# United States Patent

[11] **3,580,200**


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[54] **APPARATUS FOR AND METHOD OF FORMING A SHEETLIKE WORKPIECE**
**23 Claims, 6 Drawing Figs.**


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[51] **Int. Cl.** ..... **B21d 51/26**
[50] **Field of Search** ..... 113/1, 1 (F), 116 (FF), 121 (C), 121, 121 (A), 15, 15 (A); 29/509, 522, 522 (R); 83/1, 6, 7, 8



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**ABSTRACT:** An apparatus for and method of forming a sheetlike workpiece wherein the workpiece is formed utilizing forming dies which have control surfaces which do not engage the workpiece and such control surfaces control the action of the forming dies to assure that a known substantially exact amount of working material remains after forming such workpiece.

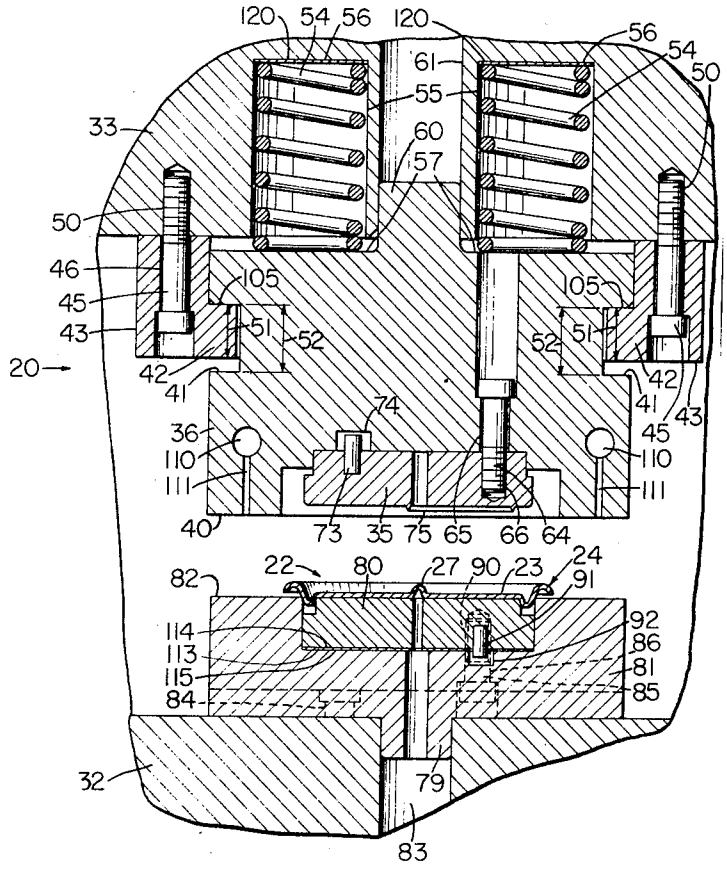



FIG-1

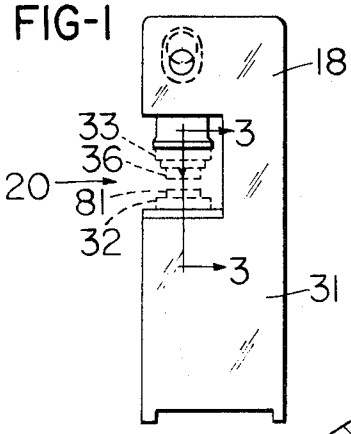



FIG-2

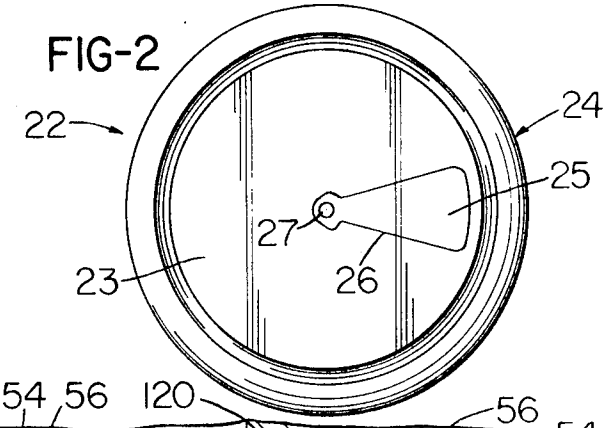
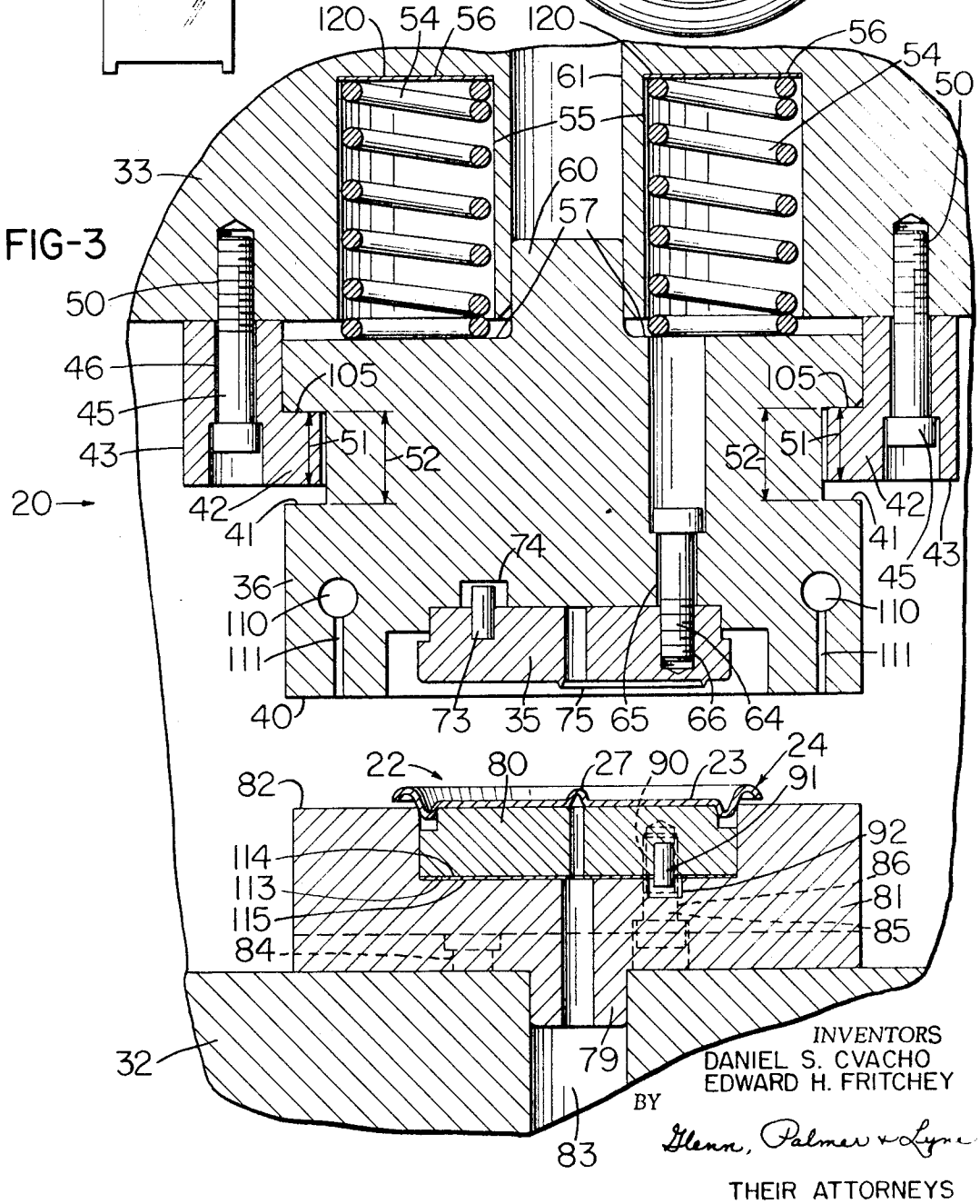



FIG-3




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FIG-4

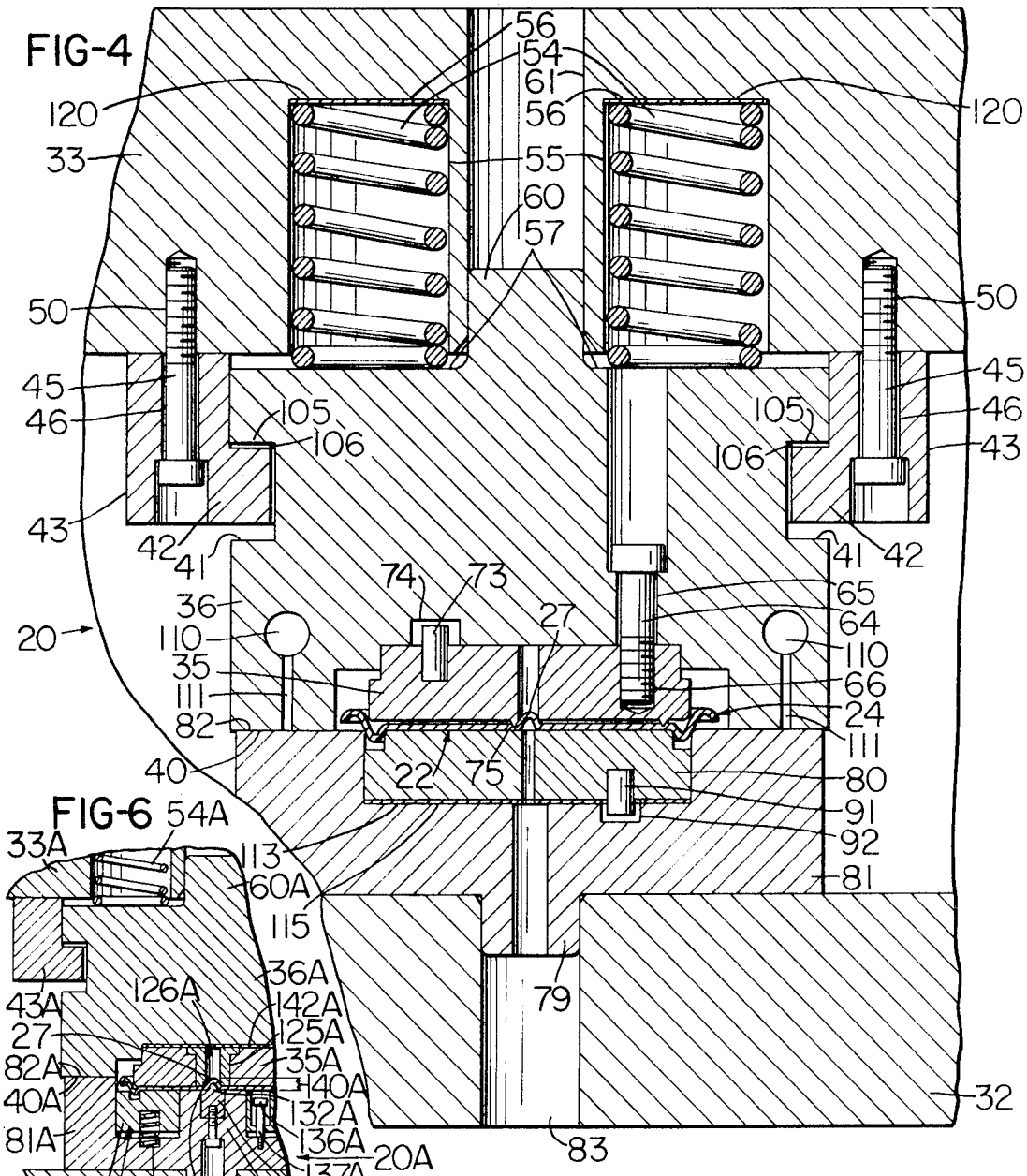
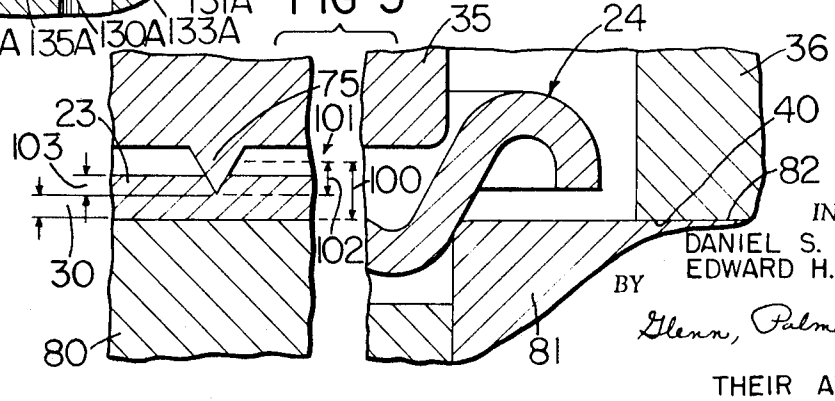



FIG-6




FIG-5




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# APPARATUS FOR AND METHOD OF FORMING A SHEETLIKE WORKPIECE

## BACKGROUND OF THE INVENTION

Many machines and methods have previously proposed for forming wall means such as easy-open end closures for metal cans and for forming and attaching associated pull tabs thereon. In general, such previously proposed machines and methods control the forming action of associated forming dies by utilizing control surfaces which actually engage the workpiece being formed. To assure economy of operation, workpieces of necessity are allowed to vary dimensionally within established limits whereby current apparatus and techniques inherently form workpieces widely varying amounts and thus provide generally unsatisfactory results.

## SUMMARY

This invention provides an improved apparatus for and method of forming a workpiece of the type particularly adapted for use in defining part of a container wherein such workpiece is formed so that a known and substantially exact amount of working material remains after forming the workpiece irrespective of the original dimensions of such workpiece.

Other details, uses, and advantages of this invention will become apparent as the following description of the embodiments thereof presented in the accompanying drawings proceeds.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings show exemplary embodiments of this invention, in which

FIG. **1** is a side view in elevation of an exemplary forming press which incorporates an exemplary embodiment of the apparatus of this invention;

FIG. **2** is a plan view of an end closure for a can formed utilizing the apparatus and method of this invention;

fig. **3** is a greatly enlarged view with parts in section and parts broken away taken essentially on the line **3–3** of FIG. **1** and illustrating one exemplary embodiment of the apparatus of this invention comprised of a cooperating set of forming dies and their associated control surfaces in an open position prior to forming a closed-loop score line in an end closure for a can to defining a tear-out strip therein;

FIG. **4** is a view similar to FIG. **3** and showing the forming dies in their closed position and their associated control surfaces abutting each other to thereby precisely control the forming action of such forming dies and define the tear-out strip in the end closure of FIG. **2**;

FIG. **5** is a greatly enlarged view with parts in section and parts broken away particularly illustrating the action of a scoring blade comprising the upper scoring die of the apparatus of FIGS. **3** and **4** and showing the manner in which the total penetration of the scoring blade within the associated end closure being scored is controlled by the control surfaces abutting each other; and

FIG. **6** is a view roughly similar to FIG. **4** and showing another exemplary embodiment of this invention utilized to form an integral nipple in the central portion of the closure shown in FIG. **2**.

## DESCRIPTION OF ILLUSTRATED EMBODIMENTS

Reference is now made to FIG. **1** of the drawings which illustrates an exemplary machine shown as a forming press **18** which has the apparatus and method of this invention provided as an integral part thereof and such apparatus and method is designated generally by the reference numeral **20**. The apparatus **20** is particularly adapted for forming as associated workpiece shown as an end closure **22**, see FIG. **2**, and the end closure **22** is adapted to be fastened in position on an associated container such as a right circular cylindrical can and in a known manner.



The exemplary end closure **22** may be made of any suitable material, such as metal containing aluminum, for example, and has a substantially planar sheetlike central portion **23** and a peripheral fastening flange **24** which is of known construction. The end closure **22** is of an easy-open type and has a tear-out strip **25** defined in its central portion **23** by utilizing one exemplary embodiment of the apparatus and method of this invention to define a closed-loop score line **26** therein; and, the end closure **22** has an integral rivet-defining nipple **27** formed in one end of the tear-out strip **25** by utilizing another exemplary embodiment of this invention and as will be presented subsequently in this specification.

The score line **26** is formed in the end closure **22** so that a known and substantially exact amount of working material in the form of residual metal remains after scoring so that the tear-out strip **25** may be easily torn out or severed. Further, it will be appreciated that the thickness of the material used in forming end closures substantially identical to the end closure **22** will vary within allowable tolerance limits. Nevertheless, the apparatus and method of this invention enables the scoring of each end closure so that substantially the same amount of residual material always remains after scoring and such residual material is indicated by the reference numeral **30** in FIG. **5**.

The apparatus **20** comprises a supporting structure **31** which in this example comprises a part of the frame structure for the press **18**. The supporting structure **31** has a bottom die shoe **32** suitably fixed thereto and supports a top die shoe **33** for movement toward and away from the bottom die shoe **32** whereby the die shoes and their associated forming dies, which will be described in detail subsequently, are relatively movable toward and away from each other.

The apparatus **20** has a first forming die **35** which is fixed to a die holder **36** and a first control surface **40** is provided as an integral part of the die holder **36** and at a fixed position relative to the fixed position of the forming die **35**. The die holder **36** has a pair of grooves **41** provided therein and each groove **41** is adapted to receive the shoulder **42** of a retainer **43** which engages and supports the die holder **36** and its forming die **35** to the top die shoe **33**. Each retainer **43** is fastened to the die shoe **33** by one or more bolts **45** and each bolt **45** extends through an associated counterbored opening **46** in the retainer and has a threaded end which is threaded within a cooperating threaded opening **50** in the die shoe **33**.

Each shoulder **42** provided on each retainer **43** has a height indicated at **51** which is substantially less than the height **52** of an associated groove **41** provided in the die holder **36**. Thus, upon fastening the die holder **36** and its associated forming die **35** to the top die shoe **33** the larger height **52** of groove **41** makes it possible to move the die holder **36** and its forming die **35** vertically, as seen in the drawings, relative to the top die shoe **33**.

The exemplary apparatus **20** has resilient holding means shown in the form of a mechanical compression spring **54** and provided for holding the forming die **35** and its associated control surface **40** in a forming position in a resilient manner and with a predetermined force. The spring **54** exerts a force which is substantially greater than the force required to accomplish the desired forming of an associated workpiece, and such force in this example is substantially greater than the force required to define the score line **26** in the end closure **22**.

Each compression spring **54** has its upper end portion received within an associated blind hole **55** provided in the top die shoe **33** and supported against a circular surface **56** defining the bottom of hole **55**. Each spring **54** has a lower end portion which engages a top surface **57** of the die holder **36** so that the die holder **36** and its associated forming die **35** and control surface **40** are held outwardly in a forming position in a resilient manner and with a predetermined force determined by the characteristics of the compression springs **54**. With the forming die **35** in the open position shown in FIG. **3** it will be appreciated that the springs merely urge and hold the die

holder 36 outwardly and tightly against the shoulders 42 of the retainers 43.

The die holder 36 also has a substantially cylindrical rodlike projection 60 extending upwardly therefrom which is adapted to be received within a cooperating cylindrical bore 61 provided in the top die shoe 33. The projection 60 and bore 61 cooperate to guide the die holder 36 and its forming die 35 as the die holder 36 is moved relative to the top die shoe 33 upon overriding the action of the springs 54. However, it will be appreciated that the total possible movement of the die holder 36 relative to the supporting die shoe 33 is determined by the difference between the height of shoulder 51 and groove 52.

The forming die 35 is fastened to its die holder 36 by one or more fasteners or bolts 64 and each bolt 64 extends through an associated counterbored opening 65 in the die holder 36 and has a threaded end which is threaded in a cooperating threaded opening 66 in the forming die 35. The forming die 35 also has a locating pin 73 which is suitably fixed thereto and the locating pin 73 is received within a cooperating opening 74 provided in the die holder 36 to precisely locate the forming die 35 and enable fastening such die in position in a fixed manner through the use of bolts 64 as previously described.

The forming die 35 of this exemplary embodiment of the apparatus 20 is presented as a scoring die 36 which has a scoring blade 75 extending therebeneath and forming an integral part thereof. The scoring blade 75 is arranged in a closed-loop path and its peripheral configuration corresponds to the configuration of the score line 26 so that once the scoring blade 75 is brought into scoring position against an associated end closure 22 the score line 26 is formed therein to define the tear-out strip 25 previously described. Because the forming die 35 of this example is a scoring die having a scoring blade 75, the detailed description which follows may also refer to the die 35 as a scoring die 35.

The apparatus 20 has a second forming die 80 which is fastened in a fixed manner to an associated die holder 81 and the forming die 80 has an associated second control surface 82 which in this example of the invention is provided as an integral part of the die holder 81 and hence provided at a fixed position relative to the forming die 80. The die holder 81 has a rodlike cylindrical projection 79 extending beneath its lower surface and such projection is received within an associated substantially cylindrical opening 83 provided in the bottom die shoe 32 of the apparatus 20. The die holder 81 is suitably fixed to the bottom die shoe 32 by a plurality of bolts 84 which extend through associated cooperating openings and in a known manner.

The forming die 80 is fastened to the die holder 81 by a plurality of fasteners or threaded bolts 85 and each bolt 85 extends through an associated counterbored opening 86 in the die holder 81 and has its threaded end threaded into a cooperating threaded opening 90 in the forming die 80. The forming die 80 also has a locating pin 91 suitably fixed thereto and the locating pin 91 is received within a cooperating opening 92 in the die holder 81 to thereby locate and position the forming die 80 in a precision manner relative to its die holder 81.

The forming die 80 of this exemplary apparatus 20 is in the form of an anvil and serves to back up the scoring die 35 and its scoring blade 75 during a scoring operation of the type performed on an associated end closure 22. Therefore, forming die 80 will also be referred to hereinafter in this specification as anvil 80.

As previously indicated it will be appreciated that in the forming of end closures of cans such as right circular cylindrical cans made of metallic and/or nonmetallic materials, it is necessary to process sheetlike workpieces (presented in this example as being made of metal) having stock thicknesses which will vary considerably due to manufacturing tolerances. For ease of presentation the workpiece, i.e. partially completed end closure, shown in FIG. 3, will also be designated by the reference numeral 22 even prior to scoring thereof. The apparatus and method of this invention enables the scoring of the workpiece so that a predetermined and exact amount of working material remains in the form of residual metal 30 after scoring of the central portion 23 of the end closure 22 and irrespective of the initial material thickness. The thickness of the residual material 30 will not vary from one end closure to the next because the forming dies 35 and 80 are fastened in fixed positions relative to their control surfaces 40 and 82 respectively. Further, the forming action on each end closure continues until the control surfaces abut each other whereby the same amount of residual metal 30 remains after forming, i.e., scoring.

The scoring die 35 and its associated stop 40 are held in a forming position in a resilient manner, as previously mentioned. In particular, the compression springs 54 resiliently urge the scoring die 35 and its scoring blade 75 outwardly with a predetermined force determined by the force exerted by the springs 54. With the technique employed by this invention it will be appreciated that as the thickness of a particular sheetlike workpiece increases the amount of total force required to score to a greater depth due to the greater workpiece thickness also increases. Therefore, the predetermined total force exerted by the compression springs 54 is substantially greater than the force required to achieve the desired scoring of even the thickest workpiece to assure that the same amount of residual metal 30 remains.

The scoring die 35 must also be protected as much as possible to prevent excessive wear and damage due to repetitive use in a mass production operation. The compression springs 54 also serve as overtravel springs allowing the scoring die 35 and its die holder 36 to move relative to their die shoe 33 once the ram portion of the press 18 and in particular the top die shoe 33 is moved to its lowermost closed position. Yet, control of the scoring action is always achieved by the stop 40 abutting stop 82 and this always controls the space between the scoring blade 75 and the top surface of the anvil 80 so that the precisely controlled amount of residual material 30 always remains irrespective of the thickness of the end closure 22.

During the scoring of a particular end closure 22 the total force required to provide the required amount of penetration so that stop 40 abuts stop 82 may be such that a top surface 105 defining one edge of an associated groove 41 in die holder 46 is moved away from the shoulder 42 of its associated retainer 43. The amount of displacement is indicated at 106 for the particular thickness end closure 22 being scored in this example of the invention. The displacement 106 will vary and in a very thick workpiece it may be necessary to compress the springs 54 of an even greater amount, greater than the displacement 106, to obtain the total required force so as to score the workpiece the depth required for stop 40 to abut its cooperating stop 82.

To further highlight the simple and unique concept of this invention, the detailed description will now proceed with a description of the general operation of the apparatus 20. In particular, it will be seen that a workpiece such as a partially formed end closure 22 is supported in forming position on the anvil 80 as shown in FIG. 3 of the drawings. With the end closure 22 thus supported the scoring die 35 is moved toward the anvil 80 so that the scoring knife 75 engages and penetrates the central portion 23 of the end closure 22.

The scoring die 35 is moved toward the anvil 80 until the control surface or stop 40 engages the control surface or stop 82 and as seen in FIG. 4. Once the stop 40 abuts the stop 82 it will be appreciated that the scoring knife 75 will have penetrated the end closure 22 so that the preset exact amount of residual material 30 remains after penetration. The exact amount of material will remain irrespective of the thickness of a particular sheetlike workpiece. To obtain the desired force so that stop 40 abuts stop 82 to score workpiece 22 of this example, the springs 54 are compressed so that surface 105 moves away from shoulder 42 by the distance indicated at 106.

In the event the central portion 23 of the end closure 22 happens to have comparatively large thickness 100 as in-

dicated in an exaggerated way by dotted lines at **101** in FIG. **5**, this merely means that the scoring blade **75** must penetrate the thicker end closure a greater distance shown at **102** rather than a comparatively small distance shown at **102** for the end closure **22** of lesser thickness and shown by solid lines. Yet, it will be seen that the amount of working material **30** is always a known substantially exact amount regardless of the thickness of the workpiece whereby the tear-out strip **25** in each end closure **22** formed on the apparatus **20** may be easily severed with a substantially known force which will not vary appreciably from one end closure to the next.

Because the forming action of the forming dies **35** and **80** is controlled by the control surface **40** abutting its cooperating control surface **82**, it is desirable to maintain the control surfaces **40** and **82** as clean as possible. To help provide this cleaning action one or both of the die holders may use air jets for cleaning the opposed control surface. In this example, the die holder **36** has a pair of passages **110** provided therein which are suitably connected to a source of air under pressure. The die holder **36** also has a plurality of orifices **111** each communicating with a passage **110** and each orifice **111** exists through the control surface **40**. Air under pressure is provided to the passages **110** from a suitable air pressure source, such as an air compressor, or the like, whereby it exits the orifices **111** at high velocity and impinges against the control surface **82** so as to clean such control surface. It will be appreciated that there is little likelihood of dirt and foreign material accumulating on the control surface **40** because of its arrangement; therefore, with surfaces **40** and **82** being comparatively clean the desired unobstructed contact is provided therebetween.

As seen in FIGS. **4** and **5**, with the forming dies **35** and **80** in their closed position and their associated control surfaces **40** and **82** in abutting relation the entire forming action, i.e. scoring action in this instance, is defined by the thus defined fixed positions of forming dies **35** and **80**. To enable precision adjustment of the relative positions of the forming surfaces and in particular the relative positions of the scoring blade **75** and the top surface of the anvil **80** a shim **113** is fastened between the anvil **80** and the die holder **81**. The shim **113** may be used to compensate for adverse dimensional stack up in assembling apparatus **20** as well as wear on the scoring blade **75**.

The shim **113** may be of any suitable construction and may be comprised of one or more sheets of precisely controlled thickness. The shim **113** has its top surface engaging an associated bearing surface **114** provided on the anvil **80** and the shim **113** has its lower surface supported on a cooperating bearing surface **115** provided on the die holder **81**. The thickness of shim **113** is thus selected to enable precise positioning of the top surface of the anvil **80** relative to its associated control surface **82** upon fastening the anvil **80** to its die holder **81** by its associated fastening bolts **85**.

Thus, to increase the amount of residual material which remains after scoring it is merely necessary to decrease the thickness of the shim **113** whereby the top surface of the anvil **80** is dropped with respect to its control surface **82** and the scoring knife **75** thereby penetrates the center portion **23** of the end closure **22** a lesser amount. To decrease the amount of residual material provided after scoring it is merely necessary to increase the thickness of a shim **113** whereby the scoring knife **75** penetrates the central portion **23** a greater amount.

It may also be desired to adjust the total force which is exerted by the compression springs **54**. For this purpose a shim **120** is provided in association with each compression spring **54** so that the upper coil of each spring engages and urges the shim **120** against a surface **56** defining the bottom of an associated opening **55**. As in the case of shim **113**, the shim **120** may be comprised of one or more layers of material of precisely controlled thickness so as to provide more or less compression of an associated spring **54** and hence increase or decrease respectively in a corresponding manner the force exerted by an associated spring **54**.

The apparatus **20** has been described in detail in connection with the provision of the score line **26** in the end closure **22**. However, it will be appreciated that control surfaces similar to surfaces **40** and **82** may be used to control the action of the forming dies in all types of operation. In the can manufacturing industry, for example, control surfaces of the character presented herein may be used with associated extrusion dies to draw and iron can bodies; to form end closures including integral ribs, integral rivets, indentations, score lines, and flanges; to form pull tabs; and to attach end closures to their associated cans and pull tabs to their rivets, and other similar operations.

To highlight this idea of utilizing control surfaces similar to the control surfaces **40** and **82** in other forming operations the detailed description will now proceed with a description of the forming of a nipple or an integral rivet **27** on the end closure **22** illustrated in FIG. **2** and for this description reference is made to the embodiment of this invention illustrated in FIG. **6** of the drawings.

In the exemplary embodiment of FIG. **6** the apparatus illustrated is very similar to the apparatus **20**; therefore, such apparatus will be designated generally by the reference numeral **20A** and those components parts of the apparatus **20A** which are similar to corresponding parts of apparatus **20** will be designated by the same reference numeral as in apparatus **20** also followed by the letter designation A and not described again. Only those component parts of apparatus **20** which are substantially different from corresponding parts of the apparatus **20** will be designated by a new reference numeral also followed by the letter designation A and described in detail.

The apparatus **20** A may also be used in the press **18** shown in FIG. **1** and it will be seen from FIG. **6** that the forming dies **35A** and **80** A have been modified to enable forming the previously mentioned nipple or integral rivet **27** in the end closure **22** while utilizing the unique action of the control surfaces **40A** and **82A**. In particular, the forming die **35A** of the apparatus **20A** has a nipple bushing **125A** suitably fixed thereto so that it forms an integral part thereof. The nipple bushing **125A** has a cylindrical opening **126A** extending centrally therethrough and the lower end of the opening **126A** has a flared configuration defined by a corresponding surface **130A** of the nipple bushing **125A**. The forming die **80A** has a nipple pin **131A** suitably fixed thereto and which has a bullet-like projection **132A** which is adapted to cooperate with the surface **130A** of the nipple bushing **125A** to define the nipple **27** in the end closure **22**.

The forming die **80A** has a central portion **133A** against which the nipple pin **131A** is fixed in position and provided essentially as an integral part thereof whereby the outer surface of the projection **132A** is fixed in position so that it remains at a fixed position with respect to the control surface **82A**. The forming die **80A** has a floating pressure pad **134A** provided substantially circumferentially around the fixed nipple pin **131A** and the pressure pad **134A** is urged outwardly by suitable means such as one or more compression springs **135A**. The total upward movement of the pressure pad **134A** is limited by the head **136A** of a bolt **137A** used to fasten the pressure pad **134A** to its associated die holder **81A**.

The pressure pad **134A** operates in a known manner to support the bottom surface of an end closure **22** essentially above the top surface of the projection **132A** and once the forming die **35A** is brought into forming engagement against the end closure **22** it is moved toward the die **80A** with the nipple bushing holder **125A** engaging the top surface of the end closure **22** and urging it against the projection **132A** of nipple pin **131A** and causing the nipple or integral rivet **27** to be formed in the end closure **22**.

Once the forming die **35A** is lowered into position each spring **135A** is compressed and the pressure pad **134A** moves downwardly without interfering with the forming of the nipple or integral rivet **27** in the end closure **22**. Upon raising the forming die **35A** the springs **135A** assure the end closure **22** is not wedged tightly against the projection **132A**.

As previously indicated, the control surfaces **40A** and **82A** of the exemplary apparatus **20A** operate in a similar manner

as corresponding surfaces **40** and **82** respectively of the apparatus **20**. In particular, the control surfaces **40A** and **82A** cooperate so that a known and substantially exact amount of working (i.e. now formed) material remains after forming the nipple **27** in the end closure **22**. Thus, once, the forming dies **35A** and **80A** are relatively moved until their associated control surfaces **40A** and **82A** abut, a known and substantially exact amount of working material, which defines the height of the integral rivet **27**, remains and as illustrated at **140A**. This substantially same amount of working material controlled by abutting surfaces **40A** and **82A** assures that the integral rivet **27** may subsequently have a pull tab, or the like, easily fastened thereto and in a known manner inasmuch as a known and sufficient height of material is always left when formed in accordance with this invention.

In this latter embodiment of the invention the thickness of the workpiece may cause the height of the working material **140A** to vary slightly, but in no event will such height be less than a desired amount because the desired amount is always determined by the control surfaces **40A** and **82A** which have their associated forming dies set to accommodate the thinnest material likely to be processed in apparatus **20A**.

It will also be appreciated that the compression springs **54A** provided in association with the apparatus **20A** hold the forming die **35A** and its associated control surface **40A** in a forming position in a resilient manner with a predetermined force which in this instance is determined by and is substantially greater than the force required to accomplish the desired forming of the nipple **27** in the end closure **22**.

The illustration of FIG. **6** shows the forming dies **35A** and **80A** in their closed positions and with the pressure pad **134A** in its lower position; however, it will be appreciated that with the forming die **35A** and **80A** in an open position the pressure pad **134A** will be raised by the springs **135A** so as to support the end closure **22** thereon in a stable manner above the projection **132A** prior to forming of the integral rivet **27** therein.

The exemplary apparatus **20A** may also utilize a shim in association with one of its forming dies. In this example a shim **142A** is provided in association with the forming die **35A** and such shim **142A** may be comprised of one or more precisely controlled sheets so as to provide a precise dimensional relationship between the nipple bushing **125A** and its associated control surface **40A**.

The integral nipple **27** for the end closure **22** is shown as being formed by the apparatus **20A** at one station. However, in actual practice such nipple may be formed in steps at a plurality of forming stations whereby the technique of utilizing similar control surfaces in association with forming dies may be utilized at each of such stations. Further it will be appreciated that at successive stations it may not be necessary to provide pressure pads similar to the pressure pad **134A** yet in each instance a precise control of the forming surfaces is maintained.

The exemplary apparatus **20** and **20A** are illustrated and described in this specification as in each instance being used in association with a press which has an upper die shoe **33** and its associated upper forming die which is movable toward and away from the fixed lower die shoe **32** and its associated forming die whereby the cooperating forming dies are relatively movable toward and away from each other.

However, it is to be understood that the upper forming die and its associated die shoe may be maintained in a fixed position and the lower die shoe and its associated forming die moved toward and away from the upper die. Similarly, both of the die shoes and their associated forming dies may be relatively moved toward and away from each other and supported by an associated supporting structure similar to the supporting structure **31** comprising the press **18**.

The upper forming die **35** of the exemplary apparatus **20** is held in a forming position in a resilient manner by the springs **54** with a predetermined force which is substantially greater than the force required to accomplish the desired forming of a particular workpiece. The workpiece, end closure **22**, is formed so that the desired exact amount of working material remains after forming and as precisely controlled by the control surfaces abutting each other. In the case of the scoring operation described above, the end closure **22** may be made of metal containing aluminum and it has been found that the springs **54** must exert a scoring pressure generally of the order of 1500 p.s.i. to score a material 0.0140 inch thick so that the residual metal is 0.0045 inch thick. However, to assure that the scoring is achieved so that 0.0045 inch of residual material remains the predetermined force exerted by the compression springs **54** is substantially greater than 1500 p.s.i. and is generally of the order of 4500 p.s.i. Where the metal thickness is substantially greater than the 0.0140 inch, yet within the upper limit of the gauge thickness normally used to form an end closure **22** for an associated can, it may be necessary to apply pressures generally of the order of 1800 p.s.i. to obtain the desired 0.0045 residual material after scoring. However, even in this latter instance it will be appreciated that the 4500 p.s.i. exerted by the springs **54** is more than adequate to assure the desired scoring.

In using the apparatus and method of this invention to perform other forming operations including but not being limited to forming an integral rivet **27** such as described in connection with apparatus **20A**, forming integral flanges in an end closure, forming integral ridges in an end closure, forming a pull tab, riveting an integral rivet in position against a pull tab, and similar operations, it will be appreciated that the force of the compression springs may be suitably varied to suit the purpose of the particular forming operation being achieved. Yet, in each instance, the technique described above is fully applicable wherein the forming action is controlled by control surfaces which are abutted against each other to control the positions of the forming dies and resilient means such as springs also serve to protect the control surfaces against damage.

In both embodiments of this invention presented in this specification a pair of compression springs **54** is utilized to hold the forming dies in a forming position with predetermined controlled force. However, it will be appreciated that any suitable means may be utilized to provide the resilient holding action.

For example, one or more pneumatic actuators may be utilized in association with one of the forming dies to provide such a resilient holding action. A particular pneumatic actuator may be supplied with air under controlled pressure while utilizing a suitable adjustable pressure regulator and it may be possible through the use of pneumatic actuation to standardize on many components utilized to perform various operations yet different pressures may be applied to different forming die for resiliently holding such dies in their associated forming positions merely by adjusting the fluid pressure exerted against each die.

While present exemplary embodiments of this invention, and methods of practicing the same, have been illustrated and described, it will be recognized that this invention may be otherwise variously embodied and practiced within the scope of the following claims.

We claim:

1. An apparatus for scoring a closed-loop score line in a workpiece so that a known substantially exact amount of residual material remains after scoring said workpiece, said apparatus comprising, a first forming die having a scoring blade extending therefrom which extends in a closed-loop path and having an associated first control surface supported at a fixed position relative to said first forming die, a second forming die having an anvil adapted to cooperate with said scoring blade and having an associated second control surface supported at a fixed position relative to said second forming die, a supporting structure for supporting each of said first and second forming dies and their associated control surfaces for relative movement, said supporting structure supporting said dies for solely axial movement toward each other during scoring of said workpiece, and said supporting structure including retaining means and resilient means, said resilient means hold-

ing one of said forming dies and its associated control surface in a forming position in a resilient manner and with a predetermined force substantially greater than the force required to accomplish the desired scoring of said workpiece, said first and second forming dies cooperating to score a closed-loop score line practically instantaneously upon movement thereof against opposite surfaces of said workpiece and said exact amount of residual material being precisely controlled by said control surfaces abutting each other, said retaining means serving to restrain said resilient means with respect to the control surface of said one die at least until said control surfaces abut each other and said resilient means serving as an overtravel device for its associated forming die to prevent damage to said forming dies and excessive wear of said control surfaces.

2. An apparatus as set forth in claim 1 and further comprising, a first die holder having said first control surface provided as an integral part thereof and having said first forming die fastened to said first die holder at a precise position relative to said first control surface, a second die holder having said second control surface provided as an integral part thereof and having said second forming die fastened to said second die holder at a precise position relative to said second control surface, and each of said die holders being supported on its supporting structure for relative movement toward and away from each other to thereby provide said movement of said forming dies toward and away from each other.

3. An apparatus as set forth in claim 2 and further comprising a fastener for detachably fastening one of said forming dies to its associated die holder, a bearing surface on said one forming die, a cooperating bearing surface on said associated die holder, and a shim fastened between said bearing surfaces to precisely position said one forming die relative to its associated control surface upon fastening said one forming die to its associated die holder with said fastener to thereby enable the amount of scoring provided by said forming dies to be adjusted.

4. An apparatus as set forth in claim 2 in which said resilient means urges and holds said first die holder and its first forming die outwardly in a resilient manner to an extended forming position.

5. An apparatus as set forth in claim 4 in which said resilient means comprises a compression spring acting between said first die holder and a cooperating support for said spring.

6. An apparatus as set forth in claim 5 and further comprising a shim mounted to provide a controlled compression of said spring to thereby provide a controlled adjustment of said predetermined force.

7. An apparatus as set forth in claim 4 in which said resilient means comprises a pneumatic actuator acting between said first die holder and a cooperating support for said pneumatic actuator.

8. An apparatus as set forth in claim 7 and further comprising means for supplying said pneumatic actuator with air at an adjustable pressure level to thereby enable resilient holding of said first forming die so that said predetermined force may be readily adjusted merely by adjusting said pressure level.

9. An apparatus as set forth in claim 1 in which said workpiece comprises metal wall means of an associated container, said scoring blade is arranged in said closed-loop path and defines a tear-out strip in said wall means, and said substantially exact amount of residual material comprises the residual metal left after scoring by said scoring die which is precisely controlled so as to enable easy severing of said tear-out strip by exerting substantially the same pulling force irrespective of the initial thickness of said material defining said wall means.

10. An apparatus for scoring a closed-loop score line in a workpiece so that a known substantially exact amount of residual material remains after scoring said workpiece, said apparatus comprising, a first forming die having a scoring blade extending therefrom which extends in a closed-loop path and having an associated first control surface supported at a fixed position relative to said first forming die, a second forming die having an anvil adapted to cooperate with said scoring blade and having an associated second control surface supported at a fixed position relative to said second forming die, a supporting structure for supporting each of said first and second forming dies and their associated control surfaces for relative movement toward and away from each other, means holding one of said forming dies and its associated control surface in a forming position in a resilient manner and with a predetermined force substantially greater than the force required to accomplish the desired scoring of said workpiece, said first and second forming dies cooperating to score a closed-loop score line substantially instantaneously upon movement thereof against opposite surfaces of said workpiece and said exact amount of residual material being precisely controlled by said control surfaces abutting each other, said holding means serving as an overtravel device for its associated forming die to prevent damage to said forming dies and excessive wear of said control surfaces, and means for ejecting a fluid under pressure against at least one of said control surfaces to prevent the accumulation of dirt and foreign materials on said control surfaces and thereby assure unobstructed contact thereof.

11. An apparatus as set forth in claim 10 in which said fluid comprises air.

12. A method of forming a workpiece so that a substantially exact amount of working material remains after forming said workpiece, said method comprising the steps of, inserting said workpiece between first and second relatively movable forming dies which are relatively movable solely toward each other along a common axis during forming of said workpiece, said first forming die having a first control surface supported at a fixed position relative thereto and said second forming die having a second control surface supported at a fixed position relative thereto, holding one of said forming dies and its associated control surface in a forming position with an associated holding means which includes resilient means with a force greater than the force required to accomplish the desired forming of said workpiece, relatively moving said forming dies toward each other along said common axis a distance determined by said control surfaces abutting each other and irrespective of the dimensional size of said workpiece to sandwich and practically instantaneously form said workpiece between said forming dies, and during said relatively moving step retaining said resilient means with respect to the control surface of said one die at least until said control surfaces abut each other and said resilient means serving as an overtravel device to prevent damage to said forming dies and excessive wear of said control surfaces upon forming said workpiece between said forming dies said greater force assuring forming of said workpiece and said control surfaces assuring said substantially exact amount of working material remains after said forming.

13. A method as set forth in claim 12 in which said step of holding one of said forming dies in its forming position comprises the steps of adjusting the amount of force with which said one forming die and its stop is held in said forming position.

14. A method as set forth in claim 12 and comprising the further step of adjusting the position of one of said forming dies with respect to its associated control surface to thereby adjust the amount of forming of said workpiece during forming to provide said substantially exact amount of working material remaining after forming thereof.

15. A method as set forth in claim 12 and particularly adapted for scoring a workpiece defined as a sheetlike workpiece, said first forming die comprises a scoring die having a scoring blade provided as an integral part thereof, said second forming die comprises an anvil adapted to cooperate with said scoring die, and said step of relatively moving said dies toward each other comprises sandwiching said sheetlike workpiece between said scoring die and anvil so that said substantially exact amount of working material is in the form of a residual material which remains after scoring.

16. A method as set forth in claim 12 and particularly adapted for forming an integral rivet-defining nipple in a workpiece defined as a metal end closure for a can, said end closure having a sheetlike central portion, said first forming die having a nipple bushing comprising a portion thereof and said second forming die having a nipple pin comprising a portion thereof and being adapted to cooperate with said nipple bushing to define said integral nipple, and said step of relatively moving said forming dies toward each other comprises sandwiching said central portion between said nipple bushing and cooperating nipple pin to form said integral nipple having an overall height which comprises said substantially exact amount of working material.

17. A method of forming a workpiece so that a known substantially exact amount of working material remains after forming said workpiece, said method comprising the steps of, inserting said workpiece between a first and a second forming die which are relatively movable toward and away from each other along a common axis, said first forming die having a first control surface supported at a fixed position relative thereto and said second forming die having a second control surface supported at a fixed position relative thereto, resiliently holding one of said forming dies and its associated control surface in a forming position with an associated holding means and with a predetermined force substantially greater than the force required to accomplish the desired forming of said workpiece, and relatively moving said forming dies toward each other a distance determined by said control surfaces abutting each other and irrespective of the dimensional size of said workpiece to sandwich and substantially instantaneously form said workpiece between said forming dies, said step of resiliently holding enabling said one forming die to move relative to its supporting structure to prevent damage to said forming dies and excessive wear of said control surfaces upon sandwiching said workpiece between said forming dies during said step of relatively moving, said predetermined force assuring forming of said workpiece and said control surfaces assuring said known substantially exact amount of working material remains after said forming, and ejecting a fluid under pressure against at least one of said control surfaces to prevent the accumulation of dirt and foreign materials on said control surfaces and thereby assure unobstructed contact thereof.

18. An apparatus for forming a sheetlike workpiece comprising, a first forming die having a nipple bushing and having an associated first control surface supported at a fixed position relative to said first forming die, a second forming die having a nipple pin and having an associated second control surface supported at a fixed position relative to said second forming die, a supporting structure for supporting each of said first and second forming dies and their associated control surfaces for relative movement, said supporting structure supporting said dies for solely axial movement toward each other during forming of said workpiece, said control surfaces being adapted to abut each other, and said supporting structure including retaining means and resilient means, said resilient means holding one of said forming dies and its associated control surface in a forming position with a force substantially greater than the force required to accomplish the forming of said workpiece, said nipple pin and nipple bushing cooperating to practically instantaneously form an integral rivet-defining nipple in said sheetlike workpiece upon movement thereof against opposite surfaces of said workpiece and upon said control surfaces abutting each other, said retaining means serving to restrain said resilient means with respect to the control surface of said one die at least until said control surfaces abut each other.

19. An apparatus for scoring a workpiece so that a predetermined amount of residual material remains after scoring said workpiece, said apparatus comprising, a first forming die having a scoring blade extending therefrom and having an associated first control surface supported at a fixed position relative to said first forming die, a second forming die having an anvil adapted to cooperate with said scoring blade and having an associated second control surface supported at a fixed position relative to said second forming die, a supporting structure for supporting each of said first and second forming dies and their associated control surfaces for relative movement, said supporting structure supporting said dies for solely axial movement toward each other during scoring of said workpiece, and said supporting structure including retaining means and resilient means, said resilient means holding one of said forming dies and its associated control surface in a forming position with a force substantially greater than the force required to accomplish the scoring of said workpiece, said first and second forming dies cooperating to score said workpiece practically instantaneously upon movement thereof against opposite surfaces of said workpiece and said predetermined amount of residual material being precisely controlled by said control surfaces abutting each other, said retaining means serving to restrain said resilient means with respect to the control surface of said one die at least until said control surfaces abut each other.

20. An apparatus as set forth in claim 19 in which, said workpiece comprises metal wall means of an associated container, said scoring blade defines a tear strip in said wall means, and said predetermined amount of residual material comprises the residual metal left after scoring by said scoring blade which is precisely controlled so as to enable easy severing of said tear strip irrespective of the initial thickness of the metal defining said wall means.

21. An apparatus for forming a workpiece, said apparatus comprising, a first forming die having a material forming surface and having an associated first control surface supported at a fixed position relative to said first forming die, a second forming die having an anvil adapted to cooperate with said material forming surface and having an associated second control surface supported at a fixed position relative to said second forming die, said control surfaces being adapted to abut each other, a supporting structure for supporting each of said first and second forming dies and their associated control surfaces for relative movement, aid supporting structure supporting said dies for solely axial movement toward each other during forming of said workpiece, and said supporting structure including retaining means and resilient means, said resilient means holding one of said control surfaces in a position with a force substantially greater than the force required to accomplish the forming of said workpiece, said first and second forming dies cooperating to form said workpiece practically instantaneously upon movement thereof against opposite surfaces of said workpiece and upon said control surfaces abutting, said material forming being controlled by said control surfaces abutting each other, said retaining means serving to restrain said resilient means with respect to said one control surface at least until said control surfaces abut each other.

22. An apparatus as set forth in claim 21 in which said material forming surface of said first forming die is in the form of a scoring blade.

23. An apparatus as set forth in claim 21 in which said material forming surface of said first forming die comprises a first member having an inside surface defining an opening therein and said anvil of said second forming die has a projection which is adapted to cooperate with said inside surface to define an integral rivet-defining nipple in said workpiece.