The invention relates generally to riveting and it has particular relation to dimple riveting and the formation of dimples in metal sheets to be riveted together.

In certain respects the present invention is related to that embodied in my copending application Serial No. 327,138, filed April 1, 1940, now Patent No. 2,292,446, wherein a simplified form of dimpling apparatus is shown along with a disclosure of methods of dimple riveting. As discussed in that application for patent, 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 counter sinking, 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 aeroplane 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 creepage 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 creepage 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 may 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 sheets 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’t 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.

Additional to the foregoing, one practice heretofore has been to employ a die member having a conically sided cavity for the metal to be
3 dimpled into and a conically sided tool for pressing the metal into the die and then to employ powerful forces or pressures which caused the sheet metal to be squeezed between the side walls of the die and tool until the dimple angles conformed to the angles of the tool and die. This type of operation is complicated by the fact that the metal naturally thins out towards the deeper part of the dimple and the angle of the dimple at the die side naturally tends to become different from that at the tool side. Furthermore, this difference between angles varies with differences in thickness of sheets and as a result, many different die and tool combinations are required and the amount of squeezing varies considerably with the variations in thickness.

A further factor involved in this prior practice and which limited the die angle or rather dimple depth at the die side of the sheets was the danger of cracking or splitting of the metal. Thus, due to limitations in the die angle, it usually was necessary to squeeze the metal even more in order to obtain the desired dimple angle at the tool side. One object of the invention is to provide a dimpling apparatus such as mentioned which may be operated from one side of the assembled sheets without requiring more than the location of a die at the other side of the sheets.

Another object of the invention is to provide an efficient, small, and easily maneuverable dimpling apparatus, which is operated by fluid pressure.

Another object of the invention is to provide dimpling apparatus such as mentioned heretofore, which includes means for centering and guiding a mandrel into the end of a dimpling tool forming part of the apparatus.

Another object of the invention is to provide a mandrel centering and guiding device such as last mentioned which automatically is retracted to an out of the way position during the dimpling operation so that it will not interfere with movement of the tool into engagement with the sheet metal.

Another object of the invention is to provide improved means for modifying the tendency of the sheets to bend during the dimpling operation so that bending will be avoided or controlled in a desirable manner.

Another object of the invention is to provide an improved dimpling apparatus having means for counteracting this tendency of the sheets to bend during the bending operation, wherein the action of this counteracting tendency of the sheets may be varied by adjustments provided for this purpose.

Another object of the invention is to provide improved dimpling apparatus wherein the means for counteracting the tendency of the sheets to bend during the dimpling operation includes a separate pressure controlled means for applying pressure to the sheets around the dimpling area.

Another object of the invention is to provide an improved dimpling apparatus for dimpling assembled metal sheets which includes mandrel or pin gripping jaws and a means for automatically retracting or releasing the jaws at the end of the dimpling operation, so that the mandrel or pin may be easily released and again inserted.

Another object of the invention is to provide an improved mechanism for dimpling metal sheets which will require minimum force while still allowing a suitable dimple to be formed without breaking or cracking of the dimpled metal.

Another object of the invention is to provide an improved mechanism for dimpling metal sheets which will enable forming the dimple with minimal forces and which will automatically govern the formation of the dimple by controlling the amount of force applied.

Another object of the invention is to provide an improved mechanism for dimpling metal sheets wherein the dimpling operation will automatically be governed by a stop means limiting the relative movement of the dimpling members.

Other objects of the invention will become apparent from the following description, from the drawings forming a part of the specification, and from the claims hereinafter set forth.

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

Figure 1 is a longitudinal view, mainly in cross-section, of apparatus for forming dimples in assembled metal sheets, as constructed according to one form of the invention;

Fig. 2 is a cross-sectional view taken substantially along the line 2—2 of Fig. 1;

Fig. 3 is a cross-sectional view taken substantially along the line 3—3 of Fig. 2;

Fig. 4 is a fragmentary view on the order of Fig. 3, illustrating the relation of parts approximately at the end of the dimpling operation;

Fig. 5 is a cross-sectional view of dimpling apparatus in general on the order of that shown by Fig. 1, as constructed according to another form of the invention;

Fig. 6 is an enlarged detail view, in cross-section, illustrating the relation of parts of the second apparatus at the beginning of the dimpling operation;

Fig. 7 is a view showing approximately the relation of the parts at the end of the dimpling operation;

Fig. 8 is a view on the order of Fig. 1, showing another form of the invention;

Figs. 9, 10, and 11 are detail views illustrating steps in the operation of the mechanism shown by Fig. 8.

Referring to Fig. 1, the dimpling mechanism or gun as shown comprises a cylinder 10 having a handle 11 secured thereto by suitable means not shown, so that the gun may be manually held and manipulated. The cylinder 10 has an inner cylindrical wall 12 slidably receiving a piston 13 having suitable sealing rings 14 for preventing a leakage of fluid between the wall and piston. At its right hand end, the cylinder is closed by an integral wall portion, excepting for a fluid passage 15, and this passage leads to an annular passage 17 at the junction of the handle and cylinder and in turn the annular passage 17 communicates with a passage 18 extending through the handle for connection with a fluid conducting line 19.

At its left end the cylinder 10 is enlarged thereby forming a shoulder 22 and within the enlargement a bushing 23 is threaded as indicated at 24. An annular end member 25 has a cylindrical portion 26 slidably receiving a piston rod 27 projecting from the piston 13 and a recess 28 having packing rings 29 engaging the rod and this member is held in position of the cylinder by a collar 30 thereon disposed between the end of the bushing 23 and the shoulder 22. A gasket 31 is located between the shoulder and collar 22 to prevent leakage of fluid at this point.

The extreme right end of the member 25 has an annular relief 35 which communicates with a fluid passage 37 extending laterally through the wall of cylinder 10 and communicating with a passage 38 leading to the handle 11. The passage 38 also extends through a projection 41 on the cylinder 10 disposed in a similar opening 42 in the
handle and from this point the passage is connected with a passage 43 leading to an outlet 44. Sealing gaskets 45 and 46 disposed at the junction of the casing and handle portions prevent leakage of fluid.

The E-plate 57, at its left end, terminates in a threaded portion 59 and on this threaded portion a jaw holder 51 is threaded and is retained in place by means of a lock nut 52. The left end of the jaw holder is provided with a plurality of circumferentially arranged sockets 53, which converge toward the left end of the jaw holder and which respectively receive similarly shaped jaws 54. The sockets and surfaces of the jaws may represent conical forms, or, in other words, the surface of each socket and the outer surface of each jaw may form a section of a conical surface, with the surfaces having substantially full surface contact when the jaws are in clamping positions. Grooves 56 in the inner faces of the jaws are adapted to engage a grooved mandrel to be mentioned presently, and when the end of the mandrel is between the jaws, movement of the jaw holder to the right will cause the jaws to grip the mandrel.

The jaws are urged towards the left end of the jaw holder by means of a jaw follower 57 mounted on a reduced end portion 55 of a plunger 59 that is slidably mounted in a bore 60 in the left end of the piston rod. A spring 61 in such bore urges the plunger 59 and jaw follower 57 to the left and hence the jaws to the left end of the jaw holder. It may be observed that the right ends of the jaws have angled or tapered faces 84 and that the left end of the follower 57 is similarly indicated at 85, and this relation of surfaces is provided in order to effect expansion of the jaws when forced to the right relatively to the jaw holder.

The bushing 33 has an outer cylindrical portion 67 threaded as indicated at 93 and upon which a barrel 63 is threaded, and the latter at its left end has an inwardly extending end wall 70 terminating in a threaded aperture 71 adjacent the end of the jaw holder 51. A metal dimpling tool 72 is threaded into the threaded aperture 71 until a head 73 thereon engages the wall 70 of the barrel and the inner end of the tool is shaped to fit the left end of the jaws so as to provide an abutment which serves to force the jaws rearwardly when the jaw holder and piston move to the left. In other words, just before the piston reaches its left limited position, the jaws strike the end of the tool 72 and are moved to the right relative to the jaw holder 51 and also radially outwardly into releasing position due to the relation of the surfaces 84 and 85 on the jaws and follower 57. Hence, the jaws move outwardly in their sockets to releasing positions and this movement is such that the mandrel mentioned previously may be freely removed axially from the jaws. It may be observed here that the tool 72 has an axial bore 78 leading to the jaws so that the mandrel may be inserted axially through the tool 72 and position between the jaws.

For dimpling sheets of metal indicated at 71 and 78 disposed in overlapping relation, a die 79 is employed which has a recess 80 into which the metal is forced during the dimpling operation and a rounded edge 81 adapted to engage the sheet metal around the dimpling face for trapping the metal. This die is centrally apertured as indicated at 82 and the mandrel previously mentioned and indicated at 84 extends through this opening. The mandrel may have a press fit in the opening 82 so that it will not easily removable and has a head portion 83 for preventing pulling of the mandrel through the die during the dimpling operation. It may be noted that the die outwardly of the recess 80 has its face next to the sheet metal 77 relieved and indented and the purpose of this is to provide a space for the sheet metal to be axially pressed to the left around the dimpling area in counteracting or modifying bending caused by the dimpling operation. The mandrel 84 has a grooved or ribbed end 86 adapted to fit between the grooved jaws 54 in order to positively lock the jaws and mandrel together during the dimpling operation. For forcing the sheet metal into the die recess 80, the tool 72 has a frusto conical end 81, which, when moved against the sheet, dimples the sheets into the die recess 80.

It is to be observed that the die recess 80 has a flat bottom 83 and a cylindrical side wall 89 and that the edge of the sheet metal is flattened against the bottom 83 during the dimpling operation while the metal between the shoulder 81 and the flattened edge is unsupported. This flattened edge is indicated at 88 and during its formation the metal is upset along the mandrel as indicated at 99. Flattening of the metal edge prevents splitting or cracking and thereby allows the dimple to be formed without danger of splitting. At the same time, by leaving the metal unsupported between the edge 88 and shoulder 81, it is easier to form the dimple and, therefore, a smaller force may be used and this is of considerable importance since smaller pressures may be used that will not endanger breaking of the mandrel 84. It may be observed that the dimple portions tend to extrude or shift towards the die along wall 89 of the latter a slight amount as indicated at 76 due principally to the fact that the diameter of the wall 89 is less than the diameter of the tool 72 plus the doubled thickness of the sheets 77 and 78.

During dimpling of sheets such as mentioned, bending of the latter around the dimpling area tends to occur, and if not counteracted or modified the sheets finally will become bowed or arcuate and this may be undesirable. To offset or modify this tendency of the sheets to bend, means are provided which will be described presently for exerting a force against the sheets during the dimpling operation and this force tends to bend the sheets over the rounded edge 81 of the die and towards the relief 86 in the die face. It may be desirable when the dimpling operation is effected to have the sheets remain flat, but again it may be desirable to variably control the amount of bending of the sheets over the edge of the die so that finally the sheets will have a desired contour. It would be feasible to so vary the force applied to the sheets to bend them that the sheets as finally dimpled would have a bent contour opposite to that which would have been obtained through the dimpling operation alone. Therefore, it should be understood that the contour of the sheets may be varied simply by varying the pressure applied to the sheets to bend them.

It may be mentioned now that the frusto-conical end of the tool 72 presents a problem of mandrel insertion into the bore 75, because the opening for inserting the mandrel is approximately the same size as the mandrel and there is nothing on the tool end to guide the mandrel into the opening. Where dimples must be formed rapidly, some delay might be incurred in repeat-
A spring 95 encircling the barrel and engaging a collar 96 at the right end of the latter. A shoulder 97 on the outer sleeve 91. Attention is directed to the fact that the barrel has a shoulder 100 which is in a position to engage the shoulder 97 on the sleeve 91 when sufficient relative movement of the barrel and sleeve occurs in an axial direction. A flange or rim 101 on the sleeve 91 normally will prevent anyone from accidentally having a finger caught between the two shoulders during operation of the mechanism and also will prevent certain objects of other character from becoming disposed in the space between the two shoulders.

The left end of the sleeve 90 has a relatively thick end wall 105 which is apertured at its center as indicated at 106 for allowing passage of the tool 72 through the wall. Now for providing a means for facilitating the insertion of the end of the mandrel into the frusto conical end of the tool 72, radially disposed guide members are provided in the end wall 105 and these members have pin portions 107 slidably mounted in radial openings 108 in such wall. Springs 109 in the openings 108 urge the members inwardly and the outer ends of the springs are retained in the openings by plugs 110 suitably secured in the outer end of the latter. The inner ends of the springs 109 carry centering or guiding portions 111, respectively, and these centering portions, when brought together as shown in Figs. 1, 2, and 3, jointly form a frusto conical cavity at the right side which fits the frusto conical end of the tool 72, and at the left side, a frusto conical cavity 112 for guiding the pin 84 into the bore of tool 72. It is to be observed that the portions 111 are disposed in an annular channel shape recess 113 and that they are guided radially by the walls of the recess. It may be noted also that the centering devices are formed at their center to provide an opening which will allow the end of the mandrel to be pushed therethrough.

With the sleeve 90 moved to its extreme left position as governed by the slots 94 and 93, it will be apparent that the spring pressed guiding devices will be urged to the positions shown in Fig. 1, so that they will form a centering and guiding cavity which renders it easy to insert the end of the mandrel. On the other hand, it will be apparent that the sleeve 90 can be moved to the right easily and against the action of the spring 95 and the plunger springs 109 and that during this operation the pivot 98 and the plunger springs 109 will be moved outwardly by the tool 72, thereby allowing the latter to pass through the end wall 105 of the sleeve.

For applying pressure to the sheets in order to modify the bending tendency, a rubber bushing 116 is mounted on the end face of the wall 105 and this bushing may be retained in place by an overhanging flange 116 although it may be desirable to bond the bushing to the end face of the wall. This rubber sleeve is adapted to engage the end of the outer sleeve 90 and is arranged in such a manner that it will tend to apply pressure thereto during the dimpling operation. Attention is directed to the fact that an angular ring 120 confines the inner corner edge of the bushing at its outer end and this washer is provided mainly to prevent the rubber from being deformed in that position where it would be caught by the tool moving into the die during the dimpling operation. In other words, it confines the corner at this point and governs the flow of rubber and at the same time a radial leg of the washer provides a metal face contact with the sheet immediately adjacent the dimpling area and this may be found desirable in order to insure flatness of the sheet immediately adjacent the edge of the dimpling area.

It has been stated that the shoulder 100 on the barrel 95 is adapted to engage the shoulder 97 on the sleeve 91, and that this engagement will occur after a predetermined relative axial movement of the sleeve and barrel. In other words, the distances between the two shoulders governs the movement required before engagement of the external resistance of the two shoulders; it is only necessary to turn the sleeves 90 and 91 relatively which will adjust the position of the shoulder 97 on the sleeve 91 with respect to the ends of slots 94 and pins 93, holding the sleeve 90 in its outermost position. While it is desirable to have the sleeves 90 and 91 relatively turnable in order to make this adjustment, it is also expedient that turning not accidentally occur and in order to normally prevent turning of sleeve 91 on the sleeve 90, a plunger 120 is provided as shown by Figs. 2 and 3. This plunger is disposed in a recess 121 in the end wall 108 of sleeve 90 and is pressed outwardly by means of a spring 122. The outer end of the plunger is adapted to selectively fit circumferentially spaced notches 123 arranged on the inner periphery of the sleeve 91 and the outer end of the sleeve overhangs the plunger 120 so that normally release of the plunger will not occur. When it is desired to relatively turn the sleeves, the plunger may be pushed inwardly by any suitable instrument and then the sleeve 91 may be turned on the sleeve 90 until the sleeves are in the positions desired, and then the plunger may be allowed to enter an adjacent notch 123. It will be apparent, of course, that the pins 93 on the barrel 95 prevent turning of the sleeve 90 relatively to the barrel.

Fluid under pressure may be conducted through the lines 19 and 44 to either side of the piston 13 and ordinarily high fluid pressure will be required at the left side of the piston since movement of the piston to the right is the working movement while a lower fluid pressure may be used to have the piston to their original position; it being understood that fluid will exhaust at one side of the piston while being allowed to flow into the cylinder at the opposite side of the piston.

Assuming that the dimpling operation is now to be repeated, the die 19 with attached pin is associated with the sheets 77 and 78 and the mandrel is passed through a previously drilled opening in the sheets around which the dimpling is to occur. The dimpling mechanism is moved over the projecting mandrel to the position shown in Fig. 1 and it now will be ready apparent that
When the mechanism is moved over the projecting end of the mandrel, the guiding devices 11 will facilitate movement of the mandrel into the end of the tool 12.

When the parts are positioned as shown in Fig. 1, and the rubber bushing is against the sheet 18, the operator applies further pushing effort to the mechanism and toward the sheet 18 and this will cause the barrel 59 and tool 72 carried thereby to move to the left relative to the sleeves 90 and 91, and as a result, the tool 72 will spread the guiding devices 111 and move through the end wall 105 and through the rubber bushing. During this action, the spring 95 is compressed and the shoulders 97 and 100 relatively approach each other. Final movement of the plunger 72 manually in this respect, causes the grooved end of the mandrel to move into the space between the jaws 54 until it engages the end of the reduced portion 58 of the plunger 55. This serves notice to the operator that the parts are in operative position and in particular that the end of the mandrel is located properly between the jaws.

When the parts are in this relation, the fluid under pressure is caused to enter the cylinder at the left side of the piston 13 and to exhaust from the right side of the piston and as a result the piston 13 will move to the right relative to the cylinder. The first part of this movement will cause the jaw holder 51 to move relative to the jaws 54 and clamping of the jaws about the end of the mandrel will occur. Further movement of the jaw holder and piston then will carry the jaws and mandrel therewith but if the sheets 71 and 78 are in a relatively fixed position, the piston 13 and parts carried thereby instead of moving, will remain stationary so to speak, while the barrel will move to the left. In any event, after the piston has moved sufficiently to cause the jaws to be clamped about the end of the mandrel, relative axial movement of the barrel and tool 72 with respect to the mandrel will occur and this will cause the frusto-conical end of the tool to move through the bushing and to press the sheets 71 and 78 into the die recess 85 thus performing the dimpling operation. During the dimpling operation, the shoulders 100 and 97 on the barrel 69 and sleeve 91, respectively, will engage each other and then the sleeves 50 and 91 will be directly and positively moved by the barrel and will forcefully press the rubber bushing to apply the pressure against the sheet 78. Thus, the pressure becomes positive and direct except for the resiliency of the rubber during the dimpling operation, although the pressure may become positive and direct earlier or only during part of the dimpling operation, depending upon the location of the shoulders 97 and 100 relatively. From this it can be seen that the shoulders 97 and 100 can be adjusted axially in a relative sense so that the barrel will pick up the sleeves 50 and 91 at a desired time to cause direct and positive pressure through the rubber bushing and against the sheet 78 and preliminary movement of the barrel relative to sleeve 91 will compress the spring 95, ordinarily this pressure would not be of such character as to bend the sheets as the spring ordinarily is used to return the sleeves 50 and 91 to their lefthand position when the parts are returned to the operative position as seen in Fig. 1. By placing the shoulders 97 and 100 closer together, positive and direct pressure to the rubber bushing can be secured earlier and it follows that the pressure applied by the rubber will become greater and greater as the tool and die move together. The amount of pressure thus can be determined by adjustment of the shoulders 97 and 100 relatively, and as stated before, modification of the bending of the sheets during the dimpling operation can be varied and the contour of the sheets can actually be governed as may be found most desirable.

Fig. 4 shows a large scale approximately at the end of the dimpling operation. Deformation of the tool 72 naturally will occur owing to its incompressible character and accordingly it will expand as shown. In effecting the aforesaid dimpling operation, a fluid pressure system may be employed as diagrammatically illustrated in Fig. 1 and which generally may correspond to the system embodied in my Patents Nos. 2,088,659 and 2,132,112. This system includes a fluid tank or reservoir 124, a motor driven pump 125, a control valve 126, solenoids 127 and 128 for moving the valves in opposite directions, respectively, and a pressure booster 129 including a small barrel 131. The supply line leading from the pump is indicated at 132 and an adjustable relief by-pass valve 133 in this line is also connected to a return line 134 leading to the tank. The valve allows the liquid to by-pass to the tank when necessary and may be so adjusted that the necessary dimpling pressures in any case will be available before by-passing occurs. Fluid is delivered to the booster when the valve 126 is in one position and from the booster barrel 131, the fluid flows through a line 133 leading to the valve 125. With the valve 126 in one axial position, fluid is supplied to line 19 directly from the pump in order to return the piston 13 to its inoperative position, whereas, when the valve is reversed, the line 48 is placed in communication with the barrel 131. Higher pressure is available therefore for the working stroke but when this pressure reaches a definite amount, the valve 133 will allow by-passing from which it follows a definite but adjustably limited pressure may be employed for governing the character of the dimpling action.

A trigger 130 on the handle 11 may control switches not shown for either energizing one or the other of the solenoids 127 and 128 depending upon whether the trigger is moved in one direction or the other.

From the foregoing it will be understood that when the trigger is operated to effect the dimpling operation, the tool 72 will press the sheets into the die recess until the edge of sheet 77 strikes the bottom 88 of the die and then continued movement of the tool will deepen the dimple since the metal is unsupported between the bottom 88 and shoulder 91 of the die, but the resistance to dimpling increases with the dimpling, and as flattening of the edge occurs and at a predetermined pressure, the valve 133 will operate to by-pass the liquid to the tank. It should be appreciated that a high pressure fluid is required to dimple the metal and to get the correct dimple angle since the die is unsupporting to the side of the dimple, while at the same time it should be appreciated that cracking in prevented by the flattening and upsetting of the edge of the sheet metal.

Under certain circumstances, liquid under pressure may be supplied to the line 44 and air under pressure to the line 19 in accordance with the system disclosed in my Patent No. 2,053,715, relating to Riveting mechanism. In this case, the trigger 130 will operate a valve on the handle for connecting and disconnecting the pas-
A fluid supplying system such as shown in the patent to Petersen No. 2,103,027 also may be employed in which case the lines 15 and 16 of such patent will correspond with the lines 44 and 45 respectively. Also, the switch 49, 51 in the patent will correspond with the trigger 130 in the present application so that operation of the trigger 130 will control the system in the manner that the switch in the patent controls the supply of fluid under pressure in the lines 15 and 16. In using a system of this character, operation of the switch will cause fluid under pressure to be supplied to line 44 until resistance is encountered such as when the end of the tool 72 first engages the plate 78 and then a higher fluid pressure may automatically be supplied to perform the dimpling operation. In this system, when the pressure on the piston reaches a determinate amount in the dimpling operation, automatic reversal of fluid flow may occur so that the piston will be reversed automatically.

In all the systems, it is desired that the control be simple and handy for the operator, such as by employing a trigger on the handle of the gun and that the lines 19 and 44 be flexible in character so that the fluid supplying or developing source can be located remotely to the dimpling mechanism from which it follows that the operator may be at some distance from the source of fluid pressure while still maintaining complete control through a simple form of controlling means on the mechanism. It may be added that where the trigger on the handle operates electrical controlling means, wires will lead from the handle to the electrically controlled valves or means at the source of pressure development.

In the construction shown by Figures 5, 6, and 7, a different means for applying pressure to the sheets is provided, and principally the difference resides in the use of fluid pressure means at the end of the casing. In this case, a barrel 142 is used which takes the place of the barrel 69 and the inner end of the barrel is threaded on the flange 67 of the brushing 23. The tool indicated at 141 is threaded into the end wall of the barrel 142, and has an annular channel 142' formed therein so that the member, barrel and tool move as a unit. The channel in the member 142, which is indicated at 141, forms a cylindrical space for a ring-like piston 145 that is adapted to be moved axially by causing a line of communicating with the channel-space at the right side of the piston 145 and which leads to the space at the left side of the piston 143. A pressure reducing valve 147 may be provided in the line 146 so that the pressure supplied to the space 144 may be varied or regulated as desired. This valve may perform the function that pressure supplied to the space 144 may be constant or a valve may be used which causes the pressure supplied to the space 144 to be proportional to the pressure supplied to the left side of the piston 143.

The ring-type piston 145 terminates at its left end in a threaded flange 145a which is threadedly connected to a threaded flange 145b extending axially from a ring plate 149. Sealing rings 150, 151 are provided in the radial inner and outer sides of the space 144 for engagement with the piston 145. In order to prevent fluid from leaking around the ring and these rings are respectively held in position by means of threaded bushings 152 and 153 threaded on the inner and outer legs of the channel member 162. The bushing 153 has an inwardly offset portion 153a which is so arranged that movement of the piston 145 is definitely limited in order to maintain the parts assembled. The plate 149 carries a rubber bushing 151 and this bushing may be on the order of that previously described in connection with Figure 1. No means for centering the end of the mandrel 84 with respect to the bore in the tool 141 is provided in this case, but it is evident that if found expedient, a centering device such as employed in Figure 1 could also be employed in the second structure. This could be readily accomplished by employing a ring plate 145 which is thicker in a direction axially of the mechanism, providing radially movable centering and guiding devices such as are provided in the end wall 165 in the structure shown by Figure 1 and providing for greater relative axial movement of the piston 145 in member 142.

In operating the structure shown in Figs. 5, 6 and 7, the mechanism is moved over the mandrel 84 until the grooved end of the latter is disposed between the jaws and upon introduction of fluid under pressure to the left side of the piston 143, the jaw holder is first moved to clamp the jaws about the end of the mandrel and then movement of the jaw holder, piston and mandrel relative to the barrel 145 occurs. It follows that the tool 141 and the mandrel 84 and die 78 will have relative movement axially of the mechanism and that the plates will be dimpled by the end of the tool, pressing the sheet into the grooves. By employing fluid pressure for forcing the rubber bushing 153 against the plate, a variable pressure may be obtained to secure the results desired and this pressure may be variably proportional to the fluid pressure employed in the dimpling operation and it may be a constant, but adjustable pressure depending upon the regulating means used. The pressure regulating means used may be of any conventional type well known in the art.

Figure 7 shows the dimpled sheets following operation of the mechanism shown by Figures 5 and 6, and shows the resilient bushing as compressed. It should be understood that the operation is repeated by alternating fluid to the right of the piston and exhausting it from the left; the movable parts will reversely move and finally that the jaws will be released so that the mandrel may be separated from the mechanism.

Now referring to Figs. 8 to 11, inclusive, the mechanism disclosed in these figures is similar to that shown by Fig. 1, with the principal exception that an anvil is movable with the tool 72 and is adapted to engage the sheet metal. In this structure, a sleeve 160 is substituted for the sleeve 88 shown in Fig. 1, but the two sleeves are threadedly connected in the same manner and cooperate with the barrel 68 and parts carried thereby in the same way that character-
izes the corresponding parts in Fig. 1. For guiding the mandrel 84 into the end of the tool 72, a guiding and centering device 161 is employed, which is on the order of that provided in Fig. 1, excepting that in this case it is slidably movable with respect to the sleeve 160, instead of being arranged in an end wall of such sleeve. The guiding and centering device 161 is in the form of a ring which has a close but sliding fit with the inner periphery of the sleeve 160, as indicated at 162, and the inner periphery of the ring slides on the outer surface of the tool 72. Also, the guiding and centering device has a tubular portion 164 at its outer side and the dimensions of this portion are sufficiently large to permit the tool 72 to move therethrough. A pad 165 comprising a ring of resilient material such as rubber, surrounds the tubular portion 164 and is maintained thereon at the outer end by means of a radial flange or shoulder 166. At its axially inner end, the rubber ring contacts a radial flange 167 on the outer end of the sleeve 160 and the character of the rubber ring is such that normally it tends to move the centering and guiding device 161 relative to the flange 167, so as to maintain the ring part of the centering device against the inner side of the flange. It may be observed that with the parts in initial positions, as shown in Fig. 8, the guiding and centering portions 161 are disposed substantially in contact with the conical end 87 of the tool 72, from which it follows that the centering portions are in position to guide the end of the mandrel into the end of the tool.

Now directing attention to enlarged views 10 and 11 in particular, it will be noted that the outer end of the tubular portion 164 terminates slightly beyond the radial flange 166 in an anvil 170, which is adapted to engage the sheet metal immediately around the area being dimpled. The anvil end face diverges outwardly with respect to the sheets as seen in Fig. 10 at an angle of 10°, for instance, and this angle is selected so that if the anvil coincides with said face, the angle which the coined surface makes with the sheet surface will be the same or slightly greater than the corresponding angle of the dimpling on the rivet embodied in an application for patent filed hereinafter to which further reference is made having respect thereto.

With respect to operation of this mechanism, several generalities may now be stated. In the first place, it is desired prior to insertion of the mandrel that the guiding and centering means be in proper position, as shown by Fig. 8, in which case the ring part of the device will be in contact with the flange 161 on the sleeve 160. It is also desired that the rubber pad be pressed against the sheets at least prior to the completion of the dimpling operation, so as to counteract and neutralize the tendency in the sheets to bend on account of the dimpling action. It is also desired that the flange 73 on the tool 72 engage the inner side of the guiding and centering device 161 so as to pick up the latter and cause it to move with the tool when the dimple has been formed to the proper depth.

Assuming that the mandrel and die are in position as shown in Fig. 8, the operator moves the handle and barrel 69 carrying the tool 72 relative to the sheets and die so as to cause the tool 72 to move through the guiding and centering device 161 until the inner end of the mandrel meets the stop previously described in connection with Fig. 1, at which time the outer end of the tool substantially contacts the sheet metal. At this time, the shoulder 160 on the barrel 69 preferably is slightly spaced from the shoulder 97 on the sleeve 81, depending on an adjustment of the sleeve 81 with respect to the sleeve 160. It will be understood in this connection that by turning the sleeve 91 relative to the sleeve 160, the shoulders 97 and 160 may be moved toward and from each other so as to govern the time when they contact and hence the time the rubber will be pressed against the sheet metal and the amount of pressure applied.

With parts as shown in Fig. 9, the operator presses the trigger 130 to cause the mechanism to function and when this occurs the mandrel and tool have relative movement which causes the conical end of the tool to press the sheet metal into the cavity in the die. When this occurs, the metal is dimpled into the die cavity and the corner edge of the inner sheet 71 becomes flattened against the base of the die cavity. At the time the dimple has the formation desired, the flange 73 on the tool contacts the inner wall of the guiding and centering device 161 so that further pressure acts through the anvil 170 in addition as well as the tool 72 and this contact serves as a means for stopping or limiting the further relative movement of the tool and die. It is intended that the pressure operating in the working stroke of the mechanism be so limited by the by-pass valve 133 or otherwise depending upon the particular system employed, that in the case of the thickest sheets of metal to be dimpled, the dimpling operation will require a little less than the maximum pressure available so that only a small differential of pressure will be taken through the anvil 170. In other words, in the case of the thickest sheets, when the anvils contacts the sheets upon formation of the dimple, only a small amount of additional pressure will be required to cause the by-pass valve 133 to function. This additional pressure may cause slight coining of the metal under the anvil, so that a shallow recess will be formed, but any movement of the anvil and tool therewith, by such additional pressure, will not undesirably change or alter the dimple. When thinner sheets are being dimpled, with the same pressure limitation as in the case of the thicker sheets, the pressure required for dimpling is much less and the relative movement of the tool is less and therefore the anvil takes a greater amount of the pressure before the value 133 by-passes, and deeper coining of the metal under the anvil will occur.

From the foregoing, it should be understood that the operator may use the mechanism for dimpling sheets of different thicknesses without varying the adjustment of the valve 133 or making any other adjustments on the mechanism. Hence, the dimples may be formed without regard to changes in the thickness that may occur in an airplane cover, for example, with the assurance that a proper dimple will be formed in each instance.

It might be added here that if a system is used such as disclosed in Peterson Patent No. 2,163,627, the mechanism would reverse just as soon as the pressure reached the limiting amount.

During the dimpling operation, the rubber is compressed against the sheets outwardly of the radial flange 166 and bends the sheets towards the die in the direction opposite that in which the sheets tend to bend as a result of the dimpling operation. As in the previous construction described, the pressure applied by the rubber may
be adjusted so that the contour of the sheets will remain flat or normal after dimpling operations are completed. If, however, the sheets are not adjusted, they may be changed to a convex or concave contour depending upon the pressure applied by the rubber, and this pressure is determined by the adjustment of the relative positions of shoulders 91 and 105 on sleeves 91 and barrel 65, respectively. The dimple or recess formed in the sheets has a conical portion 175 corresponding to the conical taper on the end of the tool 72 and at the outer edge of the dimple, the metal may be coined more or less, and a shallow recess corresponding in angularity to the angle of the anvil 170 is formed, as indicated at 176. Between the shallow recess 176 and the conical portion 175, the surface of the metal remains curved as a result of the bending action and is out of contact with the conical surface of the tool. This particular dimpling action adapts the dimpled recess to a particular rivet having a fairing for covering the shallow recess 175, if any, and for covering the curved part of the dimple, and a conical portion adapted to fit the conical portion 175 of the recess. A separate application is being filed on a rivet such as mentioned, and this application for patent is identified as Serial No. 352,205, filed August 12, 1940, now Patent No. 2,302,772.

As stated heretofore, the plates 17 and 18 may comprise laminations of an airplane cover and in this event they may be constructed of an aluminum alloy. It will be understood pursuant to this that the die 19, tool 72, pin 84, anvil 170, and other parts will be formed of suitably hard metal to perform the functions necessary in the use of the mechanism.

It will be apparent that all of the operations in so far as the use of force is involved occur at only one side of the sheets and that no backing element requiring forceful manual holding at the opposite side of the sheet is required. In other words, it is only necessary for the operator to insert the mandrel at one side of the sheet and move the die 19 thereon into position and then it is a simple matter to hold them in that position while the mechanism is moved over the mandrel at the other side of the sheet. It may be added here that after the dimpling operation, the opening through the sheets may be enlarged slightly by a drill for example, to provide a more fully cylindrical and smooth hole, as disclosed in my copending application, Serial No. 327,138, now Patent No. 2,322,446.

If the dimpling point is substantially removed from the edges of the sheet, a handle may be employed for allowing the operator to insert the mandrel at a point substantially removed from the edge. A handle 170 is shown on the die for this purpose, although it is to be understood that the handle may be replaceable so that it could be connected to the die only when needed. In any event, the handle allows the operator to place the mandrel and die in position even though the opening in the plate is substantially removed from the operator and relatively inaccessible and thus access to different points interiorly of an airplane cover, for example, may easily be had. Since it is only necessary to insert the mandrel through the opening in the plate, and lightly hold the mandrel in place while the mechanism is pushed over the end of the latter, it can be easily seen that an operator will have no difficulty in performing the work necessary at the die side of the structure. Since after the dimpling operation the mandrel is definitely released from the mechanism, all the operator needs to do is to pull the mandrel away from the sheets of metal.

Dimpling can be rapidly performed in this manner even at points inaccessible and all dimpling operations can be performed while the sheets are in place on airplane wings or fuselages or other installations where the sheets may be dimpled for subsequent riveting. Aside from this, the mechanism can be adjusted so that bending of the sheets that ordinarily would occur as a result of dimpling can be neutralized or counteracted so that finally undesirable deformations or bends can be avoided in the sheets. By having the mechanism connected to a remote source of fluid under pressure, the operator can quickly move from point to point for effecting one dimpling operation after another and since the gun is compact and light, this procedure is not fatiguing. Moreover, since the entire operation can be controlled by means of a trigger on the handle, all that the operator needs to do is to move the fluid gun from one point to another and push it over the mandrel or mandrels successively and repeatedly to move the trigger for effecting the dimpling operations. Two operators, one handling the mandrel and die device and moving it from point to point, and the other operating the dimpling mechanism and moving it from point to point, thus can rapidly effect one dimpling operation after another while the sheets are in place on the structure. Rapidity of dimpling of airplane structures is thus increased and the dimpling operations are performed accurately and uniformly.

Although more than 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. An apparatus for forming a dimple around an opening in metal sheets comprising a casing, movable fluid pressure responsive means in the casing, pin gripping means carried by the fluid pressure responsive means, a tool movable with the casing and having a central bore extending axially of the casing and having an end adapted to press the metal sheets at one side, a die element adapted to be disposed at the opposite side of the sheets and having a pin adapted to pass through the opening in the latter and through the bore in the tool and to be gripped by the pin gripping means, whereby upon actuation of the fluid pressure responsive means, the tool and die may be moved towards each other to dimple the metal, means on the casing adapted to apply pressure to the sheets around the dimpling area in order to modify bending of the sheets during the dimpling operation, and means for varying the pressure applied to the sheets by the last mentioned means during a predetermined amount of dimpling.

2. An apparatus for forming a dimple around an opening in metal sheets comprising a casing, movable fluid pressure responsive means in the casing, pin gripping means carried by the fluid pressure responsive means, a tool movable with the casing and having a central bore extending axially of the casing and having an end adapted to press the metal sheets at one side, a die element adapted to be disposed at the opposite side of the sheets and having a pin adapted to pass through the opening in the latter and through the bore in the tool and to be gripped by the pin gripping means, whereby upon actuation of the
fluid pressure responsive means, the tool and die may be moved towards each other to dimple the metal, resilient means on the casing adapted to apply pressure to the sheets around the dimpling area in order to modify bending of the sheets during the dimpling operation, and means for varying the pressure applied to the sheets by the last mentioned means during a predetermined amount of dimpling.

3. An apparatus for forming a dimple around an opening in metal sheets comprising a casing, pin gripping means movable in the casing, a tool movable with the casing and having a central bore extending axially of the casing and having an end adapted to press the metal sheets at one side, a die element adapted to be disposed at the opposite side of the sheets and having a pin adapted to pass through the opening in the latter and through the bore in the tool and to be gripped by the pin gripping means, whereby upon actuation of the fluid pressure responsive means, the tool and die may be moved towards each other to dimple the metal, means on the casing and being telescopically related to the tool, means on that end of the sleeve adjacent the metal pressing end of the tool adapted to apply pressure to the sheets around the dimpling area in order to modify bending of the sheets by the dimpling operation, and means for varying the operative position of the tool.

4. An apparatus for forming a dimple around an opening in metal sheets comprising a casing, movable fluid pressure responsive means in the casing, pin gripping means carried by the fluid pressure responsive means, a tool movable with the casing and having a central bore extending axially of the casing and having an end adapted to press the metal sheets at one side, a die element adapted to be disposed at the opposite side of the sheets and having a pin adapted to pass through the opening in the latter and through the bore in the tool and to be gripped by the pin gripping means, whereby upon actuation of the fluid pressure responsive means, the tool and die may be moved towards each other to dimple the metal, a sleeve axially slidable on the casing and being telescopically related to the tool, means on the end of the sleeve adjacent the metal pressing end of the tool adapted to apply pressure to the sheets around the dimpling area in order to modify bending of the sheets by the dimpling operation, and means for varying the operative position of the tool.
the last mentioned means in order to vary the pressure thereof during the dimpling operation.

9. An apparatus for forming a dimple around an opening in metal sheets comprising a casing, pin gripping means movable in the casing, a metal pressing element movable with the casing and having a bore extending axially of the casing and having an end adapted to press the metal at one side, a second metal pressing element cooperating with the first and adapted to press the metal at the other side and having a pin adapted to extend through the said bore and to be gripped by the pin gripping means, means for moving the pin gripping means and casing relatively whereby the two pressing elements may be moved toward each other to dimple the metal, means movable with respect to the casing for applying pressure to the sheets around the dimpling area in order to modify bending of the sheets by the dimpling operation, and abutments cooperatively carried by the casing and movable means and adapted to engage each other upon predetermined relative movement of the casing and pin gripping means during the dimpling operation.

10. An apparatus for forming a dimple around an opening in metal sheets comprising a tubular casing, pin gripping means axially movable in the casing, a tool projecting from one side of the casing and terminating in a frusto-conically shaped end adapted to press the sheets at one side, said tool having a central bore and being aligned with the pin gripping means so that a pin may be pushed through the tool and engaged by the pin gripping means, a die member to be disposed at the other side of the sheets and having a pin adapted to tool projecting through said opening in the latter and through said bore for engagement with said gripping means, means for relatively moving the gripping means and tool axially of the casing so as to bring the tool and die into sheet dimpling position and for returning the gripping means and tool to inoperative positions, and retractable guide means adjacent the frusto conical end of the tool and operative to guide the end of the pin into the bore when the tool is in inoperative position and being retractable so that during the dimpling operation the tool may move into contact with the sheets.

11. An apparatus for forming a dimple around an opening in metal sheets comprising a tubular casing, pin gripping means axially movable in the casing, a tool projecting from one end of the casing and terminating in a frusto-conically shaped end adapted to press the sheets at one side, said tool having a central bore and being aligned with the pin gripping means so that a pin may be pushed through the tool and engaged by the pin gripping means, a die member to be disposed at the other side of the sheets and having a pin adapted to tool projecting through said opening in the latter and through said bore for engagement with said gripping means, means for relatively moving the gripping means and tool axially of the casing so as to bring the tool and die into sheet dimpling positions and for returning the gripping means and tool to inoperative positions, and retractable guide means adjacent the frusto conical end of the tool and operative to guide the end of the pin into the bore when the tool is in inoperative position and being retractable so that during the dimpling operation the tool may move into contact with the sheets.

12. An apparatus for forming a dimple around an opening in metal sheets comprising a tubular casing, pin gripping means axially movable in the casing, a tool projecting from one end of the casing and terminating in a frusto-conically shaped end adapted to press the sheets at one side, said tool having a central bore and being aligned with the pin gripping means so that a pin may be pushed through the tool and engaged by the pin gripping means, a die member to be disposed at the other side of the sheets and having a pin adapted to tool projecting through said opening in the latter and through said bore for engagement with said gripping means, means for relatively moving the gripping means and tool axially of the casing so as to bring the tool and die into sheet dimpling positions and for returning the gripping means and tool to inoperative positions, and retractable guide means adjacent the frusto conical end of the tool and operative to guide the end of the pin into the bore when the tool is in inoperative position and being retractable so that during the dimpling operation the tool may move into contact with the sheets.

13. An apparatus for forming a dimple around an opening in metal sheets comprising a tubular casing, pin gripping means axially movable in the casing, a tool projecting from one side of the casing and terminating in a frusto-conically shaped end adapted to press the sheets at one side, said tool having a central bore and being aligned with the pin gripping means so that a pin may be pushed through the tool and engaged by the pin gripping means, a die member to be disposed at the other side of the sheets and having a pin adapted to tool projecting through said opening in the latter and through said bore for engagement with said gripping means, means for relatively moving the gripping means and tool axially of the casing so as to bring the tool and die into sheet dimpling positions and for returning the gripping means and tool to inoperative positions, and retractable guide means adjacent the frusto conical end of the tool and operative to guide the end of the pin into the bore when the tool is in inoperative position and being retractable so that during the dimpling operation the tool may move into contact with the sheets.

14. An apparatus for forming a dimple around an opening in metal sheets comprising a tubular casing, pin gripping means axially movable in the casing, a tool projecting from one side of the casing and terminating in a frusto-conically shaped end adapted to press the sheets at one side, said tool having a central bore and being aligned with the pin gripping means so that a pin may be pushed through the tool and engaged by the pin gripping means, a die member to be disposed at the other side of the sheets and having a pin adapted to tool projecting through said opening in the latter and through said bore for engagement with said gripping means, means for relatively moving the gripping means and tool axially of the casing so as to bring the tool and die into sheet dimpling positions and for returning the gripping means and tool to inoperative positions, and retractable guide means adjacent the frusto conical end of the tool and operative to guide the end of the pin into the bore when the tool is in inoperative position and being retractable so that during the dimpling operation the tool may move into contact with the sheets.

15. An apparatus for forming a dimple around an opening in metal sheets comprising a tubular casing, pin gripping means axially movable in the casing, a tool projecting from one side of the casing and terminating in a frusto-conically shaped end adapted to press the sheets at one side, said tool having a central bore and being aligned with the pin gripping means so that a pin may be pushed through the tool and engaged by the pin gripping means, a die member to be disposed at the other side of the sheets and having a pin adapted to tool projecting through said opening in the latter and through said bore for engagement with said gripping means, means for relatively moving the gripping means and tool axially of the casing so as to bring the tool and die into sheet dimpling positions and for returning the gripping means and tool to inoperative positions, and retractable guide means adjacent the frusto conical end of the tool and operative to guide the end of the pin into the bore when the tool is in inoperative position and being retractable so that during the dimpling operation the tool may move into contact with the sheets.
21. An apparatus for forming a frusto-conical type of dimple around an opening in sheet metal sheets comprising a die element disposed at one side of the sheets and into which the metal is pressed during the dimpling operation, a tool element having an end adapted to press the metal into the die element, abutment means movable with the tool and engageable with the sheet metal around the area to be dimpled for positively limiting movement of the tool into the die opening, resilient means movable against the sheet metal around the die element for controlling the tendency of the sheets to bend as a result of the dimpling operation.

22. An apparatus for forming a frusto-conical type of dimple around an opening in sheet metal sheets comprising a die element adapted to be disposed at one side of the sheets and into which the metal is pressed during the dimpling operation, a tool element having an end adapted to press the metal into the die element, abutment means movable with the tool and engageable with the sheet metal around the area to be dimpled for positively limiting movement of the tool into the die opening, and resilient means movable against the sheet metal around the abutment means for controlling the tendency of the sheets to bend as a result of the dimpling operation.
positions, retractible guide means adjacent the frusto-conical end of the tool and operative to guide the end of the pin into the bore when the tool is in operative position and being retractible so that the tool may move past the retractible means and into contact with the sheets, an anvil on the retractible means adapted to engage the sheet metal around the dimpling area to limit the dimpling operation, and abutment means on the tool for moving the retractible means and anvil therewith after the retractible means has been retracted to allow movement of the tool past the retractible means.

24. An apparatus for forming a dimple around an opening in metal sheets comprising a tubular casing, a pin gripping means axially movable in the casing, a tool projecting from one end of the casing and terminating in a frusto-conically shaped end adapted to press the sheets at one side, said tool having a central bore and being aligned with the pin gripping means so that a pin may be pushed through the tool and engaged by the pin gripping means, a die member to be disposed at the other side of the sheets and having a pin adapted to project through said opening in the latter and through said bore for engagement with said gripping means, means for relatively moving the gripping means and tool axially of the casing so as to bring the tool and die into sheet dimpling positions and for returning the gripping means and tool to operative positions, retractible guide means adjacent the frusto-conical end of the tool and operative to guide the end of the pin into the bore when the tool is in operative position and being retractible so that the tool may move past the retractible means and into contact with the sheets, an anvil on the retractible means adapted to engage the sheet metal around the dimpling area to limit the dimpling operation, abutment means on the tool for moving the retractible means and anvil therewith after the retractible means has been retracted to allow movement of the tool past the retractible means, and resilient means around the anvil for pressing against the sheet metal to modify bending of the sheets during the dimpling operation.

25. An apparatus for forming sheet material comprising a support, a tool member movable on the support and having a bore, a second member movable on the tool and having a pin passable into the bore of the tool and having a pin passable into the bore of the tool, means for relatively moving the tool and second member towards each other to form the material between them, and retractible guide means carried by the support adjacent the end of the tool and operative to guide the end of the pin into the bore of the tool, means for relatively moving the tool and second member towards each other to form the material between them, and retractible guide means carried by the support adjacent the end of the tool and operative to guide the end of the pin into the bore of the tool, and being retractible so that during the forming operation the guide means is in an out of the way position.

26. An apparatus for forming sheet material comprising a support, a tool member movable on the support and having a bore, a second member movable on the tool and having a pin passable into the bore of the tool, means for relatively moving the tool and second member towards each other to form the material between them, and retractible guide means carried by the support adjacent the end of the tool and operative to guide the end of the pin into the bore of the tool and being retractible so that during the forming operation the guide means is in an out of the way position.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,292,446</td>
<td>Huck</td>
<td>Aug. 11, 1942</td>
</tr>
<tr>
<td>2,088,089</td>
<td>Huck</td>
<td>Aug. 3, 1937</td>
</tr>
<tr>
<td>2,132,112</td>
<td>Huck</td>
<td>Oct. 4, 1936</td>
</tr>
<tr>
<td>192,448</td>
<td>Morgan et al.</td>
<td>June 26, 1877</td>
</tr>
<tr>
<td>1,101,434</td>
<td>Hatton</td>
<td>June 23, 1914</td>
</tr>
<tr>
<td>1,673,451</td>
<td>McKnight et al</td>
<td>Aug. 23, 1922</td>
</tr>
<tr>
<td>1,173,471</td>
<td>Wilkinson</td>
<td>Feb. 29, 1916</td>
</tr>
<tr>
<td>1,509,899</td>
<td>Coffer</td>
<td>May 15, 1928</td>
</tr>
<tr>
<td>1,926,986</td>
<td>Newton</td>
<td>Sept. 13, 1933</td>
</tr>
<tr>
<td>2,127,969</td>
<td>Dingwerth</td>
<td>Aug. 23, 1938</td>
</tr>
</tbody>
</table>