March 7, 1967 E. M. LACEY, JR., ETAL 3,307,387

METHOD AND APPARATUS FOR PERFORATING AND CORRUGATING METALLIC RIBBON

Filed Dec. 11, 1963 3 Sheets-Sheet 1

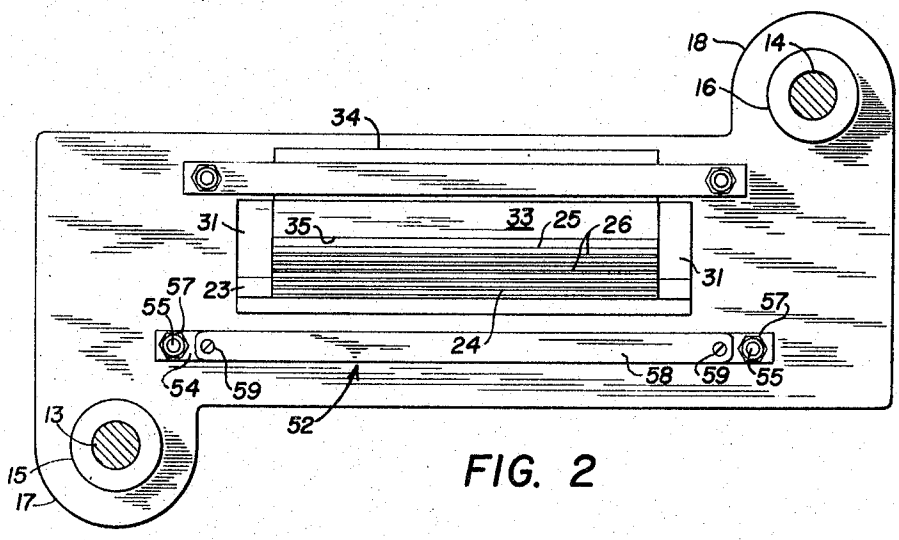



FIG. 2

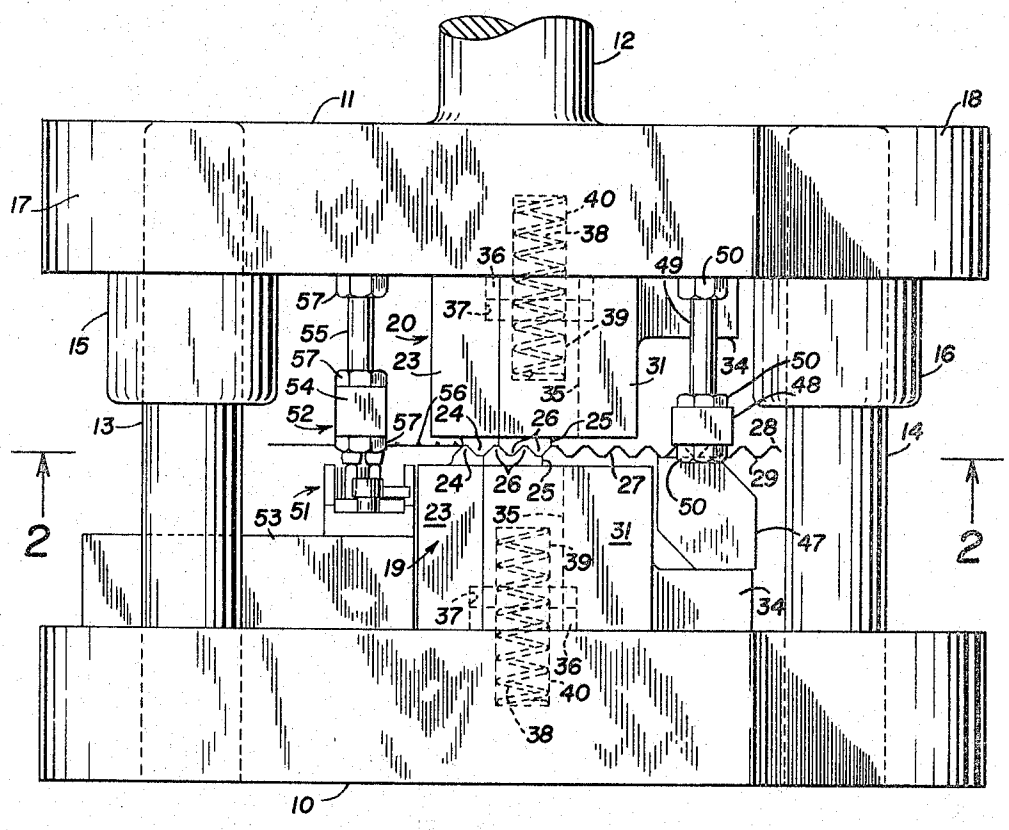



FIG. 1

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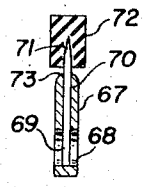



FIG. 5




FIG. 3




FIG. 11

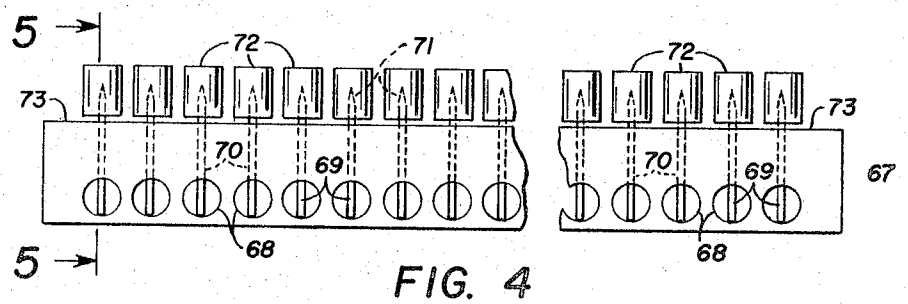



FIG. 4

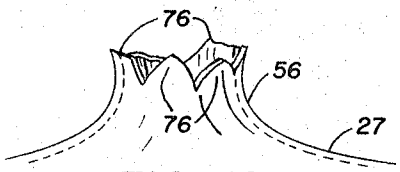



FIG. 12

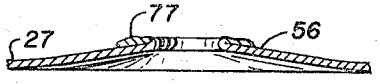



FIG. 14

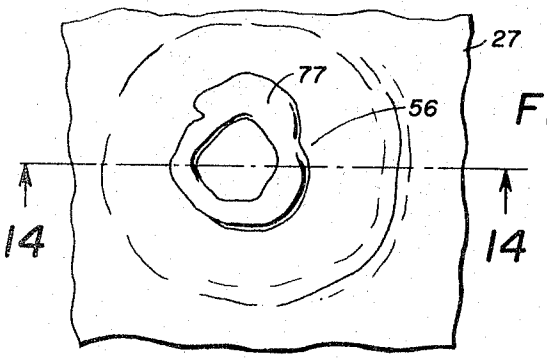



FIG. 13

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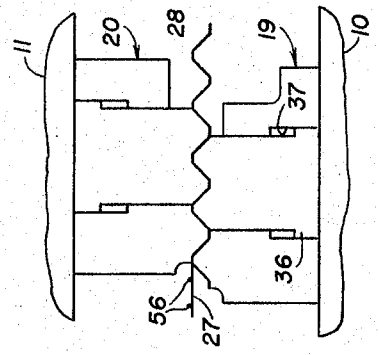


FIG. 9

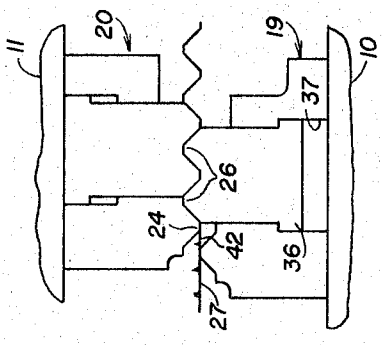


FIG. 8

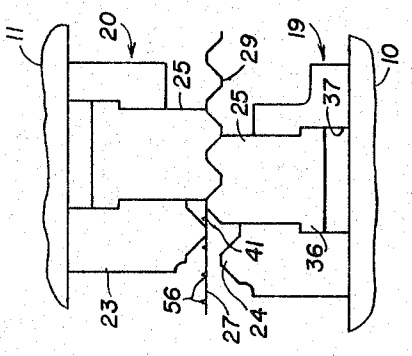


FIG. 7

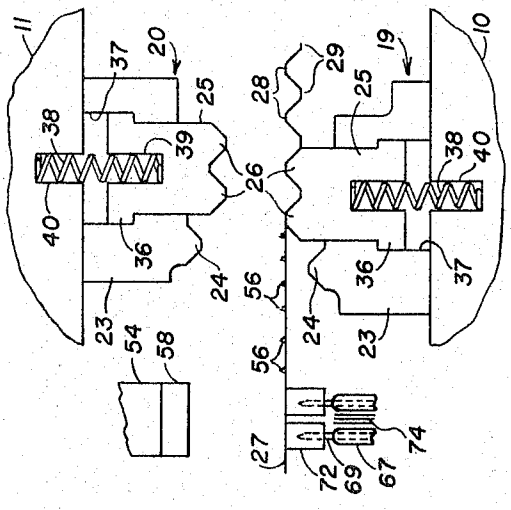


FIG. 6

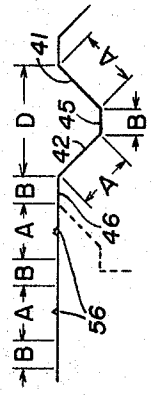


FIG. 10c

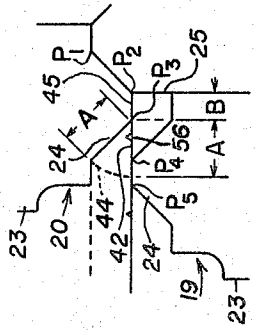


FIG. 10b

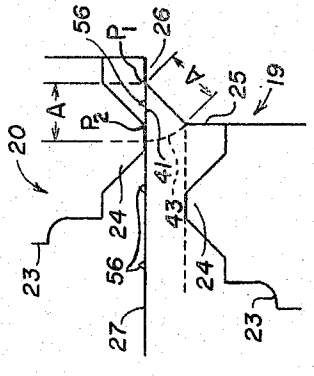


FIG. 10a

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United States Patent Office 3,307,387 Patented Mar. 7, 1967



3,307,387

# METHOD AND APPARATUS FOR PERFORATING AND CORRUGATING METALLIC RIBBON

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Filed Dec. 11, 1963, Ser. No. 329,744
15 Claims. (Cl. 72—324)

This invention relates generally to machines for fabricating honeycomb core and more particularly to a ribbon perforator for a corrugation punch press having provision for perforating unformed metallic ribbon preparatory to corrugating the same for use in the fabrication of honeycomb core.

In a core fabricating machine such as disclosed in Patent No. 3,079,487, issued to F. H. Rohr for Method and Apparatus for Fabricating Honeycomb Core, a corrugated metallic ribbon is folded back and forth upon itself to form the successive layers of the core. In order to form quality high strength core in this manner, it is necessary that the corrugations in the ribbon be precisely formed and coined without introducing appreciable distortion or strain into the ribbon material during the corrugation process. This is imperative in order that the corrugated ribbon will have the same spacing from node to node such that the nodes of the confronting ribbon layers will be aligned and abutted preparatory to the resistance welding of the nodes together to form the cells of the core. As disclosed in the aforesaid patent, wherein provision is made for programming the corrugated ribbon of successive sections of different thickness to provide a core of predetermined structural pattern and density, it is equally important that the corrugation configuration and nodal spacing be precisely maintained since these parameters provide the reference datum in determining points in the fabricated core at which changes in density are to occur in accordance with the predetermined pattern.

In the fabrication of the honeycomb core into a sandwich panel by brazing metallic skins thereto, it usually is required, moreover, that the cell walls of the honeycomb be perforated so that the inert gas which provides a protective atmosphere during brazing can circulate freely through the honeycomb structure. The perforations may be formed by the dies of the punch press itself, as by punching or blanking the openings in the manner disclosed in the aforesaid patent of Fred H. Rohr, but this arrangement is not entirely satisfactory in service for the reason that the blanks accumulate, are difficult to dispose of, and in many instances tend to find a way into and between the corrugating dies to thus obstruct the corrugation process.

Perforating the ribbon as by piercing or impaling the same as with a needle-like device is preferred to blanking, but this method heretofore has had the disadvantage of introducing incipient tearing, cracking, and fracturing of the ribbon material, which initial effect may be insidious and, in time, be the cause of a disastrous failure in flight. The pierced ribbon material has also been found to be objectionable heretofore for the reason that the resulting protuberances in the ribbon corrugations have prevented free movement of the perforated ribbon through the corrugating dies and have required inordinate undercutting of the indexing and electrode pins in order to clear the protuberances as the pins move into and out of the cells of the honeycomb in the process of fabricating the core from the corrugated ribbon.

Corrugation punch presses of the type disclosed in the aforesaid patent of Fred H. Rohr provide the required



coining of the metallic ribbon as the corrugations are formed, but have not entirely solved the problem of minimizing the stresses and strains due to the drawing and inordinate working of the ribbon as the corrugations are formed. Even where, as in the aforesaid case, stages of spring loaded corrugation punches are used in the operation so that the corrugations are formed only one at a time by the spring loaded dies, the continuous and extensive drawing of the ribbon in the formation of each corrugation prohibits the use of pierced ribbon perforations since the protuberances cannot slide over the confronting die teeth during this drawing movement of the ribbon.

A corrugation punch press suitable for use in corrugating ribbon which has been pierced to form perforations therein in accordance with the perforating process of the present invention, is disclosed and claimed in the copending application of William F. Rethwish and Dale S. Harding for Corrugation Punch Press, Serial No. 314,191, filed October 7, 1963. In accordance with the arrangement of this preferred form of corrugation press, upper and lower dies, respectively having differentially spring loaded die members, cooperate during the initial closing of the dies to yieldably clamp and holding a previously formed, substantially V-shaped ribbon corrugation between the spring loaded members and, thereafter, as the dies continue to close, to brake the unformed ribbon therebetween in two steps, to thus form the two sidewalls of a new corrugation, as the holding die members bottom in successive order, after which the dies, together and as a unit with their holding die members, forcibly more together to coin the newly formed corrugation therebetween. In this operation, the braking action involves essentially a translatory swinging movement of the unformed ribbon portions about certain of the tooth edges of the dies which act as pivotal points. The result of this action is that the necessary drawing of the ribbon from the storage reel is due essentially to the braking action, and as such, does not interfere with the desired positioning of the protuberances in what become the sidewalls of the corrugation. Working of the ribbon material, such as may occur in the corrugation process, moreover, is held to a minimum, to thus substantially prevent the introduction of stresses and strains in to corrugated ribbon. Formed nodal portions of the ribbon experience no working of the metal at all, save for ultimate coining which is desired; the nodal portions merely being translated, as required, in the corrugation process to place the nodes alternately at the peaks and valleys of the corrugated ribbon.

In using this corrugation press with the pre-pierced ribbon perforations, the same are spaced along the length of the ribbon such that the protuberances lie in what become the sidewalls of the corrugations, as aforementioned. As such, the protuberances lie in the portions of the ribbon which brake in the corrugation process, and since the drawing of the ribbon is largely incidental to the braking of the same, the protuberances readily clear the die teeth and are positioned for flattening thereby as the dies close. The flattened protuberances form an eyelet which prevent the extension of the incipient tearing due to piercing, and also minimize the undercutting of the electrode and indexing pins.

In accordance with the perforator process of the present invention, an array of piercing elements such, for example, as steel phonograph needles are supported on the anvil of the corrugation press and are arranged in rows which lie transversely of the ribbon path. Each needle extends loosely upwardly from its support on the anvil, and its tip portion is disposed or impaled within a small mass of resilient material such, for example, as

a cylinder of soft rubber which bears against or near the needle support. Each loosely mounted needle, together with its impaled rubber cylinder, is readily removed from the array for repair or replacement.

An elongated pad of resilient material, which may be of the same material as used in the cylinders, together with a backup support therefor, is also disposed transversely of the ribbon path, but these members are supported by the punch or ram of the corrugation press and depend therefrom initially in spaced relation to the ribbon such that the unformed and unperforated portion of the ribbon feeds freely between the confronting surfaces of the pad and the surface support afforded by the end faces of the array of the rubber cylinders. Following piercing of the ribbon by the needles, both the resilient backup pad and the resilient cylinders, which become compressed during the piercing operation, expand as the corrugation dies move toward open position and thus operate to strip the ribbon and its protuberances from the pad as well as from the needles whose tip portions again become fully impaled within their respective cylinders.

An object of the present invention is to provide a new and improved apparatus and process for perforating and corrugating metallic ribbon.

Another object is to provide a ribbon perforation and corrugation apparatus and process which pierces the ribbon and thereafter corrugates the same in such a manner that the protuberances which result from piercing of the ribbon fall into predetermined positions in the corrugations formed in the ribbon.

Another object resides in the provision of a ribbon perforating and corrugating process and apparatus in which protuberances resulting from piercing of the ribbon are pressed into eyelets between the confronting corrugation dies.

Still another object is to provide a ribbon piercing arrangement which is operable by the corrugation press and pierces the ribbon prior to corrugating of the same in the corrugation dies.

Yet another object in a ribbon piercing perforator resides in the provision of novel stripper arrangements for freeing the pierced ribbon and the resulting protuberances thereon from the perforator as the corrugation dies move to open position.

Still other objects, features, and advantages of the present invention other than those hereinbefore specifically set forth are inherent in, or are to be implied from the novel combination, construction, and arrangement of parts comprising the best mode thus far devised for carrying out the invention and for practicing the methods thereof. This mode and a specific embodiment thereof will become more fully apparent as the description proceeds with reference to the accompanying drawings wherein:

FIG. 1 is a view in elevation of the perforator and corrugation press of the present invention;

FIG. 2 is a view from the underside of the upper perforator and die of the corrugation press as viewed along the line **2—2** of FIG. 1 and rotated 90° counterclockwise from the position of FIG. 1;

FIG. 3 is an enlarged perspective view of the lower perforator assembly shown in FIG. 1;

FIG. 4 is a view in elevation of a needle and support assembly disclosed in FIG. 3;

FIG. 5 is a sectional view taken along the line **5—5** of FIG. 4;

FIGS. 6 to 9 are schematic views showing the successive steps of perforating a ribbon and forming a perforated ribbon corrugation therein between the dies of the corrugation press;

FIGS. 10*a* to *c* are diagrammatic views illustrating further details of the corrugation forming process performed on the perforated ribbon;

FIG. 11 is a detail view disclosing the operation involved in the piercing of the ribbon;



FIG. 12 is an enlarged view depicting the protuberance formed by piercing of the ribbon;

FIG. 13 depicts the eyelet which is formed from the ribbon protuberance when the same is pressed and coined in the corrugation press; and

FIG. 14 is a sectional view taken along the line **14—14** of FIG. 13.

Referring now to the drawing for a more complete understanding of the invention, and first more particularly to FIGS. 1 and 2 thereof, **10** and **11** designate fixed and movable die supports which, in practice, may be referred to as shoes, but for purposes herein, conveniently may be considered as the anvil **10** and the ram or punch **11** of a conventional punch press. Support **11** is normally positioned above fixed support **10** and is slidably mounted on the upstanding and suitably spaced cylindrical guides **13** and **14** for movement forcibly toward and away from the fixed support. For this purpose, guides **13** and **14** are suitably secured to fixed support **10**, and movable support **11** is suitably driven from a power source acting through its coupling member **12**. Hubs **15** and **16** on support **11** extend the bearing surface afforded thereby on guides **13** and **14**. Hubs **15** and **16** and guides **13** and **14** are disposed concentrically with respect to semi-cylindrical lateral extensions **17** and **18** of support **11**.

A die set comprising dies generally designated **19** and **20**, respectively, are suitably secured by means (not shown) to the fixed and movable supports **10** and **11**. Dies **19** and **20** are generally similar, and the same reference characters therefore, will be applied to the same or like elements of these dies throughout the several views.

Each of dies **19** and **20** comprises a forming die member **23** having one tooth **24**, and a relatively movable holding die member **25** having two teeth **26**. Die members **23** and **25** for both dies **19** and **20** are identical and their opposing teeth **24** and **26** complement each other such that the same intermesh and the line of engagement between the teeth depicts the corrugation configuration to be imparted to a metallic ribbon **27** interposed therebetween. As may be seen from this configuration, the resulting corrugations in the ribbon are generally V-shaped with flattened surfaces or welding nodes **28** and **29** respectively provided at the crests and valleys of the corrugated ribbon.

Each forming die member **23** is suitably secured at the ends thereof to a pair of end plates **31**, FIG. 2, which, in turn, are suitably secured to the die guide block and mounting member **33**. Each member **33** has a mounting flange **34** for mounting its die **19** or **20**, as the case may be, on its respective support **10** or **11**, as aforementioned. End plates **31** also have fastening means (not shown) which serve further for this purpose.

Die members **23**, **31** and **33** when asembled and secured together, as aforedescribed, provide a guide channel **35** for the holding die member **25** which is provided with a flange or shoulder **36**. Guide channel **35** is appropriately widened at **37** to accommodate the shoulder and also to provide a seat therefor to limit the movement of holding die member **25** forwardly or outwardly with respect to the forming or corrugating die member **23**. It will be noted that the widened channel **37** has a greater length than that of the shoulder thereby to permit limited relative movement between the die members **23** and **25**. Thus, when each die **19**, **20** is mounted in position on its respective support **10**, **11**, die member **25** for each die is limited in its movement in the opposite direction as the shoulder engages the mounting surface of its associated support, as may be seen in FIG. 1 wherein the dies **19** and **20** are shown to be closed and the die members **25**, in such case, are properly shown to be bottomed on their respective supports. When die members **25** are thus bottomed, they effectively become a unit with their respective corrugator die members **23**, and teeth **26** of each member **25** effectively act as a unitary structure with their as-

sociated tooth **24**. This is important in the precision forming of corrugations in metallic materials such as stainless steels wherein it is desired to coin the formed corrugations in the final blow imparted thereto by the punch press in the instant of closing of the dies on the ribbon **27** interposed therebetween.

Holding die members **25**, as may be seen in FIG. 1, are spring loaded as by coil springs **38**, so as to be normally extended yieldably outwardly or forwardly of their respective forming die members **23**, these members being sufficiently elongated, as required, to corrugate ribbons of various widths. A plurality of springs are employed for each die member, and a socket **39** is provided therein for seating each spring **38**. Similarly, supports **10** and **11**, are provided with sockets **40** which also serve to seat the springs, sockets **40** being aligned with and complementing the sockets **39** of the die members **25**.

For reasons which will become more fully apparent as the description proceeds, die members **25** are differentially spring loaded, the spring loading of die member **25** of die **19** being made greater than that of member **25** of die **20** as by using two, for example, more springs **38** for die member **25** of die **19**, than for member **25** of die **20**. It will be understood that whereas differential spring loading has been particularly disclosed herein, the differential bias and yieldable urging of the holding die members **25** may be accomplished by other means such, for example, as by using air pressure.

The corrugations formed in ribbon **27** are stretched and elongated in a controlled amount, by stretcher members **47** and **48** of which member **47** serves as an anvil and is suitably secured to support **10**. Member **48** is secured to and depends from support **11** as by the stud bolts **49** and is adjusted in position therefrom by the nuts **50**. For reasons believed inherent in the coining of the corrugations in the punch press operation, the resultant spacing between nodes invariably is less than that of the die dimensions. The adjustably mounted member **48** is elevated or lowered at either or both ends relative to support **11**, as required, to provide such spaced relation with respect to member **47** as will flatten and thereby stretch the corrugated ribbon sufficiently to compensate for the under-dimension forming of the spacing between nodes of the corrugations. In some instances, where the corrugation spacing tends to be greater at one side of the ribbon than on the other with resultant tapering of the corrugations over the width of the ribbon, this may be obviated by slightly raising or lowering one end of member **48** more or less than the other end relative to the set screws **50** individual thereto.

Means for perforating ribbon **27** preparatory to forming and coining the corrugations therein is generally disclosed in FIG. 1, and comprises a lower ribbon piercing assembly, generally designated **51**, and an upper back up plate assembly, generally designated **52**, which assemblies lie transversely of the ribbon path in confronting relation to each other and to ribbon **27** disposed therebetween. Assembly **51** is suitably supported on and secured to a block **53** which, in turn, is suitably supported on and secured to press support **10**.

Back up plate assembly **52** comprises an elongated, relatively massive metal bar **54** which prefearbly is of square cross section and depended at the ends thereof from movable press support or ram **11** as by the stud bolts **55** which are suitably secured, as by the nuts **57**, to the support **11** and bar **54**, respectively. A resilient ribbon stripper or shedder strip **58** is suitably secured at the ends thereof to bar **54**, as by screws **59**. Strip **58** may be formed of any material suitable for the purpose such, for example, as sheet rubber (Duro 65).

Referring now more particularly to FIGS. 3 to 5, it will be seen that the ribbon piercing assembly **51** comprises a channel member **60** having a base **61** and side walls **62** which are reduced as at **63** in the end regions of channel member **60** to accommodate bifurcated adjusting



plates **64** which are releasably secured to base **61** as by the screws **65**.

Channel sidewalls **62** and plates **64** form a shallow socket **66** for retaining the needle mounting and supporting members **67**, the plates **64** being slidably adjusted in the channel, as required, to position and clamp the members **67** therebetween. As may best be seen in FIGS. 4 and 5, each of members **67** is apertured transversely thereof to provide a plurality of openings **68** which taken together constitute a common bottoming plane for a plurality of needles **69**. The needles are loosely received in openings **70** which are arranged to intersect respectively with the openings **68**.

Needles **69** per se are essentially rod-like, being pointed at one end and flat at the other; and viewed as an array, are of uniform length. The needles may be of any configuration and formed of any material suitable for the purpose. For example, the needles may be commercially available Duotone filter point phonograph needles. Each needle **69** is impaled in the region of its tip portion **71** within a small resilient mass **72**, preferably of cylindrical configuration, as shown, the cylinders being positioned at or near the upper surface **73** of each of members **67**. Cylinders **72** may be formed of any material suitable for the purpose such, for example, as by being punched from soft sheet rubber (Duro 65).

Referring again to FIG. 3, it will be seen that the cylinders **72**, and hence the needles **69**, are spaced along the lengths of members **67** in accordance with the perforation pattern desired across the width of the ribbon, it being noted that the arrangement is such that the needles of one member **67** are staggered with respect to those of the other to avoid weakening of the ultimate honeycomb structure in its length dimension. In order to space the perforations in the ribbon so as to fall in the sidewalls of the successive corrugations, needle support members **67** are spaced between sidewalls **62** by a plurality of shims **74** and a marcel strip **75**. Strip **75** is interposed between one of the sidewalls and one of members **67** and yieldably urges the same toward the other sidewall. The shims are interposed between this last named sidewall and the other of the needle support members **67**, and also between the members themselves, as may be seen in the disclosed arrangement of FIG. 3.

Attention is now directed to FIGS. 6 to 14 for a description of the ribbon piercing and corrugating operation from which it will become more fully apparent how the essentially braking action of the corrugation press lends itself to the forming and coining of corrugations in a ribbon which has been pierced and protuberated.

With the parts positioned as disclosed in FIG. 6, the punch press is about to begin a new cycle of operations in which it will pierce a new double row of protuberances **56** and form a new corrugation in ribbon **27**, the ribbon having been just previously advanced one corrugation by sliding over the rubber cylinders **72**, out of and over teeth **26** of the lower holding die member **25**, and thence over anvil **47** of the stretch-out device. The ribbon preferably is advanced relative to the perforator, dies, and stretch-out as aforedescribed, by a hitch feed mechanism such as disclosed and claimed in the copending application of Elbert M. Lacey, Jr., for Method and Apparatus for Feeding Metal Strips, Serial No. 78,720, filed December 27, 1960, which application also discloses the stretch-out operation on the corrugated ribbon.

With the previously formed corrugation of ribbon **27** thus seated on the lower die member **25**, the opposing member **25** first engages the ribbon during the initial closing of die **20** toward die **19**, the ribbon then being clamped yieldably between the upper and lower ribbon holding members **25**, as depicted in FIG. 7, at which time the forming of the first portion of a new corrugation is about to begin. As die **20** continues to move toward die **19**, the same moves relative to its holding die member **25** which cannot move at this time because

of the greater spring force acting on the lower holder member **25** which does not move until after the upper die member **25** has bottomed on support **11**.

During this relative movement of die member **23** with respect to its holding die member **25**, a first unformed portion **41**, FIG. 7, of ribbon **27**, corresponding to one side of a new corrugation, is formed between tooth **24** of die **20** and confronting tooth **26** of die **19** as the dies take the position as shown in FIG. 8.

Members **23** and **25** of die **20** now move as a unit to thus move holding member **25** of die **19** yieldably against its opposing spring force until the same bottoms on support **10**, as diclosed in FIG. 9. During this movement, a second unformed portion **42**, FIG. 8, of ribbon **27**, corresponding to the remaining sidewall of the new corrugation, is formed between the confronting teeth **24** of the opposing corrugating die members **23**. In the position of FIG. 9, both die members **25** being bottomed, the newly formed corrugation is coined in the instant of forcible closing of die **20** on die **19**.

Shortly after the dies proceed to close further from the position of FIG. 8, as aforedescribed, shedder strip **58**, FIG. 6, moves to engage ribbon **27**, and on further closing of the dies, strip **58** compresses somewhat as the same moves the ribbon to compress the rubber cylders **72**. As this action progresses, of course, the needles **69** further pierce the cylinders and then pierce the ribbon to form the protuberances **56** and, thence, proceed to penetrate somewhat into strip **58**, as depicted in FIG. 11.

When the dies separate and move to open position, the compressed cylinders **72** expand and, in so doing, lift the perforated ribbon with respect to the needles **69** to thus retract the needles therefrom. The needles, of course, return to their partially impaled positions within the cylinders. The compressed shedder strip **58** likewise expands as the same moves with support **11** to pull away from the compressed cylinders **72** and, as this expansion of strip **58** occurs, the ribbon and its protuberances **56** are stripped from the shedder strip **58** and thus do not follow the continued upward movement of the strip to the open position of the dies, as depicted in FIG. 6.

Referring now more particularly to FIGS. 12 to 14, it will be seen that each of the protuberances **56** comprises a ring of more or less uniform peaks **76** distributed about the circumference of each perforation opening formed in the pierced ribbon **27**. As otherwise expressed, the initially ruptured ribbon apparently proceeds to tear along uniformly spaced lines as the perforation is enlarged by the progressive penetration of the tapered needle into the pierced ribbon. These protuberance peaks double back upon themselves during the corrugation process to form an eyelet or more or less symmetrical ring **77** about the perforation opening, as disclosed in FIGS. 13 and 14, and this ring **77** prevents further tearing of the ribbon and thus avoids an extension of the incipient tearing of the ribbon which occurs as an icidence of the ribbon perforation.

Referring now more particularly to FIGS. 10*a* to *c*, for a more detailed discussion of the metal working aspects involved in the forming of a new corrugation from the perforated ribbon **27**, it will be seen that the perforated ribbon portion **41**, which has a length A corresponding to the sidewall of the corrugations to be formed, bears critically at **P1** on tooth **26** of holding die member **25** of die **19**, and also bears critically at **P2** on tooth **24** of forming die member **23** of die **20**. As the dies close and the forming occurs, ribbon portion **41** brakes about the point **P1** in response to pressure applied at the point **P2**. It will be appreciated that the ribbon slides for a small distance over the point **P2** of tooth **24** until the same reaches the position of FIG. 10*b*. In the braking action of the unformed ribbon portion **41**, the end of the same follows the circular path about point **P1** indicated by the dashed line **43**. That diminishing portion of the unformed ribbon lying between this dashed line and point **P2**, of course, experiences a combined sliding and braking movement over point **P2**. While a purely braking action would be ideal, no adverse effects are manifested. The protuberance **56** in ribbon portion **41** is thus simply moved in a swinging motion to a position against the sidewall of tooth **26** of die member **25** of die **19** preparatory to being flattened thereagainst by the approaching surface of tooth **24** of die member **23** of die **20**.

A second unformed ribbon portion **42**, also having a length A and a protuberance **56**, brakes about the point **P3** on tooth **24** of die member **23** of die **20**, as die member **25** of die **19** moves to bottom on support **10**, and a combined sliding and braking action of the ribbon occurs about the point **P4**. The braking action of unformed ribbon portion **42** about point **P3** thus is such that the end of the ribbon portion effectively follows the circular path indicated by the dashed line **44** shown in FIG. 10*b*, and the protuberance **56** in ribbon portion **42** is simply translated in a swinging movement to a position against the sidewall of tooth **24** of die **20** preparatory to being moved and coined thereby against the confronting sidewall of tooth **24** of die **19**.

That portion of the unformed ribbon, which lies between points **P2** and **P3**, is designated **45** and has the nodal length B. Ribbon portion **45** is simply translated to the base of tooth **24** or die member **23** of die **19** as member **25** thereof moves to bottom on the die support **10**. As a practical matter, unformed but coined ribbon portion **45** together with ribbon portion **41**, may be considered to be a first unformed ribbon portion, in the same sense that the corresponding unformed but coined ribbon portion **46**, FIG. 10*c*, which lies between the points **P4** and **P5** at the closing of the dies, together with ribbon portion **42**, may be considered to be a remaining ribbon portion, required to form a new complete corrugation, which will thus be made up of ribbon portions **41**, **45**, **42** and **46**, as may best be seen in FIG. 10*c*.

Although the corrugation width, i.e., as measured from node to node, may be seen to be B plus D, a length of ribbon corresponding to 2B plus 2A is required to form the new corrugation. Of this length, as has been described, there is no working of the "B" portions; only coining. D minus B, of course, does not equal 2A, since purely braking does not occur in the forming of the "A" portions; but this is substantially the case, and the ultimate coining of the formed ribbon in the region of points **P2** and **P4** removes any adverse effects which may have been introduced in the previous working of the material as it slides over the teeth at these points. In effect, the substantial length of each "A" portion and the protuberance thereon is simply translated in a swinging movement of the unformed ribbon portion about the edge of one of the die teeth.

The results of the combined perforation and corrugation process as aforedescribed are, first, precision forming of the perforated ribbon corrugations and, second, high quality blocks of honeycomb core free of incipient tear conditions when the blocks are fabricated from the perforated and precision corrugated ribbon. Such blocks are undistorted and unwarped and have optimum welds at abutting nodes which are aligned consistently from node to node. The fabrication of cores from such ribbon desirably may be programmed with assurance that the corrugation will be of uniform spacing and the nodes will properly align and abut preparatory to welding of the same together. The cores, moreover, having the perforated cell walls may readily be fabricated into sandwich structures in any brazing process requiring the circulation through the core of a protective gaseous atmosphere.

It will be apparent from the foregoing that a perforation and corrugation press and process has been provided

which is well adapted to fulfill the aforestated objects of the invention. It will be apparent, moreover, that this invention may be embodied in other forms or carried out in other ways without departing from the spirit or essential characteristics thereof. The present embodiment of the invention is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

Having thus described our invention, what we claim as new and useful and desire to secure by Letters Patent is:

1. The method of perforating and corrugating metallic ribbon to form substantially V-shaped perforated corrugations therein having nodal portions at the crests and valleys which comprises the steps of piercing the ribbon, and concurrently corrugating eyeleting and coining the pierced ribbon so that the protuberances resulting from the piercing of the same fall into predetermined positions in the sidewalls of the corrugations, and the protuberances become eyelets in the coining of said sidewalls.

2. The method as in claim 1 and further comprising the step of stretching the corrugated ribbon to set the nodal spacing of the corrugations at a predetermined value.

3. The method of perforating and corrugating metallic ribbon to form substantially V-shaped corrugations having perforated sidewalls and nodal portions at the crests and valleys, comprising the steps of piercing the ribbon to form protuberances therein spaced along the length thereof, braking successive portions of the pierced ribbon to corrugate the same such that said protuberances fall respectively in the sidewalls of the corrugations, coining the corrugations and transforming said protuberances therein to eyelets, and stretching the corrugated ribbon to set the nodal spacing of the corrugations at a predetermined value.

4. The method of perforating and corrugating metallic ribbon to form substantially V-shaped corrugations therein having perforated sidewalls and nodal portions at the crests and valleys, comprising the steps of advancing the ribbon intermittently longitudinally of the same, piercing the ribbon as the same advances to form protuberances therein spaced along the length thereof, braking successive portions of the pierced ribbon to form said V-shaped corrugations therein such that said protuberances fall respectively in the sidewalls of the corrugations, coining the formed corrugations and eyeleting said protuberances therein, and flattening the corrugated ribbon to stretch the same and set the nodal spacing of the corrugations at a predetermined value.

5. The process as in claim 4 and wherein said piercing, corrugating, coining, eyeleting, and flattening of the ribbon occur concurrently during intervals between the intermittent advances of the ribbon.

6. A system of perforating and corrugating metallic ribbon to form V-shaped corrugations having perforated sidewalls comprising, in combination, means for piercing the ribbon transversely thereof and recurrently at predetermined spaced intervals along the length of the ribbon as the same is intermittently advanced longitudinally, and means operated concurrently with the piercing means for concurrently braking, eyeleting and coining the pierced ribbon to corrugate the same such that the resultant perforations in the ribbon fall in the sidewalls of the corrugations and become eyeletted as the corrugations are formed.

7. The system as in claim 6 and further comprising means operated concurrently with the piercing and corrugating means for stretching the formed corrugations.

8. Apparatus for perforating and corrugating metallic ribbon comprising, in combination, relatively movable and stationary members disposed for intermittent passage of a metallic ribbon therebetween longitudinally of the ribbon, die means respectively supported by said members for braking and corrugating the ribbon as the members close relatively toward each other, ribbon piercing means respectively supported by said members and disposed in advance of the corrugating means along the line of ribbon movement for forming perforations and resultant protuberances in the ribbon as the members close relatively toward each other, and corrugation stretcher means supported respectively by said members and disposed behind the corrugating means along the line of ribbon movement for flattening the formed corrugations thereby to stretch the same a predetermined amount as the members close relatively toward each other.

9. Apparatus as in claim 8, said ribbon piercing means comprising a plurality of sharpened ribbon piercing elements disposed in spaced relation in a row transversely of the ribbon and supported on the stationary member with their sharpened ends extended upwardly, a plurality of small masses of resilient ribbon stripping material impaled respectively on said ribbon piercing elements, an elongated back up plate supported by the movable member and aligned in opposed relation to said row of piercing elements, and a strip of resilient ribbon stripping material secured to said plate in confronting relation to said sharpened elements, said resilient strip serving to strip the pierced ribbon and its resultant protuberances from the strip and said small resilient masses serving to strip the pierced ribbon from said piercing elements as the fixed and movable members relatively separate following piercing of the ribbon by said piercing elements during relative closing of the members toward each other.

10. Apparatus as in claim 9, said ribbon piercing means comprising two rows of said ribbon piercing elements, the elements of one row being staggered with respect to the elements of the other row.

11. Apparatus for perforating metallic ribbon comprising, in combination, relative movable and stationary members disposed for intermittent passage of a metallic ribbon therebetween longitudinally of the ribbon, a plurality of sharpened ribbon piercing elements disposed in spaced relation in a row extended transversely of the ribbon and supported loosely and removably on the stationary member with their sharpened ends extended upwardly, a plurality of small masses of resilient ribbon stripping material impaled respectively on said ribbon piercing elements such that each of said masses of stripping material and its associated ribbon piercing element forms a removable unit, an elongated back up plate supported by the movable member and aligned in opposed relation to said row of piercing elements, and a strip of resilient ribbon stripping material secured to said plate in confronting relation to said row of sharpened elements.

12. Apparatus as in claim 11, and further comprising two rows of said ribbon piercing elements and means for supporting the elements on said stationary member, said means comprising an elongated retainer plate for each row of elements, each said retainer plate having a plurality of openings respectively receiving said elements loosely therein, each of said plurality of openings having a transversely intersecting opening defining a bottom support surface for its respective element, a channeled support for said retainer plates, spacer means for varying the spaced relation of said retainer plates within said channeled support, spring means for yieldably retaining the retainer plates in adjusted spaced relation within the channeled support, means for adjustably spacing and securing the retaining plates longitudinally of the channel support, and means for securing the channeled support to the stationary member.

13. Apparatus as in claim 11, and further comprising two rows of said ribbon piercing elements, the elements of one row being staggered with respect to the elements of the other row.

14. Apparatus as in claim 11, said ribbon piercing elements comprising conventional phonograph needles.

15. Apparatus as in claim 11, said ribbon stripper masses and strip being formed of soft rubber.


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