United States Patent [19]

Grigorenko

[11] **3,733,881**

[45] **May 22, 1973**

[54] **METHOD AND APPARATUS FOR MAKING DEEP DRAWN METAL SHELLS**

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[73] Assignee: **Shape Farm, Inc.,** Columbus, Ohio

[22] Filed: **Sept. 28, 1970**

[21] Appl. No.: **75,950**

[52] **U.S. Cl.** **72/349**

[51] **Int. Cl.** **B21d 22/24**

[58] **Field of Search** 72/349

[56] **References Cited**

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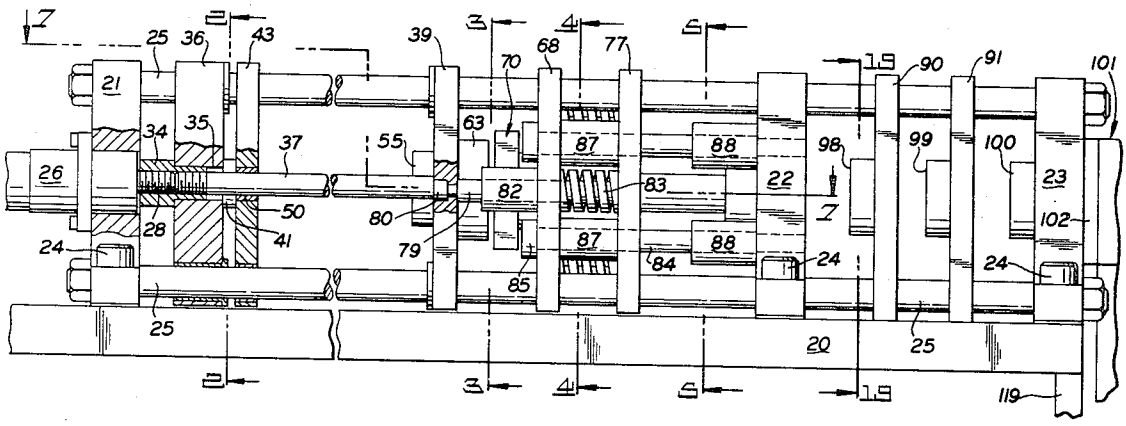
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[57] **ABSTRACT**

A method and machine for making a comparatively deep metal shell in which a piece of sheet metal is successively cut or blanked to desired size and shape, drawn in one direction into cup shape, redrawn in the opposite direction into an elongated shell, and then ironed one or more times to further elongate and decrease the wall thickness of the shell, all such steps being performed by movement of the workpiece along a linear path and in a single continuous working stroke of the machine.

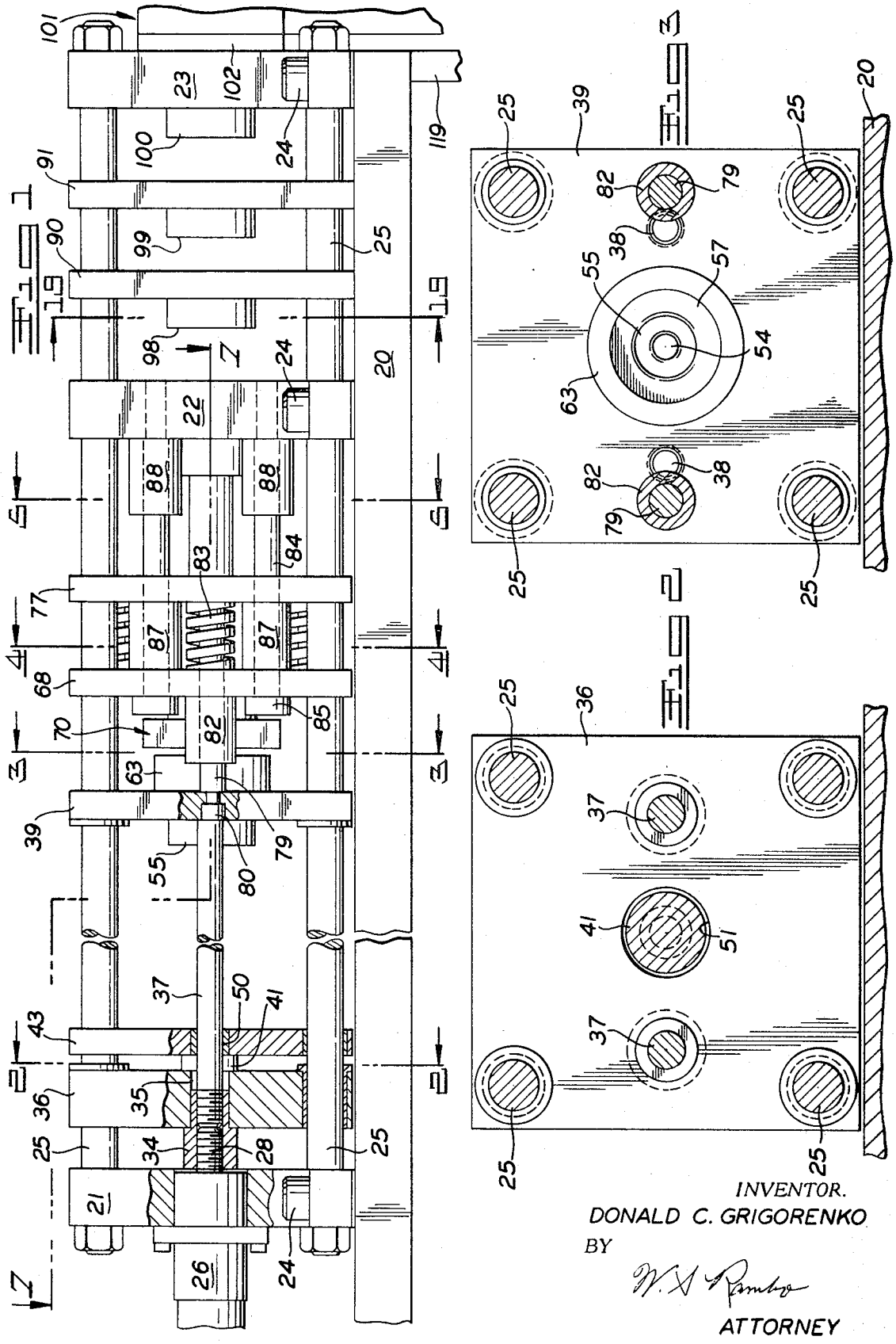
3 Claims, 20 Drawing Figures



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SHEET 1 OF 8



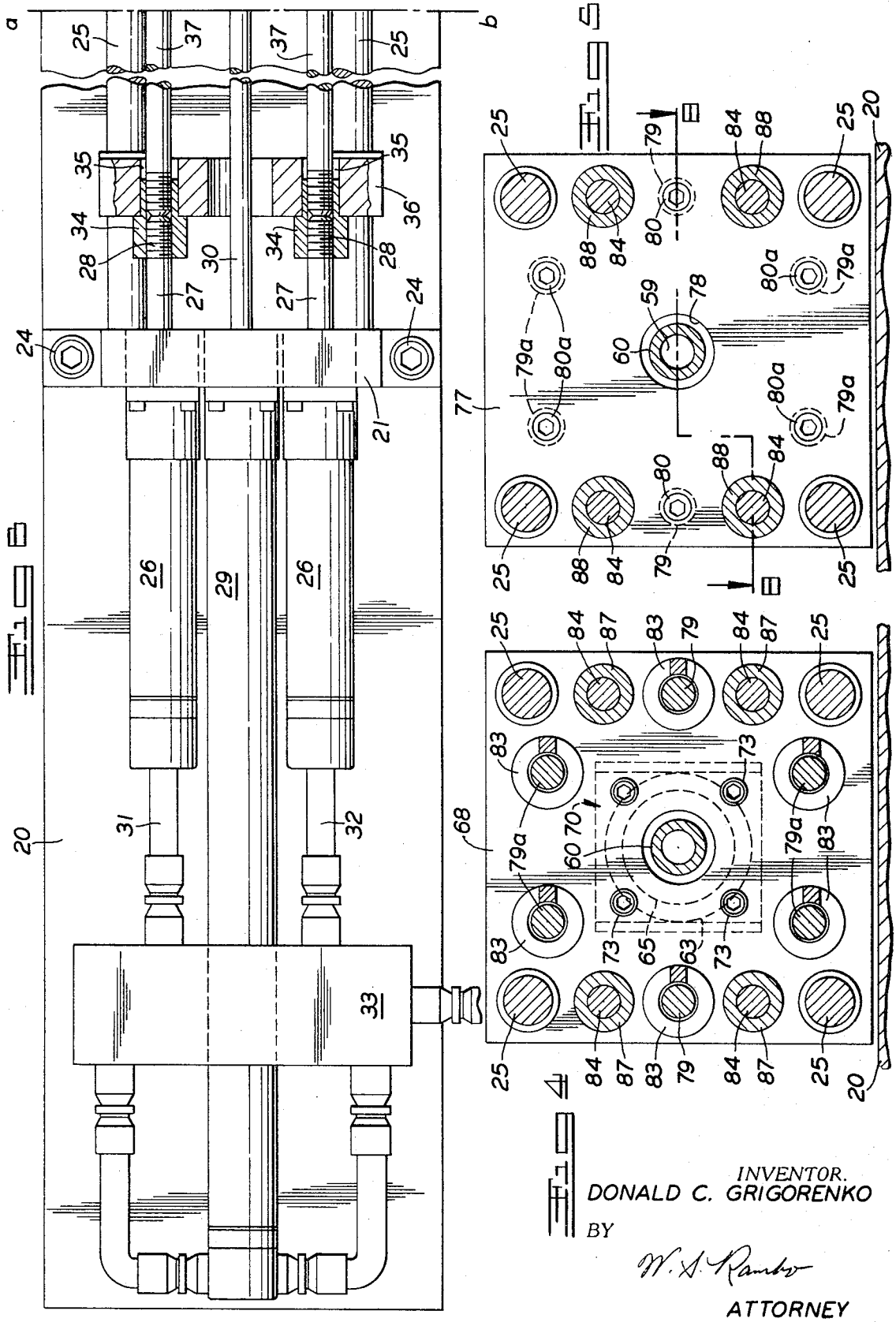


FIG 5

FIG 6

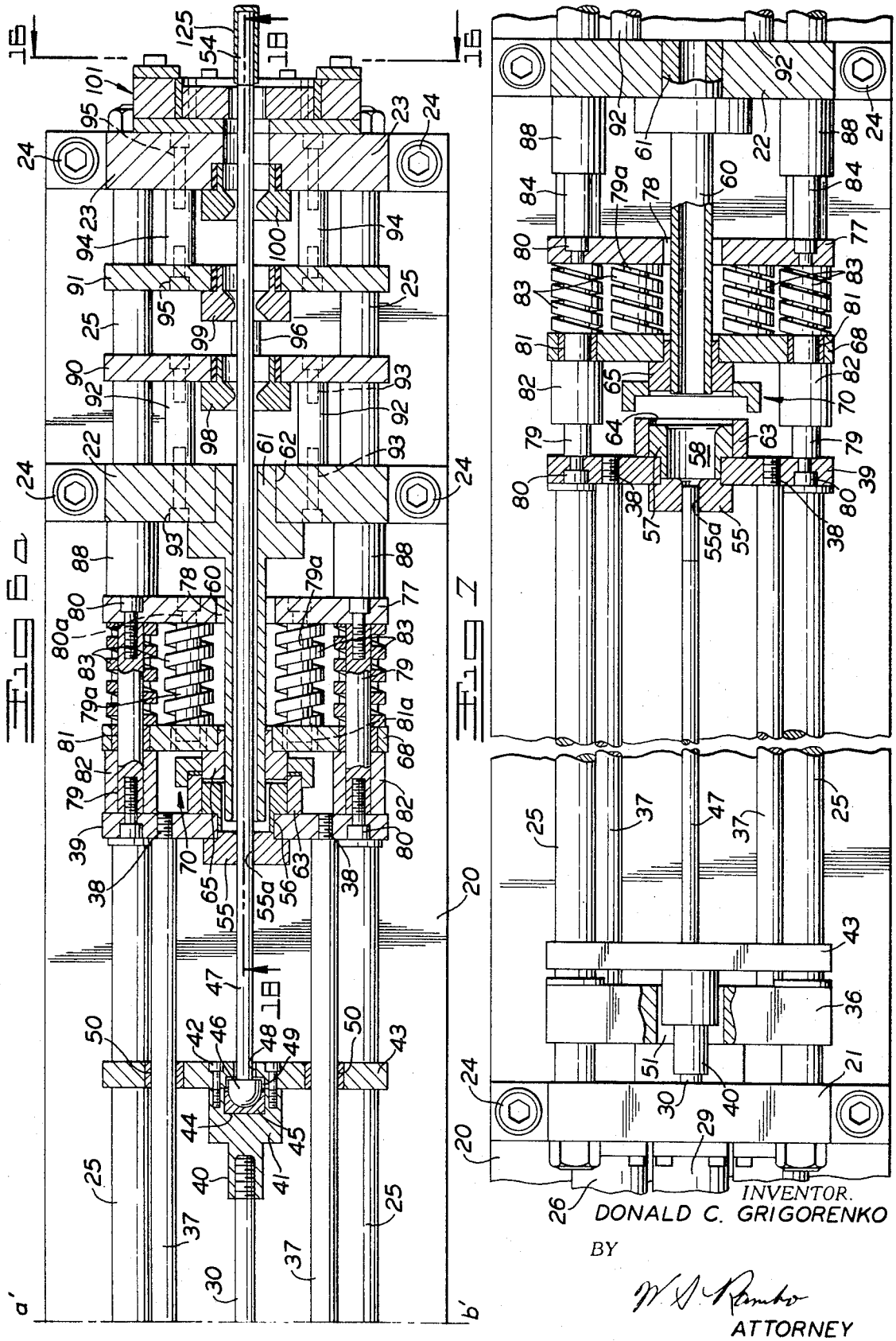
FIG 4

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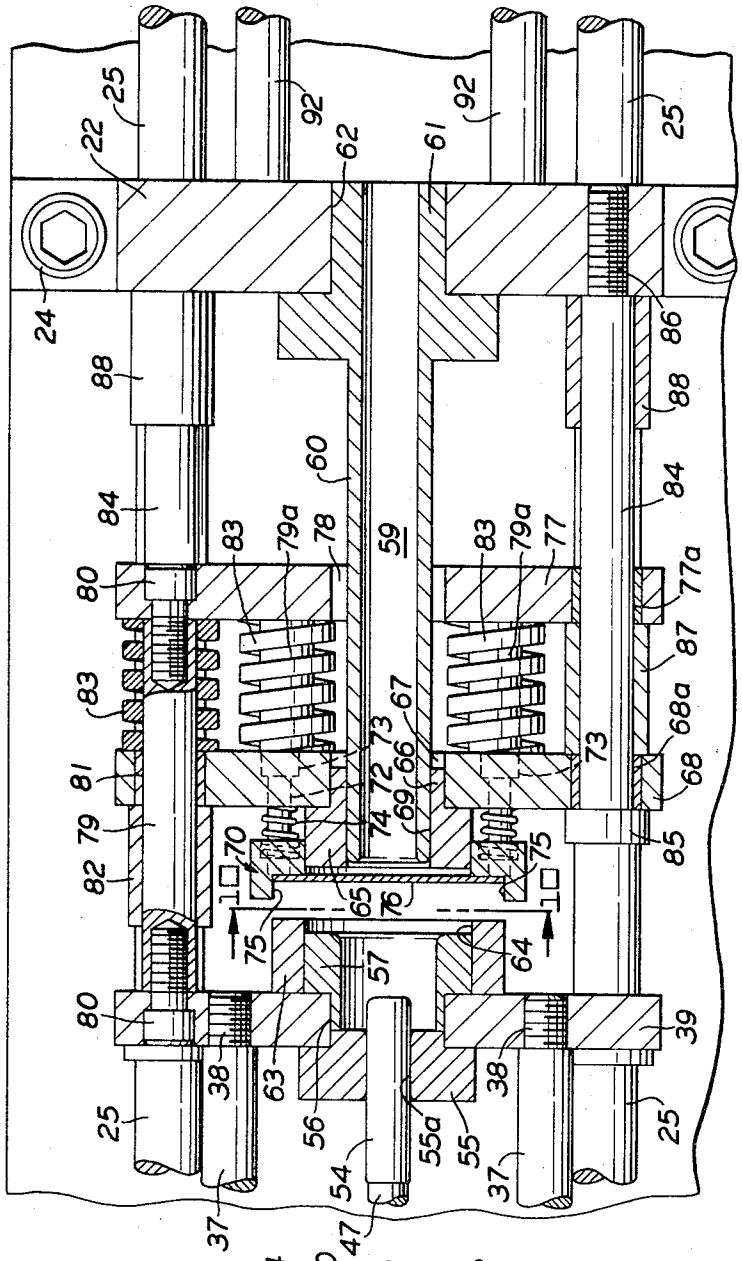


FIG 8

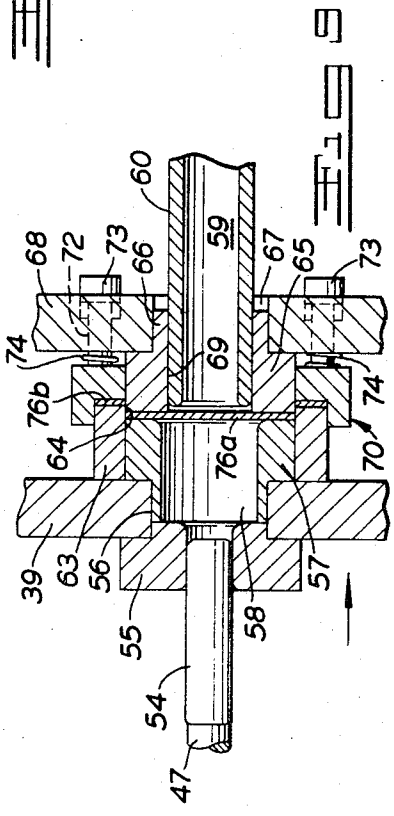


FIG 9

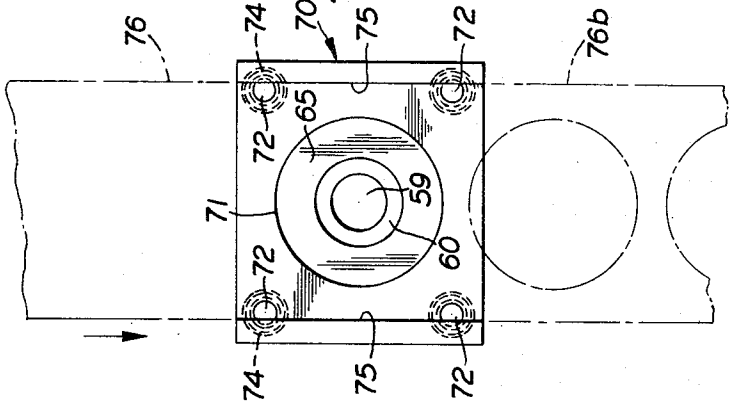


FIG 10

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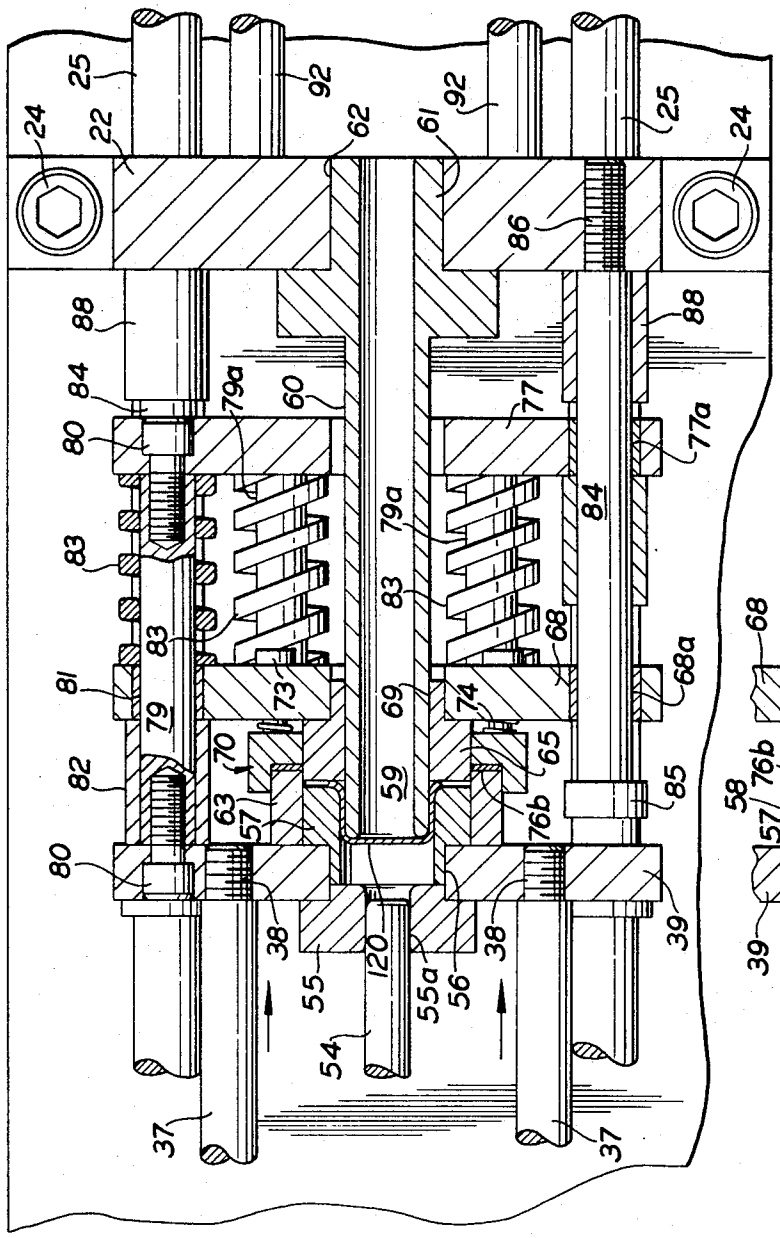


FIG 11

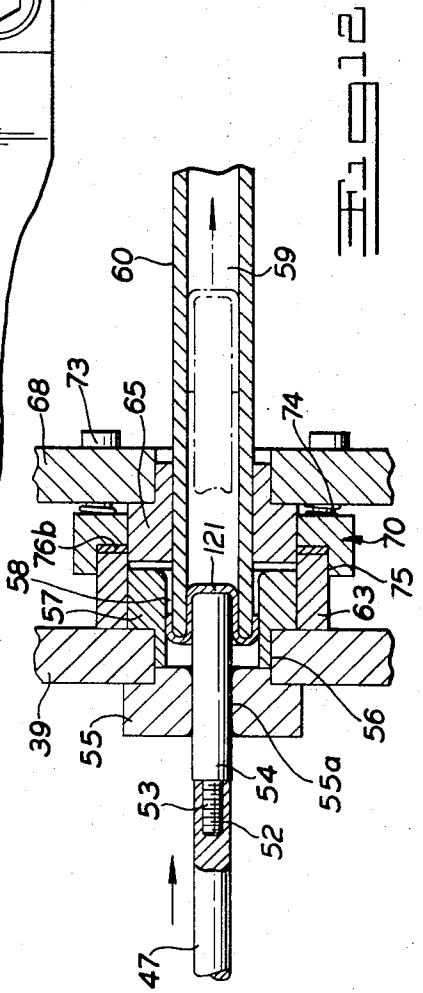


FIG 12

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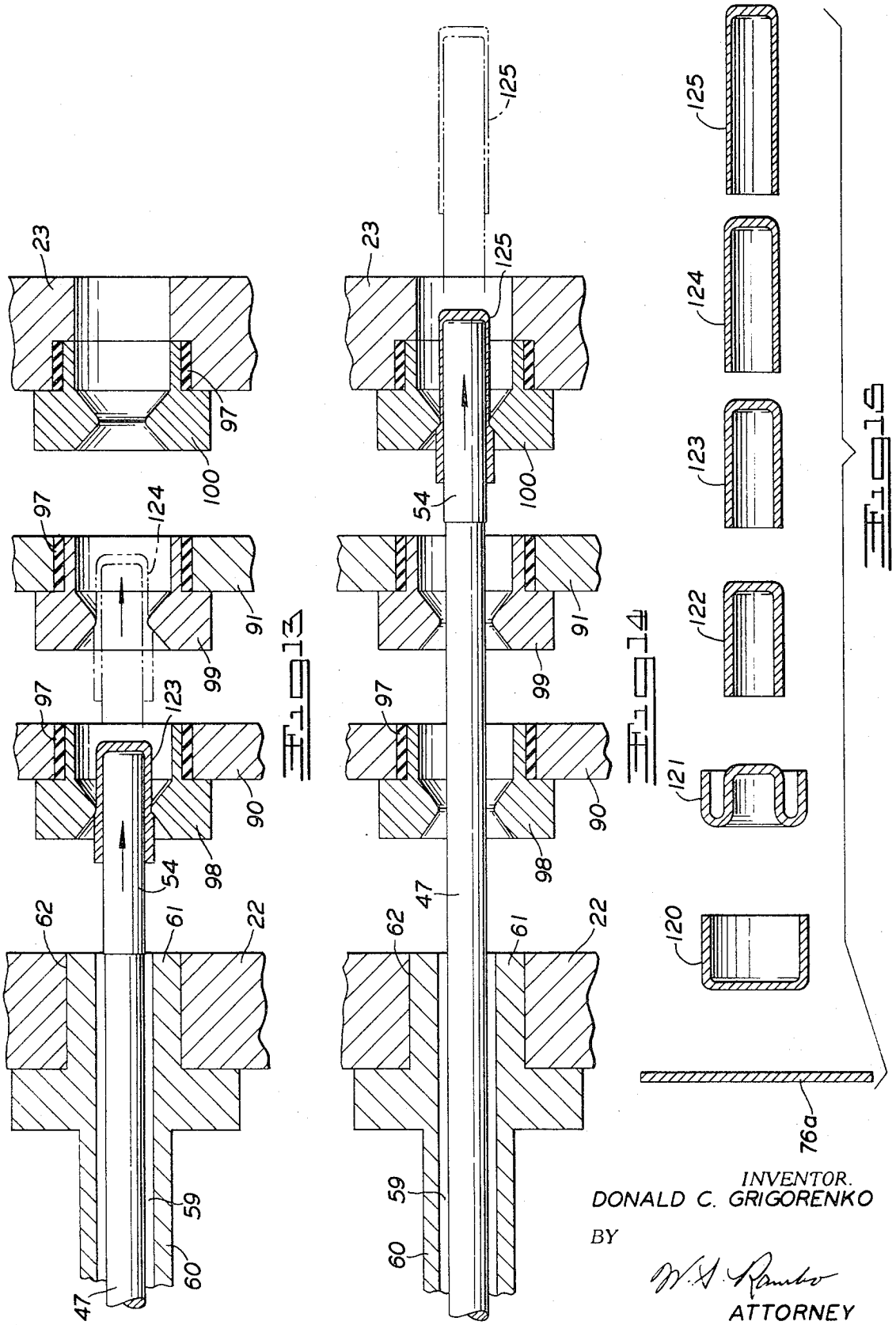


FIG 13

FIG 14

FIG 15

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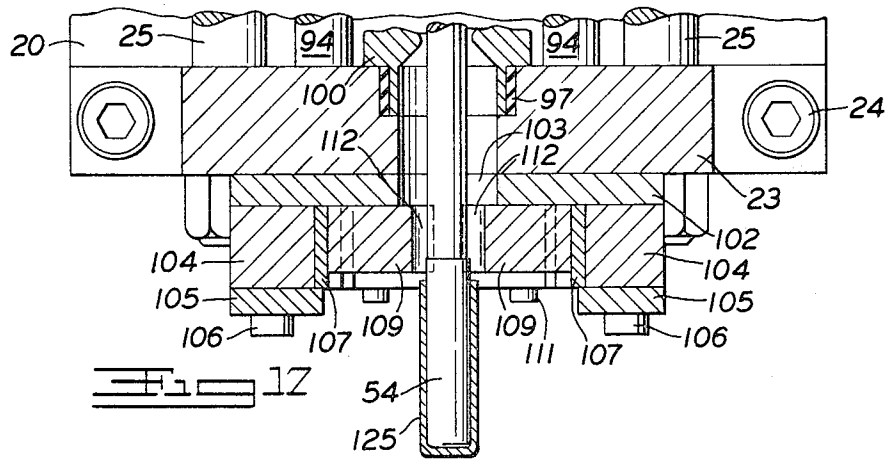


FIG 17

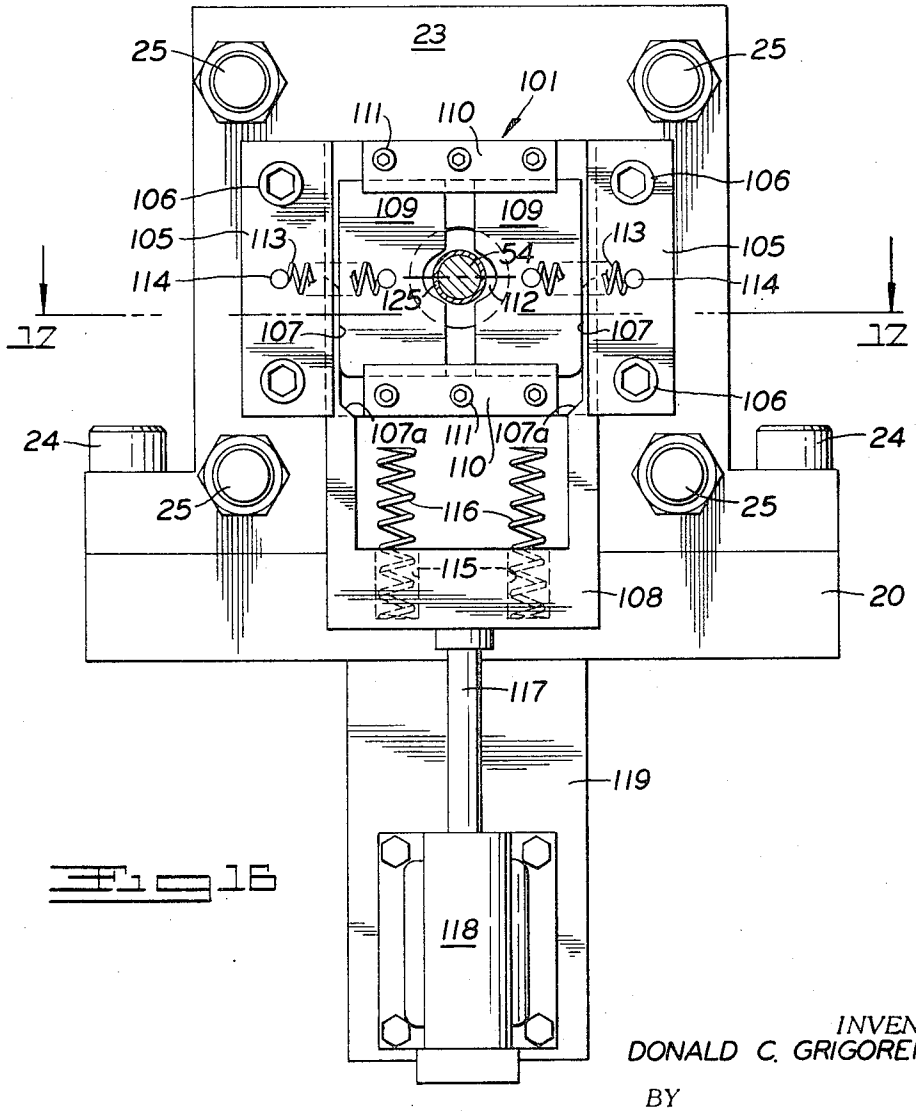


FIG 16

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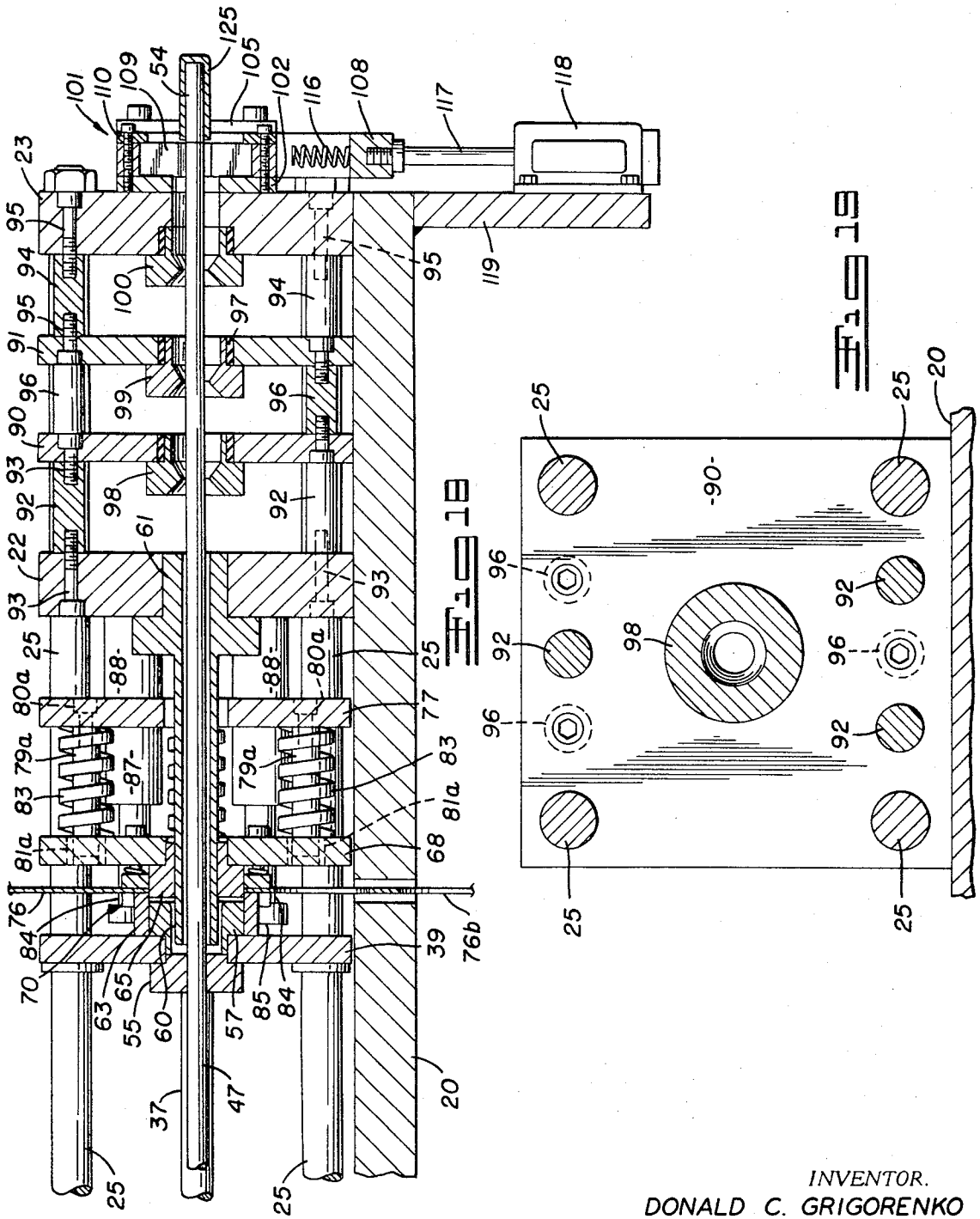


Fig. 1B

Fig. 1A

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METHOD AND APPARATUS FOR MAKING DEEP DRAWN METAL SHELLS

BACKGROUND OF THE INVENTION

This invention relates generally to the art of drawing metal, and more particularly to an improved method and apparatus for making deep drawn metal shells, such as: can bodies, closed end tubes, casings or receptacles, ordnance shells and the like.

In the past, comparatively deep drawn metal shells have been made in a single operating stroke of a press by successively drawing, redrawing and ironing an initially flat sheet metal workpiece or blank during movement of the workpiece along a linear path. An example of such a press is shown and described in U.S. Pat. No. 3,509,754 issued May 5, 1970 jointly to Jess L. Massingill and the present applicant.

It has also been proposed in the prior art to make metal shells by sequentially drawing a metal blank in one direction into initial cup shape, and then redrawing the cup shaped blank in the opposite direction to form the desired elongated metal shell. Typical examples of draw and reverse redraw methods of forming metal shells are found in U.S. Pats. Nos. 2,602,411 and 2,761,406 to Schnell. So, also, it has heretofore been proposed to form sheet metal shells or cups by first drawing the sheet metal blank and then ironing the blank to further elongate it and reduce its wall thickness. An example of this latter method is found in U.S. Pat. No. 3,203,218 issued Aug. 31, 1965 to Bolt et al.

However, so far as I am aware, it has never been proposed to form or fabricate an ultra deep drawn metal shell by the combined steps of drawing an initially flat metal blank in one direction, then redrawing the blank in the opposite direction, and then ironing the resultant elongated shell to further elongate it and reduce its wall thickness.

SUMMARY AND OBJECTS OF THE INVENTION

The present invention comprehends an improved method and apparatus in which an initially flat sheet metal strip or plate is successively blanked or cut to desired size and shape, drawn in one direction into cup shape, then redrawn in the opposite direction into an elongated shell, and then ironed one or more times to further elongate and reduce the wall thickness of the shell. Apparatus according to this invention comprises generally an hydraulically actuated press which includes a relatively stationary, tubular mandrel; a blanking or cutting die positioned adjacent one end of the tubular mandrel and operable under the influence of spring means to cut a circular blank from a strip of sheet metal fed into the machine; a drawing die movable in association with the blanking die to draw the cut blank over and around the adjacent end of the mandrel and into cup shaped configuration; an hydraulically operated ram movable into engagement with the cup shaped workpiece so as to evert and force the workpiece through the tubular mandrel in a reverse redraw operation, and then to force the resultant elongated shell through a series of ironing dies which function to further elongate and reduce the wall thickness of the workpiece into its final, deep drawn configuration.

The primary object of the present invention is to provide a mechanically efficient and economical method and apparatus for forming ultra deep drawn metal shells of generally high quality and of substantially uniform side wall thickness.

Another object of this invention is to provide a machine which is operable in one continuous stroke to sequentially blank, draw, reverse redraw, and iron a sheet metal work-piece to form therefrom a deep drawn metal shell.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of the present invention will become more readily apparent by reference to the following description and the accompanying drawings, wherein:

FIG. **1** is a side elevational view, partially in vertical section, of a deep drawing and ironing press according to this invention;

FIGS. **2, 3, 4** and **5** are transverse vertical sectional views taken along planes indicated by the correspondingly numbered section lines of FIG. **1**;

FIG. **6** is a fragmentary top plan view, partially in horizontal cross section, showing the hydraulic actuating mechanism associated with the drawing and ironing press shown in FIG. **1**;

FIG. **6***a* is a longitudinal continuation of FIG. **6** along line *a–b*, showing the workpiece-blanking, drawing, reverse redrawing, ironing, and stripping mechanisms of the press in horizontal cross section, and with the ram-actuated punch in fully extended position;

FIG. **7** is a horizontal sectional view taken along the line **7—7** of FIG. **1**, and showing the press in fully retracted position ready to begin a working cycle;

FIG. **8** is an enlarged, fragmentary horizontal sectional view taken along the line **8—8** of FIG. **5**, but showing the blanking, drawing and reverse redrawing mechanisms of the press in their retracted positions;

FIG. **9** is a fragmentary horizontal sectional view showing the blanking or cutting of the workpiece;

FIG. **10** is a fragmentary elevational view looking inwardly upon the stock or feedstrip guiding mechanism of the press approximately along a plane indicated by the line **10—10** of FIG. **8**, and showing the sheet metal stock or strip in broken lines;

FIG. **11** is a view similar to FIG. **8** but showing the machine in position for the initial drawing of the workpiece over the end of the tubular mandrel;

FIG. **12** is a horizontal sectional view similar to FIG. **9** but showing the parts in position for the eversion and redrawing of the workpiece through the tubular mandrel;

FIGS. **13** and **14** are diagrammatic cross sectional views illustrating the movement of the workpiece through the successive ironing dies of the press;

FIG. **15** is a diagrammatic sectional view showing the various stages of formation of the workpiece according to this invention;

FIG. **16** is a transverse vertical sectional view taken along a plane indicated by the line **16—16** of FIG. **6***a*, and showing particularly the mechanism for stripping or removing the finished workpiece from the end of the punch;

FIG. **17** is a fragmentary horizontal sectional view taken along the line **17—17** of FIG. **16**;

FIG. **18** is a longitudinal vertical sectional view taken along the line **18—18** of FIG. **6***a*; and

FIG. **19** is a transverse vertical sectional view taken along line **19—19** of FIG. **1**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, and FIGS. **1**, **6** and **6a**, there is illustrated an hydraulic press which comprises a stationary, supporting base or bed frame **20** to which is securely and rigidly fastened three upright, relatively spaced apart bolster plates **21**, **22** and **23**. Preferably, each of the bolster plates **21**, **22** and **23** is bolted, by cap screws **24**, to the bed frame **20**, and the plates are additionally joined together at the four corners thereof by a system of four, spaced parallel strain and guide rods **25**.

Bolted to one side of the bolster **21** are a pair of relatively spaced apart, comparatively short stroke, reciprocating hydraulic motors or rams **26**. Each of the rams **26** includes an axially extensible piston rod **27** provided with a screw-threaded outer end portion **28**. Also bolted to the bolster **21** between the rams **26** is a relatively longer stroke, double-acting hydraulic motor or ram **29** having an axially extensible piston rod **30**. Connected with the outboard rams **26** are a pair of fluid inlet-outlet conduits **31** and **32** which lead outwardly from an hydraulic manifold casing **33** which contains conventional control valves, not shown, for the rams **26** and **29** whose operation will be hereinafter more fully explained.

The threaded outer end **28** of each of the piston rods **27** is threadedly connected with a shouldered, internally threaded coupling **34** which is movable within an opening **35** formed in an upright guide plate **36** slidably carried on the strain rods **25** of the press. Threaded into the opposite ends of the couplings **34** are a pair of connecting rods **37** whose outer ends are formed with reduced diameter threaded end portions **38** connected with a movable die and bushing-supporting plate **39**. The plate **39** is slidably mounted for longitudinal movement on the strain rods **25** in response to actuation of the outboard rams **26**.

As will be noted particularly in FIG. **6a**, the outer end of the piston rod **30** of the longer stroke, inboard hydraulic ram **29** is threaded into the reduced diameter shank portion **40** of a swivel-type coupling **41**. The coupling **41**, in turn, is bolted by cap screws **42** to a movable guide plate **43** slidably mounted on the strain rods **25**. The coupling is formed in the forward end thereof with a socket **44** in which is fitted a bearing block **45**. The bearing block **45** is formed with a semi-spherical recess which conforms in size and shape to the semi-spherical head **46** of an elongated, cylindrical shaft **47**. The guide plate **43**, adjacent the head **46** and shaft **47**, is formed with a central bore **48** and a counter bore **49** of larger diameter than the shaft **47** and head **46** to thus permit limited universal swiveling movement of the head and shank relative to the plate **43** and coupling **41**. The plate **43** also slidably receives the push rods **37** of the outboard cylinders **26** in the bushed openings **50**. As shown in FIGS. **2** and **7**, the plate **36** is formed with a relatively enlarged, central bore **51** to accommodate the coupling **41** when the piston rod **30** is retracted by the inboard ram **29**.

As shown particularly in FIG. **12**, the elongated shaft or rod **47** is formed at its outer end with a screw-threaded bore **52** in which is received the cooperatively threaded shank **53** of a removable or replaceable punch head **54**. The diameter of the punch head **54** is preferably slightly larger than that of the shaft **47**, so that the head **54** will be snugly, yet slidably received within the axial bore **55***a* of a guide bushing **55** which is press-fitted in a central bore **56** formed in the die plate **39**. As will be hereinafter more fully described, the guide bushing **55** functions to exactly align the punch head **54** with a redrawing die during the reverse redraw operation, but permits slight lateral or radial play or "floating" of the punch head during the ironing operations.

Secured in the opposite end of the bore **56** of the die plate **39** is an annular drawing die **57** having a central die cavity **58** disposed in exact axial alignment with the bore **55**a of the guide bushing **55** and with the axial bore **59** of an elongated, tubular mandrel **60**. The mandrel **60** is formed with a relatively enlarged base end portion **61** which is press-fitted or otherwise rigidly secured within a central bore **62** formed in the stationary bolster plate **22** of the press. Carried in concentric, surrounding relation to the drawing die **57** is an annular blanking die **63** which has an annular cutting edge **64** projecting axially outwardly beyond the outer end of the drawing die **57**.

Cooperative with the blanking die **63** is an annular blanking punch **65** which is formed with a reduced diameter end portion **66** press-fitted or otherwise secured within a central bore **67** of a movable guide plate **68**. The blanking punch **65** is formed with a central bore **69** which closely approximates the outer diameter of the mandrel **60** so as to provide a sliding fit between the outer surface of the mandrel **60** and the blanking punch.

A rectangular workpiece guide block **70** is disposed in surrounding relation to the blanking punch **65** and is formed with a central opening **71** into which the blanking punch **65** extends. The workpiece guide block **70** is carried on four cap screws **72** having heads **73** normally positioned within counter bores formed in the guide plate **68**. Positioned between the guide block **70** and the guide plate **68**, around each of the cap screws **72**, is a coil compression spring **74** which functions normally to hold the workpiece guide block **70** in an outward direction relative to the blanking punch **65** (see FIG. **8**), but which permits inward retraction of the guide block **70** as the blanking die **63** moves into telescoping engagement with the blanking punch **65**, as shown in FIG. **9**. The workpiece guide block **70** is formed along each side thereof with a pair of inwardly projecting, transversely spaced apart guide flanges **75** which function to guide and align the side edges of a sheet metal strip **76** which is fed vertically downwardly between the guide flanges **75** from above the machine, as indicated in FIG. **10**. Upon movement of the blanking die **63** into telescoping engagement with the blanking punch **65**, a flat, circular workpiece **76***a* is blanked or cut from the incoming feed strip **76**, and the remaining selvage **76***b* is stripped away from the workpiece **76***a*.

Disposed in outwardly or forwardly spaced relation to the guide plate **68**, and slidable on the strain rods **25**, is a spring pressed carriage plate **77**. The plate **77** is formed with a central opening or bore **78** through which the mandrel **60** extends. The plate **77** is rigidly secured to the die plate **39** by a pair of spacer rods **79** which are bolted to the respective plates **39** and **77** by cap screws **80** (see FIGS. **6***a*, **8** and **11**). Each of the spacer rods **79** passes through a bushed opening **81** formed in the plate **68**. Also bolted to the plate **77** by

cap screws 80a are four guide rods 79*a* whose outer ends are slidable in openings 81*a* formed in the guide plate 68 (see FIG. 4).

Mounted on each of the spacer rods 79, between the plates 39 and 68, is a tubular stop collar or sleeve 82. As shown particularly in FIGS. 6a and 11, the stop sleeves 82 function to limit closing movement between the plates 39 and 68. Positioned between the plates 68 and 77, in encircling relation to each of the spacer rods 79 and guide rods 79a, is a helically wound compression spring 83.

Extending between the plate 68 and the stationary bolster 22 are four headed bolts 84 (see FIGS. 5, 8 and 11). Each of the bolts 84 is formed with a diametrically enlarged head 85 and a reduced diameter threaded end portion 86 which is threaded into a tapped bore formed in the bolster plate 22. The arrangement of the bolts 84 is such as to limit outward movement of the plate 68 with respect to the stationary bolster plate 22, while permitting closing movement of the plate 68 toward the plate 22. As will noted particularly in FIGS. 8 and 11, the bolts 84 pass through bushed openings 68*a* and 77*a* provided in the respective plates 68 and 77. Stop collars or sleeves 87 are positioned on the bolts 84 between the plates 68 and 77, so as to limit closing movement between the plates 68 and 77. Similarly, stop collars 88 are carried on the bolts 84 between the plate 77 and the bolster plate 22, so as to limit closing movement of the plate 77 toward the bolster plate 22.

Mounted on the strain rods 25 between the stationary bolster plates 22 and 23 are a pair of relatively stationary, ironing die-supporting plates 90 and 91. The plate 90 is stationarily connected to the intermediate bolster plate 22 by means of three triangularly spaced rods 92 which are bolted to the plates 22 and 90 by means of cap screws 93 which extend through the plates (see FIG. 19). Similarly, the plate 91 is rigidly connected with the end bolster plate 23 by spacer rods 94 and cap screws 95. The two plates 90 and 91 are also connected to one another by a similar system of spacer rods 96.

The stationary plates 90, 91 and 23 are each formed with central axial openings in which are positioned annular rubber or other resiliently flexible bushings 97. Mounted in the rubber bushing 97 of the plate 90 is the reduced diameter end portion of a first, annular ironing die 98. Similarly, a second, relatively smaller diameter ironing die 99 is mounted within the resiliently compressible bushing 97 of the plate 91, and a third, relatively smallest diameter ironing die 100 is mounted within the bushing 97 associated with the end bolster plate 23. As will be seen, the openings of the three ironing dies, 98, 99 and 100, are disposed in axial alignment with the axial passage 59 of the tubular mandrel 60, whereby to cause the punch head 54 to move successively through the ironing dies following passage thereof through the tubular mandrel 60.

Mounted on the outer side of the end bolster plate 23, opposite the ironing ring 100, is a solenoid operated workpiece-stripping mechanism 101 (see FIGS. 16 and 17). The stripping mechanism comprises a flat bearing plate 102 which is formed with a central opening or bore 103 disposed in axial alignment with the punch passage formed in the bolster plate 23. Mounted on the bearing plate 102 are a pair of vertically arranged, horizontally spaced bearing blocks 104, and secured to the front surfaces of the blocks 104 are a pair of guide plates 105. The bearing plate 102, blocks 104 and guide plates 105 are joined together as a unitary assembly by means of four cap screws 106 which are threaded into tapped openings formed in the bolster plate 23. As will be noted particularly in FIG. 17, the guide plates 105 project slightly inwardly beyond the corresponding guide blocks 104 so as to form therewith relatively shallow guide channels. Slidably carried within the guide channels or ways of the blocks 104 are the upwardly projecting legs 107 of a bifurcated, fork-shaped cam member 108. The legs 107 are integrally joined with the main body portion of the cam member 108 by inclined cam surfaces or shoulders 107*a*. Mounted between the legs 107 of the cam member 108 are a pair of laterally movable stripper blocks 109. The stripper blocks 109 are carried between the bearing plate 102 and a pair of vertically spaced guide plates 110 which are stationarily bolted by cap screws 111 to the bearing plate 102. Thus, the stripper blocks 109 are arranged for lateral sliding movement in a horizontal plane inwardly toward the axis of the machine, and the opposed inner edges of the blocks 109 are formed with semicircular notches or recesses 112 which are arranged to closely engage the outer circumference of the punch head 54 when moved inwardly thereof. Connected to each of the stripper blocks 109 is one end of a contractile spring 113 whose opposite end is secured to the adjacent guide plate 105 by a rivet or pin 114.

The cam member 108 is further formed in its base portion or yoke with a pair of upwardly opening sockets 115 in which are positioned the lower ends of a pair of upwardly projecting, coiled compression springs 116. Connected with the base portion of the cam member 108 is a connecting rod 117 whose lower end is connected to the armature of an electrically energized solenoid 118 whose frame or casing is bolted to a depending sub-frame 119 secured to the bed 20 of the press. The solenoid 118, connecting rod 117 and cam member 108 are so arranged that upon energization of the solenoid 118, the cam member 108 is forcibly projected upwardly to cause the cam shoulders 107*a* to engage the outer sides of the stripper blocks 109 and cam the blocks 109 inwardly to positively engage the notched portions 112 of the blocks with the outer circumference of the punch head 54. At the same time, the compression springs 116 are arranged so as to engage the under surface of the lower guide block 110 and to be compressed upon upward movement of the cam member 108. The springs 116 thus serve as return springs to retract the cam member 108 and connecting rod 117 upon de-energization of the solenoid 118. The contractile springs 113 also serve to return the stripper blocks 109 to their outwardly retracted positions upon retraction of the cam member 108.

OPERATION

In operation, and as indicated particularly in FIGS. 8 and 10, the incoming strip of metal or feedstock 76 is introduced vertically downwardly between the guide flanges 75 of the guide block 70 and into registry with the blanking punch 65 of the machine. Advantageously, the strip or feedstock 76 may emanate from a coil or roll of the feedstock, not shown, positioned above the blanking area of the press. A suitable mechanical feed mechanism, also not shown, may be associated with the feedstock 76 so as to advance the same downwardly in increments at the beginning of each cycle of operation of the machine and thereby insure

a continuous supply of feedstock to the blanking mechanism, and a continuous downward removal of the previously blanked selvage 76*b* from the machine. It will also be apparent that the incoming feedstock 76 may be in the form of relatively short length strips or blanks which may be hand-fed or otherwise introduced incrementally into the blanking area of the machine at the beginning of each cycle of operation thereof. Alternatively, the feedstock may comprise precut circular blanks which may be either hand or magazine fed into registry with the drawing die 57 and mandrel 60. In this latter event, the blanking die 63, blanking punch 65 and guide block 70 would be eliminated from the machine and replaced by a suitable holding mechanism for the precut circular blanks.

With the press in its fully retracted position, as shown in FIGS. 1 and 7, an operating cycle is begun by introducing fluid under pressure into the advancing areas of each of the outboard rams 26. This permits the die plate 39 and guide plate 77 to snap forwardly under force of the compressed springs 83 to a position at which the blanking die 63 shears a circular disk or blank 76*a* from the feed strip 76. The blanking operation is shown particularly in FIG. 9, wherein it will be noted that the blanking die 63 first engages the workpiece strip 76 and shears it over the leading edge of the blanking punch 65, while at the same time displacing the guide plate 70 against action of the compression springs 74 and thereby stripping the blank 76*a* from the selvage 76*b*. As the outboard rams 26 continue to advance, the connecting rods 37 force the die carrying plate 39 forwardly to engage the drawing die 57 with the circular disk-like workpiece 76*a* and force it into drawing engagement with the end of the tubular mandrel 60. During the initial drawing operation, the outer circumferential edge portion of the blank 76*a* is held under pressure between the drawing die 57 and the blanking punch 65, but as the outboard rams 26 continue to move the die plate 39 forwardly, the drawing die 57 forces the blanking punch 65 and its associated plate 68 forwardly toward the position shown in FIG. 11, thus progressively drawing the workpiece 76*a* over the end of the mandrel 60 into the cup-shaped configuration shown at 120 in FIG. 15.

As the outboard rams 26 reach the end of their advancing strokes, the central, inboard ram 29 is energized to advance the punch head 54 into engagement with the central portion of the initially drawn workpiece 120 (see FIG. 12) to evert or progressively redraw the workpiece in the opposite direction through the axial passage 59 of the tubular mandrel 60. An intermediate stage of eversion or reverse redrawing of the workpiece is indicated at 121 in FIGS. 12 and 15, while the relatively elongated, reversely redrawn, cylindrical workpiece is shown at 122 in FIG. 15.

Continued advancing movement of the punch head 54 carries the redrawn, cylindrical workpiece 122 into engagement with and through the first ironing ring or die 98 where the side wall of the workpiece is subjected to a swaging or extrusion action to elongate and reduce the outer diameter and wall thickness thereof, as indicated at 123 in FIGS. 13 and 15. The workpiece 123 then passes through the second ironing die or ring 99 where it is further elongated and reduced in outer diameter and wall thickness, as indicated at 124 in FIGS. 13 and 15. From the ironing die 99, the workpiece is finally forced through the third ironing die 100 to further elongate it and finally reduce its outer diameter and wall thickness to the desired finished dimensions, as shown at 125 in FIGS. 14 and 15. Continued advancing movement of the punch head 54 moves the finished workpiece 125 outwardly, slightly beyond the stripper mechanism 101, and to the fully extended position of the press as shown in FIGS. 6*a* and 17. As the press reaches its fully extended position, the plate 43 engages and trips a limit switch, not shown, which causes a reversal of the ram 29 and simultaneous energization of the solenoid 118. Thus, as the punch head 54 moves rearwardly in its retracting stroke, the notched edge portions 112 of the stripper blocks 109 engage the rearward edge of the workpiece 125 to arrest inward movement thereof with the punch head 54 and cause the finished workpiece 125 to be stripped from the punch head upon continued retraction of the ram 29.

As the ram 29 approaches its fully retracted position, the plate 43 carried by the piston rod 30 engages the plate 36 and moves it rearwardly to its fully retracted position, as shown in FIG. 7. The plate 36, in turn, engages the shouldered couplings 34 to thus retract the piston rods 27 of the outboard hydraulic rams 26. The connecting rods 37, in turn, pull the plates 39, 68 and 77 rearwardly in unison until the plate 68 engages the heads 85 of the bolts 84 (see FIG. 8). This arrests further rearward movement of the plate 68, but the plates 39 and 77 continue to move rearwardly against the action of the six coil springs 83 until the plate 77 engages the spacer or stop collars 87. At this position, the rams 26 and 29 are fully retracted, and the springs 83 are fully compressed, and the blanking die 64 and punch 65 are open as shown in FIGS. 7 and 8. The press is then in readiness to begin a subsequent cycle of operation as previously described.

As will be readily understood, the press is preferably automated through the use of conventional hydraulic control valves and electrical solenoids and switches, not shown, which function to continuously cycle the machine through its advancing and retracting strokes and to operate the workpiece stripping mechanism 101 and an associated sheet metal stock feeding mechanism, not shown, in desired timed sequence with the advancing and retracting strokes of the press. However, if desired, the present machine could be entirely manually controlled, or semi-automatically controlled without departing from the spirit of the invention.

So, also, the infeed of sheet metal stock to the press may be varied from a fully automatic feed mechanism and an associated selvage disposal mechanism to the manual feeding of preformed circular disks or blanks without selvage. For these reasons, no specific form of controls or stock feeding mechanisms have been illustrated in the accompanying drawings.

As previously indicated, an important feature of the drawing and ironing press illustrated and described herein is the ability of the punch head 54 to "float" or "hunt" radially during passage of the workpiece through the ironing dies of the press. This permits the punch head 54 and the workpiece carried thereon to follow "a line of least resistance" as the workpiece progresses through the ironing rings or dies 98, 99 and 100, and insures concentricity and coaxial alignment of the punch head 54 with the annular ironing dies and a consequent uniformity of side wall thickness of the finished workpiece. This "floating" action on the part of the punch head is made possible by the limited swivel

mounting of the rod **47** in the plate **43** and connector **41** and by providing a slight clearance between the outer diameter of the shaft **47** and the inner diameter of the guide bushing **55.** Also, the resilient bushings **97** permit limited radial movement of the ironing dies **98, 99** and **100** in response to an imbalance of radially directed forces which might otherwise result in the formation of relatively thick or thin areas in the sidewall of the workpiece due to axial misalignment between the ironing dies and the punch head **54.**

Another important feature of the present drawing and ironing press is the spring-actuated blanking operation provided by the springs **83** and plates **39, 68** and **77.** It will be noted that the springs **83** are compressed between the plates **68** and **77** at the very last part of the retract-ing stroke of the press, and are released immediately at the beginning of the forward operating stroke of the press by a reversal of fluid pressure from the retracting to the advancing ends of the rams **26** and **29.** The springs **83** also provide for the application of a uniform "hold-down" or clamping force to the outer circumferential edge portion of the workpiece **76***a* and assist the outboard rams **26** in the initial drawing operation.

While a single preferred embodiment of apparatus according to this invention has been illustrated and described in detail, it will be understood that various modifications as to details of construction and design may be resorted to without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. Apparatus for making a comparatively deep metal shell comprising: a stationary tubular mandrel having an open-ended passage extending axially therethrough; means for positioning a substantially flat piece of sheet metal adjacent an end of said mandrel; a die-supporting plate movable toward and away from said end of said mandrel; annular die means carried by and movable with said plate into telescoping relation to said end of said mandrel for drawing a piece of sheet metal into a cup shaped workpiece over said end of said mandrel; spring means connected with said die-supporting plate and arranged to urge said plate toward said end of said mandrel to bring said die means into engagement with a piece of metal positioned adjacent said end of said mandrel; an annular ironing die positioned in substantial axial alignment with the opposite end of said mandrel; and a punch member movable axially and successively in a single, continuous stroke through said die means, said mandrel and said ironing die and operable to evert, redraw and iron the workpiece to form therefrom an elongated metal shell.

2. Apparatus according to claim **1,** wherein said die means includes a blanking die operable in response to forces exerted by said spring means to cut a piece of sheet metal positioned adjacent said first-named end of said mandrel prior to drawing it over said end of said mandrel; and wherein said apparatus includes a first fluid pressure-operated means con-nected with said die-supporting plate and operable to move said plate toward and away from said first-named end of said mandrel, and a second fluid pressure-operated means for moving said punch member.

3. In an hydraulic press for making elongated metal shells; a supporting frame; at least three bolsters stationarily secured in relatively spaced apart relation to said frame and including a first end bolster, an intermediate bolster and an opposite end bolster, said bolsters being formed with relatively aligned openings defining a working axis for the press; a plurality of strain rods interconnecting said bolsters and disposed in radially offset, parallel relation to the working axis of the press; a tubular mandrel stationarily carried by said intermediate bolster in coaxial relation to the working axis of the press; a die-carrying plate movably carried by said strain rods between said first end bolster and said intermediate bolster; die means carried by said die-carrying plate in coaxial relation to the working axis of the press and movable with said plate into telescop-ing relation to one end of said mandrel, said die means being operable to draw an initially flat piece of sheet metal over said end of said mandrel to form it into a cup-shaped workpiece; first hydraulic ram means connected with said first end bolster and with said die-carrying plate and operable to move said die means into telescoping relation to said mandrel; an ironing die carried by said opposite end bolster and having a central opening coaxial with the working axis of the press; a punch member movable along the working axis of the press and movable successively through said die means, said mandrel and said ironing die to evert, redraw and iron said workpiece into an elongated shell; second hydraulic ram means connected with said first end bolster and with said punch member and operable to reciprocate said punch member through said die means, said mandrel and said ironing die; and stripping means carried by said opposite end bolster and operable to strip a finished elongated shell from said punch member following movement thereof through said ironing die.

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