United States Patent [19]

Bringewald

[11] **3,847,004**

[45] **Nov. 12, 1974**

[54] **APPARATUS AND METHOD FOR APPLYING PRESSURE AND DIE AND METHOD FOR FORMING A PART**

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[73] Assignee: **Bringewald Process Corporation,** Huntington, N.Y.

[22] Filed: **Mar. 25, 1971**

[21] Appl. No.: **128,085**

[52] **U.S. Cl.** **72/184,** 72/353

[51] **Int. Cl.** **B21j 13/02**

[58] **Field of Search** 72/184, 192, 207, 353, 72/403, 259, 411; 425/356

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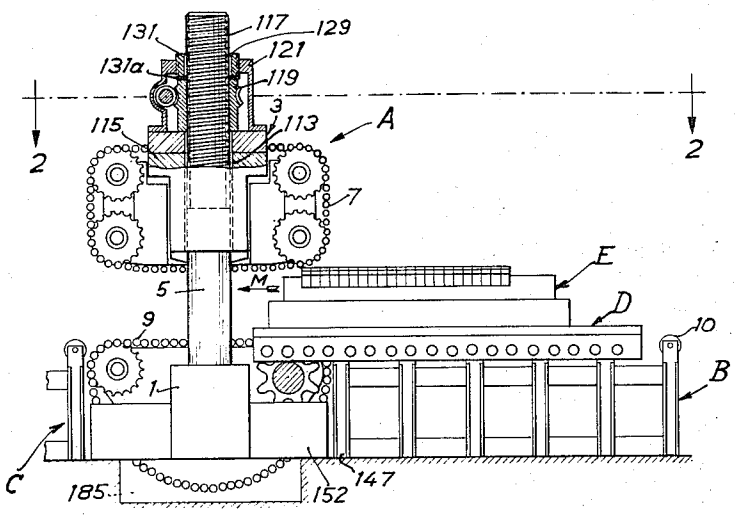
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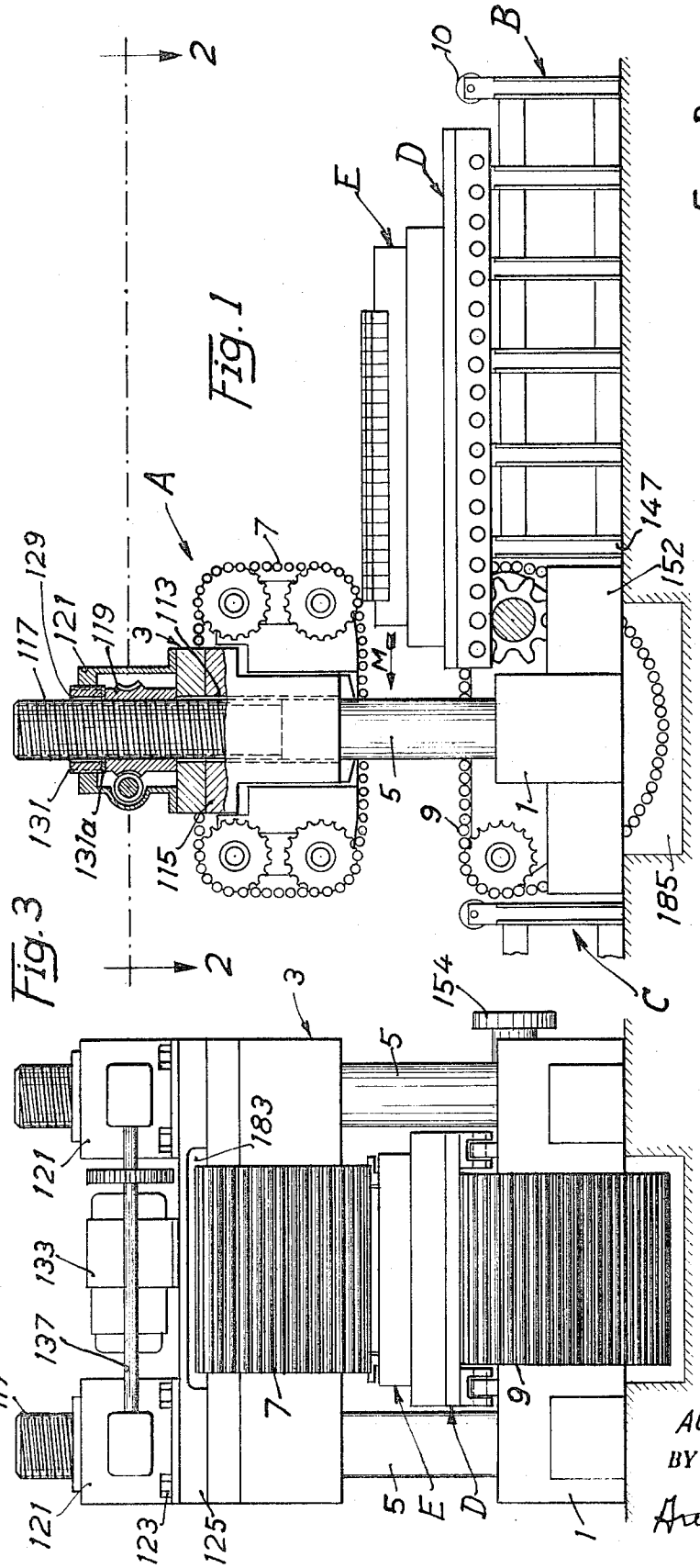
Primary Examiner—Lowell A. Larson

[57] **ABSTRACT**

Apparatus including pressure means for applying pressure, work comprising a die and a blank of material adapted to be conveyed through said pressure means to force said die into said blank to form a part, means for removably securing said die to said blank whereby said die and blank may be heated separately and conveniently assembled prior to processing, said pressure means operating on said work through roller bearing means, said die comprising a plurality of die segments having cavities on the undersurface thereof, a force translating element for each of said die segments, said force translating elements being positioned to receive rolling pressure from said roller bearing means and to transfer the applied pressure to the die segments with a minimum of rocking force, said pressure means including a main pressure unit sandwiched between two auxiliary pressure units, said main pressure unit inducing a compression force into the blank of material by way of the force translating elements and the die segments to cause flow of material into said die cavities, said auxiliary pressure units inducing into the blank of material a compression force of predetermined magnitude which is sufficient to prevent flow of blank material outside the area beneath the main pressure unit thereby preventing material buildup on the trailing edge of the blank, said pressure units being provided with inwardly inclining entries for gradually applying pressure, said roller bearing means comprising rollers for converting sliding friction into rolling friction, the diameter of said rollers being dimensionally related to the thickness of said force translating and the spacing of said rollers is controlled so as to further minimize the power required to convey the work through the pressure means.

14 Claims, 24 Drawing Figures





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Fig. 4

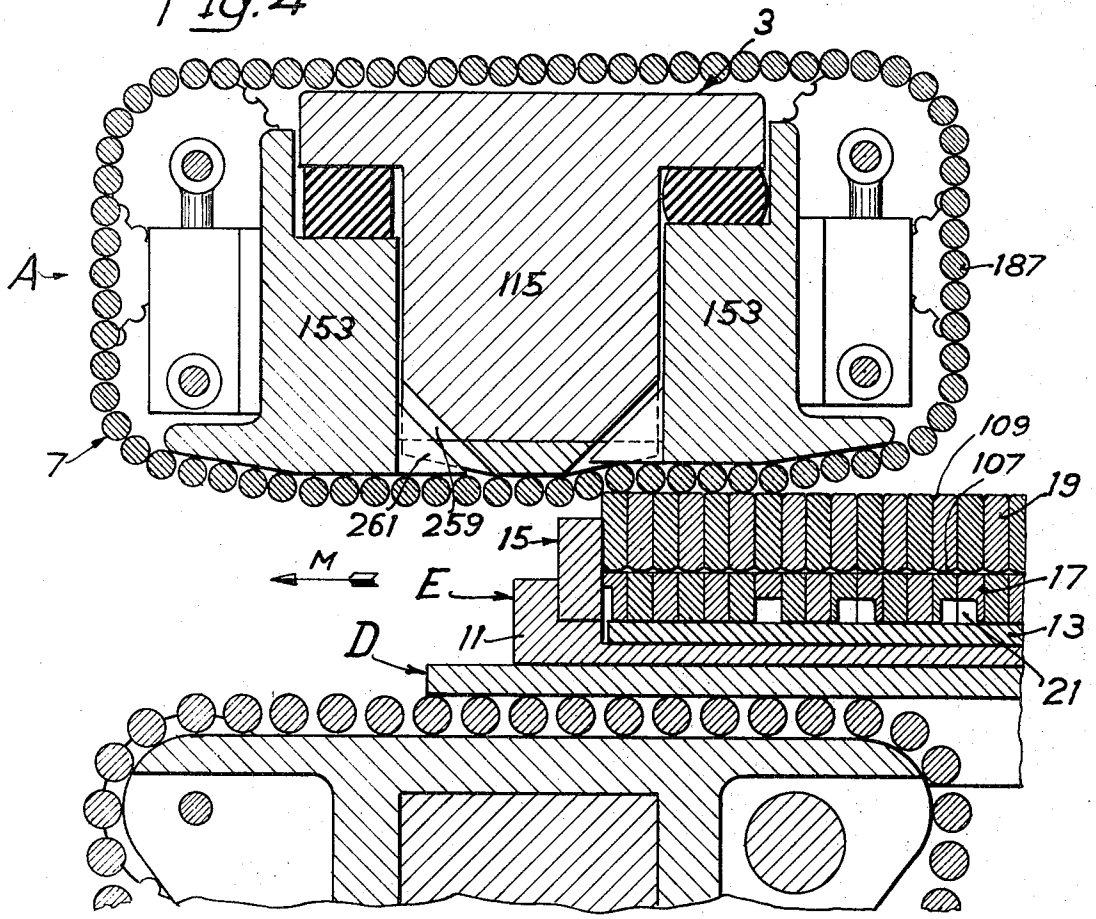
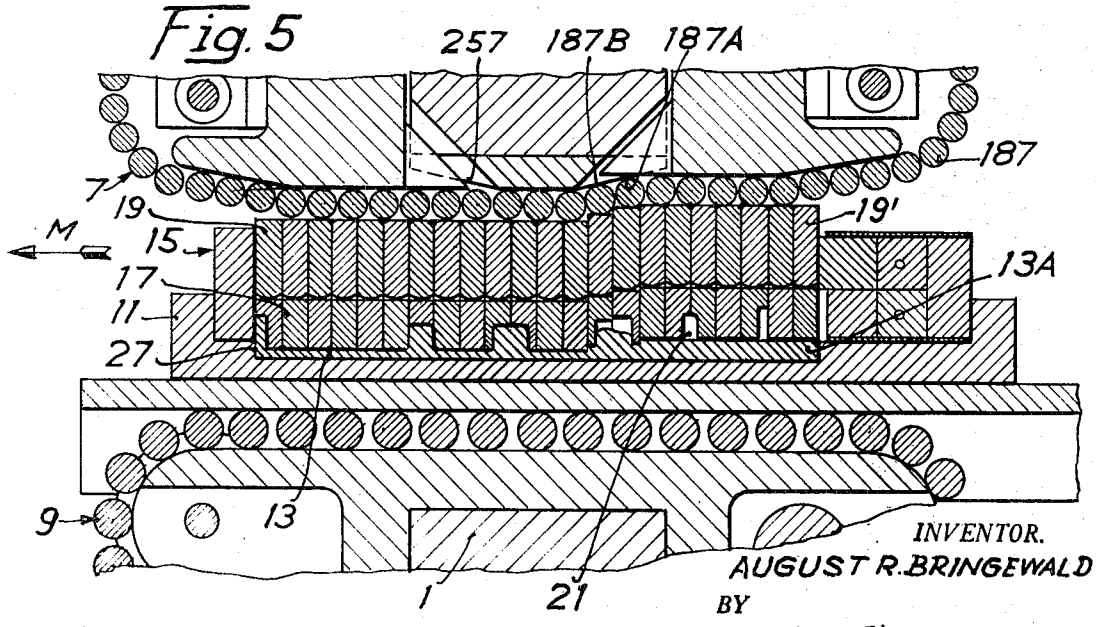


Fig. 5



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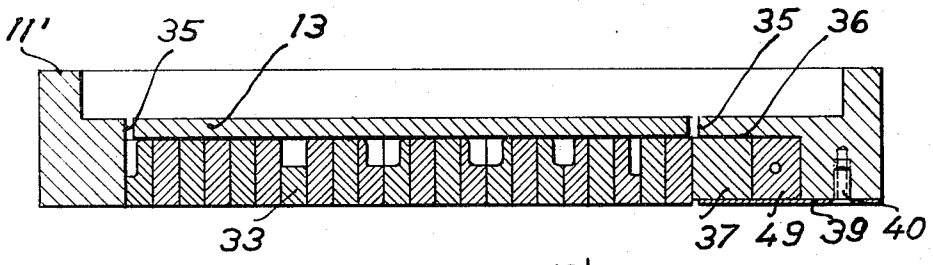


Fig. 10

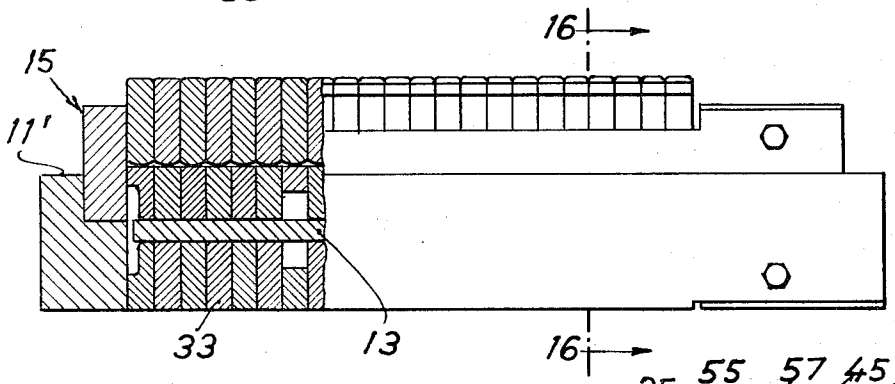


Fig. 11

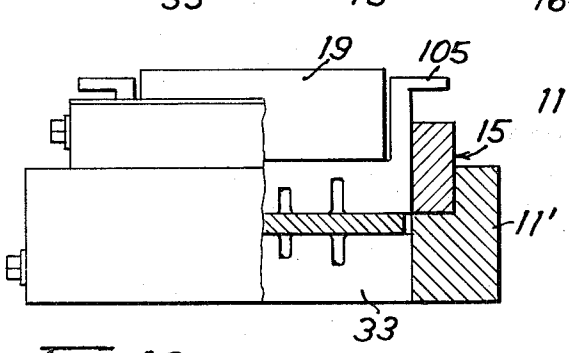


Fig. 16

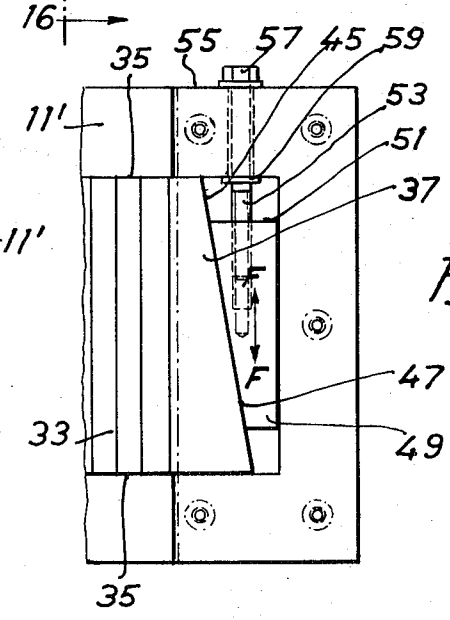


Fig. 12

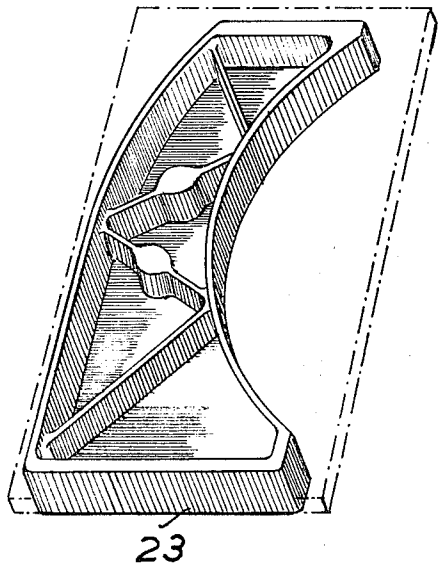


Fig. 6

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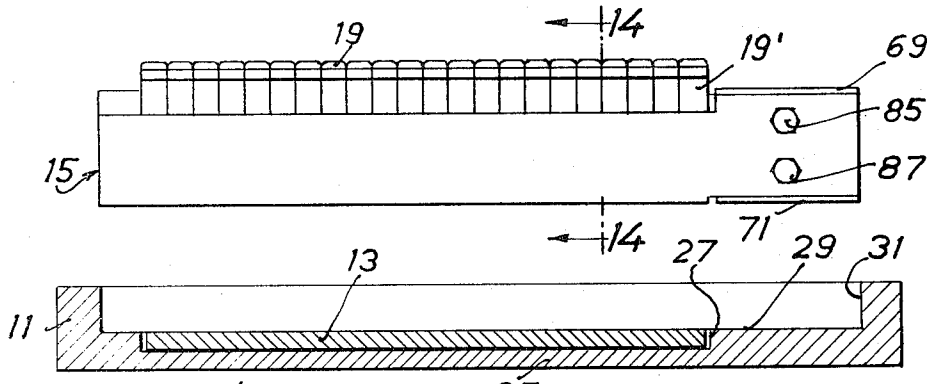


Fig. 7

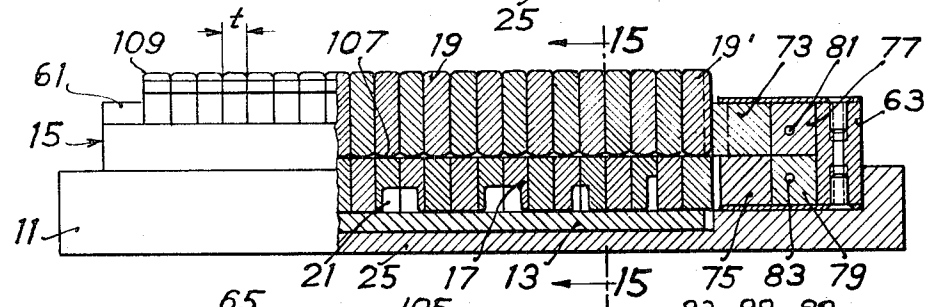


Fig. 8

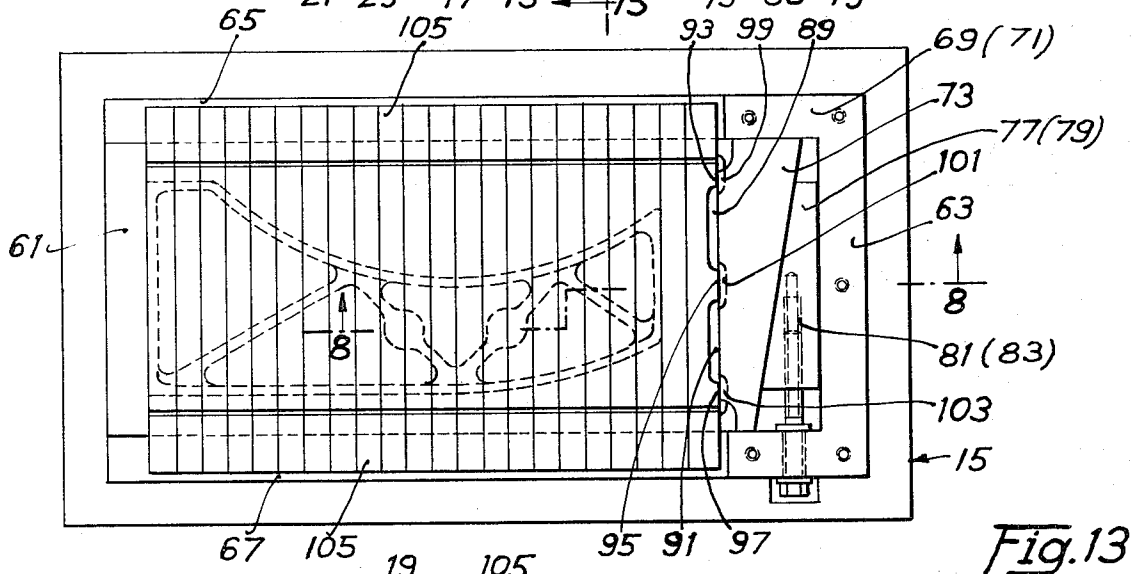


Fig. 13

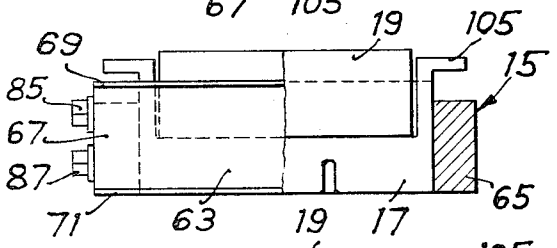


Fig. 14

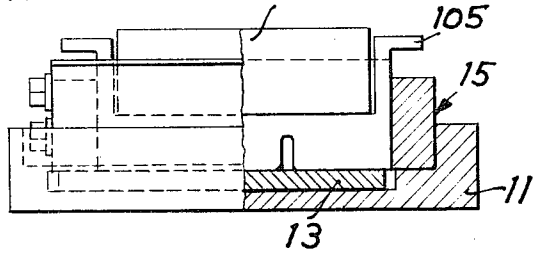


Fig. 15

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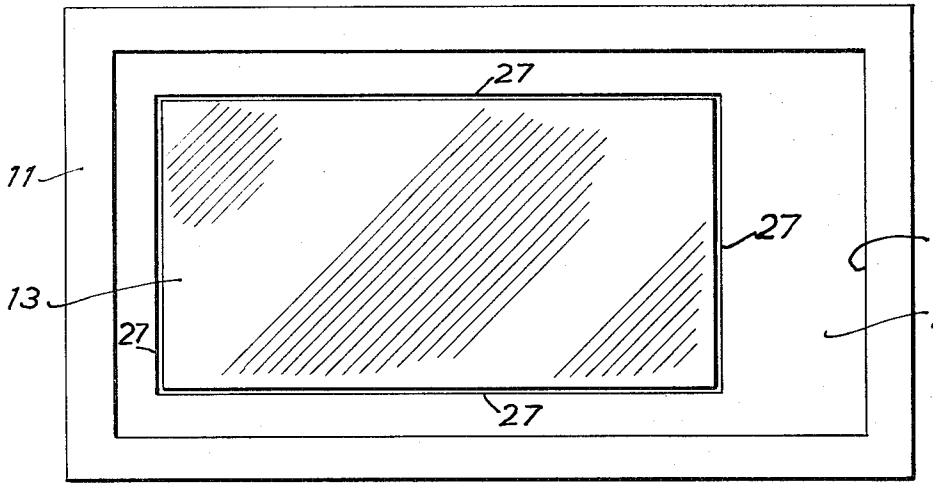


Fig. 9

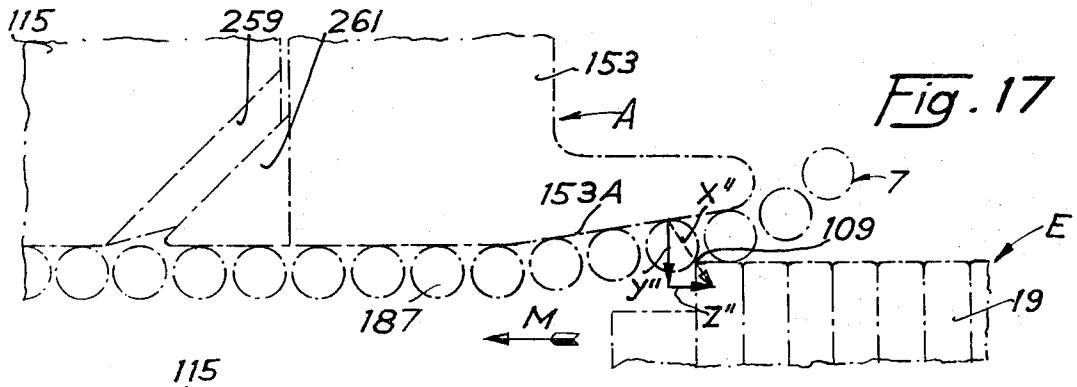


Fig. 17

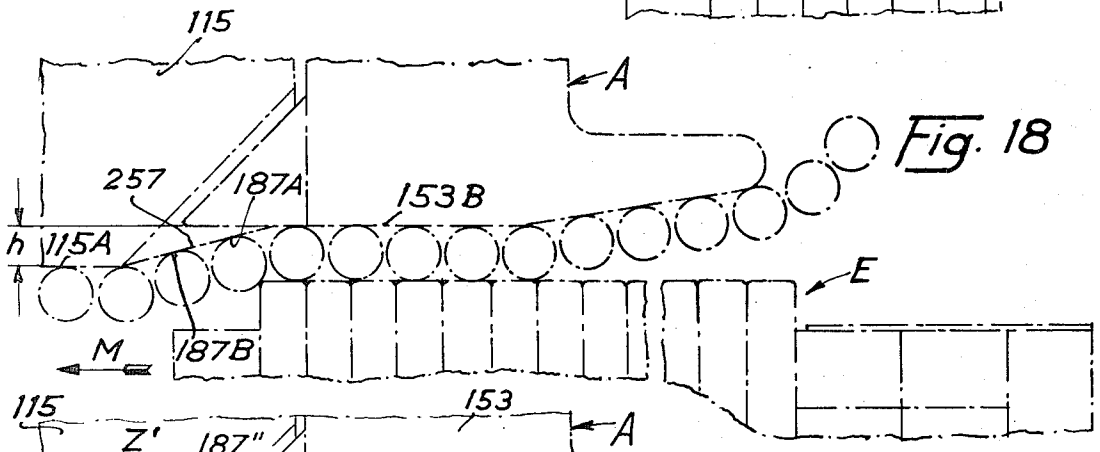


Fig. 18

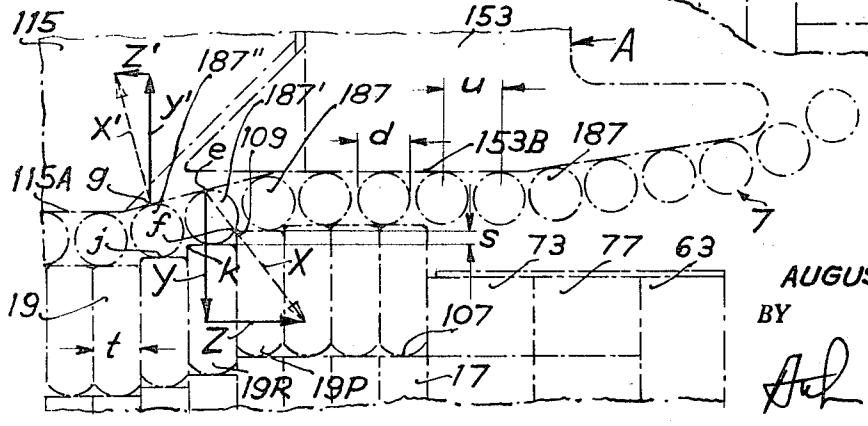
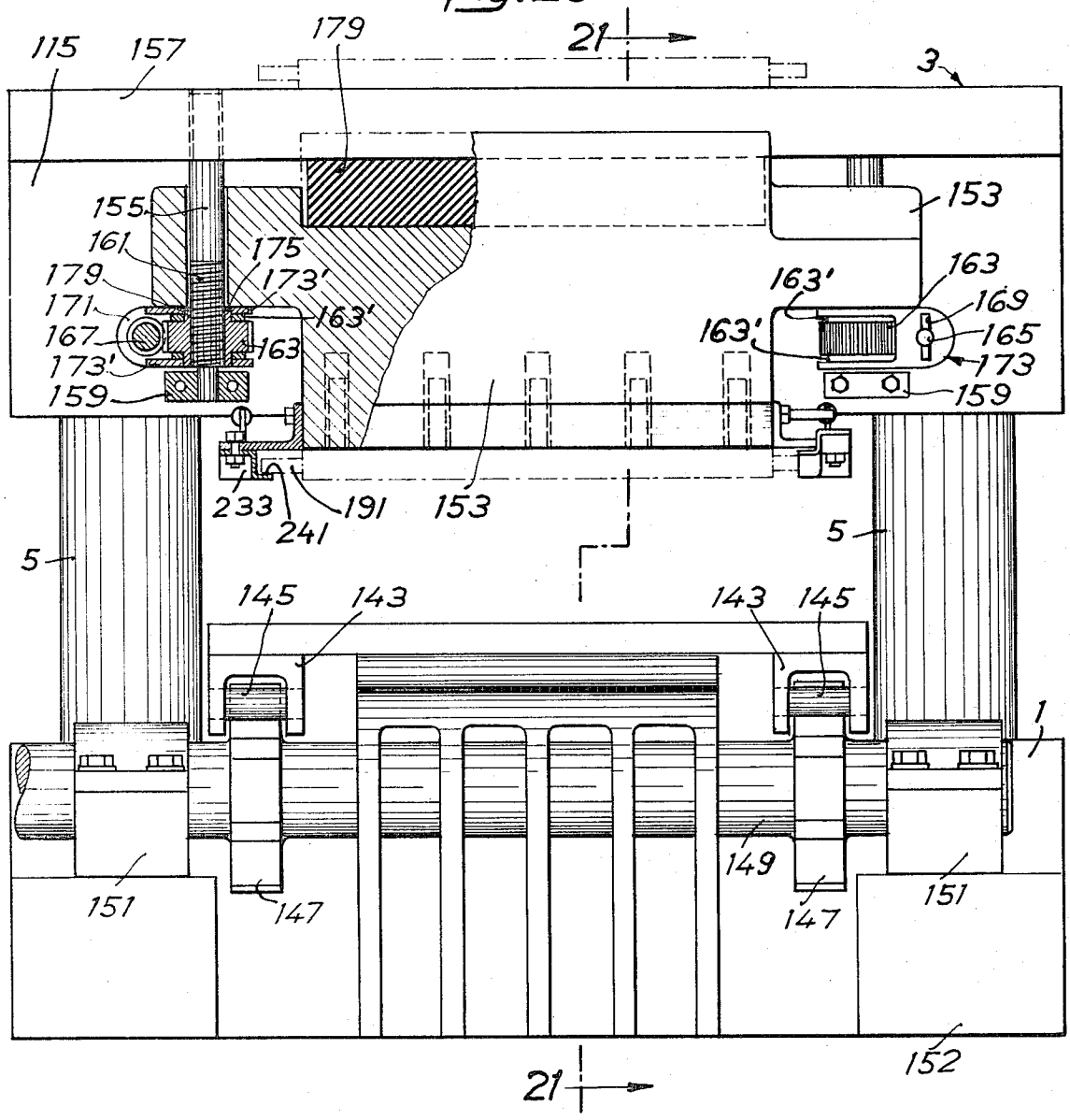


Fig. 19

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Fig. 20

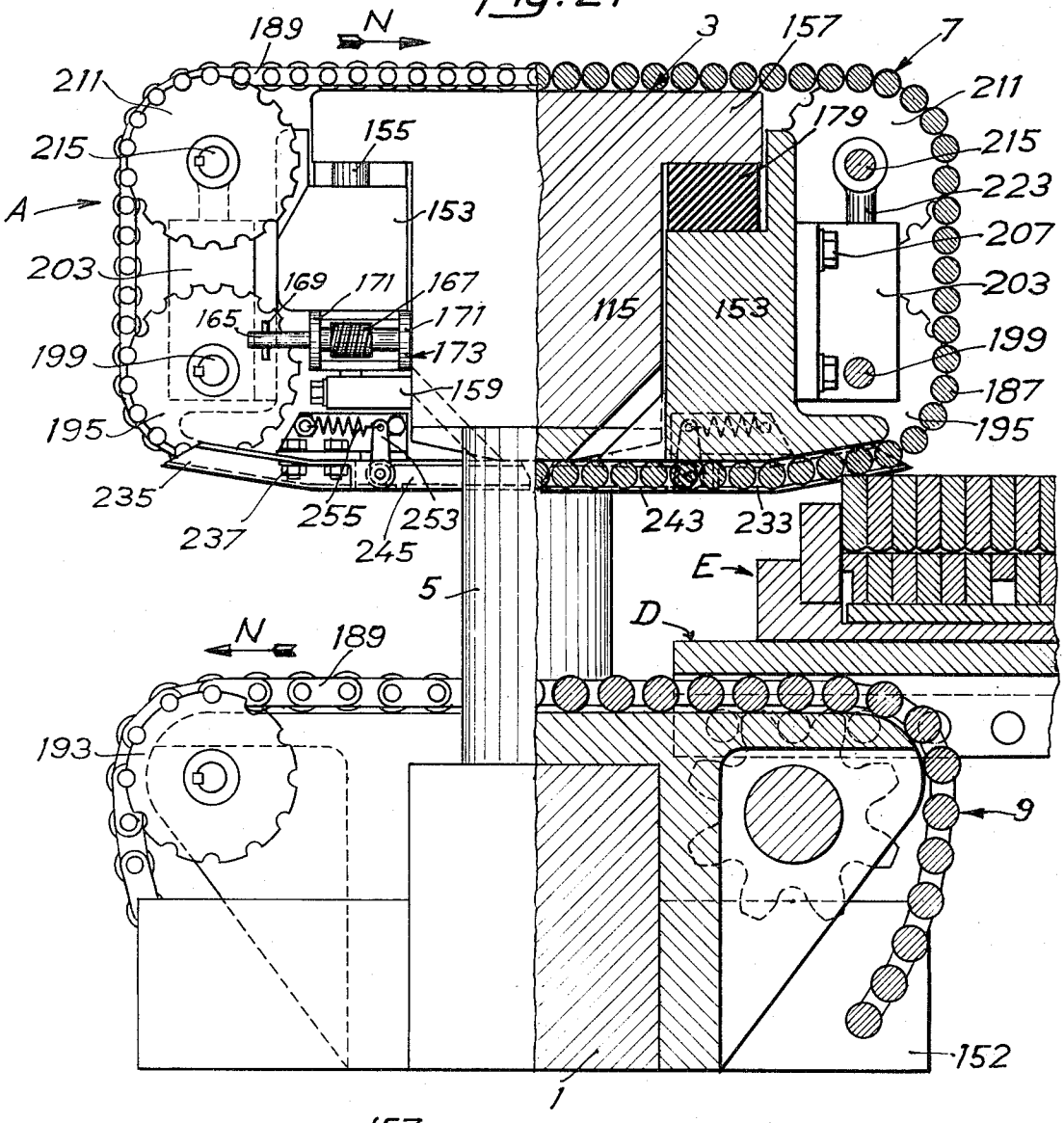


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Fig. 21



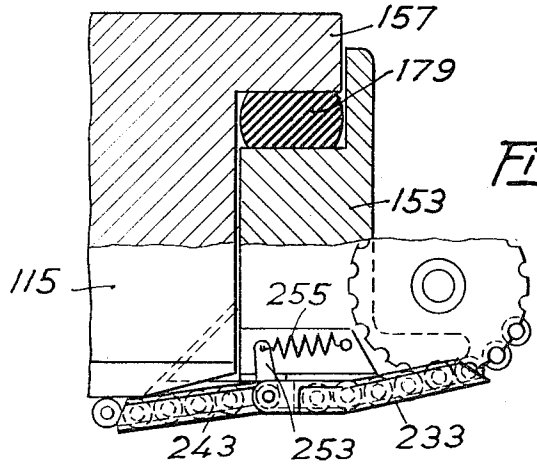


Fig. 23

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Fig. 22

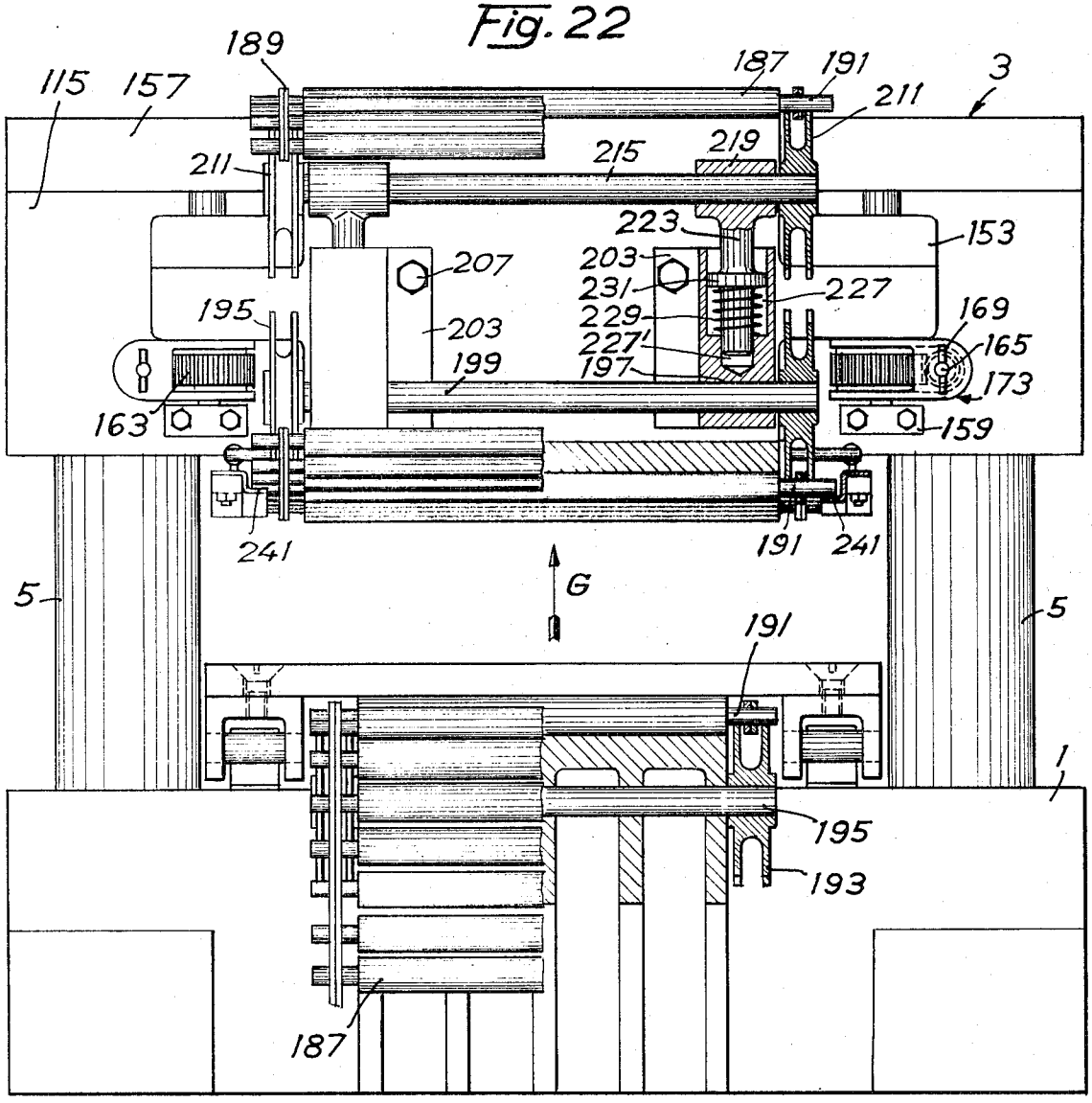
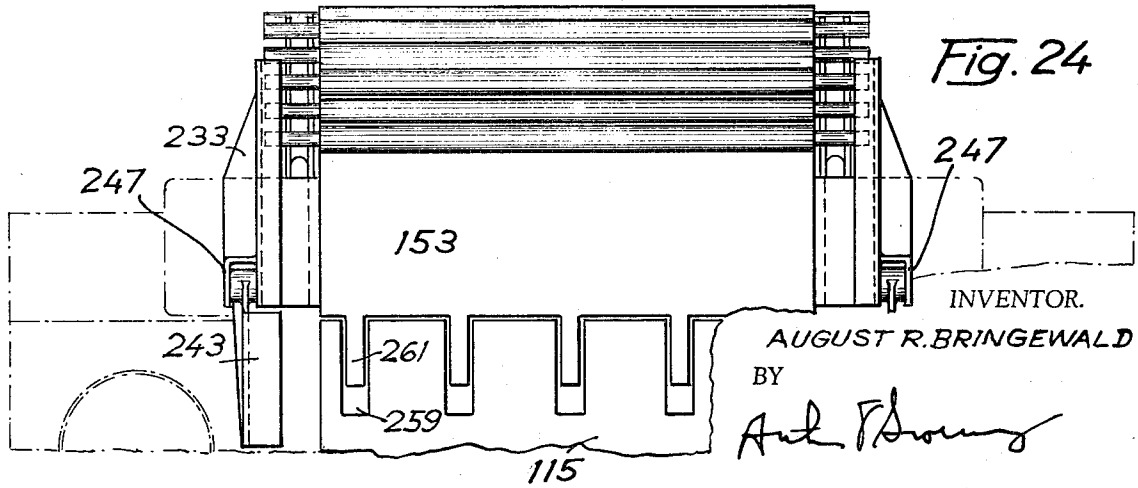


Fig. 24



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APPARATUS AND METHOD FOR APPLYING PRESSURE AND DIE AND METHOD FOR FORMING A PART

BACKGROUND OF THE INVENTION

The invention relates to method and apparatus for making parts from blanks of ductile material, and more particularly, to improvements on systems wherein a die is adapted to receive rolling pressure to cause the die to be forced into a blank of material causing the material of the blank to flow into cavities of the die and thereby from the blank into a part.

Systems of this type are described in U.S. Pat. No. 3,415,095 and U.S. Pat. No. 3,521,472, both invented by August R. Bringewald, the same inventor of the present invention. In the latter patent, an improvement over the prior art is disclosed wherein the die is formed in segments so as to maximize the applied pressure.

In systems, heretofore proposed, conventional rolling mills were used to apply the required pressure. The use of segmented dies and conventional rolling mills has presented several problems.

Firstly, the die segments tend to rock in response to rolling mill pressure resulting in undesired die marking of the part being formed.

Secondly, a problem exists in heating the die and blank prior to the forming step. As described in U.S. Pat. No. 3,521,472, the segments are clamped to the container for the blank. The very mass of this arrangement makes preheating an extremely time consuming and cumbersome operation so as to substantially hinder efficient production. If the die segments are individually heated prior to clamping in the blank container, the time involved in assembly causes substantial dissipation of the heat so as to be impractical.

Thirdly, the pressure required necessitates the use of huge, expensive rolling mills with consequent high power requirements. The power required to operate a rolling mill by which both rolls are driven directly and the load applied at the periphery of the rolls creates a high torque moment, the result of which is a high horse power requirement.

Fourthly, in order to avoid jamming, the rolls must be rotating at a predetermined velocity before the die and blank will pass therebetween. This requirement prevents speed control which is essential in forming certain configuration and in working with particular materials.

Fifthly, conventional rolling mills do not apply pressure gradually because, due to the circular nature of the roll, most of the material displacement occures during the initial portion of the period in which the roll is in contact with the work with less and less material displacement taking place as the end of the roll contact period is approached.

Sixthly, it is essential that plastic flow of the blank being formed be confined to the area subject to pressure. In using conventional rolling mills, even though the blank is containerzied to prevent material flow in areas other than the main pressure area, invariably some material gathering will occur especially at the trailing end of the blank that is being formed.

BRIEF SUMMARY OF THE INVENTION

The present invention comprises a novel pressure means through which work comprising a novel die and blank arrangement is passed so as to form the blank into a part. As the work passes through the pressure means, the die is forced into the blank causing material of the blank to flow into cavities of the die.

The speed at which the work passes through the pressure means can be adjusted and the pressure means is constructed to allow the work to pass back and forth therethrough. Means are provided for adjusting the applied pressure after each pass so that the blank is gradually formed. As a result, the part can be formed under controlled condition in a minimum period of time dependent on the configuration of the part being formed and the particular material of the blank.

The pressure means comprises a main pressure unit sandwiched between two auxiliary pressure units. The units are vertically, adjustably spaced from a base member thereby defining a pressure zone for the work. The auxiliary and main pressure units are inwardly inclined at the work entrance for gradually applying pressure. Two belts comprising rollers, linked together to form endless roller belts, constituting roller bearings, are provided with an upper belt moving about the auxiliary and main pressure units and a lower belt moving about the base member as work passes through the pressure zone. The belts function to convert sliding friction into rolling friction. The belts and inwardly inclined entries reduce the power required for conveying the work through the pressure zone. Pressure is applied through the solid material of the rollers which minimizes rolling friction.

The several rollers of the upper roller belt on the inclined surface at the work entrance of the main pressure unit provide multiple pressure contact portions for applying pressure to the work with each roller working in succession to apply increments of gradually increasing pressure. Since the first increment of pressure is limited in force, the conveyed speed of the work can be adjustably controlled without fear of jamming.

The auxiliary pressure units are adjustably mounted on the main pressure unit and spring biased downwardly to subject the work to a pressure of predetermined magnitude. This pressure prevents flow of material portion of the blank in areas other than areas beneath the main pressure unit.

The die used in the prevent invention is comprised of a pluralty of die segments as in U.S. Pat. No. 3,521,472 aforenoted, but in this instance each of the die segments has a force translating element associated therewith. The force translating elements are adapted to receive rolling pressure through rollers of the upper belt. This pressure is transmitted with a minimum of rocking force to the die segment so as to force the same into the blank.

The rollers of the upper roll belt are judicilusly spaced apart and the roll diameter is dimensionally related to the thickness of the force translating elements so that contact between the rollers and the force translating elements is such as to further minimize the power plant requirement for conveying work through the pressure zone.

A further improvement over the prior art is provided by a framework for confining the force translating elements and die segments in working relation. The framework is adapted to be dropped in place on the container for the blank within a confining wall structure which accurately positions and maintains the segmented dies in proper relation to the blank. This sepa-

rable arrangement allows heating of the die and blank separately while permitting ready assembly for processing. As a result, the preheat time period and heat dissipation after preheating is minimized. Handling problems associated with a non-separable arrangement are eliminated.

DRAWINGS

FIG. 1 is a side elevation of the pressure applying apparatus of the present invention showing the novel die and blank assembly ready for processing, the view being partly sectional to illustrate the means for adjusting the pressure head and to illustrate the drive for the work support, the view omitting a section of the supporting rollers for the work support.

FIG. 2 is a fragmentary plan view taken partly in section along line 2—2 of FIG. 1, and further extended to show supporting rollers omitted in FIG. 1.

FIG. 3 is a front elevational view of the pressure applying apparatus of FIG. 1 with the supporting rollers for the work omitted.

FIG. 4 is a cross sectional view showing the die segments and blank under the prepressure section of the pressure applying apparatus with details of the adjustable supporting structure and drive means omitted.

FIG. 5 is similar to FIG. 4 showing the die segments and blank advanced under the pressure head. In this view, the pressure head is shown only in part.

FIG. 6 is a perspective view showing a finished part.

FIG. 7 is a side elevational view of the fram containing segmented dies positioned above and ready for assembly to the container for a blank to be formed into a part, the latter being shown in section.

FIG. 8 is a side elevational view partly in section along line 8—8 of FIG. 13 showing the parts of FIG. 7 assembled.

FIG. 9 is a plan view of the blank container with the blank contained therein.

FIG. 10 is a cross sectional view of a modified container for the blank, the arrangement being modified to allow a die to underline the undersurface of the blank.

FIG. 11 is a side elevational view partly in section, illustrating the die assembly attached to the container of FIG. 10.

FIG. 12 is a fragmentary bottom surface view of the modified blank container of FIGS. 10 and 11.

FIG. 13 is a plan view of the assembled die and blank container of FIG. 8 ready for processing.

FIG. 14 is a front elevational view partly in section along line 14—14 of FIG. 7.

FIG. 15 is a front elevational view partly in section along line 15—15 of FIG. 8.

FIG. 16 is a front elevational view partly in section along line 16—16 of FIG. 11.

FIG. 17 is a framentary sectional diagram to illustrate the initial forces induced on the force translating element by the auxiliary pressure unit.

FIG. 18 is a fragmentary section diagram illustrating the auxiliary pressure unit lifted by the work to a prepressure position.

FIG. 19 is a fragmentary sectional diagram to illustrate the forces of the main pressure unit acting on the force translating elements and die segments.

FIG. 20 is an enlarged front elevational view, partly in section, to show adjustment means for the auxiliary pressure unit, details of the drive and adjustable support structure being omitted.

FIG. 21 is an enlarged side elevational view partly in section along lines 21—21 of Flg. 20.

FIG. 22 is an enlarged front elevational view of the pressure adjustement apparatus with parts omitted to show the means for maintaining the endless belt taut, details of the adjustable support structure also being omitted.

FIG. 23 is fragmentary side elevational view partly in section showing the auxiliary pressure unit under pressure and the guide track for the roller belt pivoted to adjust for relative movement between the auxiliary pressure unit and the main pressure portion.

FIG. 24 is a fragmentary view in direction G of FIG. 22 looking at the undersurface of the auxiliary and main pressure portions, with a portion of the roller belt omitted to show the coaction between these parts.

DETAIL DESCRIPTION

GENERAL

Referring to FIGS. 1, 2 & 3, the present invention is shown as comprising pressure means A and supports B and C on opposite sides of the pressure means A. The supports B and C provide rolling support for work adapted to be passed back and forth through the pressure unit A. The work comprises a works support D having work E thereon.

Each of the supports B and C comprise a supporting framework having rollers 10 supported for rotation thereon to allow work support D to be rolled thereacross. Supports B and C are identical in structure and thus support C is shown only in part.

Generally, as shown in FIGS. 1, 2 and 3 the pressure means A comprises a base member 1, a pressure head 3 adjustably mounted on the base member 1 by support columns 5 to allow pressure adjustment by adjusting the distance of pressure head 3 to base member 1. Endless roller belts 7 and 9, which extend about the pressure head 3 and base member 1 respectively, function to reduce friction as work support D together with work E pass through the pressure means A.

Referring to FIGS. 4 and 5, the work support D together with work E is shown as it passes through the pressure unit A. The work E includes a container 11 for a blank 13 adapted to be formed into a part. A frame 15 confines a plurality of die segments 17 above blank 13. The frame 15 also confines a plurality of force translating elements 19 for transferring, as hereinafter more particularly described, pressure to die segments 17 with a minimum of rocking force. As the work assembly E passes between the pressure head 3 and base 1, pressure is applied through the rollers of the roller belts 7 to the force translating elements 19.

When pressure is applied to force translating elements 19, the die segements 17 are forced into the blank 13 as shown in FIG. 5. Cavitations 21 are provided on the undersurface of die segments 17 and correspond in dimension to portions of the part to be formed. As the die 17 is forced into the blank 13 (see FIG. 5), the cavitations 21 receive material flow from the blank 13 to form the part 23 (see FIG. 6) which is a part having integral stiffeners on one side. Forming this type part without a machining requirement is a particular feature of the present invention. The unformed portions of blank 13 shown in broken lines in FIG. 6

may be cut away by any conventional means to leave remaining only part 23.

THE CONFINED BLANK

Referring to FIGS. 7, 8 and 9, container 11 is shown to include a bottom wall 25, and a stepped internal sidewall including blank confining wall 27 which surrounds the blank 13 (see FIG. 9), a support shelf 29 for the frame 15 and a frame confining wall 31. The confining wall 27 surrounds blank 13 so that when the blank 13 is subject to die pressure as in FIG. 5, material flow is stopped by wall 27 and continued pressure forces the material of blank 13 to flow into the cavitations 21 which constitute paths of least resistance. While container 11, as shown in FIGS. 7 and 8, will permit one surface of blank 13 to be formed, it is to be understood that both surfaces of blank 13 can be formed simultaneously. Referring to FIGS. 10, 11 and 12, a modified container 11' is shown to accomplish this result. In this embodiment, the bottom wall for the container is shown to comprise a segemented die 33 which underlies the blank 13 for forming the undersurface of the blank simultaneously with the upper surface. The container 11' includes a confining wall 35 which surrounds segmented die 33 and blanks 13. Along the length of one end of wall 35, a recess 36 is provided to accommodate an adjustable clamping block 37 which confines die 33. The camping block 37 is slidably and adjustably mounted between the upper wall portion of recess 36 and plate 39. Plate 39 is screwed or otherwise secured at 40 to the undersurface of container 11'.

Referring to FIGS. 10 and 12, the rear surface 45 of clamping block 37 is inclined and slidably receives the inclined surface 47 of wedge block 49 which is adapted to move transversely of the container 11' as indicated by arrow F—F. The wedge block 49 includes a threaded bore in end wall 51 thereof for receiving a threaded bolt 53 rotably mounted in wall portion 55 of the container 11'. The bolt 53 is headed at 57 and receives a snap ring at 59 to prevent longitudinal movement. Upon rotation of the bolt 53, the wedge block 49 moves clamping block 37 into clamping engagement with the die 33.

FRAME FOR DIE SEGMENTS

Referring to FIGS. 7, 8 and 13, the supporting frame 15 for the die segments 17 and for the force translating elements 19 rests on support shelf 29 formed on the stepped internal wall of container 11. The frame 13 is snugly received by wall 31 of container 11 so as to contain the frame against lateral movement yet allow the same to be dropped in place. The ready assembly permitted by this arrangement allows the frame 15 with the die segments 17 and force translating element 19 contained therein to be preheated separately from the blank 13 prior to processing.

Referring to FIGS. 7, 8 and 13, frame 15 is open at its top and bottom and includes end walls 61 and 63 and sidewalls 65 and 67. Plates 69 and 71 are screwed to the top and bottom surfaces of end wall 63 and sidewalls 65 and 67 to slidably receive clamping blocks 73 and 75. Clamping blocks 73 and 75 clamp the die segments 17 and force translating elements 19 respectively. Wedge blocks 77 and 79 are positioned between the clamping blocks 73 and 75 and end wall 63 to adjustably position the clamping blocks 73 and 75 into clamping engagement with the die segments 17 and force translating elements 19 respectively. Wedge blocks 77 and 79 include threaded bores 81 and 83 in end faces thereof to receive bolts 85 and 87 rotatably mounted in sidewall 67 of the frame 15. The bolts 85 and 87 cooperate structurally and functionally with the wedge blocks 77 and 79 in the same manner as bolt 53 cooperates with wedge block 49, hereinbefore described and shown in FIG. 12.

The separate clamping arrangement for the die segments 17 and force translating elements 19 are provided for special reason. The thickness (indicated by *t* in FIG. 8) of the die segements 17 and force translating elements 19 are meant to be identical so that the vertical force applied to each force translating element 19 is applied to only one die segement thereby maximizing the applied force. In attempting to accomplish the foregoing, some machining error might occur.

In order to compensate in the event the overall dimension of the assembled force translating elements 19 exceed the dimension of the assembled die elements 17, provision is made for allowing the end force translating element 19' to pass by the clamping block 74 for the die segment 17.

As shown in FIGS. 8 and 13, this is accomplished by providing recessed 89 and 91 in the end face of end force translating element 19' leaving only portions 93, 95 and 97 in engagement with clamping block 73. Die segment clamping block 75 is provided with recesses 99, 101 and 103 to allow passage of portions 93, 95 and 97 thereby allowing the element 19' to pass clamping block 75.

DIE SEGMENTS AND FORCE TRANSLATING ELEMENTS

Referring to FIGS. 14, 15 and 16, the die segements 17 are seen frictionally, slidably receive between side wall 65 and 67 of frame 15. Inverted L-shaped arms extend from opposite ends of each of the die segments 17 with leg portions 105 extending above and in spaced relation to the sidewalls 65 and 67 of frame 15. The leg portions 105 provide means for prying the die segments out of the blank 13 after the same has been formed into a part.

As hereinbefore described, frame 15 also clamps force translating elements 19 with one above and coextensive in thickness with each of die segments 17. For reasons hereinafter explained, the lower surface 107 (see FIG. 8) of each translating element 19 is externally convex so as to provide only line contact with the die segement 17 therebeneath. The edges of the force translating elements (see FIG. 8) are curved at 109 to receive the rolling pressure from the roller belt 7 with a minimum of jar.

Referring to FIGS. 17 – 19, force diagrams are provided to show the forces exerted on force translating elements 19 and die segement 17 as they engage the rollers of roller belt 7. A detailed description of these forces will hereinafter be described in the summary of the operation but for the present purpose of describing the function of the force translating elements 19, not is to be made that several horizontal components of force such Z'', (FIG. 17) and Z' and Z (FIG. 19) are exerted on the force translating elenents 19 as they enter and pass through pressure unit A. These horizontal components of force tend to rock the force translating elements 19.

It is to be noted that if the force translating elements were omitted, and direct contact was made with the die segments, rocking of the die segment would cause marking and damage to the part being formed. By use of the force translating element **19**, direct contact between the die segments and the rollers of roller belt **7** is avoided and, as hereinafter described, the horizontal components of force are transmitted to the frame **15** rather than to the die segment **17**.

Since the lower convex surface **107** (see FIG. **8**) of the force translating element **19** have only line contact with the center of the upper surface of die segments **17**, horizontal sliding friction between the upper surface of the die segment and lower surface **107** of the force translating elements is substantially eliminated. Rather, the horizontal components of force are transmitted by means of force translating elements **19**, clamping bar **73** and wedge block **77** to the frame **15** thereby eliminating any possible die marking.

ADJUSTABLE PRESSURE HEADS

As hereinbefore described and again referring to FIGS. **1, 2** and **3**, pressure head **3** is adjustably mounted on base member **1** by a pair of support columns **5**. The lower ends of support columns **5** are secured to the base member **1** and the upper ends of support columns **5** extend through bores **113** (see FIG. **1**) in the main pressure unit **115** of pressure head **3**. Each of the columns are threaded at **117** so as to receive an internally threaded head support member **119**.

Enclosures **121** are provided for each of the head support members **119**. Enclosures **121** are bolted at **123** to the top surface of a platform **125** which in turn is bolted (not shown) to the top surface of main pressure portion **115**. The top walls of each of the enclosure **121** includes a collar **131** having a boring **129** to permit passage of column **5**. A friction reducing annular spacer **131***a* is provided between the upper surface of head support **119** and the bottom surface of collar **131** to reduce friction during rotation of head support **119** for the purpose of adjusting the height of pressure head **3**. Collar **131** is threaded to the top wall of enclosure **121** allowing adjustment to assure a snug fit of the head support **119** between spacer **131** and the upper face of platform **125**.

Since head support **119** is confined between enclosure **121** and platform **125**, movement of the heat support **119** along column **5** carries the pressure head **3** along therewith. Head support **119** is moved along the column **5** by rotating the same. For this purpose, a reversible motor **133** is mounted on the top surface of the platform **125** and through gearing drives a shaft **137** having worm gears **139** (see FIG. **2**) at its opposite ends geared to head support member **119** at **141**. Upon energizing motor **133**, shaft **137** rotates and in turn head support **119** rotates and moves along column **5** to selectively adjust the height of pressure head **3**. The pressure head **3** is adjusted prior to work E passing therethrough so that the load requirement for motor **133** is limited to the weight of the pressure head **3**.

WORK SUPPORT D AND CONVEYOR

Referring to FIGS. **20** and **21**, and as hereinbefore described, the work support D supports work E as it passes through the pressure unit A. While not shown, the work E may be bolted or otherwise secured to the work support D so as to prevent the work E from sliding on the work support during processing.

In order to convey the work E and the work support D under the main pressure portion **115**, the latter includes inverted U-shaped channels **143** on opposite edges thereof (see FIG. **20**) with pins **145** mounted therein to form a drive rack. The pins **145** coact with drive gears **147** to drive the work support D across the roller support B, (see FIG. **1**) into and through pressure unit A, and onto opposite roller support C (see FIG. **2**). The pressure head **3** is then adjusted to a lower position so as to exert additional pressure and the work support D is then moved backwards across rollers C back into and through the pressure unit A, and onto roller support B. Driven gear **147** is fixed to a drive shaft **149** mounted for rotation in bearings **151** mounted on bearing supports **152**. An electric motor (not shown) of conventional design may be keyed to drive shaft at **154** (see FIG. **2**) to impart the aforedescribed motion.

AUXILIARY PRESSURE UNITS

When the work E is subjected to the main pressure portion **115**, material flow in the blank being processed occurs. This material flow must be prevented from flowing to areas not under the main pressure portion **115**, as otherwise material would build up, e.g., on the trailing portion **13A** (see FIG. **5**) of the blank **13**. In order to avoid this problem, the blank **13** is first subject to prepressure.

For this purpose and referring to FIGS. **20** and **21**, auxiliary pressure units **153** are provided on opposite sides of the main pressure unit **115**. The auxiliary pressure units **153** are slidably mounted on bolts **155** (see FIG. **20**) and spring based downwardly as hereinafter explained, into engagement with the force translating elements **19**. Bolts **155** are fixedly secured between overhangs **157** and support brackets **159** extending from the main pressure portion **115**. Bolts **155** are threaded as shown at **161** and have internally threaded support member **163** for auxiliary pressure units **153** adjustably threaded thereto so as to adjust the height of the auxiliary pressure units relative to the height of incoming work E.

Shafts **165**, having worm gears **167** geared to support members **163**, are adapted to be rotated by a hand operated wrench on keys **169** (see FIGS. **20** and **21**). Rotation of shaft **165** rotates support member **163** which then moves along bolt **155** and carries along therewith the auxiliary pressure units **153**.

Shafts **165** are rotatably mounted in the end walls **171** of bracket members **173**. Brackets **173** are mounted on support members **163** and for this purpose, borings **175** in the upper and lower walls **173'** of brackets **173** receive extension collars **179** of the support members **163**. The extension collars **179** are encircled by spaces **163'** provided to reduce friction between support members **163** and bracket members **173** during adjustment of the auxiliary pressure units **153**.

Referring still to FIGS. **20** and **21**, the upper surface of auxiliary pressure units are spaced from the overhangs **157**. Resilient pads **179** are set between the overhands **157** and the auxiliary pressure units **153** so as to spring bias the auxiliary pressure units **161** downwardly, to a sufficient extent to prevent material flow in the trailing edge of blank **13**. The downward pressure should be insufficient to cause die segment **17** to be forced into the blank **13**. The amount of prepressure

required will vary with the particular blank material being processed. Adjustment in prepressure can be made by judicious selection of pads 179 having the required resiliency.

ROLLER BELTS 7 AND 9

Referring to FIGS. 1 and 3, as hereinbefore described, endless roller belts 7 and 9 extend about the pressure head 3 and the base member 1 to convert sliding friction into rolling friction thereby drastically reducing the power required to force work support D together with work E through the pressure unit A. Platform 125 on main pressure portion 115 is apertured at 183 to allow roller belt 7 to pass about the pressure head 3. The lower roller belt 9 is allowed to pass through a floor recess 185 formed below and intermediate the base member 1.

Referring to FIGS. 21 and 22, the roller belts 7 and 9 comprise rollers 187 linked together in spaced relation by links 189 which are pivotally connected to extension pins 191 at opposite ends of the rollers. As shown, the diameter of the rollers in the upper roller belt 7 is different from the diameter of the rollers in the lower roller belt 9. The diameter of the rollers in the lower roller belt 9 is not critical but the diameter of the rollers in the upper roller belt 7 is significant as will be hereinafter further described in the summary of operation.

The lower roller belt 9 is generally slack and guided against skewing by sprocket guide wheels 193 which engage with extension pins 191. Guide wheels 193 are mounted on a shaft extending from base member 1.

The roller belts 7 and 9 travel about pressure head 3 and base 1 as the work passes therethrough in directions indicated by arrow N in FIG. 21 while each of the rollers 187 rotates about its individual axis during said travel. The pressure force exerted by head 3 is passed across the solid diameter of each roller 187 into the rugged back-up of the pressure head 3 and base member 1.

Due to the movement of the upper roller belt 7 and in order that uniform pressure be applied across the width of the force translating element 19 as work E enters pressure unit A, the upper roller belt 7 is provided with means to maintain itself taut with no slack particularly in the pressure application areas.

Referring to FIGS. 21 and 22, in order to maintain the upper roller belt 7 taut, it is guided around the auxiliary pressure units 153 of pressure head 3 by four pairs of guide wheels. The lower pairs of guide wheels 195 are keyed to shafts 199 which are journaled for rotation in bore 197 of bearing brackets 203 which are bolted to the auxiliary pressure units 153 at 207. The upper pairs of guide wheels 211 are secured to shafts 215 which are journaled in the horizontal part of T-shaped bearings 219. Each of the bearings 219 include a vertical shaft 223 having a collar 231 which is slidably reeived in bore 227 of bearing bracket 203. The lower end of shaft 223 is slidably received in counter 227' of bore 227. A spring 229 bottoms in bore 227 and engages collar 231 at its upper end to upwardly bias the guide wheels 211 and maintain the roller belt 7 taut. By manually depressing the upper guide wheels downwardly, the roller belt 7 is made slack and readily removable for repair or other purposes.

In order to positively assure that the lower run of roller belt 7 does not slack from its own weight and in order to maintain the rollers substantially perpendicular to the path of movement of the incoming work E, guide tracks are provided on opposite sides of the lower run of belt 7. The guide tracks are adapted to have guide extensions 191 of rollers 187 roll thereon. The guide tracks on opposite sides of the roller belt 7 are identical so only one track will be described.

As shown in FIGS. 21, 22 and 23, the guide tracks comprises fixed sections 233 and 235 which are bolted to the auxiliary pressure unit 153 such as at 237. The extensions 191 of the rollers roll on flanges 241 of the guide tracks (see FIG. 22) thereby prevented the roller belt from sagging.

Since the auxililary pressure units 153 moves relative to the main pressure portion 115, each of the guide tracks 233 and 235 have guide sections 243 and 245 pivoted thereto to accommodate the belt 7 as it enters the main pressure portion 115. Fixed guide tracks 233 and 235 have forked ends such as at 247 (see FIG. 24 which are pivoted to the ends of the pivoted guide sections 243 and 245. The other ends of the pivoted guide sections 243 and 245 are free but are pivoted upwardly in guiding engagement with the roller belt 7 through a lever arm 253 (see FIGS. 21 and 23). The lever arms 253 are integral with the pivoted guide sections 243 and 245 and are spring biased by a spring 255 so as to upwardly bias sections 243 and 245. The pivoted arrangement allows the pivoted guide tracks to self adjust when the incoming work forces the auxiliary pressure unit upwardly as shown in FIG. 23.

MAIN PRESSURE PORTION 115

Referring to FIGS. 4, 5, 17, 18 and 19, the main pressure portion 115 includes inwardly inclined surfaces 257 so that pressure is applied in a gradual manner. Each roller 187' and 187'' (see FIG. 19) will exert equal increments of material displacement in contrast to the effect of a rolling mill where, only one large roller is used and due to the circular nature of the roller the maximum material displacement occurs during the initial portions of the period in which the roll is in contact with the work with less and less material displacement occuring as the end of the roll contact period is approached. In the case of a rolling mill, if said initial portions of material displacement are excessive, shear and damage of the part to be made could result. While two rollers are shown along the incline in FIGS. 4 and 5, it is to be understood that the inclined surface could be extended so as to have more rollers working at the cost of higher power requirements. The manner in which the rollers exert pressure will be more particularly described in the Summary of Operation hereinafter described.

SUMMARY OF OPERATION

In summary, the operation for processing a part, is generally as follows:

Referring to FIG. 7, blank 13 is heated separately to the required process temperature. In order to avoid a harmful chilling effect on the blank 13, the container 11 for blank 13 as well as the frame 15 (having the die segments 17 and force translating element 19 contained therein) are also heated separately to a predetermined temperature prior to placing blank 13 in container 11 and covering the same with the assembly of frame 15. This separate heating procedure minimizes

the handling problem and allows relatively rapid preheating with minimum heat dissipation.

The preheated assembly of container **11**, blank **13** and the frame **15** together with the assembly contained in the frame constitutes what has been referred to in the specification as work E.

Preheated work E is then placed on work support D (See FIG. 1). Depending on the configuration of the part to be formed and the type of material to be worked on, the pressure head **3** and the speed at which the work support D is conveyed is adjusted. Adjustment of pressure head **3** is accomplished by operating pressure head adjustment motor **133** to adjust the position of the head support **119** (See FIGS. **1** and **3**) along the support columns **5**. The conveyed speed of work support D is controlled by adjusting the speed of driving gears **147** which are keyed to a drive shaft **149** (See FIG. **20**). It is to be understood that the particular part to be formed may require that a blank **13** be formed in several passes and thus the pressure head **3** may be initially adjusted so as to only partially force the die segments **17** into the blank **13**. After the first pass, the pressure head **3** may be initially adjusted so as to only partially force die segments **17** into blank **13**. After the first pass, the pressure head **3** can be adjusted to further force the die segments **17** into the blank **13** on a return pass. The part can be formed by making several passes back and forth through the pressure unit A.

Referring to FIG. **17**, as the work E is conveyed, it first enters the prepressure section and moves under incline **153A**. The forces incident to the initial engagement with incline **153A** are graphically illustrated as involving a resultant X'' consisting of a vertical component Y'' (the lifting force involved inducing prepressure into the blank **13**) and a horizontal component Z'' (the reacting force which is transferred to and absorbed by frame **15**, as hereinafter described).

Referring to FIG. **18**, as the work E advances, the downwardly spring biased auxiliary pressure unit **153** is lifted a distance *h* (See FIG. **18**) into a prepressure position. The prepressure of component Y'' does not cause flow of material in blank **13** but does prevent lateral flow of material to areas outside the main pressure area under the main pressure unit **115**. This controls material flow and prevents material buildups in the trailing area of blank **13**.

Referring to FIG. **19**, work E is then conveyed into and through the main pressure portion **115**. The dimensional relationship of the thickness *t* of the force translating elements **19**, the diameter d of the rollers **187** and the distance u at which two neighboring rolls are linked together has been established in such a manner that only one step S, caused by engagement of the upper front edge **109** with a roller **187** of the main pressure portion **115** does occur at a single time. In other words, in the instance shown in FIG. **19**, the main working rollers along incline **257** are rollers **187'** and **187''**. Both of these rollers are forcing force translating element **19** downwardly due to engagement at *j* and *f*. However, as can be observed, roller **187'** has just made edge engagement with a force translating **19P** at *f* while roller **187''** bears on an upper surface of a force translating element at *j*. As hereinafter described, the horizontal component of force exerted at *f* is greater than the force exerted at *j*. The force at *f* is at a maximum when roller **187'** makes edge contact. The dimensional relationship above referred to is such that only after force translating element **19P** made edge contact with roller **187'** at *f* will the force translating element **19R** make edge contact at *k* with roller **187''**. The positional definition of front edge **109** refers to the direction of movement of work E, indicated by Arrow M.

The height of step *s* is dependent on the steepness of incline **257** and the distance *u*.

These parameters can be varied by skilled mechanics in the art to meet particular applications.

As will be hereinafter described, the controlled edge engagement above described in cooperation with the friction reducing roller belts **7** and **9** achieves optimum power plant efficiency for conveying work support D with work E through the pressure unit.

With regard to the friction reducing rollers, generally the force required to move a loaded roller **187** equals the moment of rolling friction divided by the diameter of the roller. Thus the larger the diameter of the roller, the less power required to move the load.

With reference to how control of the dimensional relationship between the force translating elements **19**, the rollers **187** and the distance between the rollers **187** optimizes power plant efficiency, reference is again made to FIG. **19**. The edge **109** of a force translating **19P** contacts roller **187'** at a point *f*. Roller **187'** makes contact with incline surface **257** of the main pressure portion **115** at point *e*. A straight line, connecting point *f* and *e*, determines the angular direction of the resultant force X. Force X is composed of a vertical compression force component Y (to induce the forming pressure into the blank **13**) and the horizontal component Z, the reacting force which is transferred and absorbed by frame **15**, as hereinafter described.

As hereinbefore described, the engagement of said front edge **109** and roller **187'** at *f* causes a single step *s* movement downwardly. This presents the main obstacle to be overcome by the force of the horizontal component Z. The roller **187''** along the incline **257**, not being in contact with a front edge **109** of a force translating element **19**, is in contact with the upper surface of a force translating element **19** at a point *j* and in contact with the incline **257** at pont g. The contact at *j*, while causing downward movement of the force translating element, does not cause a step *s* downward movement. The forces along incline **257** are subject to the so-called law of inclined planes, in reference to which, the resultant X', composed of the horizontal component Z' and the vertical component Y', projects perpendicular to the incline at point *g*. Force Z is exerted in the same direction as force Z but has been illustrated as shown to keep the drawing clear. As can be observed, the vertical components Y and Y' are almost of identical magnitude but by comparing the long horizontal component Z with the short horizontal component Z', it can be understood that optimum power efficiency can be achieved when at a single time, only one of the rollers **187** along the incline **257** makes initial edge contact as at f.

While it is preferred that only one of the rollers makes edge contact at a single time, it is to be understood that the present invention is not so limited.

As above described, the power requirement is reduced by increasing the diameter of the rollers. This may dictate a compromise in that it may be better to make larger rollers to enhance power plant efficiency while simultaneously sacrificing power plant efficiency by causing a plurality of the force translating elements

19 to have edge engagement with the rollers 187 along incline 257 as illustrated at *f*.

It is also to be understood that while it is preferred to adjust the dimensional relationship above referred to, to cause discrete equal incremental steps s, the invention is not to be limited thereto.

Referring still to FIGS. 17, 18 and 19, the horizontal components Z, Z' and Z'' tend to rock the force translating elements 19 as they would rock the die segments 17 if there was direct contact between the die segments and the rollers. This would cause die marking and damage of the part to be made. Since the present invention provides the novel force translating elements 19 as an intermediate means to eliminate direct contact between the die segments 17 and rollers 187, and since there is only surface line contact between the convex lower part 197 of the force translating element 19 and the center of the upper face of the die segement 17, the reacting horizontal forces Z, Z' and Z'' by means of the intermediate force translating means elements 19 and the clamping parts 73 and 77, are transmitted to and absorbed by frame 15. Only the vertical compression force Y, Y' and Y'' are transferred through the center of the die segments and induced into the blank material 13 to produce a part without a part without rocking the die segment thereby eliminating the cause of any die marking of the part to be made.

While not shown, as an alternative, the upper surfaces of the die segments 17 may be made convex with the lower surface of the force translating elements flat. Still further, both the upper surface of the die segment 17 and the lower surface of the force translating elements 19 may be made convex.

OTHER USES

The foregoing describes a method of applying pressure through use of a roller belt to discrete units. While the particular end use described relates to forming a part by forcing a die into a blank of material, it is to be understood that the present invention can be extended to numerous and uses other than described. In general, the present invention has application to any end use where there is a requirement to apply pressure to discrete units.

While a preferred embodiment of the present invention has been disclosed, it is to be understood that various modifications may be made that fall within the scope of the invention.

What is claimed is:

1. The combination comprising a pressure base, pressure means vertically spaced above said pressure base to define a pressure zone, means for coveying work between said pressure base and said pressure means, one of the pressure base and said pressure means being inwardly inclined in the direction said work is conveyed so that pressure is gradually applied to said work, rollers for converting sliding friction into rolling friction as said work passes through said pressure zone, means for guiding said rollers as they pass under said pressure means, an auxiliary pressure unit adjustably mounted on said pressure means, and means for adjusting said guide means to compensate for movement between said pressure means and said auxiliary pressure unit.

2. The combination comprising a pressure base, pressure means vertically spaced above said pressure base to define a pressure zone, means for conveying work between said pressure base and said pressure means, one of the pressure base and said pressure means being inwardly inclined in the direction said work is conveyed so that pressure is gradually applied to said work, means for adjusting said pressure means, and means for passing said work back through said pressure means.

3. The combination comprising a plurality of die segments,
confining means for confining said die segments,
a container for a blank to be formed into a part,
said container including wall means for frictionally,
removably receiving said confining means to allow the latter to be dropped in place whereby said work blank and said die segments can be heated separately prior to processing and then readily assembled.

4. The combination of claim 3,
said container including a die underlying the blank to be formed into a part.

5. The combination of claim 3, said
said confining means including wall means,
adjustment means for adjusting at least a portion of said wall means to confine said die segments.

6. The combination of claim 3,
said die segments including means for allowing said segments to be pried out of a formed blank.

7. The combination of claim 3,
force translating elements above said die segments for minimizing the transfer of a rocking force to said die segments.

8. The combination comprising a pressure base, vertically spaced above a pressure means,
means for conveying a blank across said pressure base, under said pressure means to form blank into a part
auxiliary pressure means for preventing flow of material in portions of said blank other than areas beneath said pressure means, and
means for spring biasing said auziliary pressure means downwardly.

9. The combination of claim 8,
means for adjustably mounting said auxiliary pressure means on said first mentioned pressure means.

10. The combination comprising a plurality of die segments, a force translating element for each said die segment, confining means for confining said die segments and said force translating means being positioned to transfer pressure to said die segments with a minimum of rocking force being transmitted to said die segments, each of said die segments being in contact with at least one other die segment and each of said force translating elements being in contact with at least one other force translating element.

11. The combination as defined by claim 10, said force translating elements including a curved edge portion for receiving pressure with a minimum of jar.

12. The combination of claim 10, said confining means including a wall portion for absorbing horizontal components of force transmitted to said force translating elements.

13. The combination as defined by claim 10, each of said force translating elements having a width substantially equal to the width of said die segment so that force exerted through each force translating element is transferred to only one die segment thereby maximizing the applied pressure.

14. The combination as defined by claim 10, said confining means including wall means, adjustement means for adjusting at least a portion of said wall means for confining said die segments and said force translating elements.

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