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(54) METHOD AND APPARATUS FOR MAKING FLATTENED EXPANDED STRIP

(71) We, ELTRA CORPORATION, of 2 Pennsylvania Plaza, New York, State of New York, one of the United States of America, a Corporation organised under the Laws of the State of New York, United States of America, do hereby declare the invention, for which we pray a patent may be granted to us, 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 apparatus for and a method of making expanded strip particularly for use in fabricating plates for lead-acid secondary batteries. Lead strip is expanded into a non-planar shape with two mesh portions divided by a longitudinally extending unexpanded portion. The expanded strip is then flattened and smoothed from the non-planar shape and reduced in thickness, for use in the manufacture of electric storage batteries, and more specifically the making of expanded lead strip for use in the fabrication of positive and negative plates for secondary batteries.

One of the problems that is encountered when using expanded lead strip is obtaining expanded lead strip which is substantially flat. A further problem is that in the course of flattening the expanded lead strip there is a tendency for the individual cells of the mesh portions thereof to become distorted and non-uniform.

The principal object of the present invention is to make expanded lead strip which has uniform and undistorted cells forming the mesh portions and which is substantially flat. This can be obtained without the requirement of a pair of forming rollers, one of which is an embossed roller with a plurality of truncated pyramidal projections to stretch the reticulated portions of the strip to the desired size.

It often is desirable to reduce the thickness of the mesh portions of the expanded strip, but such reduction tends to cause the expanded strip to become wavy which is undesirable.

A further object of the invention is to reduce the thickness of the mesh portions without inducing any undulations into the expanded strip.

While lead strip will be referred to throughout, it should be understood that lead alloys, such as lead-antimony and lead-calcium-tin are included as well as any other metallic strips which are suitable for expanding.

In a preferred embodiment of the present invention, there is provided a method including; moving a lead strip through an expanding machine; operating the machine in synchronism with movement of the strip so that the strip is expanded into a non-planar shape with a pair of mesh portions divided by a central longitudinally extended unexpanded portion; flattening and smoothing the expanded strip from its non-planar shape and reducing the thickness of the flattened expanded strip.

Apparatus for carrying out the method includes an expanding machine which produces expanded strip in a non-planar shape, a pair of powered rollers which pull the lead strip through the expanding machine and reduce the thickness of the expanded strip, a diverting wheel which forces the central portion of the expanded strip to substantially the same level or slightly below the level of the transversely adjacent outer edges of the expanded strip, a single roller located so that the expanded strip passes partially around it after passing the diverting wheel, and a pair of non-powered rollers between which the expanded strip passes just before passing between the pair of powered rollers.

In the accompanying drawings which show a method and apparatus for making and expanding lead strip according to the present invention;

Figure 1 is a side elevation of an expanding machine and roller assembly for producing flattened expanded lead strip.

Figure 2 is a perspective view of the apparatus shown in Figure 1 with some of the covers removed to expose the details of the apparatus.

Figure 3 is a schematic view showing the relationship of the dies, cutter, diverting wheel and rollers,

Figure 4 is a cross-section taken along line 4—4 of Figure 3 to reveal the configuration of the expanded lead strip as it leaves the expanding machine.

Figure 5 is a plan view of the expanded lead strip showing the arrangement of the diverting wheel and rollers.

Figure 6 is a longitudinal sectional view showing the path of the strip past the diverting wheel and rollers.

Figure 7 shows the arrangement of the dies in a converging double row.

Figure 8 shows the configuration of the cutter to co-operate with the die arrangement shown in Figure 7.

Figure 9 is a view taken along line 9—9 in Figure 1.

Figure 10 is a view taken along line 10—10 in Figure 1.

Figure 11 shows a portion of the expanded lead strip after it has been flattened, smoothed and reduced in thickness.

Figure 12 shows a portion of expanded lead strip which has been reduced in thickness and is undulated.

Figure 13 is an enlarged fragmentary view of the mesh portion of the expanded lead strip before it is reduced in thickness, and

Figure 14 is similar to Figure 13, but after the mesh portion is reduced in thickness.

Referring to Figures 1 and 2 of the drawings, reference numeral 20 denotes generally the apparatus for producing flattened expanded lead strip which can be used in the manufacture of plates for batteries, and includes an expanding machine 22 of a commercially available type, a diverting wheel and a plurality of rollers. These rollers and wheel, as shown in Figures 3, 5 and 6, include a diverting wheel 24, a single roller 26, a first pair of non-powered rollers 28 and 30, a second pair of powered rollers 32 and 34 and a pair of initial feed rollers 36 and 37. The roller 32 is a compound roller and includes a central segment 39 and two reduced diameter segments 41 and 43.

The expanding machine 22 includes a stationary base 38 and a top 40 which is arranged for vertical reciprocating movement. The top 40 is mounted on a plurality of helical springs 42 located adjacent each corner thereof and is forced downwardly against the bias of the springs 42 by a pair of eccentric cams 44 mounted on parallel shafts 46 which are driven by a motor, not shown, through a belt drive 48.

Mounted in the expanding machine 22 is a cutter 50, Figure 8, connected to the base 38 and a plurality of converging dies 52, Figure 7, connected to the top 40 to form a progressive die which converges in incremental steps along a central longitudinal line, and cutter set. The dies 52 co-operate with the cutter 50 so that as the top 40 is moved up and down and a solid lead strip 54 is fed incrementally between the dies 52 and the cutter 50 from left to right, as viewed in Figure 1, the expanded lead strip 56 is formed as shown in Figure 11 which includes a pair of expanded mesh portions 58 divided by a longitudinally extending centrally disposed unexpanded portion 60. Each mesh portion is made up of a plurality of diamond-shaped cells 61 as shown in Figures 13 and 14 formed by a plurality of strands 65 interconnected at nodes 69 which are compressed when the thickness of the mesh portion is reduced as hereafter explained. It will be understood, however, that as the expanded lead strip emerges from the expanding machine 22, it has a non-planar shape and still needs to be flattened and smoothed.

Located to the front of the expanding machine 22 is the pair of initial feed rollers 36 and 37, Figure 9, journaled in a pair of trunnion blocks 62. These rollers serve to feed the lead strip 54 into the expanding machine 22 until the expanded strip 56 is gripped by rollers 32 and 34 which then pull the strip 54 through the expanding machine 22. The rollers 36 and 37 are interconnected by a pair of meshing gears 63 and the roller 37 is connected by a shaft 64 to a conventional one-way clutch 66 from which a pair of arms 68 extend. Arms 68 are connected to a wheel 70, Figure 2, mounted on one of the shafts 46 by means of a link 72 which is pivotally connected to arms 68 and wheel 70. Thus, as the shafts 46 rotate, the top 40 reciprocates vertically and the arm 68 oscillates about the shaft 64. Assuming clockwise rotation of the shafts 46, as viewed in Figure 2, the clutch 66 is arranged so that clockwise oscillation of arms 68 causes the clutch to engage and rotate rollers 36 and 37 so that the lead strip passing between the rollers will be fed into the expanding machine 22. Attached to the end of shaft 64 opposite the clutch 66 is a conventional brake 67 which prevents free rotation of the rollers 36 and 37 at any time.

Located to the rear of the expanding machine 22 are powered rollers 32 and 34, figure 10, which are journaled in a pair of trunnion blocks 74. Rollers 32 and 34 are interconnected by means of a pair of meshing gears 76. The roller 34 is driven by means of a link 78 which is pivotally connected at one end to arms 68 and at the other end thereof to a pair of arms 80, as shown in Figure 2, causes rotation of rollers 32 and 34, which rollers are held from free rotation at any time by means of a brake 84 which is connected to the roller 34 opposite from the clutch 82. Rollers 32 and 34 serve to pull expanded lead mesh through the expanding machine 22 and reduce the thickness of the

expanded lead strip passing therebetween as hereafter explained.

Mounted for rotation on a stationary bracket 86 and immediately to the rear of the expanding machine 22 and generally in line with the longitudinal axis thereof is a wheel 24 which functions to divert the central portion 60 of the expanded strip 56 to substantially the same level or slightly below the level of the edges 59 of the expanded strip 56 transversely adjacent thereto.

Immediately behind the wheel 24 the roller 26 is mounted for rotation on a pair of arms 88 which are pivotal to provide for vertical adjustment of the roller 26.

Located between the roller 26 and the rollers 32 and 34 is the pair of non-powered rollers 28 and 30 which, together with roller 26, help to smooth the flattened expanded lead strip. A ramp 90 leads up to the roller 30 and another ramp 92 spans the space between the rollers 30 and 34. These ramps facilitate threading the lead strip between the various rollers wheen initiating operation of the apparatus 20.

The lead strip is threaded through the apparatus 20, as shown in Figures 3, 5 and 6, so that it passes between the powered rollers 32 and 34 which grip the lead strip and thus pull the strip through the apparatus.

Rotation of the set of rollers 36 and 37 and the set of rollers 32 and 34 is synchronized with the opening and closing of dies 52 with the cutter 50 through the aforementioned linkage 70, 72, 78 so that a solid lead strip 54 which is fed into the expanding machine 22 emerges at the rear as an expanded lead strip 56 having a pair of mesh portions 58 with substantially diamond-shaped cells 61, the mesh portions being divided by a longitudinally extending unexpanded portion 60.

As the expanded lead strip 56 emerges from the expanding machine 22 it has substantially the non-planar configuration shown in Figure 4 with the central portion 60 raised and the mesh portions 58 curving downwardly and then up at the outer edges 59 thereof. The outer edges 59 tend to be upturned since they are maintained taut due to the rollers 32 and 34 pulling the lead strip through the apparatus 20 and the fact that the lead strip narrows from the fully expanded width to the width of the solid strip where it initially enters the expanding machine 22.

The non-planar shape of the expanded strip as it emerges from the expanding machine 22 is not suitable for use in the fabrication of battery plates, therefore the expanded strip 56 is flattened by moving it past a diverter which in this case is the wheel 24 and passing it between a pair of powered rollers 32 and 34 which grip the expanded lead strip and pull it past the wheel 24. This causes the centrally located unexpanded portion 60 to be pushed down to a point which is near or slightly below the level of the outer edges 59 of the expanded strip at a point substantially transverse therefrom. Running the expanded strip 56 past the wheel 24 is particularly effective in that as the central portion 60 of the strip is pushed down for flattening, this action at the same time, avoids collapsing or distorting the portion of the mesh adjacent central portion 60.

The roller 32, has a central segment 39 and reduced diameter segments 41 and 43 which accommodate the expanded strip 56 since the mesh portions 58 are thicker than the central unexpanded portion 60. Depending upon the spacing between rollers 32 and 34, the expanded strip 56 may only be gripped and pulled through to complete the flattening process and provide mesh portions with cells 61 as shown in Figure 13, or, if the spacing between rollers 32 and 34 is close enough, the expanded strip 56 additionally will be reduced in thickness, particularly the mesh portions 58 thereof so that the cells 61 and nodes are as shown in Figure 14.

If only the mesh portions 58 of the expanded strip 56 are reduced in thickness the entire expanded strip becomes undulated, as shown in Figure 12. This is due to the fact that reducing the thickness of mesh portions 58 causes them to lengthen, (they cannot expand sideways significantly because they are held between rollers 32 and 34) while the length of the central portion 60 remains unchanged. To avoid having the strip 56 become undulated as mesh rollers 58 are reduced in thickness the central segment 39 of roller 32 is sized relative to segments 41 and 43 so that for a given reduction in thickness of mesh portions 58 and corresponding lengthening thereof there is a reduction in thickness of the central portion 60 of the strip 56 which causes a lengthening thereof which is substantially equal to the lengthening of the mesh portions 58.

There is some tendency for the expanded strip 56 to wrinkle occasionally during flattening when only the diverter wheel 24 and powered rollers 32 and 34 are utilized. In order to avoid such wrinkling, the roller 26 is placed immediately behind the wheel 24 and located so that the expanded strip 56 must roll partially around the roller 26 as the expanded strip 56 moves past it. A further pair of rollers 28 and 30 are located between the roller 26 and rollers 32 and 34 and also serve to smooth the flattened expanded strip 56. The roller 30 is disposed so that the expanded strip must roll around it partially as it moves past roller 30. Roller 28 is located so that it just contacts the top of the expanded strip, but not sufficiently close enough so that the expanded strip is gripped between the rollers 28 and 30.

The rollers 26, 28 and 30 co-operate to provide smoothing of the expanded strip 28

during the flattening process so that as the expanded strip 56 reaches rollers 32 and 34 to pass between them the strip 56 is substantially free of any wrinkles with the result that after the expanded strip passes between the rollers 32 and 34 the product is a substantially flat wrinkle free lead strip as shown in Figure 11.

The above detailed description is intended to be illustrative only. For example, while an expanded strip having two mesh portions divided by a longitudinally extending unexpanded portion has been described our invention is equally applicable to producing expanded strip having a single mesh portion and a longitudinally extending unexpanded portion. Further, the expanded strip produced by our invention is susceptible to applications other than the fabrication of plates for batteries.

WHAT WE CLAIM IS:—

1. A method of making expanded metal strip including moving a metal strip through an expanding machine having a row of individual dies each of which is displaced laterally to the one in front of it so that the row of dies converge towards a line parallel to the direction of movement of the metal strip and a cutter, operating the machine in synchronism with movement of the strip so that the strip is expanded into a non-planar shape with a mesh portion and a longitudinally extending unexpanded portion and flattening the expanded strip from its non-planar shape by moving the expanded strip past a diverter so that the unexpanded portion is forced to a level substantially even with the outer edge of the mesh portion located transversely therefrom while the outer edge of the mesh portion is maintained substantially straight and taut.

2. A method of making expanded metal strip according to claim 1 including the step of reducing the thickness of the mesh portion while simultaneously lengthening the unexpanded portion sufficiently to compensate for the lengthening caused by reducing the thickness of the mesh portion so as to prevent the expanded strip from becoming wavy.

3. A method of making expanded lead strip including moving a lead strip through an expanding machine having two rows of individual dies, each of which dies is displaced laterally to the one in front of it so that each row of dies converges towards a line parallel to the direction of movement of the metal strip and cutters, operating the machine in synchronism with movement of the strip so that the strip is expanded into a non-planar shape with two mesh portions divided by a central longitudinally extending unexpanded portion and flattening the expanded strip from its non-planar shape by moving the expanded strip past a diverter so that the central portion is forced to a level substantially even with the outer edges of the expanded strip located transversely therefrom while the outer edges are maintained substantially straight and taut.

4. A method of making expanded lead strip according to claim 3 including the step of reducing the thickness of the mesh portions while simultaneously lengthening the unexpanded portion sufficiently to compensate for the lengthening caused by reducing the thickness of the mesh portions so as to prevent the expanded strip from becoming wavy.

5. A method of making expanded metal strip according to claim 1 or 3 including moving the expanded strip in its non-planar shape past a diverter to force the central portion to a level near the level of the outer edges of the expanded strip located transversely therefrom, and passing the expanded strip between a pair of rollers which reduce the thickness of the mesh portions to a predetermined thickness and lengthen the central portion sufficiently to compensate for the lengthening caused by reducing the thickness of the mesh portions so as to prevent the expanded strip from becoming wavy.

6. A method of making expanded metal strip according to claim 1 or 3 wherein the central portion of the expanded strip is forced to a level past the outer edges of the expanded strip located transversely therefrom while passing the expanded strip between a pair of rollers which grip the expanded strip and pull it therethrough.

7. A method of making expanded metal strip according to claim 1 or 3 including the moving of the expanded strip in its non-planar shape past a diverter to force the central portion to a level past the level of the outer edges of the expanded strip located transversely therefrom, moving the expanded strip around a first roller and between a first pair of rollers and passing the expanded strip between a second pair of rollers which grip the expanded strip and pull it therethrough.

8. A method of making expanded metal strip according to claim 1 or 3 including moving the expanded strip in its non-planar shape past a diverter to force the central portion to a level past the level of the outer edges of the expanded strip located transversely therefrom, moving the expanded strip around a first roller and between a first pair of rollers, and passing the expanded strip between a second pair of rollers which reduce the thickness of the mesh portions to a predetermined thickness and lengthen the central portion sufficiently to compensate for the lengthening of the mesh portions caused by reducing the thickness of the mesh portions so as to prevent the expanded strip from becoming wavy.

9. Apparatus for producing flattened ex-

panded strip from a solid strip including an expanding machine which produces expanded strip in a non-planar shape and having a mesh portion and a longitudinally extending unexpanded portion, means which diverts the unexpanded portion to substantially the same level as the outer edge of the mesh portion located transversely therefrom and means which grips the expanded strip and pulls it through the machine and past the diverting means, the gripping means co-operating with the expanding machine so that the outer edge of the mesh portion is moved linearly and maintained taut.

10. Apparatus for producing flattened expanded strip according to claim 9 wherein the gripping and pulling means is a pair of powered rollers.

11. Apparatus for producing flattened expanded strip from a solid strip including an expanding machine which produces expanded strip in a non-planar shape and having a pair of mesh portions divided by a central longitudinally extending unexpanded portion, means for diverting the central portion to a level past the level of the outer edges of the expanded strip located transversely therefrom, and means for gripping the expanded strip and pulling it through the machine and past the diverting means, the gripping means co-operating with the expanding machine so that the outer edges of the expanding strip are moved linearly and maintained taut between the machine and the gripping means.

12. Apparatus for producing flattened expanded strip according to claim 11 wherein the diverting means is a wheel mounted for rotation on a stationary support.

13. Apparatus for producing flattened expanded strip according to claim 11 wherein the gripping and pulling means is a pair of powered rollers.

14. Apparatus for producing flattened expanded strip according to claim 13 wherein one of the powered rollers has a central segment with a given diameter and two segments with a smaller diameter located on each side of the central segment.

15. Apparatus for producing flattened expanded strip according to claim 11 including means for smoothing the expanded strip.

16. Apparatus for producing expanded strip according to claim 15 wherein the smoothed means includes a single roller disposed to engage the expanded strip.

17. Apparatus for producing flattened expanded strip according to claim 11 wherein there are provided means for reducing the thickness of the mesh portion sufficiently to compensate for the lengthening of the mesh portions caused by reducing the thickness of the mesh portions so as to prevent the expanded strip from becoming wavy.

18. Apparatus for producing flattened expanded strip according to claim 17 including means for smoothing the expanded strip.

19. Apparatus for producing flattened expanded strip according to claims 17 and 18 wherein the diverting means includes a stationary support and a wheel mounted for rotation on the support, the gripping means includes a pair of powered rollers, one of which rollers having a central segment with a given diameter and two segments with a smaller diameter located on each side of the central segments and the smoothing means includes a single roller located between the wheel and the pair of powered rollers and disposed to engage the expanded strip.

20. A method of making expanded strip substantially as hereinbefore described with reference to Figures 1 to 11 and 13 and 14 of the accompanying drawings.

21. Apparatus for producing flattened expanded strip from a solid strip substantially as hereinbefore described with reference to Figures 1 to 11 and 13 and 14 of the accompanying drawings.

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Agent for the Applicants.

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1589902 COMPLETE SPECIFICATION

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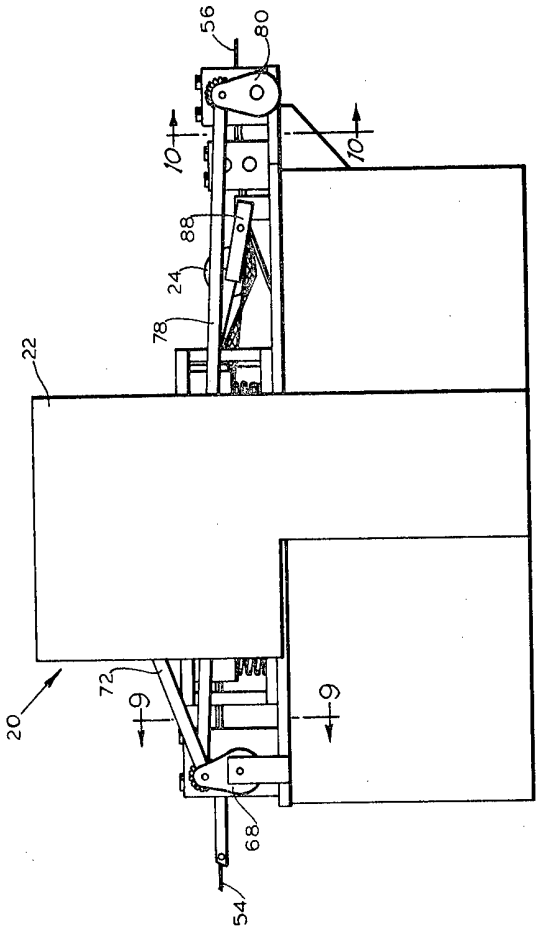

Fig. 1

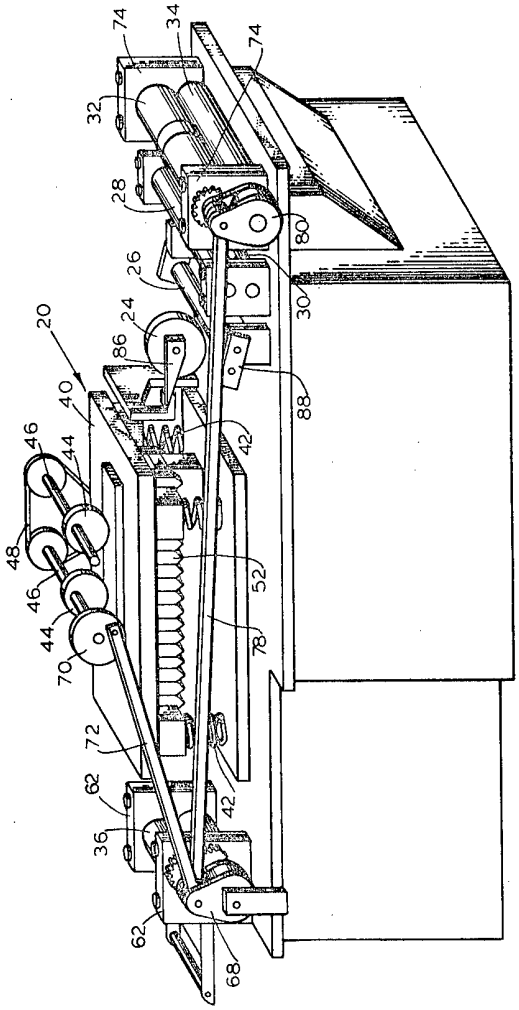
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Fig. 2

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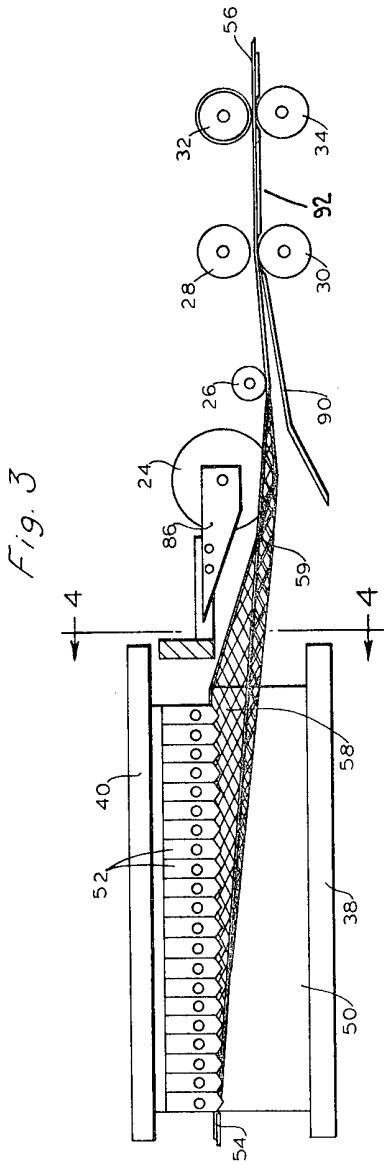

Fig. 3

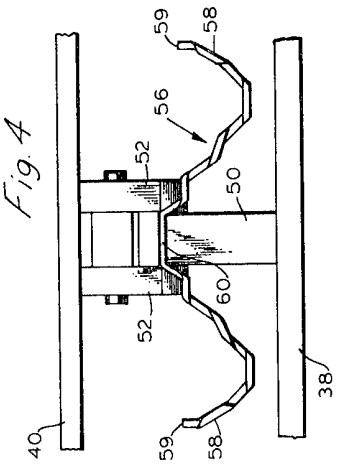

Fig. 4

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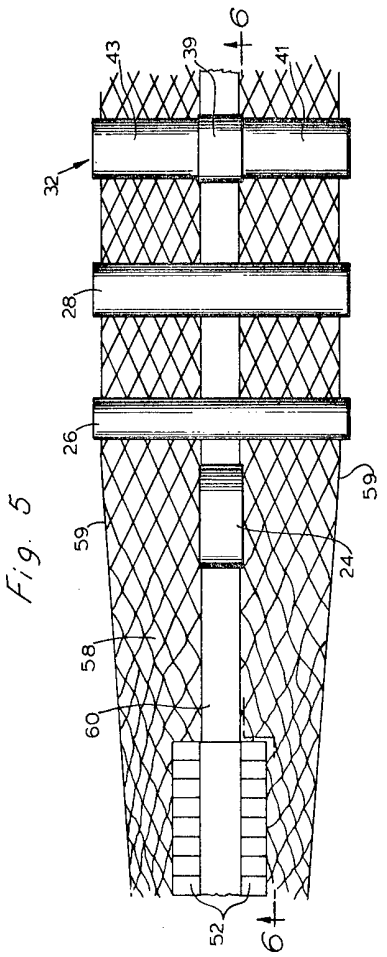

Fig. 5

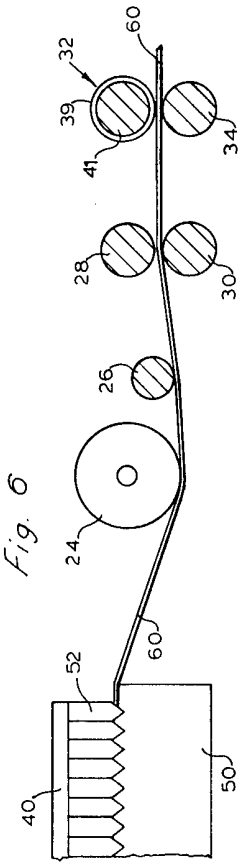

Fig. 6

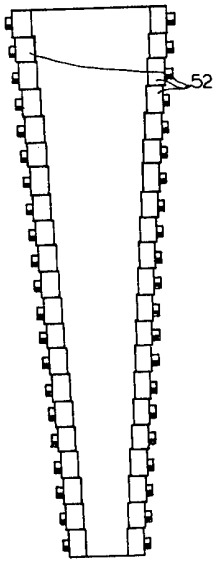

Fig. 7

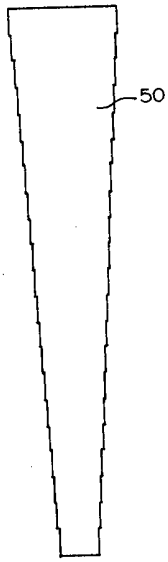

Fig. 8

Fig. 9

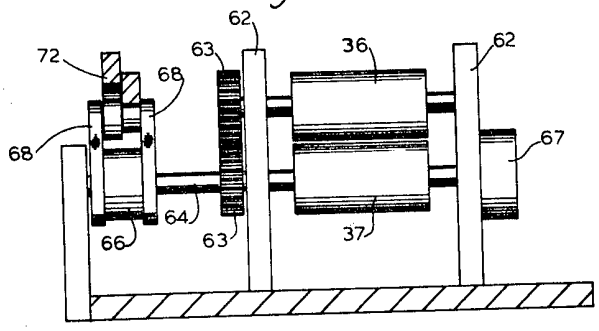
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Fig. 10

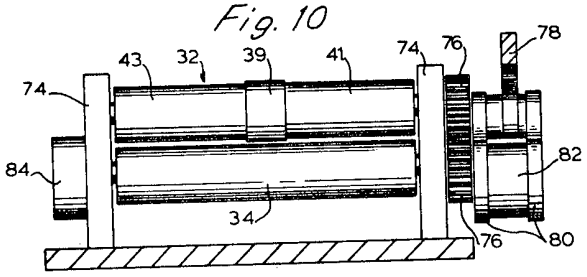
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Fig. 11

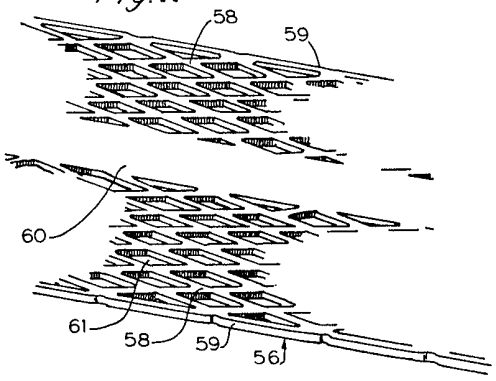
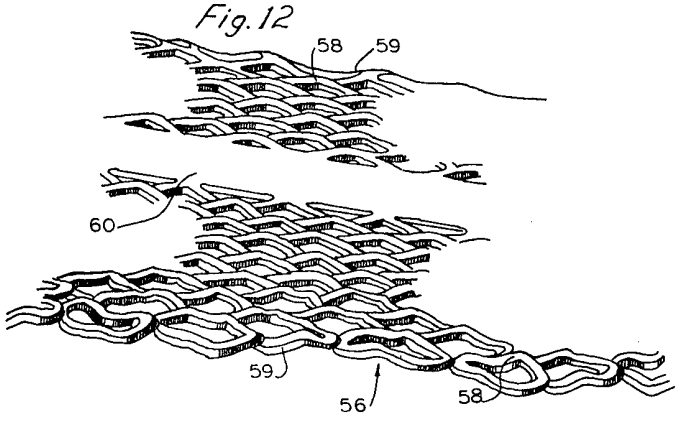


Fig. 12



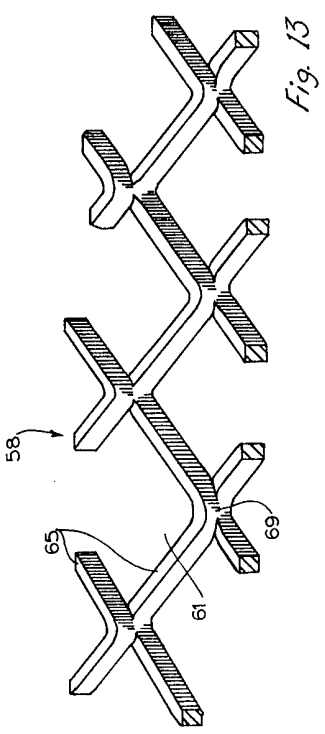


Fig. 13

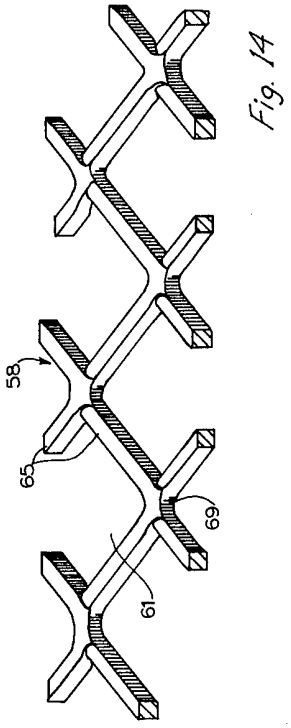


Fig. 14