United States Patent [19]

Jezik

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[45] **Nov. 27, 1973**

[54] **APPARATUS FOR AND METHOD OF FORMING A WORKPIECE**

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[73] Assignee: **United States Steel Corporation,** Pittsburgh, Pa.

[22] Filed: **Mar. 24, 1971**

[21] Appl. No.: **127,699**

[52] **U.S. Cl.** **72/42,** 72/349

[51] **Int. Cl.** **B21d 22/28**

[58] **Field of Search** ..... 72/41, 42, 43, 44, 72/45, 347, 348, 349; 113/120 H

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Attorney—Robert J. Leek, Jr.

[57] **ABSTRACT**

An apparatus for and method of forming a workpiece are disclosed.

A. The apparatus for forming a workpiece has a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of the body, the die being adapted to register with the workpiece and the cavity and utilized for forming the workpiece. A ram is adjacent the die assembly in registry with the workpiece and the die. Lubricating means are adjacent the workpiece for coating one side of the workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles. The particles have a diameter less than about five microns to prevent one member of the die and the ram from picking up workpiece particles during the forming operation. The ram is operable to move the workpiece through the die and into the cavity to form the workpiece without embedding the abrasive particles in the one side of the workpiece thereby eliminating weakening of the wall of the one side of the formed workpiece, contamination of the one side of the workpiece with abrasive particles and reduced reflectivity of the one side of the formed workpiece.

B. A method of forming a workpiece includes the steps of:

a. receiving the workpiece in a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body registering the workpiece with the die preparatory for forming the workpiece;

b. positioning a ram adjacent the die assembly in registry with the workpiece and the die;

c. lubricating the workpiece on one side of the workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles, the particles having a diameter less than five microns to prevent one member of the die and the ram from picking up workpiece particles during the forming operation; and

d. moving the ram to move the workpiece through the die and into the cavity to form the workpiece without embedding the abrasive particles in the one side of the workpiece thereby eliminating weakening of the wall of the one side of the formed workpiece, contamination of the one side of the workpiece with abrasive particles and reduced reflectivity of the one side of the formed workpiece.

64 Claims, 14 Drawing Figures

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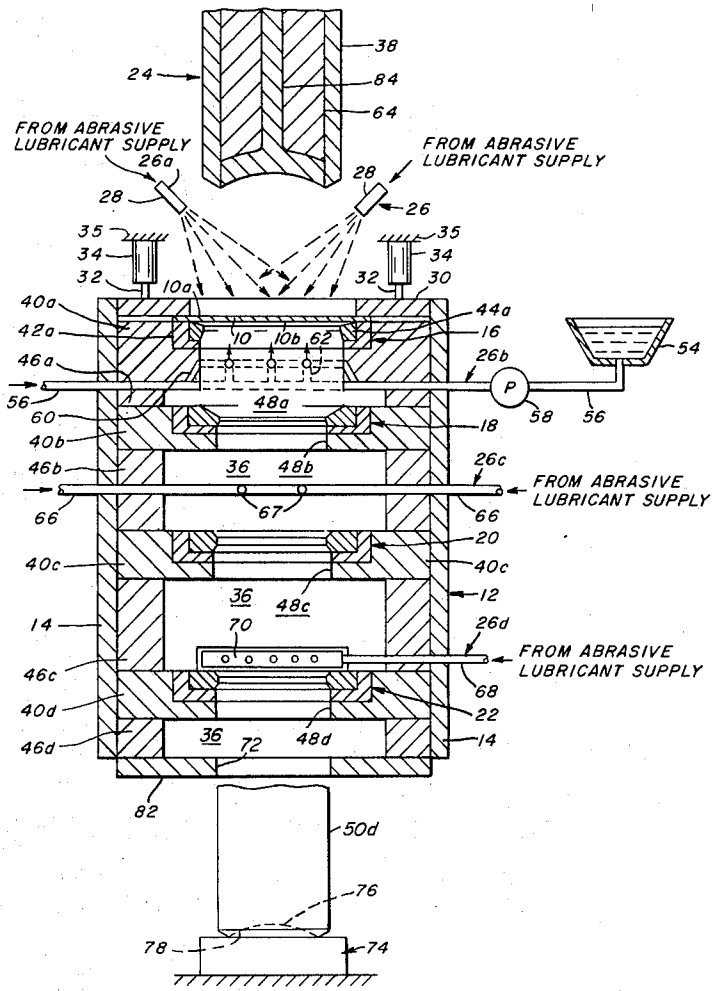

FIG. 1.

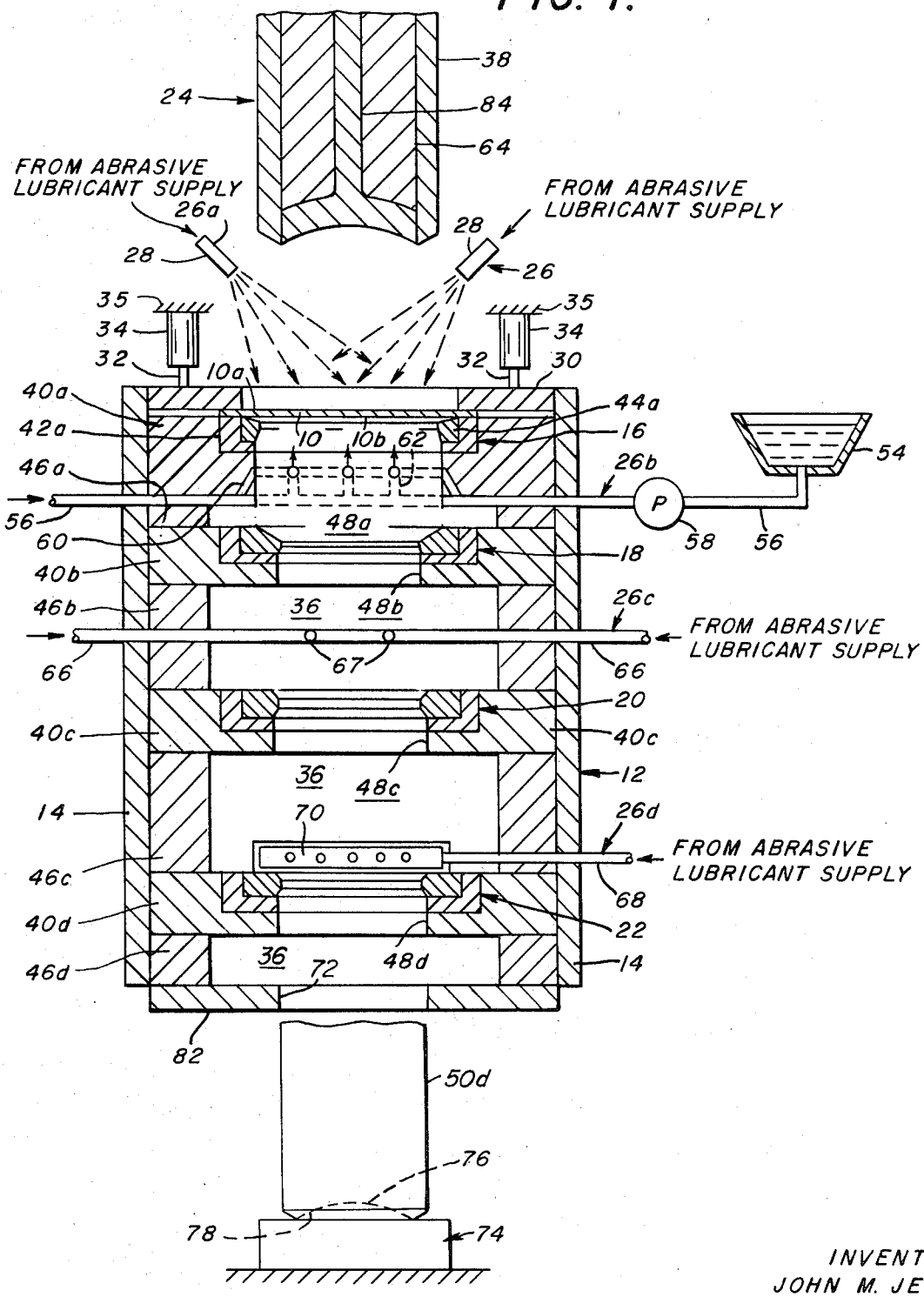

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FIG. 2.

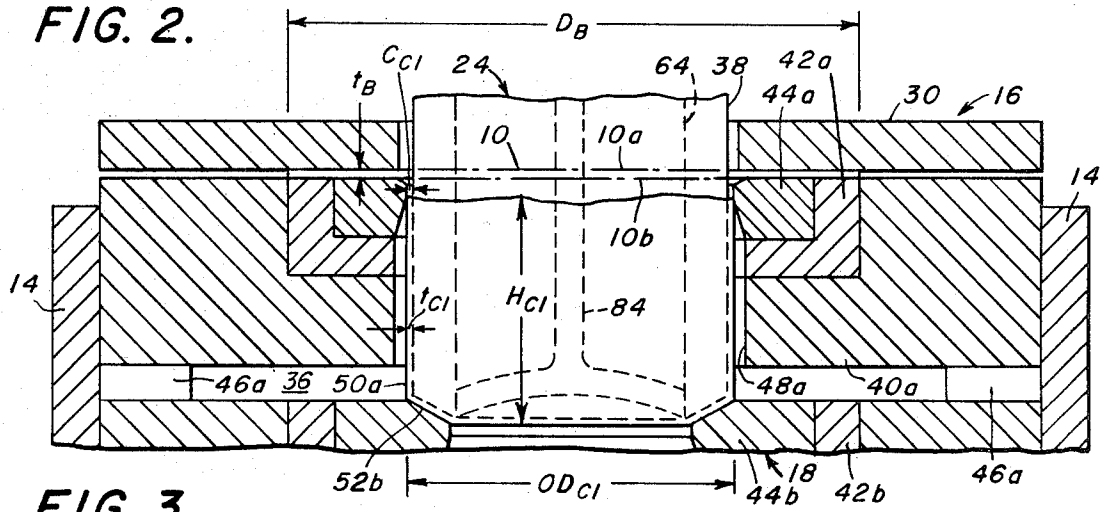

FIG. 3.

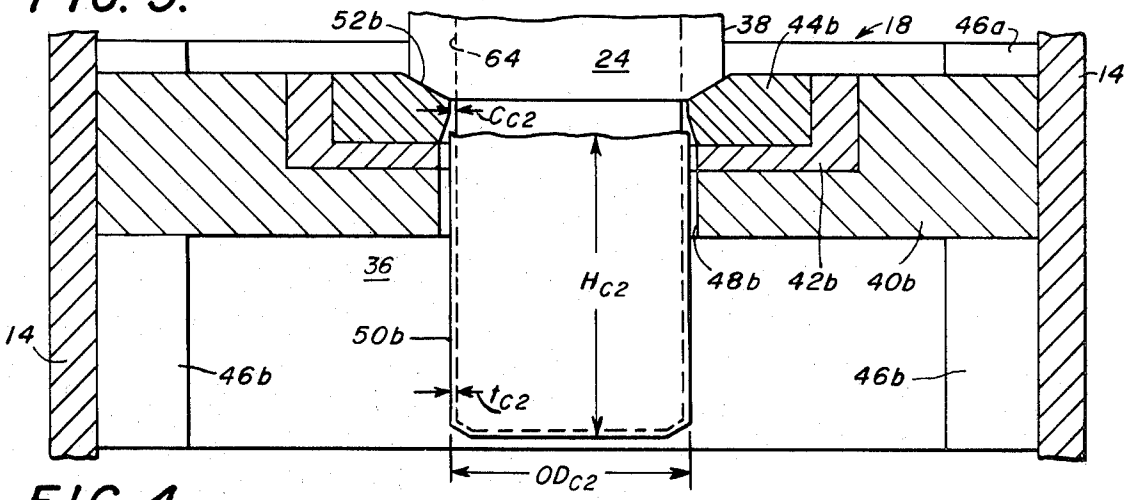

FIG. 4.

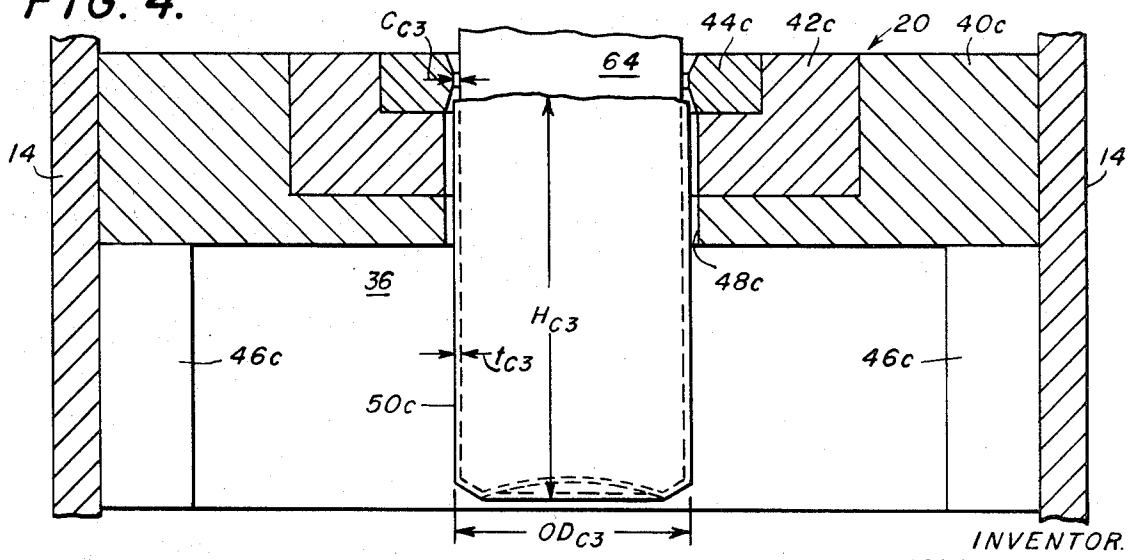

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FIG. 5.

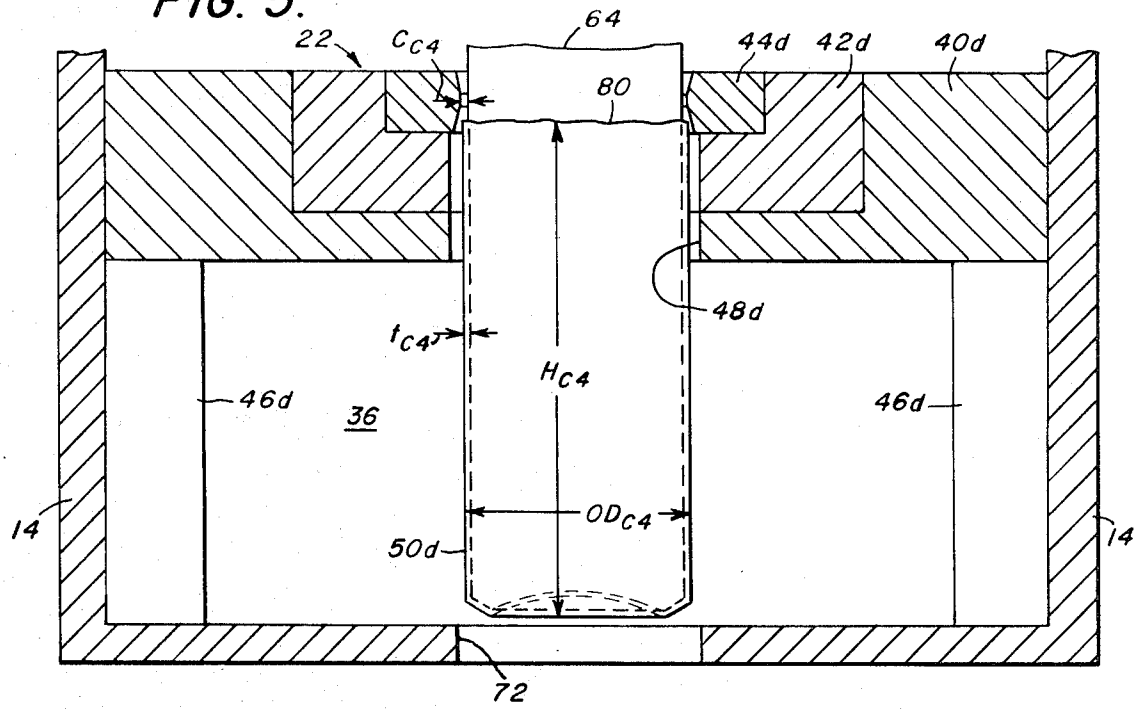

FIG. 6.

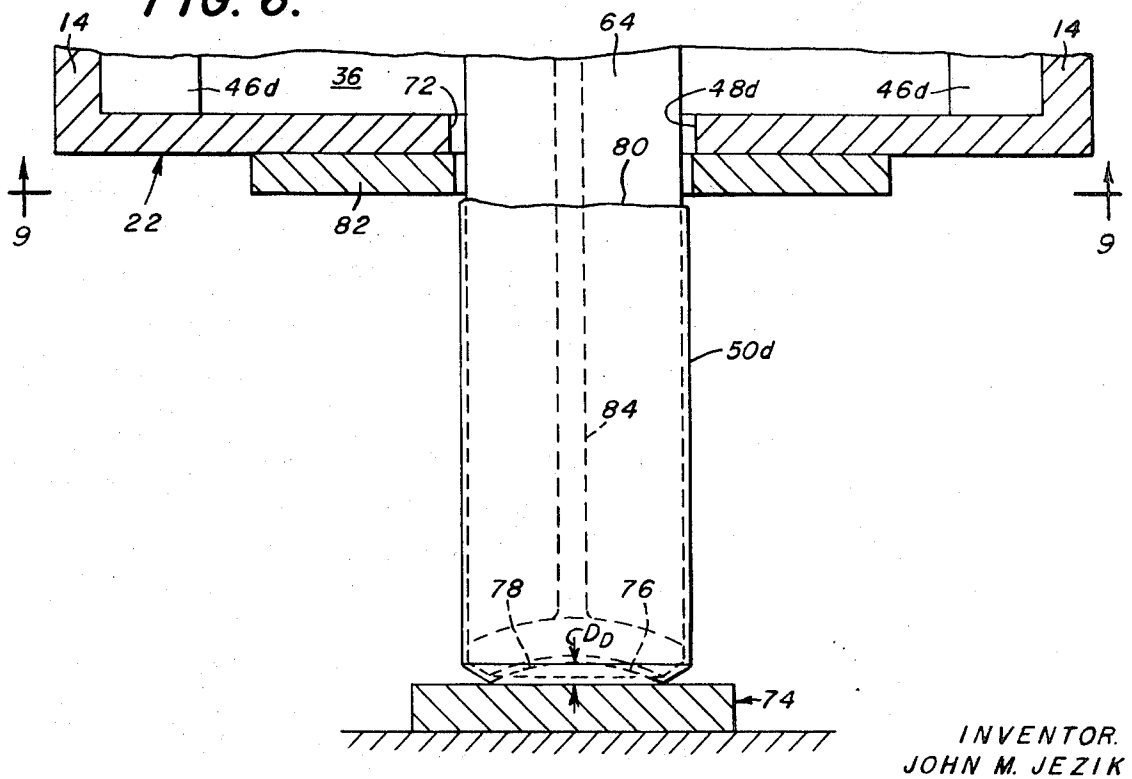

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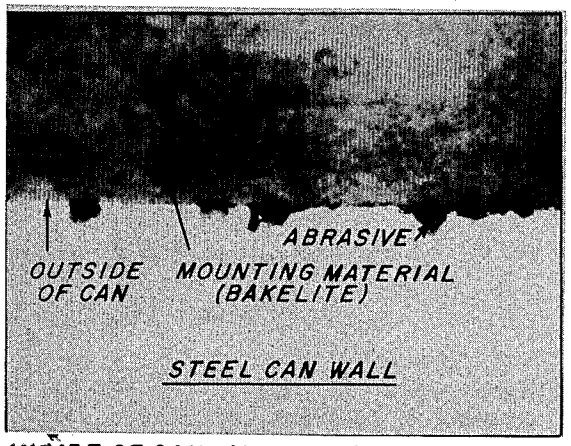
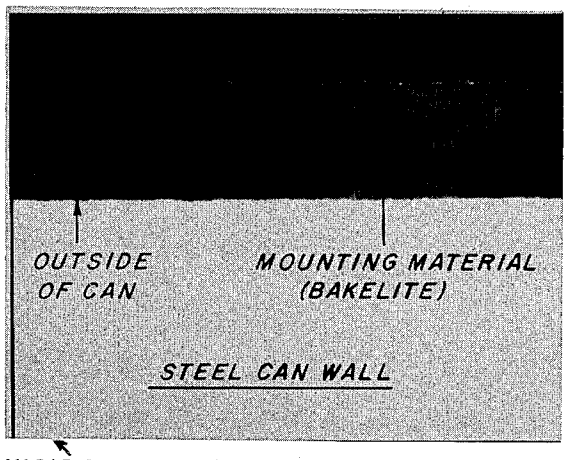
FIG. 7.



INSIDE OF CAN (ALUMINA) 20u ABRASIVE

FIG. 8.



INSIDE OF CAN (ALUMINA) 0.3u ABRASIVE

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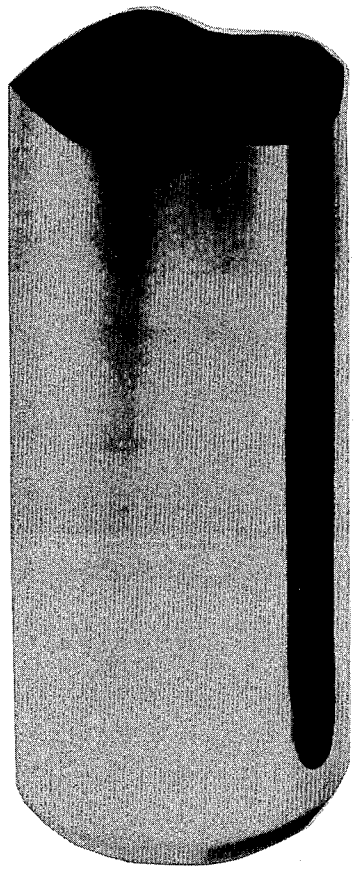
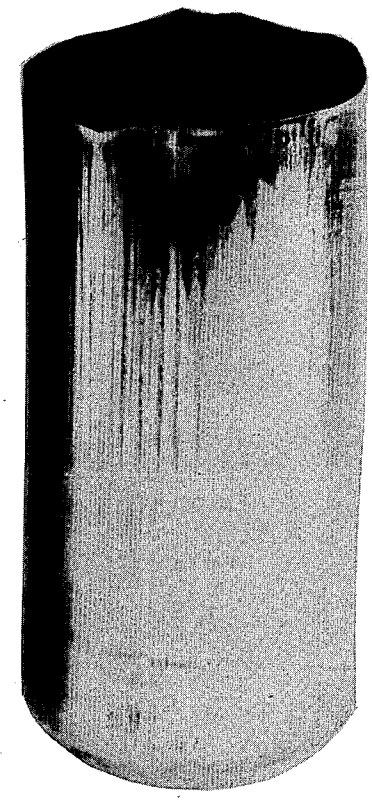
FIG. 8A.



0.3u ALUMINA

FIG. 8B.



20u ALUMINA

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FIG. 9.

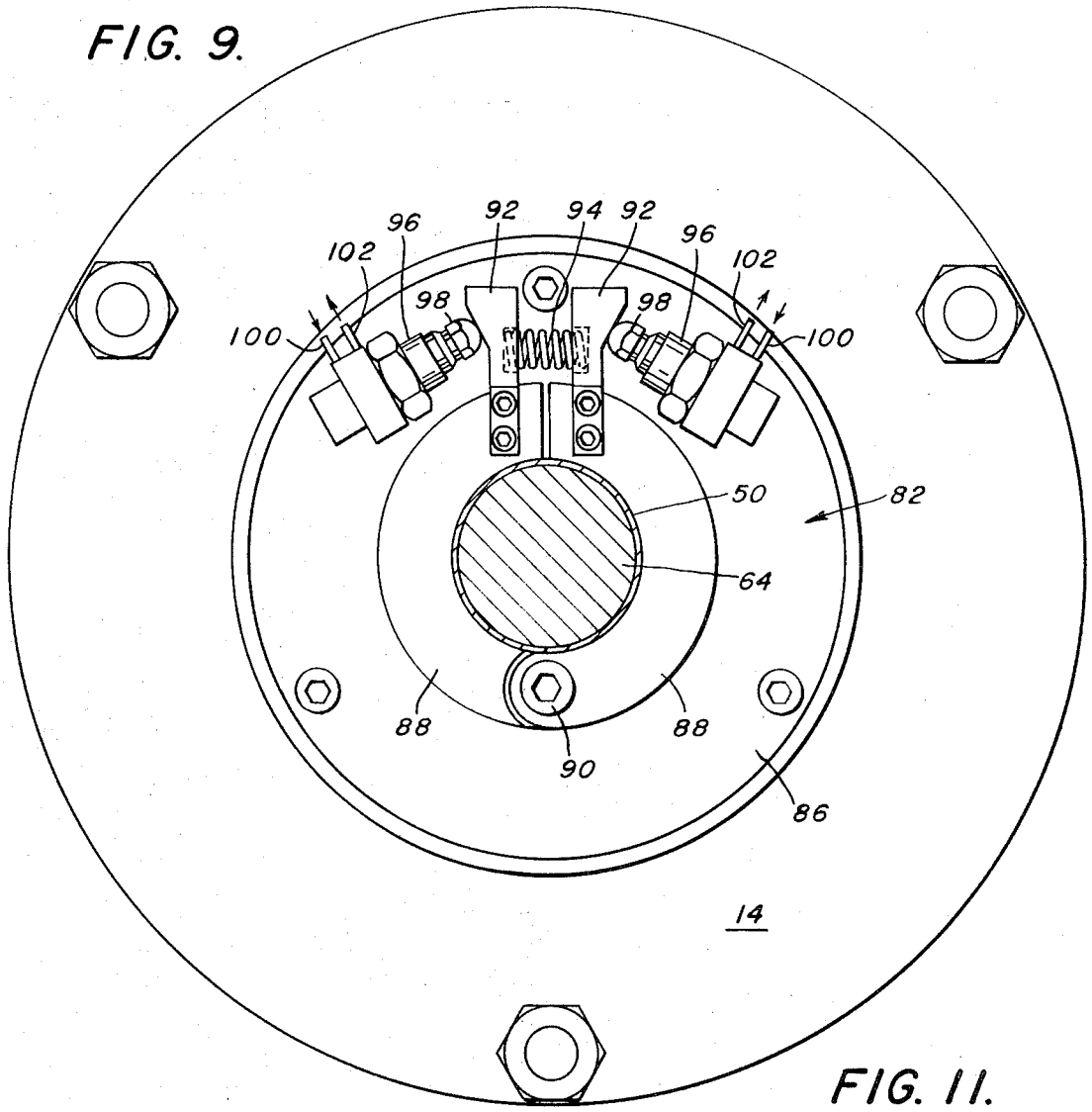


FIG. 10.

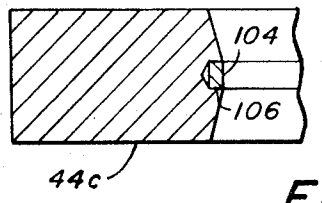


FIG. 11.

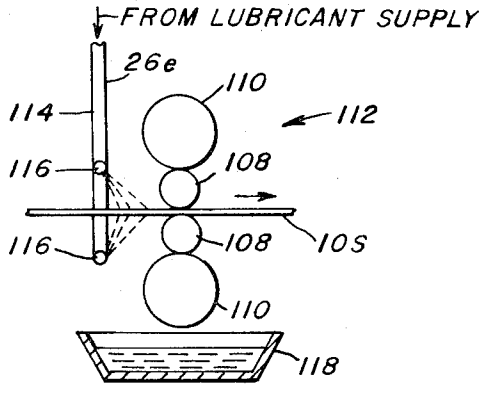
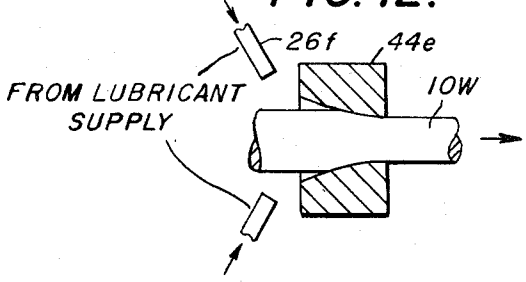


FIG. 12.



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APPARATUS FOR AND METHOD OF FORMING A WORKPIECE

BACKGROUND OF THE INVENTION

Heretofore, in drawing and ironing beverage cans made from black plate (uncoated sheet of tinplate gage), no lubricant tested (of about 25 different brands and formulations) gave a surface free of scoring and galling after a few cans were made. All the lubricants tested failed to produce a smooth, highly polished surface on the uncoated sheet and the best lubricant would produce only two or three cans with an acceptable surface. After 10 cans were made, the surface of the dies was so scored with fine lines (i.e., had a matte finish) which required polishing the dies with a relatively coarse abrasive (i.e., about 3 micron diamond paste) to remove embedded particles of the uncoated sheet from the dies.

Prior to my invention, the method of making cans of black plate included the step of alternating tinplate blanks with black plate blanks so that the lubricity of the tin on the tinplate carried over onto the dies and provided an acceptable finish on the black plate. Furthermore, it appeared that for these reasons, any commercial production of drawn and ironed steel cans would require a minimal tin coating to obtain the high polish necessary for lithography and to prevent alteration of color values. Black plate cans could not be made continuously as die-polishing required disassembly of the die pack when the cans become heavily scored. Since the application of my invention to drawing and ironing of beverage cans from black plate, the die pack has not been disassembled for removal of scores or die pick-up in the dies as was required previously.

I am aware of U.S. Pat. No. 2,112,632 issued Mar. 29, 1938, to H. A. Montgomery for "Process and Composition for Plastic Deformation of Metals."

This patented composition of matter adapted to use in the art of configurating sheet metal by plastic deformation comprises about 2 to 15 percent by weight of finely divided matter of the type exemplified by ground silica, ground pumice stone, ground alumina, ground limestone, ground emery dust, beryl, feldspar, and the like of about 250 mesh fineness dispersed in an oleaginous vehicle, such as cutting lard, lard oil, tallow, woof fat, mineral oil and the like, and containing about ½ to 3.0 percent by weight of free fatty acid, such as plametic, oleic, stearic, tallow acid and the like, to stably maintain the finely divided matter in the vehicle.

The patented method of drawing a sheet of metal into a product by means of dies under heavy pressure includes the steps of coating the surfaces of the sheet of metal with the above described composition of matter to provide a layer on the sheet which assists the dies to bite into the metal of the sheet to facilitate plastic deformation but which particles also possess (1) the capacity to maintain separation of the surfaces of the sheet of metal and the surfaces of the dies to prevent scoring of the metal; and (2) the capacity to provide uniform frictional pressure over the areas of the dies, and drawing the sheet to form the product.

Montgomery embeds desirably the abrasive particles in the workpiece thereby weakening the wall of a workpiece, such as a container, a sheet, a wire, or the like. In the case of a sheet usable for a container or of a container, these embedded particles will contaminate the interior of such containers or reduce the reflectivity of the drawn surfaces. Montgomery utilizes a draw ring die which clamps down on the workpiece and exerts a pressure tending to retard the flow of the workpiece with respect to the force of the ram. In my invention relating to the drawing and ironing of a container, the pressure pad, the outer punch and finally the inner punch replace the draw ring. Further, Montgomery polishes the workpiece but not to a sufficient polish to permit lithographic printing thereon.

In addition, Montgomery teaches that the particles should be relatively harder than the sheet metal workpiece. I have found that for long die life, the particles should be softer than the dies. Further, the viscosity of the vehicle should be in the range of about 25 to 800 SUS and preferably in the range of about 25–300 SUS and its coefficient of friction (u) should be in the range of about 0.094 to 0.236 as determined by the LFW-4 press fit test, which test evaluates lubricants in elastic contact and is conducted on the Dow Corning Lubricant, Friction and Wear Testing Machine as outlined in ASTM TCL 1–2 test.

In addition, during the conventional drawing and ironing operation of Montgomery, the die punch and the dies will pick up workpiece particles or material.

OBJECTS OF THE INVENTION

It is the general object of this invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of an improved apparatus for and method of drawing, which, apparatus and method:

1. highly polish the workpiece without, at the same time, causing excessive wear of the dies;
2. provide a high polish on a workpiece made from black plate or similar uncoated material by the drawing and/or ironing (reduction) process;
3. provide a high polish on a manufactured workpiece made from uncoated materials by other processes than drawing and ironing, such as by cold reduction by rolling, extrusion, or the like;
4. eliminate embedding of the particles in the workpiece;
5. eliminate weakening or reduction of the wall thickness of the workpiece to prevent corrosion of the wall thereat or explosion or leakage through such weakened section;
6. eliminate contamination of one surface of the workpiece with abrasive lubricant particles;
7. provide a workpiece finish having a high reflectivity;
8. eliminate pickup of particles of the workpiece by the drawing and reducing dies and die punch;
9. provide a highly polished surface on the formed product suitable for easy cleaning, laquering, or printing thereon;
10. does not damage the associated pumps with the abrasive lubricant particles; and
11. provide good hold down characteristics during forming of the workpiece.

BRIEF SUMMARY OF THE INVENTION

The aforesaid objects of this invention, and other objects which will become apparent as the description proceeds, are achieved by providing an improved apparatus for and method of forming a workpiece.

A. The apparatus for forming a workpiece has a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of the body, the die being adapted to register with the workpiece and the cavity and utilized for forming the workpiece. A ram is adjacent the die assembly in registry with the workpiece and the die. Lubricating means are adjacent the workpiece for coating one side of the workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles. The particles have a diameter less than about five microns to prevent one member of the die and the ram from picking up workpiece particles during the forming operation. The ram is operable to move the workpiece through the die and into the cavity to form the workpiece without embedding the abrasive particles in the one side of the workpiece thereby eliminating weakening of the wall of the one side of the formed workpiece, contamination of the one side of the workpiece with abrasive particles and reduced reflectivity of the one side of the formed workpiece.

B. A method of forming a workpiece includes the steps of:

a. receiving the workpiece in a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body registering the workpiece with the die preparatory for forming the workpiece;
b. positioning a ram adjacent the die assembly in registry with the workpiece and the die;
c. lubricating the workpiece on one side of the workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles, the particles having a diameter less than about five microns to prevent one member of the die and the ram from picking up workpiece particles during the forming operation; and
d. moving the ram to move the workpiece through the die and into the cavity to form the workpiece without embedding the abrasive particles in the one side of the workpiece thereby eliminating weakening of the wall of the one side of the formed workpiece, contamination of the one side of the workpiece with abrasive particles and reduced reflectivity of the one side of the formed workpiece.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

For a better understanding of this invention, reference should be had to the accompanying drawings, wherein like numerals of reference indicate similar parts through the several views and wherein:

FIG. **1** is a vertical sectional view of a die assembly or die pack showing a ram having an outer punch, inner punch, and stripping punch; a disc-like blank held in position by a pressure pack or plate; the lubricating means for introducing the abrasive lubricant; a first draw die assembly, a second draw die assembly, a first ironing or reducing die assembly, and a second reducing die assembly; and the finished fourth cup resting on a doming die;

FIG. **2** is an enlarged vertical sectional view of the first draw die assembly showing the first formed cup and the outer punch at the end of its travel against the bottom of the cavity in the top of the second draw die to hold down the first formed cup preparatory for the second draw operation and showing the stripper punch of FIG. **1**;

FIG. **3** is a view similar to FIG. **2** showing the second draw die assembly and the second formed cup with the inner punch at the bottom of the cavity of such second draw die assembly preparatory for the first ironing operation and omitting for clarity the stripper punch of FIGS. **1,2**;

FIG. **4** is a view similar to FIGS. **2,3** showing the third formed cup in the first reducing die assembly and the inner punch at the bottom of the cavity of such first reducing die assembly preparatory for the second ironing operation;

FIG. **5** is a view similar to FIGS. **2–4** showing the fourth formed finished cup in the second reducing die assembly and on the inner punch at the bottom of the cavity of the second reducing die preparatory for the doming and stripping operation;

FIG. **6** is a view similar to FIGS. **2–5** showing the fourth formed finished cup clear of the die pack and the stripper means on the bottom of the frame of such die pack with such finished cup positioned at the end of the doming operation on the doming die and showing also the stripper punch (shown in FIG. **1**), with both the stripper means and the stripper punch being in position preparatory for the stripping operation;

FIG. **7** is a photomicrograph of the portion of a section of the wall of a workpiece formed with an abrasive lubricant having abrasive particles greater than about 5 microns (i.e., about 20 microns alumina) and showing the embedded abrasive particles in the polished outer wall, the weakening of the outer wall, and the reduced reflectivity of the surface of the section;

FIG. **8** is another photomicrograph, similar to FIG. **7**, of a section of a portion of the wall of a workpiece formed with an abrasive lubricant having abrasive particles less than about 5 microns (i.e., about 0.3 micron alumina) showing the elimination of embedded abrasive particles in the surface of the section, elimination of the resultant defects shown in FIG. **7**, the highly polished surface of the section suitable for lithographic printing thereon, and for easy cleaning and lacquering thereof;

FIG. **8A** is a photograph of a fourth formed finished cup formed with a lubricant having about 0.3 microns alumina;

FIG. **8B** is a photograph of a fourth formed finished cup formed with a lubricant having about 20 microns alumina;

FIG. **9** is a horizontal sectional view of the can body, inner punch and stripper means in the closed position taken along the line **9—9** of FIG. **6** in the direction of the arrows and showing the stripper means in the closed position about the inner punch preparatory for the retraction of such inner punch so that the fourth formed finished cup is arrested by the closed half members of the stripper means (when the inner punch is retracted) and is stripped from such inner punch;

FIG. **10** is a vertical sectional view, for example, of a portion of a reducing die showing the improved land insert;

FIG. **11** is a schematic side elevational view of reducing rolls for reducing a sheet workpiece and showing the lubricating means for applying the abrasive lubricant to both sides of the sheet; and

FIG. 12 is a vertical sectional view of a wire reducing or drawing die showing the lubricating means for applying the abrasive lubricant to both sides of the wire.

Although the principles of this invention are broadly applicable to the forming of a workpiece, this invention is particularly adapted for use in conjunction with the drawing and reduction of a workpiece into a cup; the reduction of a metal sheet and the reduction of an elongated member, and hence it has been so illustrated and will be so described.

DETAILED DESCRIPTION

With specific reference to the form of this invention illustrated in the drawings and referring particularly to FIG. 1, an apparatus for forming a disc-like workpiece blank **10** is indicated generally by the reference numeral **12.**

FORMING APPARATUS 12

The forming apparatus or die pack **12,** shown in FIG. **1,** has a frame or housing **14** (FIGS. **1–6**). Such die pack **12** is provided with a first draw die assembly **16** (FIGS. **1,2**), a second draw die assembly **18** (FIGS. **1,2,3**), a first ironing or reducing die assembly **20** (FIGS. **1,4**) and a second reducing die assembly **22** (FIGS. **1,5**), all stacked in the above mentioned order within the housing **14** of the die pack **12.** The blank **10** is suitably a disc-like metallic member formed of black plate steel or the like having a thickness T_B (FIG. 2) of about 0.0117 inch and an outside diameter D_B (FIG. 2) of about 6.062 inches as shown in FIG. **2.**

A ram **24** (FIGS. **1–3**) is disposed above the first draw die assembly **16** in registry with the workpiece blank **10** and the first draw die assembly **16.** Lubricating means **26** (FIG. **1**) are disposed adjacent the workpiece blank **10** for coating one or both sides of the workpiece blank **10** with an abrasive lubricant (having a liquid vehicle containing finely divided abrasive particles having a diameter less than about **5** microns) to prevent the die assemblies **16,18,20,22** and the ram **24** from picking up workpiece particles during the hereafter described forming operation. An external or preliminary lubricating means **26***a* (FIG. **1**) has a pair of nozzles **28** (FIG. **1**) for directing a supply of lubricant indicated by the arrows in FIG. **1** and the legend "from abrasive lubricant supply" onto the outside surface **10***a* of the blank **10,** held or positioned in registry with the first draw die assembly **16** by a pressure pad **30** (FIGS. **1,2**), which pressure pad **30** is held down against the blank **10** by pistons **32** (FIG. **1**) of fluid cylinders **34** affixed to a frame **35.**

In general, the ram **24** (FIGS. **1–6**) is operable to successively move the blank **10** through the first draw die assembly **16,** etc. and into the cavity **36** (FIG. **1**), etc. associated with each of the successive die assemblies **16,** etc. to form the workpiece **10** without embedding abrasive particles in one or both sides of the workpiece **10** thereby eliminating weakening of the wall of the abrasive lubricant coated side or sides of the formed workpiece **10,** contamination of the lubricant coated side or sides of the workpiece **10** with the abrasive particles, and reduced reflectivity from the lubricant coated side or sides of the formed workpiece **10.**

The forming operation associated with the die pack **12** will now be described with respect to the successive forming operations shown in FIGS. **2–6.**

FIRST DRAW DIE ASSEMBLY 16

The blank **10** positioned by the pressure pad **30** with respect to the first draw die assembly **16** is shown in the dash-dot lines of FIG. **2** and is engaged by an outer punch **38** (FIGS. **1–3**) of the ram **24** as such ram **24** moves from the position shown in FIG. **1** into engagement with the blank **10.** Such first draw die assembly **16** has a body **40***a* (FIGS. **1,2**), a die mounting ring **42***a* (FIGS. **1,2**) mounted on the body **40***a* and a first die **44***a* (FIGS. **1,2**) secured in the die mounting ring **42***a.* A first spacer **46***a* (FIGS. **1,2**) separates the body **40***a* of the first draw die **16** from the second draw die assembly **18** (FIG. **2**). The body **40***a* is provided with a cavity **48***a* (FIGS. **1,2**) adapted to receive the formed blank **10** after such blank **10** has been forced through the die **44***a.*

The outer punch **38** of the ram **24** moves the blank **10** from the dash-dot line position shown in FIG. **2** and the solid line position shown in FIG. **1** into the solid line position of FIG. **2** in the cavity **48***a,* until the outer punch **38** bottoms the now-formed first cup **50***a* (FIG. **2**) against an upper tapered portion **52***b* of the second draw die assembly **18.**

FIRST DRAW DIE LUBRICATING MEANS 26*b*

As shown in FIG. **1,** the under side **10***b* (FIGS. **1,2**) of the blank **10** may be coated with the abrasive lubricant by a first draw die lubricating means **26***b* (FIG. **1**). This first draw die lubricating means **26***b* has a tank **54** or tanks **54** (FIG. **1**) containing the abrasive lubricant, which tank **54** is connected by a line **56** or lines **56** (FIG. **1**) through a pump or pumps **58** (FIG. **1**) to a manifold **60** having a series of upwardly extending apertures **62** (FIG. **1**) for directing the abrasive lubricant fluid, as shown by the arrows in FIG. **1,** against the under side **10***b* of the blank **10.**

At the end of the first drawing operation, the first cup **50***a* (FIG. **2**) has the following approximate dimensional characteristics shown below:

outside diameter	$OD_{C1} = 3.5252''$
height	$H_{C1} = 2.500''$
wall thickness	$t_{C1} = 0.0117''$
clearance between the first draw die **44***a* and the outer punch **38** C_{C1}	$= 0.117$

This first draw operation results in an approximate 42 percent draw reduction in the diameter and about 0 percent wall reduction of $t_{C1} = 0.0117$ inch.

SECOND DRAW DIE ASSEMBLY 18

With the first cup **50***a* held by the outer punch **38** against the upper tapered portion **52***b* of the second draw die assembly **18,** the inner punch **64** (FIGS. **1–6**) (having an outside diameter of about 2.5900 inch) moves from the position shown in FIG. **2** to the position shown in FIG. **3** to form the second cup **50***b* (FIG. **3**). At the end of the second drawing operation, the second cup **50***b* (FIG. **3**) has the following approximate dimensional characteristics shown below:

Outside diameter	$OD_{C2} = 2.6080''$
height	$H_{C2} = 3.25''$
wall thickness	$t_{C2} = 0.009''$
clearance between the second draw die **44***b* and the inner punch **64** C_{C2}	$= 0.009''$

The second draw operation results in an approximate 26 percent draw reduction in the diameter and about 24 percent wall reduction of $t_{C2} = 0.009$ inch.

SECOND LUBRICATING MEANS 26c

As shown in FIG. 1, another lubricating means **26c** associated with second draw die assembly **18** has an inlet line **66** extending from an abrasive lubricant supply (indicated by the arrows and legend "From Abrasive Lubricant Supply") to apertures **67** (FIG. 1) formed in the wall of the cavity **48b** to the outside of the second cup **50b** preparatory for the first reducing operation. Meanwhile, the first lubricating means **26a** (FIG. 1) continues to coat the inside of the die pack **12.**

FIRST REDUCING DIE ASSEMBLY 20

As shown in FIGS. **1,4,** the inner punch **64** moves from the final position shown in FIG. **3** through the first reducing die assembly **20** to the position shown in FIG. **4** to form the third cup **50c.** This third cup **50c** has the following approximate dimensional characteristics:

outside diameter	$OD_{C3} = 2.6030''$
height	$H_{C3} = 4.25''$
wall thickness	$t_{C3} = 0.0065''$
clearance between the first reducing die **44c** and the inner punch **64** C_{C3}	$= 0.0065''$

THIRD LUBRICATING MEANS 26d

As shown in FIG. **1,** a lubricating means **26d** is associated with the first reducing die assembly **20** to lubricate the outside of the third cup **50c** preparatory for the second reducing operation. Such lubricating means **26d** has an inlet line **68** leading to a ring type manifold **70** disposed in the body **40c** of the first reducing die assembly **20** about the side walls of the cavity **48c** to coat the outside surface of the third cup **50c** preparatory for the second reducing operation.

The first reducing operation performs about a 28 percent reduction of the wall thickness of the cup **50c** from about 0.009 inch to about 0.0065 inch.

SECOND REDUCING DIE ASSEMBLY 22

As shown in FIGS. **1,5,** the inner punch **64** moves from the final position shown in FIG. **4** through the second reducing die assembly **22** to the position shown in FIG. **5** to form the fourth cup **50d.** Such fourth cup **50d** has the following approximate dimensional characteristics:

outside diameter	$OD_{C4} = 2.6000''$
height	$H_{C4} = 5.25''$
wall thickness	$t_{C4} = 0.005''$
clearance between the second reducing die **44d** and the inner punch **64** C_{C4}	$= 0.005''$

DOMING DIE 74

Thereafter, the inner punch **64** and the now-formed fourth cup **50d** moves through a discharge opening **72** (FIGS. **5,6**) in the bottom of the housing or frame **14** of the die pack **12** to the position shown in FIG. **6** against a doming die **74,** shown in FIGS. **1** and **6,** to form the dome **76** (FIGS. **1,6**) in the closed end **78** (FIGS. **1,6**) of the fourth cup **50d.** It will be noted from a consideration of FIG. **6** that the top **80** (FIGS. **5,6**) of the fourth cup **50d** has cleared a stripping means **82** shown in FIGS. **1,6** and **9.**

After the forming of the dome **76** in the closed end **78** (FIGS. **1,6**) of the fourth cup **50d,** such fourth cup **50d** may be stripped from the inner punch **64** by either of two means. First, a stripping punch **84** (FIGS. **1,2,6**) in the ram **24** remains in contact with the doming die **74** while the inner punch **64** is retracted through the opening or discharge aperture **72** in the housing **14.** Alternatively, the stripping means **82** shown in FIGS. **1,6,** and **9** may close about the inner punch **64** (FIG. **9**) to strip the fourth cup **50d** from the retracting inner punch **64.**

STRIPPING MEANS 82

As shown in FIG. **9,** the stripping means **82** has a mounting plate **86** on which the generally semi-circular half members **88** are provided at **90.** Each of the half members **88** are provided with projecting arms **92** (FIG. **9**) which arms **92** are normally biased apart by a spring **94.** Adjacent the outer surface of each of the arms **92** (FIG. **9**) are positioned a pair of mini fluid cylinders **96** having their pistons **98** in engagement with such arms **92.** Inlet and outlet lines **100** and **102** control the movement of the piston **98.** As the inner punch **64** carrying the now-formed fourth cup **50d** moves past the stripping means **82** into contact with the doming die **74,** as shown in FIG. **6,** the mini fluid cylinders **96** are energized through inlet line **100** to move the plungers or pistons **98** forward against the biasing action of the spring **94** to close the half members **88** about the inner punch **64,** so that when the inner punch **64** is retracted, the fourth cup **50d** engages the now-closed half members **88** to strip the fourth cup **50d** from the retracting inner punch **64.**

ABRASIVE LUBRICANT

The vehicle employed in the abrasive lubricant may be either water based or oil based and, for example, may be one of the following:

ATLANTIC SOLUBLE **4,** the trade name for a water based vehicle manufactured by the Atlantic Richfield Company of Philadelphia, Pennsylvania;

DIE-GARD 210, a water based lubricant manufactured under such trade name by the Riley-Whiteman Walton Company, Conshohocken, Pennsylvania;

DUO-KOTE 58, a trade name for an oil-based lubricant manufactured by such Riley-Whiteman Walton Company; and

RYCOSOL 69, a trade name for a water based lubricant manufactured by Riley-Whiteman Walton Company, Conshohocken, Pennsylvania.

The abrasive particles may be selected from the group consisting of alumina, emery dust, pumice stone, beryl, silica, feldspar, limestone, alpha form aluminum oxide, gamma form aluminum oxide, chromium oxide, cerium oxide, diamond paste, or the like.

The vehicle should have a viscosity in the range of about 25 to 800 SUS (Saybolt Universal Seconds), a measure of viscosity by the length of time the particular vehicle requires to pass through a standard orifice of specified dimensions at a specified temperature, such as 100°F. Desirably, such vehicle should have a viscosity in the range of about 25–300 SUS. In addition, the vehicle should have a coefficient of friction in the range of about 0.094–0.236.

Such abrasive lubricant should contain the above described abrasive particles in the range by volume of about 3.3 to 20.0 percent of the vehicle or abrasive lu-

bricant and, preferably, in the range by volume of 15.0–20.0 percent of the vehicle.

Table I shown below shows examples of selected abrasives in any one of the lubricants cited above:

TABLE I

Abrasive Particles	Particle Size	Abrasive Lubricant (by volume)
Aluminum oxide	0.05 micron	1 part abrasive to 5 parts abrasive lubricant
Do.	0.3 micron	1 part abrasive to 5 parts abrasive lubricant
Do.	1.0 micron	1 part abrasive to 5 parts abrasive lubricant
Do.	0.05 micron	1 part abrasive to 5 parts abrasive lubricant
Do.	0.3 micron	1 part abrasive to 5 parts abrasive lubricant
Do.	1.0 micron	1 part abrasive to 5 parts abrasive lubricant
Chrome oxide	0.1 micron	1 part abrasive to 5 parts abrasive lubricant
Do.	0.1 micron	1 part abrasive to 5 parts abrasive lubricant
Aluminum oxide	0.05 micron	1 part abrasive to 5 parts Rycosol 69
Do.	5.0 micron	1 part abrasive to 5 parts abrasive lubricant
Diamond paste	3.0 micron	1 part abrasive to 5 parts abrasive lubricant
Aluminum oxide	3.0 micron	1 part abrasive to 5 parts water

As shown in Table II below, a comparison of the relative hardness in Mohs between the workpiece **10**, abrasive particles, ram **24** and dies **40***a*–**40***d* is shown:

TABLE II

Workpiece=3.5–3.8

Abrasive particles=5.5–10.0

Ram **24** and dies **40***a*–**40***d*=7.7–8.5

Referring now to a comparison of the micrographs shown in FIGS. **7** and **8**, it will be noted by those skilled in the art that the micrograph of the section of the workpiece shown in FIG. **7** and formed with an abrasive lubricant having abrasive particles greater than about 5 microns, i.e., alumina of about 20 microns, shows embedded abrasive particles, which embedded particles weaken the wall of the section, thereby providing reduced reflectivity of the surface of such section. The scoring and galling of such surface by the over-size abrasive particles is similar to the longitudinal streaks shown in FIG. **8B**.

FIG. **8** is a photomicrograph of a section of the workpiece (formed with an abrasive lubricant having abrasive particles less than about 5 microns of the type shown in Table I above) and shows the elimination of embedded abrasive particles in the surface of the can wall; the elimination of resulting deleterious results shown in FIG. **7**; and the highly polished surface (FIG. **8A**) of the section suitable for lithographic printing thereon and easy cleaning and laquering thereof.

ALTERNATIVE EMBODIMENTS

It will be understood by those skilled in the art that alternatively as shown in FIG. **10**, any one of the above described dies **44***a*, **44***b*, **44***c*, **44***d*, for example, the first reducing die **44***c*, may be provided with a land insert **104** formed of one of the group consisting of plasma-arc fused zirconium oxide, aluminum oxide, tungsten carbide, boron nitride, silica carbide, zirconium silicate, mulite, and the like. Such land insert **104** may be deposited in the land insert cavity **106** of the die **44***c* by the plasma arc method and apparatus of the type described in the following patents:

Patent No.	Inventor	Issued
2,806,124	Gage	9/10/57
2,858,411	Gage	10/28/58
2,862,099	Gage	11/25/58
2,868,950	Gage	1/13/59
3,024,350	Skinner et al.	3/6/62
3,050,616	Gage	8/21/62
3,076,085	Sundstrom	1/29/63
3,130,292	Gage et al.	4/21/64
3,147,329	Gage	9/1/64
3,147,330	Gage	9/1/64
3,173,981	Myers et al.	3/16/65
3,194,941	Baird	7/13/65
3,257,197	Death et al.	6/21/66
3,347,766	Death et al.	10/17/67
3,422,206	Baker et al.	1/14/69

In this process of reducing or melting the above mentioned material and its oxide in a work chamber having a controlled atmosphere, the product to be melted is introduced to the controlled atmosphere from outside the controlled chamber. To perform this operation efficiently, an effective seal is needed between the chamber entry and the feed stock, and of the type shown in U.S. Pat. application Ser. No. 88,029, filed Nov. 19, 1970, by T. G. Bengel et al., and assigned to the same assignee as the present invention.

As shown in FIG. **11**, a sheet **10***s* passes between the reduction rolls **108** (backed by backing rolls **110**) of a sheet reduction mill **112**. Prior to entry of the sheet **10***s* into the reduction mill **112**, lubricating means **26***e* feed the abrasive lubricant through a supply line **114** to nozzles **116** to coat both sides of the sheet **10***s*, as shown in FIG. **11**. The drainage or residue of the abrasive lubricant is collected in a tank **118**.

FIG. **12** shows a workpiece in the form of a wire **10***w* passing through a reduction die **44***e* in the direction of the arrow shown in FIG. **12**. Again, prior to entrance of the wire **10***w* through the die **44***e*, lubricating means **26***f* coat the abrasive fluid onto the wire **10***w*.

SUMMARY OF THE ACHIEVEMENTS OF THE OBJECTS OF THE INVENTION

It will be understood by those skilled in the art that the objects of this invention have been achieved by providing an improved apparatus **12** (FIGS. **1–7**), **12**^{11} (FIG. **11**), and **12**^{12} (FIG. **12**) and a method of forming a workpiece **10** (FIGS. **1–7**), **10***s* (FIG. **11**), and **10***w* (FIG. **12**), which apparatus and method highly polish the workpieces **10**,**10***s*,**10***w* without, at the same time, causing wear on the dies **44***a*,**44***b*,**44***c*,**44***d* (FIGS. **1–7**), the reduction rolls **108** (FIG. **11**) and the reducing die **44***f* (FIG. **12**); provide a high polish on such workpieces **10** (FIGS. **1–7**), etc. made from black plate or similar uncoated material by the drawing or reduction process; provide a high polish on the manufactured workpiece **10** (FIGS. **1–7**, etc.) made from uncoated materials by a process as rolling, extrusion, or the like; eliminate embedding of the abrasive particles of the workpiece **10** (FIGS. **1–7**, etc.) and in the ram **24**, the dies **44***a*–**44***d* (FIGS. **1–7**), the reduction rolls **108** (FIG. **11**) and the reducing die **44***f* (FIG. **12**); eliminate weakening or reduction of the wall thickness T_{C4} of the fourth cup **50***d* to prevent corrosion of such wall or leakage or explosion through such weakened section; eliminate contamination of one surface **10***b* (FIGS.

1–7, etc.) with abrasive lubricant particles; provide a workpiece finish having a high reflectivity; provide a highly polished surface on the formed product either the finished cup **50**d (FIGS. 1–7), the reduced sheet **10**s (FIG. **11**), or the reduced wire **10**w (FIG. **12**), suitable for easy cleaning, laquering or printing thereon; do not damage the associated pump with the abrasive lubricant particles; and provide good hold-down characteristics during the forming of the workpiece **10** (FIGS. 1–7) etc.

While in accordance with the patent statutes, preferred and alternative embodiments of this invention have been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

I claim:

1. Apparatus for forming a workpiece and having:

a. a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body and adapted to register with said workpiece and said cavity and for forming said workpiece;

b. a ram adjacent said die assembly in registry with said workpiece and said die;

c. lubricating means adjacent said workpiece for coating one side of said workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles;

1. said particles having a diameter less than about five microns to prevent one member of said die and said ram from picking up workpiece particles during the forming operation;

d. said ram being operable to move said workpiece through said die and into said cavity to form said workpiece without embedding said abrasive particles in said one side of said workpiece thereby eliminating weakening of the wall of said one side of said formed workpiece, contamination of said one side of said workpiece with abrasive particles and reduced reflectivity of said one side of said formed workpiece;

e. said abrasive lubricant contains said abrasive particles in the range by volume of about 3.3 to 20.0 percent and has a viscosity in the range of about 25 to 800 SUS.

2. The apparatus recited in claim **1** wherein said die is a drawing die.

3. The apparatus recited in claim **1** wherein said die is a reducing die.

4. The apparatus recited in claim **1** wherein said workpiece is precoated on one side with said abrasive lubricant.

5. The apparatus recited in claim **3** wherein said abrasive lubricant provides a highly polished surface on said one side suitable for easy cleaning thereof, printing thereon, or coating thereof.

6. The apparatus recited in claim **1** wherein said vehicle has a viscosity in the range of about 25 to 800 SUS.

7. The apparatus recited in claim **1** wherein said vehicle has a coefficient of friction in the range of about 0.094 to 0.236.

8. The apparatus recited in claim **1** wherein said vehicle is oil based.

9. The apparatus recited in claim **1** wherein said vehicle is water based.

10. The apparatus recited in claim **1** wherein said abrasive particles are one of a group consisting of alumina, emery dust, pumice stone, beryl, silica, feldspar, limestone, alpha form aluminum oxide, gamma form aluminum oxide, chrome oxide, cerium oxide, and diamond paste.

11. The apparatus recited in claim **1** and having hold down means for securing said workpiece in registry with said die.

12. The apparatus recited in claim **1** wherein said hold down means is a pressure pad.

13. The apparatus recited in claim **1** wherein said ram has an outer punch and an inner punch.

14. The apparatus recited in claim **13** wherein said outer punch holds down said workpiece in registry with said die.

15. The apparatus recited in claim **1** and having stripping means associated with said die assembly for removing said formed workpiece from said ram.

16. The apparatus recited in claim **1** wherein said ram has a stripper punch for forcing said formed workpiece off said ram.

17. The apparatus recited in claim **15** wherein said stripping means is disposed adjacent the other end of said body and is operable to close about said ram spaced from said formed workpiece so that said formed workpiece is stripped from said ram when said ram is retracted.

18. The apparatus recited in claim **1** and having a doming die adjacent said other end of said die assembly to permit said ram to form a dome in a closed end of said workpiece.

19. The apparatus recited in claim **17** wherein said stripping means has a pair of half members pivoted on said die assembly, biasing means for normally maintaining said half members in the open position, and drive means associated with said half members for moving said half members into the closed position about said ram so that said workpiece is arrested by said closed half members when said ram is retracted through said die assembly.

20. The apparatus recited in claim **1** wherein said abrasive particles are substantially harder than said workpiece.

21. The apparatus recited in claim **1** wherein said die has a die insert.

22. The apparatus recited in claim **21** wherein said die insert is formed of one of zirconium oxide, aluminum oxide, tungsten carbide, titanium carbide, boron nitride, silicon carbide, zirconium silicate and mulite.

23. The apparatus recited in claim **21** wherein said die insert has a land insert.

24. The apparatus recited in claim **23** wherein said land insert is formed of one of zirconium oxide, aluminum oxide, tungsten carbide, boron nitride, silicon carbide, zirconium silicate and mulite.

25. The apparatus recited in claim **1** wherein said abrasive lubricant contains abrasive particles in the range by volume of about 15 to 20%.

26. The apparatus recited in claim **1** wherein said formed workpiece is a container.

27. The apparatus recited in claim **1** wherein said workpiece is a wire.

28. The apparatus recited in claim **3** wherein said workpiece is a sheet, said body is a roll, and said ram is a reducing roll.

29. A method of forming a workpiece and including the steps of:

a. receiving said workpiece in a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body and registering said workpiece with said die preparatory for forming said workpiece;
b. positioning a ram adjacent said die assembly in registry with said workpiece and said die;
c. lubricating said workpiece on one side of said workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles,
1. said particles having a diameter less than five microns to prevent one member of said die and said ram from picking up workpiece particles during the forming operation;
2. said abrasive lubricant containing said abrasive particles in the range by volume of about 3.3 to 20.0 percent and has a viscosity in the range of about 25 to 800 SUS;
d. moving said ram to move said workpiece through said die and into said cavity to form said workpiece without embedding said abrasive particles in said one side of said workpiece thereby eliminating weakening of the wall of said one side of said formed workpiece, contamination of said one side of said workpiece with abrasive particles and reduced reflectivity of said one side of said formed workpiece.

30. The method recited in claim **29** including the steps of registering said workpiece with a drawing die.

31. The method recited in claim **29** including the step of registering said workpiece with a reducing die.

32. The method recited in claim **29** including the step of precoating one side of said workpiece with said abrasive lubricant.

33. The method recited in claim **29** including the step of producing with said abrasive lubricant a highly polished surface on said one side suitable for easy cleaning thereof, printing thereon or coating thereof.

34. The method recited in claim **29** including the step of using a vehicle having a coefficient of friction in the range of about 0.094 to 0.236.

35. The method recited in claim **29** including the step of using a vehicle which is oil based.

36. The method recited in claim **29** including the step of using a vehicle which is water based.

37. The method recited in claim **29** including the step of using abrasive particles which are one of a group consisting of alumina, emery dust, pumice stone, beryl, silica, feldspar, limestone, alpha form aluminum oxide, gamma form aluminum oxide, chrome oxide, cerium oxide, and diamond paste.

38. The method recited in claim **29** including the step of holding down said workpiece to secure said workpiece in registry with said die.

39. The method recited in claim **29** including the step of holding down said workpiece by a pressure pad.

40. The method recited in claim **28** including the step of using a ram having an outer punch and an inner punch.

41. The method recited in claim **40** including the step of holding down said workpiece in registry with said die by said outer punch.

42. The method recited in claim **29** including the step of stripping said formed workpiece from said ram.

43. The method recited in claim **29** including the step of stripping said workpiece from said ram by a stripper punch which forces said formed workpiece off said ram.

44. The method recited in claim **42** including the step of stripping said workpiece from said ram by closing a stripping means about said ram spaced from said formed workpiece so that said formed workpiece is stripped from said ram when said ram is retracted.

45. The method recited in claim **29** including the step of forming a dome in a closed end of said workpiece.

46. The method recited in claim **44** including the step of pivoting a pair of half members of a stripping means on said die assembly, normally maintaining said half members in the open position, and moving said half members into the closed position about said ram so that said workpiece is arrested by said closed half members when said ram is retracted through said die assembly.

47. The method recited in claim **29** including the step of forming said workpiece with a die having a die insert.

48. The method recited in claim **47** including the step of forming said workpiece with a die insert formed of tungsten carbide.

49. The method recited in claim **47** including the step of forming said workpiece with a die insert formed of one of zirconium oxide, aluminum oxide, tungsten carbide, titanium carbide, boron nitride, silicon carbide, zirconium silicate and mulite.

50. The method recited in claim **47** including the step of forming said workpiece with a die insert having a land insert.

51. The method recited in claim **50** including the step of forming said workpiece with a land insert formed of one of zirconium oxide, aluminum oxide, tungsten carbide, boron nitride, silicon carbide, zirconium silicate and mulite.

52. The method recited in claim **29** including the step of using a vehicle having a viscosity in the range of about **25** to **300** SUS.

53. The method recited in claim **29** including the step of using a lubricant containing abrasive particles in the range by volume of about 15 to 20 percent.

54. The method recited in claim **29** including the step of forming said workpiece into a container.

55. The method recited in claim **29** including the step of forming said workpiece into a wire.

56. The method recited in claim **31** including the steps of reducing said workpiece between a roll and a reducing roll.

57. For apparatus for forming a workpiece and having a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body and adapted to register with said workpiece and said cavity and for forming said workpiece; a ram adjacent said die assembly in registry with said workpiece and said die; and lubricating means adjacent said workpiece for coating one side of said workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles, said particles having a diameter less than five microns to prevent one member of said die and said ram from picking up workpiece particles during the forming operation; said ram being operable to move said workpiece through said die and into said cavity to form said workpiece without embedding said abrasive particles in said one side of said workpiece thereby eliminating weakening of the wall of said one side of said formed workpiece, contamination of said one side of said workpiece with

abrasive particles and reduced reflectivity of said one side of formed workpiece;

a. stripper means for forcing said formed workpiece off said ram.

58. The stripper means recited in claim **57** wherein said stripping means is disposed adjacent the other end of said body and is operable to close about said ram spaced from said formed workpiece so that said formed workpiece is stripped from said ram when said ram is retracted.

59. The stripper means recited in claim **57** wherein said stripper means is a stripper punch on said ram.

60. The stripper means recited in claim **57** wherein said stripping means has a pair of half members pivoted on said die assembly, biasing means for normally maintaining said half members in the open position, and drive means associated with said half members for moving said half members into the closed position about said ram so that said workpiece is arrested by said closed half members when said ram is retracted through said die assembly.

61. Apparatus for forming a workpiece and having:

a. a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body and adapted to register with said workpiece and said cavity and for forming said workpiece;

b. a ram adjacent said die assembly in registry with said workpiece and said die; and

c. lubricating means adjacent said workpiece for coating one side of said workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles,

1. said particles having a diameter less than about five microns to prevent one member of said die and said ram from picking up workpiece particles during the forming operation;

d. said ram being operable to move said workpiece through said die and into said cavity to form said workpiece without embedding said abrasive particles in said one side of said workpiece thereby eliminating weakening of the wall of said one side of said formed workpiece, contamination of said one side of said workpiece with abrasive particles and reduced reflectivity of said one side of said formed workpiece.

62. Apparatus for forming a workpiece and having:

a. a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body and adapted to register with said workpiece and said cavity and for forming said workpiece;

b. a ram adjacent said die assembly in registry with said workpiece and said die;

c. lubricating means adjacent said workpiece for coating one side of said workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles;

1. said particles having a diameter less than about five microns to prevent one member of said die and said ram from picking up workpiece particles during the forming operation;

d. said ram being operable to move said workpiece through said die and into said cavity to form said workpiece without embedding said abrasive particles in said one side of said workpiece thereby eliminating weakening of the wall of said one side of said formed workpiece, contamination of said one side of said workpiece with abrasive particles and reduced reflectivity of said one side of said formed workpiece; and

e. said abrasive lubricant contains said abrasive particles in the range by volume of about 3.3 to 20.0 percent.

63. A method of forming a workpiece and including the steps of:

a. receiving said workpiece in a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body and registering said workpiece with said die preparatory for forming said workpiece;

b. positioning a ram adjacent said die assembly in registry with said workpiece and said die;

c. lubricating said workpiece on one side of said workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles,

1. said particles having a diameter less than five microns to prevent one member of said die and said ram from picking up workpiece particles during the forming operation; and

d. moving said ram to move said workpiece through said die and into said cavity to form said workpiece without embedding said abrasive particles in said one side of said workpiece thereby eliminating weakening of the wall of said one side of said formed workpiece, contamination of said one side of said workpiece with abrasive particles and reduced reflectivity of said one side of said formed workpiece.

64. A method of forming a workpiece and including the steps of:

a. receiving said workpiece in a die assembly having a body provided with a cavity adapted to receive the formed workpiece and a die at one end of said body and registering said workpiece with said die preparatory for forming said workpiece;

b. positioning a ram adjacent said die assembly in registry with said workpiece and said die;

c. lubricating said workpiece on one side of said workpiece with an abrasive lubricant having a liquid vehicle containing finely divided abrasive particles,

1. said particles having a diameter less than five microns to prevent one member of said die and said ram from picking up workpiece particles during the forming operation;

2. said abrasive lubricant containing said abrasive particles in the range by volume of about 3.3 to 20.0 percent; and

d. moving said ram to move said workpiece through said die and into said cavity to form said workpiece without embedding said abrasive particles in said one side of said workpiece thereby eliminating weakening of the wall of said one side of said formed workpiece, contamination of said one side of said workpiece with abrasive particles and reduced reflectivity of said one side of said formed workpiece.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,774,426 Dated November 27, 1973

Inventor(s) John M. Jezik

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

In the specification,

Column 8, line 16, "provided" should read -- pivoted --.

Signed and sealed this 3rd day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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