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METAL FABRICATION

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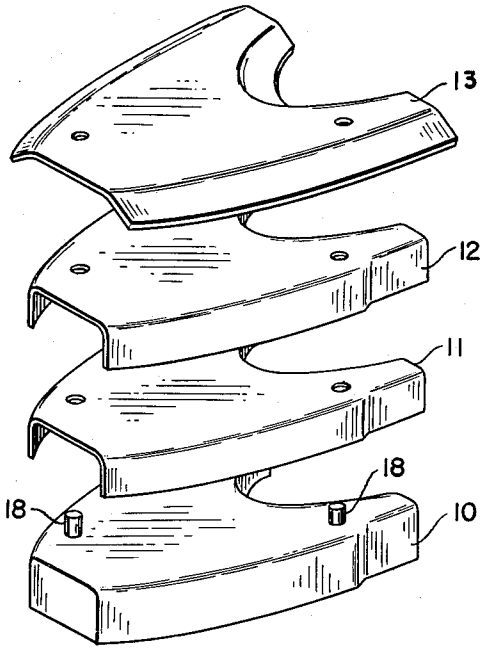

FIG. I

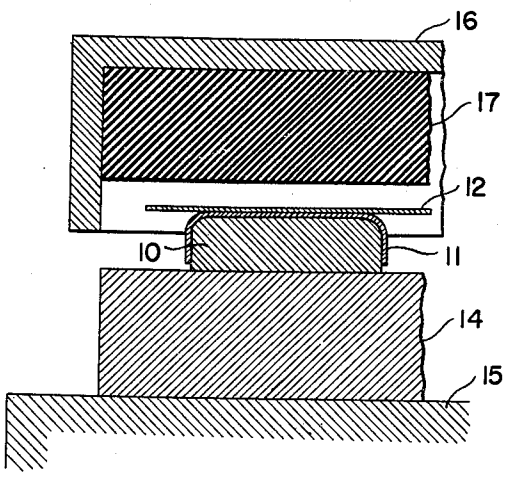

FIG. II

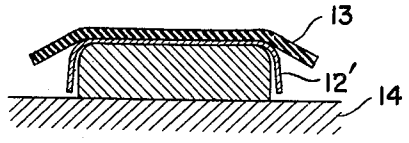

FIG. III

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METAL FABRICATION

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This invention relates to the shaping or drawing of sheet material into predetermined form, and more particularly to an improved method of and apparatus for forming sheet material into desired shapes precisely conforming to the forming surface, thus eliminating the necessity for hand finishing operations.

The so-called Guerin process of forming and shearing sheet metal into desired shape has long been known to industry, and a number of patents have been issued thereupon. The apparatus used in such a process includes a support or table adapted to support a die about which the metal sheet may be formed, and a head member movable toward the table. Secured to the head member is a block or body of fluid-like, flowable material such as rubber, which has a tendency to deform in a manner to surround a body against which it is pressed. To restrain the flowable material from lateral flow when it is under vertical pressure, it is confined within a box or wall so that the material is contained within a completely closed space prior to and during the time it is in engagement with the die and the upper surface of the table. The process consists essentially in placing a sheet of metal over the die and forcibly applying pressure through the head member to the metal sheet to cause it to assume a shape as near as possible to the contour of the die.

The foregoing process has many advantages, particularly when it is desired to form a small number of metal parts, since the need for the relatively expensive companion punch and die members, and the skill and time required to dispose them in mating relationship in ordinary punch presses is eliminated. Its disadvantages reside in the fact that extremely high forming pressures cannot be applied directly to the material to be formed, for due to the lateral flow tendency of the rubber, unsatisfactory and incomplete formation of the shaped articles is often obtained, which results in expensive hand operations necessary to form the article to required shape. In addition, due to compression of the sheet, wrinkles in the shaped article are frequently encountered, which also necessitates a hand finishing operation. The fact that a fluid-like material such as rubber is used in the head member often results in inadequate formation of the lower portion of the shaped article. This is especially true when the article being formed has side walls or flanges, for the side walls are always under inadequate pressure, which permits them to spring back when the article is removed from the forming surface.

Various prior art arrangement have been directed to solving the problem of preventing the wrinkling and/or spring-back of flanges, but in each known instance the solution necessitated the use of an expedient such as a clamping ring to hold the edge of the sheet to prevent it from wrinkling while the article is being formed, or an edge restraining member arranged to recede in the direction of the applied pressure in such a manner that the flanges will be properly supported during the operation. However, such apparatus has been comparatively complicated, necessitating a substantial amount of time for adapting the hydraulic press or drop hammer for the particular operation.

Therefore, the solution commonly resorted to in the aircraft industry for the manufacture of aircraft parts

such as gussets, nose ribs, frames and the like has been to employ two form blocks or dies for the manufacture of such parts. The sheet material to be formed was cut approximately to the proper size and then placed upon the first form block. A hydraulic press or drop hammer was then employed to shape the sheet material to the proper configuration, this more specifically being accomplished by placing the first form block (known as a spring-back block) upon the base or platen of the press, and then lowering the press head so as to cause the sheet material to assume the configuration of the block. It has been found from experience that if any substantial forming of the part was involved, it was then necessary to transfer the part to the second form block (known as a hammer block) for the finishing operation. This latter block is made closely to engineering dimensions, and the part was placed upon it and a rawhide hammer, wooden mallet or the like was then employed for finish forming the part, thereby to eliminate wrinkles and any spring-back of the flanges. This finish forming step was very expensive, for it delayed production, required double tooling, and involved considerable labor costs.

According to the present invention, articles may be formed of sheet at a rapid rate in a straightforward, uncomplicated manner, using a single form block, with the elimination of prior art hand finishing operations. Furthermore, no time is required to adapt the press or hammer for the forming operation according to this invention, for the single forming block or die block can be placed directly upon the base of the press or hammer, without the necessity for employing any other tooling.

The process for forming an article according to this invention may be carried out utilizing a hydraulic press or drop hammer, and involves the use of an underlay in conjunction with the article or part being formed, as well as, in most instances, an overlay. More specifically, this process involves placing the underlay, such as of thin aluminium, upon the form block, the underlay conforming quite closely to the active surfaces of the block. The sheet to be formed is then placed upon the form block in the proper manner, and then the overlay, such as of plastic, may be placed on the sheet. To facilitate alignment of the several components, on the form block two or so locating pins are preferably utilized, to project upwardly through tooling holes provided in the components to be placed upon the block. The press head press pad having the general characteristics of rubber is then moved toward the forming block so as to initially form the sheet. The several components are then removed from the form block, the underlay set aside, and the article to be formed fitted directly upon the forming block so that it can be resubjected to the pressure of the press head whereby to finish form the article. As in the initial forming step, the overlay again may be utilized between the press head and the article to improve upon the action of the captive rubber head.

It will be observed that the foregoing method involves the simplest of materials and tools, it being unnecessary to utilize complicated, prior art expedients. Because of the presence of the underlay, the initial forming of the article according to this invention results in the side walls or flanges being formed somewhat less severely than required by design standards. Therefore, when the underlay is removed and the article restruck, the result is that the extent of curvature of the flanges of the article will be increased, and the article caused to conform precisely to the contour of the forming block, with no tendency of the flanges to spring back away from the desired configuration. The use of the overlay enhances the action of the captive rubber head upon the part being formed, for instead of flowing out of the way as rubber

does rather it is firm enough to assure accurate conforming of the article to the forming block, for it pushes and compresses the sheet in such a manner as to eliminate wrinkles.

If heat treating of the articles is involved, such as when 6061–SO aluminum is being used, the aluminum is preferably in the annealed condition during the forming operation, with the heat treating and age hardening steps being performed afterward. However, depending upon the size of the article being formed and the complexity of the forming operation, it may be desirable to heat treat the article before the initial forming operation, or between the initial forming operation and the final forming operation.

The invention will now be further described in conjunction with the drawings wherein:

FIGURE I shows in exploded relation the forming block, underlay, article being formed, and the overlay;

FIGURE II illustrates to a somewhat different scale the cross sectional view of a forming machine, indicating the placement of the underlay upon the form block, and sheet material in the unformed condition resting upon the underlay; and

FIGURE III illustrates a view taken before the second forming operation, showing the article being formed resting upon the form block with the overlay in place thereon.

In FIGURE I, a nose rib is being manufactured, with the basic components involved in the operation being a forming block or die **10**, underlay **11**, article **12'** being formed (i.e. nose rib), and overlay **13**. The forming block **10** is to be placed upon the base or platen **14** of a hydraulic press **15**, with underlay **11** fitted upon the block **10** in the manner shown in FIGURE II. The sheet material **12**, cut approximately to size, is placed upon the underlay with the margins overhanging the sides of the block. The press head **16** shown in FIGURE II can be operated to bring the block or body of rubber or other elastic or fluid-like material **17** into compressive contact with material **12**, to form it into the desired shape. In most instances, it is desirable in the practice of this invention to use an overlay **13** to prevent lateral flow of the rubber-like material **17** from occurring. So that the components **11**, **12** and **13** can be maintained in proper alignment upon block **11**, two or so locating pins **18** may be provided upon block **10**, which are adapted to project through tooling holes in the component conveniently provided.

Upon the components being assembled in the manner shown in the drawing, the head **16** of the press or drop hammer is lowered so as to cause the article to conform precisely to the configuration of the active surfaces of underlay **11** resting upon the forming block with the result being the formation of an article **12'** as illustrated in exploded relation in FIGURE I. The underlay **11** is then removed, and the article **12'** replaced directly upon the forming block, with the relationship of the article **12'** and overlay **13**, if used, being approximately that illustrated in FIGURE III. The head is then lowered again to further shape the article **12'**, this causing the flanges to closely assume the configuration of the forming block, after which the flanges do not tend to spring back into the position of the flanges before the final forming.

As to the underlay, thin aluminum is quite satisfactory for this purpose, in which event, it may be formed simultaneously with the forming of the first article **12'** being manufactured. It will, of course, be obvious that after the first forming operation, the underlay will have assumed the configuration of the form block, and in most instances an underlay may be used many thousands of times for subsequent forming operations.

As to the overlay, plastic is preferred, such as polyvinyl chloride in approximately ⅛ inch or ¼ inch thickness. A vinyl marketed under the trade name "Vyflex" has been determined to be highly successful for this purpose. When thick vinyl is being used, the vinyl is preferably heated to approximately 300° F. preparatory to the first stroke, but after that the vinyl has curled or bent edges and may continue to be used a large number of times.

Sheet material of a large number of different aluminum alloys has been successfully employed, such as 7075, 2024, etc. Although such is more difficult, this invention may also be used for the forming of other metals such as some alloys of titanium or steel, as well as for the forming of other sheet materials.

When aluminum articles are being manufactured, the metal preferably is in the annealed (SO) condition, with heat treating and age hardening steps being performed according to the size and complexity of the part. As a first example, if a small heavy part is being formed, after the performance of the first forming step utilizing the underlay, the article may then be heat treated at approximately 900° F. for approximately 20 minutes, and then free-fall quenched. The second or final forming operation is then performed without using the underlay, this latter forming operation serving the double purpose of eliminating distortion caused by the heat treating, as well as finish forming the part. The article is then aged at approximately 300° F. for approximately 8 hours so as to bring it up to full hardness.

As another example, if large thin parts are to be formed, the annealed material is initially heat treated at approximately 900° F. for approximately 20 minutes before either of the forming operations, for heat distortion in large thin parts is typically so severe that they must be level rolled prior to either of the forming operations. Therefore, the first forming operation would be performed in the as-quenched condition with the underlay in place, and immediately thereafter, the second forming operation is performed without using the underlay. It should be noted that these operations should be performed within a thirty minute period following the 900° F. heat treating. After the second forming operation, the part is then placed in a furnace at approximately 300° F. for eight to twenty-four hours so as to bring the material to the T6 or full hardness condition. As is to be noted, the heat treat process may be performed before the initial forming operation, between the initial and final forming operations, or after the final forming operation.

This invention has been successfully used with a variety of sheet materials for the formation of both large and small items. As an example of large items, frames for aircraft have been manufactured which measure 4' by 8' and larger.

We claim:

1. A process of forming a sheet into a flanged article comprising placing an underlay upon a forming block, placing the sheet thereupon, with an edge portion of the sheet projecting from the edge of said forming block, placing a plastic overlay upon said sheet, moving a body of flowable material toward said forming block so as to initially flange said sheet, and conform it to the general contour of said forming block, removing said underlay, said sheet and said overlay from said form block, and replacing said sheet directly upon said form block, replacing said overlay, and then resubjecting said sheet to the pressure of said flowable material whereby to finish form said article, and thereby make unnecessary any hand finishing to eliminate springback of the flanges thereof.

2. The process as defined in claim 1 wherein said article to be formed is heat treated in the interval between initial forming and finish forming.

3. The process defined in claim 1 in which said article to be formed is heat treated after finish forming thereof.

4. A die set for producing marginally flanged sheet metal parts in finished condition comprising a forming block having top and side portions adapted for the form-

ing of sheet metal parts, a comparatively thin reuseable metal underlay adapted to be fitted upon said forming block during the initial forming of a part, and to be removed therefrom during finish forming of the part, and a rubber die member movable into engagement with said part to conform it to the shape of the underlay during the initial forming step, and to the shape of the forming block during the finish forming thereof, whereby to form metal parts needing no hand finishing.

5. A die set for producing marginally flanged sheet metal parts in finished condition comprising a forming block having top and side portions adapted for the forming of sheet metal parts, a comparatively thin reuseable metal underlay adapted to be fitted upon said forming block during the initial forming of a part, and to be removed therefrom during finish forming of the part, a plastic overlay to be placed upon said part to be formed during both the initial forming and final forming thereof, and a rubber die member movable into engagement with said plastic overlay to conform said part to be formed to the shape of the underlay during the initial forming step, and to the shape of the forming block during the finish forming thereof, whereby to form metal parts needing no hand finishing.

6. The process of forming marginally flanged articles which consists in laying sheet material on an underlay residing upon a rigid forming block, with the margins of the material overhanging the sides of said underlay, forcing a confined body of flowable material against substantially the entire area of the upper surface of the sheet material with sufficient pressure to bend said overhanging margins against the sides of said underlay and conform it to the top and sides of said underlay, removing the article so formed of sheet material and the underlay from said block, and then replacing the article directly upon said block, again forcing said confined body

of flowable material against substantially the entire area of the article so as to conform it to the active sides of said block forming whereby said flanges will be wrinkle-free and have no tendency to spring back away from the desired configuration.

7. The process as defined in the claim 6 in which an overlay is placed between said sheet material and said confined body of flowable material during said forming operations.

8. The process as defined in claim 6 in which the article to be formed is heat treated before the step of forming upon said form block without said underlay.

9. The process as defined in claim 6 in which the article to be formed is heat treated after the second-recited forming step.

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