

April 29, 1969

R. K. HEATH

3,440,852

BENDING APPARATUS

Filed Nov. 28, 1966

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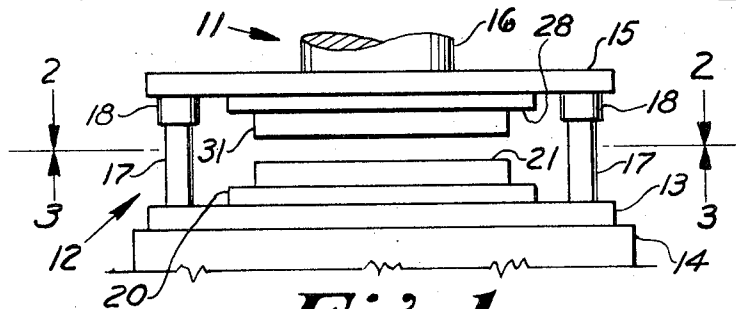


Fig. 1.

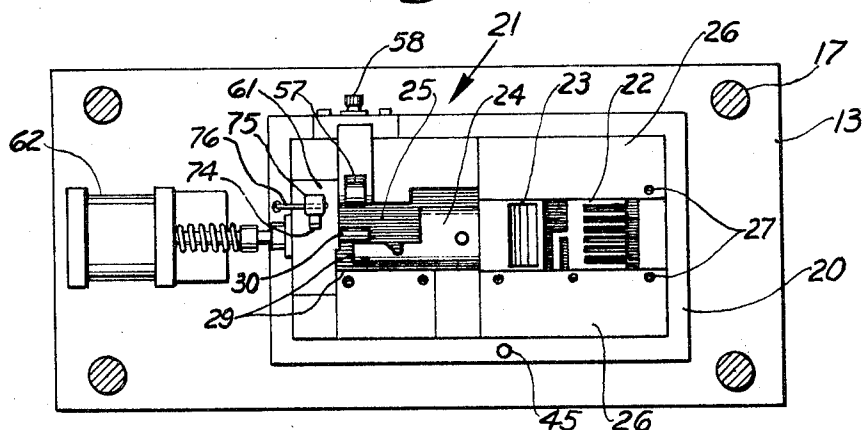


Fig. 2.

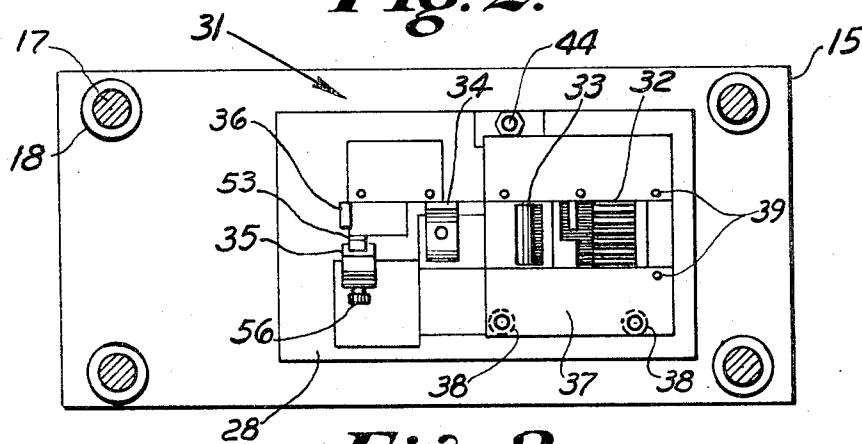


Fig. 3.

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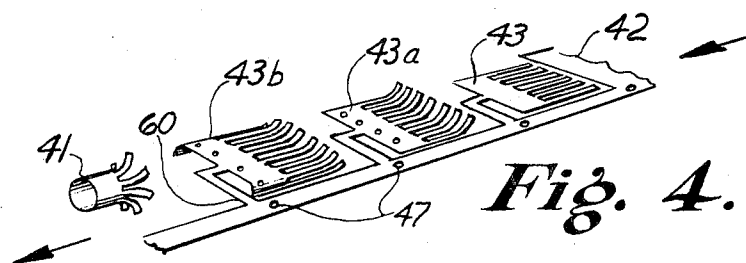


Fig. 4.

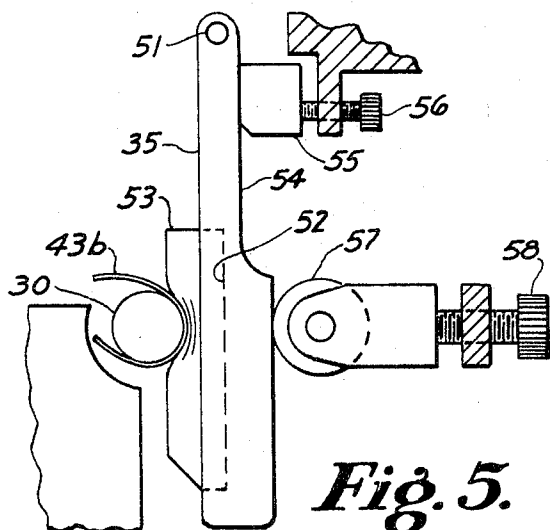


Fig. 5.

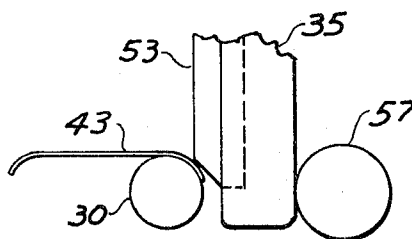


Fig. 5a.

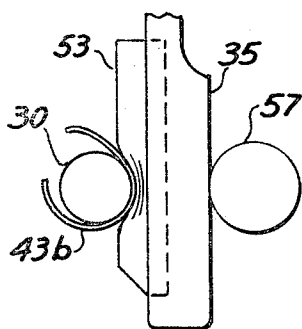


Fig. 5b.

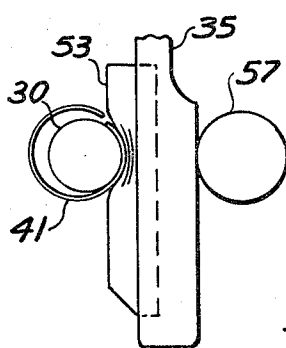


Fig. 5c.

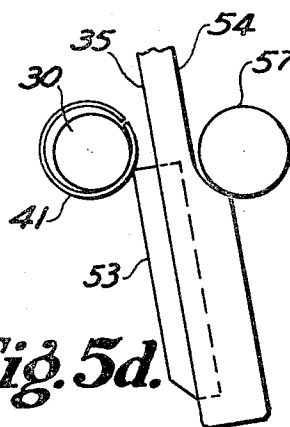


Fig. 5d.

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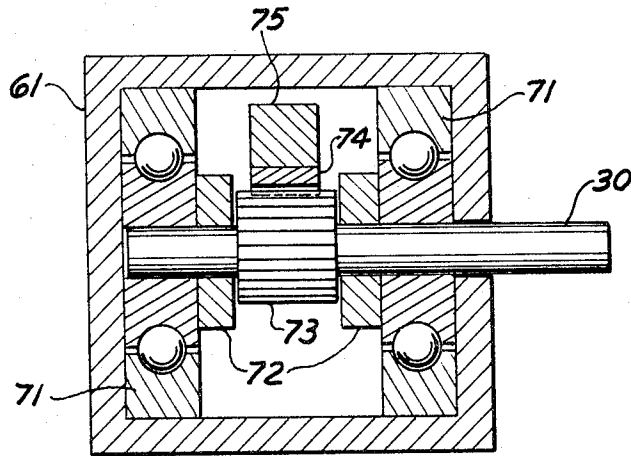


Fig. 6.

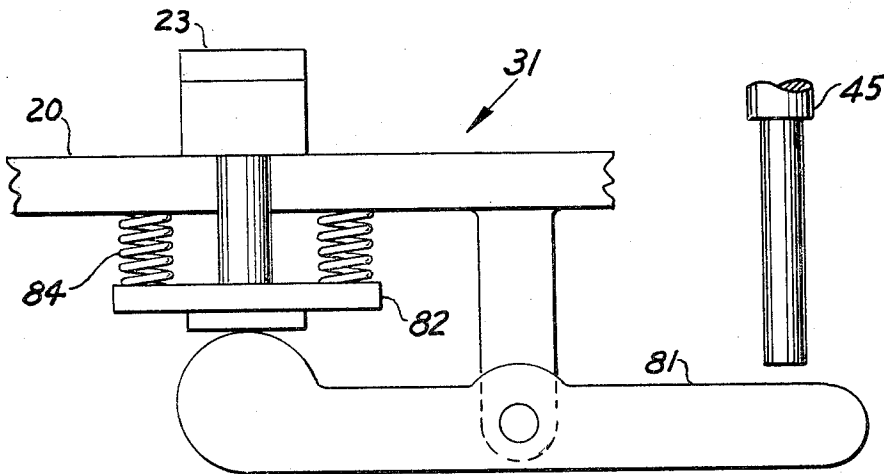


Fig. 7.

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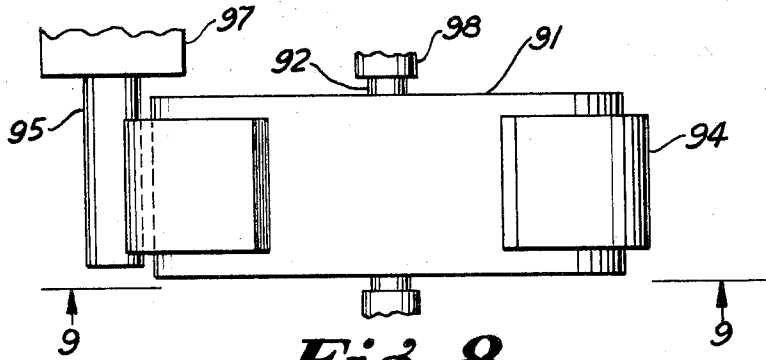


Fig. 8.

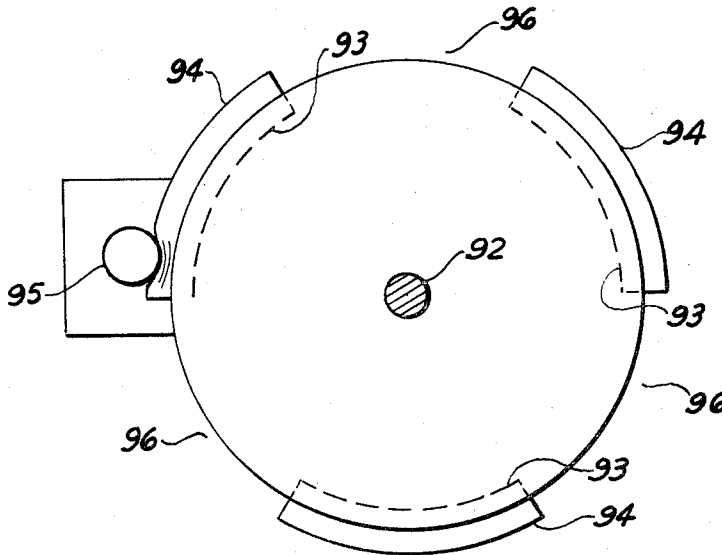


Fig. 9.

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Filed Nov. 28, 1966, Ser. No. 597,338
Int. Cl. B21d 5/14, 22/10

U.S. Cl. 72-207

18 Claims

ABSTRACT OF THE DISCLOSURE

A cylinder forming tool having a reciprocating resilient surface which tangentially contacts a rotatable rigid cylinder to form thereon cylindrical pieces from sheet material inserts. The tool automatically produces periods of reduced contact pressure between the forming parts so as to permit removal of the formed pieces.

This invention relates generally to apparatus for forming blanks of sheet material and, more particularly, relates to apparatus for forming sheet metal into arcuate shapes and especially into hollow cylindrical form.

Machine tools of various types have been developed for forming tubular components from sheet metal stock. These machine tools have included devices designed for manual as well as for automatic and semi-automatic operation. Although useful in many tube forming applications, all known tools of this type have been generally ineffective for applications requiring the formation of relatively small and precise hollow cylindrical parts from certain types of hardened sheet metal stock such as Phosphor bronze alloys. The need for a machine tool having this capability has risen steadily with the increasing requirement for such cylindrical parts, particularly in the electronics industry.

The general object of this invention, therefore, is to provide an improved apparatus for arcuately forming sheet material stock.

A more particular object of the invention is to provide an improved automatic machine tool for forming precise and relatively small, hollow cylinders from extremely hard sheet metal stock.

A primary feature of the invention is the provision of a sheet material bending apparatus having a resilient driver mechanism mounted for linear reciprocative motion and adapted to engage in a moving pressure contact with and be deformed by a rotatable rigid forming cylinder while moving on a path substantially tangent thereto. This combination of a rotatable rigid forming cylinder and tangentially engaging, linearly moving resilient surface is extremely effective in forming small and exact hollow cylinders from hard sheet metal work pieces.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured type having a mechanism for automatically reducing the contact pressure between the rigid forming cylinder and the resilient surface during a portion of its reciprocal movement. This period of reduced pressure permits removal from the rigid forming cylinder of cylindrical pieces formed from work pieces inserted between the engaging forming cylinder and the resilient surface.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured types including a mechanism for automatically removing from the rigid cylinder the formed cylindrical pieces during the period of reduced pressure contact.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured types wherein the automatic cylinder removal mechanism produces an axial withdrawal of the rigid forming cyl-

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inder from the formed cylindrical piece so as to induce separation thereof.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured types wherein the resilient surface mechanism is adapted for attachment to and operation by a conventional power press. With this arrangement a common and readily available power press can be utilized as the motive for driving an automatic cylinder forming device.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured types including a feed mechanism for inserting sheet metal piece parts between the engaging surfaces of the rigid cylinder and resilient driver.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured type wherein the feed mechanism performs a plurality of sequential operations which prepare and separate individual work pieces form a continuous strip of sheet metal stock and wherein the feed mechanism inserts the individual work pieces between the engaging surfaces simultaneously with a final cutting operation which completely separates the individual work piece from the continuous strip of sheet metal stock. With this arrangement, an extremely rigid mechanical control can be maintained over the individual pieces during the entire forming operation.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured types wherein the feed mechanism further includes a preforming assembly for arcuately preforming at least one end of the individual work pieces before insertion thereof between the engaging surfaces of the resilient driver and rigid forming cylinder. The preforming of the work piece insures the formation of a fully closed cylindrical piece while minimizing the contact pressure required between the resilient driver and rigid forming cylinder.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured types wherein the feed mechanism includes cutter punches actuated by the power press and adapted to cut a plurality of parallel fingers in the individual work pieces and a bending punch also operated by the power press and adapted to bend the ends of the finger sections in a direction away from the axis of the cylindrical piece being formed. This combination provides an automatic machine tool uniquely suited for forming the female electrical terminals of the type used in electrical switchboards and the like.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured type including a motion converting mechanism which converts the linear motion of the power press into a rotary motion for driving the rigid cylinder during each cylinder forming operation. In this way, a desirable rotary drive of the rigid cylinder is obtained in an extremely simple, efficient and inexpensive manner.

Another feature of this invention is the provision of a sheet material bending apparatus of the above featured types wherein the feed mechanism feeds the individual piece parts between the engaging surfaces of the resilient driver and the rigid cylinder in a direction substantially parallel to the axis thereof. This arrangement provides a desired flexibility of operation and is particularly useful for producing bends with the grain of work pieces cut from continuous metal stock.

These and other features and objects of the present invention will become apparent upon a perusal of the following specification taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a partial schematic view of a preferred bending apparatus embodiment of the invention;

FIG. 2 is a partial cross-sectional view taken along the lines 2—2 of FIG. 1;

FIG. 3 is a partial cross-sectional view taken along the lines 3—3 of FIG. 1;

FIG. 4 is a progressive view of a work piece formed by the bending apparatus embodiment shown in FIGS. 1—3;

FIG. 5 is a schematic cross-sectional end view of the cooperating elements 35 and 30 shown in FIGS. 2 and 3;

FIGS. 5a—5d are schematic progressive views illustrating the operation of the apparatus shown in FIG. 5;

FIG. 6 is a cross-sectional view of the element 61 shown in FIG. 2;

FIG. 7 is a schematic view of the operating mechanism connecting the elements 23 and 45 shown in FIG. 2;

FIG. 8 is a front schematic view of another preferred bending apparatus embodiment; and

FIG. 9 is a schematic view taken along the lines 9—9 of FIG. 8.

Shown schematically in FIG. 1 are the power press 11 and operatively connected sheet material bending device 12. The power press 11 can be of any conventional type such as flywheel, pneumatic, hydraulic, etc. The bending device 12 includes the dieholder 13 supported by the press bed 14 and the punch holder 15 attached to the press ram 16. Alignment of the dieholder 13 and punch holder 15 is provided by the guide posts 17 and accommodating guide bushings 18.

Mounted on the dieholder 13 is the die plate 20 (FIG. 2) of the progressive die 21 which includes the cutting station 22, the bending station 23, the preforming station 24 and the final forming station 25 comprising the final cutting edges 29 and the rigid forming cylinder 30. Straddling the die stations 22—25 are the stock guides 26 having the pilot apertures 27.

Secured to the punch holder 15 is the punch plate 28 of the punch assembly 31 (FIG. 3) which includes the cutting punch 32 vertically aligned with the die cutting station 22, the bending punch 33 vertically aligned with the die bending station 23, the preforming punch 34 vertically aligned with the die preforming station 24 and the forming drive member 35 and associated final cutting punch 36 vertically aligned, respectively, with the rigid cylinder 30 and the cutting edges 29 in the die forming station 25. Also included in the punch assembly 31 are the stripper plate 37 supported by the stripper springs 38 and the pilot pins 39 aligned for engagement with the pilot apertures 27 in the stock guides 26.

The particular machine tool embodiment illustrated in FIGS. 1—3 is specifically suited for and its operation will be described in conjunction with the formation of female electrical terminals 41 (shown in FIG. 4) for use in electrical switch boards and the like. As the continuous sheet metal strip 42 passes between the stock guides 26 and through the die 21 each uniform section of the strip will undergo the progressive physical changes illustrated in FIG. 4. At die station 22, a downward stroke of the press ram 16 will drive the cutting punch 32 into the stock strip 42 thereby forming the work piece 43 having a plurality of parallel finger sections. The strip 42 is then moved inwardly to position the work piece 43 in the die station 23 before the next power stroke of the ram 16 which causes contact between the adjustable stop pin 44 and the actuating pin 45 and upward movement of the curved die station 23 in a manner described in greater detail below. This upward motion of the die station 23 bends upwardly the ends of the work piece finger sections against the mating curved surface of the bending punch 33 thereby producing the work piece of the form shown at 43a. Before the next power stroke of the ram 16, the stock strip 42 is again moved inwardly and the work piece 43a positioned in the preforming die station 24. The next downward stroke of the ram 16 drives the

preforming punch 34 against the appropriately formed die station 24 producing the work piece 43b having both outside edges arcuately preformed. The final inward movement of the stock strip 42 positions one preformed edge of the work piece 43b over the rigid forming cylinder 30 for engagement by the driver member 35 during the next power stroke of the ram 16. This action results in the formation of the cylindrical piece 41 in a manner to be described more fully below. During progressive movement of the strip 42, each individual work piece is accurately positioned in its particular die station by passage of the pilot pins 39 through the stock alignment apertures 27. It will be obvious that each of the above described operations will be simultaneously performed on distinct work pieces during each downward stroke of the press ram 16 so that a single cylindrical piece 41 will be produced during each stroke. Also, it should be noted that the stock strip 42 may be pushed through the progressive die 21 either manually or by a suitable automatic device (not shown).

To more clearly illustrate the final cylinder forming operation, a partial schematic end view of the forming station 25 is shown in FIG. 5. The driver arm 35 is pivotally connected at 51 to the punch plate 28 and possesses in one surface a slot 52 which retains the element 53 formed of a suitable resilient material such as urethane. The opposite surface of the arm 35 possesses a recessed cam surface 54 which engages the stop 55 whose horizontal position can be adjusted by the adjustment screw 56.

During a downward stroke of the press 16, the driver arm 35 is guided by the control roller 57 so as to move the outer surface of the resilient element 53 along a path substantially tangent to the rigid forming cylinder 30. Horizontal adjustment of the control roller 57 is possible with the adjusting screw 58 so as to establish between the rigid cylinder 30 and resilient element 53 a desired degree of contact pressure and resultant surface deformation of the element 53. Simultaneously with the engagement of the downwardly moving resilient element 53 and the rigid cylinder 30, the corresponding movement of the final cutting punch 36 will sever on the die cutting edges 29 the remaining stock strip portion 60 (FIG. 4) thereby completely separating the work piece 43b. As illustrated in FIGS. 5a—5d, downward movement of the arm 35 will produce a moving contact between the resilient element 53 and rigid cylinder 30 so as to drive a work piece 43b inserted therebetween around the rigid cylinder 30. This operation results in the formation of the cylindrical piece 41 shown in FIG. 4.

As shown in FIG. 5d, completion of a driver arm 35 downstroke moves the control roller 57 into the arm's recessed cam surface 54. This allows some horizontal movement of the pivoted driver arm 35 and reduces the degree of contact pressure exerted between the rigid cylinder 30 and the resilient element 53. During this period of reduced pressure, the formed cylindrical piece 41 is automatically removed from the rigid forming cylinder 30 in the manner described below.

The rigid cylinder 30 is rotatably fixed in the support housing 61 (FIG. 2) which is mounted to permit horizontal movement and is operatively connected to the air operated cylinder 62. Operation of the air cylinder 62 by an air supply source and suitable valve assembly (not shown) is controlled in a conventional manner by movement from the power press 11 so as to produce a power stroke of the air cylinder 62 simultaneously with the completion of a press ram 16 down stroke. This causes retraction of the housing 61 and supported rigid cylinder 30 along an axial path. However, the just formed cylindrical piece 41 is retained in its horizontal position by the still somewhat engaged resilient element 53 thereby causing removal of the cylindrical piece 41 over the free end of the retracting rigid cylinder 30.

The cross-sectional view through the support housing 61 (FIG. 6) illustrates a suitable mechanism for con-

verting the linear motion of the press ram 16 into a rotational drive for the rigid forming cylinder 30. Supporting the cylinder 30 within the housing 61 are the annular bearing assemblies 71 separated by the annular spacers 72. Positioned between the spacers 72 and mounted for rotation with the cylinder 30 is the pinion gear 73 which engages the vertically disposed rack gear 74. The combination of the rack gear 74 and its supporting column 75 extend through and for some distance above the support housing 61 and are biased in their uppermost position by the spring member 76. Thus, during each cylinder forming stroke of the driver arm 35, the punch assembly 31 will engage and force the rack column 75 downwardly to produce rotation of the rigid cylinder 30. This driving of the rigid forming cylinder 30 during the cylinder forming operation has proved to be extremely desirable when great uniformity and precision is required in the formed cylindrical pieces.

A suitable mechanism for reversing the downward motion of the press ram 16 so as to produce an upward thrust of the die station 23 is shown schematically in FIG. 7. Downward movement of the actuating pin 45 causes rotation of the centrally pivoted camming arm 81. The resultant upward movement of the support surface 82 causes a similar movement of the die station 23 attached thereto by the connecting rod 83 which extends through an aperture in the die plate 20. Biasing springs 84 positioned between the support surface 82 and the die plate 20 insure return of the die station 33 to its lowest position after actuation by the actuating pin 45.

The illustrated embodiment wherein the work pieces to be formed are fed between the driver arm 35 and rigid cylinder 30 along a path substantially parallel to the axis thereof provides distinct advantages for many applications. For example only, this method of work piece feed simplifies the insertion of a work piece having edges arcuately preformed in the manner described above. Also, it enables one to produce from elongated strips of metal stock material cylindrical pieces which are bent with rather than across the material grain which normally runs longitudinally of the strip.

The invention embodiment illustrated has been successfully operated to form, from Phosphor bronze stock, extremely uniform, completely closed cylindrical pieces having a diameter of less than 0.5 inch. Exactness and uniformity of the finished parts have been maintained with the tool operating at speeds sufficient to produce over 50 pieces per minute.

Although the invention has been described in conjunction with a preferred electrical terminal forming application, it will be obvious the basic principles disclosed can be used in the formation of other elements having various configurations and uses. For example, infinite form variations can be obtained by altering the punch and die assemblies or by replacing the rigid circular cylinder 30 with a cylinder of modified shape. Similarly, the arcuate dimensions of the finished piece can be modified by varying the size of the rigid cylinder 30, the resilience of the element 53, the pressure exerted between the rigid cylinder 30 and resilient element 53, the mechanical characteristics of the stock material, etc.

FIGS. 8 and 9 show another invention embodiment including the circular driver wheel 91 mounted for rotation with the vertically disposed and centrally located spindle 92. Positioned in circumferential slots 93 around the periphery of the driver wheel 91 are the plurality of resilient inserts 94. The spindle 92 is adapted for connection to a suitable rotational motive means such as an electrical motor. Also mounted for rotational movement is the vertically disposed rigid forming cylinder 95 positioned for substantially tangential contact with the rotating resilient inserts 94.

During operation of this embodiment, the rotating spindle 92 controls movement of the resilient inserts 94 so as to produce forming periods during which a sub-

stantial moving contact pressure is provided between the rigid forming cylinder 95 and an adjacent resilient insert 94 and removal periods when the rigid forming cylinder 95 is adjacent the recesses 96 so as to eliminate contact pressure. A work piece inserted between the rigid cylinder 95 and engaging resilient insert 94 will be formed into a cylinder around the rigid cylinder 95 in the manner described above. During a subsequent removal period when the rigid cylinder 95 is within an adjacent recess 96, the previously formed cylindrical piece will be automatically removed from the cylinder 95 by freely falling under the influence of gravity.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. For example only, the invention embodiment shown in FIGS. 8 and 9 can be modified by replacing the recessed driver wheel 91 with a driver cylinder (not shown) having a smooth, continuous resilient surface and adapted for periodic lateral movement relative to the forming cylinder so as to produce the finished piece removal periods. Similarly, pieces having other than circular cylindrical shapes can be obtained by utilizing forming cylinders having non-circular outer surfaces. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A sheet material bending apparatus comprising a rigid forming cylinder, said rigid forming cylinder being mounted for rotational movement, a driver means having a resilient surface, said driver means being mounted for linear reciprocative motion, control means for guiding movement of said driver means resilient surface along a path substantially tangent to said rigid forming cylinder, said path of movement producing a moving contact pressure between said rigid forming cylinder and said driver means resilient surface so as to cause deformation thereof, and automatic cylinder removal means adapted to automatically remove substantially closed cylindrical pieces formed around said rigid forming cylinder from work pieces inserted between said rigid forming cylinder and said resilient surface.

2. A sheet material bending apparatus according to claim 1 including guide means adapted to direct work pieces in a direction substantially parallel to the axis of said rigid forming cylinder and between said resilient surface and said rigid forming cylinder so as to cause formation thereon of the substantially closed cylindrical pieces.

3. A sheet material bending apparatus according to claim 1 wherein said automatic cylinder removal means comprises drive means adapted to produce axial movement of said cylindrical forming cylinder.

4. A sheet material bending apparatus according to claim 1 wherein said automatic cylinder removal means comprises pressure relief means adapted to automatically reduce the contact pressure between said rigid forming cylinder and said resilient surface during a portion of said reciprocal movement.

5. A sheet material bending apparatus according to claim 4 wherein said automatic cylinder removal means comprises drive means adapted to produce axial movement of said cylindrical forming cylinder.

6. A sheet material bending apparatus according to claim 5 including guide means adapted to direct work pieces in a direction substantially parallel to the axis of said rigid forming cylinder and between said resilient surface and said rigid forming cylinder so as to cause formation thereon of the substantially closed cylindrical pieces.

7. A sheet material bending apparatus according to claim 5 wherein said driver means is adapted to be driven in said linear reciprocative motion by a power press means.

8. A sheet material bending apparatus according to claim 6 wherein said guide means includes preforming

means adapted for actuation by said power press means to arcuately preform at least one end of said work pieces before feeding thereof between said resilient surface and rigid forming cylinder.

9. A sheet material bending apparatus according to claim 8 wherein said guide means further includes cutting means adapted for actuation by said power press means to cut a plurality of elongated substantially parallel slots along one side of said work pieces so as to form therein a plurality of elongated finger sections lying substantially parallel to the axis of the cylindrical piece to be formed.

10. A sheet material bending apparatus according to claim 9 wherein said guide means further comprises bending means adapted to bend the end of said finger sections in a direction away from the axis of the cylindrical piece to be formed between said rigid forming cylinder and said resilient surface, and motion reversal means powered by said power press means and adapted to drive said bending means in a direction opposite to that of said power press means.

11. A sheet material bending apparatus according to claim 10 including motion converting means adapted to convert the linear motion of said power press means into a rotary motion for driving said rigid forming cylinder.

12. A sheet material bending apparatus comprising a rigid forming cylinder, said rigid forming cylinder being mounted for rotational movement, a driver means having a resilient surface, said driver means being mounted for linear reciprocative motion, control means for guiding movement of said driver means resilient surface along a path substantially tangent to said rigid forming cylinder and wherein said path of movement produces a moving contact pressure between said rigid forming cylinder and said driver means resilient surface so as to cause deformation thereof, said driver means adapted to be driven in said linear reciprocative motion by a power press means, and motion converting means adapted to convert the linear motion of said power press means into a rotary motion for driving said rigid forming cylinder.

13. A sheet material bending apparatus according to claim 12 including guide means adapted to direct work pieces in a direction substantially parallel to the axis of said rigid forming cylinder and between said resilient surface and said rigid forming cylinder so as to cause formation thereon of substantially closed cylindrical pieces.

14. An automatic cylinder forming apparatus comprising a rotatively mounted rigid forming cylinder, resilient surface means adapted to move along a path substantially tangent to said rigid forming cylinder, automatic drive control means adapted alternately to produce forming periods during which a substantial moving contact pressure is applied between said rigid forming cylinder and said resilient surface means so as to cause deformation thereof and formation of substantially closed cylindrical

pieces around said rigid forming cylinder from work pieces inserted between said resilient surface means and said rigid forming cylinder and removal periods during which the contact pressure between said resilient surface and said rigid forming cylinder is substantially eliminated, and wherein said rigid cylinder has one free end to permit removal of the formed cylindrical pieces therefrom during said removal periods.

15. An automatic cylinder forming apparatus according to claim 14 wherein said drive control means comprises adjustment means for adjusting the degree of pressure contact produced between said rigid forming cylinder and said resilient surface during said forming periods.

16. An automatic cylinder forming apparatus according to claim 14 wherein said drive control means is adapted to produce axial movement of said cylindrical forming cylinder during said removal periods.

17. An automatic cylinder forming apparatus according to claim 13 wherein said resilient surface means comprises a rotatively mounted driver wheel having an irregular periphery formed by a plurality of resilient surface portions adapted during rotation of said wheel to engage said rigid forming cylinder and create said forming periods and a plurality of recessed portions adapted during rotation of said wheel to reduce the pressure contact between said wheel and said rigid forming cylinder and create said removal periods.

18. An automatic cylinder forming apparatus according to claim 17 wherein said recessed portions are adapted to completely eliminate contact between said wheel and said rigid forming cylinder and said cylinder removal means comprises wheel mount means adapted to support said wheel for rotation in a substantially horizontal plane and rigid cylinder mount means to support said rigid cylinder in a substantially vertical position and wherein the lower end of said rigid cylinder is said free end so as to permit free fall of formed cylindrical pieces during said removal periods.

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U.S. Cl. X.R.

72-368, 465