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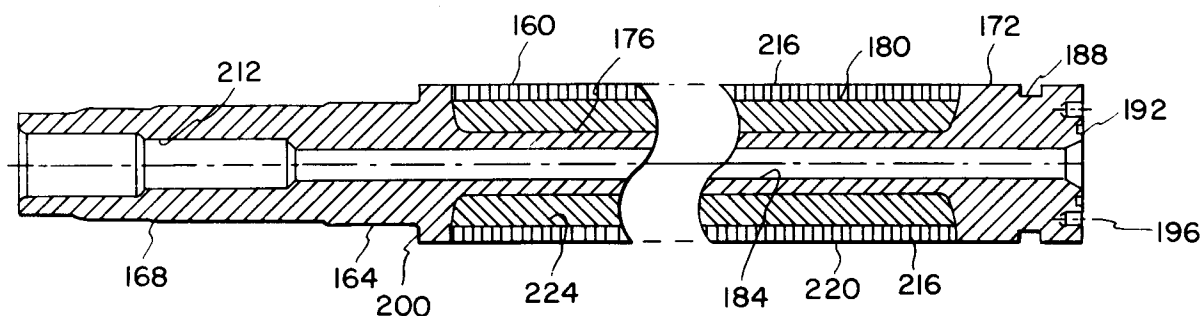
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D-80538 München (DE)(54) **Apparatus for forming container bodies which utilizes a reinforced composite ram.**

(57) An apparatus for forming container bodies utilizing a ram which is formed at least in part from a reinforced composite material (e.g., rams having a combination of structural components with at least one component being formed from an appropriate metal(s) and another component being formed from the composite material, rams formed entirely of the composite material). In one embodiment, the ram is incorporated into a bodymaker for drawn and ironed containers and includes first and second ram portions, the first ram portion being formed from an appropriate metal, the second ram portion being formed from the composite material. The first ram

portion has first and second ends with an interconnecting portion therebetween such that a punch and ram drive assembly may be connected to such first and second ends, respectively. The second ram portion is thus positioned about the interconnecting portion to reduce the weight of the ram, as well as to allow for an improvement of the rigidity thereof. Consequently, the speed at which the ram may be advanced through the ironing rings may be increased and the deflection of the ram when passing therethrough may be reduced to enhance the container body formation process.

FIG. 4

Field of the Invention:

The present invention generally relates to the field of forming container bodies and, more particularly, to forming such container bodies by utilizing a reinforced composite ram to interconnect the ram drive assembly and the particular forming tool.

Background of the Invention:

There have been significant developments in the beverage container industry directed toward reducing production costs (e.g., designing containers which require less raw material such as by reducing the sidewall thickness of the container body), as well as increasing production capacity/efficiency in an effort to gain a competitive advantage in the marketplace. Although increases in production capacity can of course be achieved by capital expenditures (e.g., adding production lines), increases can also be achieved by increasing the overall speed of the container-forming process.

Two-piece containers (i.e., those having a continuous bottom and sidewall with a separate end piece attached to and closing the upper portion of the container body) are typically formed by a drawing and ironing procedure, a drawing and redrawing procedure, or some combination/variation thereof. Generally, in one type of such a procedure a circular disc is blanked/punched from a piece of sheet metal stock and provided to a draw die for the formation of a cup therefrom. More particularly, the circular disc is positioned over the upwardly open cylindrical cavity of the draw die and is forcibly driven therein by a draw punch. This forces the disc into substantial conformance with the contour of the draw die to thereby form a cup having a bottom and integral sidewall. The cup, however, has a greater inner and outer diameter than the container body to be formed therefrom, and also is shorter than the desired container body. Therefore, the cup must be subjected to further processing.

The container body having the desired specifications is formed from the cup by redrawing the cup and thereafter ironing its sidewalls in a bodymaker. More particularly, the cup is forced through a redraw die by a punch which is typically interconnected with an appropriate ram drive assembly (e.g., an assembly capable of providing linear/axial motion) by a ram. The redraw die reduces the inner and outer diameter of the cup to that of what is generally desired for the container body by substantially conforming the cup to the sidewall of the punch. In order to reduce the thickness of the sidewall of the redrawn cup by generally increasing the length thereof, the punch continues to drive the redrawn cup through a plurality of ironing rings which are substantially linearly

aligned with the redraw die. After passing through the last ironing ring, the end of the container body may be engaged by a doming die which interacts with the end of the punch to form a dome on the bottom portion of the container body. When the ram is retracted, the formed container body is removed from the punch in an appropriate manner, such as by stripping fingers which engage the sidewall of the container body.

Based upon the foregoing, it can be appreciated that one parameter which affects the overall container-forming process is the speed at which the punch is driven through the redraw die and ironing rings by the ram. However, there are a number of factors which may effectively limit any attempts to increase production capacities by merely increasing ram speed. For instance, the rams are typically formed entirely from carbon steel or other appropriate metals. Since the ram must be of a sufficient length to drive the cup through the redraw die and the plurality of ironing rings (e.g., a stroke length for the ram typically ranges from 18 inches to 26 inches), the overall weight of the ram is such that inertial forces become a concern. Relatedly, in the event that the bodymaker is of a horizontal configuration (i.e., the ram travels along a horizontal path), the weight of the ram may also affect the alignment of such when passing through the redraw die and ironing rings.

The ram in a horizontal bodymaker configuration is effectively a cantilevered beam since only an end portion of the ram is connected to the ram drive assembly. However, in order to direct the ram through the redraw die, some bodymakers incorporate some type of a ram guidance system which also provides some support for the ram prior to passing through the redraw die. Furthermore, as the ram passes through the redraw die and ironing rings during the formation of the container body, additional support may be provided for the ram at these spaced locations due to the presence of the container body between the punch and the redraw die/ironing rings. Since relatively close tolerances are maintained between the ram and each of the redraw die and ironing rings when passing therethrough, however, this support of the ram may be insufficient to maintain proper alignment. For instance, deflections of the ram on the order of 0.010 inch or even less may cause sufficient misalignment to damage components of the bodymaker and/or the container body being formed. More particularly, deflections of this magnitude may result in the punch impacting the redraw die and/or ironing rings which could damage such components, as well as the container body being formed. In addition, such deflections of the ram may cause certain defects in the structure of the container body (e.g.,

an uneven sidewall distribution, increased stresses in the sidewall of the container body, tearing of the sidewall of the container body). Due to the existing material selections for the ram (e.g., carbon steel), the weight of the ram thus increases the potential for experiencing deflections of or exceeding this magnitude during container-forming operations.

Based upon the foregoing, it can be appreciated that it would be desirable to provide a ram constructed in a manner to reduce the total weight thereof, while also increasing the rigidity of the ram. A reduction in weight would allow for an increase in speed of the ram in passing through the redraw die and ironing rings to thereby increase production capacity. Moreover, weight reduction would reduce the deflection of the ram as it extends through the redraw die and ironing rings, as would an increase in the rigidity of the ram. This reduction of ram deflection would therefore reduce the potential for ram misalignment which could damage various components of the bodymaker and/or the container body being formed.

Summary of the Invention:

The present invention relates to an apparatus for forming container bodies which have a bottom and an integral sidewall (e.g., a drawn and ironed container body, a cup which undergoes some type of a drawing and ironing procedure for the formation of such a container body therefrom). Advantageously, the present invention utilizes a ram which is formed at least in part from a reinforced composite material to reduce the total weight of the ram. Consequently, the speed at which the ram may be advanced through, for instance, a plurality of substantially linearly-aligned ironing rings in the case where the present invention is incorporated into a bodymaker for drawn and ironed containers, can be increased to thereby increase the production capacity of the bodymaker. Moreover, ram deflection may be desirably reduced. For instance, in the event that the ram assumes a generally horizontal configuration within a bodymaker, the amount of deflection of the ram may be reduced as it extends through the above-identified plurality of ironing rings during formation of the container body. In addition, by utilizing a reinforced composite material in its structure the rigidity of the ram can be increased to further reduce the amount of ram deflection. Therefore, the potential for the ram becoming misaligned in a manner which would damage components of the bodymaker and/or the container body formed thereby is reduced.

In one embodiment, the present invention utilizes a punch which is axially advanced by, for instance, a ram to engage a piece of sheet metal stock with an end portion of the punch. In the case

where the present invention is incorporated into a cupping apparatus (e.g., which forms a cup having a bottom and integral sidewall from which a drawn and ironed container body may be formed), the piece of sheet metal stock may be a substantially circular disc and the punch would thus engage one of its substantially planar surfaces. In the case where the present invention is incorporated into a bodymaker for drawn and ironed containers, the piece of sheet metal stock may be the above-defined cup. Consequently, depending upon the positioning of the cup relative to the punch, the punch may extend through the open end of the cup to engage its bottom portion (i.e., the open end of the cup faces the punch), or alternatively the punch may engage the bottom portion without entering the interior of the cup (i.e., the open end of the cup faces away from the punch).

With regard to the ram of this embodiment of the present invention, it is formed at least in part from a reinforced composite material (e.g., a fiber-reinforced composite) to reduce the weight of the ram and/or to allow for increased rigidity thereof to provide the above-identified types of advantages. As can be appreciated, a maximum weight reduction can be realized by forming the entire ram from the reinforced composite material which may be desirable under certain conditions. However, utilizing a combination of such a reinforced composite material and an appropriate metal in the structural configuration of the ram may be desirable under some circumstances, such as in allowing for the continued use of the types of interconnections for the punch and ram drive assembly which are presently used with existing all-metal ram configurations in the case where the present invention is incorporated into a bodymaker for drawn and ironed containers.

Once the piece of sheet metal stock is engaged in the above-described manner by the end portion of the punch, portions of the sheet metal stock are forced to substantially conform to the sidewall portion of the punch as the punch continues to be axially advanced by the ram. In one embodiment in which the present invention is incorporated into a cupping apparatus, this substantial conformance may be provided by passing the punch and the above-identified disc through a draw die to form the cup therefrom. This substantial conformance thus provides the general configuration of a container body, namely a body having a bottom and integral sidewall. In another embodiment in which the present invention is incorporated into a bodymaker for drawn and ironed containers, this substantial conformance may be provided by further processing of this cup. For instance, under some circumstances the specifications of the cup are not the desired specifications for the end prod-

uct container body. Therefore, the thickness of the cup's sidewall may be reduced and the length of such sidewall may be increased as the punch continues to be axially advanced to achieve the final, desired specifications for the container body. In one embodiment, this is provided by passing the punch and the cup through a redraw die and thereafter continuing to pass the redrawn cup through a plurality of substantially linearly-aligned ironing rings.

In another embodiment, the present invention relates to a bodymaker for drawn and ironed containers which includes a punch, having an end portion and a sidewall portion, and which is detachably connected to a ram. The ram in this instance has first, second, and third longitudinally-aligned ram portions. The first and third ram portions are formed from an appropriate metal, whereas the second ram portion is formed from a reinforced composite material (e.g., fiber-reinforced composites) and is positioned longitudinally between the first and third ram portions. In this general configuration, the first, second, and third ram portions may each be individual components and appropriately connected such as by an appropriate binder, or the first and third ram portions may actually be interconnected with an intermediate portion (e.g., such that the first and third portions are of unitary construction) such that the second ram portion may be positioned about and secured to the intermediate portion. Regardless of the actual configuration utilized, the weight of the ram is reduced from that of an all-metal ram configuration and the rigidity of the ram associated with the present invention may be increased to achieve the above-identified types of advantages.

Based upon the particular configuration of the ram in this embodiment of the present invention, the type of interconnection between the punch and ram may be similar to that utilized for existing all-metal ram configurations in bodymakers. For instance, the punch may be interconnected to the first ram portion by a metal punch bolt which threadably engages the first ram portion along a substantially longitudinal portion thereof such that there is a metal-on-metal interface between the punch and ram. This metal-on-metal interface also advantageously provides for an interconnection which is able to withstand the stresses imposed upon this interconnection during the container body forming process.

A drive mechanism is provided for axially advancing the described ram and is detachably connected to the third ram portion. Although a variety of types of interconnections may be utilized, in one embodiment a circumferential portion of the ram is engaged by an metal interconnector associated with the ram drive assembly which is presently

used with all-metal ram configurations. Consequently, only minimal retrofitting is required to adapt the composite ram for use with such a ram drive assembly. Moreover, this interconnection also provides for a metal-on-metal interface, which again provides for an interconnection that is able to withstand the stresses imposed upon such during the container body forming process.

As the ram is axially advanced by the above-described ram drive assembly, the punch engages the piece of sheet metal stock and portions of the sheet metal stock are forced to substantially conform to the sidewall portion of the punch, thereby providing a general configuration of the desired container body, namely a body having a bottom and integral sidewall. For instance, the piece of sheet metal stock may be a cup generally of the above-identified type and the substantial conformance achieved by passing the punch and cup through a redraw die. Thereafter, the thickness of the body's (e.g., redrawn cup's) sidewall is reduced while the length of such sidewall is increased to provide a container body having the desired dimensional specifications (e.g., by passing the punch and redrawn cup through a plurality of ironing rings). Once the container body is formed in this manner, it may be removed from the punch, such as by introducing a flow or an appropriate medium (e.g., air) through a conduit which extends through the ram and punch, preferably about their respective central axes.

In another embodiment, the present invention relates to a bodymaker for drawn and ironed containers which utilizes a ram having first and second ram portions, the first ram portion having first and second end portions which are interconnected by an intermediate portion, the second ram portion being positioned about the intermediate portion. The first ram portion is formed from an appropriate metal, whereas the second ram portion is formed from an appropriate reinforced composite material (e.g., a fiber-reinforced composite) to reduce the weight of the ram and to allow for an increase in rigidity of the ram to thereby provide the above-described types of advantages.

A punch is detachably connected to the first end portion and a ram drive assembly for axially advancing the ram is detachably connected to the second end portion. Consequently, interconnections similar to those of the above-identified embodiment may continue to be utilized to provide the above-described types of advantages. Since the first and second end portions are integrally interconnected by the intermediate portion, the effects of the stresses imposed upon the interconnection of the reinforced composite material of the second ram portion to the first ram portion may be minimized.

As the ram is axially advanced by the ram drive assembly, the piece of sheet metal stock is engaged by an end portion of the punch and at least a portion of the sheet metal stock is forced to substantially conform to a sidewall of the punch. For instance, the piece of sheet metal stock may be a cup generally of the above-identified type such that the punch engages the bottom of the cup and forces the cup through a redraw die to reduce the inner and outer diameter of the cup. This again provides the general configuration of a container body, namely a body having a bottom and integral sidewall (e.g., redrawn cup). Thereafter, the thickness of the body's (e.g., redrawn cup's) sidewall is reduced and the length of such sidewall is increased to achieve the final, desired dimensional specifications for the container body. This again may be achieved by continuing to pass the redrawn cup through a plurality of ironing rings. In order to at least assist in removing the container body from the punch such that the punch and ram may be retracted for reinitialization of the bodymaker, in one embodiment a conduit extends through the entire length of the ram and punch such that an appropriate medium may be forced therethrough to engage the bottom of the container body and force said container body off of the punch.

Brief Description of the Drawings:

Fig. 1 is a schematic representation of a blanking and cupping operation in a double action press which forms a cup from a piece of sheet metal stock that may be provided to a bodymaker for formation of a container body therefrom;

Figs. 2A-2C more particularly illustrate certain steps in the formation of the cup utilizing the press of Fig. 1;

Fig. 3 is a schematic representation of one embodiment of a redraw and ironing procedure for forming a container body from a sheet metal cup;

Fig. 4 is a longitudinal cross-sectional view of one embodiment of a ram for use in a bodymaker of the present invention;

Fig. 5 is a longitudinal cross-sectional view of an interconnection of the ram of Fig. 4 to one embodiment of a punch assembly;

Fig. 6 is an enlarged, partial cross-sectional view of one embodiment of the internal threads of the ram for establishing the interconnection of Fig. 5 between the punch assembly and ram;

Fig. 7 is a longitudinal cross-sectional view of one embodiment of an interconnection of the ram of Fig. 4 to a ram drive assembly;

Fig. 8 is an end view of the ram of Fig. 4;

Fig. 9 is a general representation of one type of a ram drive assembly;

Fig. 10 is a schematic representation of one embodiment of a ram guidance system for engaging one embodiment of a ram; and

Fig. 11 is a longitudinal cross-sectional view of another embodiment of a ram for use in a bodymaker of the present invention.

Detailed Description:

The present invention will be described with reference to the accompanying drawings which assist in illustrating the pertinent features thereof. Generally, the present invention is an apparatus for forming container bodies from a piece of sheet metal stock, such as by a cupping procedure for forming cups from which drawn and ironed containers are formed, or by some type of a drawing and ironing procedure for producing drawn and ironed containers from, for instance, such cups. Advantageously, the ram utilized by the present invention is formed at least in part from a reinforced composite material (e.g., fiber-reinforced composites). Consequently, the speed at which the ram may be advanced for the formation of the container bodies may be increased, which thereby increases production capacity. Moreover, ram deflection may be reduced. For instance, in the event that the ram assumes a substantially horizontal orientation, the amount of deflection of the ram during operation may be reduced by the weight reduction and/or by increasing the rigidity of the ram due to utilizing the composite material for at least a portion of the structure of the ram. This thereby reduces the potential for the ram becoming misaligned during container body forming operations. As can be appreciated, such ram misalignment may cause damage to various components of the apparatus of the present invention, which increases maintenance and/or material costs in terms of replacement parts, as well as to the container body being formed, which also increases raw material costs since such container bodies are typically scrapped.

The present invention is an apparatus for forming a container body from a piece of sheet metal stock, such as by a drawing and ironing procedure or some variation thereof. One embodiment of a drawing procedure for forming a cup (illustrated in part in Fig. 2C and generally in Fig. 3) from which a container body 128 (Fig. 3) may be formed is generally illustrated in Fig. 1. The double action press or cupping apparatus 20 initially forms a substantially circular, disc-shaped blank 28 (shown already partially formed into the cup 32) from a piece of sheet metal stock 24. More particularly, a blanking die 48 is driven down upon the sheet metal stock 24 in the direction of the arrows A to

shear the sheet metal stock 24 between the interface of the blanking die 48 and a blank punch and draw die 56 which is positioned below the blanking die 48 and which remains substantially stationary relative thereto. When advancing in this manner to shear the sheet metal stock 24 and produce the disc-shaped blank 28, the blanking die 48 acts against a stripper plate 60 which is biased in the direction of the arrows B by springs 64. This biasing force is used to strip the sheet metal stock 24 from the blank punch and draw die 56.

A peripheral portion of the disc-shaped blank 28 is clamped between a draw pad 52, which is biased in the direction of the arrow F by, for instance, springs 66, and the blank punch and draw die 56 as illustrated in Figs. 1 and 2A. This biasing force is used to reduce the potential for wrinkling of the disk-shaped blank 28 as it is drawn into a smaller diameter cup 32 by the draw punch 68. With the disc-shaped blank 28 retained in this manner, a draw punch 68 is driven down upon the blank 28 in the direction of the arrow C and passes within a cavity defined by the draw pad 52 and the blank punch and draw die 56. As the draw punch 68 is advanced in this manner, the blank 28 begins to take the shape of a cup 32 by a thinning/stretching of the metal from the region proximate the bottom 44 of the partially formed cup 32 as illustrated in Fig. 2B. This causes the portion of the blank 28 retained between the draw pad 52 and blank punch and draw die 56 to increase in thickness, which thereby forces the draw pad 52, and thus the blanking die 48, in the direction of the arrows B and as further illustrated in Fig. 2B. Once the draw punch 68 completes its downward stroke, a cup 32 is formed which has a bottom 44 and integrally formed sidewall 40 as illustrated in Figs. 2C and 3.

The cup 32 formed in the embodiment of the drawing procedure illustrated in Figs. 1 and 2A-C may be further formed into a container body 128 by a redraw and ironing procedure. One embodiment of such a procedure is illustrated in Fig. 3 as provided by a bodymaker 80. In this regard, the cup 32 is positioned substantially proximate to and aligned with an interior portion of a redraw die 84. A redraw sleeve 96, positioned between the redraw die 84 and the cup 32, is driven in the direction of the arrow D to retain the cup 32 against a shoulder 92 of the redraw die 84 (i.e., the redraw sleeve 96 passes through the open end of cup 32 and clamps its bottom 44 against the shoulder 92 of the redraw die 84). This clamping force is necessary to reduce the potential for wrinkling of the redrawn cup 112 as it is drawn from the larger diameter cup 32. The redraw sleeve 96 thus clamps and positions the cup 32 as a punch 100 advances therethrough to redraw the cup 32. In this regard, the

punch 100 is driven by an appropriate drive mechanism in the direction of the arrow D to pass through the open end of the cup 32 to engage its bottom 44 and advance the cup 32 through the redraw die 84. This substantially conforms the cup 32 to the sidewall 104 of the punch 100 and thereby reduces the inner and outer diameter of the cup 32 to that of the redrawn cup 112. As is known in the art, the orientation of the cup 32 relative to the punch 100 may be substantially reversed in that the bottom 44 of the cup 32 may actually face the punch 100 (not shown). In this case, a clamping mechanism and a redraw die (not shown) of a different configuration may be required.

Once the redrawn cup 112 is formed, the punch 100 continues to advance the redrawn cup 112 through a plurality of ironing rings 124 to reduce the wall thickness of the redrawn cup 112 to a desired thickness for the container body 128 by lengthening the sidewall 116 of the redrawn cup 112. After passing through the last of the ironing rings 124, the punch 100 may interact with a compound doming die 144 to form a domed end 140 for the container body 128. Stripping fingers 148 thereafter engage the sidewall 132 of the container body 128 as the punch 100 is retracted in the direction of the arrow E to reinitiate the bodymaker 80 for formation of additional container bodies 128 in the described manner.

Although the drawing and ironing procedure of Figs. 1-3 generally involves forming a cup 32 from a disc-shaped blank 28 produced from a piece of sheet metal stock 24, redrawing the cup 32 to a redrawn cup 112, and thereafter ironing the sidewalls 116 of the redrawn cup 112 to provide the container body 128, the present invention and its use of a reinforced composite ram is not limited to the specifics of the illustrated procedures. For instance, it may be possible to combine the drawing and ironing aspects into a single in-line assembly such that a single punch can be utilized (e.g., a disc-shaped blank may be drawn and ironed by passing through a plurality of in-line dies). Moreover, there may be alternatives to the described redraw die 84 and ironing rings 124 to provide for the noted functions of such components, namely that of providing substantial conformance to the punch 100. As will be appreciated based upon the following, the present invention and its use of a reinforced composite ram accommodates for such alternatives, and thus such are within the scope of the present invention.

The punch 100 of Fig. 3 is reciprocated in the direction of the arrows D and E by a ram which interconnects the punch 100 with a drive system (not shown) capable of reciprocating the ram, and thus the punch 100, along a substantially lin-

ear/axial path through the redraw die 84 and ironing rings 124. In certain all-metal ram configurations in bodymakers, the ironing rings 124 are actually offset to a certain degree (i.e., the rings 124 are not linearly aligned on a horizontal plane) to account for the deflection of such rams due to their weight. As noted above, ram deflection produces a number of problems in a bodymaker for drawn and ironed containers. Initially, deflection can result in the punch 100 impacting the redraw die 84 and/or the ironing rings 124, each of which could damage such components and/or the container body 128 being formed. Even if such an impact does not occur, ram deflection can cause certain defects in the structure of the container body 128. For instance, there can be an uneven distribution of metal along the body's 128 sidewall 132 and/or the stresses within the sidewall 132 can be increased to an undesirable degree. Moreover, the sidewall 132 of the container body 128 may actually tear. Although offsetting the ironing rings 124 may provide some benefit in avoiding these types of problems associated with ram misalignment, it can be appreciated that inaccuracies in establishing this offset will often inevitably occur due to a plurality of factors. Moreover, providing for this offset of course increases the set-up time for a production run for a given container body 128 and ram.

One embodiment of a ram which is formed at least in part from a reinforced composite material to reduce the weight thereof and/or increase the rigidity thereof in accordance with the principles of the present invention, and to thus reduce deflection to reduce the potential for the above-identified types of problems, is illustrated in Fig. 4. The ram 160 of Fig. 4 generally includes first and second ram portions 164, 180. The first ram portion 164 is formed from an appropriate metal such as a carbon steel, which as will be discussed below at least in part allows for interconnection of the ram 160 with the punch assembly 260 (Fig. 5) and ram drive assembly 288 (Figs. 7, 9) in a manner which minimizes the amount of retrofitting, if any, required to use the ram 160 with existing configurations of such assemblies 260, 288. This also allows for maintenance of a metal-on-metal interface to enhance the strength of the described interconnections. The second ram portion 180 is formed from an appropriate reinforced composite material. Although a variety of reinforced composites may be appropriate for this particular application, in one embodiment the reinforced composite material is carbon and/or graphite fibers, impregnated with an appropriate resin (e.g., T5012K/ERL 1908 prepreg tape/prepreg tow from Amoco Corporation), which are applied to the ram 160 in a manner discussed below. However, a variety of types of fibers from both a materials standpoint and/or from a configuration standpoint (e.g., continuous fibers, long fibers, short fibers), as well as a variety of other types of reinforced matrices may be appropriate. Nonetheless, based upon this use of a reinforced composite material, the weight of the ram 160 is desirably reduced and the manner in which the composite material is applied may increase the rigidity and/or affect other properties of the ram 160 in a desirable manner.

The first ram portion 164 has first and second end portions 168, 172 which are integrally connected by an intermediate portion 176 (i.e., the first ram portion 164 is of unitary construction). Consequently, the first and second end portions 168, 172 of the first ram portion 164 and the second ram portion 180 thus define three longitudinally aligned portions, the second ram portion 180 being positioned longitudinally between the first and second end portions 168, 172.

The first end portion 168 is interconnected to an appropriate punch assembly which is integral in the formation of the container body 128 as described above with regard to the redrawing and ironing procedure of Fig. 3. One embodiment of a punch assembly 260 currently used with existing configurations of all-metal rams (not shown) is illustrated in Fig. 5 as it could be interconnected to the ram 160. The punch assembly 260 generally includes a punch sleeve 264, a punch nose 276, and a punch bolt 280 which are detachably interconnected and assembled in a desirable manner. Generally, the punch nose 276 is in one embodiment formed from tool steel and defines at least a portion of the configuration of the bottom 136 of the container body 128 by engaging the bottom 44 of the cup 32 in the above-described redraw and ironing procedure of Fig. 3, including the annular supporting surface 138 of the container body 128. Moreover, the punch nose 276 also defines the portion of the body 128 which tapers in from the sidewall 132 of the container body 128 to the annular supporting surface 138. Furthermore, the punch nose 276 defines a portion of the container body 128 which interconnects the annular supporting surface 138 with the dome 140 of the container body 128 formed by the interaction between the punch assembly 260 and, for instance, the compound doming die 144 as noted above with regard to Fig. 3. Consequently, it can be appreciated that the punch nose 276 is an integral portion of the punch assembly 260 and would typically be most affected by an impacting of the redraw die 84 and/or ironing rings 124 of Fig. 3 due to misalignment of the ram 160. Therefore, in order to avoid having to replace an entire ram 160 if the punch nose 276 becomes damaged and/or to allow for the same bodymaker to be used to form container bodies having differing bottom configurations, the

punch nose 276 is detachably connected to the ram 160.

The punch sleeve 264 is in one embodiment formed from carbide and interfaces with the punch nose 276 and a shoulder 200 of the first end portion 168 of the ram 160 to define the configuration for the container body's 128 sidewall 132 and to allow for an effective interconnection of the punch assembly 260 to the ram 160. In order to assist in the alignment of the punch sleeve 264 on the first end portion 168 and to reduce manufacturing tolerances, the first end portion 168 and punch sleeve 264 include a plurality of steps 204, 268, respectively, which are interconnected by step connectors 208, 272, respectively. By utilizing this interface between the punch sleeve 264 and the first end portion 168 it is not necessary to attempt to obtain uniform contact along the entire length of the interconnection of the sleeve 264 and first end portion 168 while maintaining the desired orientation of the punch sleeve 264 (e.g., being generally cylindrical and substantially parallel to the central axis of the ram 160). For instance, in one embodiment the length of the punch sleeve 264 is approximately seven inches and it may thus be difficult to achieve uniform contact along the entire distance and/or within a preferred range of tolerances.

The punch bolt 280 interconnects the punch nose 276 and punch sleeve 264 on the first end portion 168 and also is utilized in the formation of the dome 140 of the container body 128 by interacting with, for instance, the compound doming die 144 (Fig. 3). With regard to the actual interconnection, an end of the punch sleeve 264 engages a shoulder 200 of the first end portion 168 and is retained thereagainst by the punch nose 276 which engages an opposite end of the punch sleeve 264. The punch nose 276 is acted upon by the punch bolt 280 to force the punch nose 276 into engagement with the punch sleeve 264 in the described manner. Consequently, the punch sleeve 264 is firmly retained between the shoulder 200 of the first end portion 168 and the punch nose 276. Although a variety of connections may be appropriate for interconnecting the punch bolt 280 and the first end portion 168, in one embodiment a threaded connection is utilized and is preferably formed by utilizing threads formed by a SPIRALOCK® tap. Generally, the threads 212 of the ram 160 are specifically configured as illustrated in Fig. 6 to effectively distribute the forces imparted upon the punch assembly 260 during operation. This is desirable in that the interconnection between the punch assembly 260 and the ram 160 may experience about 5,000-7,000 pounds in compressive load when passing through the redraw die 84 and ironing rings 124 and when impacted by the compound doming die 144 (Fig. 3) when for-

ming the container body 128 at a certain production rate, and about 2700 pounds in tensile forces when the punch assembly 260 and ram 160 are retracted through the ironing rings 124 and redraw die 84 for reinitialization and formation of another container body 128.

Since there is a metal-on-metal interface between the punch assembly 260 and the ram 160, namely in the threaded connection established between the punch bolt 280 and the first end portion 168, the strength of the interconnection is maintained at a level to sufficiently withstand the above-identified stresses encountered during the redraw and ironing procedure illustrated in Fig. 3. Moreover, this configuration of the first end portion 168 allows punch assemblies of an existing configuration to continue to be used with the ram 160 of the present invention, thereby minimizing the amount of retrofitting of the bodymaker required to utilize the ram 160.

As noted above, the container body 128 is substantially conformed to the contour of the punch assembly 260 during the redraw and ironing procedure of Fig. 3. In order to remove the container body 128 from the punch assembly 260 when the ram is retracted in the direction of the arrow E in Fig. 3, such as by the ram drive assembly 288 to be discussed below, stripping fingers 148 (Fig. 3) may be used to engage the sidewall 132 of the container body 128 and remove such from the punch assembly 260. In order to at least assist in this removal of the container body 128, in one embodiment a conduit 184 extends through substantially the entire length of the ram 160 substantially about its central axis. Moreover, a conduit 284 extends through the punch bolt 280 of the above-described punch assembly 260 and is aligned with the conduit 184. Therefore, an appropriate medium such as air may be forced through the conduits 184, 284 to at least assist in the removal of the container body 128 from the punch assembly 260. In this instance, it may be desirable to position an o-ring (not shown) within the o-ring groove 192 on the end of the second end portion 172.

The ram 160 is interconnected to an appropriate ram drive assembly 288 (Figs. 7, 9) such that the punch assembly 260 may be advanced through the redraw die 84 and ironing rings 124 of Fig. 3 in the above-described manner. In this regard, the second end portion 172 of the first ram portion 164 as noted above is formed from a metal (as is the entire first ram portion 164), and thus allows for a metal-on-metal interface for this interconnection. This also minimizes the amount of retrofitting required to adapt the ram 160 for use with certain existing ram drive mechanisms of bodymakers. Although a variety of interconnections may be appropriate, one such interconnection is

illustrated in Fig. 7.

With regard to one type of an interconnection between the ram 160 and the ram drive assembly 288, the second end portion 172 includes a notch 188 which extends about a substantially circumferential portion of the second end portion 172. A split ring 236 is positioned within the notch 188 and is engaged between a split ring retainer 240 and a ram block 244. Consequently, by engaging the split ring retainer 240 and ram block 244 with screws which are positioned in holes 248, the ram 160 may be securely interconnected to the ram drive assembly 288. Screws and/or dowels (not shown) may also be positioned within the screw holes 196 to reduce the potential for relative rotation between the ram 160 and the ram drive assembly 288 as also illustrated in Fig. 8.

As noted above, the second ram portion 180 is formed from an appropriate reinforced composite material to reduce the total weight of the ram 160. As can be appreciated, the type of reinforced composite material utilized as well as the manner in which the composite material is incorporated on the ram 160 may be varied to provide desirable properties for the ram 160 (e.g., various matrices may be appropriate, various manners of reinforcement may be appropriate). For instance, in the case where the composite material is reinforced with appropriate fibers, such as carbon and/or graphite fibers impregnated/coated with an appropriate resin matrix, the manner in which such fibers are applied to/about the intermediate portion 176 of the first ram portion 164 may be varied to alter the properties of the ram 160 (e.g., to vary the rigidity of the ram 160). In one embodiment high modulus carbon fibers impregnated with a resin matrix such as the above-noted ERL 1908 are applied to the intermediate portion 176 in a multiple layer configuration. In this case, layers of lengthwise as well as radial windings of fibers may be applied to the intermediate portion 176 to provide desirable characteristics for the ram 160. Although a variety of fibers may be utilized, preferably the modulus of elasticity of this particular fiber-reinforced composite material itself ranges from about 51.3×10^6 psi to about 62.7×10^6 psi.

The above-described ram 160 could be incorporated into the bodymaker 80 to propel the punch assembly 260 through the redraw die 84 and ironing rings 124 in the configuration of Fig. 3. In this regard, the interconnection of Fig. 7 between the ram 160 and the ram block 244 could be utilized to allow for use of the ram drive assembly 288 of Fig. 9. Generally, the ram drive assembly 288 includes a rotatable wheel 290 having a first crank pin 291 attached thereto. A linkage 292 interconnects the first crank pin 291 to a second crank pin 294 which is attached to the ram block 244. The ram block

244 is restrained so as to have reciprocating linear motion along one axis only. Consequently, upon rotation of the wheel 290 it can be appreciated that the ram block 244, and thus the ram 160 attached thereto, is reciprocated in a substantially axial direction.

In order to provide support for the cantilevered connection between the ram 160 and the ram drive assembly 288, a ram guidance system may be positioned proximate the redraw die 84. For instance, this ram guidance system may be provided by hydrostatic bearings (not shown) which engage the ram 160. Another type of ram guidance system 296 is illustrated in Fig. 10 and includes a three cam rollers 300 for engaging the ram 160. In order to enhance the interface between the rollers 300 and the ram 160, the ram 160 may have multiple inclined engaging surfaces 216 defining its perimeter as illustrated in Figs. 8 and 10. Although three rollers 300 are illustrated, it can be appreciated that other combinations may be utilized, including using a single roller to engage the lower-most portion of the ram 160.

In one embodiment, the above-described fiber-reinforced composite material of the second ram portion 180 is positioned about the intermediate portion 176 of the first ram portion 164 and is thereafter machined to form the multiple perimeter surface configuration. Although the composite material of the second ram portion 180 may directly engage the rollers 300 of the ram guidance system 296, in one embodiment steel wear strips 220 are positioned within notches 224 in each of the six surfaces as illustrated in Figs. 4 and 8. Therefore, only the wear strips 220 will require replacement if need be versus the entire ram 160. In order to allow for the expiration of a longer period of time between replacement of wear strips 220, the ram 160 may be rotated to engage three alternate surfaces and wear strips 220.

With further regard to the configuration which incorporates the wear strips 220, particularly one manner in which the ram 160 may be formed in such a configuration, initially a unidirectional prepreg (e.g., carbon fibers impregnated with an appropriate resin) is wrapped around the intermediate portion 176 of the ram at various angles to form a base of the second ram portion 180. The ram 160 is then cured at a temperature of 350°F for 8 hours, including 1 hour to build up to 350°F and 1 hour to cool down therefrom. The base of the second ram portion 180 is then machined down to a substantially cylindrical form and the wear strips 220 are applied and bonded thereto in an appropriate manner. In one embodiment, opposing wear strips 220 are bonded to the machined portion and thereafter cured at a temperature of 150°F to 250°F for 1 to $1\frac{1}{2}$ hours. After all of the wear strips

220 have been bonded in this manner, the prepreg is laid up longitudinally between the wear strips 220 to an outer diameter which is slightly larger than that of the wear strips 220. Thereafter, the ram 160 is appropriately wrapped and cured again at a temperature of 350°F for 8 hours. Once appropriately cured, the second ram portion 180 may be machined to the desired specifications.

Notwithstanding the support provided to the ram utilized in a given bodymaker by the ram guidance system 296 or other functional equivalents thereof, as well as any support provided by the redraw die 84 and ironing rings 124 when the ram 160 is passing therethrough during formation of the container body 128 (i.e., the presence of the container body 128 between the ram 160 and the redraw die 84/ironing rings 124 may provide some degree of support to the ram 160 under certain conditions, but such support will not be provided by the redraw die 84/ironing rings 124 during retraction of the ram 160 since there is a clearance therebetween), there is a relatively close tolerance between the ram and the redraw die 84 and the ironing rings 124 such that a certain amount of deflection of the ram may cause a misalignment of the ram. Certain degrees of misalignment may cause a number of problems. For instance, misalignment or a drooping of the ram may cause an uneven distribution in the sidewall of the cylindrical container body 128 and/or may increase the potential for a tearing of the container body 128 during formation. Furthermore, such misalignment may cause increased stresses in the sidewall 132 of the container body 128 which may lead to failure of the container body 128 in subsequent processing and/or use. Moreover, the punch nose 276 may impact the redraw die 84 and/or ironing rings 124 in a manner which will damage the punch nose 276, redraw die 84, and/or ironing rings 124 and/or the compound doming die 144 in a manner which will require replacement of the damaged components. Moreover, ironing rings 124 may wear unevenly causing the container body 128 to be out of round, which thereby increases the potential for subsequent processing failure.

The ram 160 provides a number of advantages over existing all-metal ram configurations (not shown) by addressing the above-identified types of problems. For instance, a steel ram formed in a configuration similar to the ram 160 and having a length of approximately 49 inches weighs approximately 70 pounds with the punch assembly 260 attached thereto, whereas the ram 160 with the punch assembly 260 attached thereto weighs approximately 30 pounds. Consequently, the speed at which the present invention may be operated with its reinforced composite ram, due at least in part to this weight reduction, is believed to be increased

by at least 10% over an all-metal configuration. For instance, in one type of bodymaker the speed at which the all-metal ram (e.g., carbon steel) may be advanced through its redraw die and ironing rings is only approximately 250 strokes per minute. In contrast, based upon the weight reduction achieved by utilizing the composite material in the configuration of the ram 160, it is believed that the same bodymaker utilizing the ram 160 can be operated at speeds greater than 275 strokes per minute. Therefore, the production capacity of a bodymaker utilizing the principles of the present invention may be desirably increased.

With further regard to advantages of the ram 160 utilizing the principles of the present invention, in a bodymaker the ram is often extended a length of between 18 and 26 inches from the associated ram guidance system to fully form the given container body (e.g., the stroke of the bodymaker's ram is typically greater than 15 inches, and usually ranges from an 18 inch stroke to a 26 inch stroke). In the above-identified all-metal ram configuration with a 24 inch stroke (not shown), the ram has a deflection of 0.0094 inches. In contrast, the ram 160 utilizing the composite material for the described portion of its structure has a deflection of only about 0.0030. In the event that a longer stroke is utilized, this magnitude of deflection would be further magnified, and would thus further increase the potential for damage to the bodymaker and/or container body of the above-described types. As can be appreciated, a variety of lengths of strokes in bodymakers may be utilized depending upon, for instance, the size/type of container being formed. Nonetheless, even a bodymaker having a relatively short stroke may achieve certain advantages by incorporating a ram utilizing the principles of the present invention.

Another embodiment of the present invention which incorporates a reinforced composite material of the above-described type, and thereby provides similar advantages to the ram 160, is the ram 304 of Fig. 11. The ram 304 generally includes first, second, and third ram portions 308, 312, 316 which are preferably longitudinally aligned. The first and third ram portions 308, 316 are formed from an appropriate metal and may be configured similarly to the first and second end portions 168, 172 of the ram 160 to allow for interconnection to the punch assembly 260 and ram drive assembly 288, respectively, in the above-described manners. Moreover, the second ram portion 312 is formed from an appropriate reinforced composite material such as those noted above to reduce the overall weight of the ram 304 and allow for increased rigidity thereof.

In one embodiment, the second ram portion 312 of the ram 304 is interconnected with each of

the first and third ram portions 308, 316 by an appropriate binder. As noted above, the ram 304 experiences relatively significant compressive and tension stresses in forcing the cup 32 (Fig. 3) through the redraw die 84 and ironing rings 124, and in being retracted therethrough after the container body 128 is formed, respectively. Consequently, in order to increase the bonding area between the interface between the second ram portion 312 and each of the first and third ram portions 308, 316, it may be desirable to incorporate a number of first and second annular surfaces 320, 324 as illustrated in Fig. 10. Although it can be appreciated that the weight of the ram 304 may be reduced by this configuration, the interconnections between the second ram portion 312 and each of the first and third ram portions 308, 316 must be able to withstand the stresses involved during the container body forming procedure. Moreover, the complexity of the interconnections may make manufacturing the ram 304 somewhat difficult.

Based upon the foregoing, it can be appreciated that the present invention provides a number of advantages. Moreover, the principles may be extended to applications relating to the formation of container bodies other than the described drawing and ironing procedure for the bodymaker 80. For instance, it may be desirable to incorporate a ram, which is formed at least in part from a reinforced composite material, into an apparatus for forming cups 32 as generally illustrated in Fig. 3. Furthermore, various geometrical configuration of rams (e.g., round) may be employed depending upon prescribed circumstances, and the "composition" of the ram may range from an all reinforced composite material variety, to one which includes a combination of such material with an appropriate metal (e.g., ram 160, ram 304). In any case, by incorporating a reinforced composite material it may be possible to reduce the weight of a particular ram utilized in the container body forming process to about 20-50% of an all steel ram of a similar configuration.

The foregoing-description of the present invention has been presented for purposes of illustration and description. Furthermore, the description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, and skill and knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are further intended to explain best modes known of practicing the invention to enable others skilled in the art to utilize the invention, and such other embodiments, and with various modifications required by the particular applications or uses of the present invention. It is

intended that the appended claims be construed to include alternative embodiments to the extent permitted by the prior art.

Preferred embodiments of the invention are disclosed in the claims and also the dependent claims, which should be read as depending not only on the specified claims, but on any other claim and combination thereof. The same is true for the following summary of the invention.

The invention may be summarized as follows:

1. An apparatus for forming a container body from a piece of sheet metal stock, comprising:
punch means having an end portion and a sidewall portion;
means for axially advancing said punch means, said means for axially advancing comprising a reinforced composite material, said end portion of said punch means being engageable with at least a portion of said piece of sheet metal stock; and
means for substantially conforming to at least a portion of said piece of sheet metal stock to said sidewall portion of said punch means as said punch means is axially advanced, wherein a container body having a bottom and integral sidewall is formed.
2. An apparatus, as in 1, wherein:
said punch means is detachably connected to an end portion of said means for axially advancing.
3. An apparatus, as in 1, wherein:
said composite material has a modulus of elasticity ranging from about 51.3×10^6 pounds per square inch to about 62.7×10^6 pounds per square inch.
4. An apparatus, as in 1, wherein:
said composite material comprises at least one of carbon fibers and graphite fibers having a resin thereon.
5. An apparatus, as in 1, wherein:
said means for axially advancing is a composite ram, said composite ram having a weight ranging from about 20% to about 50% of a similarly configured all carbon steel ram.
6. An apparatus, as in 1, wherein:
said means for axially advancing is a composite ram and comprises first, second, and third longitudinally-aligned ram portions, said first and third ram portions comprising a metal, said second ram portion comprising said composite material and being positioned longitudinally between said first and third ram portions.
7. An apparatus, as in 6, further comprising:
drive means for driving said composite ram between at least first and second positions, said drive means being detachably connected to said

third ram portion, said punch means being detachably connected to said first ram portion.

8. An apparatus, as in 6, wherein:

said first and third ram portions are integrally connected by an intermediate ram portion, said second ram portion being positioned about and secured to said intermediate ram portion.

9. An apparatus, as in 1, further comprising:

means for guiding said means for axially advancing toward said means for conforming.

10. An apparatus, as in 9, wherein:

said means for axially advancing comprises a ram, wherein a perimeter of at least a first longitudinal portion of said ram comprises a plurality of substantially planar surfaces, said means for guiding engaging at least one of said surfaces.

11. An apparatus, as in 9, further comprising:

wear strip means positioned on said means for axially advancing, said wear strip means interfacing with said means for guiding.

12. An apparatus, as in 9, wherein:

said punch means extends beyond said means for guiding a distance of at least 15 inches when said punch means completes its interaction with said means for conforming.

13. An apparatus, as in 1, further comprising:

means for forcing a medium through a longitudinal conduit portion of said means for axially advancing to at least assist in a removal of said container body from said punch means.

14. An apparatus, as in 1, wherein:

said means for axially advancing is a substantially horizontally positioned ram.

15. An apparatus, as in 1, further comprising:

drive means for driving said means for axially advancing between at least first and second positions to define a stroke for said means for axially advancing, said means for axially advancing comprising a composite ram, said container body being formed in driving said composite ram from said first position to said second position.

16. An apparatus, as in 15, wherein:

said drive means drives said composite ram between said first and second positions at a rate which is at least ten percent greater than a similarly configured all carbon steel ram.

17. An apparatus, as in 1, wherein:

said means for conforming comprises a re-draw die.

18. An apparatus, as in 1, wherein:

said first means comprises a plurality of linearly aligned and spaced ironing rings.

19. An apparatus, as in 1, further comprising:

means for reducing a thickness of and increasing a length of said sidewall portion of said container body to further form said container

body as said punch means is axially advanced.

20. An apparatus for forming a container body from a piece of sheet metal stock, comprising:

punch means having an end portion and a sidewall portion;

ram means comprising first, second, and third longitudinally-aligned ram portions, said first and third ram portions comprising a metal, said second ram portion comprising a reinforced composite material and being longitudinally positioned between said first and third portions, wherein said punch means is detachably connected to said first ram portion;

drive means for axially advancing said ram means, said drive means being detachably connected to said third ram portion, said end portion of said punch means being engageable with said piece of sheet metal stock; means for substantially conforming at least a portion

of said piece of sheet metal stock to said sidewall portion of said punch means to form a body having a bottom and integral sidewall as said ram means is axially advanced; and

first means for reducing a thickness of and increasing a length of said sidewall of said body as said ram means is axially advanced to form said container body.

21. An apparatus, as in 20, wherein:

said composite material has a modulus of elasticity ranging from about 51.3×10^6 pounds per square inch to about 62.7×10^6 pounds per square inch.

22. An apparatus, as in 20, wherein:

said composite material comprises at least one of carbon fiber and graphite fiber having a resin thereon.

23. An apparatus, as in 20, wherein:

said ram means has a weight ranging from about 20% to about 50% of a similarly configured all carbon steel ram.

24. An apparatus, as in 20, wherein:

said second ram portion is adhesively attached to each of said first and third ram portions.

25. An apparatus, as in 24, wherein:

an interface between said second ram portion and each of said first and third ram portions comprises a plurality of radially spaced, substantially annular, planar first surfaces which are substantially perpendicular to a central axis of said ram means, said first surfaces which are radially adjacent being interconnected by a substantially annular second surface which is substantially parallel to said central axis.

26. An apparatus, as in 20, wherein:

said first and third ram portions are integrally connected by an intermediate ram portion, said second ram portion being positioned about

and secured to said intermediate ram portion.

27. An apparatus, as in 20, wherein:

said ram means is substantially horizontally positioned.

28. An apparatus, as in 20, further comprising:

means for forcing a medium through a longitudinal conduit portion of said ram means to remove said container body from said punch means.

29. An apparatus, as in 20, wherein:

said drive means axially advances said ram means through a stroke to form a single said container body, said stroke comprising advancing said ram means from a first position to a second position and thereafter retracting said ram means to said first position, said drive means advancing said ram means at a rate which is at least ten percent greater than achievable using a similarly configured all carbon steel ram.

30. An apparatus for forming a container body from a piece of sheet metal stock, comprising:

punch means having an end portion and a sidewall portion;

ram means comprising first and second ram portions, said first ram portion comprising a metal and having first and second end portions integrally interconnected by an intermediate portion extending between said first and second end portions, said second ram portion comprising a reinforced composite material and being positioned about said intermediate portion, wherein said punch means is detachably connected to said first end portion;

drive means for axially advancing said ram means, said drive means being detachably connected to said second end portion, said end portion of said punch means being engageable with said piece of sheet metal stock;

means for substantially conforming at least a portion of said piece of sheet metal stock to said sidewall portion of said punch means as said ram means is advanced axially to form a body having a bottom and integral sidewall; and

first means for reducing a thickness of and increasing a length of said sidewall portion of said body to form said container body as said ram means is axially advanced.

31. An apparatus, as in 30, wherein:

said punch means is detachably connected to said first end portion along a substantially longitudinal portion which is positioned about a central axis of said ram means.

32. An apparatus, as in 30, wherein:

said second ram portion has a modulus of elasticity ranging from about 51.3×10^6 pounds per square inch to about 62.7×10^6 pounds per square inch.

33. An apparatus, as in 30, wherein:

said reinforced composite material comprises at least one of carbon fiber and graphite fiber having a resin thereon.

34. An apparatus, as in 30, wherein:

said ram means has a weight ranging from about 20% to about 50% of a corresponding, similarly configured all carbon steel ram.

35. An apparatus, as in 30, wherein:

said ram means is substantially horizontally positioned.

36. An apparatus, as in 30, further comprising:

a substantially circumferential notch portion on said second end portion of said first ram portion for interconnecting said ram means and said drive means.

37. An apparatus, as in 30, further comprising:

conduit means, extending through said first and second ram portions about a central axis of said ram means, for advancing a medium through said ram means to remove said container body from said punch means.

38. An apparatus, as in 30, wherein:

said drive means axially advances said ram means between at least first and second positions to define a stroke, said drive means axially advancing said ram means at a rate which is at least 10% strokes per minute greater than achievable using a similarly configured all carbon steel ram, said container body being formed in advancing said ram means from said first to said second position, said container body being removed from said punch means in advancing said ram means from said second position to said first position.

Claims

1. An apparatus for forming a container body from a piece of sheet metal stock, comprising:

punch means having an end portion and a sidewall portion;

ram means comprising first, second, and third longitudinally-aligned ram portions, said first and third ram portions comprising a metal, said second ram portion comprising a reinforced composite material and being longitudinally positioned between said first and third portions, wherein said punch means is detachably connected to said first ram portion;

drive means for axially advancing said ram means, said drive means being detachably connected to said third ram portion, said end portion of said punch means being engageable with said piece of sheet metal stock;

means for substantially conforming at least a portion of said piece of sheet metal stock to said sidewall portion of said punch means to

form a body having a bottom and integral sidewall as said ram means is axially advanced; and

first means for reducing a thickness of and increasing a length of said sidewall of said body as said ram means is axially advanced to form said container body.

2. An apparatus, as claimed in Claim 1, wherein:
said composite material has a modulus of elasticity ranging from about 51.3×10^6 pounds per square inch to about 62.7×10^6 pounds per square inch. 10
3. An apparatus, as claimed in Claim 1, wherein:
said composite material comprises at least one of carbon fiber and graphite fiber having a resin thereon. 15
4. An apparatus, as claimed in Claim 1, wherein:
said ram means has a weight ranging from about 20% to about 50% of a similarly configured all carbon steel ram. 20
5. An apparatus, as claimed in Claim 1, wherein:
said second ram portion is adhesively attached to each of said first and third ram portions. 25
6. An apparatus, as claimed in Claim 5, wherein:
an interface between said second ram portion and each of said first and third ram portions comprises a plurality of radially spaced, substantially annular, planar first surfaces which are substantially perpendicular to a central axis of said ram means, said first surfaces which are radially adjacent being interconnected by a substantially annular second surface which is substantially parallel to said central axis. 30
35
40
7. An apparatus, as claimed in Claim 1, wherein:
said first and third ram portions are integrally connected by an intermediate ram portion, said second ram portion being positioned about and secured to said intermediate ram portion. 45
8. An apparatus, as claimed in Claim 1, wherein:
said ram means is substantially horizontally positioned. 50
9. An apparatus, as claimed in Claim 1, further comprising:
means for forcing a medium through a longitudinal conduit portion of said ram means to remove said container body from said punch means. 55

10. An apparatus, as claimed in Claim 1, wherein:
said drive means axially advances said ram means through a stroke to form a single said container body, said stroke comprising advancing said ram means from a first position to a second position and thereafter retracting said ram means to said first position, said drive means advancing said ram means at a rate which is at least ten percent greater than achievable using a similarly configured all carbon steel ram.

FIG. 1

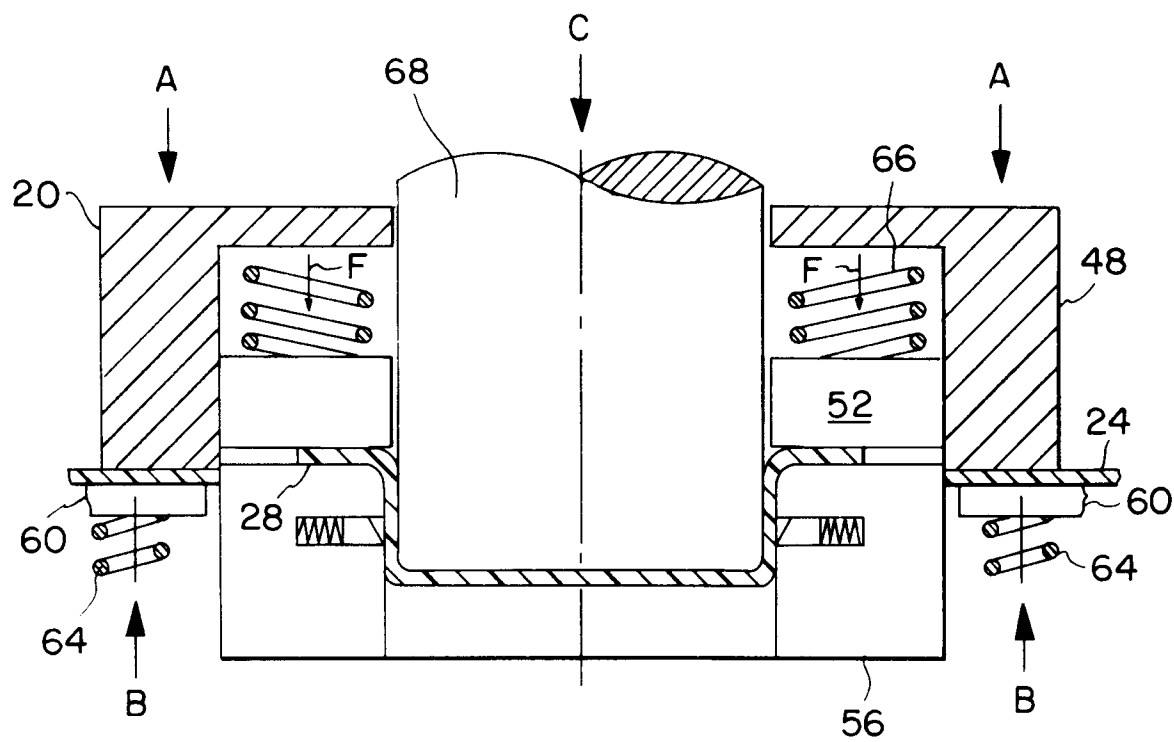


FIG. 2A

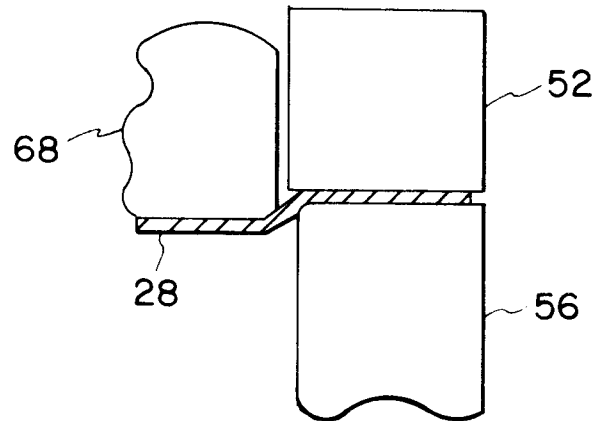


FIG. 2B

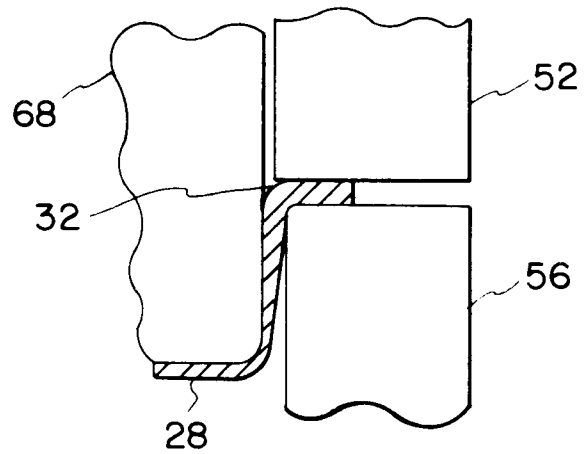


FIG. 2C

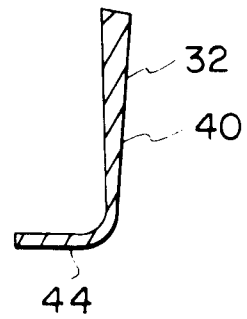


FIG. 3

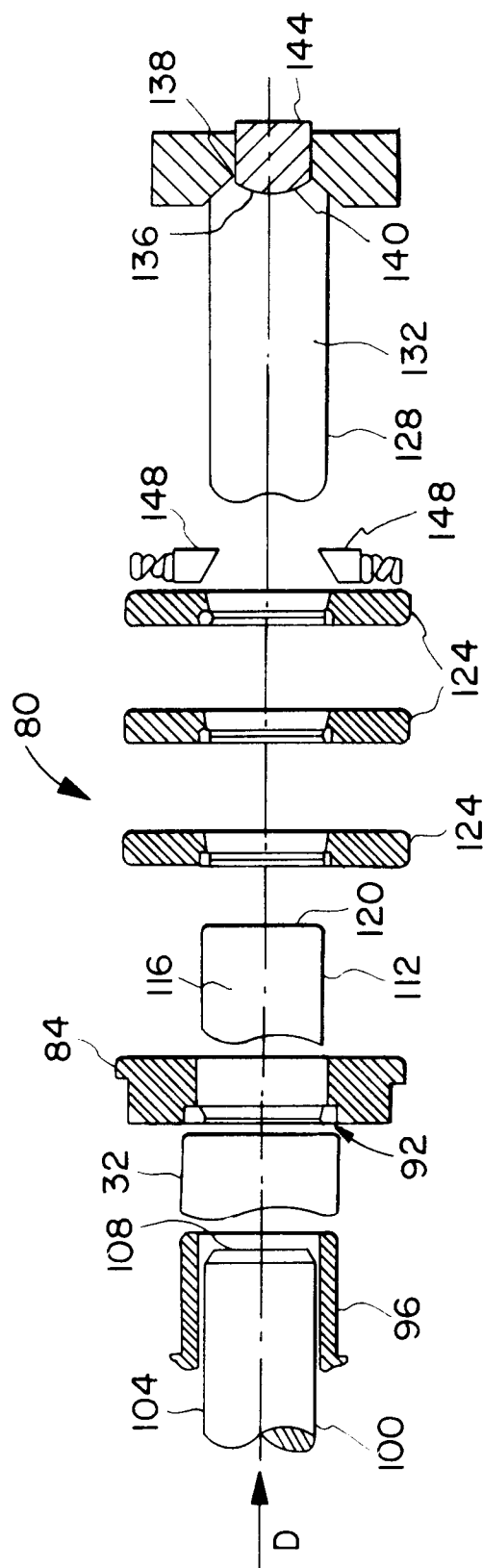


FIG. 4

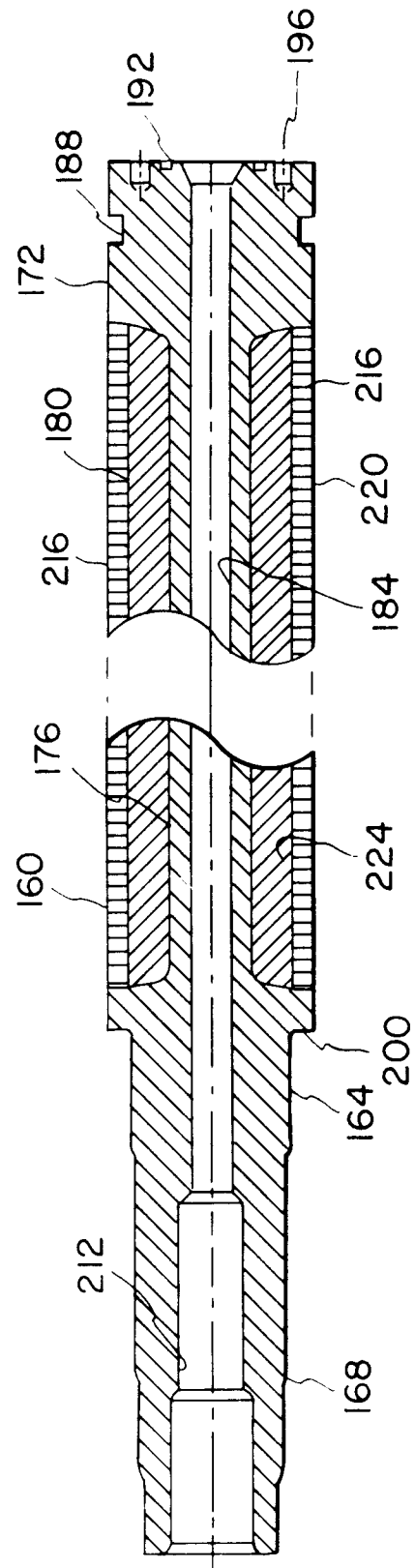


FIG. 5

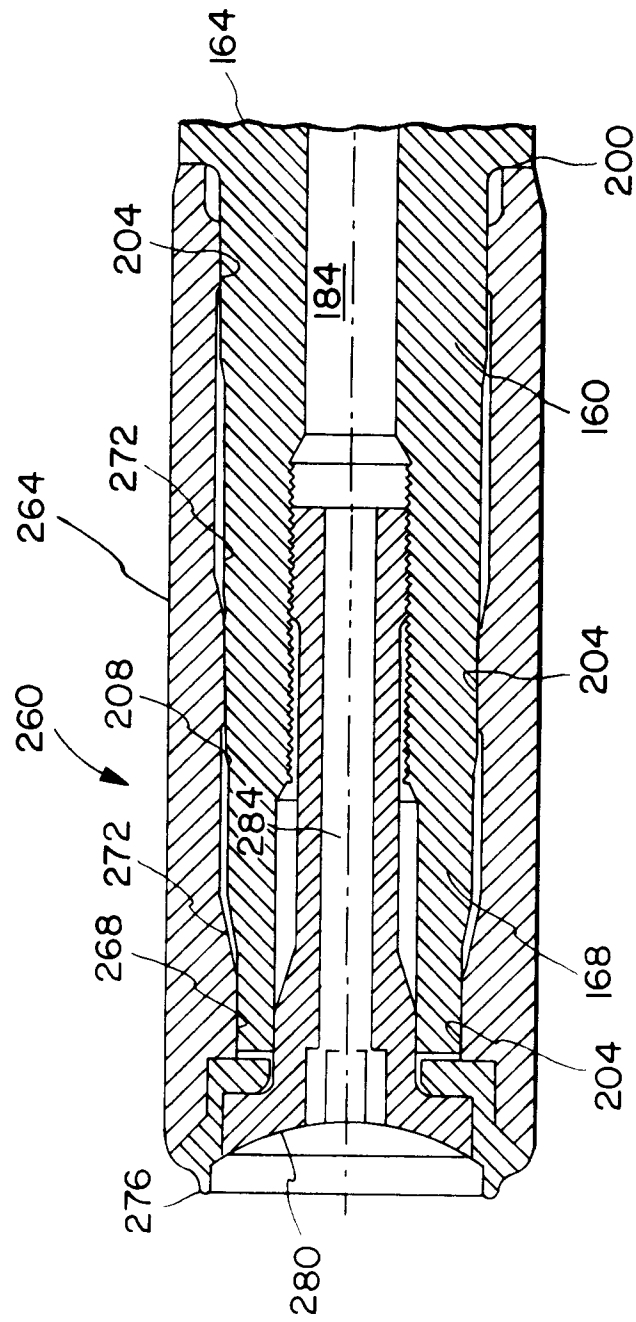


FIG. 6

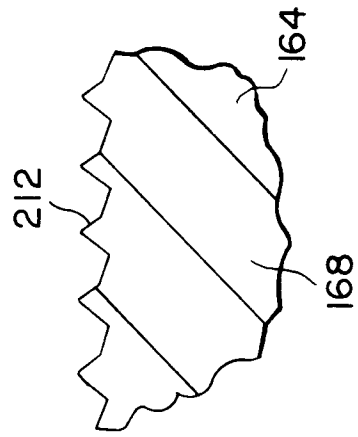


FIG. 7

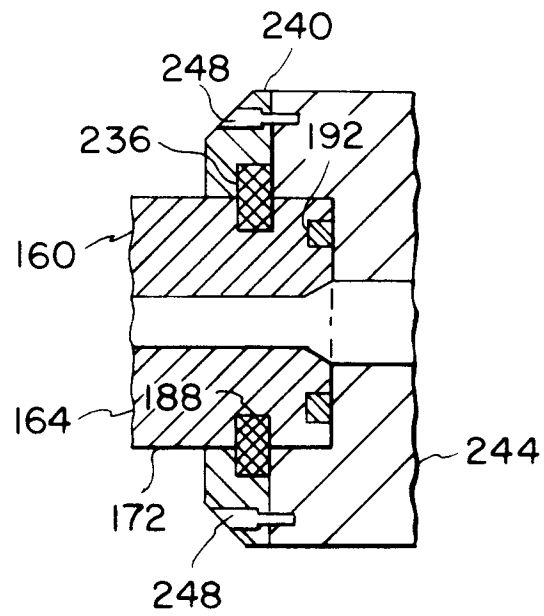


FIG. 8

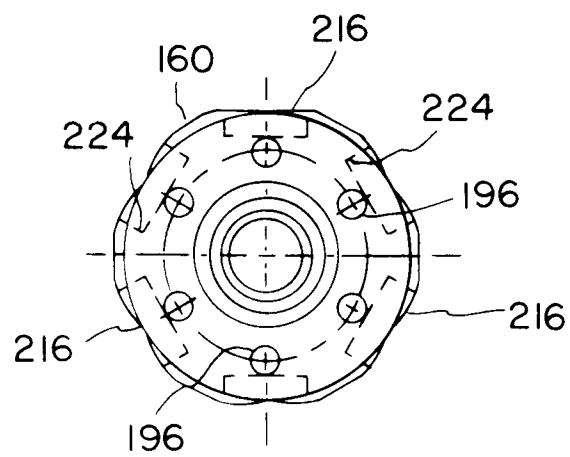


FIG. 9

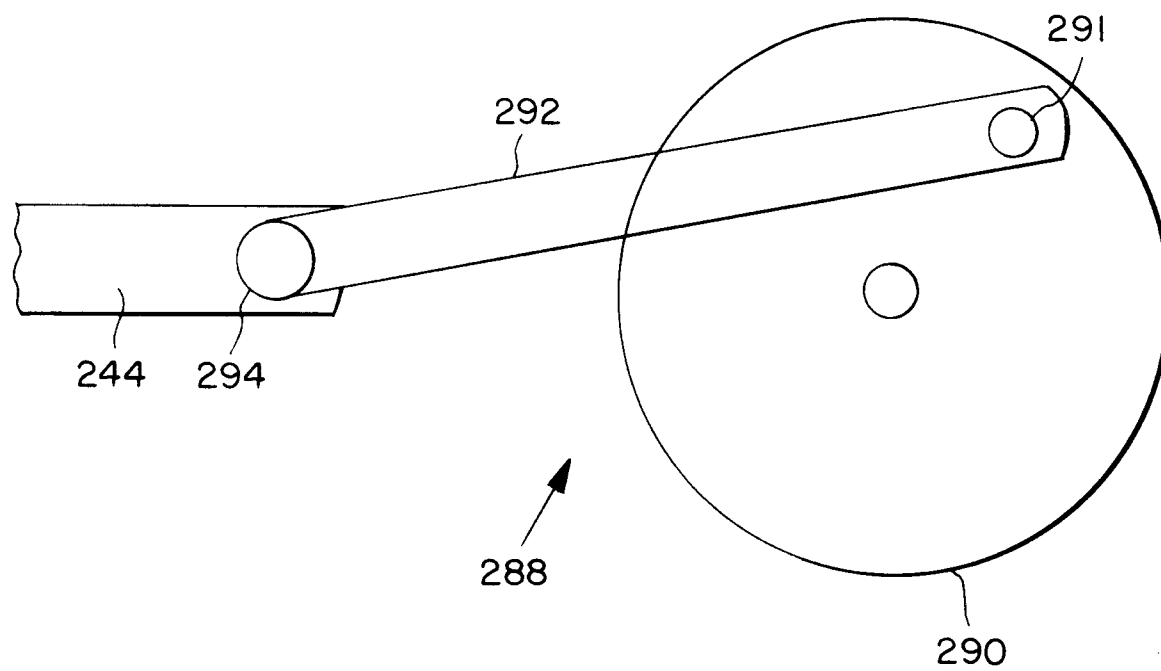


FIG. 10

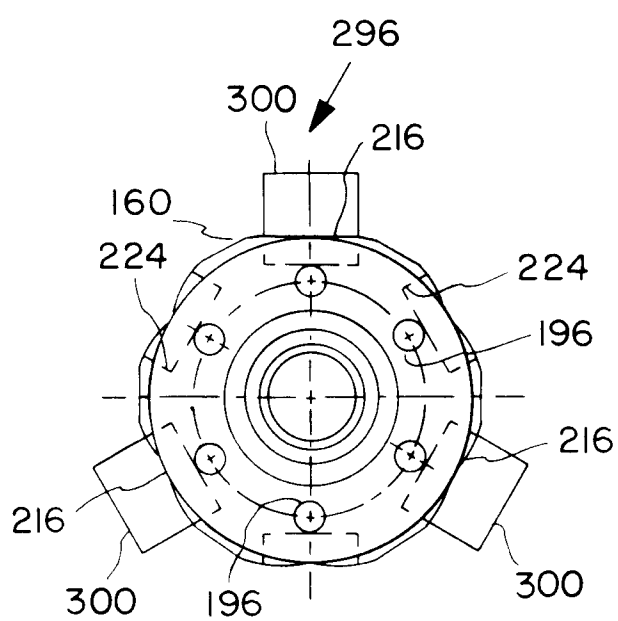
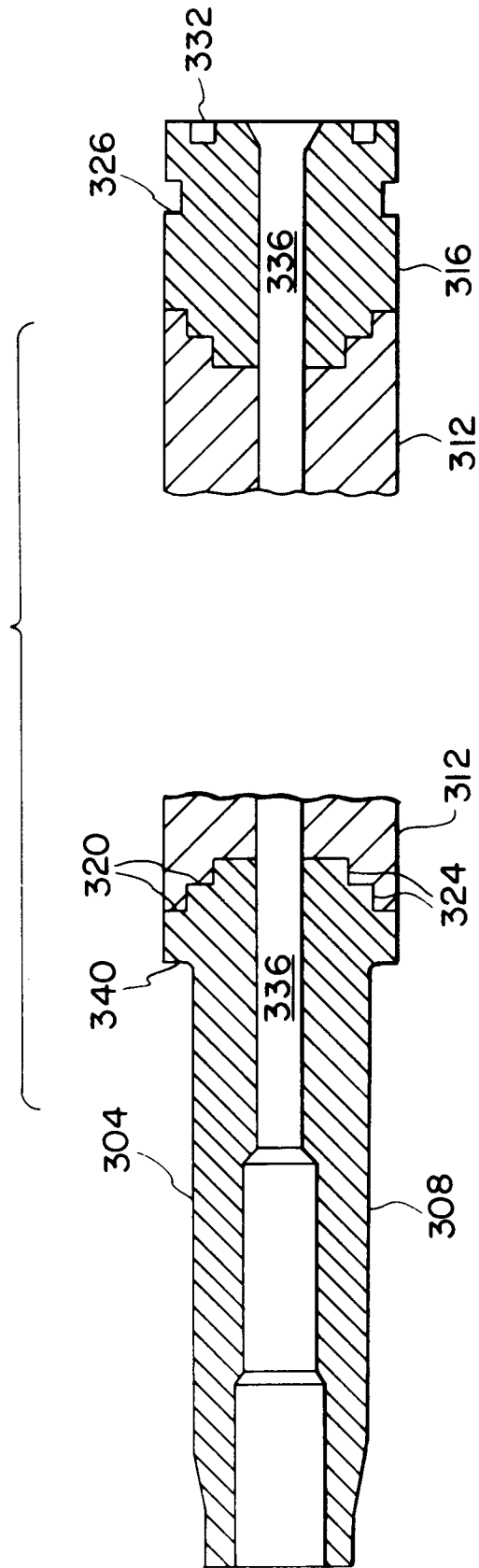


FIG. 11





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 11 3503

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	US-A-3 733 881 (GRIGORENKO) * column 3, line 40 - column 4, line 9; figures 6,14 * ---	1,3,4, 8-10	B21D22/30 B30B15/06
Y	DE-A-32 15 795 (FESTO-MASCHINENFABRIK) * page 9, paragraph 3 - page 10, paragraph 1; claims 1,2,10 * ---	1,3,4, 8-10	
A	EP-A-0 069 579 (DEERE & COMPANY) * page 2, line 32 - page 3, line 30; figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			B21D B30B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 8 November 1993	Examiner GERARD, O
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			