June 7, 1955

M. S. REED

2,709,933

PLURAL FORGING

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Fig. 1.

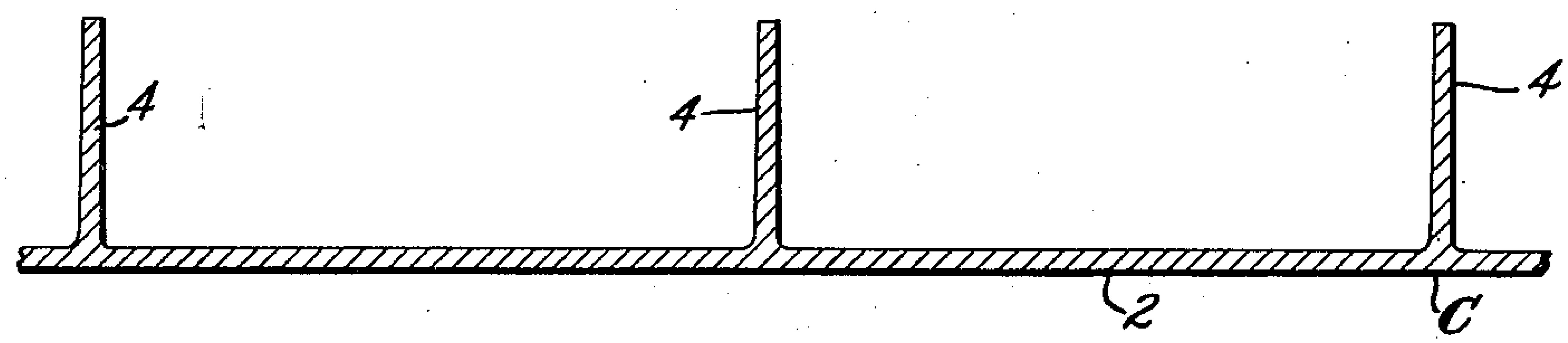
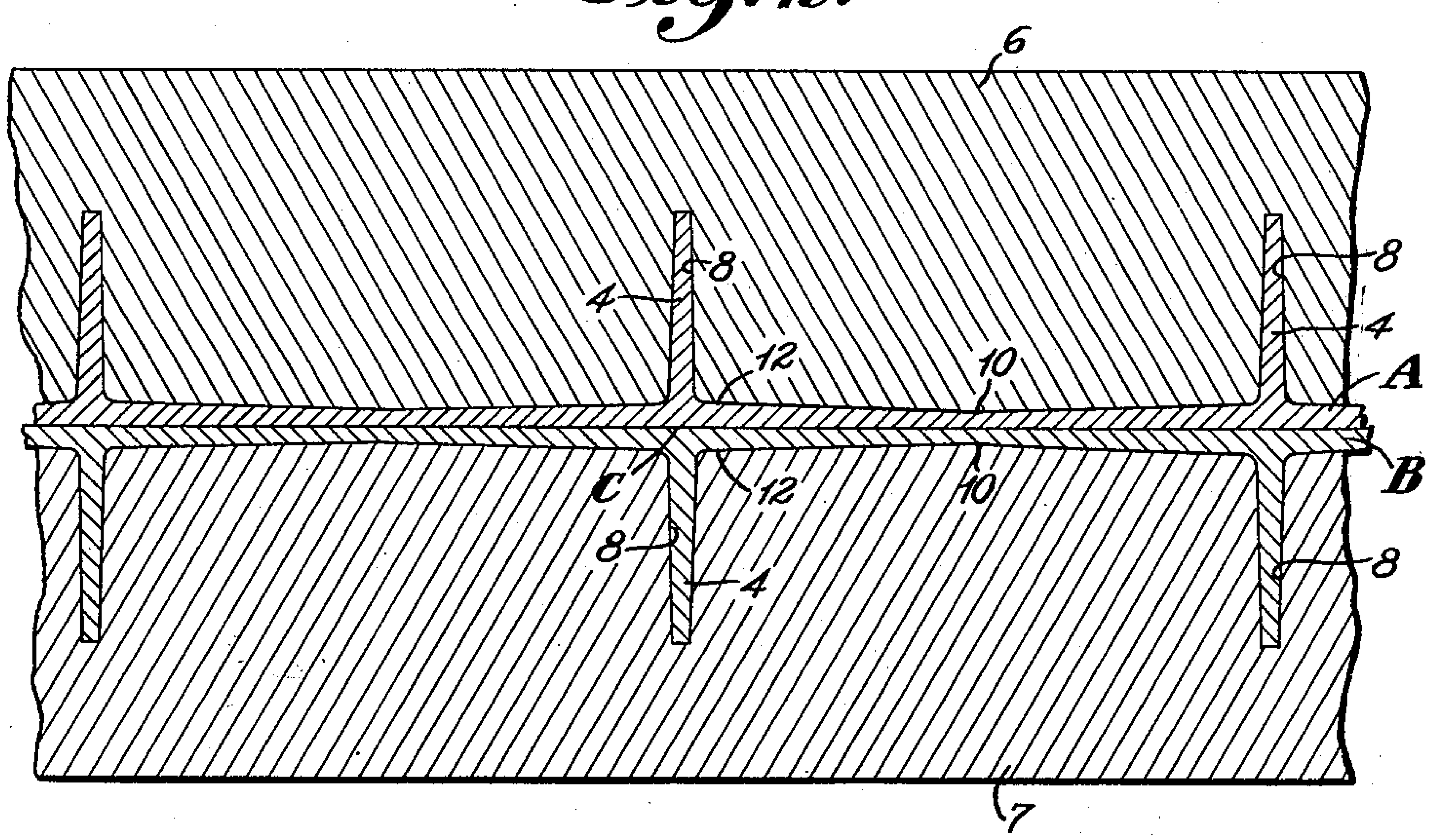


Fig. 2.



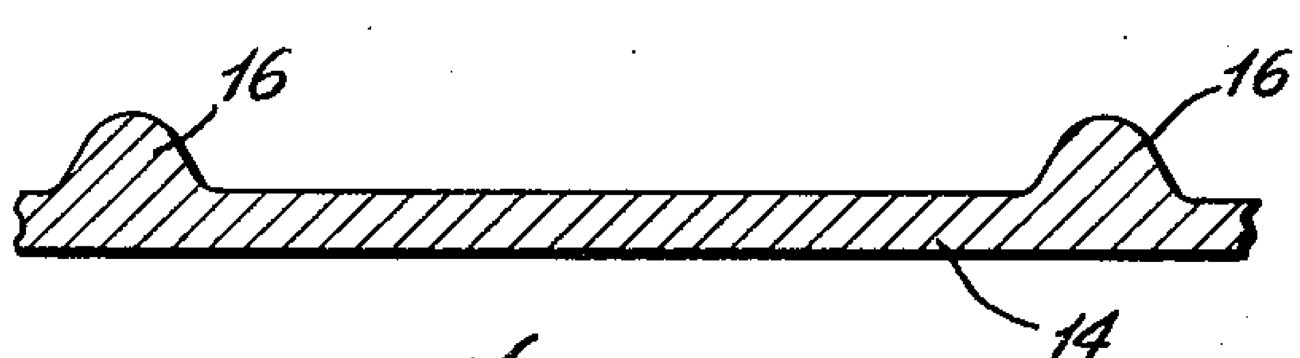


Fig. 3.

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4 Claims. (Cl. 29—552)

This invention relates to methods of forging sheets and particularly to the forging of thin sheets having integral upstanding ribs, usually referred to as integrally-stiffened panels.

It is desirable, especially in the aircraft industry, to have sheets of relatively large surface area and quite thin provided with integral upstanding ribs or flanges formed integrally therewith to provide stiffening whereby such sheets may be employed as a rigid "skin" for the aircraft. It is usually desirable to have the ribs parallel to each other but the present invention is not limited to such an arrangement, as the ribs may be arranged to form any other necessary or desirable pattern. The forging of such structural sheets has heretofore been impossible by practical methods since it is extremely difficult to squeeze a rib or flange of the required height and thickness from a thin sheet of material. In general, it is desirable that finished sheets of a thickness of the order of magnitude of $\frac{3}{32}$ inch be provided with integral ribs or flanges projecting from one surface and spaced apart from 1½ to 3 inches. The ribs are desirably of a height of the general order of 1 inch or more. It can readily be seen that integral structural shapes of those dimensions are extremely difficult to produce by practical methods.

Forging has heretofore been contemplated as a possible means of producing integrally stiffened panels of the required type but the previous techniques limited the thickness of the sheets to a value considerably greater than that desired and definite limitations existed as to the possible spacing between and dimensions of the ribs. A number of factors contributed to the difficulties, among which were the relation between rib dimensions and skin thickness and the problem of flow of material as related to pressure placed on the die. All such operations involving press forging of sheets to the required dimensions resulted in defects known as "suck-in" at the base of the ribs or flanges. In causing the material to flow until the skin thickness reached the desired values the friction against the die surfaces created conditions such that the surface of the sheet opposite each rib cavity developed depressions where the surface material was drawn or pushed into the cavity, thus resulting in a product having grooves on the face opposite the base of each rib. Such defects render the product unacceptable to the aircraft industry.

The present invention relates to a manner of forging such shapes by a method resulting in acceptable products of the desired dimensions without the defects of "suck-in." It is known that the pressure required to cause flow of the material being forged increases with the ratio of the least lateral dimension to the thickness of the metal in the direction in which the pressure is applied. Thus, if the lateral dimensions of a piece are the same in both cases, it requires considerably less pressure to cause the metal to flow if the sheet is ¼ of an inch thick than the pressure required if the piece is only ⅛ of an inch thick.

The present invention contemplates taking two sheets of stock material and simultaneously forging opposite faces thereof by means of opposed dies in a suitable press or hammer. Bearing in mind the pressure requirements discussed above, it will be seen that the effective thickness of material between the dies at the time the required reduction has been accomplished is twice that between the die and bed where a single sheet is forged to the required thickness. The present invention contemplates employing two forming dies, each having rib-or-flange-defining cavities on opposite sides. Thus, for symmetrical designs each sheet may be identical to the other and for non-symmetrical designs each sheet may be a "mirror" image of the other. Also, the two sheets may have different designs consisting of non-opposed ribs. At the completion of a forging operation according to the present invention two finished products result from each stroke of the press or hammer and the total pressure required remains less than that which would be required to forge a single sheet by prior methods. This method offers additional advantages, among which are: the ability to forge materials to thicknesses otherwise not forgeable, the making of thin-walled forgings with less pressure, the making of more than one piece at a time and creating conditions for better flow of material. The surfaces of the two sheets originally placed in abutment remain as flat surfaces and are readily separable upon removal from the dies.

It is therefore an object of this invention to provide a method of forging sheets more efficiently and more economically than by methods heretofore known.

Another object of this invention is to provide a method of forging integrally stiffened panels of sheet metal of practical dimensions.

It is still another object of this invention to provide a method for forging sheet material whereby larger pieces may be fabricated than possible with previously known press or hammer forging methods.

A still further object of this invention is the provision of a method for forging sheets whereby sheets of thinner final section may be produced, on any given press or hammer than heretofore possible.

Still another object of this invention is the provision of a method for forging structural shapes resulting in a doubled output for each machine since each stroke thereof produces two finished articles.

Further objects and advantages will appear to those skilled in the art as the description proceeds in connection with the accompanying drawings, wherein:

Fig. 1 represents a cross-sectional view of an ideal integrally stiffened panel illustrating the approximate desired dimensions;

Fig. 2 is a transverse sectional view through a pair of dies illustrating the production of two finished sheets in accordance with the present invention; and

Fig. 3 is a fragmentary sectional view of a partially preformed sheet of stock material that may be employed to practice the present invention.

Fig. 1 illustrates generally the desired product consisting of a relatively thin "skin" **2** which may be of aluminum, aluminum alloy, or a suitable magnesium alloy for use in covering aircraft frames, or which may be any other suitable material. The skin **2** has integrally formed thereon spaced parallel upstanding ribs or flanges **4** joined integrally to one surface of the skin **2**. In general, a satisfactory stiffened panel may be of a thickness of the order of $\frac{3}{32}$ inch having ribs **4** also of about $\frac{3}{32}$ inch and projecting from skin **2** a distance of the order of 1 inch. In some applications it is desirable that the ribs be closer than illustrated and such stiffened panels may readily be produced by the present invention. Fig. 1, in illustrating an ideal or desirable shape, shows opposite surfaces of the skin 2 as being parallel and opposite faces of the ribs 4 as parallel. In producing such shapes by press forging it may be desirable that the ribs taper slightly toward their outer edge to provide for "draft" to facilitate removal from the dies and, as is well known in press forging, the skin surfaces may be made to taper slightly in a direction away from each rib to thus cause the material to flow more readily.

Fig. 2 illustrates an upper die 6 and a lower die 7. In practicing the present invention the die 7 will be fixedly mounted on the stationary bed of a press and the die 6 will be mounted on the movable head of the press. Each die is provided with suitable cavities 8 complementary to the ribs or flanges 4 to be produced, and as shown are provided with sufficient "draft" to facilitate removal of the finished forgings. The dies 6 and 7 are mounted with their cavities 8 (in the form illustrated cavities 8 comprise elongated parallel grooves) opposite each other. The portions of the die faces between grooves 8 are shown as tapered toward the opposite die whereby the finished forging is thinner at 10 than at 12 adjacent the bases of ribs 4. As is well known in press forging, this tapering of the skin results in making the material flow more readily and with less pressure and the difference in skin thickness at the base of the ribs and at the mid-portion of the area between the ribs is not sufficiently great to render the product undesirable. The tapering of the surfaces, commonly known as "fullering," also causes the material to flow into the die cavities more readily.

If the top die 6 were mounted in a press having a perfectly parallel or flat bed and a single sheet of stock material were employed a product similar to the top forging A would be produced but if reduced to the dimensions shown much greater pressure would be required and the forging would be defective at points C because of "suck-in" previously referred to. By employing two sheets of stock material and a pair of opposed dies, as shown, serious "suck-in" is not encountered since the method completely eliminates die friction against the abutting surfaces of the two work pieces.

If desired, the sheets of stock material placed between the dies 6 and 7 may be preformed by a preliminary press forging operation or by rolling, or otherwise, to an intermediate form as illustrated in Fig. 3. In Fig. 3 the sheet 14 is thicker than that desired in the final product and has an integral rib or body of material 16 projecting from one face thereof at the desired position of each rib or flange 4. The bodies 16 are in the form of parallel stubby ribs spaced apart a distance corresponding to the space between the ribs in the final product. A pair of such sheets as shown in Fig. 3 may be placed in back-to-back relation with their planar faces in abutment and positioned between dies 6 and 7 with the integral bodies 16 registering with the entrances to cavities 8. By thus preforming the stock sheets sufficient material is gathered at the location of the ribs so that a minimum amount of "flow" is necessary to produce the final shape shown in Fig. 2. It is further contemplated that the dies be so formed and shaped as to produce suitable fillets and radii at the edges and corners of the finished product, as dictated by engineering practice.

While a single species of the invention has been shown and described herein, it is to be understood that many modifications may be resorted to within the scope of the invention as defined by the appended claims.

I claim:

1. In a method of press forging structural shapes from thin sheet stock wherein said shapes comprise thin sheets having spaced integral ribs upstanding from one face thereof and wherein the height and spacing of said ribs are multiples of the thickness of said sheets, by causing the body material of said sheet stock to flow sideways into said ribs and wherein the volume of and spacing between said ribs is so related to the thickness of said sheets that excessive die resistance to flow is encountered, the improvement comprising the steps of: superimposing two sheets of said stock in face abutting surface contact, applying pressure to the opposite outer faces of said sheets, the pressure applied to said sheets being applied simultaneously over the entire extent of opposed spaced areas other than the rib locations to simultaneously thin said sheets and cause material thereof to flow outwardly between said spaced areas to form said ribs.

2. The method defined in claim 1 wherein the spacing between said spaced areas is of the same order of magnitude as the thickness of one sheet.

3. The method defined in claim 1 including the step of directing and confining the material that flows outwardly between said areas to form ribs of predetermined shape.

4. A method as defined in claim 1 including the step of applying pressure to said areas in such manner that the central portions thereof are thinned to a greater extent than the portions adjacent said spaces.

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