March 3, 1964 E. M. LACEY, JR 3,123,125

METHOD AND APPARATUS FOR FEEDING METAL STRIPS

Filed Dec. 27, 1960 2 Sheets-Sheet 1

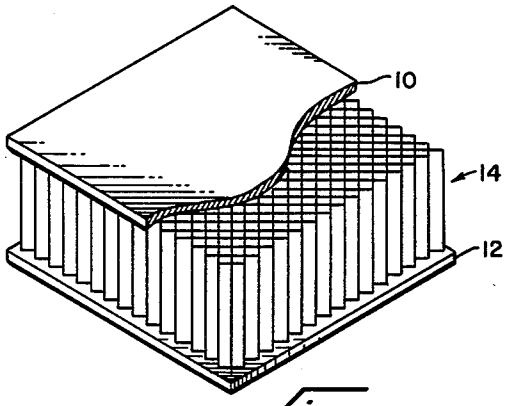


fig - 1

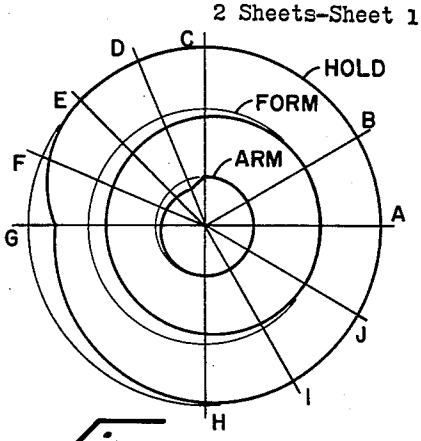


fig - 6

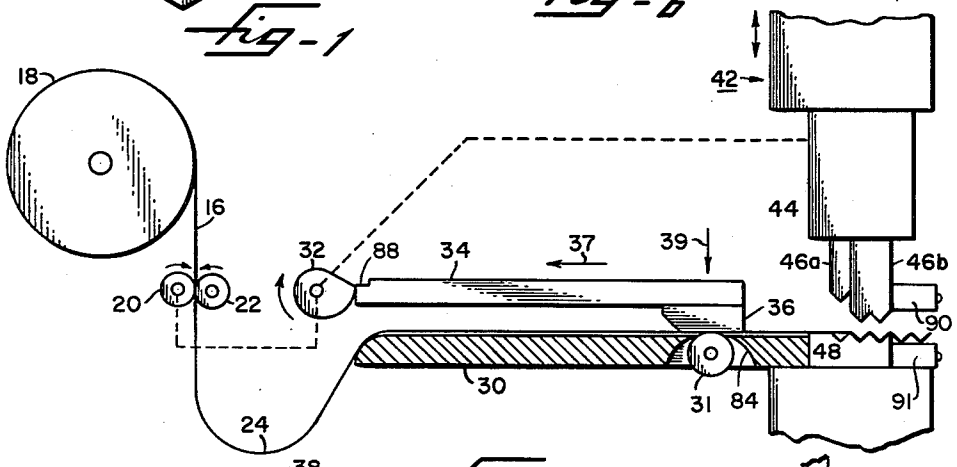


fig - 2

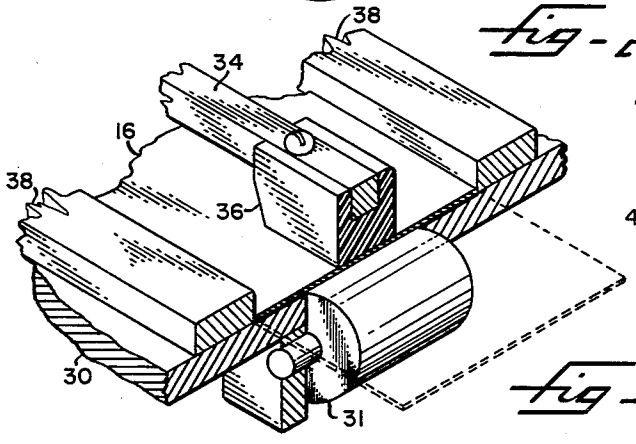


fig - 3

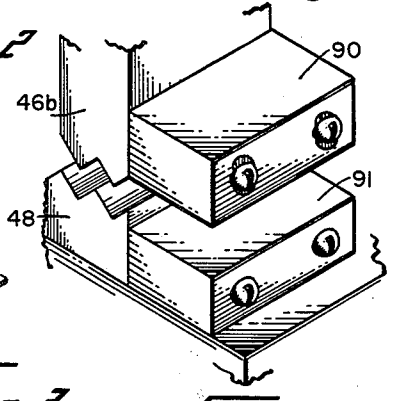


fig - 7

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METHOD AND APPARATUS FOR FEEDING METAL STRIPS

Filed Dec. 27, 1960 2 Sheets-Sheet 2

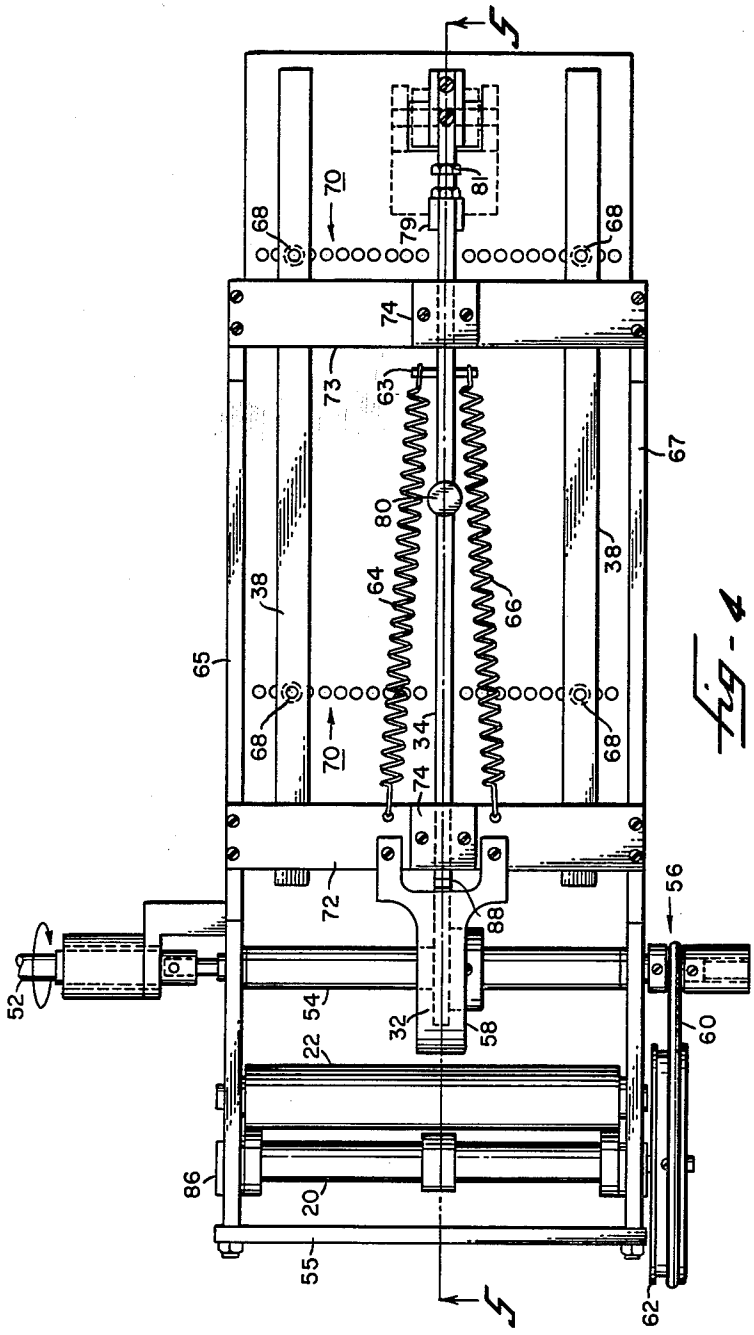


Fig. 4

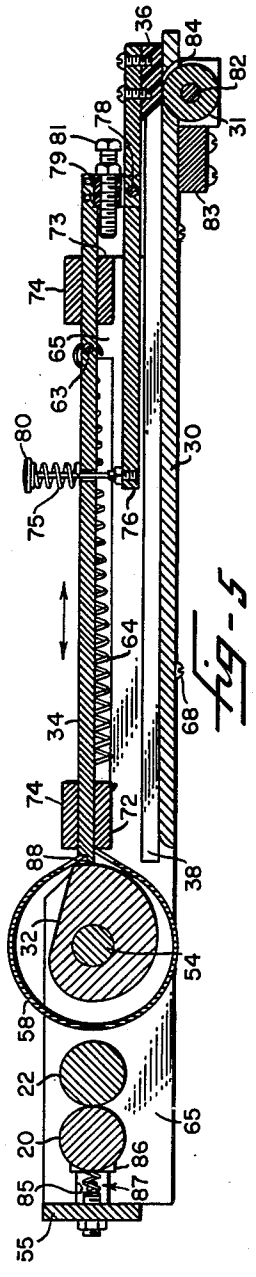


Fig. 5

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United States Patent Office 3,123,125 Patented Mar. 3, 1964

3,123,125
METHOD AND APPARATUS FOR FEEDING METAL STRIPS

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Filed Dec. 27, 1960, Ser. No. 78,720
7 Claims. (Cl. 153—76)

This invention relates to the intermittent moving of a strip of material, and more particularly to a method and apparatus for precisely feeding a flat strip of metal, and corrugating it into a pattern having parallel transverse crests and troughs.

There is an increasing need—particularly in airplane wings, floors, and other such applications—for structures that are both extremely light and extremely strong. One of the most satisfactory structures for these uses is the so-called "honeycomb," which comprises, in part, strips of corrugated metal having the crests of adjacently disposed and oppositely corrugated strips welded together. In order for this structure to be completely satisfactory, each corrugation must be precisely formed and spaced, so that the crests and troughs—known as "nodes" of adjacent strips abut exactly.

In the past, these corrugations were usually formed by passing a flat metal strip between the meshed teeth of corrugating rollers. As these revolve, the metal strip is drawn between the meshed gear teeth, thus forming the metal strip into corrugations. The inherent action of gearing, however, is such that the metal is stressed between the nodes with the result that, subsequent to forming, the stresses tend to relieve themselves, resulting in a corrugated ribbon having differences in spacing between the nodes. When these nodes are juxtaposed for welding, the differences in spacing prevent the nodes of one strip from abutting the nodes on the adjacent strip, thus resulting in a non-uniform, unsatisfactory honeycomb.

It is therefore the principal object of my invention to provide an improved strip feeding device and method.

It is another object of my invention to provide an improved strip feeding device that lends itself to the subsequent precise corrugation of the strip.

It is another object of my invention to provide an improved ribbon feeding device that feeds the ribbon in a precisely predetermined amount in a positive manner.

It is another object of my invention to provide apparatus for feeding a ribbon of metal in only a given direction while permitting the same to be drawn in said direction.

It is another object of my invention to provide a ribbon feeding apparatus wherein the feeding mechanism is frictional, but positive acting.

It is another object of my invention to provide apparatus wherein a corrugated strip of metal is formed without introducing any undesired stresses into the material.

It is another object of my invention to provide ribbon feeding and corrugating apparatus that produces a corrugated strip of material wherein the nodes are precisely spaced over the entire length of the ribbon.

Another object is to provide for precise stretching of the corrugations subsequent to forming of the same.

The attainment of these objects and other will be realized from the following specification, taken in conjunction with the drawings, of which:

FIG. 1 shows a typical honeycomb structure;

FIG. 2 shows a schematic representation of apparatus for feeding and corrugating a strip of metal;

FIG. 3 shows the feeding apparatus;

FIG. 4 shows a top view of one form of feeding apparatus;

FIG. 5 shows a cross sectional view of the feeding apparatus;

FIG. 6 is a diagrammatic view showing the sequence of operations; and

FIG. 7 is a fragmentary view, somewhat enlarged, of the corrugation stretcher apparatus disclosed in FIG. 2.

FIG. 1 shows that the finished honeycomb structure comprises a "sandwich," wherein the top 10 and the bottom 12 are flat sheets of metal that are bonded to the ends of the honeycomb core 14. The core 14 itself is made of strips of corrugated metal that have been juxtaposed with the nodes of adjacent strips welded to each other. As may be seen, the core has "cells" of square or diamond-shaped cross section; resulting in structure which provides extreme lightness due to the thin metal; yet is very strong.

It is apparent from FIG. 1 that the corrugations must be precisely made and spaced, else the nodes will not abut each other for proper welding, and the resultant structure will not have the requisite high quality, uniformity and maximum strength.

As may be seen from the schematic presentation of FIG. 2, the process starts with a flat strip 16 of metal having suitable characteristics width, thickness, etc., the strip being most conveniently carried on a storage reel 18. Strip 16 passes between two feed rollers 20 and 22, and after forming a sagging loop 24, passes along a bed 30. Bed 30 contains a "pressure" roller 31 that has its upper surface projecting slightly above the surface of bed 30.

A feeding arrangement is positioned above bed 30, and comprises a rotatable cam 32 that activates a pushing arm 34. Arm 34 has at its distal end a pushing foot 36 of material such as rubber, nylon, metal, etc., that has a suitable coefficient of friction when pressed against metal strip 16. A spring or some other suitable means (not shown, but indicated by arrow 37) yieldably urges and holds arm 34 against the working surface of cam 32. A weight or spring arrangement (not shown, but indicated by arrow 39) yieldably urges and presses foot 36 against the upper surface of metal strip 16. Thus, strip 16 is engaged by pusher foot 36 on its upper surface, and by pressure roller 31 on its lower surface.

My apparatus operates as follows: the flat strip 16 is threaded between feed rollers 20 and 22, placed along bed 30, and positioned between pusher foot 36 and pressure roller 31. The apparatus is then activated, and the rotation of cam 32 extends arm 34, the friction between pusher foot 36 and strip 16 advancing strip 16 as roller 31 rotates.

This action will be better understood from the enlargement shown in FIG. 3. Pressure roller 31 projects slightly above the top of bed 30; and strip 16 therefore rests on the top of roller 31 between guide bars 38—rather than on the bed 30. Since the strip 16 is merely resting lightly on bed 30, there is no appreciable opposing friction between it and the surface of the bed, and any slight forward movement of pusher foot 36 causes strip 16 to advance on the revolving pressure roller 31, as shown by the dotted lines. In this way strip 16 is fed forward with a positive action and without introducing any strain therein. The rolling friction of roller 31 is not sufficient to cause relative movement between pressure foot 36 and strip 16; hence the positive driving connection therebetween and their advance as a unitary structure over the perimeter of roller 31. Roller 31 thus serves as an adequate support for developing the requisite positive driving connection between foot 36 and strip 16 while presenting negligible opposition to their longitudinal advance. Advantage is thus taken in this feed mechanism of the lesser friction inherent in rolling friction, as in the roller mounting of roller 31, than in the

sliding friction involved in the frictional driving connection between foot 36 and strip 16.

To further minimize the possibility of straining strip 16, the rotation of feed rollers 20 and 22 of FIG. 2 is adjusted so that an appreciable loop 24 is maintained. In this way the movement of pusher foot 36 takes material from loop 24, and does not have to rotate reel 18—thus further reducing the amount of friction required between pusher foot 36 and strip 16.

For reasons to be discussed later, it is essential that strip 16 is always advanced the same precisely predetermined amount; a result that is accomplished by my apparatus. Prior-art frictional feeding apparatus is not capable of this precise feeding for the following reason. In prior-art apparatus such, for example, as that disclosed in the copending application of Fred H. Rohr, Serial No. 846,903, filed October 16, 1959, now Patent No. 3,079,487, for Method and Apparatus for Fabricating Honeycomb Core, the strip rests on the bed, and the downward pressure of the pushing foot produces an opposing friction between the bed and the strip. At times this opposing friction becomes so large as to prevent the free movement of the strip. This unreliability of prior-art friction feeds prevents their achieving full utility as where consistent, positive and precise feeding is required in the production of core of maximum quality.

One proposed solution for overcoming the shortcoming f prior-art apparatus was to lubricate the bed; but the lubricant contaminated the material that formed the strip. Another proposed solution suggested that the bed be made from slippery material, but this type of material does not sand up under continuous use.

Thus, my apparatus overcomes the shortcomings of prior-art friction feeds, and permits the use of this economical arrangement in cases that require precise advancement of strips of material.

The overall operation of my corrugating apparatus may be understood by referring back to FIG. 2. As shown, the corrugator comprises a vertically reciprocating punch press 42, whose ram 44 contains a "split" punch comprising a forming punch 46*a* and a holding punch 46*b*, each of which is capable of independent vertical movement. Punches 46 fit into a die 48 that has matching V-shaped grooves.

The corrugating operation is as follows, assuming that several cycles have already taken place as indicated in FIG. 2 by the presence of corrugations that extend beyond die 48.

At the instant shown in FIG. 2, cam 32 has just advanced strip 16, which is ready to have another corrugation formed therein. Ram 44 descends, and holding punch 46*b* catches the two last-formed corrugations and seats them into die 48.

Concurrently, the corrugations which have just previously been moved outwardly of the die are pressed between, and elongated in a controlled predetermined amount, by stretcher members 90 and 91; these members, as may best be seen in FIG. 7, are adjustably and fixedly mounted on punch 46*b* and die 48 for this purpose. The punches 46 and die 48 preferably are formed precisely in accordance with the dimensions desired of the corrugated ribbon. For reasons believed inherent in the coining of the corrugations in the punch press operation, however, the resultant spacing between nodes invariably is less than that of the punch and die dimensions. The adjustably mounted member 90 is elevated or lowered at either or both ends relative to punch 46*b*, as required, to provide such spaced relation with respect to member 91 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 90 more or less than the other end relative to the set screws individual thereto.

Holding punch 46*b* is mounted on a spring, so that as ram 44 descends further, the spring-loaded holding punch becomes even more securely seated—thus holding strip 16 securely. Continued downward movement of ram 44 causes the tip of forming punch 46*a* to touch the portion of strip 16 that is bridged across the first V notch of die 48. Since the corrugation to be formed is V shaped, it obviously requires a greater length of strip than that available from the bridged V groove. Since the distal end of the corrugated ribbon is securely held by the holding die 46*b*, as forming die 46*a* descends into the notch, it depresses the bridging portion of strip 16; thus drawing the slight extra length of material necessary to form the corrugation from loop 24. This extra length passes between roller 31 and the now-stationary foot 36; the lower surface of the strip rotating the roller forward, while the upper surface of the strip slides forward under the stationary pusher foot. Due to the light pressure exerted by foot 36, the sliding of the strip under the foot does not strain the material.

At this time, the continued rotation of the cam brings it to a position that permits feeding arm 34 to be retracted. Since the strip 16 is still securely held by the holding punch 46*b*, the retraction of the feeding arm causes the pushing foot to slide backwards over strip 16, while the strip 16 and the roller 31 remain stationary. When arm 34 is fully retracted, cam rotation again causes pushing foot 36 to advance strip 16. Both punches are now raised, and the strip is advanced a distance such that the newly-formed corrugation is in position to be seated by the holding punch. This advancement must be exact, else the holding punch will deform the corrugation, rather than seating it.

Once the newly formed corrugation has been properly advanced to be seated by the holding die, the corrugating operation is repeated.

It will be noted that strip 16 is always held by either the punch and die assembly or by the pusher foot, so that it is impossible for the strip of material to inadvertently shift from its desired position. Furthermore, each corrugation is made by the same forming punch, so that they are all identical. Moreover, the required material is obtained from a loop without introducing any stress; thus producing a plurality of equally spaced unstrained corrugations.

The movement of punches 46*a* and 46*b*, feed rollers 20 and 22, cam 32 and arm 34 are all controlled from the same source of power—as schematically indicated—and therefore are synchronized.

As the corrugated ribbon leaves the die, it travels along an inclined guide to a welder such as disclosed in the patent application of Fred H. Rohr, aforesaid, that forms the corrugated ribbon into a honeycomb core such as core 14 depicted in FIG. 1.

FIGS. 3, 4 and 5 show one form of structure that may be used to practice my invention. Here a driving mechanism such as may include a cable 52 coupled to punch press 42 rotates a shaft 54 that carries cam 32 and an adjustable driving pulley generally designated 56. A guard 58 protects cam 32. Driving pulley 56 has an endless belt 60 to rotate a driven pulley 62, which in turn rotates feed roller 20. Feed roller 20 has its central portion undercut an amount equal to the thickness of strip 16, so that when strip 16 is threaded between feed rollers 20 and 22, the entire surface of the central portion of feed roller 20 is pressed against strip 16, and the outer roller portions are in full engagement with the confronting surfaces of roller 22.

As previously indicated, the feed rollers control the movement of the strip at such a rate that loop 24 is maintained at the desired size. If the loop becomes too short, pusher foot 36 would have to rotate the storage reel, an operation which is undesirable because it may strain the

strip of material. On the other hand, if the loop were to become too large, this action is cumulative; and must either be corrected manually, or must have automatic means to prevent the enlarged loop from dragging on the floor. I choose to assure correct loop size by having the feed rollers rotate at the correct speed. To accomplish this, driving pulley **56** has two separate relatively adjustable parts, the outer one of which may be moved toward or away from the other. The facing portions of these parts are tapered, to thus change the effective diameter of pulley **56**.

To increase the speed of strip **16**, the adjustable part of driving pulley **56** is moved toward the other, the tapered portions thus increasing the effective radius of the driving pulley. To decrease the speed of strip **16**, the adjustable portion of driving pulley is moved away from the other; the tapered portions thus decreasing the effective radius of the driving pulley. In this manner I assure that strip **16** moves at the correct speed to maintain the desired loop size.

In order to guide strip **16** as it moves along the bed **30**, guide bars **38** are fastened at the required spacing, according to the width of the strip, by means of screws **68** that fit into appropriate holes of hole-sets **70** in bed **30**. When a strip of a different width is to be corrugated, guide bars **38** are readily re-positioned.

One convenient form of pushing arm **34** and pushing foot **36** is shown in FIG. 5. As has been explained, pushing arm **34** is reciprocated, and guides for this reciprocating movement are formed by crossbars **72** and **73** and bridges **74**. The guides thus formed assure that the pushing arm moves in a longitudinal path, without moving up or down. The crossbars are suitably secured, as by screws as shown, to side members **65** and **67**, in turn, suitably secured to bed **30**. Arm **34** carries a pin **63** to which springs **64** and **66** are attached, one on each side of the arm. The other ends of these springs are suitably secured, as shown, to crossbar **72** to thus yieldably urge arm **34** against cam **32**.

The vertical downward pressure of pushing foot **36** is produced by a pivotal extension of arm **34** in the form of a lever **76** which is pivotally connected as at **78** to a member **79** secured to and depended from arm **34**. Pressure foot **36** is attached to lever **76** at one end and is yieldably urged toward roller **31** by a suitable tensioning means including a spring **75**. Spring **75** is adjustably compressed between arm **34** and the head of a bolt **80** which makes an adjustable connection with and, hence, pulls upwards on the other end of lever **76**. The upward pressure of spring **75** causes pushing foot **36** to press down onto strip **16** with as much force as may be desired by adjustment of bolt **80**.

In the previous explanation, it was implied that the reciprocating movement of pushing arm **34** was controlled entirely by cam **32**. While this would be satisfactory, it would mean that a new cam is required when the width of the corrugation is changed. To obviate the need for changing the cam, I prefer that the cam be designed so that it is capable of extending the pushing arm as far as may be required for the widest corrugation. When less movement of the arm is needed, adjustment screw **81**, carried by member **79**, is reset, so that the retraction of the pushing arm causes the end of the adjusting screw to strike crossbar **73**. The retraction of the pushing arm is thus stopped at any desired point, having the same effect as substituting a new cam having a smaller "throw" than the old one.

Roller **31** is suitably journalled as at **82** on a member **83** secured to the underside of bed **30**, a suitable opening **84** being provided in the bed to accommodate the roller and permit its projection above the upper surface of the bed for the purpose aforedescribed.

Shaft **54** and rollers **20** and **22** are suitably journalled in and supported between side frames **65** and **67** which are secured together at this end by a crossbar **55**. Side

frame **65** is slotted as indicated at **85** in FIG. 5 to provide for a slidable bearing support **86** for roller **20**. By this means bearing support **86**, and hence roller **20**, may be urged yieldably, as by an adjustable spring assembly **87**, into confronting engagement with roller **22** and with a strip of material threaded between the rollers.

As shown, cam guard **58** conveniently is supported on, and secured to opposite sides of crossbar **72**. Attention is also directed to the reduction, as at **88**, in the thickness dimension of arm **34** which thus serves to improve the accuracy of the timed relationships between the movements of arm **34** and the punch press operations as effected by the driving connections between the punch press and cam **32** and the cam follower coaction of arm **34** with cam **32**.

FIG. 6 illustrates the timed cyclical relationship between the movements of arm **34** and those of the punch press as involved in the sequence of operations of the aforedescribed mechanism. The movements of the arm are shown on the inner circle; the movements of the forming punch are shown on the intermediate circle; and the movement of the holding punch are shown on the outer circle.

For simplicity of explanation, the circles indicate a complete cycle of operations of each of the parts depicted and one new action takes place at each indicated point.

At "A" the previous corrugating operation has been completed, both punches are down, and the arm is fully extended.

At "B" the holding punch remains down, the forming punch starts to rise, and the arm remains fully extended.

At "C" the holding punch remains down, the forming punch continues to rise, and the arm starts to retract—sliding backwards along the stationary strip that is being held by the holding punch.

At "D" the holding punch remains down, the forming punch continues to rise, and the arm finishes its retracting movement under power of springs **64** and **66**.

At "E" the holding punch starts to rise, the forming punch continues to rise, and the arm remains retracted.

At "F" the holding punch continues to rise, the forming punch continues to rise, and the arm starts to extend—thus advancing the corrugations under the rising punches.

At "G" the holding and forming punches reach to top of their strokes and begin to descend, the arm continuing to extend and advance the strip.

At "H" both punches are still descending, and the arm is fully extended—thus stopping the strip in its advanced position.

At "I" the holding punch seats the now stationary strip, the forming punch is still descending, and the arm remains fully extended.

At "J" the holding punch continues to hold the stationary strip, the forming punch makes the corrugation, and the arm remains fully extended.

This finishes the cycle, and conditions are the same as at "A" to start another cycle.

The above sequence may of course be modified as desired. For example, to save time the retraction of the arm (at "C") may be started earlier by reshaping the cam. Similarly, if the corrugations are deep, it may be necessary to allow the punches to rise higher before the strip is advanced. This would require the arm to start advancing later than at "F", thus necessitating a cam that rises faster. Other modifications may be made as desired or required.

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 my invention, what I claim as

new and useful and desire to secure by Letters Patent is:

1. The method of forming a flat strip of metal into a corrugated ribbon, comprising the steps of placing said strip of flat metal on a roller adapted to permit said strip to move in its longitudinal direction, placing a frictional engaging element on the upper surface of said strip above said roller, advancing said frictional engaging element to cause said strip, said element, and the surface of said roller to advance together without any slippage between their surfaces, holding said advanced strip so that it is stationary, forming a corrugation in said stationary strip, the extra length of strip necessary for said corrugation sliding under said stationary frictional element and rotating said roller in its forward direction, and retracting said frictional element slidably along said stationary strip so that said element may again advance said strip, whereby said strip moves forward intermittently in its longitudinal direction.

2. The method of forming a flat strip of metal into a corrugated ribbon, comprising the steps of placing said strip of flat metal on a roller adapted to permit said strip to move in its longitudinal direction, placing a frictional engaging element on the upper surface of said strip, advancing said frictional engaging element to cause said strip, said element, and the surface of said roller to advance together without any slippage between their surfaces, holding said advanced strip so that it is stationary, forming a corrugation in said stationary strip, the extra length of strip necessary for said corrugation sliding forward under said stationary frictional element and rotating said roller in its forward direction, retracting said frictional element slidably along said stationary strip so that it may again advance said strip, advancing said strip as in steps 2 and 3, a predetermined amount—whereby said strip moves forward intermittently in its longitudinal direction.

3. In a device for intermittently advancing a ribbon in a longitudinal direction, the combination comprising means including a roller for supporting said ribbon, means comprising a foot in continuous frictional engagement with the ribbon for urging said ribbon against said roller, means for causing said foot to reciprocate along the longitudinal axis of said ribbon, means for holding said ribbon while said foot is retracting whereby said ribbon is caused to advance incrementally, means for releasing said holding means while said foot is advancing whereby said ribbon advances intermittently; and means for corrugating and incidentally drawing said ribbon slidably relative to said foot after it has been advanced by the same.

4. In a device for intermittently advancing a ribbon in a given direction, the combination comprising means including a reel for storing and feeding said ribbon in a loop, means including a roller for receiving and supporting said looped ribbon, means including a foot in continuous frictional engagement with the ribbon for urging said ribbon against said roller, means for causing said foot to reciprocate along the longitudinal axis of said ribbon, means for holding said ribbon while said foot is retracting, means for releasing said holding means while said foot is advancing whereby said ribbon is advanced intermittently, and means for corrugating said ribbon after it has been advanced and for slidably drawing said ribbon from said loop between said roller and said foot.

5. Apparatus for corrugating a ribbon of material, comprising means including a reel for storing and feeding said ribbon in a loop, means including a bed and a roller for supporting said looped ribbon for longitudinal movement, means including a foot in continuous frictional engagement with the ribbon for urging said ribbon against said roller, means including a cam for causing said foot to reciprocate along the longitudinal axis of said ribbon, means for holding said ribbon while said foot is retracting, said means comprising a holding punch, means for releasing said holding means while said foot is advancing whereby said ribbon slides along said bed and rolls on said roller and is advanced intermittently, means for corrugating said ribbon after it has been advanced and for slidably drawing said ribbon from said loop between said roller and said foot, said means comprising a forming punch.

6. Apparatus for corrugating a ribbon of metal, comprising: means including a reel for storing and feeding said ribbon in a loop; means including a bed and a roller for receiving and supporting said looped ribbon; means including a foot in continuous frictional engagement with the ribbon for urging said ribbon against said roller; means including a cam for causing said foot to reciprocate along the longitudinal axis of said ribbon; a corrugator comprising a forming punch, a holding punch, and a coacting die; means comprising said holding punch and said die for holding said ribbon while said foot is retracting; means for releasing said holding means while said foot is advancing whereby said ribbon is advanced intermittently by said forward movement of said foot; and means for corrugating said ribbon after it has been advanced and for slidably drawing said ribbon from said loop between said roller and said foot.

7. Apparatus for corrugating a strip of metallic ribbon comprising: means comprising a reel for storing a length of said metal strip; means comprising a pair of feed rollers for removing said strip from said reel at a given rate and forming said removed strip into a loop; a bed having a pressure roller positioned with its upper surface protruding above the surface of said bed; a feeding arm having a pushing foot positioned on the upper surface of said roller; means for directing said strip to pass from said loop along said bed between said foot and said roller; means for causing said foot to press against said strip and frictionally engage the same continuously; a cam; means for causing said cam to energize said arm whereby said foot reciprocates; a V-shaped forming die; a V-shaped holding die; means comprising said cam for causing said foot to advance said strip a given distance so that said strip is positioned at said dies; means for causing said strip to be held by said holding die; means for causing said strip to be corrugated by said forming die and incidentally drawing the strip slidably relative to said foot frictionally engaged therewith whereby the metal required for said corrugation is obtained from said loop; means for retracting said foot while said strip is being held by said dies whereby said foot is repositioned on said strip so that it may again advance said strip; means for releasing said dies and simultaneously causing said foot to advance said corrugation so that said corrugation is at said holding die; and means for synchronizing the movement of said feed rollers, said cam, and said dies.

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