United States Patent

Rech

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[54] METHOD OF AND APPARATUS FOR CORRUGATING PLIABLE MATERIAL

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[52] **U.S. Cl.**.....**72/133**, 72/185, 72/187, 72/379, 72/405

[51] **Int. Cl.**.....**B21d 13/00**

[58] **Field of Search**.....72/133, 176, 177, 185, 187, 72/190, 384, 385, 405, 379; 264/286, 287, 339; 156/589, 590, 592, 594

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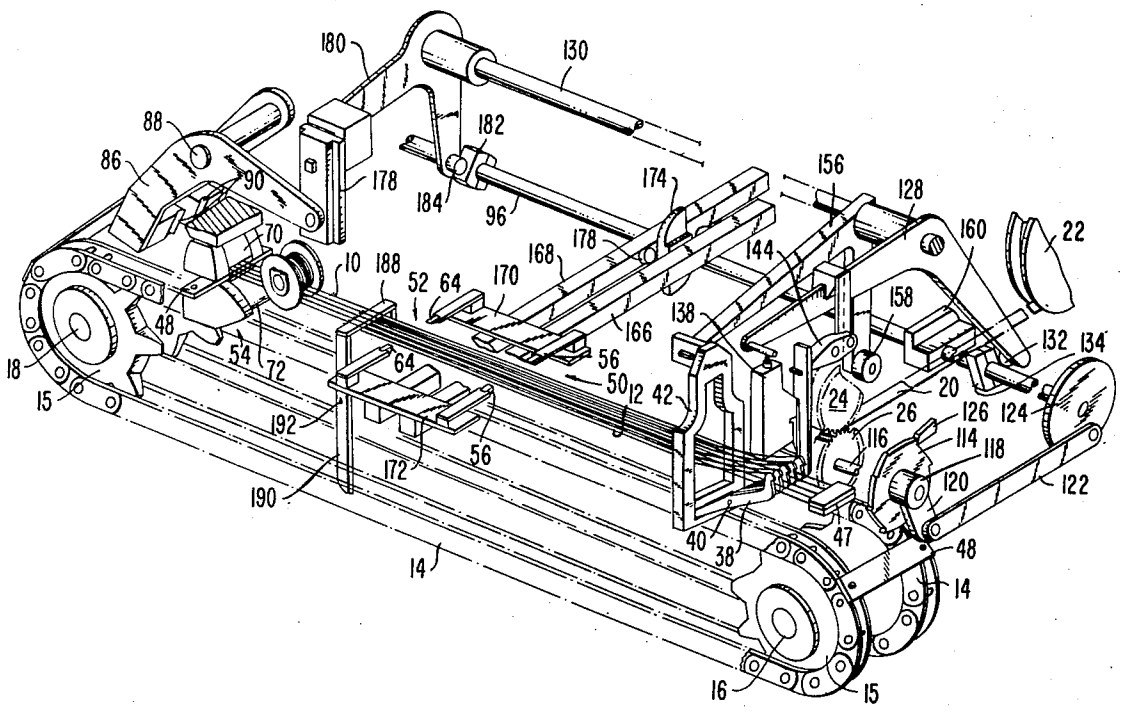
[57] **ABSTRACT**

Forming corrugations in pliable material, such as metallic sheet stock, including the steps of imparting an initial relatively widely spaced apart corrugations in a workpiece composed of this material, following which the workpiece is introduced between two sets of flexible rods or wires which are arranged to seat in the loops of the corrugations on opposite sides of the workpiece. Thereafter, each such workpiece is transported by sliding motion along the wires and at one or more stations therealong the workpiece is subjected to endwise compression causing contouring of the loops of the corrugations around the wires as mandrels to form a relatively densely corrugated article. The wires are capable of lateral displacement with respect to one another with the result that during endwise compression of the workpiece they will move closer together to accommodate the contraction of the workpiece and the reduced spacing of the convolutions.

25 Claims, 12 Drawing Figures



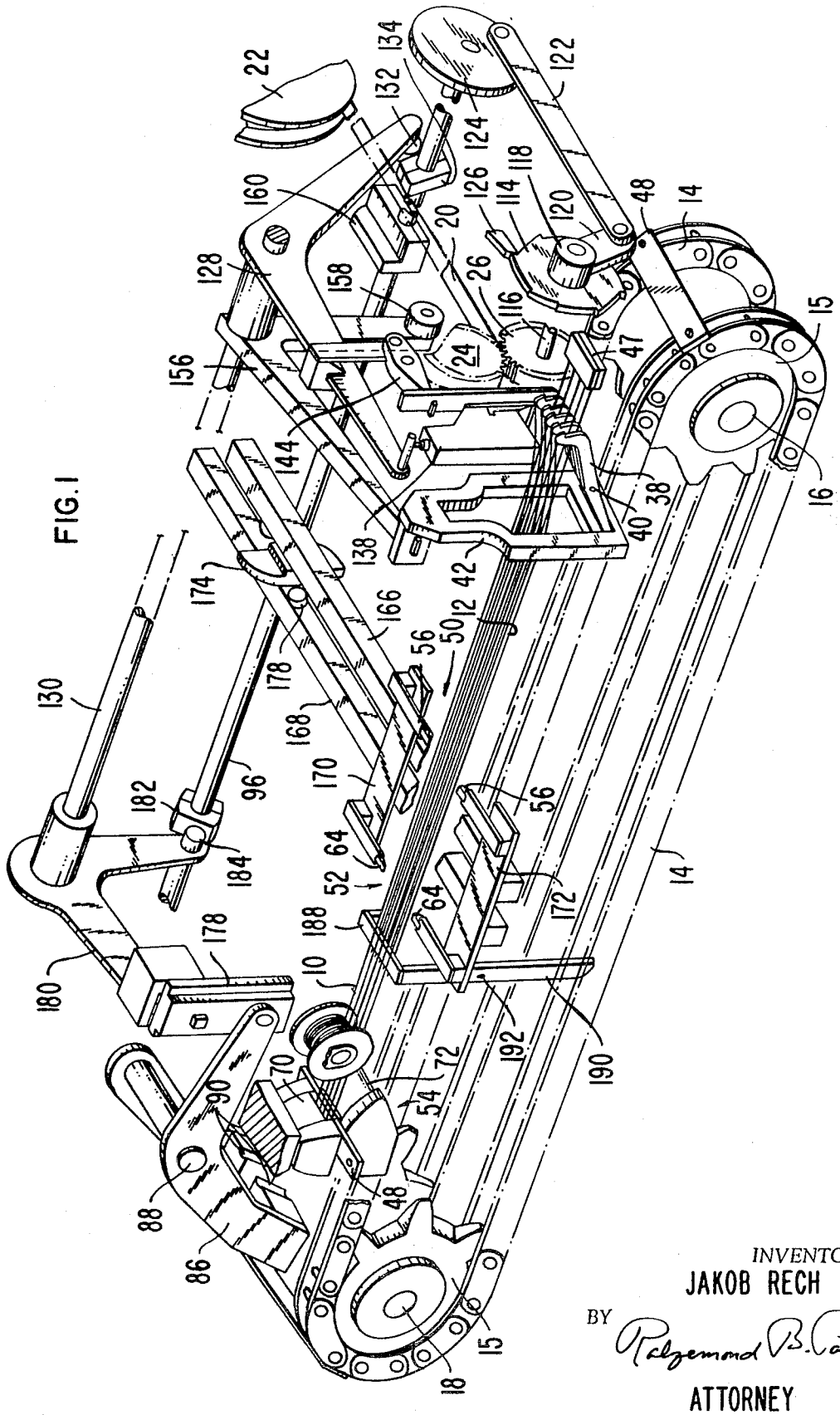


FIG. 1

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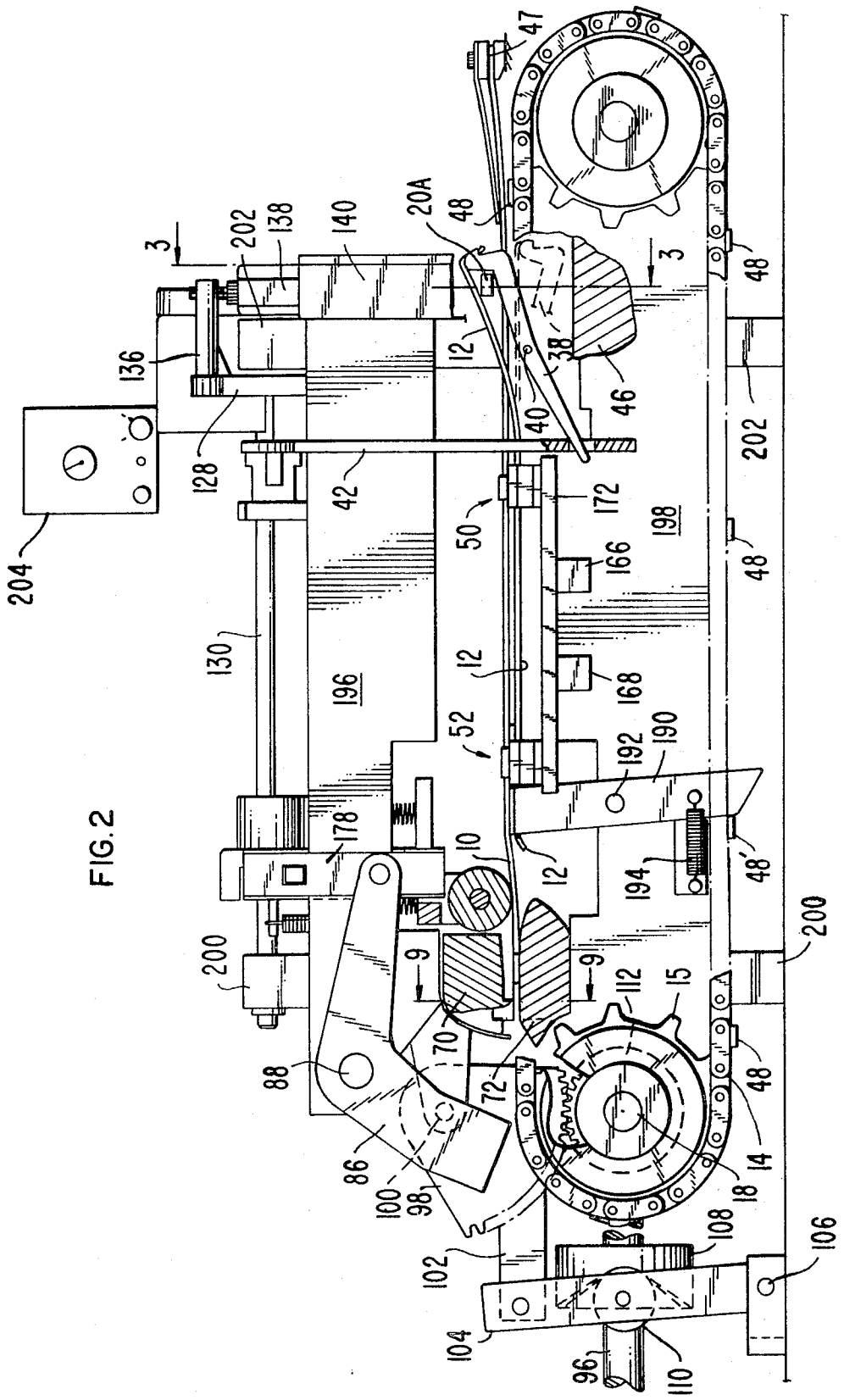
47
48
20A
3
202
138
140
136
12
38
46
40
128
42
172
50
166
198
204
130
196
168
52
192
190
178
10
194
200
9
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70
72
88
86
100
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18
108
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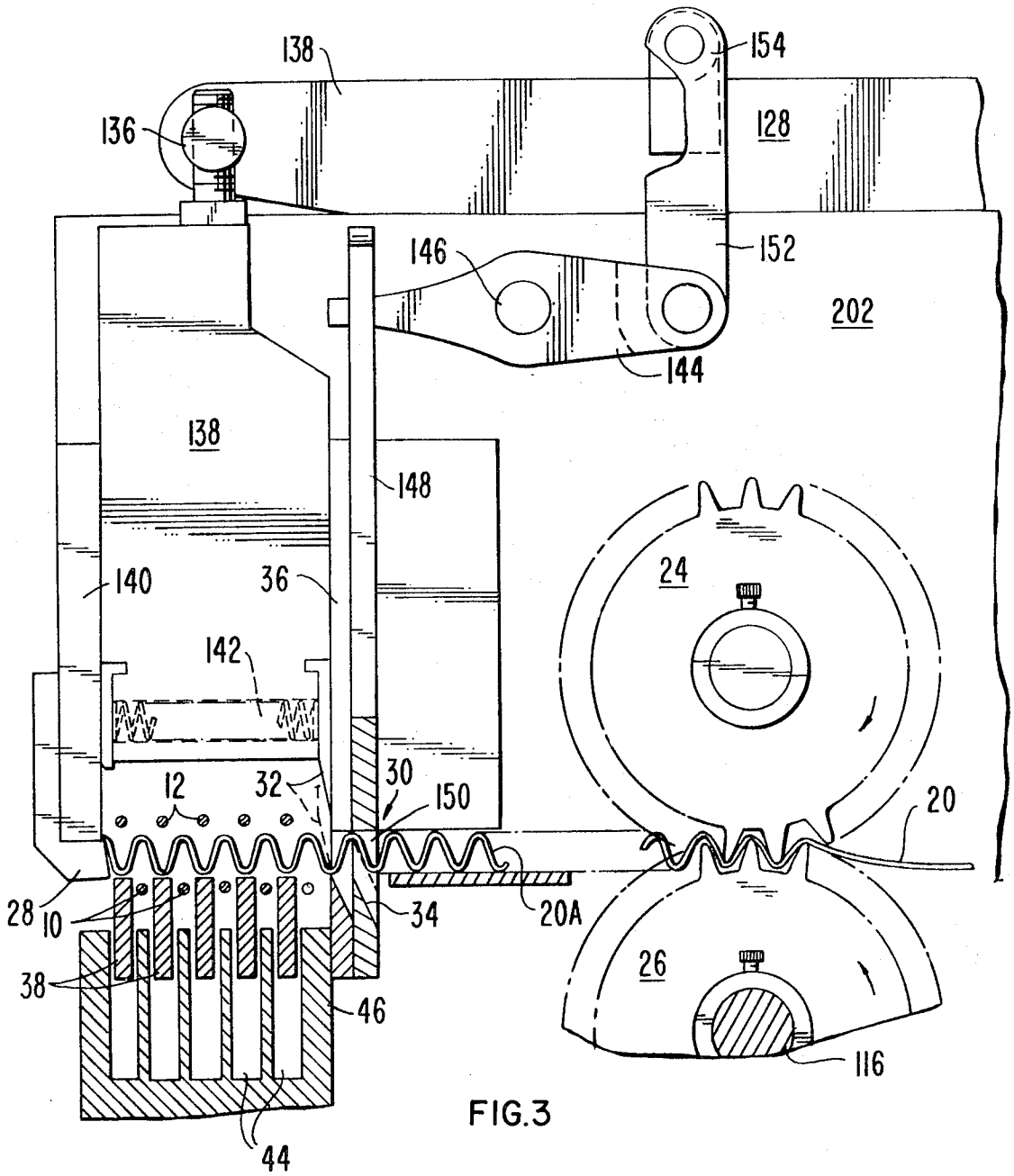
104
96
110

FIG. 2


138
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202
144
138
148
140
36
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142
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28
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34
20A
38
26
46
116
44

FIG.3

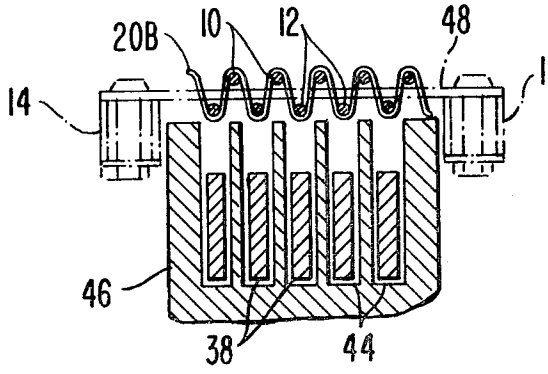

20B
10
12
48
14
14
46
38
44

FIG.4

FIG.5

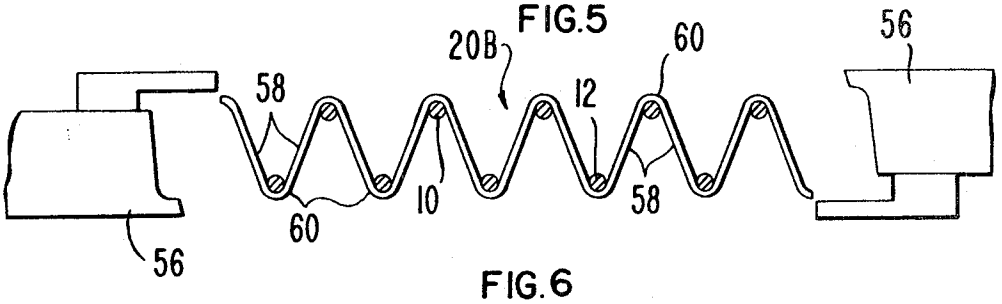
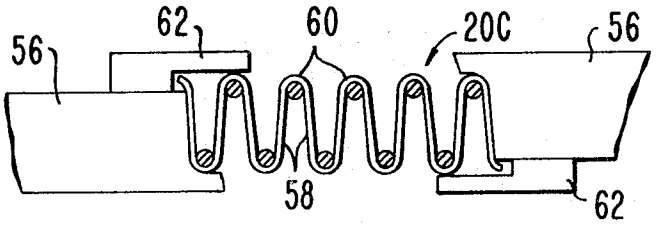


FIG.6



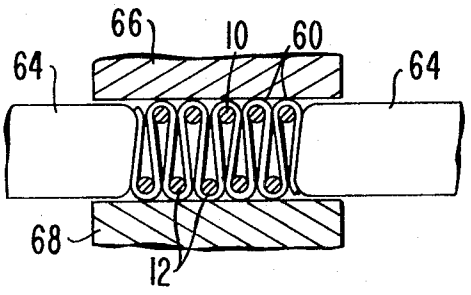


FIG.7

FIG.8

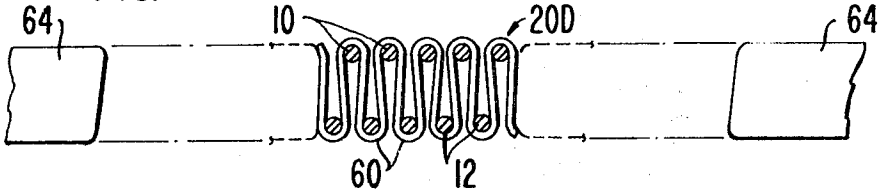


FIG.9

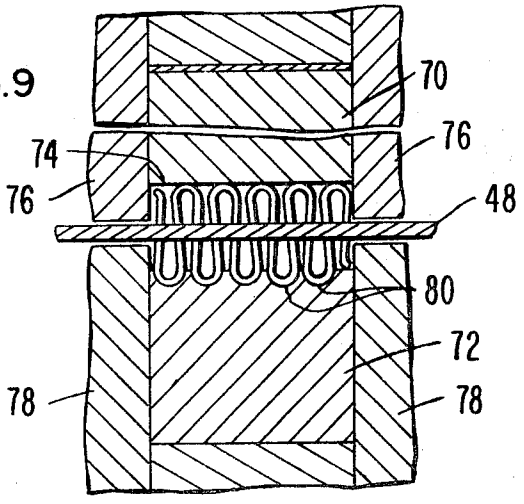


FIG.10

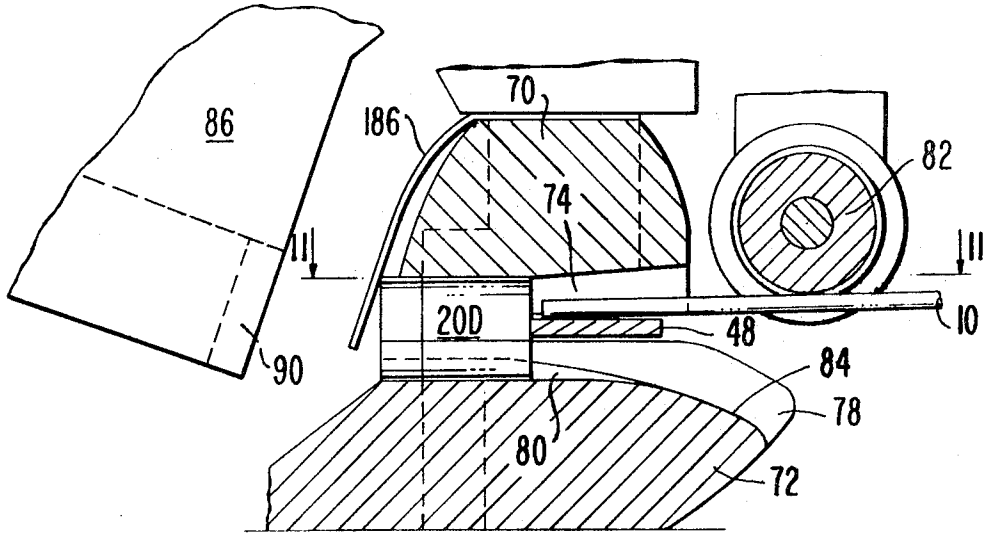
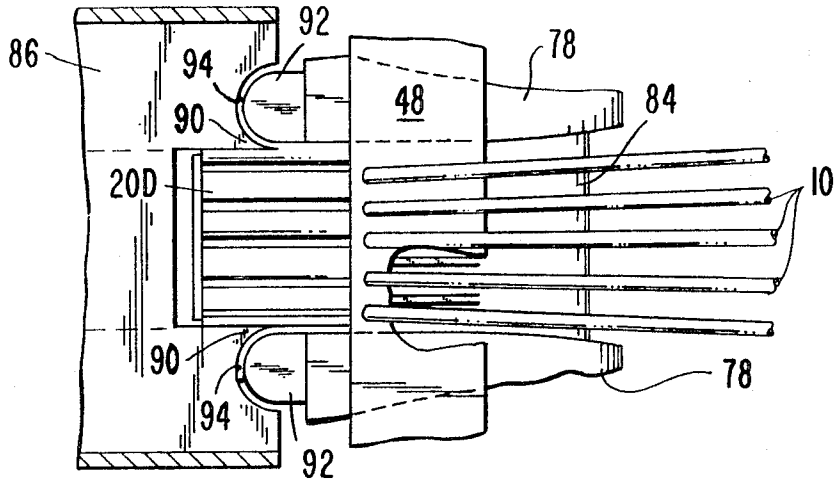


FIG.11



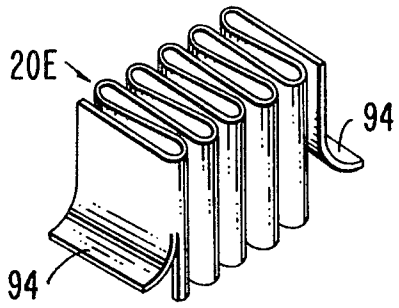


FIG.12

METHOD OF AND APPARATUS FOR CORRUGATING PLIABLE MATERIAL

BACKGROUND OF THE INVENTION

This invention is directed to that field of art pertaining to fabrication of sinuous contoured shapes and more particularly to the formation of corrugations in pliable material such as relatively thin metallic sheet stock.

Various suggestions have been advanced in the past for making such corrugated products and providing apparatus capable of imparting convolutions in such material. Exemplary of such past practices are the patents to Harter U.S. Pat. Nos. 1,485,917; Andre 2,513,777; and Robinson 3,003,540. In the apparatus such as illustrated in these patents, care had to be taken for preventing the drawing or stretching of the material, such as metal, as the convolutions were formed therein. Apparatus of the prior art may have achieved creditable results but with relatively expensive and complex equipment requiring careful control and maintenance to assure proper operation.

SUMMARY OF THE INVENTION

An important object of the invention is to provide an improved method and apparatus for sinuously contouring material into corrugations which avoids drawing or stretching of the material as it is worked into the desired formation.

Another important object of the invention is to provide an improved method of forming corrugations in pliable material which is simple and inexpensive to perform and which provides precisely uniformly shaped corrugations in the resulting articles.

A further important object of the invention is to provide a workpiece transporting mechanism having improved means for not only conveying the workpiece but also for serving as mandrels about which folds or corrugations are formed.

In carrying out the objects of the invention, the method and apparatus contemplates the fabrication of a sinuous contours in a workpiece by transporting it along rod-like elements or wires which also serve as mandrels about which corrugations are shaped. Such shaping operations will result in the contraction of the workpiece, and the wires upon which it is transported have a permitted lateral displacement enabling them to be bunched closer together during this contraction and thereby avoid subjecting the material of which the article is composed to extensive tensile stress.

Preferably, as illustrated in the disclosed embodiment of the invention, the guiding wires are disposed generally parallel to one another in two sets, the individual wires of each set being alternately staggered in spaced apart relation to those of the other set in order to receive therebetween a workpiece which may be initially slightly corrugated as it is fed from sheet stock. The two sets of wires are then relatively laterally moved with respect to one another to seat within the loops of the corrugations in the workpiece and to serve collectively as a guiding support or track along which the workpiece will be advanced. For providing the transporting movement, pushers are provided which interleave between the two sets of wires and individually engage and slide each workpiece along the wires. One or more forming stations are located along the track provided by the wires for exerting forces which progressively contract the workpiece and further contour the individual loops about the wires and which at the same time laterally move the wires of each set toward one another to accommodate the contraction as these actions are taking place.

The above and other objects, advantages and meritorious features of the invention will be further explained in the following detailed description. For a more complete understanding of the invention reference made be had to the following detailed description in conjunction with the drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic exploded view in perspective of apparatus embodying the invention, with parts omitted for purpose of clarity, and showing in general the procedure for forming the desired corrugations in a workpiece conveyed therethrough;

FIG. **2** is a side elevation of the machine illustrated in FIG. **1** but in completely assembled condition;

FIG. **3** is a vertical sectional view taken along line **3—3** of FIG. **2** and illustrating the mechanism for imparting the initially corrugation in the material and for inserting the same between the two sets of guide wires;

FIG. **4** is a detailed sectional view of a part of mechanism shown in FIG. **3** and illustrating another position of the wires;

FIG. **5** is an enlarged detailed view showing the condition of the workpiece prior to being endwise compressed at the first forming station to which it is conveyed on the wires;

FIG. **6** is a view similar to FIG. **5** but showing the condition of the workpiece at the maximum extent of compression at the station illustrated in FIG. **5**;

FIG. **7** is a detailed view showing the maximum extent of the endwise compression of the workpiece in the second forming station along the wires;

FIG. **8** is a view of the workpiece on the wires following the shaping operation performed at the station illustrated in FIG. **7**;

FIG. **9** is an enlarged cross-sectional view at the last forming station of the apparatus taken along line **9-9** of FIG. **2**;

FIG. **10** is an enlarged vertical sectional view taken of the parts constituting the last forming station of the apparatus;

FIG. **11** is a horizontal sectional view taken along line **11—11** of FIG. **10** but showing the forming tool at the conclusion of its stroke; and

FIG. **12** is an enlarged perspective view of the finished article performed by the method and apparatus illustrated herein.

DESCRIPTION OF A PREFERRED EMBODIMENT

With further reference to the drawings, FIG. **1** illustrates an exploded perspective view of a particular embodiment of the invention designed in this instance to corrugate metallic strips into closely crimped reversely looped articles such as the one illustrated in FIG. **12**. The apparatus of FIG. **1**, in general, comprises two sets of rod-like elements or wires **10** and **12** which extend generally in the same direction on two different levels and are alternately staggered in spaced apart relation with respect to one another as shown in FIGS. **3** to **9**. Moreover, these two sets of wires overlie and extend generally parallel to a conveyor formed, in this instance, of a pair of similar endless chains **14—14** disposed in slightly spaced side by side relationship and supported upon and operated from sprocket gears **15—15** carried on shafts **16** and **18**. The two sets of wires **10** and **12** are supported above the endless chain conveyor but do not move therewith. However, as will be pointed out in more detail hereinafter these sets of wires have certain distinctive movements with respect to one another and in conjunction with the formation of the corrugations of the workpieces shaped by the apparatus. The rods or wires **10** and **12** in the illustrated embodiment have the same circular cross sectional dimension and although relatively stiff are easily flexed out of their normal straight formation.

The material to be corrugated, in this instance, flat metallic ribbon stock, is indicated at **20** in FIGS. **1** and **3** and shown as being fed from a supply reel **22** in a direction from the side of the endless conveyor **14—14** and toward one end thereof. This metallic ribbon is fed between two pairs of toothed wheels or gears **24** and **26** constituting the first forming station of the apparatus and which, as shown in FIG. **3**, form an initial corrugation to the ribbon. The teeth of the gears are so shaped and spatially arranged as to impart loops which are relatively widely spaced apart. This initially slightly corrugated ribbon portion now identified as **20A** is fed from the two gears **24** and **26** and into the space between the two sets of wires **10** and **12**

at a time in the operation of the machine when the ends of the wire set **12** are above the adjacent ends of the wire set **10** as illustrated in FIG. **3**. The initially corrugated ribbon is fed between these two sets of wires until the forward end thereof abuts a stop, such as indicated at **28**, at which time further forward advancement ceases.

A cutting mechanism generally indicated at **30** operates to sever that section of the corrugated ribbon **20A** lying between the wires **10** and **12** from the balance of the ribbon and while the forward end thereof abuts the stop **28**. In the illustrated apparatus, the cutting mechanism comprises two blades **32** and **34** which reciprocate in opposite directions along parallel planes which are spaced apart from one another so that the upper blade **32** cuts through one loop of the corrugated ribbon while the lower blade **34** severs the next adjacent loop of the ribbon with the result that a small section forming half a pleat is cut out of the ribbon and discarded. In the illustrated embodiment of the invention, the two cutter blades **32** and **34** are mounted so as to slide along the opposite flat parallel surfaces of a stationary plate **36** having a width equal to the distance between the adjacent loops of the initially corrugated ribbon portion **20A**.

Following the positioning and severance of the corrugated strip lying between the two sets of wires **10** and **12**, and now identified as workpiece **20B**, the ends of wire set **12** are now lowered below the wires **10**, the common ends of the two wire sets now taking a reversed relationship to one another as shown by comparing FIG. **4**, representing the new position, with FIG. **3**. The purpose of moving wire set **12** with respect to wire set **10** is to enable the initially corrugated strip **20A** to be fed therebetween from the side after which the levels of the two sets of wires are transposed bringing the wires **12** to the bottom of the upwardly opening loops of the severed corrugated strip **20B** and the wires **10** in the top of the downwardly opening loops thereof.

Flexing of the wires **12** for accomplishing this action is provided by a set of rocking members **38** each individually connected at one end to the extremity of a wire **12**. As shown in FIGS. **1** and **2**, these rocking members are pivoted about a common axis constituted by a cross pin **40** and have their opposite ends received within a rectangular opening of a vertically reciprocating yoke-shaped member **42** which straddles the two wire sets **10** and **12**. The rocking members **38** swing in parallel planes in upwardly opening vertical slots **44** formed in a stationary block **46** positioned between the pair of endless chains **14—14** near their support shaft **16**. Reciprocating movement of the yoke member **42** will raise and lower and thereby flex the ends of wires **12** in an upward and downward direction and between the stationary wires **10**. The latter have their adjacent extremities held from movement by a clamping fixture **47**. The flexure of the wires **12** by the rockers **38** is performed in timed relationship to the receipt and stoppage of the initially corrugated ribbon portion **20A** between the two sets of wires.

With a severed corrugated workpiece **20B** now fitted on the rods or wires **10** and **12** in this fashion, it is capable of being slid along the wires to one or more forming stations therealong. Each workpiece **20B** is transported down the sets of wires from the entrance point of the conveyor adjacent to the cutting mechanism **30** by means of a pusher member **48** carried by the pair of endless chains **14—14**. In the apparatus disclosed herein, a plurality of such pushers are secured to the endless chains at spaced intervals as shown in FIG. **2**, each pusher **48** bridging the space between the two chains **14—14**. During their travel along the uppermost path of their endless movement, the pushers advance in a plane approximately midway between the upper set of wires **10** and the lower set of wires **12** and thus they will engage intermediate portions of the corrugated workpieces and slide the same along the wires **10** and **12**. One such pusher member **48** is illustrated in dot-dash outline in FIG. **4** in the position it assumes between the two sets of wires as it is pushing against the rear of a workpiece. As further illustrated in this Figure, the pusher extends in a plane between the two wire sets and has its opposite extremities projecting therebeyond and secured to the endless chains **14—14** for movement therewith.

In the operation of the illustrated machine as a whole, several forming operations are performed which progressively modify the shape of the workpiece for imparting the desired corrugated formation thereto as exemplified by the finished article illustrated in FIG. **12**. One forming station has been already described, namely, the corrugating station comprising the two gears **24** and **26** which applies the initial slightly corrugated formation shown in FIGS. **3** and **7** to the metallic ribbon prior to severance. After each severed corrugated workpiece **20B** is introduced between and slidably fitted on the wires **10** and **12**, it is guided along these wires to additional forming stations. One such additional forming station is generally indicated at **50** in FIGS. **1** and **3** and a second such station is indicated at **52**. The concluding or finishing station is generally indicated at **54**. The two sets of wires **10** and **12** extend in their alternately staggered, different level relationship through the two forming stations **50** and **52**. The function of these two stations is to further fold or contour the loops around the wires **10** and **12**, and in the case of the illustrated embodiment to ultimately impart a reverse bend to adjacent pleats of the workpiece.

The progressive forming operations of these two stations are illustrated in FIGS. **5** to **8**. At station **50** two similar opposing members **56—56** are moved toward one another so as to engage the opposite ends of a workpiece **20B** shown in FIG. **5** and compress the individual folds or pleats thereof upon one another to the extent that the connecting portions **58** between the loops **60** extend generally parallel to one another as shown in FIG. **6**. In so compressing the workpiece, now identified in FIG. **6** as **20C**, each loop is further bent or folded about the wire seated therein, the latter serving during this action as a mandrel about which the loop is further contoured. It should be noted that as this endwise compression is imposed on the workpiece, the flexible wire elements **10** and **12** are displaced or bunched closer together thus assisting in the desired compressed formation of the workpiece. Since there may be a tendency, as endwise compression is exerted on the workpiece, for the ends thereof to spring out of the station, each forming member **56** is provided with a forward extension **62** which slides past the cut extremity of the workpiece and forms a pocket, as shown in FIG. **6**, where the extremity may be received and held from escape while the workpiece is compressed.

At the next forming station **52** each workpiece is further compressed and folded upon itself by a pair of similar endwise compressing members **64—64** shown in FIG. **7**. At this station it may be desirable to provide both top and bottom cooperating members **66** and **68** to fully enclose the workpiece in order to prevent any unwanted lateral displacement of the individual folds thereof during this forming operation. FIG. **7** illustrates the condition at station **52** when maximum compression is being exerted on the ends of the workpiece further folding the loops about the wires and laternately reversely bending the connecting portions **58** of the workpiece so that each loop abuts its neighbor. When the compressing members **64—64** are withdrawn, as shown in FIG. **8**, the inherent resiliency of the material may cause the workpiece to expand slightly with the result that each loop is slightly spaced apart from its neighbor. The resulting closely convoluted article as formed by station **52** is illustrated in FIG. **8** and because of its new shape it is identified as **20D**. Depending upon the final formation desired, the substantially completely compressed corrugated workpiece is ready either for discharge from the apparatus in the condition shown in FIG. **8** or for further conveyance down the wires **10** and **12** toward the last work station **54** for the final shaping operation.

The ends of the wires **10** and **12** toward which the workpieces are slid by the pushers terminate freely in order that the workpieces may be discharged therefrom. In the illustrated embodiment of the invention, the lower set of wires **12** ter-

minates before the upper set and between the two forming stations **52** and **54** as shown in both FIGS. **1** and **2**. Thus, after shortly leaving the forming station **52**, each workpiece is slidably supported on only the wires **10** for approach to the final forming station **54**.

At forming station **54**, two superposed blocks **70** and **72** are provided which are spaced apart from one another to form a passage **74** barely sufficient to admit a workpiecea and into which each workpiece **20D** is fed as it leaves the terminating ends of the upper set of wires **10**. The two blocks **70** and **72** are shown in detail in FIGS. **9** to **11** disposed between side plates **76—76** and **78—78** respectively. The lower of the two blocks **72** is provided on its upper face with parallel grooves **80** corresponding to the spatial relation and the dimensions of the loops **60** of the workpiece **20D** and aligning with the terminating ends of the wires **10**. As shown in FIG. **10**, the ends of the wires **10** partially enter the passage **74** between the two blocks **70** and **72**. A lightly spring-pressed spool shaped roller **82**, grooved to receive the wires **10**, may rest thereon and hold the ends of the wires from spreading apart. The portion of the lower block **70** under the roller **82** is flared downwardly as at **84** to provide a lip for guiding each workpiece into the passage **74** between the two blocks. With the parts so related, a corrugated workpiece of the formation shown in FIG. **8** and identified as **20D** is advanced by a pusher **48** from the forming station **52** and is slid along the wires **10** until the bottom edge thereof strikes the lip **84** of the station **54** and then thereafter it will ride up the lip and seat in the grooves **80** as the workpiece leaves the wires **10** in the manner shown in FIG. **9**.

After the workpiece **20D** arrives at the opposite end of the passage **80** of station **54** and projects slightly therebeyond, as shown by the workpiece **20D** in FIG. **10**, it is struck by a tool carried on the end of a lever **86** pivoted at **88** and comprising a pair of curved blades **90—90** which cooperate with a pair of stationary rounded abutments **92—92** formed on the confronting edges of the side plates **74—74** and **76—76**. When struck by the tool, the outermost pleats of the corrugated workpiece **20D** will be partially severed from the balance and curved away to form the tangs or flanges **94—94** shown on the workpiece within the last forming station in FIG. **11** and on the completed article illustrated in FIG. **12**.

It is evident from the description of the apparatus thus far presented that in a broad sense pliable sheet material is introduced to and slidably fitted upon a plurality of elongated rod-like elements or wires which are held against longitudinal movement but have a permitted lateral displacement so as to move closer together and further apart. These elements or wires not only serve as a support or track for guiding a workpiece formed of this pliable material in a particular direction and past particular force applying tools but also they serve as shaping members or mandrels about which the workpiece is modified or contoured into the desired formation. At the conclusion of its advancement along the guide wires, the workpiece is discharged from the ends thereof with the desired formation determined by the individual shape of the wires and their spatial relationship to one another.

In a more specific sense, the method is carried out by introducing a slightly corrugated workpiece between two sets of guiding wires which are arranged on two different levels to receive the workpiece therebetween. After receiving the workpiece, the two sets of wires exchange their respective levels to seat within the loops of the convolutions. Thereafter, the corrugated workpiece, by means of a pusher element interposed between the two sets of wires is slidably guided along the wires through one or more forming stations before discharging from the ends of the wires. As the corrugated workpiece advances through each forming station, it is subjected to endwise compression which further bends or folds the loops around the wires, at which time the wires serve as mandrels in the formation of these loops. The wires are so formed and supported that they have a bodily displacement toward and away from one another to accommodate themselves to the contraction of the workpiece as it is subjected to the endwise compression at the forming stations.

It is also evident from the description thus far that the various different operating steps performed on the workpieces are timed with their advance along the wires. In the illustrated embodiment of the invention, power for moving the operating parts is driven from a primary drive shaft **96** normally rotating continuously in one direction during the operation of the machine. This shaft extends parallel to the endless conveyor chains **14—14** along the rear side of the machine as illustrated in FIG. **1**. The pair of endless conveyor chains **14—14** are intermittently driven in unison from the shaft **96** so that the corrugated workpiece conveyed by the pushers thereon are stopped at the several forming stations for further shaping operations. This intermittent movement of the conveyor is accomplished in the illustrated apparatus by means of a sector gear **98** shown in FIG. **2** supported for oscillatory motion about a shaft **100** by means of a link **102** pivotally connected to the end of an arm **104**. The arm is rocked about its axis **106** by a cam **108** acting on a roller **110** journaled to an intermediate portion of arm **104**. The cam **108** is fixed to the drive shaft **96** for joint rotation therewith, and it is evident that the roller **110** will impart oscillatory motion to the arm **104**, link **102** and the sector **98** to which the latter is connected. The sector **98** engages a gear **112** journaled on conveyor drive shaft **18** and the latter has a one way drive clutch connection to the shaft such that when sector gear **98** is rocked in a clockwise direction it will drive the gear and shaft and the endless conveyor chains **14—14** in the same direction, but when the sector gear is oscillated or rocked in the reverse direction the gear **112** is inoperative to rotate the shaft **18** with the result that the endless chains are halted thus stopping movement of the workpieces conveyed along the two sets of wires **10** and **12**.

In addition to operating the endless conveyor system, the drive shaft **96** also imparts movement to the various operating mechanisms heretofore described in the formation of the workpieces. For example, with reference to FIG. **1** the two initial corrugating gear wheels **24** and **26** are intermittently rotated about their respective axes by means of a connection to the drive shaft **96** including a ratchet wheel **114** secured to a shaft **116** common to gear **26** and connected to a one way drive clutch **118**, which in turn, is oscillated about the axis of shaft **116**. Oscillatory motion is imparted to the clutch by means of a pair of links **120** and **122**, the latter of which has its remote end revolved in one direction around the master drive shaft **96** by means of a wheel **124**. It is apparent from the drive relation of these parts that the one way drive clutch will intermittently rotate the ratchet in the direction indicated by the arrow, and that this motion in turn will be imparted through shaft **116** to the gear **26** and its companion gear **24**. Reverse motion of link **122** will be ineffective, and to assure non-return movement of the ratchet a dog **126** may be provided for this purpose.

As described in connection with FIG. **3**, the slightly corrugated ribbon or strip **20A** is fed between the two sets of wires **10** and **12** and the gears **24** and **26** are timed to discontinue rotation when the forward end of the strip abuts the stop **28**. This intermittent motion is controlled by the one way drive mechanism **114-124** previously described. Timed with the stoppage of the corrugated strip **20A** between the two sets of wires in the severing operation performed by the blades **32** and **34**. As previously described these blades will reciprocate in opposite directions to one another to cut a half pleat section out of the strip during the interval of time it is stationary.

The cutting action of the two blades **32** and **34** is accomplished by means of a lever **128** fulcrumed intermediate its ends on a stationary shaft **130** which is mounted above and parallel to the main drive shaft **96**. The rear end section of the lever **128** carries a roller **132** which is engaged by a cam **134** fixed to the drive shaft **96**. The front end section of the lever carries a laterally extending rod **136** from which a reciprocating block **138** is suspended and with which the cutter blade **32** is interlocked for joint movement therewith. As shown in FIG. **3**, the block **138** is guided in its reciprocation between two side walls, one of which is formed by the stationary plate **36**

earlier described herein and the other by a stationary plate **140**. To assure sliding engagement of the cutter blade with plate **36**, it may be spring urged thereagainst as by coiled spring **142**. It is evident that rocking movement of the lever **128** will cause its front section to raise and lower the plate **140** carried thereby.

The companion cutter blade **34** is reciprocated in the opposite direction to the cutter blade **32** by a linkage shown in FIG. **3** comprising a rocking arm **144** pivoted at **146** and carrying on one end thereof a depending plate **148** which is shaped at its lower end with an aperture **150** through which the corrugated ribbon **20A** is advanced and the lower edge of which is constituted by the blade **34**. The opposite end of the arm **144** is pivotally connected to a link **152** which has its upper end **154** straddling an intermediate portion of the front end section **138** of the lever. It will be evident that upon rocking motion of the lever the drive connection provided between arm **144** and link **152** will reciprocate the blade **34** in timed relationship with the blade **32** but in opposite direction thereto.

As earlier described herein, after the workpiece has been severed from its initially corrugated ribbon **20A**, the two levels of the wires **10** and **12** are transposed with respect to one another by the joint movements of the rockers **38** which will pull down the ends of the wires **12** below the level of the wires **10** and seat them in the upwardly opening loops of the workpiece to assume the position shown in FIG. **4**. As earlier described herein, this rocking motion is accomplished by means of a vertical reciprocating yoke member **42** which straddles the two sets of wires **10** and **12**. The vertical movement of the yoke **42** is controlled by means of a lever **156** which is pivotally mounted on the shaft **130** intermediate its ends and carries the yoke member **42** on the front end section thereof. The rear end section of the lever carries on the lower extremity thereof a roller **158**. This roller is positioned to be momentarily engaged by a cam member **160** having a rounded camming face which during a relatively small angular movement of the cam will strike the roller **158** and rock the lever **156** in the direction to raise the yoke member **42**. This will swing the rockers **38** in the direction to carry the connected end sections of the wires **12** below the wires **10** to the position shown in FIG. **4**. During this interval of time when these end sections of the wires **12** are below the wires **10**, a pusher **48** is advanced therebetween by the endless conveyor chains so that it is interleaved between the two sets of wires and engages the just severed workpiece **20B** to slide the same along the wires.

At the two forming stations **50** and **52**, the opposing workpiece compression members respectively identified at **56—56** and **64—64** are moved toward and away from one another under the control of two reciprocating parallel extending bars **166** and **168**. As shown in FIG. **1**, the two workpiece compression members **56** and **64** on one side of the wires are secured to a cross member **170** fixed to the reciprocating bar **168**. Similarly, the two compression members **56** and **64** on the opposite sides of the wires are secured to a cross member **172** fixed to the remaining reciprocating bar **166**. Reverse reciprocating motion is imparted to these two bars by means of a common rotating cam member **174** positioned therebetween and fixed to the drive shaft **96**. One side of the cam member **174** is provided with a cam face which is engageable with a roller **176** carried by the bar **168**. Similarly, the cam member **174** has a cam face which is engageable with a roller fixed to the other bar **166**. It is evident that upon rotation of the cam member **174**, it will engage the rollers and cause movement of the bars **166** and **168** in opposite directions at the same time, thereby advancing and retracting the compression members **56—56** and **64—64** in timed relation to one another. The cam member **174** and its respective cam surfaces for driving the bars are so shaped that the active movement of the compression members **56—56** and **64—64** are timed to the intermittent advancement of corrugated workpieces along the wires **10** and **12**. In other words, during the time a workpiece is halted between each opposing pair of compression members **56—56** and **64—64**, the two bars will be reciprocated in the directions to cause compressible force to be exerted on the ends of the workpieces thereby contracting the workpieces and further folding the loops around the wires in the manner described earlier herein in connection with FIGS. **5** to **8** inclusive.

At the last forming station **54**, the lever **86** carrying the cutting blades **90—90** is rocked about its axis **88** by a driving connection to the main shaft **96**. As shown in FIG. **1**, the end of the lever remote from the blades **90—90** is pivotally connected to a depending link **178** connected at its upper end to one end of a lever **180** pivoted on shaft **130** and rocked about its axis by a cam **182** fixed to the main shaft **96** and engaging roller **184**. The operating connection between the drive shaft **96** and the lever **86** is such that when a workpiece **20D** has been advanced by its pusher fully into the passage **74** of the last forming station, the lever will be swung in the direction to bring its cutting elements **90—90** into engagement with the end pleats of the workpiece partially severing the same and forming the outwardly curved flanges **94—94** of the finished article. To prevent the workpiece from falling out of the passage **74** or from following the return stroke of the blades **90—90**, a flexible member **186** may be provided which extends across the discharge opening of the passage temporarily holding the workpiece therein. However, when activated by its pusher **48**, the workpiece will cause the member **186** to yield and permit the workpiece to fall into a discharge chute.

It is desirable to provide means at the second corrugating station **52** of the machine which will hold the workpiece from further movement on the wires **10** and **12** while it is advanced and stopped between the two force applying members **64—64**. As described in connection with FIG. **7**, the workpiece at this station is enclosed at the top and bottom by member **66** and **68**. Moreover, its pusher **48** in this station backs up the workpiece as it is being compressed by the force applying members **64—64**. For preventing any dislocation of the workpiece in the forward direction at this station, there is provided a cross member **188** similar in shape to the pushers **48** and capable of interleaving between the two sets of wires **10** and **12** as shown in FIG. **1**. This cross member is carried upon upper ends of similar legs **190—190** pivoted intermediate their ends at **192** and having the remote ends extending along the inner sides of the lower return section of the endless chains **14—14**. A coiled spring **194**, shown in FIG. **2**, yieldingly urges the legs **190—190** in a clockwise direction about their common axis to swing the cross member **188** over the terminating ends of the wires **12** and between the same and the wires **10** and thence into engagement with the front edge of a workpiece momentarily halted in station **52**. To retract the cross arm **188** from its workpiece abutting position in station **52**, advantage is taken of the return movement of the pushers by the lower section of the endless chains. The legs **190—190** are so designed that each will be abutted by a returning pusher, such as that identified at **48'** in FIG. **2**, and swung in a counterclockwise direction pulling the cross arm **188** out of the two sets of wires and permitting the workpiece in station **52** to be conveyed along the wires **10** to station **54**. While this is occurring the pusher **48'** will be sliding toward the ends of the legs for disengagement therefrom, at which time the spring **194** will swing the legs and cross member back to the position shown in FIG. **2**.

As for the supporting structure of the machine, any suitable provisions may be employed for mounting and journaling the operating parts thereof. In the illustrated apparatus, two main upper and lower longitudinal extending structural members are shown in FIG. **2** at **196** and **198**. Partly shown in this Figure are spaced apart end plates **200** and **202** forming additional framework of the apparatus. The lower supporting member **198** serves to mount, among other elements, the endless chains **14—14** and associated parts and the reciprocating bars **166** and **168**. The upper supporting member **196** carries the lever **86** and cooperates with the end plate **202** for supporting the strip cutting blade assembly **30** at

the right end of the machine as viewed in FIG. 2. The end plates 200 and 202 carry the fixed shaft 130 upon which the levers 128, 156 and 180 are pivotally mounted. It is understandable that in other forms of apparatus embodying this invention the mounting arrangement of the parts is very likely to differ.

As for the control of the machine, the main power shaft 96 may be driven from an electrical motor (not shown). A suitable control box, such as that illustrated at 204 in FIG. 2, may be employed for turning the power on and off and for varying as well as indicating the speed of rotation of the motor and the power shaft.

The machine illustrated and described herein is designed for the fabrication of relatively small corrugated articles of the characters shown in FIG. 12 and which, in this instance, may be used in the production of magnetic recording and reading heads employed in electronic computer equipment. An example, of the use of such a corrugated article is illustrated in the patent application of John Stencel, Jr. et al, Ser. No. 647,720, filed June 21, 1967, now U.S. Pat. No. 3,508,229, of common ownership herewith where a similar corrugated member is utilized as an electrostatic shield separating a plurality of small magnetic core elements having their gap portions individually contained within the loops of the corrugations.

It is evident that the apparatus and method of this invention is capable of forming other corrugated formations in articles and that various modifications may be made within the scope of the invention. For example, the supporting rod-like elements or wires may have cross sections other than circular to impart a different shape to the corrugations. Another example is the omission of the last forming station 54 when all that is wanted is a corrugated formation. Moreover, in place of two forming stations 50 and 52 for folding the convolutions about the wires, only one station might suffice for this purpose. It is also evident that the wires 10 and 12 serve as a very convenient guide or track and may very well function in this capacity for transporting corrugated articles while subject to treatments other than those disclosed herein. Lastly, instead of an intermittent advancement of the workpieces through the apparatus, the invention lends itself to an arrangement where the articles are continuously moved while undergoing shaping operations.

While a particular embodiment of the invention has been shown and described, it will be understood, of course, that it is not desired that the invention be limited thereto since modifications may be made, and it is, therefore, contemplated by the appending claims to cover any such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. Apparatus for forming corrugations in a sheet-like member comprising:
- a plurality of rods extending in a generally parallel spaced apart relationship to one another and divided into two alternately staggered sets on opposite sides of a common plane lying therebetween;
- means for sliding a sheet-like member when placed in said common plane along said rods to one or more forming stations located therealong; and
- means at said one or more forming stations for applying compressive forces upon the member to shape convolutions therein generally conforming to the surface configurations of the rods, said rods having a permitted lateral displacement with respect to one another whereby they are shiftable closer together during application of said compressive force.

2. Apparatus for corrugating sheet material including, in combination:
- a workpiece transporting and shaping structure composed of a plurality of rod-like elements extending generally parallel to one another in spaced apart alternately staggered relationshiop to one another;
- means for placing a relatively slightly corrugated sheet-like member between said the rod-like elements with the latter individually seated within the corrugations thereof;
- means for sliding each such sheet-like member along said rod-like elements to one or more forming stations located along the length thereof; and
- means at each of said one or more forming stations for exerting compressive force upon each such sheet-like member received therein to conform the corrugations thereof to the surface configuration of the individual rod-like element seated therein.

3. A machine for forming a metallic strip into corrugated pieces, including:
- a workpiece transporting and shaping structure composed of a plurality of rods extending generally parallel and in spaced apart alternately staggered relationship to one another;
- means for forming initial corrugations in a metallic strip transversely to its longitudinal dimension and for feeding the corrugated strip into the space between the alternately staggered rods so that the rods are individually received within the corrugations of the strip;
- means for sliding each such workpiece along said rods to one or more forming stations located along the length of the rods; and
- means at said one or more forming stations for exerting compressive force upon the workpiece to more fully conform the convolutions thereof to the configuration of the rods.

4. A machine as defined in claim 3 wherein the apparatus has means for slitting at least one of the outermost pleats of the corrugations of the workpiece to form an outwardly extending flange thereon.

5. A machine as defined in claim 3 wherein the means for sliding each such workpiece is provided by an endless conveyor having spaced apart pusher elements for engaging and pushing each workpiece along the rods.

6. A machine as defined in claim 5 wherein drive means intermittently advances said endless conveyor to momentarily stop each workpiece at each of said one or more forming stations.

7. A machine as defined in claim 3 wherein means is provided for severing the initially corrugated strip from strip stock which comprises a pair of cutting blades spaced apart so that the path of movement of the first blade is in alignment with an upper loop portion of one of the pleats and that the path of movement of the second blade is in alignment with the lower loop portion of the next adjacent pleat, the two blades being operable to remove that portion of the strip between said upper and lower loops.

8. A machine as defined in claim 7 wherein the cutting blades operate vertically and simultaneously.

9. A machine as defined in claim 7 wherein the cutting edges of said blades slide over stationary surfaces to produce a scissor-like action when severing said portion of the strip.

10. A machine as defined in claim 3, wherein said rods are laterally displaceable with respect to one another at said one or more forming stations and will shift closer together when each workpiece thereon is subjected to compression.

11. A machine as defined in claim 3, wherein the first of said one or more forming stations applies endwise compression to the corrugated workpiece so that the sides of the pleats thereof are generally parallel to one another.

12. A machine as defined in claim 11, wherein the second of said forming stations applies endwise compression to the corrugated workpiece so that the sides of the pleats thereof are alternately reversely inclined with respect to one another.

13. The method of forming a sheet metal article which comprises interleaving a sheet metal workpiece among a group of rod-like elements extending generally parallel to one another and having a permitted lateral displacement toward one another;
- advancing the workpiece along the group of rod-like elements toward one end thereof; and
- applying compressive forces on the workpiece during its advancement along the rod-like elements to contract the workpiece individually about the rod-like elements, the

rod-like elements shifting closer together during the application of such forces to accommodate the contraction of the workpiece.

14. The method of corrugating sheet material comprising placing a workpiece of such material between two sets of wires extending generally parallel to one another, the individual wires of the two sets being spaced apart in alternately staggered relationship and capable of lateral displacement with respect to one another; and

applying a compressive force on the workpiece in the direction crosswise of the two sets of wires to progressively contract the workpiece and to cause intermediate portions of the workpiece to fold individually about said wires to form corrugations therein, the wires displacing themselves closer together during the application of such compressive force to accommodate the contraction of the workpiece.

15. The method defined in claim 14 characterized in that following placement between the two sets of wires the workpiece is slid along the wires to a forming station where the aforesaid compressive force is applied.

16. The method of forming a flat sheet material into a corrugated article, comprising the steps of:

placing the strip of such material transversely between two sets of rod-like elements extending generally parallel to one another and such that one wire set is located on one side of the strip and the other wire set is located on the other side thereof,

applying endwise compressive force to the strip to contract the same upon the rod-like elements and to fold the material of the strip partially around the rod-like elements,

the rod-like elements shifting closer together during the application of said endwise compressive force to accommodate the contraction of the strip.

17. In the method of forming a corrugated article from an elongated metal strip, the steps comprising:

initially slightly corrugating the metal strip,

introducing the slightly corrugated metal strip between two sets of wire-like elements extending generally parallel to one another and capable of lateral displacement with respect to one another, and

subjecting the metal strip to endwise compressive force dimensionally reducing its length while further folding the strip about the wire-like elements, the elements accommodating the contraction of the strip by moving closer together during the application of the compressive force.

18. The method of forming a corrugated member from sheet material comprising the steps of:

initially slightly corrugating the sheet material,

introducing the slightly corrugated sheet material between two sets of parallely extending laterally displaceable wire-like elements so that the elements individually lie within the corrugations, and

subjecting the sheet material to compressive forces acting transversely to the corrugations to contract the sheet material and to further fold the corrugations about the wire-like elements, the elements accommodating the contraction of the sheet material by displacing themselves closer together.

19. The method defined in claim 18 characterized in that following placement between the two sets of wire-like elements the sheet material is slid along the wire-like elements to one or more forming stations where the aforesaid compressive forces are applied.

20. The method of handling corrugated sheet material including the steps of:

initially slightly corrugating the sheet material,

introducing the slightly corrugated sheet material between two sets of parallelly extending wire-like elements so that the elements individually lie within the corrugations,

transporting the sheet material from one position to another position by sliding the same along the wire-like elements, and

during its transportation along the wire-like elements applying pressures to the corrugated sheet material acting transversely to its corrugations to shape the sheet material about the wire-like elements.

21. The method of forming a corrugated member from sheet material comprising the steps of:

initially slightly corrugating the sheet material,

introducing the slightly corrugated sheet material between two sets of parallelly extending wire-like elements so that the elements individually lie within the corrugations,

conveying the sheet material along the wire-like elements toward one end thereof, and

subjecting the sheet material to increasingly greater pressures acting transversely to its corrugations while it is supported by and conveyed along the wire-like elements toward said one end thereof to further fold the corrugations about the wire-like elements.

22. In apparatus for progressively modifying the shape of a workpiece, the combination:

a plurality of rods extending in a generally parallel spaced apart relationship to one another and divided into two sets of such rods on opposite sides of a common plane lying therebetween, the rods of each set being relatively fixed against lateral displacement with respect to one another adjacent to one common end thereof but being relatively free for the balance thereof so as to have a permitted lateral displacement with respect to one another,

means for sliding a workpiece occupying said common plane between the two sets of rods from a position adjacent the fixed end thereof toward the opposite end thereof, and

means for progressively modifying the shape of the workpiece as it is slid along said rods, said rods shifting laterally with respect to one another as the shape-modifying operation is performed.

23. The apparatus defined in claim 22 further characterized in that means is provided for feeding a corrugated workpiece into said common plane between the two sets of rods adjacent to the fixed ends thereof, and that further means is provided for transposing the two sets of rods with respect to the common plane therebetween to bring the rods into the loops of the corrugations of the workpiece.

24. Apparatus for corrugating material including, in combination:

a transporting and shaping mechanism composed of a plurality of spaced-apart rod-like elements extending generally in one direction to form a track and divided into two sets of such rods alternately staggered with respect to one another on opposite sides of a common plane extending therebetween;

means for introducing corrugated material into the common plane between the two sets of rod-like elements and for seating the elements individually in the corrugations of the material;

means for advancing such corrugated material along the track formed by said rod-like elements; and

means cooperating with said rod-like elements and exerting pressure on the corrugated material as it is advanced along the rod-like elements for contouring the loops of the corrugations of the material to the positions and the surface configurations of the rod-like elements seated therein.

25. The method defined in claim 17 characterized in that following introduction of the metal strip between the two sets of wire-like elements and before application of the compressive force the two wire sets are transposed with respect to the plane of the strip to seat the wire elements in the loops of the corrugations of the metal strip.

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