APPARATUS FOR FORMING SHEET METAL ARTICLES

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Application February 2, 1942, Serial No. 429,200

Claims. (Cl. 153—7)

This invention relates to improved apparatus for forming sheet metal into arcuate or annular disk-like spacing members having corrugations extending between the inner and outer edges of the annulus so as to increase the effective or over-all thickness of the members, and relates more particularly to apparatus and methods for forming such members from straight metallic strip stock.

It is an object of the invention to provide apparatus comprising a die mechanism capable of bending straight metallic strip stock so as to corrugate the strip transversely and form it into an annulus of the character in question without substantially drawing or stretching the metal.

A further object of the invention is to provide apparatus capable of operating automatically to form straight metallic strip stock into edgewise-curved, transversely-corrugated arcuate or circular form without substantially stretching or drawing the sheet metal.

Another object of the invention is to provide apparatus for forming relatively inextensible metallic strip stock into an annular or arcuate corrugated member having an effective thickness at its outer periphery which is at least as great as the effective thickness at its inner periphery.

Another object of the invention is to provide apparatus capable of operating more or less automatically to form straight metallic strip stock into edgewise-curved, transversely-corrugated arcuate or circular forms, and in which the corrugating means form major corrugations and minor corrugations in alternating arrangements with the crests of the major corrugations aligned so as to define either a pair of spaced, parallel surfaces, or a pair of spaced conical surfaces which diverge outwardly.

A further object of the invention is to provide apparatus such as last referred to in which the corrugating means form minor corrugations having crests which decrease in height from the inner edge to the outer edge of the formed member and also form major corrugations having either uniform height from the inner edge to the outer edge of the formed member, or height which increases slightly from the inner edge to the outer edge, whereby a predetermined over-all or effective thickness of the member may be secured by simple bending operations without drawing or stretching the sheet metal.

Another object of the invention is to provide apparatus for forming straight metal strip stock into edgewise-curved, transversely-corrugated arcuate or circular forms, and in which apparatus the corrugating means comprise a unitary circular series of spaced die elements adapted to engage the strip stock on one side thereof and a movable die element adapted to engage the strip stock on the other side thereof, in combination with means for indexing the circular series of die elements so as to bring successive die elements and successive parts of the strip stock into position to be engaged by the movable die element.

Another object of the invention is to provide improved indexing means for the die mechanism.

Another object of the invention is to provide apparatus capable of forming straight metal strip stock into edgewise-curved, transversely-corrugated arcuate or circular forms, the apparatus being characterized by simple construction and reliable automatic operation.

With the foregoing objects and other more or less incidental or ancillary objects in view, the improved apparatus consists in certain forms, combinations and arrangements of parts, as hereinafter set forth and explained in connection with the accompanying drawings and more particularly defined in the appended claims.

In the drawings:

Fig. 1 is a side view, with parts broken away, of a clutch disk having a spacing member typical of the corrugated annular spacing members produced by the improved apparatus and methods of the invention.

Fig. 2 is a fragmentary sectional view of the edge of the clutch disk shown in Fig. 1.

Fig. 3 is a fragmentary sectional view taken on the line 3—3 of Fig. 1 and indicating the corrugated form of the annular spacing member at the inner edge thereof.

Fig. 4 is a radial sectional view taken along line 4—4 of Fig. 1.

Fig. 5 is a corresponding radial sectional view, but is taken along the line 5—5 of Fig. 1.

Fig. 6 is a plan view of my improved apparatus for forming spacing members, with parts thereof, especially of the upper reciprocating portion thereof broken away or removed to better show various features of construction and with some parts shown in section, the main section being on the line 6—6 of Fig. 3.

Fig. 7 is a fragmentary vertical section taken on the line 7—7 of Fig. 6, and shows the machine in its closed position.

Fig. 8 is a fragmentary sectional view with the section taken on line 8—8 of Figs. 9, 8 and 7.
and showing the parts when the machine is in its open position.

Fig. 9 is a fragmentary vertical section on the line 9—9 of Figs. 8 and 12.

Fig. 10 is a vertical section on the line 10—10 of Fig. 6 and shows one form of ratcheting and indexing apparatus of suitable construction, with the various parts thereof in the positions which they occupy when the machine is in its closed position.

Fig. 11 is a fragmentary vertical section on line 11—11 of Fig. 7 showing the hold-down device.

Fig. 12 is a fragmentary vertical section on the line 12—12 of Fig. 8.

Fig. 13 is a fragmentary sectional rear elevation with the section taken on the line 13—13 of Fig. 8.

Fig. 14 is a fragmentary front elevation showing a portion of the machine as viewed from the line 14—14 of Fig. 8.

Fig. 15 is a fragmentary sectional elevation, the section being taken on the line 15—15 of Fig. 7.

Fig. 16 is a fragmentary vertical section on the line 16—16 of Fig. 6.

Fig. 17 is an elevational view of a blade suitable for use in the rotating die member of Fig. 6.

Fig. 18 is a fragmentary vertical section taken similarly to Fig. 7, and showing the hold-down in the position which its blades occupy when the rotating die member of Figs. 6 and 7 has been advanced two spaces to the left from the position shown in Fig. 7.

Fig. 19 is a vertical sectional view of a modified device, the view corresponding to Fig. 7 above.

Fig. 20 is a side view showing the construction of one of the forming blades used in the device of Fig. 19.

Fig. 21 is a side view of another forming blade which is used in the device of Fig. 19.

Fig. 22 is a sectional view taken on the line 22—22 of Fig. 19 and shows the structure of the cam and their relation to the various other parts of the device at a time period slightly ahead of that in which the parts have the relationship shown in Fig. 19.

Fig. 23 is a diagrammatic sectional view illustrating a further modification. The view corresponds to the section taken on the line 23—23 of Fig. 24.

Fig. 24 is a vertical sectional view taken along the line 24—24 of Fig. 23.

Corrugated sheet metal members such as have been referred to above have various applications or uses. An important use to which I have put spacing members of this character is in the construction of ventilated friction clutch disks, and for the purpose of explaining my improved forming apparatus and methods I have shown in Figs. 1 to 5 of the drawings a clutch disk having a corrugated spacer such as the forming apparatus illustrated in the drawings is adapted to produce.

Referring now to Figs. 1—5 inclusive, the friction clutch assembly shown in the figures comprises a pair of backing or supporting disks 1 and 2 spaced apart axially at their centers by a spacing ring 3 and by the flange 4 of hub 5, the disks, flange and spacing ring being secured together by means of rivets 6, 6. Friction facing layers 7, 7 are secured to the outer faces of the supporting disks. A corrugated spacing member 8, such as my improved apparatus and methods are designed to produce, is disposed between the disks in register with the facing layers, the corrugations in the spacing member extending approximately radially across it and being of sufficient length to support the friction facing layers throughout their full width. The form of the corrugations contributes to the floating action of the spacing member and will be described in detail below. The spacing member 8 is in the form of a full ring or annulus, the ends of which are lapped as shown at 9 and spot-welded together. It is secured to the backing disk 1 in any suitable manner, but preferably by means of spot-welds 10, 10 located at a sufficient number of points to provide the desired strength and restraint. One set of such spot-welds 10 may serve also to unite the lapped ends of member 8. Additional spot-welds 11 may also be provided to secure the spacing member 8 to the other supporting disk 2. Air inlet openings 12, 12 are provided in the assembly at appropriate locations to permit access of air to the inside of the assembly, thereby to permit forced-draft cooling or ventilation of the assembly when the disk is rotating.

Referring now to Figs. 2 and 3 which show the appearance of the outer and inner edges respectively of the assembly, it will be seen that the spacing member consists of a repeating series of corrugations, each series including a major corrugation A, two intervening minor corrugations B, C, a second major corrugation D directed in the opposite direction with respect to major corrugation A, and another pair of intervening minor corrugations E and F. The series then repeats itself beginning with the major corrugation A'. The major corrugations A and D of each series contact the supporting disks 1 and 1, respectively, while the minor corrugations B, C, E and F are preferably of such effective height that they do not contact the supporting disks at any time, even when the friction disk is clamped in working engagement between the cooperating pressure plates of the clutch. It will be recognized that by reason of this construction, the backing disks and the facing layers are resiliently or floatingly supported upon the major corrugations and hence are cushioned over their entire area, the minor corrugations permitting variations in the over-all or effective thickness of the spacing member as the disks 1 and 2 move forward or away from each other. The minor corrugations may, of course, be designed so that they kind come into contact with the supporting disks 1 and 2 when the clutch is in engagement, but the advantages of the floating-type of support are then largely lost.

In order to form corrugated segments or circles from straight strip metal, it is necessary to crease or gather a given length of metal into a shorter space on one edge of the strip than on the other edge. This, of course, is due to the fact that one edge forms a circle of smaller diameter than the other. The minor corrugations in the corrugated spacing member shown in Figs. 1—5 permit the metal to be gathered at the inner edge to such an extent that straight strip stock may be formed into circular annuli having inner diameters only a fraction of an inch or so upward, and having wide ranges of annular width. It will be noted from Figs. 2 and 3 that this is possible because, as mentioned above, the metal may be gathered in the minor corrugations B, C, E, and F, the heights of these corrugations being adjustable to absorb whatever annular width occurs at the inner edge. Referring specifically to the series of corrugations beginning on the outer edge (Fig. 2) at the crest of major corruga-
tion A and ending at the crest of major corrugation A', it will be seen that this series of corrugations is not parallel to the crest of the major corrugations, the crest of minor corrugation B in Fig. 4, for example, being inclined in one direction with respect to the crest of the major corrugations, while the crest of minor corrugation F/ of Fig. 5 is inclined in the opposite direction. This is because the height of the minor corrugations at the inner edge of the annulus needs to be greater than the height of the same minor corrugations at the outer edge in order to absorb the metal properly. It will consequently be appreciated that if the height of the minor corrugations with respect to that of the major corrugations is adjusted to provide the desired deflection of the spacing member at the inner edge, the heights of the minor corrugations at their outer ends will automatically be smaller, the limiting condition being that in which the minor corrugations disappear at the outer edge leaving a straight web extending from one major corrugation to the next. This extreme condition should generally be avoided since it impairs the resilience of the spacing member at the outer edge.

As has been indicated, the corrugated spring member 8 shown in Figs. 1 to 5 typifies the sort of arcuate members which my improved apparatus and methods are designed to produce. The machine shown in Figs. 6–15, inclusive, illustrates one form of machine which may be used for this purpose. Referring now to Figs. 6–10, inclusive, it will be seen that the machine consists of an assembly which is designed to be installed in a punch press for actuation thereby. The machine consists of a base 20 adapted to be secured fixedly as at 21 and 22 to the bed of a suitable punch press the slider or ram of which is indicated at 23 in Figs. 7 and 8. The base is provided with two upstanding guide pins 24 and 25 rigidly secured thereto to act as guides for a moveable top plate 26 which is connected to the slider 23 of the punch press so as to be reciprocated in an up and down manner parallel to the vertical axes of guide pins 24 and 25. As will be seen more clearly in Fig. 6, the fixed base 20 carries a rotating die structure G which is disposed flatwise thereupon and constrained thereon for rotary motion about a central fixed hub 28. The rotating die structure 28 having a central recessed portion 30 whose thickness is about the same as the height of hub 28 above the top surface of base 20. A washer 31 is secured to the top end of the hub concentrically therewith so as to overhang a portion of the said recessed portion 30. It will thus be understood that the washer is effective in holding the disk 29 in contact with the upper surface of base 20 while permitting the disk to rotate freely about the hub 28. The washer 31 may be secured to the hub in any suitable manner, as by means of screws 32, 33. The un recessed face portion of the disk 29 is provided with a circular series of radially directed slots 33 extending a convenient depth into the disk. The number of slots is optional, depending largely on the size of the annulus which is to be formed, but a series of slots which is provided should preferably be a multiple of three when forming a spacing member corresponding to member 8 of Figs. 1–5. Each of these slots carries a blade 34 disposed therein on edge and projecting from the exposed top surface of the die base 28. The upper edge of each blade provides a rectilinear forming surface over which the strip metal may be bent, as will be understood subsequently. Each of the blades 34 is provided with a triangular portion which projects from the inner end thereof, the function of which is to aid in securing the blade in the die assembly. A typical blade is illustrated in Fig. 17 and the triangular portion is shown at 35. The blades are disposed in said slots with the triangular portions at the inner ends of the slots, as shown in Fig. 6. A beveled locking ring 36 is disposed between the inner ends of the blades and the washer 31, and is secured as by screws 37, 37 to disk 29 so that its beveled edge portion 38 is brought to bear against the triangular projecting portions 35, 35 of the said blades. As will be understood through reference to Fig. 8, this construction prevents the blades from being pulled out of the rotating die. The rotating die is completed by means of a peripheral toothed ring 39 provided with a multitude of teeth 40, 41, the number of teeth thus corresponding to the number of blades in the rotating die member. A slot 41 of suitable width separates adjacent teeth of said toothed ring, this slot extending radially across the ring and downwardly to a level which is at least slightly above the plane of the upper surface of disk 29. The toothed ring is secured to the periphery of the disk 29 by means of a plurality of circumferentially spaced screws 38a, but is positioned on the periphery of the disk 29 so that each slot 41 lies midway between a pair of blades 34, 34. Thus the slots lie at the extremity of each of the forming cavities 42 of the die member and each is centered with respect to its corresponding cavity. This construction permits a vertically movable blade (described hereafter) to be forced downwardly on edge into each cavity while being aligned with the cavity by one of the radial slots 41 of the toothed ring.

As will be understood more fully hereafter, the blades of the rotating die member are arranged to form a repeating sequence of high and low forming edges with intermediate forming cavities 42. Such a sequence is required in forming the corrugations of the spacing member 8 of Figs. 1–5 inclusive. Thus the blades are arranged in sets so that there is one high or major blade followed...
4. by two low or minor blades, the latter being followed by another set having the same succession of one high blade followed by two low blades. By using a number of blades which is a multiple of three, the successive sets of blades cooperate to provide a continuous forming die in which the repeating sequence is endless. The major blades as shown have their forming edges parallel to the surface of the die base 20 but the forming edges of the minor blades are inclined. Considering a median plane of the said minor blades disposed midway between the surface of the base 20 and the forming edges of the said blades, the forming edges of the minor blades are above said plane and incline inward and upward from it.

The fixed base 20 also carries an inclined guiding assembly H adapted to guide the strip stock in a flatwise position tangentially into the rotating die member. This guiding assembly consists of a support 43 secured to base 20 by means of suitable screws 44. On the upper surface of the support is secured an elongated frame 45 having a shallow groove 46 formed in the top face thereof. The said frame is secured to the support by means of screws 47, 47. A guiding attachment is mounted upon the frame so that it may be moved back and forth in the groove 46 thereof for suitable adjustment of its radial position relative to the center of the rotating die member. The guiding attachment consists of a beveled bar 48 having slots 49 at its opposite ends, and a pair of guide plates 50 and 51 secured to each other and to said bar in such manner as to form a thin opening through which the strip stock may be fed in flatwise position. The guiding attachment is secured to frame 45 by means of screws 52, 52 positioned in the said slots 49 at opposite ends of the bar 48.

The fixed base also carries a stationary hold-down J, the function of which is to hold the corrugated stock in mesh with the forming edges and forming cavities of the rotating die member. This hold-down consists of a segmental plate 54 having three studs 55 secured thereto to lie on a radius of the segment. This construction will be understood more fully through reference to Fig. 9. The three studs extend upwardly through openings in a frame member and carry a bell 51, 57 on their upper extremities. The frame member is secured to a support 58 and to the base 20 by means of screws 59, 59. A spring 60 is interposed between said segmental plate 54 and said frame member 56 so as to resiliently impel said segmental plate downwardly with respect to the fixed frame member. It will be understood that this construction permits the segmental plate to be retained in position above the rotating die member, or to be forced into contact with the top edges of the high blades thereof under yield. The functions of the hold-down will be explained subsequently in connection with the operation of the device. It will be further understood, however, that the fixed hold-down must necessarily be positioned so that its segmental plate may be effective in holding the corrugated strip stock firmly in mesh with the rotating die member, without interfering with the action of the forming blade, or with the movable hold-downs described hereafter.

A rear guide assembly K for the forming blade 91 is secured to base 20 a short distance beyond the periphery of the rotating die member. This guide assembly is best shown in Fig. 13, where it will be seen to consist of a U-shaped frame 81 secured to base 20 by means of screws 82, 82, and a renewable insert 83 which is secured between the upright legs of the U-shaped frame by means of screws 84. The insert is provided with a slot 85 of suitable depth, and the whole guide assembly is positioned on the base 20 so that this slot is in radial alignment with the center of rotation of the rotating die member, as shown in Fig. 6.

A brake assembly L is also secured to the base 20 so as to engage the blade member from rotating too freely. This brake assembly consists of a hinged arm 86 pivoted at one end about a screw 87 so as to be rotatable about said screw toward and away from the periphery of the rotating die member. The other end of the arm 86 carries a block 88 of suitable friction material, preferably of the sintered metal variety. The arm and its attached friction material is resiliently pressed toward the rotating die member by means of a spring 89. Pressure is applied to the spring by means of a screw 90. A cup 91 is attached to the end of the screw 90 and serves to hold the spring 89 in place.

The screw 76 is threaded into a trunnion block 72, the latter being secured to the base 20 by means of screws 73. The position of the screw 78 relative to trunnion block 72 may be fixed by means of a lock-nut 74 threaded on said screw 78. The function and operation of this assembly is evident.

A ratcheting and indexing mechanism M is also secured to the base in a position which permits a ratchet thereof to engage with the teeth of toothed ring 83. This ratcheting and indexing mechanism is shown most fully in Fig. 10 to which reference is now made. It will be seen to consist of a frame 75 secured to the base 20 by means of screws 76. A rocker plate 77 is secured to the frame by means of pivot screw 78, and at one of its ends it is pivotally attached to a pawl 79 which is adapted to engage the upper ends of the teeth 80 of the toothed ring 83 of the rotating die member. Adjacent the other end of the rocker plate is connected a link 81 which is turn is connected to a lever 81, the latter being pivoted with respect to the frame about a pivot screw 82. The rocker plate 77 is also provided with a projecting portion 83 through which motivating energy is transmitted to the ratcheting and indexing mechanism. The pivotal lever 81 carries a ratcheting and indexing screw 84 at its remote extremity, and the frame 75 carries a cylinder and plunger assembly directly beneath said adjusting screw. The cylinder is shown at 85 and is secured to the frame by means of screws 86, 86 (Fig. 6). Plunger 87 is disposed within the cylinder and is adapted to move vertically up and down therein in response to pressure applied to it through adjusting screw 84 and lever 81. The plunger is prevented from rotating in the cylinder by means of a transverse pin 88, the outer ends of which are guided by slots 89, 89 in the walls of said cylinder 85. A coil spring 90 is interposed between the plunger and the bottom of the cylinder and serves to retract the plunger when the lever 81 is not pressing it downwardly. The bottom end of the cylinder is provided with a V-shaped point which is adapted to extend downwardly into the slot between adjacent teeth of the toothed ring 83 until the edges of the point engage the walls of adjacent teeth 80, 80. It will be understood that the purpose of the ratcheting and indexing mechanism is to advance the rotating die one tooth at a time and then to bring the die member to rest so that the
are brought consecutively into exact radial alignment with the slot of the rear guiding assembly. The reciprocating top plate 25 is guided on the two guide pins 24 and 25 of base 20 so as to be movable up and down or bowdard and away from the rotating die member. This reciprocating plate carries a forming blade 91 which, as shown in Fig. 6, extends radially across the full annular width of the rotating die member and is guided into position on die member G by the slot of rear guiding assembly K and by a front guide 93. As will be understood subsequently, this blade has the function of bending the strip stock over the top edges of the fixed blades 34, 34 of the rotating die member and of bending the stock around its lower edge. In order to be effective in forming corrugations of the proper configuration, the blade is pivoted near its inner end so as to be rotatable in a vertical radial plane relative to the rotating die structure G. The structure of the blade mounting assembly N is shown more clearly in Figs. 8 and 12. The assembly includes an angle iron frame 92 secured to the top of the blade by means of screws 93. A pivot block 94 is secured to the depending leg 95 of angle 92 by means of screws 96. This pivot block is recessed as at 97 to receive the head of a pivot screw 98, and carries a bushing 99 at a face of pivot block 94 by means of pivot screw 98. The blade is guided near its rear end by means of the guide assembly P shown in Fig. 13. The said guide assembly P (Fig. 13) consists of a pair of plates 102 and 103 fastened together in spaced relation to provide a channel of the proper width in which blade 91 may move in edgewise directions. The guide assembly P is secured to the depending leg 95 of angle 92 by means of screws 104. From this construction, it will be seen that the blade is free to undergo limited motion of the required direction as its center of rotation while, at the same time, being rigidly connected to the reciprocating top plate 26.

A coil spring 105 is connected between the angle 92 and the blade 91 to bias the blade against the face of a cam 106, as shown in Figs. 8 and 15. The cam is rotatable about a horizontal axis and is of such configuration as to cause theinclination of the forming blade to be changed periodically as the cam rotates through its various positions. As shown best in Figs. 7 and 8, the cam is secured to the depending leg 95 of angle 92 at a position thereon intermediate the pivot screw 98 and rear guide assembly P. The construction of the cam assembly Q is shown most clearly in Fig. 7 where it will be seen that the cam 106 forms the head of a spindle having a first cylin- drical portion 107 followed by a second threaded portion 108, and then by a cylindrical threaded portion 109. The cylindrical portion 107 is journaled in a supporting plate 110 which is secured flatwise against depending leg 95 of angle 92 by means of a nut 111 (Fig. 8). A ratchet wheel 112 having a square thread is carried by the square shoudered portion 108 of the spindle. A washer 113 is interposed between the ratchet wheel 112 and a bearing boss 114 on plate 108. Another washer 115 is disposed on the threaded screw portion 109 adjacent the other face of ratchet wheel 112 and faces of plate 110.

By adjusting the spring pressure, the frictional force between the cam assembly and the plate 110 may be adjusted and thus utilized to prevent the cam from rotating too freely. Washer 113 may be composed of sintered metal friction material if desired, so as to introduce more friction than could be obtained from an ordinary metal washer.

Referring now to Figs. 8 and 15, it will be seen that the cam 1065 is provided with six distinct bearing surfaces, four of them being arranged in two pairs disposed on opposite sides of the cam and separated by curved end portions. The four flat faces of the cam are all tangent to the same circle while the curved sections are portions of a circle of greater diameter. Accordingly, it will be seen that the cam produces a sequence of positions by which it is capable of depressing the blade 91 to a maximum depth in one position, and then of permitting the blade to be retracted to a lesser depth in two succeeding positions. As the cam rotates further, it repeats a sequence of positions, thereby providing two complete cycles of the same tri-position sequence. The ratchet wheel carries six teeth equally spaced circumferentially and positioned relative to the cam so that rotation of the ratchet wheel may be effected in sixty degree intervals to bring the six faces of the cam consecutively in contact with the top edge of blade 91.

The mounting and construction of the blade 91 and its cam actuating devices are such that the forming edge of the blade, when it is inserted between a major blade and a minor blade of the female die, is below the median plane of the major blades of the female die and inclines inward and downward away from said plane.

Rotation of the ratchet wheel and cam assembly Q is effected by the upward motion imparted to the top plate by the punch press. For this purpose a bell crank 116 is pivoted on pivot pin 119 relative to the dependent leg 95 of angle 92. One leg of the crank extends outwardly beyond the end of angle 92 and is provided with a striking pin 120, as shown in Figs. 8 and 14. The other leg of the crank is pivotally connected through pin 121 to a ratchet link 122 carrying a hook 123 adapted to engage the teeth of ratchet wheel 112. Spring 124 holds the hook in contact with the ratchet wheel, and spring 125 serves to bias the hook laterally against a stop pin 126. A bracket 127 is secured to washer 31 by means of screw 128 and carries an upright slotted portion 129 to which is attached a block 130 as by means of screw 131. The block 130 is positioned so that striking pin 120 will be brought into engagement with it during at least a part of the upward motion of top plate 26. When the striking pin has thus been brought into engagement, further motion of the platen upwardly causes the bell crank to be moved in a direction about pivot 119. This, in turn, causes the hook 123 to be pulled away from stop pin 126 and thereby to engage a tooth of ratchet wheel 112 and cause the ratchet wheel and as
associated cam to be rotated through about sixty degrees of angle. As the top platens moves downward, this cycle of motions is reversed and hook 123 slides back over the adjacent tooth of ratchet wheel 12 and ultimately comes to rest against stop pin 126. It will thus be seen that the up and down motion of the top platens is utilized to effect rotation of the cam in synchronism with the reciprocating motion of the platens.

The reciprocating motion of the top platens is also utilized to actuate the ratchet and indexing mechanism M. As shown in Figs. 6 and 10, the top platens carries a depending adjustable hook 132 adapted to come into engagement with the projecting portion 83 of rocker plate 77 during at least a part of the upward motion of the platens. The hook 132 is carried on an angle frame 133 by means of screw 134, the angle being in turn secured to platen 26 by means of screws 135. It will be understood that this construction causes the ratcheting and indexing mechanism to move in synchronism with the reciprocating movement of the platens.

For the purpose of retaining the formed or corrugated strip stock in contact with the rotating die member while succeeding portions of the strip stock are formed, a resilient hold-down B is provided. This hold-down is shown in Figs. 7, 11 and 18, and will be seen to consist of a box-like frame composed of side plates 136, 136, and end pieces 137, 137. The frame is secured to top platens 26 by means of screws 138. The opposite end pieces 137, 137 of the frame are provided with inwardly directed shoulders 139, 139. Within the cavity of the frame are positioned two blade carriages 140 and 141, both of which carry outwardly directed shoulders 142, 142 adapted to engage shoulders 139, 139 of the frame and thereby prevent the carriages from dropping out of the plane. The blade carriages are mounted against sponge rubber pads 143 so as to be resiliently pressed downwardly, but at the same time to be free to move independently of each other. The blade carriages 140 and 141 support hold-down blades 144 and 145. The blades of the hold-down extend radially across the annular portion of the rotating die section G, as shown in Fig. 6, and are dimensioned in length so as to be guided by adjacent slots 41, 41 of the fixed base member. The inner ends of the hold-down blades are loosely guided by means of a guide member 146 which is secured to washer 81 of the fixed base. As shown in Fig. 7, the hold-down blades 144 and 145 are adapted to contact the corrugated strip in the troughs of adjacent corrugations thereof, and thereby to hold the corrugated strip in mesh with the blades and cavities used in forming the various corrugations.

The corrugated strip is thereby held firmly in position on the rotating die member while the forming blade 91 is bending a succeeding unformed portion of the strip stock around the top edge of an adjacent fixed blade. As will be seen by comparing Figs. 7 and 18, the sponge rubber mounting for the blades 144 and 145 permits each of the blades to accommodate itself to the height and inclination of whatever trough corrugation comes into position beneath it, while pressing each corrugation firmly downward against the fixed blades of the rotary die member.

Now that the various elements of the structure have been described, it will be recognized that before the device can be placed in opera-
into contact with the top edge of the forming blade 91. With the punch press in its open position, the rotating die member should then be rotated so as to bring two adjacent minor blades together into its locking positions on opposite sides of the forming blade 91 so that when the punch press is actuated to move the assembly to its closed position, the forming blade will be depressed into the cavity which lies between the said minor blades.

Timing of the cam relative to the upward motion of the platen

In order that cam 106 may be rotated at the proper point of time in the cycle of operations, it is necessary that the block 130 be properly positioned on bracket 129. To do this, the cam 106 should be rotated until one of its curved end portions has been brought into contact with the top edge of forming blade 91. With the cam in this position, the punch press and the platen should be raised until the bottom edge of the forming blade 91 has been raised slightly above the top of teeth 40 of the toothed ring 39. The adjustable striking block 130 should then be fastened to the upper right bracket 129 so that its bottom face is in contact with the striking pin 120 of bell crank 110. The proper time intervals on completion of the event described should be raised to the uppermost position (open position). When it has been brought to this position, the hook 123 should have been effective in rotating the ratchet wheel 112 and cam 106 through an angle of about 60°. If this is done, the adjustment is correct. If, however, the cam 106 is rotated through an angle much greater than 60°, then the striking block 130 should be raised upwardly on bracket 129 to reduce the angular rotation to the desired value of 60°.

Timing the advancing and indexing mechanism relative to the upward motion of the platen

It will be recognized that pawl 79 should not begin to advance the rotating die member until after forming blade 91 has been raised high enough to allow the top edge of the forming blade slightly above the top of the teeth 40 of toothed ring 39. Furthermore, the pawl should have been effective in completing the advancing action since the time the platen 26 has been raised to its uppermost position. An adjustment of member 132 can be found which will make the pawl perform its functions at the proper time intervals. To find the proper adjustment, cam 106 should be rotated until one of its curved end portions has been brought into contact with the top edge of forming blade 91. The punch press should then be actuated so as to raise the platen far enough to lift the bottom edge of the forming blade slightly above the top of the teeth 40 of toothed ring 39. Member 132 should then be fastened to the platen by means of screw 134 so that its hooked end portion bears against the bottom face of the projecting portion 83 on rocker plate 77. With the member so fastened, the platen should then be raised to its uppermost position to make certain that pawl 79 does not move too far as a result of this further upward movement of its lateral motion is found to be too great, with the result that the rotating die member is rotated a distance of more than one tooth, then member 132 should be lowered relative to platen 26 until an adjustment is found which causes the pawl to move forward and back the required distance. The adjustment should then be checked again by moving the platen from its lowermost (closed) position to its uppermost (open) position while observing pawl 79 and plunger 87. If the adjustment of member 132 is correct, then the pawl 79 will advance the rotating die member only one tooth at a time, and plunger 87 will move downwardly in such a manner that it will not strike the top of any tooth of the toothed ring 39 in its descent. Furthermore, when the platen has reached its uppermost position, the pawl should have reached the extremity of its forward stroke while the plunger 87 should have come to rest with the face of its V-shaped point in light but firm engagement with the adjacent walls of adjacent teeth 40 of the ring 39. Screw 84 should be adjusted until such an adjustment of the plunger 87 has been obtained.

After the preceding adjustments have been made as indicated, the next step which is involved to place the device in operation is that of threading the strip stock 147 through the device. This threading step is essentially a procedure which must be done by the operator before the machine can be expected to operate automatically and without attendance. Threading is accomplished in the following manner: With the machine in its open position, metal strip stock 147 of the desired width and gauge and of appropriate composition and mechanical properties for its intended use in the corrugated condition, is inserted into the rotating die member by sliding it longitudinally through the opening between plates 50 and 51 of guide H. The stock is advanced into the die member far enough so that its leading edge is slightly beyond the forming blade 91. The punch press may then be set in motion so as to complete only one revolution. This motion of the punch press will first depress the forming blade, thereby bending the strip to form a corrugation, and thereafter will again raise the platen to its open position. The corrugation thus formed is apt to be of imperfect configuration because of the fact that the stock had not been suitably restrained while it was being bent. However, the corrugation should not be severed from the strip or discarded until after the second corrugation has been formed. The stock is then removed from the machine since it is needed for this purpose. To this end, the operator should hold it in the cavity in which it was formed while the upward motion of the platen acts to advance the rotating die member one space to the left. When this is done, the rotation of the die member is effective in pulling additional strip stock beneath the forming blade. The press may then be set in motion to form a second corrugation. On this next downward stroke of the punch press, the movable hold-down blade 144 should be effective in holding the stock in place while the forming blade forms the succeeding corrugation. It will be noted that when it is so held by the hold-down blade 144, the strip is effectively anchored relative to the blades of the die member. As a result, the forming blade assumes substantially its complete function in forming the succeeding corrugation. This function is essentially that of causing the unformed strip stock to slide around and beneath its forming edge as the blade moves downwardly into the cavity. The downward motion of the blade is thereby effective in pulling or gathering the strip stock into the cavity without subjecting it to stresses which exceed its elastic limit. In consequence thereof, the stock will not be broken even though it is of such temper and composition that it has substantially no elongation. After the second corrugation has been formed, the operator must hold both the first and second corrugations
In their respective cavities while the rotating die member is advanced to bring the third cavity beneath the forming blade. On the third downward stroke of the punch press, both of the movable hold-down blades 144 and 145 contact the corrugated stock and hold it in position while the third corrugation is being formed. Upon completion of the third corrugation, the operator must again hold the corrugations in the rotating die member as the latter is being advanced. Ultimately, however, a crest corrugation will have been formed around the top edge of one of the major blades of the die member will be in a position to pass beneath plate 54 of the fixed hold-down. After such a corrugation has been brought under this plate, further attention by the operator is unnecessary since thereafter the corrugated stock will be held in position automatically as the rotating die member is advanced. The threading operation is thereupon complete.

Assuming now that the strip stock has been threaded into the machine and that the machine has been adjusted and timed for automatic operation, as described above, the action of the various parts may be traced. It will be understood that due to the function of the hold-down plate 54, the advancing die member pulls a succeeding portion of unformed strip stock beneath the forming blade as the rotating die member is advanced after completion of each corrugation. The hold-down plate 54 anchors the leading end of the stock to permit the die member to do this. It will also be understood that as the forming blade is then depressed into each cavity, it bends the stock downwardly into the cavity while pulling enough additional strip stock in also to form a corrugation of the desired configuration. Furthermore, it will be understood that as the platen moves upwardly upon completion of each corrugation, the movable hold-down blades 144 and 145, and the forming blade 91, are retracted and are carried upwardly to a height which causes their lower edges to rise above the top of the teeth 40 of the toothed ring 39. When this has been accomplished, the adjustment of hook 32 in Fig. 10 should be such that it comes into contact with portion 83 of rocker plate 71. Further upward motion of the platen then sets the advancing and indexing mechanism of Fig. 10 in operation, pawl 19 engaging the die member to the left or in a counter-clockwise direction, and lever 81 causing plunger 87 to move downwardly toward the toothed ring 39. By the time the platen has reached its uppermost position, pawl 19 is in its extreme position toward the left, and the V-shaped point of plunger 87 has been brought to rest in mesh with the walls of a pair of adjacent teeth. Meanwhile the apparatus of Fig. 8 has also been motivated by the upward motion of the platen. As explained previously, during the upward motion of the platen, striking pin 120 of bell crank 118 is brought into contact with the adjustable stop block 138, carried by bracket 129. Further upward motion of the platen thereafter causes the hook link 123 to engage a tooth of a ratchet wheel 112, causing the latter to rotate through approximately 60° of angle. This rotation advances the cam 106 of Fig. 15 to its next succeeding position, thereby establishing the inclination of forming blade 81 which is needed in forming the next corrugation. In summary, therefore, it will be recognized that after the platen has been raised upwardly by the punch press to a point where the forming blade and hold-down blades have cleared the teeth of the toothed ring 39, the indexing mechanism advances the rotating die section one forming cavity to the left, and the inclination of the forming blade is meanwhile adjusted to prepare it for the next corrugation which it will perform.

In the operation of the machine, as the corrugated and accurately-curved member formed from the straight strip stock passes out from under the hold-down plate 54, it gradually springs upward out of the die depressions and falls over the sides of the circumferential top form on the floor or other support at the side of the machine. A stripping guide 5 may be provided to facilitate this removal or stripping of the corrugated material from the rotary die member.

From the foregoing description, it will be apparent that the machine is capable of handling strip stock from long coils or rolls, and of corrugating such stock in a continuous manner so as to form continuous spirals of corrugated material. The latter may subsequently be cut into portions of the proper length for use in the clutch assembly of Figs. 1 through 9. In view of this feature and of the fact that the annulus is formed from strip stock rather than from circumferencing squares of sheet metal, or otherwise, there is practically no waste involved, all of the strip stock used in forming corrugated stock which may be used without waste forming jointed annular spacing members for the clutch plate assembly. From what has been said previously, it will also be recognized that the machine may handle strip stock of any appropriate composition, form and of the fact that the annulus is formed from strip stock (that is, stock having little or no elongation), it may be used equally well in corrugating ductile stock having large values of elongation. It should be noted, however, that when material of this latter class is corrugated in the machine, it is not subjected to stresses which cause it to be stretched or permanently deformed except by bending operations. Consequently, there is no mechanical deformation involved beyond that of simple bending, and the resultant corrugated stock is only slightly work-hardened.

It will be appreciated that any given die structure G may be used to form annuli of a limited range of diameters if its blades 44 are wider than the strip stock which is to be corrugated. A wider range of diameters is needed, it is usually preferable to provide several machines with rotating die members of different sizes, rather than to attempt to design one rotating die member capable of accommodating all of the different annulus diameters. This is the result of structural limitations imposed on the design by mechanical considerations, rather than by any failure of the basic principles to permit such a die member to be provided.

These skilled in the art will appreciate that the basic principles of the device of Figs. 6-18 inclusive may be embodied in various machines which depart in mechanical structure and arrangement from the machine thus far described and explained. Two of such alternative constructions are illustrated in Figs. 19-24 inclusive.

One alternative construction is illustrated in Figs. 19-23 inclusive. In this device a rotating die member 150 of the type shown in Figs. 6-18 inclusive is employed and is mounted for rotation about a center on a fixed base 151. The construction of the device is as shown in Figs. 6-18 so far as the rotating die member and fixed base are.
concerned. A fixed hold-down 152 is provided and may have the construction shown in Figs. 7 and 9 above. The movable forming blade 91 of Fig. 7 has been replaced in the modification here illustrated. In the device of Fig. 19, a stationery box-like frame 153 is provided above the rotating die member and carries five blades 154, 155, 156, 157, and 158, each of which is mounted therein for concentric motion toward and away from the die member 150. Blades 154 and 155 have the same functions as hold-down blades 144 and 145 of Figs. 6–18 inclusive. Blades 156, 157 and 158 are combined in their individual functions so as to take the place of the single moveable forming blade 91 supra. As will be understood from the preceding discussion of Figs. 6–18 inclusive, the forming blade 91 assumed three positions in its complete cycle of operations, these positions being imparted to it by the various positions assumed by cam 106. In the device of Fig. 19, each of the blades 156, 157 and 158 has its respective forming edge 156', 157', 158', shaped properly so that each one makes only a single corrugation of predetermined configuration. Thus blades 156 and 158 are beveled as shown in Fig. 21, the bevel corresponding to the inclination which would be assumed by blade 91 at the two shallow or inclined positions of the latter if it were forming the same annulus. Blade 157 has a forming edge which is substantially parallel to the top surface of the rotating die member. It thus has the construction shown in Fig. 20 and will be recognized to duplicate the position assumed by blade 91 when the cam 106 has been rotated to bring either of its curved end portions into contact with the top edge of the blade. As indicated above, blades 154 and 158 serve as hold-down blades. Blade 155 is similar in construction to blade 157 and is shaped substantially as shown in Fig. 20. Blade 155 corresponds to blades 156 and 158 and is similar to the blade shown in Fig. 21. The five blades carried within frame 152 may be actuated by any suitable means and will move in the proper consecutive sequence and at the proper points of time. A rotary cam assembly 159 is shown in Fig. 19 and it carries 5 cams 160, 161, 162, 163 and 164 which actuate the blades in the desired sequence and with the proper timing. The contour of each of the various cams is shown in Fig. 22.

The operation of the device is as follows: As will be noted, the die member 150 is shown with the strip stock 156 threaded therethrough and in a position such that a major trough corrugation is directly below blade 154 and with a minor trough corrugation below blade 155. The strip stock to the right of fixed blade 156 is in position to be corrugated. In order to corrugate this unformed strip stock, the device is operated by depressing blades 154 and 155 sufficiently to bring their forming edges into firm contact with the troughs of the corrugations which are directly beneath them. As will be understood, when these blades have been so depressed, they anchor the corrugated stock firmly in contact with the rotating die member. Blade 156 may then be depressed to the position shown in the dotted lines, thus forming the minor corrugation 167 by drawing additional strip stock under its forming edge as it moves downwardly to its ultimate position. As shown, blade 156 has been brought to rest in its ultimate position, or slightly before, blade 157 may begin its downward descent. In any event, this blade should not contact the unformed strip stock appreciably before blade 156 has come to rest at its lowermost position. With this sequence of events, blade 157 pulls additional strip stock into the cavity between blades 156 and 156, and when it has been depressed to its ultimate position it will have completed the formation of the major corrugation 166. When this has occurred, or slightly before, blade 156 may begin its upward movement. When this latter blade has finally come to rest in its ultimate position, it will have pulled strip stock into the cavity between the blades 158 and 171 to form the final minor corrugation 172 of the series. It will be recognized that at this point of time all five blades are in contact with the strip stock. The next step in operating the device is to raise all five blades upwardly far enough to permit the rotating die member 150 to be indexed beneath them. This is accomplished by further rotation of the cam assembly, as will be understood from Fig. 22, to permit the blades to be retracted into frame 153. Retraction may be effected by mounting each blade on springs which are compressed when the blade is pressed downwardly. The springs may be disposed beneath lugs 173, 174 on opposite sides of each blade. When the blade 153 has been raised high enough to clear the die member, the die member 150 is indexed to the left a distance corresponding to three forming cavities. Thus it is indexed sufficiently so that major blade 171 is moved laterally to occupy the position which major blade 190 is shown to occupy in Fig. 19. When this has been done, major trough corrugation 171 will lie directly beneath hold-down blade 154, and minor corrugation 172 will lie directly beneath hold-down blade 156. The device is then ready for a repetition of the steps described to form three more corrugations by depressing blades 156, 157 and 158 in sequence. Any convenient means may be used to synchronize the indexing action with the rotation or the cams, as will be understood from the foregoing discussion of Figs. 6–18.

It will be recognized that the device of Fig. 19 embodies each of the basic principles involved in the device of Figs. 6–18. It should be especially noted that the three forming blades are not depressed simultaneously. If this were done, the unformed strip stock would not be pulled into each of the forming cavities in succession but rather would be clamped by the forming blade and subjected to a drawing operation which would break each relatively inextensible stock as the device is designed to accommodate. On the contrary, by depressing the three blades in sequence, the inextensible stock is drawn freely into each consecutive cavity to form one corrugation at a time, and consequently is not subjected to stresses which would cause it to break. This feature will, of course, be thoroughly understood from the discussion of Figs. 6–18.

The modification shown in Figs. 23 and 24 involves the substitution of a conical rotating die member 174 for the annular rotating die member G to Figs. 6–18. The pivoted forming blade 175 is connected to punch holder 176 mounted in the slide of a punch press for use in combination with the conical die member. Its construction and operation is similar to that of pivoted forming blade 91 of Figs. 6, 7 and 8. The strip stock 177 is fed through a guide 178 which delivers it to a desire dosition on the fixed forming blades 179 and 180 of the conical die member. The pivotal forming blade 175 re-
ciprocates toward and away from the conical section and forms one corrugation at a time. Its inclination is changed suitably before each downward stroke to gather the required amount of strip stock into each successive cavity. Cam 181, which functions like cam 188 supra, effects the change in inclination. A pair of spring-pressed hold-down blades 182 and 183 are also provided to anchor the corrugated stock in the conical die member while blade 175 bends the strip stock. A hold-down 184 is also provided to control functions of the hold-down plate 54 of Figs. 7 and 9. A stripping plate 185 may be disposed adjacent the periphery of the conical die member to peel the corrugated stock away from the conical die member as the latter rotates intermittently. It will, of course, be recognized that the intermittently rotating die member 174 is indexed clockwise (as viewed in Fig. 23) for a distance of one forming cavity at a time after each complete stroke of the forming blade. This synchronized indexing action duplicates that of the device of Figs. 6-18 and will therefore be fully understood without further explanation. Fig. 23 shows the die member indexed through half of its usual angular distance to show how it pulls the strip stock with it as it rotates.

Those skilled in the art will recognize that the modifications illustrated in Figs. 19-23 inclusive represent only a few of the numerous constructions which may be devised to utilize the principles of operation disclosed herein, since many machines may be constructed in which male and female die members are utilized to bend metal strip stock into rectilinear corrugations of different depths by successive bending operations. Either the male or female die member may reciprocate relative to the other, and it is not necessary that either one have rotary or arcuate motion in the plane of the strip stock since those skilled in the art will recognize that the metal stock may itself be suitably indexed relative to both die members so as to bring the successive transverse portions thereof into position to be bent into corru-

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2. Apparatus as claimed in claim 1 in which the male die blade is pivotedly carried by the male die structure, and the means for positioning the rectilinear edge of the male die blade includes cam means for inclining said rectilinear edge of the male die blade when it is reciprocated between a major and minor blade.

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