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(54) Abstract Title
Multi-piece hydroforming tool

(57) A multi-piece hydroforming tool is provided having a tooling die and a hydraulic pressure source. The tooling die includes a plurality of tooling cavities 26. Each tooling cavity includes a injector manifold in fluid communication with the hydraulic pressure source. The injector manifolds supply pressurized hydraulic fluid to each of the plurality of tooling cavities independently. Thus, multiple pieces may be formed simultaneously and independently, thereby minimizing the need to discard all the hydroformed pieces if one piece become defective. The die may be used to form a plurality of vehicle control arms 10 in a single operation.

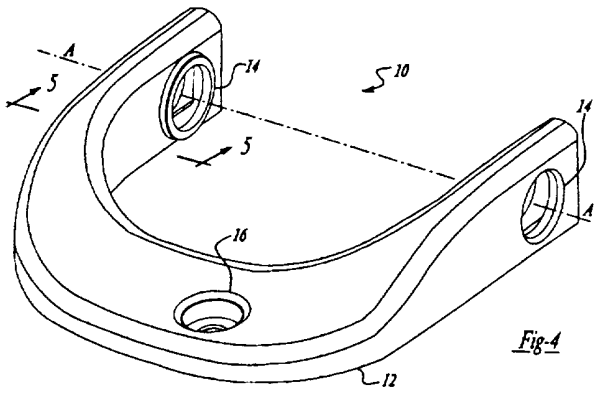

Fig-4

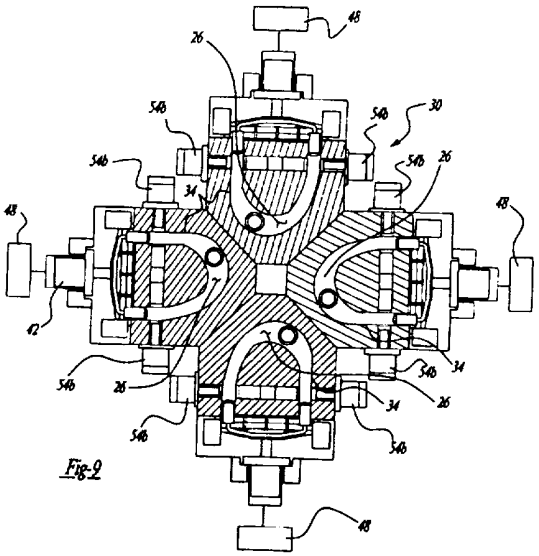

Fig-9

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

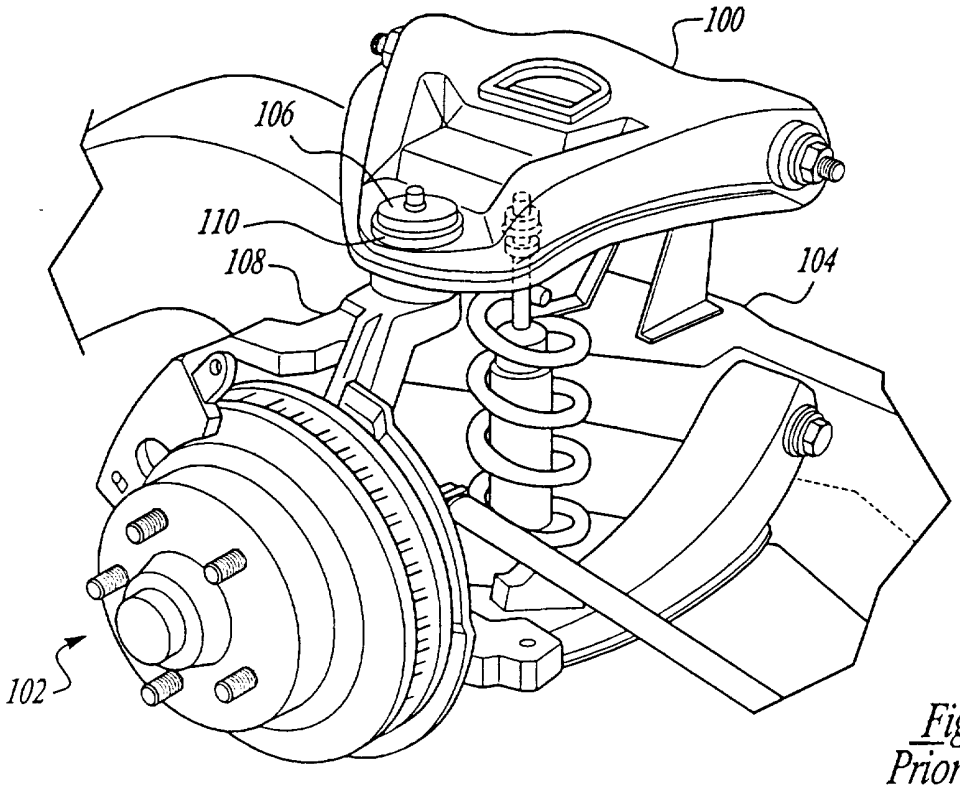


Fig-1
Prior Art

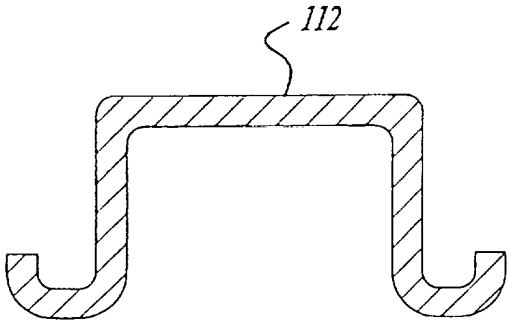


Fig-2
Prior Art

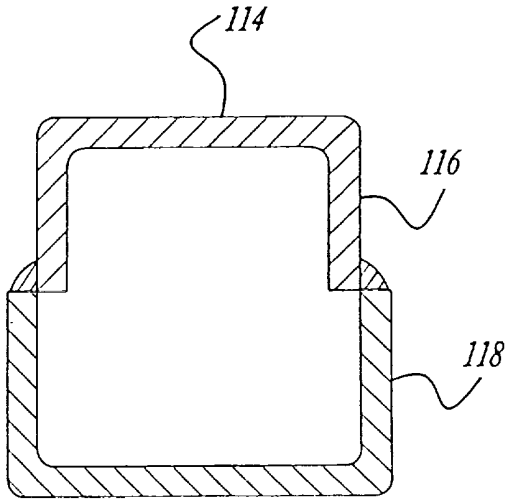


Fig-3
Prior Art

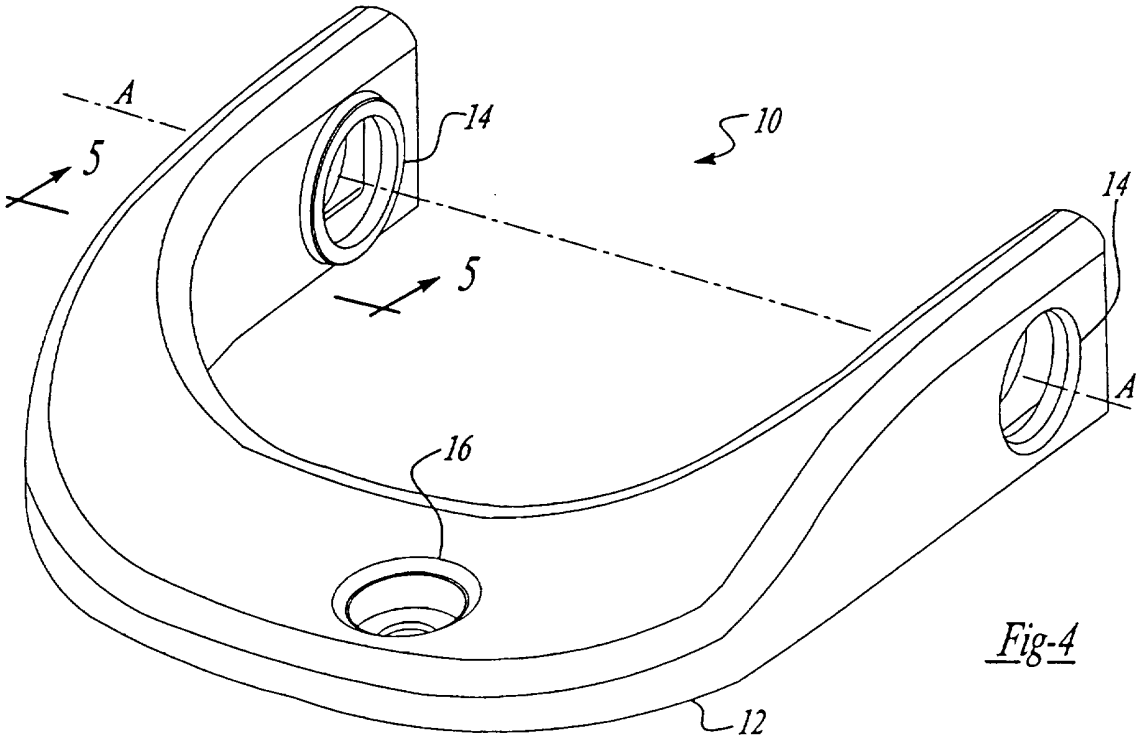


Fig-4

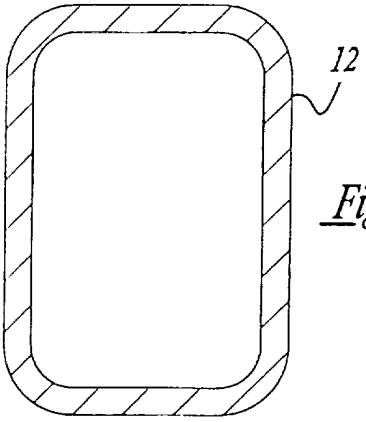
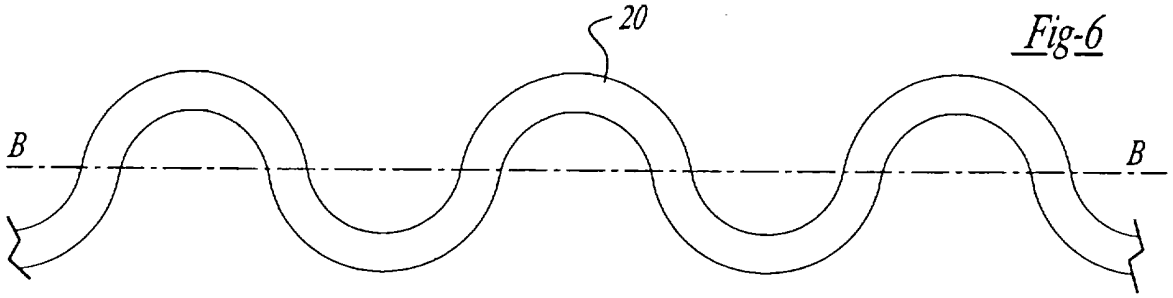


Fig-5

Fig-6



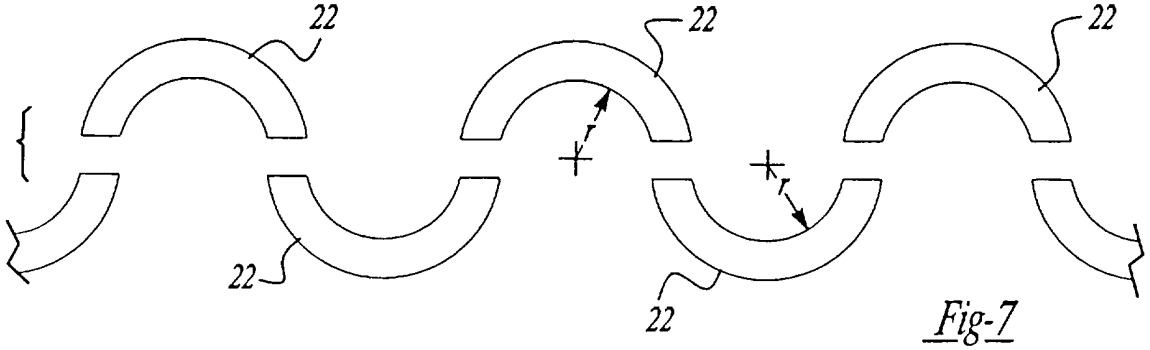


Fig-7

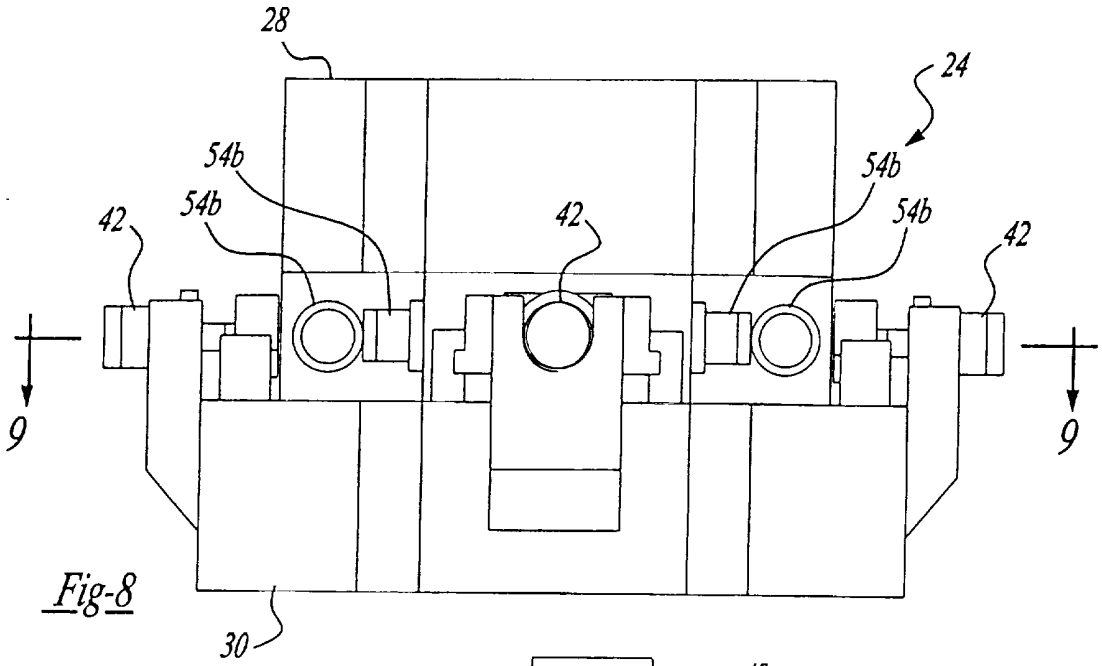
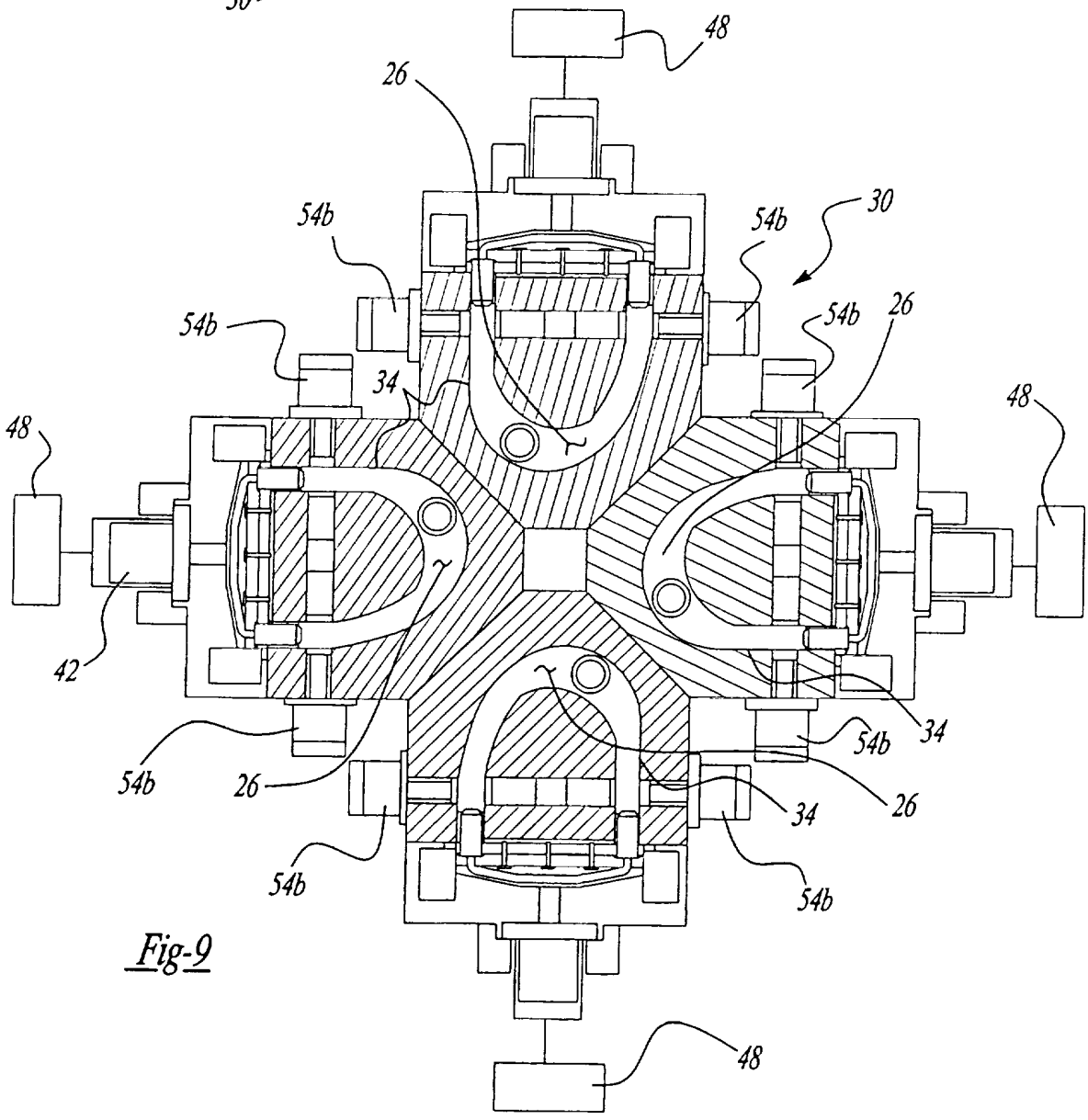

28
24
54b
54b
54b
54b
42
42
42
9
9
30

Fig-8


48
26
54b
54b
30
54b
54b
26
34
48
48
42
54b
26
34
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26
34
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54b
48

Fig-9

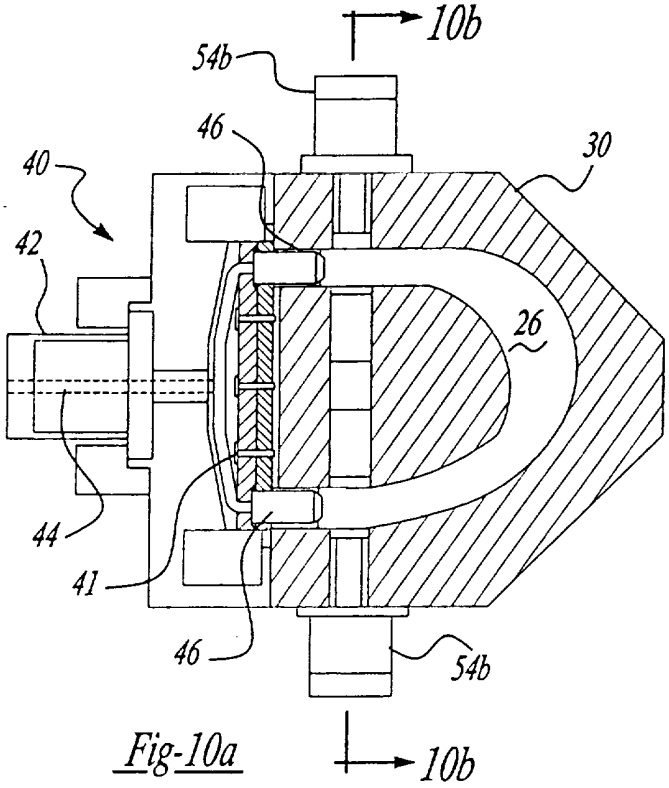

Fig-10a

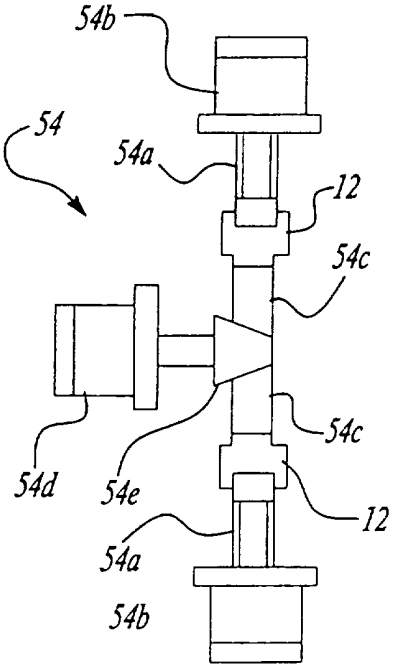

Fig-10b

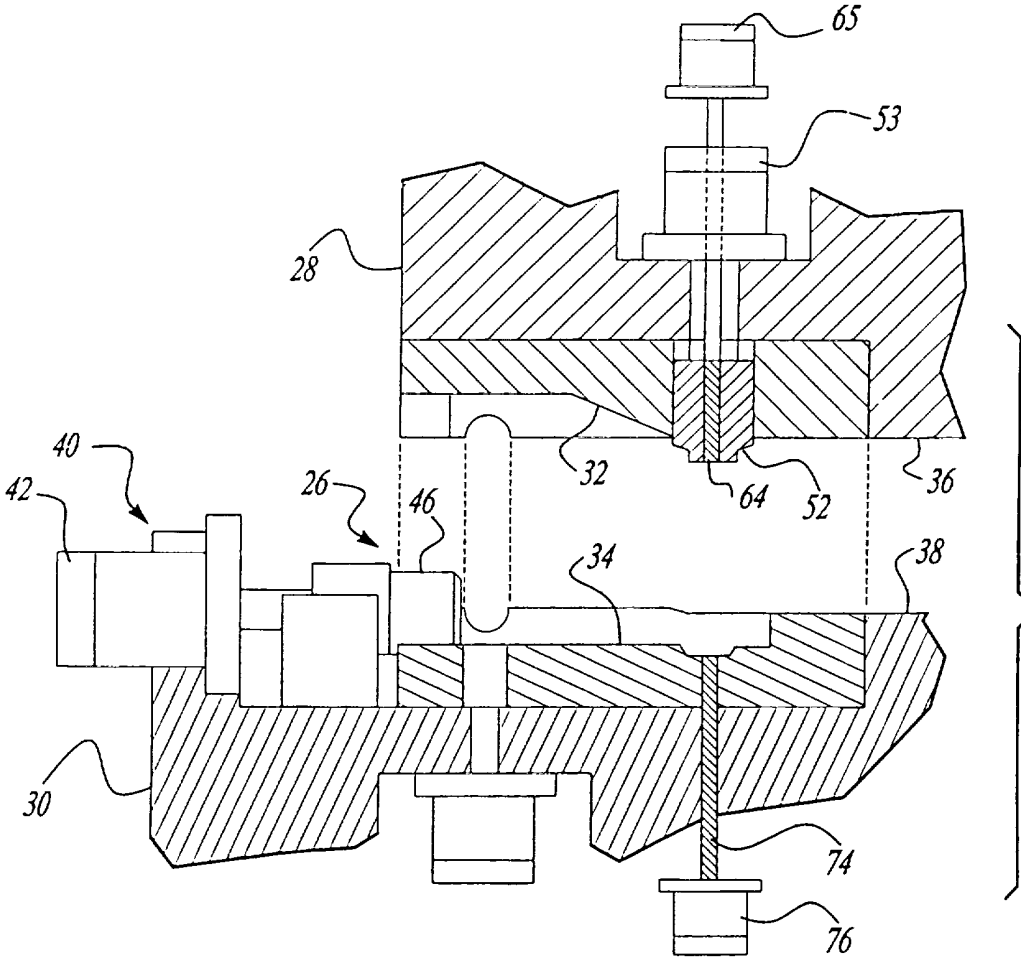

Fig-11

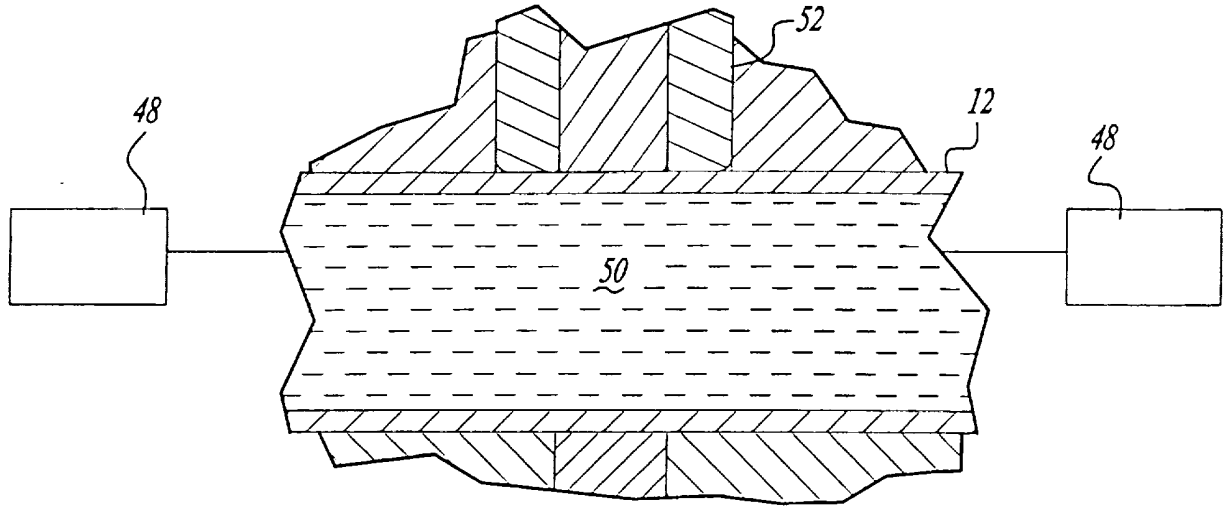

Fig-12

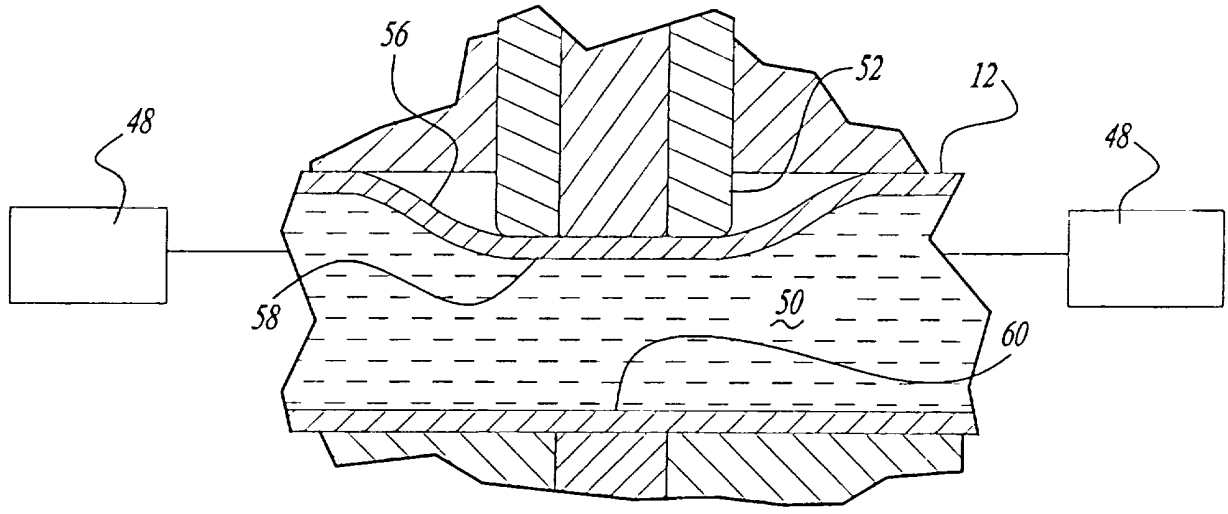

Fig-13

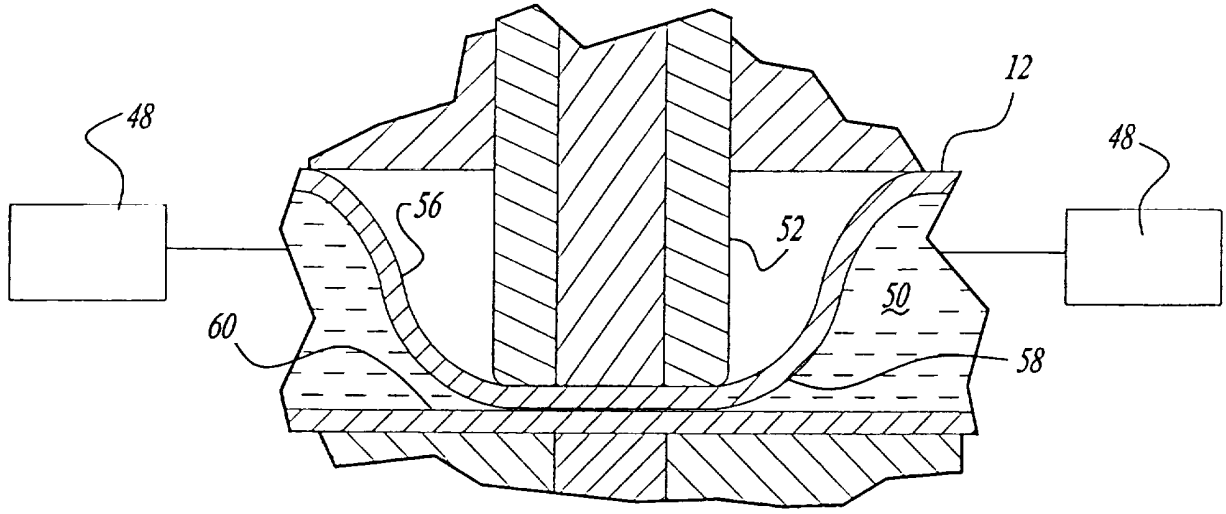

Fig-14

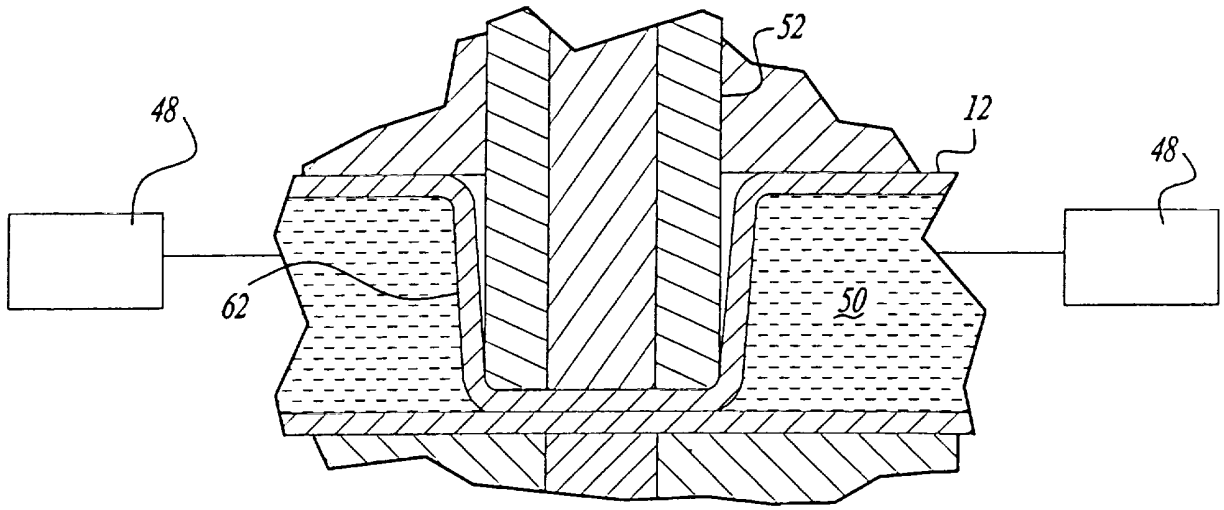

Fig-15

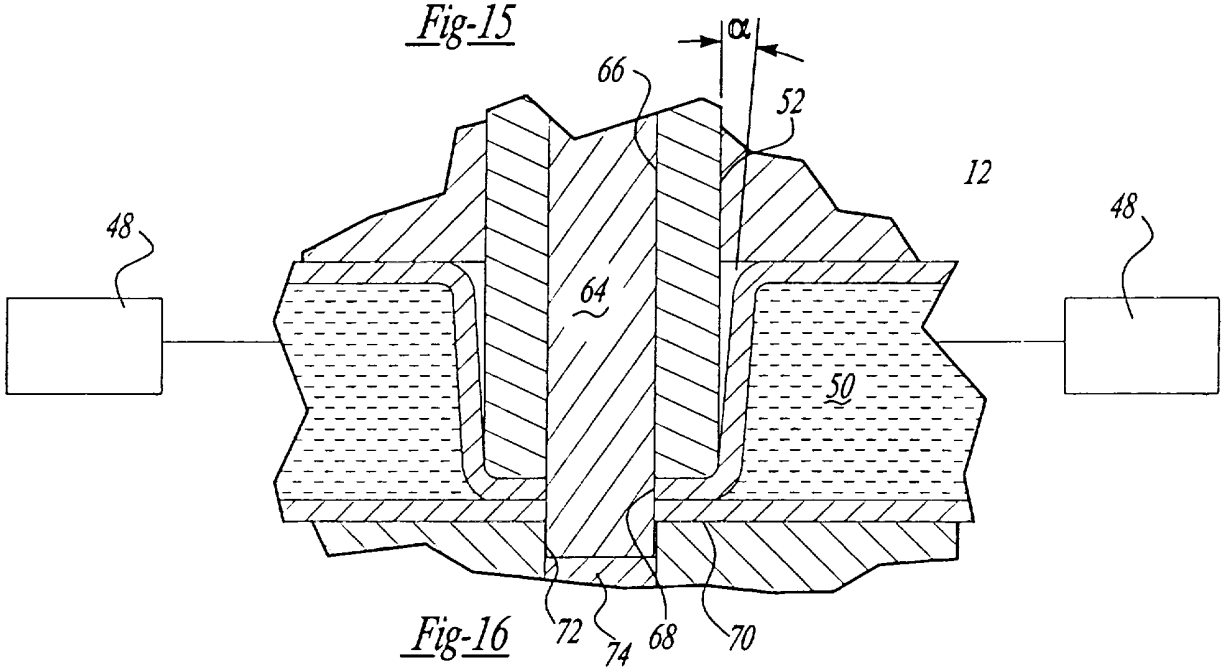

Fig-16

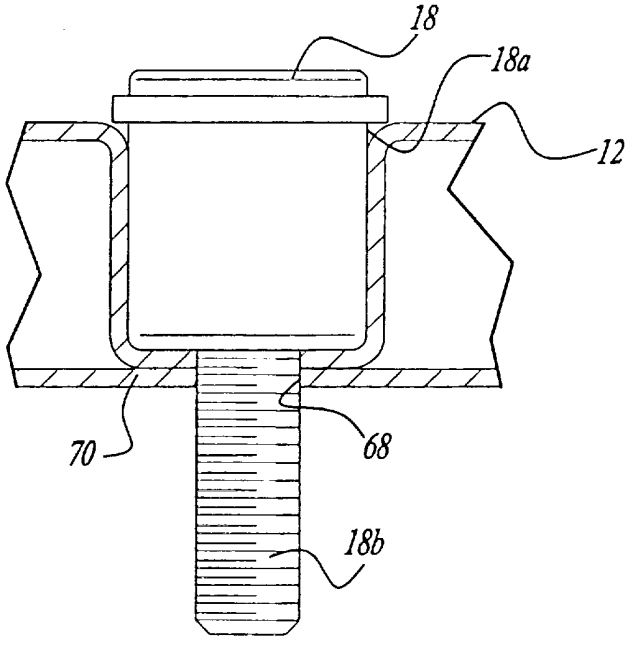

Fig-17

MULTI-PIECE HYDROFORMING TOOL

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a hydroforming tool and, more particularly, to a multi-piece hydroforming tool capable of independently forming multiple control arms during a single die cycle.

BACKGROUND AND SUMMARY OF THE INVENTION

Hydroforming tools are commonly used in the manufacture of structural members for various industries, such as the automotive industry, where strength, weight, and manufacturing productivity are design factors. Hydroforming is the method of expanding a continuous elongated tube to closely correspond to a cavity in a die. The continuous elongated tube is expanded by increasing the hydraulic pressure within the interior of the tube to force the walls of the tube outward. Consequently, hydroforming tools enable relatively complex structural members to be manufactured from a single, continuous elongated tube. This method

increases the structural integrity of the member being formed while, simultaneously, decreases the overall weight of the member.

Typically, hydroforming tools form one part per die cycle. A die cycle is complete each time the die is opened. This method of forming a single part per die cycle fails to achieve optimal productivity levels for industries with high manufacturing quotas, such as the automotive industry.

Consequently, hydroforming tools have attempted to produce multiple parts per die cycle. These multi-piece designs typically have only two injection cylinders. The injection cylinders inject hydraulic fluid into the hydroforming cavities to form the multiple pieces. However, if any defect occurs during the hydroforming process (*e.g.* parts splitting), then the process is stopped and all the parts are discarded. This method, consequently, fails to maximize production output and minimize production waste.

The present invention finds particular utility in the manufacture of vehicle control arms. Thus, a brief background of control arms as used in vehicle wheel suspension systems is believed to be beneficial. It should be appreciated that the multi-piece hydroforming machine according to the present invention may be used to form pieces other than control arms.

Control arms are commonly used in vehicle wheel suspension systems to provide a stable connection between multiple suspension components. A traditional control arm **100** is shown in FIG. 1, wherein control arm **100** is pivotally connected between the axle housing **102** and the vehicle chassis **104**. The pivot connection allows for vertical displacement of the axle and wheel assembly. Traditional control arm **100** further includes a ball joint **106** pivotally coupled to a steering knuckle **108**.

Still further, traditional control arm **100** includes at least one rubber bushing **110** connected to the ball joint **106**.

In operation, control arms must withstand extreme driving and braking torques created by the vehicle. To this end, it is necessary for control arms to be designed to maximize their structural integrity for improved tolerance of high vehicle loading forces caused by severe road damage, heavy braking, etc. It is also preferable for control arms to be designed to minimize the overall weight of the wheel suspension system.

As seen in FIG. 2, a cross-section of a typical control arm **112** is shown having a convoluted "hat-shaped" cross-section. Although the "hat-shaped" design is relatively simple to manufacture, it may not afford maximum structural integrity. Additionally, the hat-shaped design generally requires the use of bushing element **110** to properly receive ball joint **106**. Consequently, the "hat-shaped" design often fails to provide an optimal system.

Another typical control arm **114** is shown in FIG. 3 having a two-piece stamped construction, wherein the pieces **116**, **118** of the control arm are welded together. This design provides improved structural rigidity over the prior design shown in FIG. 2. However, like the prior design, the design shown in FIG. 3 requires the use of bushing element **110** to properly receive ball joint **106**. Moreover, this design fails to minimize the overall weight of the system.

Accordingly, there exists a need in the relevant art to provide a hydroforming machine capable of hydroforming multiple vehicle control arms simultaneously. Furthermore, there exists a need in the relevant art to provide a multi-piece hydroforming machine capable of forming each piece independently to

minimize production waste. Moreover, there exists a need in the relevant art to improve manufacturing methods to increase production, without compromising product reliability.

According to a preferred embodiment of the present invention, a multi-piece hydroforming tool for independently forming a plurality of hydroformed pieces is provided having a tooling die. The tooling die includes a plurality of tooling cavites disposed therein. The hydroforming tool further includes a hydraulic pressure source and a plurality of injector manifolds. Each injector manifold is in fluid communication with the hydraulic pressure source and the corresponding tooling cavity. This arrangement enables each hydroformed piece to be formed independently from the others. Consequently, multiple pieces may be formed simultaneously, without the need to scrap all the pieces if one piece become defective.

According to a more preferred embodiment of the present invention, the multi-piece hydroforming tool further includes a plurality of forming tools. The plurality of forming tools enables cavities to be formed in each hydroformed piece. Additionally, the multi-piece hydroforming tool includes a plurality of piercing tools. The piercing tools enable apertures to also be formed in each hydroformed piece. Still further, the multi-piece hydroforming tools includes a plurality of extruding tools for extruding a plurality of bores in each hydroformed piece.

Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood however that the detailed description and specific examples, while indicating preferred embodiments of the invention, are intended for purposes of illustration only, since

various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. 1 is a perspective view of a wheel suspension system according to a prior art method of assembly;

FIG. 2 is a partial cross-sectional view of a prior art vehicle control arm;

FIG. 3 is a partial cross-sectional view of another prior art vehicle control arm;

FIG. 4 is a perspective view of a hydroformed control arm;

FIG. 5 is a cross-sectional view of FIG. 4, taken along line 5-5;

FIG. 6 is a top plan view of an elongated S-shaped constant-radius tube which is used as starting material to make the control arms;

FIG. 7 is a top plan view of a plurality of U-shaped round tubes which have been cut from the tube of FIG. 6;

FIG. 8 is a front view of a multi-piece hydroforming tool;

FIG. 9 is a cross-sectional view of FIG. 8, taken along line 9-9;

FIG. 10a is an exploded view, with portions in cross-section, of the multi-piece hydroforming tool;

FIG. 10b is a cross-sectional view of FIG. 10a, taken along line 10b-10b;

FIG. 11 is an exploded cross-sectional view of the multi-piece hydroforming tool in an opened position;

FIGS. 12-16 illustrate progressive steps in forming the ball joint cavity in the control arm; and

FIG. 17 is a cross-sectional view of the hydroformed control arm having a ball joint disposed in the ball joint cavity of the control arm.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following description of the preferred embodiment is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. For example, the techniques disclosed herein may have utility in forming a wide variety of different parts.

Referring to the drawings, a hydroformed vehicle control arm **10**, and a method of making the same, is provided having a generally U-shaped member **12**. U-shaped member **12** is hydroformed from a single, constant-radius circular tube. As best seen in FIG. 4, hydroformed control arm **10** further includes a pair of pivot bores **14**. Pivot bores **14** are disposed on each end of generally U-shaped member **12** to enable hydroformed control arm **10** to pivot about an axis "A". Hydroformed control arm **10** further includes a ball joint cavity **16**. Ball joint cavity **16** is generally located at an apex of U-shaped member **12**. As will be described, ball joint cavity **16** provides means for retaining a ball joint **18** (FIG. 17) therein, without the need of the additional bushing element **110**. Ball joint **18** includes a base portion **18a** and a threaded portion **18b** to fixedly interconnect hydroformed control arm **10** with steering knuckle **108**.

As can be appreciated from FIGS. 4 and 5, hydroformed control arm **10** is preferably formed with varying cross-sectional areas to provide optimal structural rigidity and performance. Furthermore, hydroformed control arm **10** is seamlessly constructed, thereby requiring no welding or stamping.

According to a preferred method of forming hydroformed control arm **10**, a straight tube having uniform wall thickness is first provided (not shown). By way of non-limiting example, the tube is approximately three (3) feet in length, two (2) inches in diameter, made of Steel 1008-1010 having a wall thickness of one-tenth (0.1) inch. More preferably, the tube is welded with scarfed weld seams. Generally straight tubes are readily available in the marketplace to facilitate mass production of hydroformed control arm **10**.

During manufacture, the generally straight tube is bent along its length to form a tube **20** having generally serpentine or S-shaped bends. Mandrels are preferably used during the bending process, if the combination of the tube wall thickness, tube material and bending radius is likely to cause wrinkling in S-shaped tube **20**. S-shaped tube **20** is then cut along a center line "B" to form a plurality of generally U-shaped tubes **22**, each tube having a constant radius "r", as seen in FIGS. 6 and 7.

Referring to FIG. 8 through 11, a multi-piece hydroforming tool **24** is shown having preferably four U-shaped cavities **26** disposed therein. As best seen in FIG. 8, multi-piece hydroforming tool **24** includes an upper die member **28** and a lower die member **30**. Upper die member **28** and lower die member **30** include opposed surfaces **32**, **34**, respectively. As best seen in FIG. 11, opposed surface **32** is disposed in a bottom portion **36** of upper die member **28**. Similarly, opposed

surface **34** is disposed in a top portion **38** of lower die member **30**. Opposed surfaces **32, 34** are aligned and spaced to define U-shaped cavity **26** when bottom portion **36** of upper die member **28** contacts top portion **38** of lower die member **30**.

Still referring to FIGS. 10a, 10b, and 11, multi-piece hydroforming tool **24** further includes an injector manifold **40** secured to each U-shaped cavity **26** using a plurality of pre-stretched fasteners **41**. Injector manifold **42** delivers pressurized hydraulic fluid to U-shaped cavity **26**. Specifically, injector manifold **40** includes an inlet port **42** and a fluid aperture **44** extending through a pair of fluid nozzles **46**. Fluid aperture **44** defines fluid communication means between inlet port **42** and generally U-shaped cavity **26**.

As best seen in FIG. 9, multi-piece hydroforming tool **24** still further includes a hydraulic pressure source **48** in fluid communication with inlet port **42**. Hydraulic pressure source **48** provides hydraulic fluid **50** under extreme pressure, typically in the range of 15,000 psi to 90,000 psi, to each inlet port **42**.

Turning to FIGS. 10a, 10b, and 11, multi-piece hydroforming tool **24** includes a plurality of forming tools **52** provided in upper die member **28** of multi-piece hydroforming tool **24**. Each U-shaped cavity **26** includes at least one forming tool **52** and corresponding forming cylinder **53** for forming ball joint cavity **16** in hydroformed control arm **10**.

Similarly, multi-piece hydroforming tool **24** further includes an extruding device **54** for extruding pivot bores **14** in hydroformed control arm **10**. Specifically, each extruding device **54** includes a pair of outer extruding tools **54a** preferably disposed orthogonal to the ends of U-shaped cavity **26**. Each outer extruding tool **54a** is operably connected to corresponding outer extruding cylinder

54b. In operation, outer extruding cylinder 54b drives outer extruding tool 54a into the sides of U-shaped tube 12, thereby forming an outer pivot bore depression. Similarly, each extruding device 54 further includes a pair of inner extruding tools 54c preferably disposed orthogonal to the ends of U-shaped cavity 26 and further disposed coaxially oriented relative to outer extruding tools 54a. Inner extruding tools 54c are operably connected to a single inner extruding cylinder 54d. In operation, inner pivot bore depressions are formed by retracting an inner extruding ram 54e using inner extruding cylinder 54d, thereby retracting inner extruding tools 54c. Internal hydraulic pressure within U-shaped tube 12 causes a pair of inner pivot bore depression to be formed. After hydroforming, pivot bores 14 are formed by preferably drilling through inner and outer pivot bore depressions. However, it is anticipated that pivot bores 14 may also be formed by cutting or boring depending on tolerance requirements.

During operation of multi-piece hydroforming tool 24, upper die member 28 is preferably moved from a closed position to an opened position. Generally U-shaped round tubes 22 are then placed in generally U-shaped cavities 26 of multi-piece hydroforming tool 24. Generally U-shaped round tubes 22 are oriented such that the ends of generally U-shaped round tube 22 extend outward from U-shaped cavities 26. Upper die member 28 is then moved to a closed position. A closed position is defined as the point when bottom portion 36 of upper die member 28 contacts top portion 38 of lower die member 30. Injector manifolds 42 are then positioned to deliver pressurized hydraulic fluid 50 to U-shaped cavities 26. Specifically, injector manifolds 42 are retained in multi-piece hydroforming tool 24 using a plurality of pre-scretched fasteners (not shown). The pre-scretched fasteners

are preferably attached to lower die member **30**, thereby offsetting the hydroforming fluid pressure. A pair of fluid nozzles **46** of injector manifold **42** are in fluid communication with the opened ends of generally U-shaped round tube **22**, thereby creating a fluid seal between fluid nozzle **46** and the ends of U-shaped round tube **22**.

Referring to FIG. 9, hydraulic pressure source **48** forces hydraulic fluid **50** into an interior volume of generally U-shaped round tube **22** such that U-shaped round tube **22** expands to closely conform to the shape of opposed surfaces **32**, **34** of U-shaped cavity **26**. This technique is known as hydroforming.

Referring to FIGS. 12 through 16, a method of forming ball joint cavity **16** in hydroformed control arm **10** is provided. As seen in FIG. 11 and as noted above, hydraulic pressure source **48** provides hydraulic fluid **50** at extreme pressure so as to expand U-shaped round tube **22** to conform with opposed surfaces **32**, **34** of multi-piece hydroforming tool **24**. As best seen in FIG. 13, forming tool **52** extends from opposed surface **32** of upper die member **28** and applies pressure to form a generally sloping depression **56** in hydroformed control arm **10**. This step allows uniform stretching of the material of hydroformed control arm **10**. The uniform stretching of the material minimizes possible stress fractures formed during manufacture. Forming tool **52** continues to form sloping depression **56** until a first interior wall **58** of hydroformed control arm **10** contacts an opposing second interior wall **60**. The contact prevents further movement of forming tool **52**.

As best seen in FIG. 15, once forming tool **52** has completely formed sloping depression **56**, the pressure of hydraulic fluid **50** is increased to force the walls of the tube defining sloping depression **56** to generally conform to the shape of forming tool **52**. Generally vertical walls **62** of ball joint cavity **16** are thereby

formed. As can be appreciated from FIG. 15, generally vertical wall **62** include a draft angle "α" to allow for improved tooling of hydroformed control arm **10**.

Without intending to be limited by example, a draft angle of approximately three to four degrees (3-4°) from vertical has been found to be sufficient.

Referring to FIGS. 11-16, a piercing tool **64** is shown as being slidably received within a bore **66** of each forming tool **52**. Piercing tool **64** is further shown operably connected to a mechanical device or piercing cylinder **65**. Piercing tool **64** creates an aperture **68** in a bottom portion **70** of ball joint cavity **16**. Specifically, piercing cylinder **65** forces piercing tool **64** through first interior wall **58** and second interior wall **60** while forming tool **52** remains in ball joint cavity **16**. During the piercing process, piercing tool **64** is received within a corresponding receiving chamber **72** of lower die member **30**. Receiving chamber **72** is created by retracting a receiving tool **74** using a receiving tool cylinder **76**. This method enables opposed surface **34** to remain flat during hydroforming of U-shaped member **12**, yet accommodate an end of piercing tool **64** during the piercing operation. A completed hydroformed control arm **10** is then removed from generally U-shaped cavity **26** of multi-piece hydroforming tool **24**.

Referring to FIG. 17, ball joint **18** is shown disposed in ball joint cavity **16** of hydroformed control arm **10**. Preferably, the outer diameter of ball joint **18** is greater than the inner diameter of ball joint cavity **16**, thereby creating a press fit connection between ball joint **18** and ball joint cavity **16**. The press fit connection eliminates the need to provide the additional bushing element **110** disposed between

hydroformed control arm **10** and the ball joint **18** of the prior art constructions discussed above.

It should be appreciated that the multi-piece hydroforming tool of the present invention enables multiple control arms to be hydroformed simultaneously. However, unlike the prior art method, the present invention hydroforms multiple control arms independently in a single die. This method of hydroforming minimizes the need to discard all of the hydroformed control arms if one hydroformed control arm is found to be defective. Furthermore, it should be appreciated that unlike the prior art methods of making a control arm, the present inventions provides a continuous, unitary hydroformed control arm. The unitary construction of the control arm is believed to improve the structural integrity of the control arm, thereby providing a more optimal design.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

CLAIMS

1. A multi-piece hydroforming tool for independently forming a plurality of control arms, said multi-piece hydroforming tool comprising:

a tooling die;

a plurality of tooling cavities disposed in said tooling die;

a hydraulic pressure source for supplying a pressurized hydraulic fluid; and

a plurality of injector manifolds in fluid communication with said hydraulic pressure source and said plurality of tooling cavities, each of said plurality of injector manifolds communicating said pressurized hydraulic fluid to said corresponding tooling cavity.

2. The multi-piece hydroforming tool according to Claim 1 wherein said tooling die comprises:

an upper die member having a top portion and a bottom portion;

a lower die member having a top portion and a bottom portion, at least one of said die members being vertically movable relative to the other of said die members;

a plurality of upper contoured surfaces disposed in said bottom portion of said upper die member; and

a plurality of lower contoured surfaces disposed in said top portion of said lower die member, said plurality of lower contoured surfaces being aligned and spaced adjacent to said plurality of upper contoured surfaces, thereby defining said plurality of tooling cavities.

3. The multi-piece hydroforming tool according to Claim 2, further comprising:

a plurality of forming tools for forming a ball joint cavity in each of the plurality of control arms, said plurality of forming tools disposed in at least one of said die members.

4. The multi-piece hydroforming tool according to Claim 3, further comprising a plurality of piercing tools for piercing an aperture through each of said ball joint cavities, said plurality of piercing tools being disposed within said plurality of forming tools.

5. The multi-piece hydroforming tool according to Claim 2, further comprising:

a plurality of extruding tools for extruding pivot bores in the plurality of control arms, said plurality of extruding tools being disposed in at least one of said die members.

6. The multi-piece hydroforming tool according to Claim 1, wherein each of said plurality of injector manifolds includes:

an inlet port for receiving said pressurized hydraulic fluid from said hydraulic pressure source, said inlet port disposed on a first end of said injector manifold;

a fluid nozzle for delivering said pressurized hydraulic fluid into said corresponding tooling cavity, said fluid nozzle disposed on a second end of said injector manifold; and

an aperture being in fluid communication with said inlet port and said fluid nozzle, said aperture completing a fluid circuit extending between said hydraulic pressure source and said corresponding tooling cavity.

7. A multi-piece hydroforming die for forming a member, said multi-piece hydroforming tool comprising:

a pair of die members, at least one of said pair of die members being vertically movable relative to the other of said pair of die members;

a plurality of contoured surfaces disposed in said pair of die members, said plurality of contoured surfaces being aligned and spaced to define a plurality of hydroforming cavities;

a hydraulic pressure source for supplying a pressurized hydraulic fluid; and

a plurality of injector manifolds in fluid communication with said hydraulic pressure source and said plurality of hydroforming cavities, said plurality of injector manifolds communicating said pressurized hydraulic fluid to said plurality of hydroforming cavities.

8. The multi-piece hydroforming die according to Claim 7, wherein each of said plurality of injector manifolds includes:

an inlet port for receiving said pressurized hydraulic fluid from said hydraulic pressure source, said inlet port disposed on a first end of said injector manifold;

a fluid nozzle for delivering said pressurized hydraulic fluid into said hydroforming cavity, said fluid nozzle disposed on a second end of said injector manifold; and

an aperture being in fluid communication with said inlet port and said fluid nozzle, said aperture completing the fluid circuit extending between said hydraulic pressure source and said hydroforming cavity.

9. The multi-piece hydroforming die according to Claim 7, further comprising:

a plurality of forming tools for forming a cavity in the member, said plurality of forming tools disposed in at least one of said pair of die members;

a plurality of piercing tools disposed within said plurality of forming tools for piercing an aperture through the member; and

a plurality of extruding tools for extruding the member, said plurality of extruding tools being disposed in at least one of said pair of die members.

10. A hydroforming tool for independently forming a plurality of pieces, said hydroforming tool comprising:

a die;

a plurality of cavities disposed in said die;

a hydraulic pressure source for supplying a pressurized hydraulic fluid;

a plurality of injector manifolds in fluid communication with said hydraulic pressure source and said plurality of cavities, each of said plurality of injector manifolds communicating said pressurized hydraulic fluid to said corresponding cavity; and

a plurality of forming tools for forming a depression in each of the pieces, said plurality of forming tools disposed in said die.

11. The hydroforming tool according to Claim 10, further comprising a plurality of piercing tools for piercing an aperture through each of said depressions, said plurality of piercing tools being disposed within said plurality of forming tools.

12. The hydroforming tool according to Claim 10, further comprising:

a plurality of extruding tools for extruding pivot bores in each of the plurality of pieces, said plurality of extruding tools being disposed in said die.

13. The hydroforming tool according to Claim 11 wherein said die further comprises:

an upper die member having a plurality of contoured surfaces; and

a lower die member having a plurality of contoured surfaces, said plurality of contoured surfaces of said upper and lower die members defining a plurality of tooling cavities.

14. The hydroforming tool according to Claim 13, wherein each of said plurality of injector manifolds include:

an inlet port for receiving said pressurized hydraulic fluid from said hydraulic pressure source, said inlet port disposed on a first end of said injector manifold;

a fluid nozzle for delivering said pressurized hydraulic fluid into said corresponding cavity, said fluid nozzle disposed on a second end of said injector manifold; and

an aperture being in fluid communication with said inlet port and said fluid nozzle, said aperture completing a fluid circuit extending between said hydraulic pressure source and said corresponding cavity.

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Application No: GB 9906284.6 **Examiner:** A.R.Martin
Claims searched: All claims **Date of search:** 29 April 1999

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): B3Q

Int Cl (Ed.6): B21D 26/00

Other: On line databases WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 2304613 A	Rolls-Royce see Figure 1	Claims 1,7 and 10 at least
Y	US 5363544 A	Benteler see column 4 lines 45-55	"
Y	US 5799524 A	Schafer see claim 1 and column 1 lines 30-40	"
Y	US 5662349 A	Honda see column 3 line 50 -column 4 line 30	"
Y	US 5641176 A	Mascotech see claim 1	"
Y	US 5673929 A	Mascotech see claim 1	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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