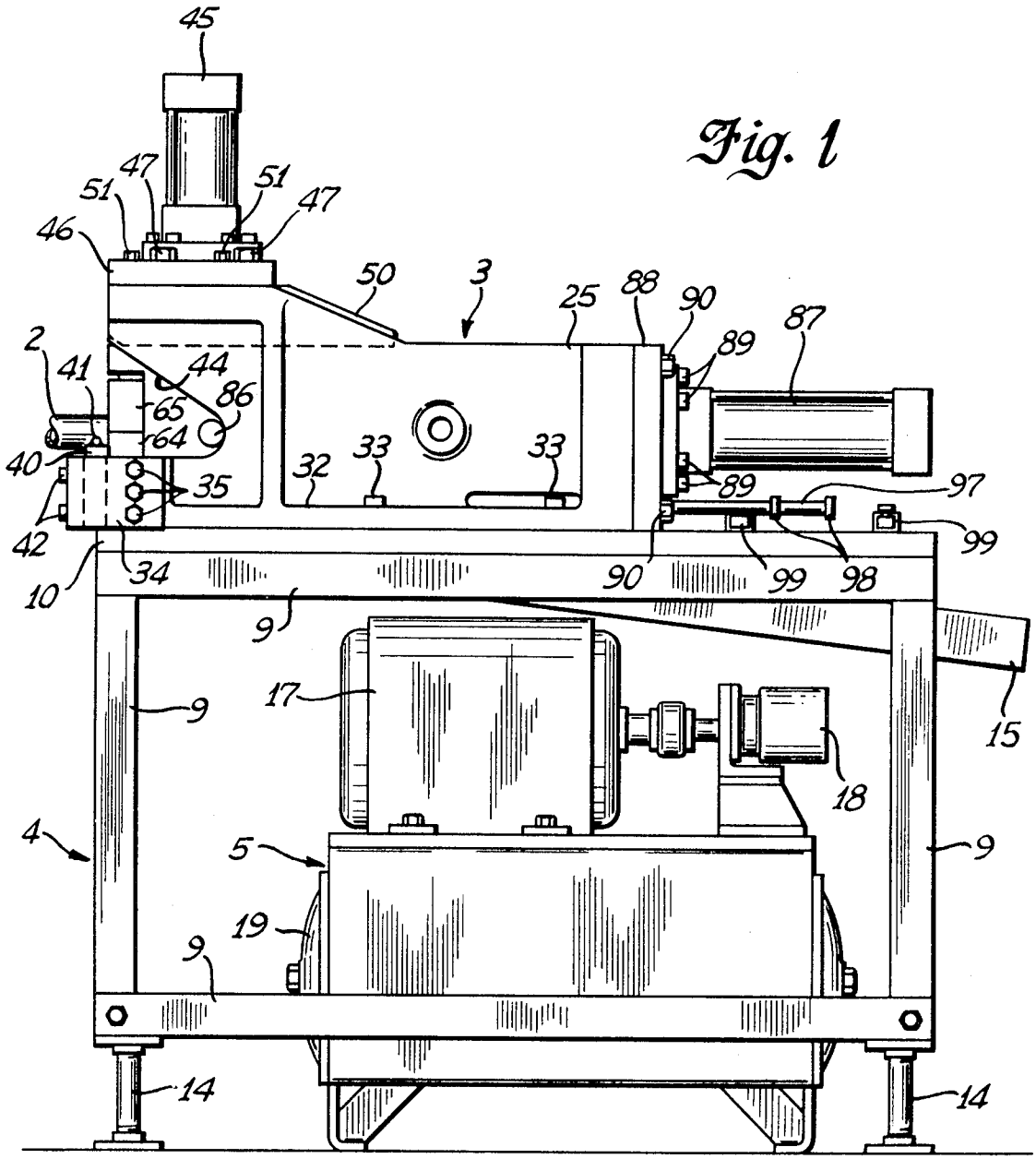
Oct. 5, 1971 F. H. BULTMAN 3,610,016

UNITIZED TUBE ENDS FORMING MACHINE

Filed Aug. 12, 1969 6 Sheets-Sheet 1

Fig. 1



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UNITIZED TUBE ENDS FORMING MACHINE

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Fig. 2

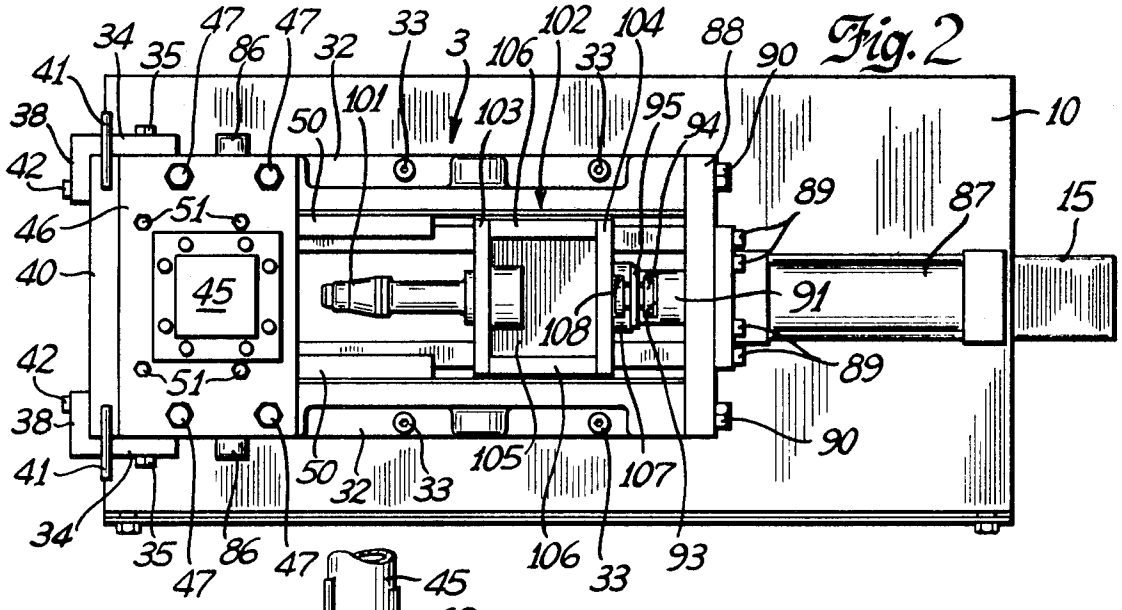
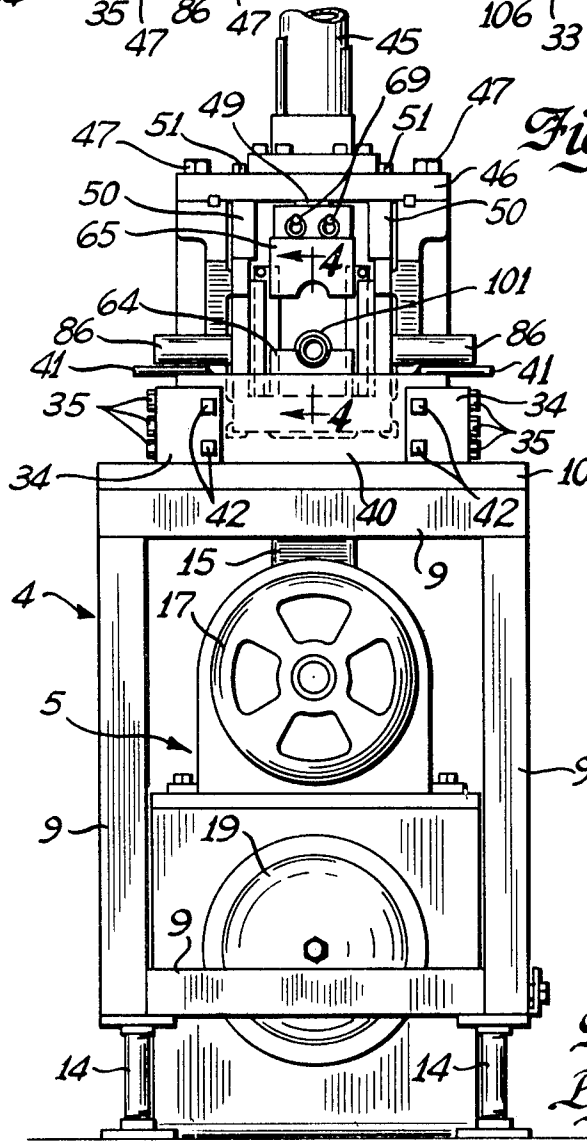


Fig. 3



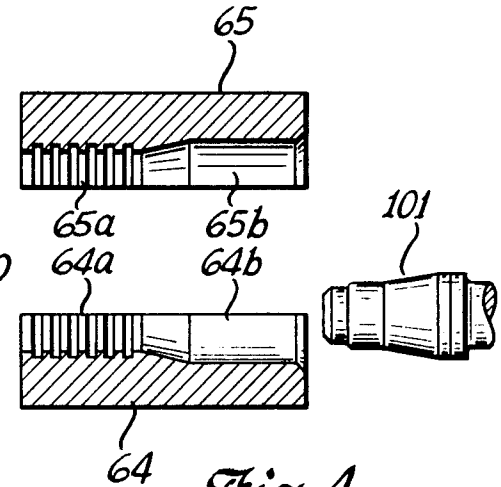


Fig. 4

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UNITIZED TUBE ENDS FORMING MACHINE

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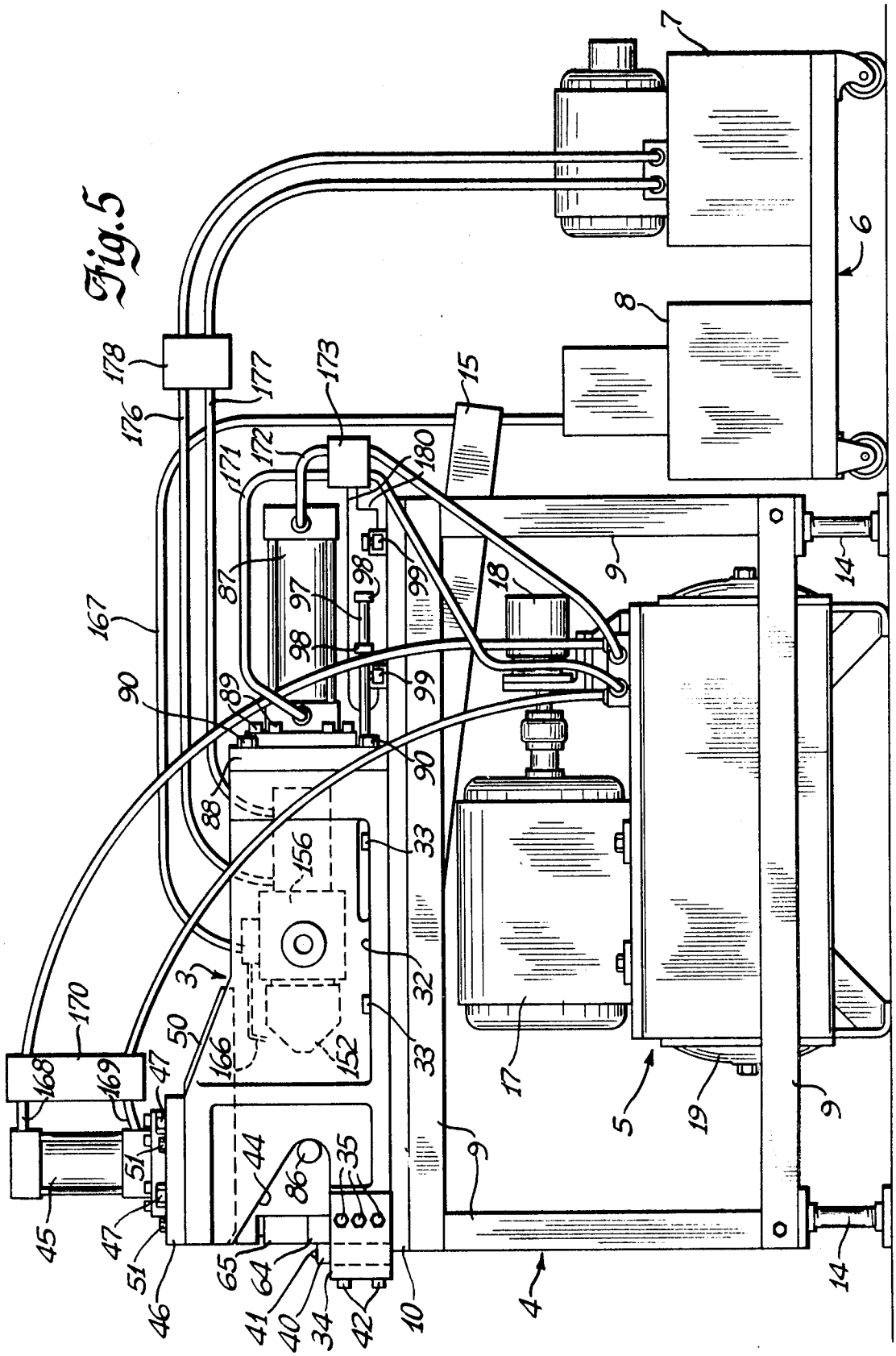
Fig. 5



UNITIZED TUBE ENDS FORMING MACHINE

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Fig. 6

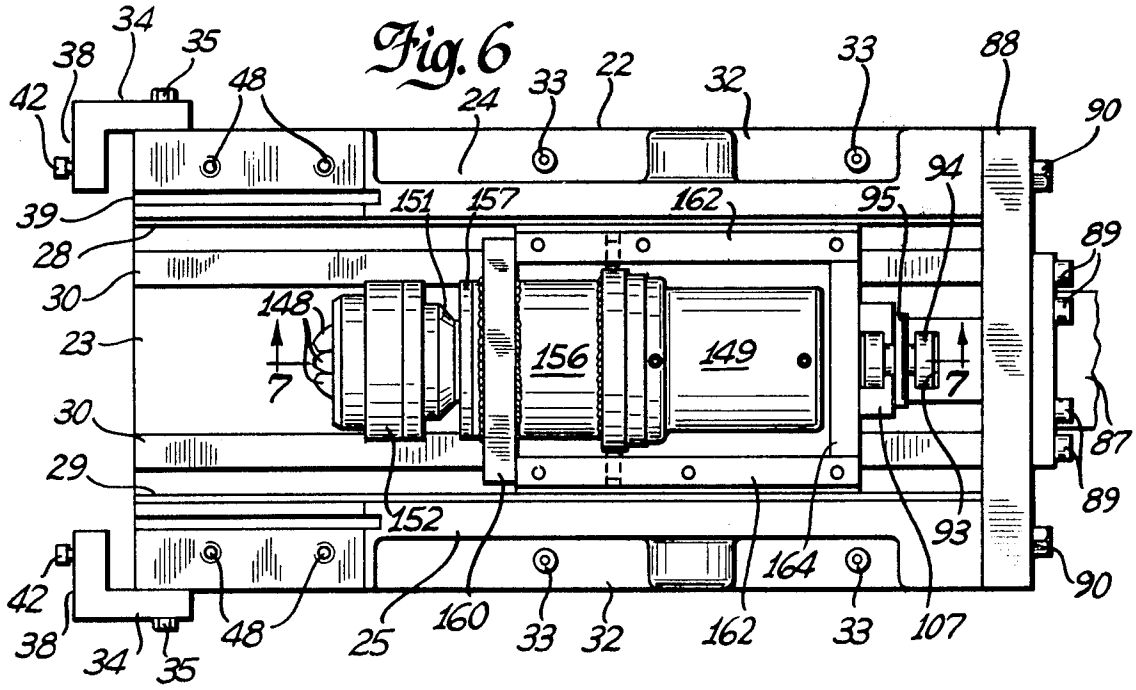
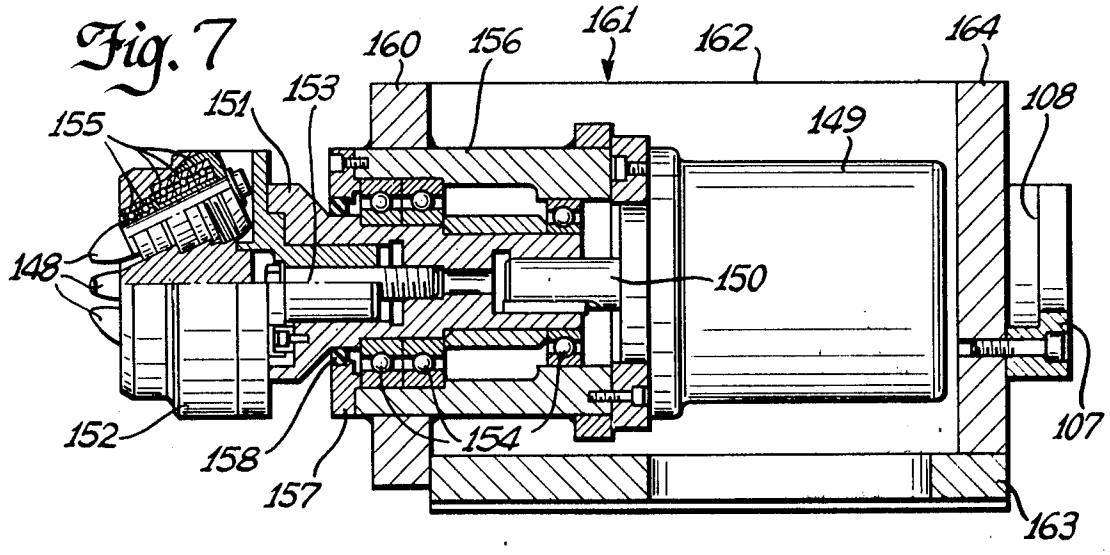


Fig. 7



EXPANDING

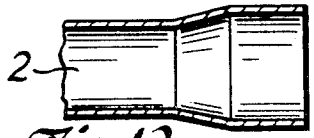


Fig. 13

SPHERICAL FLARING

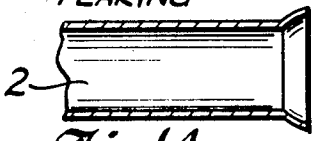


Fig. 14

BALL FORM BUBBLING

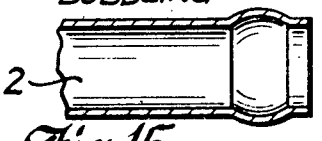


Fig. 15

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Fig. 8

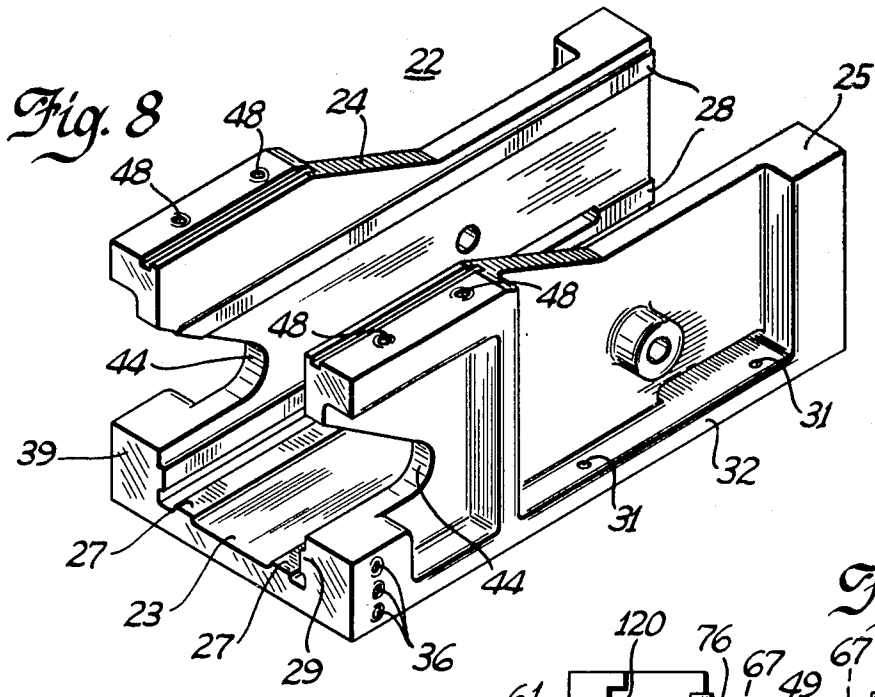


Fig. 9

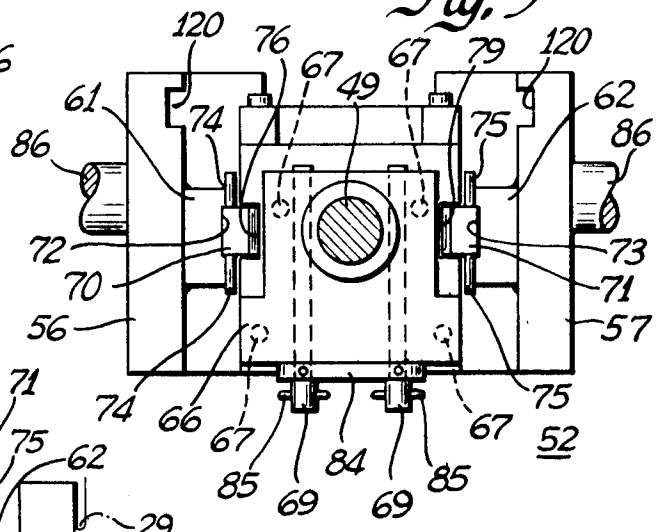
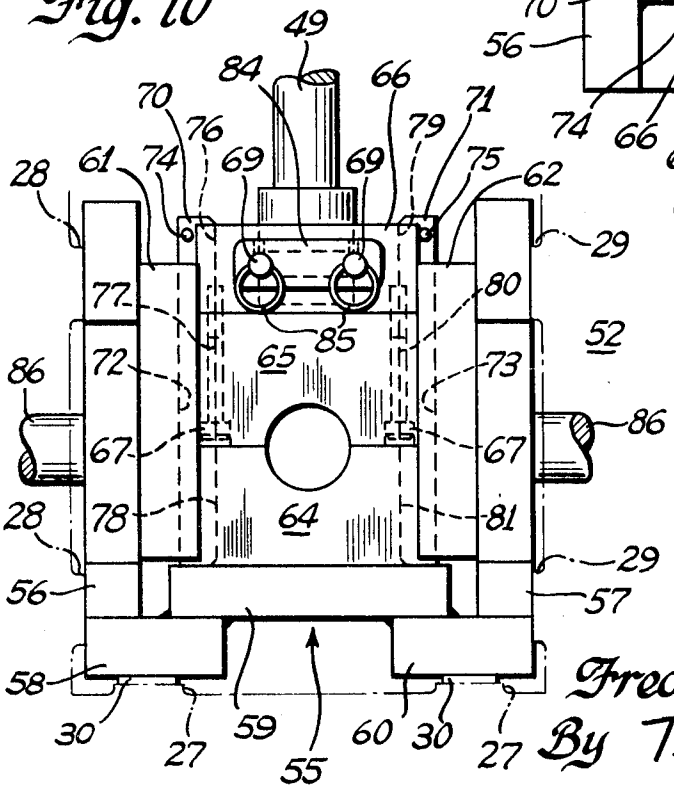


Fig. 10



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UNITIZED TUBE ENDS FORMING MACHINE

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Fig. 11

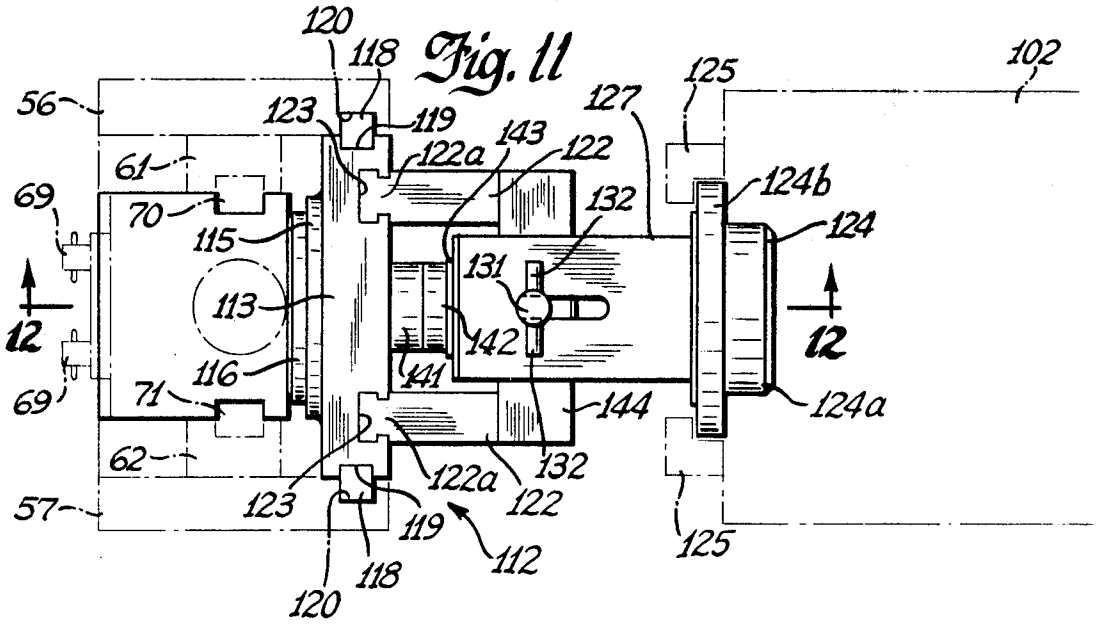
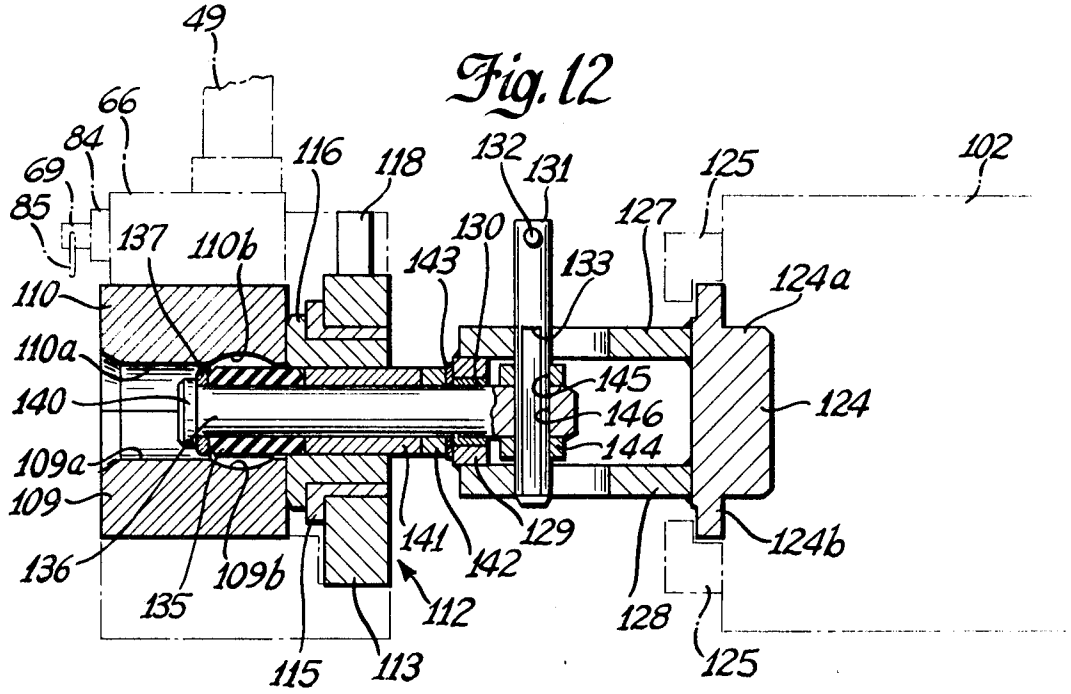


Fig. 12



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United States Patent Office 3,610,016 Patented Oct. 5, 1971

3,610,016

UNITIZED TUBE END FORMING MACHINE

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Int. Cl. B21d 39/02
U.S. Cl. 72—317 7 Claims

ABSTRACT OF THE DISCLOSURE

A machine for performing a wide variety of forming operations on the end of a metallic tubular article. The machine comprises a frame for receiving and holding various unitized assemblies which may be assembled in various combinations in order to permit a variety of end forming operations to be accomplished by the same basic machine.

BACKGROUND OF THE INVENTION

This invention relates to metal working machinery for forming ends of tubular articles.

There are in existence a wide variety of end forming machines for tubes which are generally specialized for performing individual end forming operations such as swaging, expanding, nibbing, dimpling, flanging and flaring. These and other operations performed by end operation machines utilize various metal forming tooling devices such as punches, rollers, mandrels, reducing dies and elastomeric expanding tools. Additionally there must be provided means for releasably clamping the tube in the machine.

Commonly, a specialized machine was required for each type of operation or group of similar operations.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a unitized end operations machine for tubular articles which machine is adaptable to perform a wide variety of end forming operations by providing a variety of interchangeable and removable operation performing sub-assemblies which may be inserted into the machine assembly. The machine may thereby be quickly and easily adapted to perform a variety of operations using a common basic assembly including a frame and power source.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a unitized hydraulically powered end forming machine embodying the present invention;

FIG. 2 is a top view of the machine shown in FIG. 1;

FIG. 3 is a front view of the machine shown in FIG. 1;

FIG. 4 is a fragmentary sectional view taken on line 4—4 of FIG. 3;

FIG. 5 is a side elevational view of a machine similar to that shown in FIG. 1 together with an auxiliary hydraulic power supply;

FIG. 6 is a top view of a portion of the apparatus of FIG. 5 with certain upper components removed;

FIG. 7 is a sectional view taken on line 6—6 of FIG. 6;

FIG. 8 is an isometric view of the frame casting of the assembly shown in FIGS. 1 and 5;

FIG. 9 is a top view of a portion of the clamping sub-assembly of the machines shown in FIGS. 1 and 5;

FIG. 10 is a front elevational view of the apparatus shown in FIG. 9;

FIG. 11 is a top view of a sub-assembly suitable for use in the basic machine as shown in FIG. 1;

FIG. 12 is a sectional view taken on line 12—12 of FIG. 11; and

FIGS. 13, 14, and 15 are cross sectional views of tubing formed by the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 there is shown hydraulically powered apparatus for forming the end of a pipe or tubular article 2 which might for example be a section of automotive exhaust pipe. The apparatus comprises generally a hydraulically operated end operations machine 3, a stand 4 upon which machine 3 is mounted, and a hydraulic power supply 5. FIG. 5 additionally illustrates a portable device 6 which includes an auxiliary hydraulic power supply 7 and a coolant supply 8.

End operations machine 3 rests upon and is fastened to stand 4 which comprises a framework of angle iron members 9 topped by a heavy steel plate 10. Stand 4 rests at its four corners upon four adjustable legs 14. A coolant return trough 15 is provided beneath plate 10 to return liquid coolant when used to coolant supply 8 as shown in FIG. 5. The coolant flows from end operations machine 3 through apertures (not shown) in plate 10.

Hydraulic power supply 5 rests upon the floor beneath plate 10 of stand 4 and within the framework of stand 4. Hydraulic power supply 5 comprises an electric motor 17, a hydraulic pump 18, and a fluid reservoir 19. Hydraulic power supply 5 is conventional in its construction and operation.

The auxiliary coolant and hydraulic power supply unit 6 as shown in FIG. 5 comprises the auxiliary power supply 7 and the coolant supply 8. Coolant supply 8 is conventional in its operation and includes an electrically powered coolant pump (not shown). Coolant return trough 15 discharges into the open upper end of coolant supply 8.

The end operations machine 3 itself is an assembly, the basic member of which is a frame 22 which is best illustrated in FIG. 8. Frame 22 is a channel shaped rigid casting having a generally U-shaped cross section. Frame 22 comprises a base portion 23 and sides 24 and 25 which extend upwardly from the lateral edges of base 23. In their construction sides 24 and 25 bear a mirror image relationship to one another.

A pair of longitudinal ways or gibs 27 are provided on the base 23 of frame 22 to provide sliding support for machine elements to be assembled within frame 22. Similarly, a pair of machined gibs 28 are provided on the inner surface of side 24 and gibs 29 are provided on the inner surface of side 25 to laterally support elements assembled within frame 22. As shown in FIG. 10 a pair of wear strips 30 made out of a good bearing material such as brass are mounted on top of the lower gibs 27.

Four holes 31 are provided through the lower flanged edges 32 of frame 22 through which machine screws 33 pass to threadingly engage tapped holes (not shown) in plate 10 to fasten frame 22 to stand 4.

A similar pair of L shaped brackets 34 are fastened to the sides 24 and 25 of frame 22 adjacent the front end of frame 22 by means of six machine screws 35 which are threaded into tapped holes 36. The inwardly extending shorter lengths 38 are spaced from the front surface 39 of frame 22 to provide vertical slots to accommodate the ends of a retainer plate 40. Retainer plate 40 slides vertically within the slots so formed and when in place rests at its lower edge upon the top surface of plate 10. A pair of oppositely extending handles 41 project from the top edge of plate 40 to facilitate

the lifting of plate **40**. Set screws **42** are threaded through the inner ends of legs **38** and may be turned to firmly secure plate **40** in place.

The front edges of sides **24** and **25** of frame **22** are provided with recessess **44**.

A vertically operable hydraulic cylinder **45** of conventional construction and operation is mounted on the top of frame **22** adjacent the front end of frame **22**. Cylinder **45** is bolted to a top plate **46** which is in turn bolted to the top front edges of sides **24** and **25** by means of machine screws **47** which are threaded into holes **48**.

A piston rod **49** extends downwardly from the end of piston **45** and through top plate **46**. A pair of similar guide plates **50** are bolted to the lower side of top plate **46**.

A clamping module **52** is assembled within frame **22** beneath upper plate **46** and guide plates **50** as best shown in FIGS. 9 and 10. Clamping module **52** includes supporting means comprising a U shaped weldment **55** having side plates **56** and **57**, bottom plates **58**, **59**, and **60**, and vertically aligned guides **61** and **62**. Guides **61** and **62** are welded to the inside faces of side plates **56** and **57**. A stationary bottom jaw **64** rests upon bottom plate **59**. A vertically moveable top jaw **65** is slidingly mounted between guides **61** and **62**. Top jaw **65** is fastened to an adaptor block **65** by means of bolts **67**. Adaptor block **66** is in turn removeably fastened to the lower end of piston rod **49** by means of a pair of pull pins **69** which pass through adaptor block **66** to engage a circumferential groove **70** formed adjacent the lower end of piston rod **49**.

A pair of vertical parallel keys **70** and **71** are slidingly fit into keyways **72** and **73**, respectively, which keyways **72** and **73** are formed in the inward facing edges of guides **61** and **62**, respectively. Handles **74** and **75** are provided adjacent the upper ends of keys **70** and **71** to facilitate reremoval of keys **70** and **71**. When in assembly, keys **70** and **71** slidingly engage aligned grooves on the sides of adaptor block **66**, upper jaw **65** and bottom jaw **64**. Thus key **70** slidingly engages groove **76** in adaptor block **66**, groove **77** in upper jaw **65** and groove **78** in lower jaw **64**. Similarly, key **71** engages groove **79** in adaptor block **66**, groove **80** in jaw **65** and groove **81** in lower jaw **64**. Thus it may be seen that the tooling within framework **55** may be removed simply and easily by the withdrawal of keys **70** and **71** which permits jaws **64** and **65** and adaptor block **66** to be then withdrawn from the front of framework **55** of clamping module **52**. Adaptor block **66** can easily be removed from the lower end of piston rod **49** by the withdrawal of pull pins **69**. The outer ends of pull pins **69** are joined together by a pull plate **84** and are furnished with rings **85** to facilitate the removal of pull pins **69**.

A pair of oppositely extending locating pins are provided on side plates **56** and **57** to engage the inner end of recesses **44** to prevent the inward movement of clamping module **52**.

It can therefore be seen that the entire clamping module including framework **55**, jaws **64** and **65**, and adaptor block **66** can quickly be inserted or removed from the front end of frame **22** when retainer plate **40** is removed and when adaptor block **66** is disconnected from the lower end of piston rod **49** by removing pull pins **69** and retracting piston rod **49** to its upper position.

At the back end of frame **22** there is furnished another hydraulic cylinder for the purpose of horizontally moving operating modules within frame **22**. Hydraulic cylinder **87** is fastened to a back plate **88** by means of machine screws **89**. Back plate **88** is in turn fastened to the rear edges of sides **24** and **25** of frame **22** by means of machine screws **90**. As shown in FIG. 6, a piston rod **91** extends from the front end of hydraulic cylinder **87** and through back plate **88**. The front end of piston rod **90** is furnished with a T slot **93** to accommodate one end

of a roughly dumbbell shaped pull plug **94** which serves to mechanically connect piston rod **90** to operating modules within frame **22**. A handle **95** extends upwardly from pull plug **94** to facilitate removal and insertion of pull plug **94**.

A control rod **97** is attached to the lower side of piston rod **90** adjacent its front end and extends rearwardly through plate **88**. A pair of axially adjustable collars **98** are attached to the rearwardly extending end of control rod **97** to engage limits which is **99** to thereby limit the extent of the axial movement of piston rod **90**.

The variety of operating tooling which might be placed within frame **22** and moved by piston rod **90** is almost limitless. For exemplary purposes, three types of tooling are herein shown and described. Tooling for flaring by spinning is shown in FIGS. 5, 6, and 7. Expanding tooling is shown in FIGS. 2, 3 and 4. Tooling for bubbling is shown in FIGS. 11 and 12. The tube end forms resulting from expanding, flaring, and bubbling are shown in FIGS. 13, 14, and 15, respectively.

Referring to FIGS. 2, 3, and 4 there is shown tooling for performing an expanding operation on the end of a tube **2** to obtain the tube end form shown in FIG. 13. The bottom jaw **64** and the top jaw **65** have oppositely facing grooved areas **64A** and **65A**, respectively, for gripping tube **2** when jaws **64** and **65** are pressed together by hydraulic cylinder **45**. Lower jaw **64** and upper jaw **65** have oppositely facing enlarged portions **64B** and **65B**, respectively, to accommodate and form the expanded end portion of tube **2**. A partly conical expanding tool **101** is forced into the end of tube **2** when tube **2** is gripped by jaws **64** and **65** to expand tube **2** outwardly into the cavity portions **64B** and **65B**.

Expander **101** is mounted on the front face of a rectangular spacing weldment **102** which consists of a front plate **103**, a rear plate **104**, a bottom plate **105** and two side plates **106**. Expander tool **101** is mounted in an aperture in the approximate center of front plate **103**.

Spacer **102** is reciprocally slidable within frame **22** on gibs **27**, **28**, and **29**. A pull plate is fastened to the rear plate **104** of spacer **102** and a T slot **108** is formed therein to accommodate the other end of pull plug **94**. Spacer **102** is thereby mechanically connected to piston rod **90**. Actuation of hydraulic cylinder **87** will therefore cause expander tool **101** to be moved into and out of contact with the end of tube **2**.

When spacer **102** is in the position shown in FIG. 2, spacer **102** and expander **101** may be quickly and easily removed or inserted into the assembly either through the open top of frame **22** or through the front end of frame **22** when clamping assembly **52** is removed. Spacer **102** is disconnected from piston rod **90** simply by pulling on handle **95** to remove pull plug **94**.

Apparatus and tooling used to accomplish ball form bubbling to form the shape shown in FIG. 16 is illustrated in FIGS. 11 and 12. A bottom jaw **109** and a top Jaw **110** are furnished with cavities **109A** and **110A**, respectively, which form a cylindrical portion fitting closely around a pipe when inserted therein. There is also formed therein a spherical cavity comprising upper portion **110B** and a lower portion **109B**. In other respects lower jaw **109** and upper jaw **110** are similar to the previously described lower jaw **64** and upper jaw **65**.

Immediately behind jaws **109** and **110** there is a stop assembly **112** comprising a plate **113**, a cylindrical sleeve **114**, a bushing **115** and an internal cylindrical bushing **116**. The bushing **115** is welded to plate **113**. Internal bushing **116** is pressed into sleeve **114** and may be reremoved and replaced with a bushing with a different internal diameter for use with a different size tubing.

Plate **113** is prevented from moving forwardly or rearwardly by keys **118** which engage keyways **119** formed in the lateral edges of plate **113** and the corresponding keyways **120** formed on the inner faces of side plates **61** and **62** of clamping module **52**.

A pair of stop blocks extend rearwardly from plate **113** and are removably assembled thereto by the engagement of the T shaped portions **122A** of blocks **122** with corresponding T shaped slots **123** formed in plate **113**. Slots **123** are open at the top of plate **113**. Blocks **122** may therefore be easily inserted or removed by sliding the T shaped portions **122A** within slots **123**.

The male portion of the bubbling tooling comprises an assembly mounted on the front face of the sliding spacer **102**. A base **124** has a rearwardly extending cylindrical portion which fits closely within an aperture centrally located within the front plate **103** of spacer **102**. The base **124** further comprises a flange **124B** which overlies the front face of plate **123**. A plurality of clamps **125** engage the periphery of flange **124B** and are fastened to plate **103** to hold base **124** in place.

Extending forwardly from base **124** are an upper plate **127** and a lower plate **128**. A plate **129** is welded between the ends of plates **127** and **128**. A cylindrical bearing **130** is supported in the center of plate **129**. Both upper and lower plates **127** and **128** are slotted to provide for the relative movement therein of a pin **131**. Pin **131** is provided with handles **132** to facilitate the removal thereof. The lower portion of pin **131** is flattened slightly on each side and when pin **131** is in assembly a pair of shoulders support pin **131** in the position shown in FIG. 12 by the engagement of shoulders **133** with the upper surface of plate **127**.

An elastomeric expanding member **135** of cylindrical form is supported by a pin **136**. The elements assembled on pin **136** are assembled in the following order. First a washer **137** is placed over pin **136** and moved along pin **136** until it engages head **140** of pin **136**. Next the elastomeric sleeve **135** is placed over pin **136** followed by one or more cylindrical loosely fitting sleeves such as sleeves **141** and **142**. A washer **143** is then placed over the end of pin **136**. The small end of pin **136** is then inserted through bearing **130** and a cross piece **144** with a central aperture is placed over the end of pin **136** in a position as shown in FIG. 12. Pin **131** is then inserted through the aligned apertures **145** of cross piece **144** and aperture **146** adjacent the end of pin **136**.

In operation a tube **2** is inserted into the cavities **109A** and **110A** from the front of end operations machine **3** until the end of the tube **2** hits the front surface of bushing **116**. Hydraulic cylinder **145** is then actuated to bring upper jaw **110** downwardly to grip tube **2**. Hydraulic cylinder **87** is then energized to move sliding spacer **102** toward the front of machine **3**. When the bubbling tooling shown in FIGS. 11 and 12 reaches the position shown therein and cross piece **144** contacts stop blocks **122**, pin **131** holds pin **136** from further movement while plates **127** and **128** are pressed further towards the front of machine **3**. A force is thereby exerted against washer **143** and through washers **141** and **142** against the back end of elastomeric sleeve **135**. Since washer **137** holds the front end of elastomeric sleeve **135** against further movement, elastomeric sleeve **135** is compressed and expands outwardly to press tube **2** outwardly into the spherical cavities **109B** and **110B** thereby forming the ball form as shown in FIG. 16. Reversal of the movements of hydraulic cylinders **87** and **45** reverses the above described process to permit the end of tube **2** to be withdrawn from the machine.

A third exemplary type of tooling which may be used in machine **3** is illustrated in FIGS. 5, 6, and 7. The tooling there shown is of the spinning type where four rollers **148** are pressed while turning into the end of tube **2** to form the spherical flare as illustrated in FIG. 14. This apparatus comprises an hydraulic motor **149** with its shaft **150** connected to a shaft **151** by a key **152**. A rotating tool holder **152** is fastened to the forward end of shaft **151** by a bolt **153**. Shaft **151** is supported by three sets of ball bearings **154**. Each of rollers **148** is supported by ball bearings **155**. Ball bearings **154** are supported by an enclosure **156** in which a lubricant may be placed. The forward end of enclosure **156** is closed by a cover plate **157** and a seal **158**. Hydraulic motor **149** is fastened to the other end of enclosure **156**.

Enclosure **156** is supported by a front plate **160** of a sliding support **161**. Sliding support **161** further comprises side plates **162**, a bottom plate **163** and a back plate **164**. Pull plate **107** is bolted to the back plate **164**. Sliding support **161** slides within frame **22** and is connected to piston rod **90** in the same manner as the sliding spacer **102** previously described. Support **160** together with the tooling mounted thereon may also be easily removed through the front or top of frame **22**.

The entire apparatus used for the spinning operation is illustrated in FIG. 5. A liquid coolant is delivered to the vicinity of rollers **148** through a tube **166** and a hose **167** from coolant supply **8**. Hydraulic cylinder **45** may be operated in either direction by hydraulic pressure delivered by means of hoses **168** and **169** through a hydraulic control **170** from hydraulic power supply **5**. Similarly, hydraulic cylinder **87** may be operated in either direction by hydraulic pressure delivered through hoses **171** and **172** through a hydraulic control **173** from hydraulic power supply **5**. Hydraulic power is supplied to hydraulic motor **149** by means of hoses **176** and **177** through hydraulic control **178** from the auxiliary hydraulic power supply **7**. Limit switches **99** are connected to hydraulic control **173** by electrical cables **180**.

I claim:

1. A machine for forming ends of tubular articles comprising the combination of:

frame means comprising an open topped channel shaped elongated member having a front end and a back end and having a generally U shaped cross section;

clamping means for gripping a tubular article when the end of said tubular article is inserted in said front end of said frame means, said clamping means comprising jaw means movable to grip said articles and support means for supporting said jaw means, said jaw means and support means comprising a unitary module removably mounted within said frame adjacent said front end of said frame means;

first operating means for operating said jaw means and being removably assembled to said frame on the top of said frame over said clamping means;

operation performing means for performing a forming operation on said end of said article within said machine comprising tooling means for engaging said end and tool supporting means for supporting said tooling, said tooling means and said tool supporting means comprising a unitary operating module removably assembled within said frame and reciprocally movable therein toward and away from said front end to engage said end of said tube; and

second operating means for reciprocally moving said operation performing means and being mounted on said back end of said frame.

2. The invention as defined in claim **1** wherein said first operating means comprises hydraulic cylinder means.

3. The invention as defined in claim **1** wherein said second operating means comprises hydraulic cylinder means.

4. The invention as defined in claim **1** wherein said operation performing means comprises hydraulically powered spinning means.

5. The invention as defined in claim **4** together with an auxiliary hydraulic power source for furnishing power to said spinning means.

6. The invention as defined in claim **5** in which said auxiliary hydraulic power source is part of an auxiliary unit which further includes a coolant supply which furnishes liquid coolant to said spinning means.

7. The invention as defined in claim **1** in which said jaw means comprises a plurality of jaw members, at least one of said jaw members being slidable within said

supporting means and releasably connected to said first operating means.

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RICHARD J. HERBST, Primary Examiner

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