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APPARATUS AND METHOD FOR RIVETING AIRPLANE STRUCTURES OR THE LIKE

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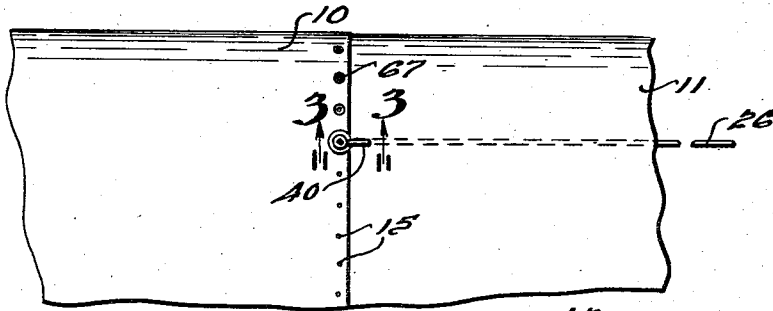


FIG. 1.

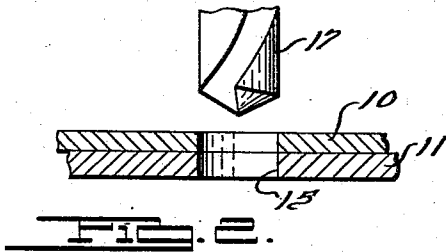


FIG. 2.

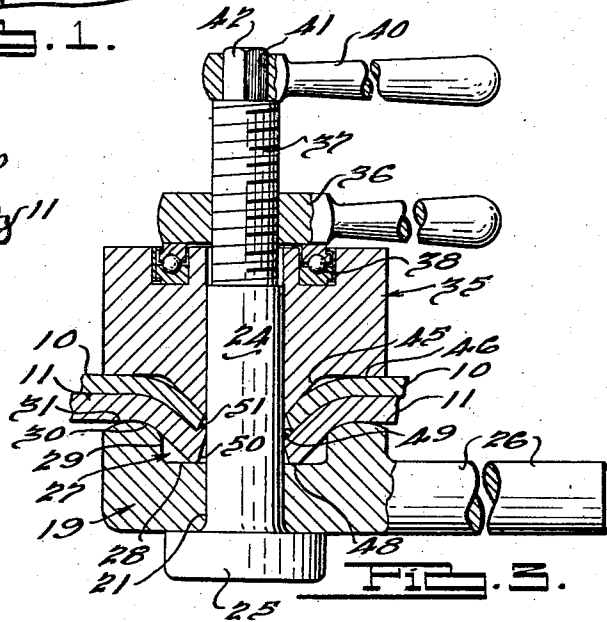


FIG. 3.

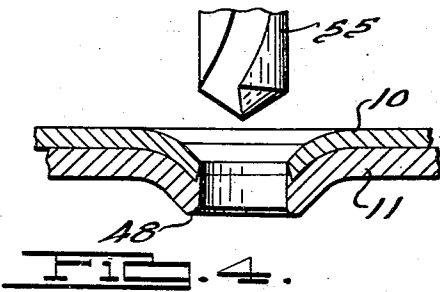


FIG. 4.

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APPARATUS AND METHOD FOR RIVETING
AIRPLANE STRUCTURES OR THE LIKE

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11 Claims. (Cl. 153—10)

This invention relates generally to the application of sheet metal covers to airplanes or similar structures, and it has particular relation to methods of dimpling and riveting such covers.

In many instances, at the present time, and especially in conjunction with aircraft, it is extremely desirable in the riveting of the metal skin or cover, to employ rivets having heads flush with the surface of the cover in order to eliminate projections on surfaces exposed to air flow. It is a general practice in such cases where the metal cover is too thin to allow countersinking, to dimple the metal around each rivet hole so as to provide a recess for the rivet head. Dimpling of the metal is particularly advantageous, in that it increases the shear strength of the riveted joint, since the contacting dimpled portions of the overlapping metal sheets provide a means, in addition to the rivet, for carrying the shear load.

One known method for dimpling overlapping sheets which are to be riveted consists in assembling the sheets, drilling a number of rivet holes, then disassembling the sheets and dimpling each sheet separately. This method has several disadvantages and an important disadvantage is that the process is expensive due to the amount of handling required. Another disadvantage is that the sheets may vary in thickness, especially in the case of airplane wing covers where the thickness of the metal is progressively decreased towards the tip of the wing and in this case dimpling of one sheet will effect a certain amount of creeping or growing of the metal while dimpling of another sheet of a different thickness will effect a different amount of growing or creeping of the metal. This difference in creeping or growing of the metal may also occur even when the metal sheets are of the same thickness as the angle of the bottom sheet dimple is usually somewhat different from the angle of the top sheet dimple due to the fact that as the metal is deformed, its thickness decreases. Difference in creeping or growing may also occur when the metal sheets have different degrees of hardness. It follows, therefore, that the dimple spacings in the two sheets will not be identical, due to the growing or creeping of the metal differently in the two sheets and when the sheets are thereafter riveted, the misfitting will tend to cause waves in the sheet which represent the excess lengths between dimples of the sheet that has crept or grown the most. Furthermore, considerable difficulty is encountered in having the dimple in one sheet fit the corresponding dimple in another sheet owing to the fact that the angles

of the dimples in the two sheets are usually not the same and the difference moreover varies with the thickness of the sheet. Under these circumstances, any attempt to provide accurate fits between the dimples necessarily requires a large number of tools adapted, respectively, to be applicable to different conditions.

In another method of dimple riveting, the rivet itself is used in the formation of the dimple after the rivet hole is drilled through the sheets. In a case of this kind, backing up tools are required at the inner side of the sheets in addition to squeezing or hammering means on the outer side of the sheets, and since the dimples are formed during a hammering or squeezing operation, it is not ascertainable whether or not the dimples are properly formed. Aside from this, a major disadvantage of the hammering process is that a pressure pad for counteracting the bending of the sheets during dimpling can not be used, at least practically, and, therefore, simultaneous riveting and dimpling by hammering the rivet would leave a bend in the sheets.

Also, a major disadvantage of the squeezing process is that squeezing apparatus usually involves a yoke which would not be practical in many places because of inaccessibility. Moreover, the yoke arms would have to be quite long in some instances and correspondingly heavier and stronger whereas in many other instances a small yoke would be required. In fact, at different points of riveting, yokes of different length would be necessary and thus a number of riveting apparatus would be required.

According to another method, both sheets may be dimpled simultaneously in place by a punch on the one side and a die on the other, respectively mounted on the arms of a press, but ordinarily this method is not very practical due to inaccessibility to both sides of the sheet, to practical limits to the length of the arms of the press, and to the different length yokes required, as stated previously. Use of hammer equipment for forming the dimples according to this method, also would not be practical due to the inability to use a pressure pad, as also mentioned heretofore.

The invention is concerned principally with the formation of dimples in sheet covering members such as mentioned and the application of dimpled rivets, and a general object of the invention is to provide an efficient, economical method of forming the dimples in overlapping sheets simultaneously, to the end that simul-

taneous dimpling may be rendered more practical.

Another object of the invention is to provide a method of simultaneously dimpling overlapping metal members which enables effecting simultaneous dimpling even though the inner side of the members normally might be generally inaccessible.

Another object of the invention is to provide an improved method of forming dimples in overlapping sheet members and thereafter riveting the members together, which results in greater accuracy of fit between the dimpled portions, and between the rivet and the dimpled portions, all to the end that a better, stronger, and more efficient rivet connection will be obtained.

Another object of the invention is to provide means for dimpling a plurality of sheets simultaneously under conditions where normally it would be impractical to effect the dimpling due to inaccessibility.

Another object of the invention is to provide an improved means for simultaneously dimpling a plurality of sheet metal members, which enables dimpling more rapidly and in locations usually considered inaccessible.

A further general object of the invention is to provide an improved method of dimple riveting, which enables forming the dimples in the overlapping sheets and subsequently applying the rivets all in a rapid manner by the use of apparatus operable at the outer or accessible side of the assembled sheets.

Other objects of the invention will become apparent from the following description, from the drawing to which the specification relates, and from the claims hereinafter set forth.

For a better understanding of the invention, reference may be had to the drawing, wherein:

Figure 1 is a fragmentary plan view of overlapping sheet metal members adapted to be riveted, illustrating a stage in the formation of the dimples;

Fig. 2 is a fragmentary, cross-sectional view of the overlapping parts of the sheets, as shown by Fig. 1, illustrating the first step of drilling a rivet hole;

Fig. 3 is a cross-sectional view on a larger scale taken substantially along the line 3-3 of Fig. 1, illustrating application of the apparatus for forming the dimples in the sheets;

Fig. 4 is a view on the order of Fig. 2, illustrating the step of drilling the rivet holes to a larger and final size.

Referring to Fig. 1, sheet metal sheets or plates 10 and 11 are illustrated and these are disposed in edge overlapping relation. Such sheets may constitute a part of the skin or cover of an airplane wing or fuselage or other structure adapted to be covered with sheets of metal. Usually the sheets will be applied to an internal supporting structure and at certain locations only the overlapping edge portions of the sheets will be riveted together, whereas at other locations flanges or ribs on the supporting structure may be riveted to one or both sheets. In the practice of the invention it is to be understood that the flanges will be dimpled also at points where they are riveted to the sheets.

With the two adjacent sheets or plates 10 and 11 disposed in proper positions and with their edges overlapping as shown, one or more rivet openings 15, having a diameter somewhat less than the diameter of the rivet to be driven, are formed in the overlapping portions and these

openings may be formed by a drill 17, although the hole in either or both sheets may be punched. Where only one hole is punched, it would be smaller than the drill, so as to serve as a templet in drilling the other hole. After each opening is formed, a backing up die element 19 is inserted inwardly under the sheets and this die element has a central opening 21 which closely fits a pin 24 having a head 25 engaging the under side of the die element. The die element has a long handle 26 by means of which it may be manually inserted as far as necessary under the sheets in order to place the die under the opening to be dimpled and the pin 24 may have a sufficiently tight fit in the opening 21 so that it will not easily be dislodged therefrom. It will be understood in this connection that the pin is associated with the die element and that both are inserted under the metal sheets until the end of the pin can be pushed outwardly through the openings 15 in the sheets. The die element 19 also has a recess 27 defined by a radial wall 28 and a generally cylindrical side 29 and the latter terminates in a rounded shoulder 30 which in turn merges with a downwardly flaring face 31.

At the outer side of the outer sheet 10, a punch element 35 fits closely but slidably on the pin 24 so as to be centered thereon and to be guided thereby and this element is adapted to be moved towards the die 19 by means of an arm 36 having threaded engagement with a threaded extension 37 on the outer end of the pin. For facilitating turning of the arm 36 relative to the punch while still applying thrust against the latter, a thrust ball bearing 38 may be provided in the outer part of the punch and between the latter and arm. For the purpose of preventing turning of the pin when the arm 36 is turned, a second arm 40 may be provided on the outer end of the pin and this arm has a polygonal opening 41 engaging a polygonal portion 42 on the outer end of the pin.

The punch 35 has a conical projection 45 centered relative to the pin opening therein and terminating in a substantially sharp, lower edge close to the pin surface, and outwardly of the projection the punch has a flat surface 46 adapted to contact the sheet 10 and limit the dimpling action. Instead of having the surface 46 contact the sheet 10, such surface may be cut back to space it from the sheet when the punch is in the position shown and a rubber pressure pad or ring may be interposed between the surface and sheet. This ring should be of such thickness that it will resiliently press against the sheet during downward movement of the punch so that it tends to curve the sheets over the downwardly flared face 31 of the die while the punch is depressing the metal into the die. This will offset or counteract the bending of the sheets by the dimpling operation.

With the die element 19 in position and the pin 24 projecting upwardly through the opening 15 in the sheets, the punch 35 and handles 36 and 40 are arranged on the pin and by turning handle 36 and holding handle 40, the punch is pressed towards the die, thus causing the metal around the hole to be dimpled. During this operation, the metal in sheet 10 under the conical projection 45 serves as an intermediate punch for depressing the metal in sheet 11 and this will provide assurance that the dimples will have a proper fit one with the other. During this dimpling operation, sheet 11 will bend downwardly over

the rounded shoulder 30, and the edge of the sheet around the opening therein will be forcefully pressed against the wall 28 in the die 18 and will flatten, as indicated at 48, and some of the metal will be extruded into the flared space around the edge of sheet 18, as indicated at 49. When the sheets are dimpled, the edges flare away from the pin 24 so as to leave flaring spaces 50 and 51 and it therefore will be appreciated that flattening of the edge of sheet 11 will tend to reduce this flaring action of the edges of the sheets and this and the extrusion mentioned will tend to hold the opening nearer to cylindrical contour. Providing the flat mentioned on sheet 11 will also avoid a tendency to initiate cracking of the edges of the sheets when dimpling is effected.

After the dimples are formed, both arms 36 and 40 are removed and then the punch and die are withdrawn from the inner side of sheet 11. Following this procedure, a drill 55 or reamer of larger and correct size for the diameter of rivet used is passed through the opening in the plates, and the corners on the edges of the plates are generally removed so as to provide a generally cylindrical hole surface. This is advantageous in several ways and of importance first is the fact that the corners may have slight cracks caused by the dimpling operation and thus weak points are eliminated that might later lead to failure of the metal. Additionally, by providing a substantially cylindrical surface, filling of the hole by the riveting operation to be performed is made easier and thus the rivet may fit the hole better and more fully.

With the dimpled hole now in the form shown by Figure 4, a flush type rivet may be applied, such as generally in accordance with that type disclosed in my Patent No. 2,061,628, issued November 24, 1936.

In general, it may now be stated that the dimpling procedure insures a proper and accurate fit between the dimples since one forms the other; that the dimples are accurately centered and aligned; that the hole for the rivet is less irregular and that the edges of the metal sheets around the hole are more resistant to failure; that the dimpled parts are tightly held in nested relation; that the rivet fills the hole more fully and therefore has greater contact with the sides of the hole; and that the outer surface of the rivet head is substantially flush with the outer surface of sheet 10. From this it follows that the dimples will act efficiently to carry shear loads and that the rivet, in addition to being adaptable to taking shear load, will hold the dimples in proper, shear load-carrying relation. Moreover, the disadvantages of creeping or growing of the meal may be practically avoided by the simultaneous dimpling and thus the finished construction will be free from a wavy contour caused by difference in length of the sheets between the dimples.

It also may be stated that the procedure enables dimpling simultaneously with the sheets in place even though the inner side of the covering is normally considered inaccessible. The die with its relatively short pin and its long handle may be located without difficulty even though obstructions be present, although it may be added here that the handle may be bent or otherwise arranged to project from the die in a manner that would be most accommodating to the inner side of the sheets. Additionally, the procedure enables doing all work, with the exception of

locating the inner die, at the outer side of the sheets. Generally, it may be said further that the invention allows the dimpling operations to be effected with greater rapidity, with precision and with uniformity.

Although only one form of the invention has been illustrated and described in detail, it will be apparent to those skilled in the art that various modifications may be made without departing from the scope of the appended claims.

What is claimed is:

1. The method of dimpling metal plates together for riveting which comprising providing aligned holes through the plates which are drilled under size, dimpling the metal around the holes by pressing it in one direction axially of the hole, then drilling the hole to larger size whereby the corner edges of the metal apt to be cracked or weakened are removed and the surface of the hole is rendered more cylindrical in character.

2. The method of dimpling the metal about an opening in laminated metal sheets which comprises providing a tool having a frusto-conical end adapted to press the sheets from one side, marginally supporting the opposite sides of the sheets around the area to be dimpled, providing an abutment at said opposite side of the sheets and against which the corner like edge at the smaller end of the dimple in the adjacent dimpling sheet is adapted to strike prior to final movement of the tool and final shaping of the dimple to substantial conformity to the tool so that said edge of the sheet metal will be flattened, and moving the tool relative to the marginal support and abutment to finally shape the dimple in conformity to the tool and to effect flattening of said edge while leaving the sheet metal unsupported between the marginal support and the abutment, whereby breaking or cracking of said edge is prevented by flattening thereof while still allowing the tool to form a deep dimple with minimum force requirements.

3. The method of dimpling the metal about an opening in laminated metal sheets, which comprises providing a tool having a conical end adapted to press the sheets from one side, marginally supporting the opposite side of the sheets around the area to be dimpled, providing an abutment at said opposite side of the sheets and against which the corner like edge at the smaller end of the dimple in the adjacent dimpling sheet is adapted to strike prior to final movement of the tool, so that said corner edge will be flattened, moving the tool relative to the marginal support and abutment to shape the dimple in conformity to the tool and to effect flattening of said edge while leaving the sheet metal unsupported between the marginal support and the abutment, and limiting such dimpling and edge flattening operations by limiting the movement of the tool relative to the sheet metal around the area being dimpled.

4. Apparatus for dimpling the metal around an opening in laminated metal sheets preparatory to riveting the sheets, comprising a tool having a frusto-conical end adapted to press the sheets from one side, means for marginally supporting the opposite side of the sheets around the area to be dimpled, means providing an abutment within the marginal support at said opposite side of the sheets and against which the corner-like edge of the smaller end of the dimple in the adjacent sheet is adapted to strike, the area be-

tween the marginal support and abutment means being open so that in the dimpling operation when the corner edge initially contacts the abutment means, the sheet is unsupported between the marginal support and the abutment means, and means for moving the tool relative to the marginal support and abutment in order to form the dimple and flatten said corner edge.

5. Apparatus for dimpling the metal around an opening in laminated metal sheets preparatory to riveting the sheets, comprising a tool having a frusto-conical end adapted to press the sheets from one side, a die element adapted to be disposed at the opposite side of the sheets, said die having an annular shoulder adapted to support the sheets around the margin to be dimpled and a central recess into which the dimple is formed, a pin connected to the die element and projecting from the center of the recess, and which is adapted to extend through the opening in the sheets, said tool having an opening through which the pin extends, and means for pulling the pin through the tool and applying the reactionary force to the tool.

6. Apparatus for dimpling the metal around an opening in laminated metal sheets preparatory to riveting the sheets, comprising a tool having a frusto-conical end adapted to press the sheets from one side, a die element adapted to be disposed at the opposite side of the sheets, said die having an annular shoulder adapted to support the sheets around the margin to be dimpled and a central recess into which the dimple is formed, a pin connected to the die element and projecting from the center of the recess, and which is adapted to extend through the opening in the sheets, said tool having an opening through which the pin extends, and means for pulling the pin through the tool and applying the reactionary force to the tool, the recess in the die element being of such character that during the dimpling operation the corner-like edge of the smaller end of the dimple in the sheet adjacent the recess will strike the bottom of the recess while the sheet is unsupported between such edge and the marginal shoulder support.

7. Apparatus for dimpling the metal around an opening in laminated metal sheets preparatory to riveting the sheets, comprising a tool having a frusto-conical end adapted to press the sheets from one side, means for marginally supporting the opposite side of the sheets around the area to be dimpled, means providing an abutment within the marginal support at said opposite side of the sheets and against which the corner-like edge of the smaller end of the dimple in the adjacent sheet is adapted to strike, the area between the marginal support and abutment means being open so that in the dimpling operation when the corner edge initially contacts the abutment means, the sheet is unsupported between the marginal support and the abutment means, means for moving the tool relative to the marginal support and abutment in order to form the dimple and flatten said corner edge, and means for automatically limiting such relative movement of the tool, support, and abutment.

8. Apparatus for dimpling the metal around an opening in laminated metal sheets preparatory to riveting the sheets, comprising a tool

having a frusto-conical end adapted to press the sheets from one side, a die element adapted to be disposed at the opposite side of the sheets, said die having an annular shoulder adapted to support the sheets around the margin to be dimpled and a central recess into which the dimple is formed, a pin connected to the die element and projecting from the center of the recess, and which is adapted to extend through the opening in the sheets, said tool having an opening through which the pin extends, means for pulling the pin through the tool and applying the reactionary force to the tool, and means for automatically limiting such relative movement of the tool and pin.

9. Apparatus for dimpling the metal around an opening in laminated metal sheets preparatory to riveting the sheets, comprising a tool having a frusto-conical end adapted to press the sheets from one side, a die element adapted to be disposed at the opposite side of the sheets, said die having an annular shoulder adapted to support the sheets around the margin to be dimpled and a central recess into which the dimple is formed, a pin connected to the die element and projecting from the center of the recess, and which is adapted to extend through the opening in the sheets, said tool and frusto-conical end thereof having an opening closely but slidably receiving the projecting pin with the smaller end of the frusto conical portion defining a substantially sharp edge around and close to the pin surface, and means for pulling the pin through the tool and applying the reactionary force to the tool.

10. Apparatus for dimpling the metal about an opening in laminated metal sheets which comprises a tool having a frusto-conical end adapted to press the sheets from one side, means for marginally supporting the opposite side of the sheets around and in close proximity to the area to be dimpled, means for moving the tool relative to the marginal support, and means for automatically limiting the relative movement of the tool and support, in order to limit the dimpling action, the structure being such that the surface of the frusto conical metal between the edge of the opening and the marginal support at the side opposite the tool is unsupported during the entire dimple forming operation.

11. Apparatus for dimpling the metal around an opening in laminated sheets preparatory to riveting the sheets, comprising a tool element having a frusto-conical end adapted to press the sheets from one side, a die element adapted to be disposed at the opposite side of the sheets, and die element having an annular shoulder adapted to support the sheets around the margin to be dimpled and a central recess into which the dimple is formed, a pin connected to and projecting centrally from one element and adapted to extend through the opening in the sheets, the other element having a central opening through which the free end of the pin projects, and means for pulling the projecting end of the pin and applying the reactionary force to said other element so as to move the frusto-conical end of the tool into the die recess.

LOUIS C. HUCK.

CERTIFICATE OF CORRECTION.

Patent No. 2,292,446.

August 11, 1942.

LOUIS C. HUCK.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 58, for the word "meal" read --metal--; and second column, line 13, claim 1, for "comprising" read --comprises--; page 4, second column, line 56, claim 11, for "and" read --said--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of September, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.