having a height of about 1 metre, are so heavy that in the return run they must be supported by supporting belts or straps. This requires corrugations of great transverse depth; however, corrugations having this characteristic tend to accumulate substantial amounts of conveyed material which settles in them.

The embodiment in Figure 10 counteracts this by providing each sidewall 35 with the illustrated main corrugations MC and minor folds 7, the minor folds 7 being respectively directed outwardly from the major folds 5 and inwardly from the major folds 6 in which they are respectively formed, as shown. The relative depths are indicated at *a* and *b*. In this embodiment the openness of the flexing points is greatly increased so that the accumulation of conveyed material is avoided or at least substantially reduced.

Figure 11 shows an embodiment wherein the sidewall 36 is provided with corrugations MC and with minor folds 7 of the arrangement and shape illustrated, i.e. with the minor folds 7 all directed in the same inward direction. This embodiment is especially advantageous if high extensibility and compressibility are needed in conjunction with improved sidewall stability, but if relatively small transverse corrugation depth is desired.

Figure 12, finally, illustrates still a further embodiment in which only the outer main folds 5 of the corrugations MC of the sidewall 37 are provided with minor folds 7, which extend in direction outwardly. This embodiment is characterised by excellent self-cleaning ability and extensibility but does not offer such improved compressibility.

No details are provided concerning the materials used for the belts, including the sidewalls, since such materials are conventional in this art and the particular type of material does not form part of the invention. In other words, all materials conventionally used for flexible endless conveyor belts can be employed. Of course, the belt may also be reinforced, e.g. with textile material, metal fabrics, cords, fibrous silver or natural or synthetic floc mixed in with the belt material.

Moreover, the invention is not restricted to the particular box belt cross-sections shown in the drawings, nor to exclusively smooth belt surfaces. Other known features of the technique of corrugated sidewalls well-known up to now are also applicable for the sidewalls of the belts of this invention.

WHAT I CLAIM IS:-

1. An endless flexible conveyor belt comprising an elongate flexible bottom wall and a pair of transversely-corrugated elongate flexible side walls projecting from the bottom wall on one side thereof, the bottom wall and the side walls together defining a material-accommodating channel extending lengthwise of the belt, in which each side wall has a series of transverse corrugations distributed along its length, whereof each complete corrugation comprises a pair of oppositely-directed major wave formations, referred to as minor folds, incorporated in it in region of its peak, each of the major and minor folds in those portions of the belt which are longitudinally straight at any given time being of substantially-uniform cross-sectional shape and size in that part of the respective side wall which extends from the free outer edge of the side wall towards the bottom wall over the greater part of the height of the side wall.

2. A conveyor belt as defined in Claim 1, wherein the side walls are perpendicular to the bottom wall of the belt.

3. A conveyor belt as defined in Claim 1, wherein the side walls are oblique to the bottom wall of the belt.

4. A conveyor belt as defined in any one of Claims 1 to 3, wherein at least one of the minor folds in each corrugation is formed with its peak directed inwardly towards the material-accommodating channel of the belt.

5. A conveyor belt as defined in any one of Claims 1 to 4, wherein at least one of the minor folds in each corrugation is formed with its peak directed outwardly away from the material-accommodating channel of the belt.

6. A conveyor belt as claimed in any one of Claims 1 to 5, in which each corrugation has in one of its major folds a minor fold whose peak is directed inwardly towards the material-accommodating channel and has in the other of its major folds a minor fold whose peak is directed outwardly away from the said channel.

7. A conveyor belt as claimed in any one of Claims 1 to 6, in which in each corrugation there is a major fold incorporating a minor fold which is directed oppositely to the major fold.

8. A conveyor belt as claimed in any one of Claims 1 to 7, in which in each corrugation there is a major fold incorporating a minor fold which is directed in the same direction as that major fold.

9. A conveyor belt as defined in any one of Claims 1 to 8 wherein each corrugation has two minor folds formed side by side in at least one of its major folds, both these minor folds being directed in the same direction.

10. A conveyor belt as defined in any one of Claims 1 to 9, wherein the depth of each minor fold is smaller than that of the respective major fold.

11. A conveyor belt as defined in Claim 10, wherein the depth of each minor fold is less than half the depth of the respective major fold.

12. A conveyor belt as defined in any one of Claims 1 to 11, wherein the thickness of each sidewall is non-uniform along the length of that sidewall.

13. A conveyor belt as defined in Claim 12, wherein the thickness of each sidewall at least in the free edge thereof is less where the minor folds are formed than elsewhere in that sidewall.

14. A conveyor belt as defined in Claim 13, wherein the thickness of each sidewall is less in the crest region of each minor fold than elsewhere in the sidewall.

15. A conveyor belt as claimed in any of the preceding claims wherein each side wall is formed at its edge adjacent to the bottom wall with an integral flange by which it is joined to the bottom wall and is further formed with a local thickening adjacent to the flange, which thickening merges smoothly into the flange.

16. A conveyor belt substantially as specifically described herein with reference to Figure 4, or to Figures 5 and 6, or to Figure 7, of the accompanying drawings.

17. A conveyor belt substantially as specifically described herein with reference to any one of Figures 8 to 12 of the accompanying drawings.

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Chartered Patent Agents,
Agents for the Applicants.

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1567074 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1 PRIOR ART

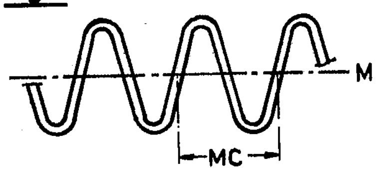

Fig. 2 PRIOR ART

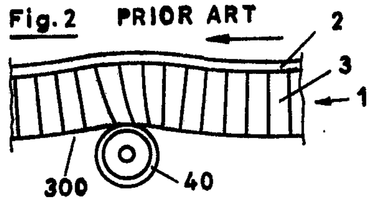

Fig. 3

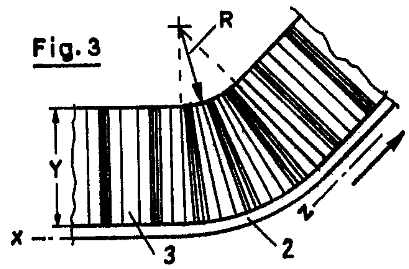

Fig. 4

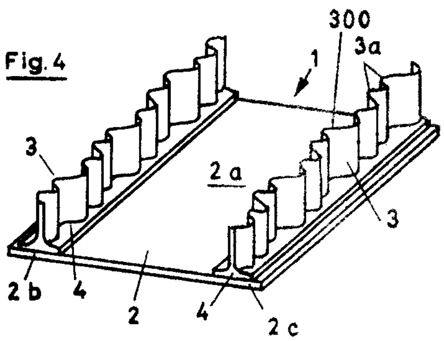

Fig. 5

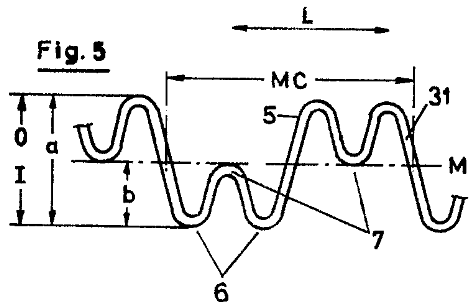

Fig. 6

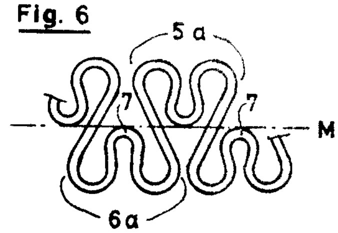

Fig. 7

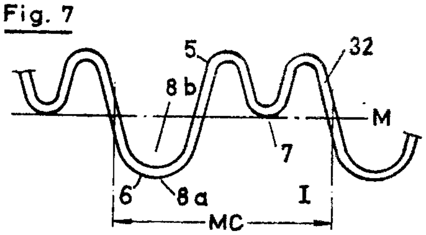

Fig. 8

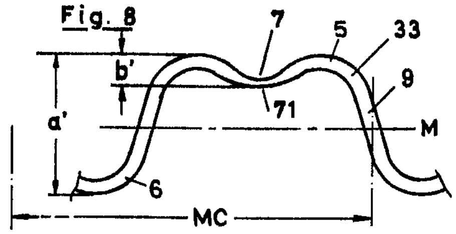

Fig. 9

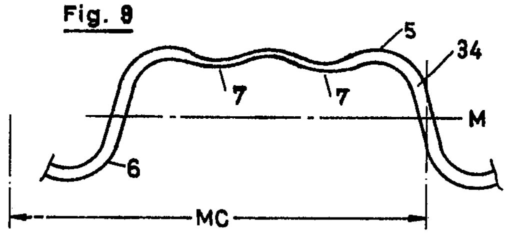

Fig. 10

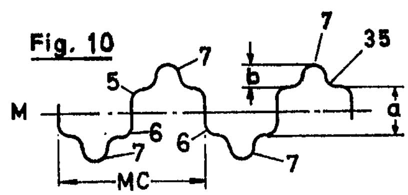

Fig. 11

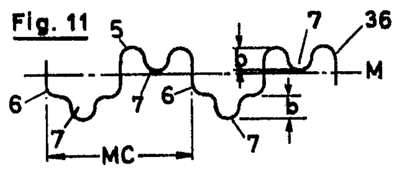

Fig. 12