Dec. 29, 1970 W. A. SWANSON 3,550,420

METAL-FORMING SYSTEM

Filed Nov. 13, 1967 2 Sheets-Sheet 1

FIG. 1

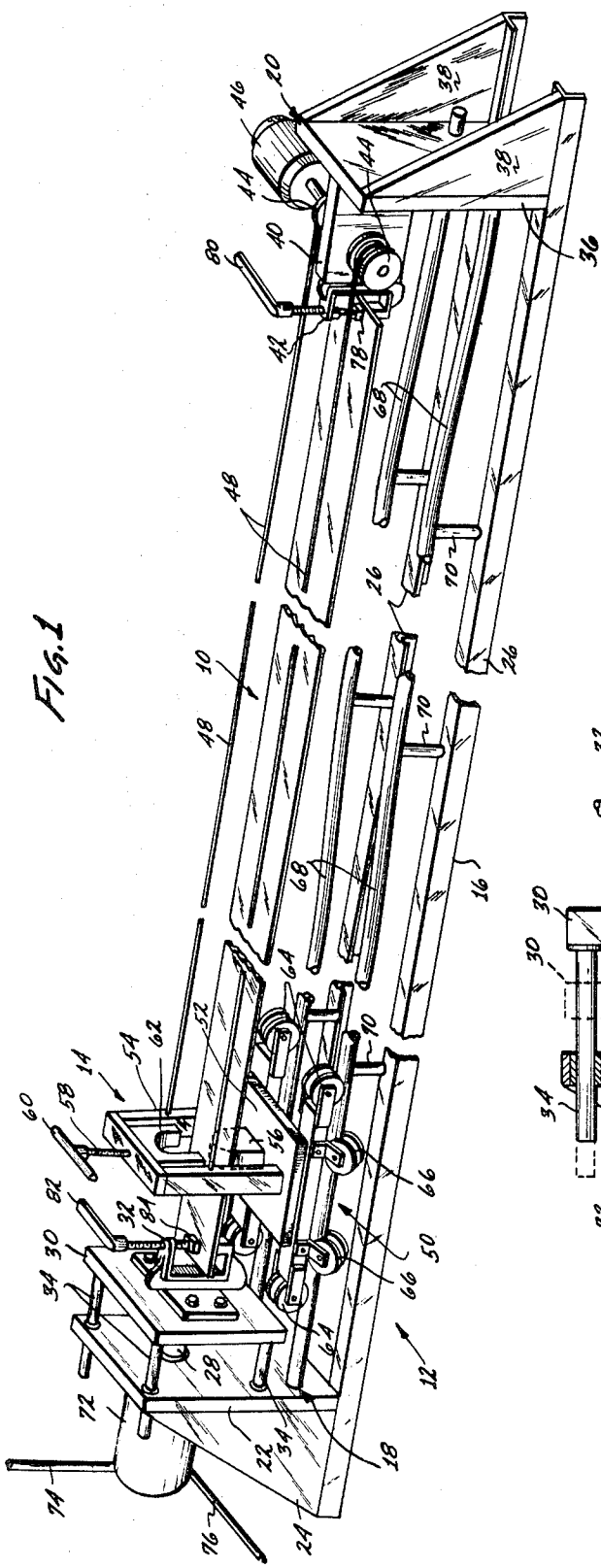
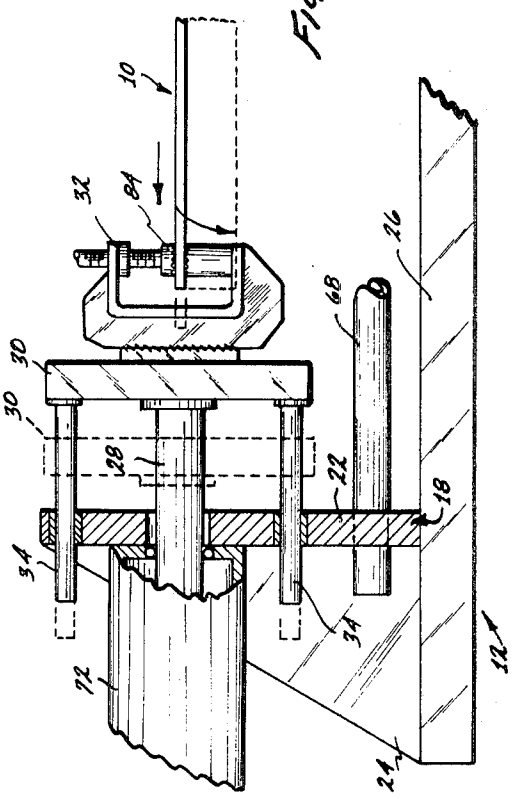


FIG. 2



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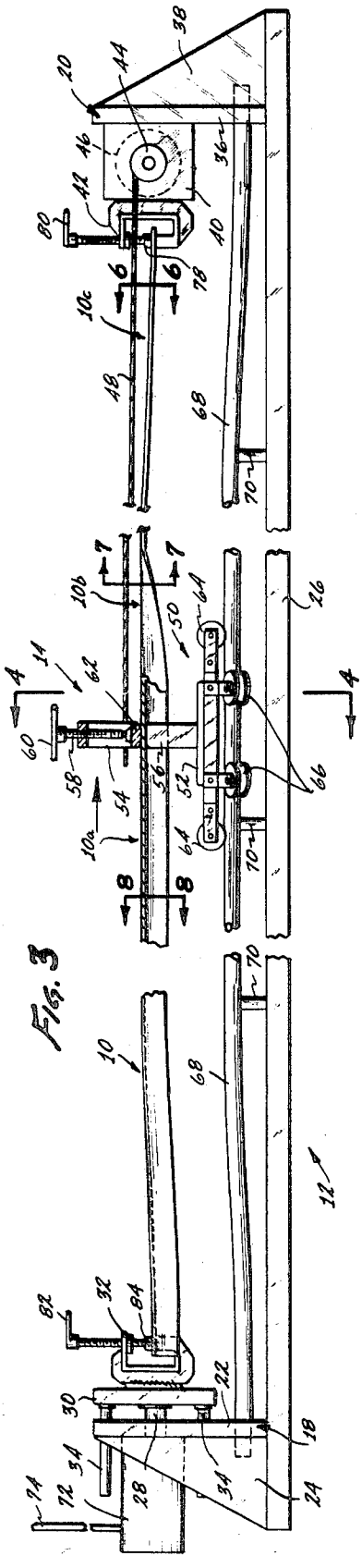


FIG. 3

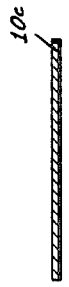


FIG. 6



FIG. 7

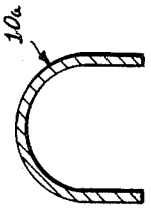


FIG. 8

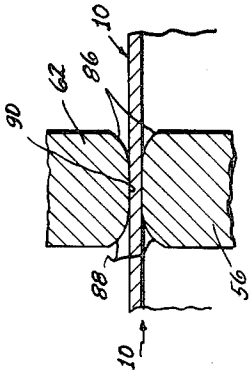


FIG. 5

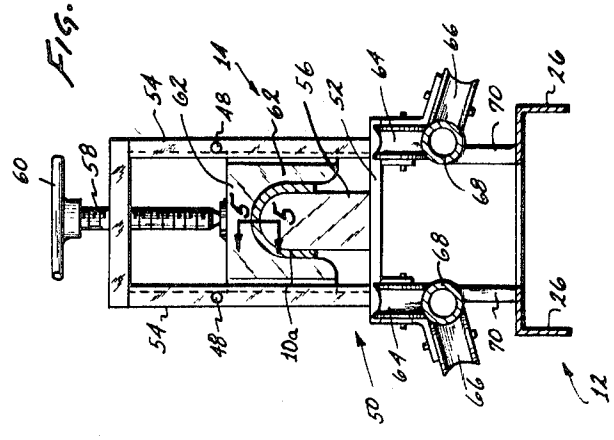


FIG. 4

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METAL-FORMING SYSTEM

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Int. Cl. B21d 11/02
U.S. Cl. 72—296 3 Claims

ABSTRACT OF THE DISCLOSURE

A system is disclosed for forming various metal shapes, utilizing prestressing techniques. In the illustrative example of the disclosure, a section of sheet metal is formed into a U-shaped channel, which also has a substantial variation or deviation along the length of the channel. The structure includes means for straining the section of sheet metal along an axis to resiliently elongate the sheet of metal. A two-dimentional mechanical forming die then traverses the length of sheet metal, generally along the path of strain, whereby to shape the metal to the desired configuration. Subsequent to the shaping operation, as disclosed, the stressing forces are relieved with the result that the sheet is formed in the desired three-dimensional shape.

BACKGROUND AND SUMMARY OF THE INVENTION

Metal-working machines and techniques represent a highly-developed art capable of accommodating the use of mass-production methods for many different products. However, generally, conventional metal-working machines are massive, are extremely expensive and require tremendous operating power. For example, different types of metal-working machines of large-part capability, conventionally either incorporate apparatus for heating a workpiece or alternatively they utilize huge presses capable of exerting immense distorting forces. As a result, machines of either type require considerable energy and are very expensive to operate. Therefore, a substantial need exists for a relatively-simple, economical system for providing certain sizable metal shapes without great initial expenditures for dies, heavy equipment and so on and operable at a relatively low cost.

In utilizing conventional metal-shaping techniques, considerable difficulty may be experienced in attempting to form thin sheet metal of particular types, e.g., stainless steel. For example, in working with very thin metals, large forming dies frequently tend to create wrinkles and other defects. Therefore, a considerable need exists for a metal-shaping system capable of forming thin sheets of metal into various shapes without material defects.

In general, the present invention resides in the discovery that metal can be effectively formed by applying stress which coincide with the path of a two-dimensional forming die (e.g., extrusion type) that is moved along the metal workpiece. More specifically, the present invention involves structure for straining a section of sheet metal (as long a particular path) operative with means for progressively deforming the sheet metal, including a two-dimensional die and means for moving the die through a path (not necessarily linear) to define the desired shape and which path is maintained coincident with the stressing force path straining the workpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawing, which constitutes a part of this specification, an exemplary embodiment demonstrating various objectives and features hereof is set forth, specifically:

FIG. 1 is a perspective view of an apparatus constructed in accordance with the present invention;

FIG. 2 is a sectional and diagrammatic view of a portion of the structure of FIG. 1 illustrating the operation of such structure;

FIG. 3 is a front elevation view of the apparatus of FIG. 1;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 3;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 4;

FIG. 6 is a sectional view taken along line 6—6 of FIG. 3;

FIG. 7 is a sectional view taken along line 7—7 of FIG. 3;

FIG. 8 is a sectional view taken along line 8—8 of FIG. 3.

DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENT

As required, a detailed illustrative embodiment of the invention is disclosed herein. However, it is to be understood that the embodiment merely exemplifies the invention which may be embodied in many forms that are radically different from the illustrative embodiment. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims defining the scope of the invention.

Referring initially to FIG. 1, there is shown an elongate sheet metal workpiece **10** which is strained by stress forces, as it is held in a supporting structure **12**. While in a strained configuration, the workpiece **10** is shaped by a two-dimensional die **14** which traverses the length of the workpiece. Thus, the structure of FIG. 1 illustrates the process hereof with respect to the formation of an elongate channel member which is offset along the length thereof, i.e., the path of the die mechanism **14** is not linear. In this regard, as will be explained in detail below, it is important to recognize that as the die mechanism **14** does not traverse a linear path, the workpiece is formed in three dimensions.

Considering the structure of FIG. 1 in somewhat greater detail, the stressing apparatus or structure **12** includes an elongate support frame **16** supporting opposed upright end brackets **18** and **20**. The bracket **18** includes a face plate **22** which is back-supported by reinforcing abutments **24**, that are attached to the elongate base beams **26**.

The head-end face plate **22** contains a central aperture or bore which receives a force column or shaft **28** for driving a head structure **30** which carries a clamp **32**. The head structure **30** also includes readwardly-extending, horizontal guide posts **34** which are matingly received through corner-disposed bores in the face plate **22**.

At the opposite end (tail end) of the supporting structure **12**, the bracket **20** provides a vertical face plate **36** supported by corner abutments **38**. The face plate **36**, in turn, supports a perpendicularly mounted beam **40**, which, in turn, supports a clamp **42** and a pair of cable spools **44** connected to be rotated by a motor **46**. The motor **46** acts through the spools **44** and parallel horizontal cables **48** to traverse the forming mechanism **14** along the workpiece **10**. In this regard, the motor **46** may comprise a unit of relatively low horsepower incorporating a speed-reducing gear chain and a relatively low overload circuit breaker.

The movement of the shaping mechanism **14** along the workpiece **10** is facilitated by a supporting carriage **50**. Specifically, the carriage **50** (shown at the head end) includes a platform **52** supporting an upright yoke **54** and a male two-dimensional forming die **56**. The yoke **54** threadably receives a screw **58** that is topped by a handle **60**, and which screw supports a female two-dimensional

forming die **62** for matingly engaging the workpiece **10** over the die **56**.

The platform **52** of the carriage **50** (bearing the die structure) is supported on vertical rollers **64** and outboard horizontal rollers **66**, both of which engage rails **68** defining a track along the length of the structure **12**. The rails **68** are supportably affixed into the face plates **22** and **36** and additionally are supported by vertical posts **70** (of varying height) mounted under the rails along the length of the track and extending to the horizontal base beams **26**.

Recapitulating, it may now be seen that the structure as shown in FIG. 1 functions to hold the workpiece **10** in a strained state, while mating dies **56** and **62** are traversed along the length of the workpiece **10**. Of course, a wide variety of different structures may be provided to accomplish these operations. However, the exemplary forming machine set forth herein has been found to function effectively and may be constructed at a relatively low cost. In this regard, the structure may be made of steel, and may incorporate a hydraulic jack **72** with a manual actuator **74** to withdraw the load shaft **28** and apply the stressing force to the workpiece **10**. A hydraulic input line **76** is indicated for supplying hydraulic fluid from a reservoir to the jack **72**. Somewhat in this regard, it is to be noted that the stress to the workpiece **10** is applied centrally thereof, coinciding substantially to the central section which will undergo the greater distortion during the forming operation.

Just as the machine hereof may be provided in a wide variety of different forms, it may be adapted to shape workpieces into a wide variety of different forms. As indicated above, the embodiment disclosed herein functions to develop an elongate channel member which is nonlinear along its length. Specifically, the workpiece **10** may comprise thin stainless steel and may be formed as the leading edge of an airfoil.

Pursuing the exemplary structure of FIG. 1 to accomplish the exemplary workpiece **10**, a complete understanding of the system may now best be perfected by considering the sequence of a cycle of operation. The initial operation involves loading the workpiece **10** into the structure as shown in FIG. 1. In this regard, the handle **60** is turned to raise the female die **64** (as shown) so that the workpiece **10** may be passed between the dies **56** and **62**, i.e., through the yoke **54**. The ends of the workpiece **10** next are engaged by the clamps **32** and **42** at the head end and tail-end respectively of the machine. Specifically, the tail-end (right, as shown) of the workpiece **10** is fitted into the jaws **78** of the clamp **42** and the handle **80** of the clamp is turned so that the jaws **78** firmly grasp the workpiece **10**. At the opposite end (head) the workpiece **10** is set in the clamp **32** so that the jaws **84** lockingly engage the workpiece while the load shaft **28** is inward.

Next, the hydraulic jack **72** is manually driven, through the actuator **74**, to withdraw the load shaft **28**, moving the head structure **30** to a position as indicated in phantom in FIG. 2. As a result, the workpiece **10** is strained along a path extending between the clamps **32** and **42**, which strain path is distorted to a nonlinear form during the actual shaping of the workpiece **10**.

The degree to which the workpiece **10** is strained varies widely depending upon the material in the workpiece and the nature of the shaping operation. However, in general it has been found desirable to strain the workpiece substantially to the threshold of its elastic limit.

The next step in the process involves the initial deformation of the workpiece **10** between the dies **56** and **62** (FIG. 4). This deformation is accomplished by carefully turning the handle **60** to drive the screw **58** downward so that it carries the die **62** into mating engagement with the die **56**, with the workpiece **10** therebetween. In this regard, it is to be noted that the dies **62** and **56** are completely closed on the workpiece **10** (FIG. 5). However, both the leading edges **86** and the trailing edges **88** of the mating die surfaces are somewhat relieved to afford a tapered guiding structure into the closed, two-dimensional die passage **90**.

With the dies **56** and **62** closed on the workpiece **10** (FIG. 4) the system next is actuated to form the entire length of the workpiece **10**. Specifically, the motor **46** (shown in phantom, FIG. 3) is energized, causing the spools **44** to take up or draw in the cables **48**, thereby pulling the carriage **50** along the rails **68**. As a result, the workpiece **10** is scanned along its length, one section at a time, traversing it through the mated dies **56** and **62**. Thus, the desired shape is accomplished.

It is to be noted, that the rails **68** are offset from the horizontal and therefore extend in two dimensions. Of course, one of those dimensions is parallel to the two-dimensional passage **90** (FIG. 5) of the forming die; while the other dimension is perpendicular thereto (up and down). The result of the two dimensional aspect of the rails **68** is the fact that the structure hereof (although using a two dimensional forming die) may readily form workpieces in three dimensions. Specifically, the workpiece **10** is not only deformed to provide a U-channel but furthermore is also formed to include a very shallow U-shape along its length.

Considering the formative operation in greater detail, as the carriage **50** traverses the rails **68** (FIG. 3), an initial workpiece section **10***a* is first completely formed, as indicated in FIG. 8. The following workpiece section **10***b*, which lies immediately before the die forming passage **90**, is slightly tapered as indicated in FIG. 7, as it is guiding into the dies. Well ahead of the dies, the workpiece section **10***c* is substantially unaffected as shown in FIG. 6.

As the carriage **50** traverses the full length of the workpiece **10**, the workpiece is formed to the desired configuration. As the carriage **50** encounters the rise and drop in the rails **68**, such a rise and drop are incorporated in the shape of the workpiece **10**, as indicated above. However, it is important to recognize that the path of strain through the workpiece **10** is essentially coincident with the instantaneous forming position of the dies **56** and **62**.

On traversing the workpiece **10** (completing the forming operation), the drive motor **46** (FIG. 3) may be cut off automatically by any of a variety of switching structures or simply by allowing the carriage **50** to reach the end of the rails **68** at which the motor **46** becomes overloaded and automatically cuts off.

At the conclusion of the forming operation the hydraulic jack **72** is relieved, thereby allowing the head **30** to be moved inwardly by the elastic force of the workpiece **10**. Thereafter, the workpiece **10** is removed simply by releasing the clamps **32** and **42** and the mating dies **56** and **62**.

Subsequently, the workpiece **10** may be trimmed at its sides and ends, to formulate the desired member. However, obviously, such finish process steps will depend entirely upon the specific nature of the workpiece **10** and its contemplated application.

From a consideration of the above, it may be seen that the structure hereof may be employed, utilizing the process hereof to accomplish three-dimensional metal shapes with relatively inexpensive tooling and equipment. Furthermore, considerable experience and experimentation with the subject hereof has indicated that workpieces may be formed to exceedingly high standards. In this regard, the system hereof is capable of completing high-tolerance jobs both with regard to specified shapes and with regard to defects.

Of course, as indicated above, the system hereof may be readily adapted to provide a wide variety of different shapes and may be incorporated in a wide variety of different machines; therefore, the system as disclosed herein is to be deemed merely an exemplary embodiment and the scope hereof shall not be restricted accordingly but

rather shall be interpreted in accordance with the claims set forth below:

What is claimed is:

1. A process of forming a substantially uniform thickness, elongated sheet of nonductile metal, as stainless steel, comprising the steps of:

straining said elongated sheet of metal along the length thereof, to the threshold of its elastic limit thereof to thereby resiliently elongate said sheet of metal;

matingly engaging a two dimensional forming die to said sheet of metal to deform a portion of said sheet transversely to the length thereof and thereby shape a section of said sheet;

traveling said two dimensional forming dies along the length of said sheet of metal to transversely deform said sheet along its length; and

relieving said sheet of metal from strain.

2. A process according to claim 1, further including the step of directing said forming die to travel along a nonlinear path whereby to distort said sheet of metal along the length thereof.

3. A metal-forming apparatus for distortedly shaping a section of uniform thickness sheet metal having nonductile characteristics, as stainless steel, to form a predetermined form, comprising:

stress means for straining said section of sheet metal along a path lying substantially along the length thereof to the threshold of the elastic limit;

distortion die means for engaging said sheet metal to distort a segment thereof, transversely to the length of said sheet, which distortion die extends to shape said sheet along two dimensions that are transverse to said path of strain; and

means for moving said distortion die means in relation to said section of sheet metal along a nonlinear path whereby to progressively distort said section of sheet metal transversely and along the length thereof to provide a predetermined form.

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U.S. Cl. X.R.

72—305