

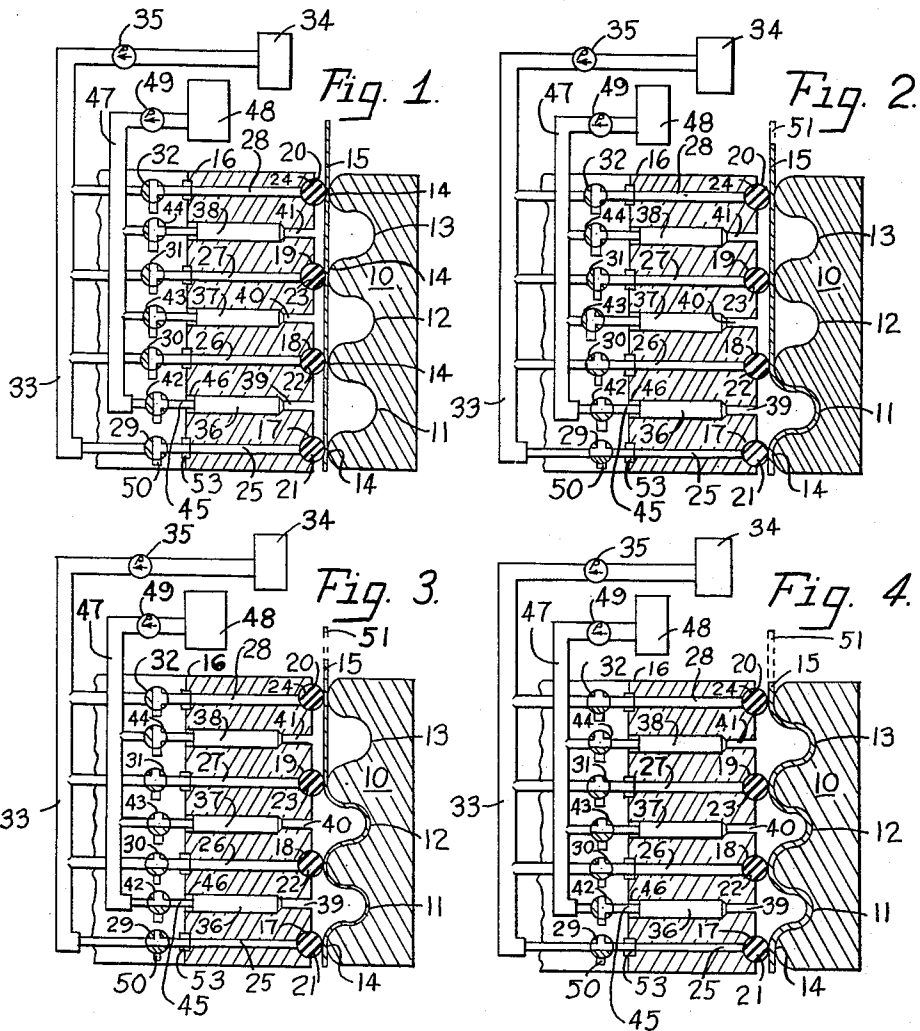
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HYDROFOLDING OF METAL

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HYDROFOLDING OF METAL

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4 Claims. (Cl. 153—73)

This invention relates to a method and apparatus for producing grooves in thin metal sheets and is particularly directed to producing grooves in stainless steel or titanium metals.

In the hydro-forming processes for producing grooves in thin metal sheets the metal is stretched into the grooves. If this stretching exceeds the elongation characteristics of the metal, serious structural deficiencies result. This is particularly true in the formation of generally tubular insulating structures for airplanes where the inner skins must have deep circumferential grooves which can withstand relatively large collapsing forces. For other reasons, these structures must often be made of titanium, which has relatively little elongation characteristics. Thus, the usual hydro-forming methods for forming grooves would result in serious structural deficiencies.

It is a primary object of this invention to provide a simple and effective method and apparatus for forming grooves in metal, and particularly in situations where substantial elongation of the metal in the groove-forming operation is undesirable.

This invention provides apparatus for the hydro-folding of metal in which the grooves are essentially drawn into the metal. A die having internal circumferential grooves is adapted to receive a plug having openings adjacent to the grooves. A plurality of rubber sealing rings are positioned in the plug to coincide with the lands between the grooves in the die. Hydraulic fluid is forced through the openings to annular grooves in the plug between the sealing rings to force the metal into the grooves. The grooves are formed in sequence working away from the first groove toward the end of the metal so that there is no stretching of the metal. The axial length of the metal is shortened by the drawing of the metal into the grooves. The resultant grooved metal has no induced structural deficiencies in the grooved portions.

The invention will be more fully understood and further objects and advantages thereof will become apparent when reference is made to the following detailed description of a preferred embodiment of the invention and the accompanying drawings in which:

Figs. 1-4 are schematic representations in cross section of an apparatus for the hydro-folding of metal; and

Fig. 5 is a rotated bottom plan view of the apparatus of Figs. 1-4.

In Figs. 1-4, there is illustrated an apparatus for the hydro-folding of grooves in thin metal sheets. A cylindrical die 10, having a plurality of grooves 11, 12 and 13 with corresponding lands 14 formed in the inner surface thereof, is adapted to receive the metal sheet 15 in which the grooves are to be formed. The die 10 is made in two sections which are detachably secured together in any convenient manner. As illustrated in Fig. 5, the die 10 is made in two semi-circular sections having longitudinal edge flanges 46. The sections are joined in operative relation by nuts 47 and bolts 48 passing through openings in the flanges.

A circular plug 16 fits within the die 10 so that the metal

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sheet 15 may be received between the plug 16 and the die 10 and is so designed to provide for minimum tolerances between the die, the metal and the plug. The plug 16 has a plurality of circumferential, annular grooves 17, 18, 19 and 20 which receive the rubber sealing rings 21, 22, 23 and 24, respectively, so that each of the rings 21, 22, 23 and 24 contacts the metal sheet 15 adjacent one of the lands 14. Under normal conditions the rings 21, 22, 23 and 24 allow the metal 15 to have a relative sliding movement to the plug 16 and the die 10. The grooves 17, 18, 19 and 20 are connected respectively by passages 25, 26, 27 and 28 to a source of hydraulic fluid, the pressure of which with regard to the passages and grooves, is controlled respectively by two-position valves 29, 30, 31 and 32 which are connected to the passages 25, 26, 27 and 28 by suitable fittings 53. This allows hydraulic fluid to be pumped selectively into the grooves 17, 18, 19 and 20 to expand the sealing rings 21, 22, 23 and 24 to provide a positive seal and yet allow for the relative sliding movement of the metal 15 as desired. The valves 29, 30, 31 and 32 are connected by the line 33 to a source of hydraulic fluid 34 through a variable pressure pump 35. If it is desired, additional pressure may be supplied to the grooves 17, 18, 19 and 20 to force the rings 21, 22, 23 and 24 outwardly with sufficient pressure to prevent the relative sliding movement of the metal 15. This would be desired where it was necessary to apply a small amount of stretching to the metal in the groove for setting purposes, as explained below.

The plug 16 is provided with a plurality of passages 36, 37 and 38 leading respectively to circumferential, annular grooves 39, 40 and 41 in the plug 16 located respectively between the sealing rings 21, 22, 23 and 24. The hydraulic pressure in the passages 36, 37 and 38 is controlled respectively by two-position valves 42, 43 and 44 which are connected by lines 45 and fittings 46 to the passages. The valves are coupled to a supply line 47 in which hydraulic fluid is supplied from a source 48 by the variable pressure pump 49. Each valve 29, 30, 31, 32, 42, 43 and 44 is provided with a drain port 50 which is connected to a common collection sump in any suitable manner. The hydraulic fluid under pressure, admitted in sequence between pairs of the sealing rings 21, 22, 23 and 24, functions to force the metal 15 successively into conformation with the grooves 11, 12 and 13.

The operation of the apparatus is illustrated in Figs. 1-4 which disclose the sequential formation of a plurality of grooves in a thin metal sheet. As viewed in Fig. 1, the metal sheet 15 has been positioned between the die 10 and the plug 16 so that the sheet 15 contacts the sealing rings 21, 22, 23 and 24. Hydraulic fluid under pressure from pump 35 is admitted by valves 29 and 30 through passages 25 and 26 to extend the sealing rings 21 and 22 into sealing engagement with the metal 15. Hydraulic fluid under pressure from pump 49 is admitted through valve 42, passage 36 and annular groove 39 into the area between the sealing rings 21 and 22. The hydraulic fluid from pump 49, as illustrated in Fig. 2, forces the metal in the sheet 15 into conformation with the groove 11. The sealing rings 21 and 22 prevent the escape of the hydraulic fluid but permit the metal to slide relative to the sealing rings. As the first groove is formed, the transverse axial length of the metal sheet 15 is shortened as indicated by the dotted line 51.

Fig. 3 illustrates the formation of the second groove. The hydraulic pressure is maintained through the annular groove 39 on the metal in the groove and also on seals 21 and 22. This forms a positive brake so that the pressure on the metal 15 in groove 11 prevents the axial movement of the metal 15. Valve 31 is opened allowing hydraulic fluid under pressure from pump 35

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to flow through passage 27 to expand sealing ring 23 into sealing engagement with the metal 15. Valve 43 is opened to admit hydraulic fluid under pressure through passage 37 and annular groove 40 into the area between the sealing rings 22 and 23 to force the metal in the tube 15 into conformation with the groove 12. The sealing rings 22 and 23 prevent the escape of hydraulic fluid but the sealing ring 23 allows the metal sheet 15 to slide in an axial direction relative to the ring 23. As the second groove is formed, the transverse axial length of the metal sheet 15 is further shortened as indicated by the increased length of the dotted line 51.

After the second groove has been formed, the hydraulic pressure in the area of groove 11 is released by closing valve 42 which allows the hydraulic fluid to escape through port 50 to the collection sump. Valve 32 is opened allowing hydraulic fluid under pressure from pump 35 to flow through passage 28 into groove 20 to expand the sealing ring 24 outwardly into sealing engagement with the metal sheet 15. Valve 44 is opened to admit hydraulic fluid under pressure from pump 49 through passage 38 and annular groove 40 into the area between the sealing rings 23 and 24 to force the metal in the sheet 15 into conformation with the groove 13. The sealing rings 23 and 24 prevent the escape of the hydraulic fluid while the ring 24 allows for the relative transverse sliding movement of the metal 15. As illustrated in Fig. 4, the axial length of the tube 15 has been shortened the amount indicated by the dotted line 51 during the formation of the grooves. After the grooves have been formed, the hydraulic pressure is released by closing all the valves to allow the hydraulic fluid to empty through ports 50; the die is separated, and the grooved metal sheet removed from the plug.

To satisfy specific requirements, it is sometimes necessary that there be a slight stretching of the metal in the groove. The instant invention has incorporated therein apparatus for accomplishing the required stretching. If it is desired to impart a slight stretching, valves 29 and 30 are opened to allow hydraulic fluid under pressure from pump 35 to flow through passages 25 and 26 to expand sealing rings 23 and 24 outwardly into sealing engagement with the metal sheet 15. Valve 42 is opened allowing hydraulic fluid under pressure to flow through passage 36 and groove 39 to force the metal in the sheet 15 between the sealing rings 21 and 22 outwardly. The hydraulic pressure acting through passage 36 and groove 39 on the metal in the sheet 15 is regulated by the pump 49 so that the metal is not forced completely into conformation with the groove 11. The hydraulic pressure acting through passages 25 and 26 on the sealing rings 21 and 22 is then increased by regulating the pump 35. This additional pressure on the sealing rings 21 and 22 forces the sealing rings 21 and 22 outwardly against the metal sheet 15 with sufficient pressure to prevent the relative sliding movement of the metal on the sheet 15. The hydraulic pressure acting through passage 36 and groove 39 on the metal in the sheet 15 is then increased by regulating the pump 49 so that the metal in the sheet 15 between the sealing rings 21 and 22 is stretched into conformation with the groove 11 in the die 10. Thus, a predetermined amount of stretch may be imparted to the metal in the formation of the grooves. Succeeding grooves in the metal sheet 15 would be formed in sequence according to the steps illustrated above.

Having thus described the invention in rather full detail, it will be understood that these details need not be strictly adhered to and that various changes and modifications may suggest themselves to one skilled in the art, all falling within the scope of the invention as defined by the subjoined claims.

What I claim is:

1. Apparatus for forming grooves in a thin metal sheet which is formed into a generally tubular work-piece comprising a generally tubular die having a plu-

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rality of grooves formed in one surface thereof and adapted to receive the generally tubular work-piece to be grooved, a corresponding land between each of said grooves, a plug positioned within said die, said generally tubular work-piece being positioned between said die and said plug, a plurality of seals comprising a rubber-like material on said plug and positioned to be in alignment with said lands and allowing for relative sliding movement between said generally tubular work-piece and said seals, and means in said plug for supplying hydraulic fluid under pressure to the area between adjacent pairs of said seals to sequentially force the metal in said generally tubular work-piece into conformation with said grooves.

2. Apparatus for forming grooves in a thin metal sheet which is formed into a generally circular work-piece comprising a generally circular die having a plurality of circumferential grooves in the inner surface thereof, said die being adapted to receive the generally circular work-piece to be grooved, a corresponding land between adjacent grooves, a plug positioned within said die, said generally circular work-piece being positioned between said die and said plug, a plurality of sealing rings comprising a rubber-like material on said plug, said sealing rings being positioned in alignment with said lands, said sealing rings contacting said generally circular work-piece to form a plurality of fluid tight compartments, each of said compartments being defined by said plug, said generally circular work-piece and adjacent pairs of said sealing rings, and means in said plug for supplying hydraulic fluid under pressure to said compartments in sequence to force the metal in said generally circular work-piece into conformation with said grooves so that a plurality of grooves are successively formed in said generally circular work-piece.

3. Apparatus for forming grooves in a thin metal sheet which is formed into a generally circular work-piece comprising a generally circular die having a plurality of circumferential grooves formed in the inner surface thereof, said die being adapted to receive the generally circular work-piece to be grooved, a corresponding land between adjacent grooves, a plug positioned within said die, said generally circular work-piece being positioned between said die and said plug, a plurality of sealing rings comprising a rubber-like material on said plug, said sealing rings contacting said generally circular work-piece to allow for relative sliding movement between said generally circular work-piece and said sealing rings, said sealing rings being positioned in alignment with said lands, said sealing rings contacting said generally circular work-piece to form a plurality of fluid tight compartments, each of said compartments being defined by said plug, said generally circular work-piece and adjacent pairs of said sealing rings, and means in said plug for supplying hydraulic fluid under pressure to each of said compartments in sequence to force the metal in said generally circular work-piece into conformation with the grooves in said die.

4. Apparatus for forming grooves in a thin metal sheet which is formed into a generally circular work-piece comprising a generally circular die having a plurality of circumferential grooves formed in the inner surface thereof, said die being adapted to receive the generally circular work-piece to be grooved, a plurality of corresponding lands between adjacent grooves, a hollow generally circular plug adapted to be positioned within said die, said generally circular work-piece being positioned between said die and said plug, a plurality of sealing rings comprising a rubber-like material seated in annular grooves in said plug, said sealing rings positioned to be in alignment with said lands, said sealing rings contacting said generally circular work-piece to form a plurality of fluid tight compartments, each of said compartments being defined by said plug, said generally circular work-piece and adjacent pairs of said sealing rings,

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said sealing rings allowing for relative sliding movement between said rings and said generally circular work-piece, means in said plug for supplying hydraulic fluid under pressure to each of said compartments in sequence to force the metal in said generally circular work-piece into partial conformation with an aligned groove in said die, means for supplying hydraulic fluid under pressure to expand a predetermined pair of sealing rings outwardly to prevent relative sliding movement between said rings and said generally circular work-piece, and means to increase the pressure in said compartment to stretch the metal in said generally circular work-piece between said

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pair of sealing rings into complete conformation with the aligned groove in said die.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,960,141

November 15, 1960

Donald P. Rutter

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 53, for "extend" read -- expand --.

Signed and sealed this 21st day of November 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents

USCOMM-DC