United States Patent [19]

Garner et al.

[11] **3,851,516**

[45] **Dec. 3, 1974**

[54] **METAL WORKING APPARATUS**

[75] Inventors: **Kenneth Bishop Garner**, Tulsa, Okla.; **Lewis Shepherd Roberson**, Chattanooga, Tenn.

[73] Assignee: **Combustion Engineering, Inc.**, Windsor, Conn.

[22] Filed: **July 23, 1973**

[21] Appl. No.: **381,833**

[52] **U.S. Cl.** **72/256**, 72/267

[51] **Int. Cl.** **B21c 23/00**

[58] **Field of Search** 72/325, 256, 266, 267

[56] **References Cited**

UNITED STATES PATENTS

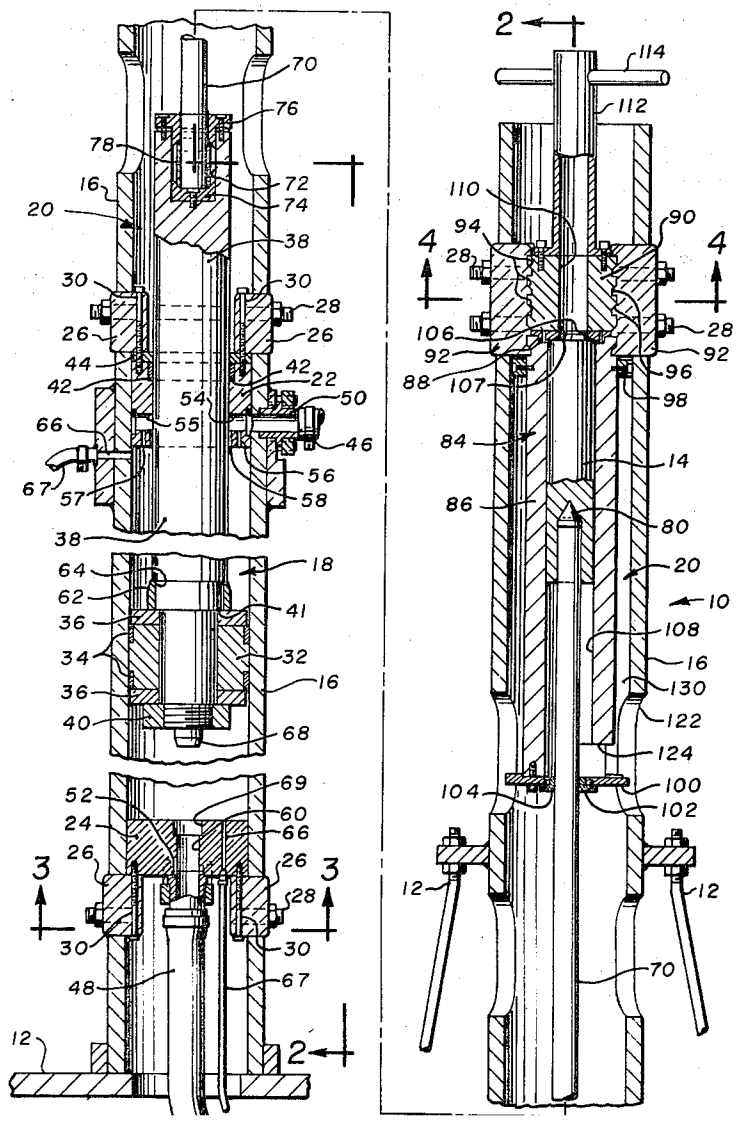
3,408,846 11/1968 Schofield 72/256

Primary Examiner—C. W. Lanham
Assistant Examiner—Robert M. Rogers
Attorney, Agent, or Firm—John R. Nelson

[57] **ABSTRACT**

A press for metal working of cylindrically shaped metal ingots or billets. The press comprises a longitudinally extending hollow tubular member in which a pair of cylinder end members are supported. The two cylinder end members divide the interior of the tubular member into a cylinder portion therebetween and a working portion. A mandrel, aligned with the axis of the tubular member, is provided in the working portion of the tubular member and is connected to a piston provided in the cylinder portion. A die means having a billet chamber and a longitudinal passage therethrough to permit passage of the mandrel into and through the billet chamber is supported in the working portion of the tubular member so as to have the axis of the billet chamber and the longitudinal passage aligned with the axis of the tubular member. Supply means are provided for supplying fluid to the cylinder portion of the tubular member to drive the piston longitudinally between the two cylinder end members and accordingly the mandrel to perform the metal working on the billet.

8 Claims, 9 Drawing Figures



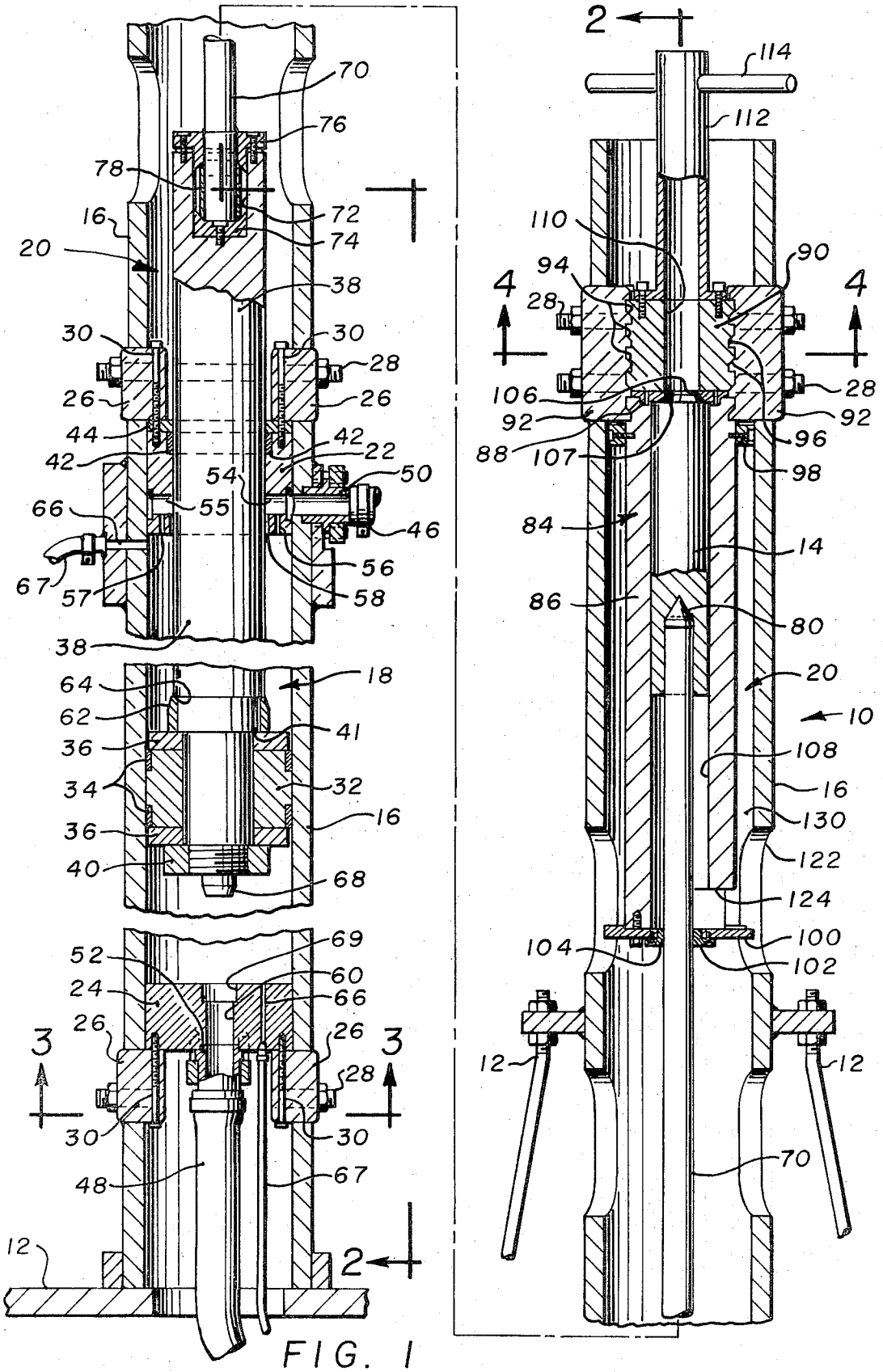

70
76
78
72
74
16
20
38
30
30
28
26
26
44
42
42
22
54
50
55
66
46
56
67
57
58
38
64
18
62
41
36
34
32
36
16
40
68
69
52
60
24
66
26
26
3
3
28
30
30
48
67
12
2
2
114
112
110
90
94
4
4
28
28
106
92
92
88
107
96
98
84
14
86
80
20
10
108
16
130
122
124
104
100
102
12
12
70

FIG. 1

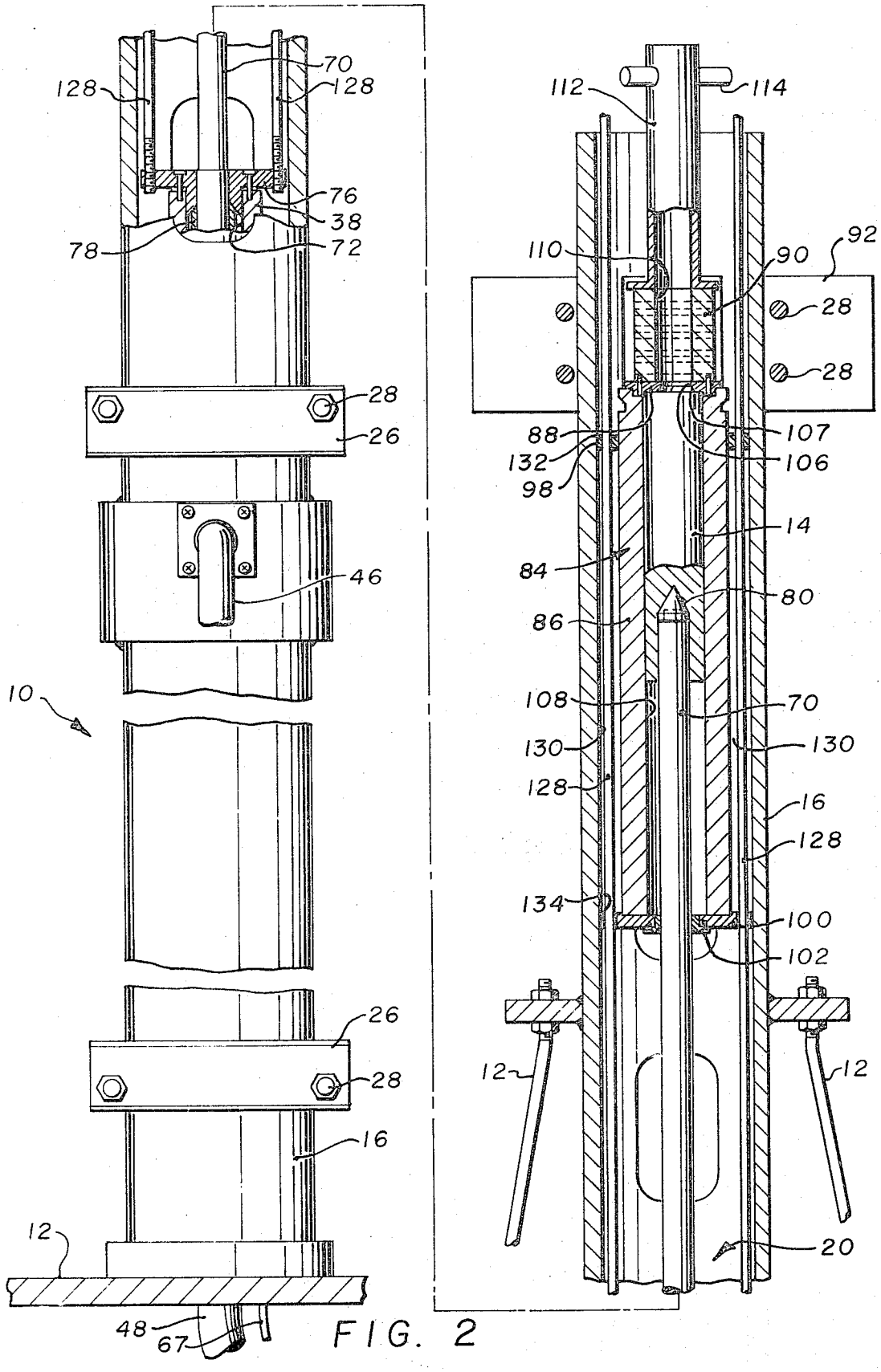

70
128
128
76
38
78
72
28
26
46
10
26
28
16
12
48
67
112
114
110
90
92
28
28
88
107
132
106
98
14
84
80
86
108
70
130
130
128
16
128
134
100
102
12
12
20

FIG. 2

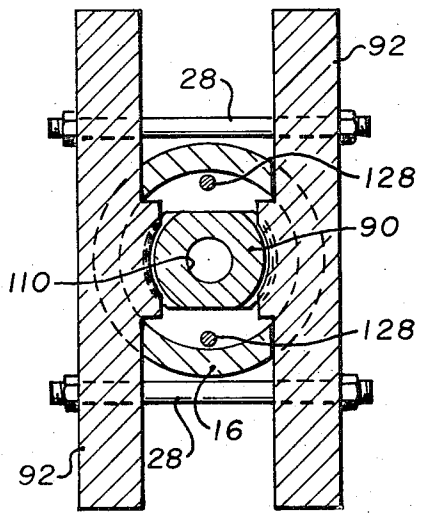


FIG. 4

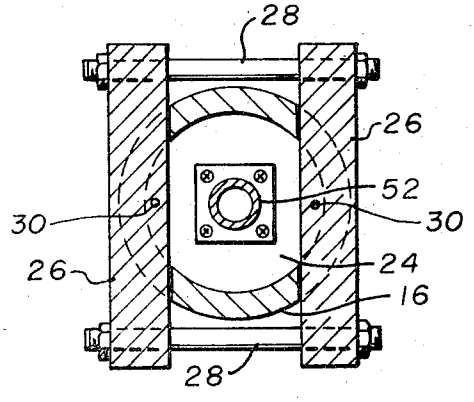


FIG. 3

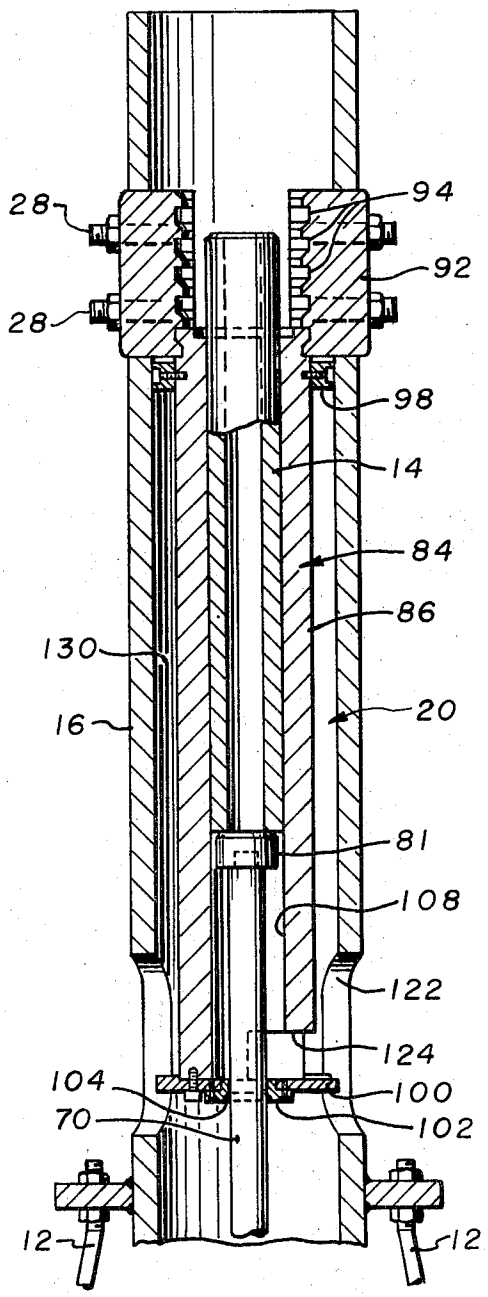


FIG. 5

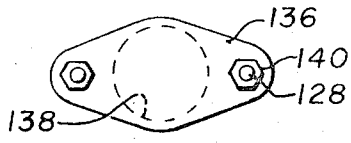


FIG. 7

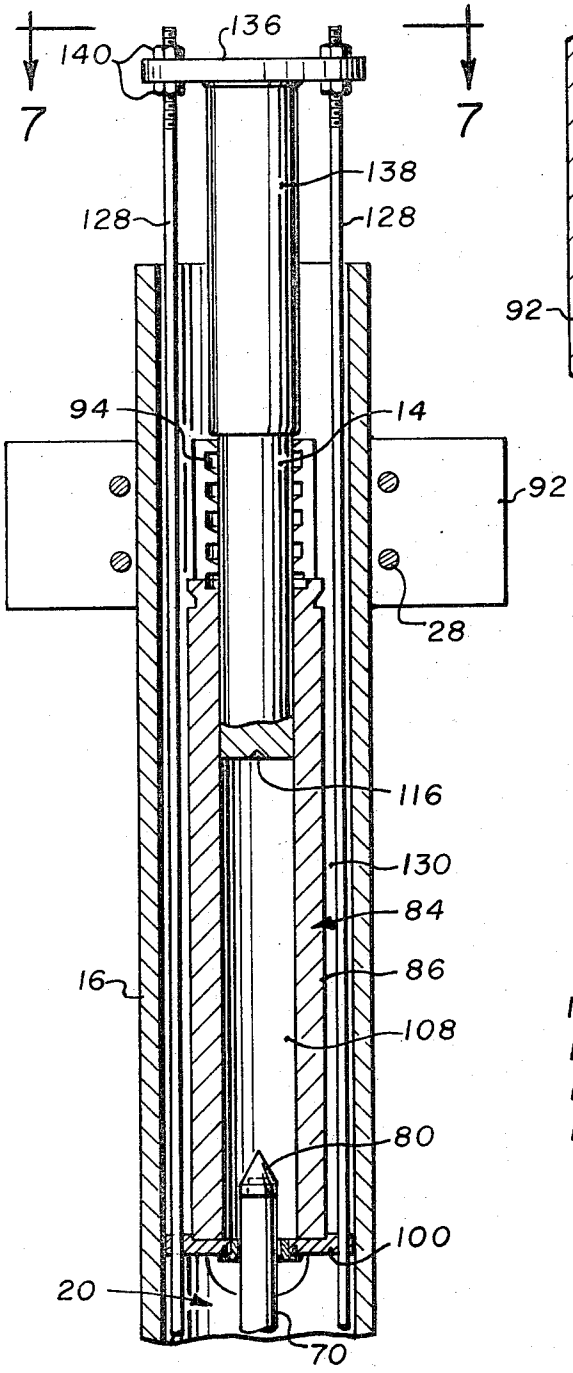
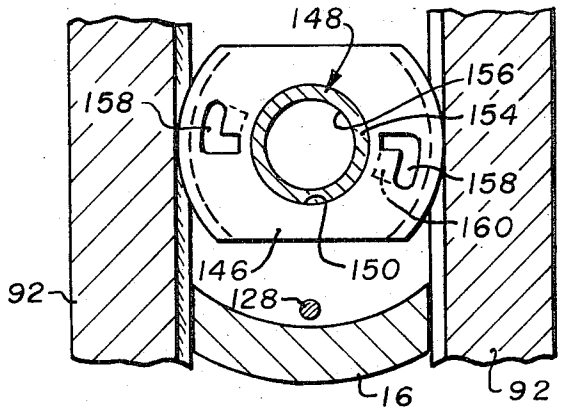


FIG. 6

FIG. 9



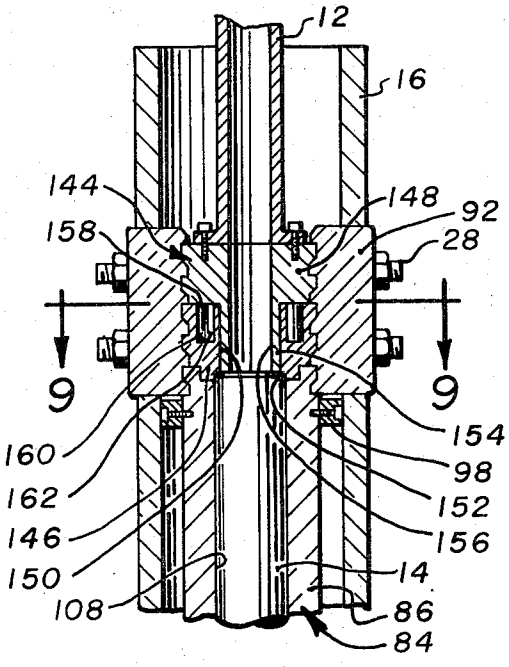


FIG. 8

METAL WORKING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to the art of metal working and more particularly to an apparatus for metal working of metal ingots. Further still the invention concerns an apparatus for piercing and/or extruding a cylindrical metal ingot.

In one method of making a high quality alloy seamless tube, the first step is to pierce a hole in a relatively short, thick solid circular cylinder called a billet. Normally this is done after heating the billet to 2,000°F or more. During this piercing process in which a mandrel is forced through the heated billet, the billet will lengthen to form what is known as a tube hollow or simply a hollow. As can be appreciated, one of the critical factors in piercing is to maintain the concentricity of the pierced hole throughout the billet length. This hot working of the billet is necessary to give the billet sufficient refinement to permit the tube hollow to be cold worked to form the final seamless tube. In some instances, depending on the billet constituents and the final tube geometry, it is necessary to further hot work the pierced billet. In such situations, the tube hollow can be extruded after piercing in a second operation. Extrusion consists of forcing the heated hollow through a restriction while controlling the internal hole size by a mandrel, thereby lengthening the hollow.

Conventional mechanical and hydraulic presses for piercing and extruding usually have two spaced platens which move toward one another during operation. One of the platens has a billet container positioned thereon in alignment with a mandrel fixed to the other platen. A billet is placed within the container between the two platens and the two platens are moved toward one another to perform the metal working of the billet. As can be appreciated, in order to obtain a high quality pierced and/or extruded billet, the mandrel must be coaxial with the billet container and the mandrel must also move in a straight line toward the center of the container. Elaborate devices have been designed for aligning and guiding the mandrel and billet container during this operation. However, these devices are very expensive and have not always proven to be successful in producing concentrically pierced and extruded billets.

Furthermore, the loading of the billet between the two platens in a conventional press leads to other problems. First, assuming that the mandrel is attached to the upper platen as is normally the case, the upper platen must be withdrawn high enough that the mandrel does not obstruct loading of the billet into the billet container. This longer stroke requirement increases equipment cost and may detract from concentricity. Secondly, the upper platen limits the mechanical means which are available for lifting of a hot billet into the container.

SUMMARY OF THE INVENTION

Accordingly, there is provided a novel apparatus for metal working of cylindrically shaped ingots. The apparatus comprises a longitudinally extending hollow tubular member in which a pair of axially spaced cylinder end members are transversely supported. The two cylinder end members divide the interior of the tubular member into a cylinder portion located between the two end members and a working portion. A piston is provided in the cylinder portion for longitudinal movement between the two end members. A longitudinally extending working mandrel, having at least a portion of its longitudinal length disposed in the working portion, is aligned with the longitudinal axis of the tubular member and is connected to the piston for movement therewith. A die means, having a longitudinally extending billet chamber and a longitudinal passage therethrough to permit passage of the working mandrel into and through the billet chamber, is supported in the working portion of the tubular member so that its axis is aligned with the axis of a tubular member. Supply means is provided for supplying fluid to the cylinder portion to move the piston longitudinally therewithin and accordingly to move the mandrel to perform the metal working on the cylindrically shaped ingot.

The use of a single multi-purpose tubular member which serves the multiple purposes of being the main body of the press, the hydraulic cylinder which motivates the operation, the means of retaining and accurately aligning the billet container with the piston rod and the mandrel, and the structural member which contains large forces and reactions between the members is largely responsible for achieving an economical metal working apparatus and for achieving excellent alignment of the components. This is an essential condition for producing concentric holes in metal billets. Furthermore, the axis of the billet is vertical rather than horizontal. This keeps the weight of the billet, the container, the piston rod, and the piercing mandrel from contributing directly to the eccentricity as might otherwise occur with a horizontal press. It also lessens the indirect effects such as the billets's tendency to lay in one side of the container and be cooled asymmetrically. Further still the press is axisymmetrical in design which minimizes the asymmetrical temperatures and asymmetrical strains as possible causes of eccentricity. Still further the press permits unobstructed billet leading of the container at the opposite end from the mandrel.

BRIEF DESCRIPTION OF THE DRAWINGS.

FIG. 1 is an elevation view in section of a metal working press according to the present invention.

FIG. 2 is a side elevation view partially in section taken along line 2—2 of FIG. 1.

FIG. 3 is a cross sectional view taken along line 3—3 of FIG. 1.

FIG. 4 is a cross sectional view taken along line 4—4 of FIG. 1.

FIG. 5 is an elevation view similar to the upper portion of FIG. 1 showing how a pierced billet may be extracted from the metal working press.

FIG. 6 is a side elevation view similar to the upper portion of FIG. 2 showing how a billet may be forcibly inserted into the metal working press.

FIG. 7 is a plan view taken along line 7—7 of FIG. 6.

FIG. 8 is an elevation view in section showing an alternative arrangement for the billet chamber end member of the press.

FIG. 9 is a sectional view taken along line 9—9 of FIG. 8.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, FIGS. 1 and 2 show

a metal working press **10** for metal working of a short, thick generally circular cylinder **14** called a billet. The billet **14** is normally heated to about 2000°F or more in order that it may be hot worked thereby giving it more ductility. The increased ductility will allow the hot worked billet to then be cold worked into high quality seamless tubing. In particular, the press **10** is a piercing and/or extrusion press although it may easily be modified to perform other types of metal working operations. In the preferred embodiment the press **10** is vertically mounted and supported on and by a base **12.**

The press **10** is comprised of an elongated multipurpose hollow tubular member **16.** Upper and lower cylinder end members **22** and **24** are supported within the interior of the tubular member **16** to divide the interior into a cylinder portion **18** defined between the two members **22** and **24** and a working portion **20** defined by the remainder of the interior of the tubular member **16.** The cylinder portion **18** forms the hydraulic cylinder of the press **10** which motivates the metal working operation. Each of the two end members **22** and **24** are supported by means of two diametrically opposed, bolt stabilized transverse keys or bars **26.** The bars **26** are disposed in diametrically opposed openings in the side wall of the tubular member **16** adjacent the desired elevations of the end members **22, 24.** The openings are each of a rectangular configuration in order that a portion of each bar **26** extends into the working portion **20** of the tubular member **16** to overlay a portion of one of the cylinder end members **22** or **24.** The interior lying portion of each of the bars **26** is bolted by bolts **30** to the cylinder end member **22** and **24.** Outside of the tubular member **16,** the two bars **26** adjacent each elevation of the cylinder end members are bolted to each other by bolts **28** to stabilize and retain the bars **26** within the openings in the side wall of the tubular member **16.** This provides an economical means for positioning the two end closures **22, 24** of the hydraulic cylinder **18** in the tubular member **16** and for transferring the load imposed thereon to the tubular member **16** without interrupting its basic continuity.

A piston **32** whose outside diameter is substantially equal to the inside diameter of the tubular member **16** is provided in the cylinder portion **18** for longitudinal movement between the two cylinder end members **22** and **24.** Piston sealing means **34,** such as for example leather chevron packing seals, are positioned in recesses in the outer cylindrical surface of piston **32** and are held there in place by seal hold rings **36.** One end of a piston rod **38** passes through a central bore in the piston **32** and seal hold rings **36** and is connected thereto by means of a nut **40** which forces the piston **32** and seal hold rings **36** against the shoulder **41** on piston rod **38.** This arrangement further serves to maintain a proper relationship between the piston **32** and seal hold rings **36.** The other end of the piston rod **38** extends longitudinally upward through a central bore in the upper end member **22** into the working portion **20** of the tubular member **16.** Upper cylinder end member seals **42,** which again may be leather chevron packing seals, are provided in the bore of the upper end member **22** to seal the cylinder portion **18** from the working portion **20.** A seal retaining ring **44** is provided and retained in place between the upper end member **22** and the interior lying portion of the transverse bars **26** dry bolts **30.**

If desired, a pliable washer (not shown) may be provided between the retaining ring **42** and the bars **26** for keeping debris free from the piston rod **38** as it moves longitudinally through the cylinder end member **22.**

Fluid lines **46** and **48** are coupled or clamped respectively to fluid connectors **50** and **52** for supplying actuating fluid to the cylinder **18** to drive the piston **32** longitudinally between end members **22** and **24.** Actuating fluid is supplied, in a well-known manner, from a fluid source and control mechanism (not shown) to which the other end of lines **46** and **48** are connected. Upper fluid connector **50** is bolted to the sidewall of the tubular member **16** and communicates with side port **54** in the upper end member **22.** Side port **54** in turn communicates with cylinder portion **18** above the piston **32** through longitudinal port **56** and annular opening **58.** Similar side and longitudinal ports **55, 57** are provided in the end member **22** diametrically opposite to the ports **54, 56** are for insuring a minimum fluid communication to the cylinder portion **18** when the annular opening **58** is closed as described hereinbelow. Lower fluid connector **52** is bolted to the lower cylinder end member **24** and communicates with the cylinder portion **18** below piston **32** through central bore **60** in the lower end member **24.** Pressure relief opening **66** to which fluid lines **67** are coupled are provided near the upper and lower end members **22** and **24** in order to limit and control the buildup of fluid pressure in the cylinder portion **18** when the piston moves toward either one of the upper or lower end members. A tapered ring **62** is attached to the piston rod **38** between a shoulder **64** on the piston rod **38** and the upper seal hold ring **36.** The tapered ring **62** acts as a cushion or decelerator to slow the upward movement of the piston **32** by gradually closing off the fluid passage through annular opening **58** as the piston is moved upward. The lower tapered end **68** of the piston rod **38** provides a similar cushioning or decelerating effect as it enters the enlarged portion **69** of the central bore **60** in the lower end member **24** when the piston **32** is moved downward.

A longitudinal extending working mandrel **70,** aligned with the longitudinal axis of the tubular member **16,** is attached to the upper end of the piston rod **38.** In the preferred embodiment a collet chuck is used for this purpose which comprises a base member **74** fixed in a central bore **72** in the piston rod **38** and having an upper annular tapered portion, an upper plate member **76** having a lower annular tapered portion, and a segmented ring member **78** having complimentary upper and lower tapered portions engageable with the tapered portions of the base member **74** and the plate member **76.** The plate member **76,** through which the lower end of the mandrel **70** extends into the central bore of the piston rod **38** is bolted to the piston rod **38** to bias the segmented ring **78** inwardly to center and frictionally hold the lower end of the mandrel **70.** It should be noted that the use of a collet chuck is not the only means for attaching and aligning the lower end of the mandrel **70** with the piston rod **38.** Other alternatives may include threading or welding of mandrel **70** to the end of piston rod **38.** The other end of the mandrel **70** is provided with a removable working tip **80** for performing the desired working operation on the billet **14.** In FIGS. **1** and **2** this working tip is a piercing tip **80.** The piercing tip **80** may be removed and replaced, for example, with an extraction plug **81** (see FIG. **5**) or

an extrusion tip depending upon the desired operation for the press **10**.

An upper die means **84** for the billet **14** is positioned in the upper end of the working portion **20** of the tubular member **16**. In the embodiment shown in FIGS. **1** and **2** the upper die means **84** comprises a billet container **86** having a billet chamber **108**, a billet centering plate **88**, and a chamber end member **90**. These three components **86**, **88** and **90** are supported within the tubular member **16** by means of a breech lock arrangement which in turn is supported by the tubular member **16** in a manner similar to the support of the cylinder end member transverse keys **26**. Breech lock keys or bars **92**, each of which has an inner lateral portion having a series of convolutions **94** formed on the longitudinal surface thereof, are disposed in diametrically opposed openings in the sidewall of the tubular member **16** such that the inner lateral portions lie within the working portion **20** of the tubular member **16** and are diametrically opposed to one another. The bars **92** are retained thereinplace by cross bolts **28** which pass outwardly of the tubular member **16**. Complimentary convolutions **96** are provided on opposite portions of the longitudinal surface of the die means **84**, in particular on opposite portions of the billet container **86** and the chamber end member **90**, for engagement with the convolutions **94** of the breech lock keys **92** to support and retain the die means **84** in the working portion **20** of the tubular member **16**. As can be seen in FIG. **1**, the convolutions **94**, **96** are preferably tapered to make them stronger at the base of the longitudinal surfaces where the shear forces are the greatest.

The longitudinal extending billet container **86** has a central bore therethrough which defines the billet chamber **108** in which the billet **14** is placed. Upper and lower centering rings **98**, **100** are attached to the outer surface of the billet container **86** adjacent the upper and lower ends respectively thereof to align the billet chamber **108** with the longitudinal axis of a tubular member **16**. The lower centering ring **100**, which is bolted to the bottom of the container **86**, has a lower mandrel centering plate **102** bolted thereto for centering and aligning the mandrel **70** as it passes therethrough into the billet chamber **108**. The tapered entrance **104** of the centering plate **102** serves to guide the mandrel **70** into this alignment at the lower end of the billet chamber **108**.

The chamber end member **90** forms the upper end closure for the billet chamber **108** and sustains the reaction of the billet as it is worked by the mandrel **70**. The billet centering plate **88** is bolted to the bottom of the chamber end member **90** so as to have its central opening **106** aligned with the billet chamber **108** when the chamber end member **90** is locked in place by the breech lock keys **92**. The billet centering member **88** is provided with a tapered entrance **107** to the opening **106** which serves to initially align the billet **14** in the billet chamber **108**, as described herein below. As can be seen in FIGS. **1** and **2**, the chamber end member **90** has a central bore **10** therethrough in alignment with the central opening **106** in the billet centering member **88** to allow for passage of the mandrel **70** therethrough on its upward stroke during a piercing metal working operation. The upper end of the chamber end member **90** has a tubular extension member **112** bolted thereto to which a handle **114** is attached for rotating the chamber end member **90** relative to the breech lock keys **92** in order to facilitate removal from the breech lock arrangement. As can be seen in FIG. **4**, the necessary rotation for removal of a chamber end member **90** (and accordingly the billet centering plate **88**) is approximately 90°.

The operation of the press **10** for a piercing operation is as follows. The chamber end member **90** with attached billet centering plate **88** is removed from the breech lock arrangement and a heated billet **14** is inserted into the chamber **108**. The billet preferably has a centralized recess **116** in the lower surface thereof (see for example FIG. **6** although this FIG. shows a billet **14** being forcibly inserted into the chamber **108**) which is aligned with the billet axis and into which will fit the piercing tip **80** of the mandrel **70**. This will center the lower end of the billet **14** in the billet chamber **108**. Also the billet **14** is preferably of such a size that it loosely fits into the billet chamber **108** so that on the first upward action of the mandrel **70**, it will force the billet into the tapered entrance **107** of the billet centering plate **88** to center the upper end of the billet **14** in the chamber **108**. This use of centralized recess **116** and tapering entrance **107** improves the symmetry and concentricity of the resulting pierced billet by insuring that the billet **14** is aligned at both its upper and lower ends. After the billet **14** has been inserted in the chamber **108** and the chamber end member **90** locked in place, fluid is introduced through line **48** into the cylinder **18** below the piston **32** in order to drive the piston upward. This causes the mandrel **70** to pass through the lower centering plate **102** into the lower end of billet chamber **108** where piercing tip **80** of the mandrel **70** engages the centralized recess **116** of the billet **14** and forces the billet **14** upward and into alignment in the billet container **108** as described hereinbefore. The mandrel **70** continues upward, thereby piercing the billet **14**, until the tapered ring **67** on the piston rod **38** engages the annular opening **58** in the cylinder upper end member **22** to terminate the upward movement of the piston **32**. During this piercing operation, the billet **14** will grow longitudinally and accordingly the lower end of the pierced billet **14** will move downwardly (since it is retained at the top by the chamber end member **90**) in the billet chamber **108**. Additionally, a small portion of the metal billet **14** will be forced out through the central opening in the billet centering plate **88** and chamber end member **90** as the mandrel **70** passes therethrough to its fully extended position. After the piercing operation has been completed, the piston **32** is retracted within the cylinder **18** of the tubular member **16** by introducing fluid to the cylinder portion **18** through line **46**.

In order to remove the pierced billet **14** or tube hollow from the billet chamber **108**, the chamber end member **90** is removed and an extraction plug **81** (see FIG. **5**) is inserted into the billet chamber **108** adjacent its lower end through opening **122** in the sidewall of member **16** and similar opening **124** in the sidewall of billet container **86**. If desired the piercing tip **80** may be removed and extraction plug **81** attached to the end of the mandrel **70**, although this would not be necessary if the extraction plug **81** were provided with a centralized recess or opening in which the pirecing tip **80** would fit. The extraction plug **81** is sized so that its outer diameter is substantially equal to but slightly less than the diameter of the billet chamber **108** so that it may move longitudinally there within. A second stroke

of the mandrel **70** will then cause the extraction plug **81** to engage the lower end of the pierced billet **14** and force the billet upward out of the billet chamber **108.**

As referred to hereinbefore, it is desirable that the heated unpierced billet **14** loosely fit into the billet chamber **108.** However, in some instances it may be necessary to forcibly insert the billet **14** into the chamber **108.** Furthermore, in other operations it may be desirable to exert a force downwardly instead of upwardly. Accordingly, the press **10** has been provided with two diametrically opposite pull rods **128** which are removably connected to the upper plate member **76** which attaches the mandrel **70** to the piston rod **38.** As can best be seen in FIGS. **2, 4, 6** and **7** the pull rods **128** extend longitudinally upward through the annular space **130** between the inner surface of tubular member **16** and the outer surface of tubular member **16** and the outer surface of billet chamber **86** to above the upper end of tubular member **16.** Each of the pull rods **128** extends through appropriately located and sized holes **132, 134** on the upper and lower centering rings **98** and **100.** Also, the pull rods **128** are positioned on opposite sides of the chamber end member **90** between the breech lock keys **92** so as not to interfere with the operation of the breech lock arrangement. The pull rods **128** move with the mandrel **70** and may extend as far above the press **10** as desired. For example, as shown in FIG. **6** and **7,** the pull rods **128** are connected together above tubular member **16** cross connecting member **136** in order to be able to forcibly insert a billet **14** into the billet chamber **108.** The cross member **136** is coupled to the pull rods **128** by nuts **140** and is provided with a lower extension **138** which will contact and push a billet **14** into the billet chamber **108** as the mandrel **70** is retracted. As can be appreciated, the extension **138** is necessary since the lateral dimension of the cross connecting member **136** is larger than the inside diameter of the billet container **86.** After the billet **14** is inserted, the cross connecting member **136** is removed by loosening the nuts **140** and the chamber end member **90** is inserted and locked between the breech lock keys **92.**

FIGS. **8** and **9** show and alternative arrangement **144** for the chamber end member **90** to provide for combination piercing and extrusion in which the billet **14** is first pierced and then extruded by a second stroke of a working manual **70.** The alternative chamber end member **144** is of a two-part construction having an outer part **146** and an inner part **148.** The outer part **146** acts as an extrusion die and has a central bore **150** therethrough whose diameter is slightly less than the diameter of the billet chamber **108.** Also there is provided a tapered entrance **152** at the lower end of the outerpart **146** which performs the function of the billet centering plate **88** described hereinabove with reference to FIGS. **1** through **7.** The inner part **148** has a lower extension **154** which fits into the bore **150** of the outer part **146** and additionally has a central bore **156** to allow passage therethrough of the working manual **70** during the piercing operation. For the piercing operation, both parts **146** and **148** are locked in place by the breeched lock arrangment as shown in FIG. **8** and the billet **14** is pierced in a manner similar to that as previously described. After the mandrel **70** is retracted, only the inner part **148** is removed such as by rotation of the tubular extension **112** attached thereto. This leaves the outer part **146** in position. An extrusion tip (not shown) may then be attached to the mandrel **70** and a second stroke made which will force the pierced billet **14** or hollow through the reduced diameter of the bore **150** thereby reducing or extruding the diameter of the pierced billet **14.**

In order to remove the outer part **146** from the breech lock keys **92,** the upper surface of the outer part **148** is provided with two dog legged shaped longitudinal slots **158** located on diametrically opposite sides of the bore **150.** Lateral slots **160** extend from these longitudinal slots **158** in the interior of the outer part **146** to provide an upper shoulder **162.** Accordingly, an appropriate shaped tool (not shown) having longitudinally extending legs with lateral projections extending inwardly therefrom may be inserted in the longitudinal slots **158** and rotated to rotate the outer part **146** out of engagement with the breech lock keys **92.** The lateral projections would then engage the upper shoulder **162** to permit the outer part **146** to be lifted out of the tubular member **16.**

Accordingly, the present invention discloses a novel metal working press **10** in which a single multi-purpose tubular member **16** serves the multiple purposes of being the main body of the press **10,** the hydraulic cylinder **18** which motivates the operation, the means of retaining and accurately aligning the billet container **86** with the mandrel **70,** and the structural member which contains the large force and reactions between the members. Another advantage is that the press **10** minimizes possible causes of eccentricity and improves the symmetry and concentricity of the pierced hole in the billet **14.** First, the axis of the billet **14** is vertical and accordingly prevents the weights of the billet **14,** the billet container **86** and the mandrel **70** from directly contributing to possible eccentricity. This fact also lessens the indirect effects of eccentricity such as the billet laying on one side and being cooled assymetrically Secondly, the press **10** in being axisymmetrical in design minimizes assymetrical temperatures and assymetrical strains. Finally, the billet **14** in being pierced is aligned at both its top and bottom ends. A further advantage is that the billet **14** is loaded into the billet container **86** from above out of the way of the press **10** rather than from beneath or between the press as in conventional arrangements. This affords for a more convenient operation of the press **10.**

While these preferred embodiments of the invention have been shown and described, it will be understood that they are merely illustrative and that changes may be made without departing from the scope of the invention as claimed.

What is claimed is:

1. Apparatus for metal working of a billet comprising:

a longitudinally extending hollow tubular member;

a pair of axially spaced end members transversely supported in said tubular member to divide the interior of said tubular member into a cylinder portion located between said two end members and a working portion;

a plurality of openings in the side wall of said tubular member adjacent each of the longitudinal positions of said end members;

end member support bodies retained in said openings in said tubular member, said support bodies having portions thereof extending into the interior of said

tubular member which overlie and are connected to a portion of said end members for transferring the load imposed on said end members to said tubular member;

a piston in said cylinder portion of said tubular member, said piston being longitudinally movable between said two end members;

a longitudinally extending working mandrel having its longitudinal axis aligned with the longitudinal axis of said tubular member, said mandrel being connected to said piston for longitudinal movement therewith, and having at least a portion of its longitudinal length disposed in said working portion of said tubular member;

a die means having a longitudinally extending billet chamber, said die means having a longitudinal passage therethrough to permit said working mandrel to enter into and pass through said billet chamber to perform the metal working of the billet;

means for supporting said die means in the working portion of said tubular member so that the axis of said billet chamber and said passage are aligned with the axis of said tubular member; and

supply means for supplying fluid to said cylinder portion for moving said piston longitudinally within said cylinder portion of said tubular member.

2. Apparatus for metal working of a billet comprising:

a longitudinally extending hollow tubular member;

a pair of axially spaced end members transversely supported in said tubular member to divide the interior of said tubular member into a cylinder portion located between said two end members and a working portion;

a piston in said cylinder portion of said tubular member, said piston being longitudinally movable between said two end members;

a longitudinally extending working mandrel having its longitudinal axis aligned with the longitudinal axis of said tubular member, said mandrel being connected to said piston for longitudinal movement therewith, and having at least a portion of its longitudinal length disposed in said working portion of said tubular member;

a die means, including a longitudinally extending billet chamber, a chamber end member, and a billet centering member, supported in the working portion of said tubular member, said die means having a longitudinal passage therethrough to permit said working mandrel to enter into and pass through said billet chamber to perform the metal working of the billet, said chamber end member being positioned in said longitudinal passage adjacent the end of said billet chamber which is remote from the end through which said working mandrel enters and said chamber end member being removable from said die means to allow for insertion of the billet into said billet chamber through said end remote from said entry end of said working mandrel, and said billet centering member being positioned at the end of said chamber end member adjacent to said billet chamber for centering the billet in said billet chamber as said working mandrel performs the metal working on the billet;

means for supporting said die means in the working portion of said tubular member so that the axis of said billet chamber and said longitudinal passage are aligned with the axis of said tubular member, and said supporting means comprising means for retaining said chamber end member in position within said longitudinal passage of said die means, said means for retaining comprising two diametrically opposed openings in the side wall of said tubular member adjacent the longitudinal position of said chamber end member, a series of convolutions formed on laterally opposite sides of the longitudinal surface of said chamber end member, and two support bodies retained in said openings in said tubular member each of which has a series of convolutions on a portion thereof extending into the interior of said tubular member for mating engagement with said series of convolutions on said chamber end member; and

supply means for supplying fluid to said cylinder portion for moving said piston longitudinally within said cylinder portion of said tubular member.

3. The apparatus of claim **1** wherein said portions of said end member support bodies extend into said working portion of said tubular member.

4. The apparatus of claim **3** wherein said plurality of openings adjacent each of the longitudinal positions of said end members is two, each of said two openings being diametrically opposed to one another and communicating with said working portion of said tubular member; where each of said end member support bodies is a bar having a portion of its length intermediate its two ends positioned in said openings; and wherein there is provided connecting means at each of said longitudinal positions of said end members, each of said connecting means connecting together the ends of said bars positioned in said two diametrically opposed openings to retain said bars therein.

5. The apparatus of claim **2** wherein said working mandrel has a piercing end face for piercing the billet in said chamber and wherein said chamber end member has a longitudinal opening therethrough aligned with the longitudinal axis of said billet chamber, the size of the opening being such as to permit passage therethrough of said mandrel and to prevent passage therethrough of the billet.

6. The apparatus of claim **2** wherein said chamber end member comprises a first outer member which has a longitudinal bore therethrough, the size of said bore being smaller than the size of the opening in said billet chamber; and a second inner-member which fits into the bore of said first member, said second inner-member having a longitudinal bore therethrough which is smaller than said bore of said first outer member, said first and second members being individually and separably removable from said die means.

7. The apparatus of claim **2** wherein said working mandrel is connected to said piston by a longitudinally extending piston rod having one end attached to said piston and having the other end extending through one of said end members into said working portion of said tubular member, said mandrel being attached to said other end of said piston rod.

8. The apparatus of claim **7** further including a pair of longitudinal extending pull rods positioned in said working portion of said tubular member between said die means and the wall of said tubular member, each of said pull rods having one end attached to said piston rod and having the other end extending beyond said die means; and a cross member removably attached to both of said other ends of said pull rods, said cross member being engagable with a billet to force said billet into said billet chamber when said chamber end member is removed and said piston rod is moved in a direction away from said die means.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,851,516

DATED : December 3, 1974

INVENTOR(S) : Kenneth Bishop Garner and Lewis Shepherd Roberson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, lines 39 and 40	delete "leading" and insert --loading--.
Column 3, line 32	delete "member" and insert --members--.
Column 5, line 60	delete "10" and insert --110--.
Column 7, line 44	delete "and" and insert --an--.
Column 8, lines 13 and 14	delete "appropriate" and insert --appropriately--.
Column 10, line 26	delete "where" and insert --wherein--.
Column 10, line 28	following "in" insert --one of--.
Column 10, line 57	delete "longitudinal" and insert --longitudinally--.
Column 3, line 66	delete "dry" and insert --by--.
Column 6, line 63	delete "pirecing" and insert --piercing--.
Column 7, line 60	delete "manual" and insert --mandrel--.
Column 7, line 63	delete "arrangment" and insert --arrangement--.

Signed and Sealed this

twentieth Day of *April 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks