Feb. 20, 1962 E. M. LACEY, JR 3,021,803

DIE FOR METAL FORMING

Filed Dec. 16, 1957

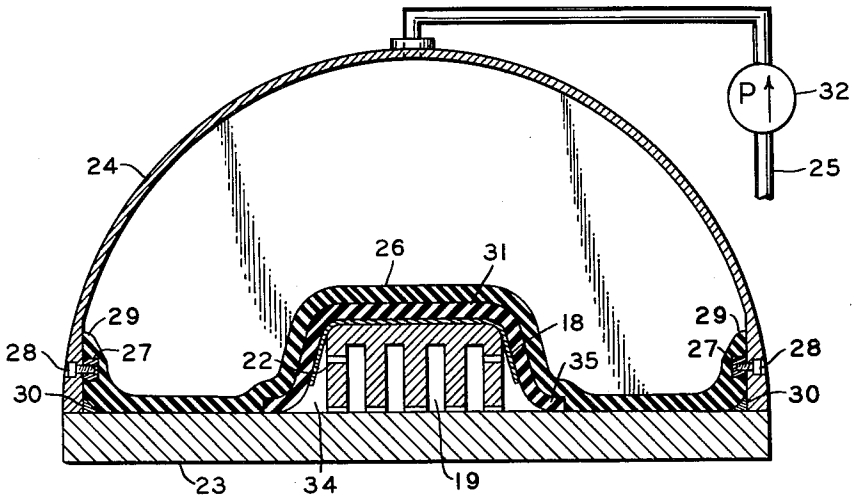


fig - 3

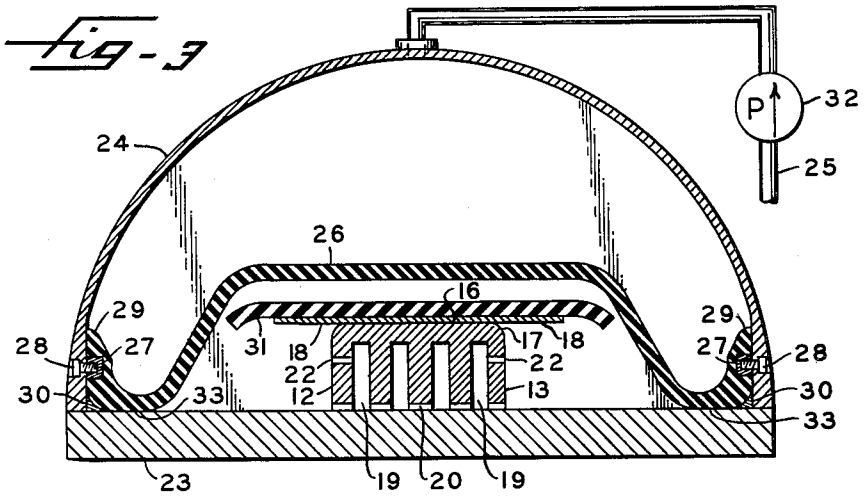


fig - 2

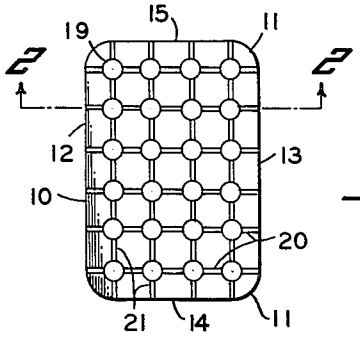


fig - 1

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United States Patent Office 3,021,803 Patented Feb. 20, 1962



# 3,021,803
# DIE FOR METAL FORMING

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Filed Dec. 16, 1957, Ser. No. 703,204
3 Claims. (Cl. 113—49)

This invention relates to the forming of a metal sheet to the shape of a die by bending adjacent portions of the sheet in succession and causing them to come into contact with adjacent portions or areas of the peripheral face of the die. This bending of the sheet has been accomplished, as illustrated in United States Patent 2,418,393, by placing a rubber mat on top of the sheet and applying fluid pressure to a flexible diaphragm mounted above the mat.

The die is supported on a flat table and I have found that as successively lower portions of the sheet become pressed against the die, a continuous portion or area of the mat becomes pressed against the table at a region remote from the die so that a large volume of air is entrapped between the bent mat and die. As the hydraulic pressure on the diaphragm is increased, and portions of the mat closer to the die become pressed against the table, the entrapped air progressively decreases in volume with a corresponding increase in pressure since there is no place for this air to go. With dies of certain curvature some of this compressed air may lie in pockets located between the metal sheet and die, these air pockets preventing the sheet from bending into contact with the die so that in these regions the sheet is not conformed to the shape of the die.

Furthermore in case the sheet extends down near the table, the entrapped air can prevent the portion of the mat closest to but still spaced a substantial distance from the lower end of the die from bending in any closer to the die even when the hydraulic pressure on the diaphragm is raised to the safe limit. The result is that the lower portion of the sheet is not pressed against the die and the sheet consequently never conforms to the shape of the die.

It is a main purpose of my invention to overcome the aforementioned disadvantages in sheet forming by providing an internal cavity or chamber in the die to receive such entrapped air and thereby permit the entire sheet to be pressed into contact with the die and brought to the desired shape.

Another object of the invention is to provide a set of holes through the side of the die to convey the entrapped air into said cavity.

A further object is to provide a set of shallow grooves in the bottom face of the die to convey entrapped air into said cavity.

Another object is to subdivide the said cavity into a number of compartments separated by solid walls which serve to reinforce and strengthen the die.

Other objects will become apparent as a description of my novel die construction proceeds. For a better understanding of the invention reference is made to the accompanying drawings, in which:

FIG. 1 is a bottom view of a forming die embodying the invention;

FIG. 2 is a sectional view through the die of FIG. 1 taken on line 2—2 and a forming press constructed to press a sheet of metal against the die to form it and;

FIG. 3 is a sectional view similar to FIG. 2 showing the shape the sheet might take after forming in the absence of my invention.

The die **10** is of generally rectangular shape with rounded corners **11** and whose vertical ends **12**, **13** and front and rear faces **14**, **15** are connected with the flat top face **16** by the arcuate faces **17**. However, it will be



understood that this die shape is merely illustrative and the external face of the die could take a great variety of other shapes and still come within the scope of the invention. The die is preferably made of metal but it could be made of any other hard material which would take the pressure necessary to effect the bending of the ductile metal sheet **18** placed on the die. For forming thin aluminum or stainless steel sheets to make component parts of airplanes, an excellent material for the die is Kirksite, an alloy consisting of approximately 93 percent zinc, 3 percent copper and 4 percent aluminum. The die has one or more holes **19** in it. These holes may be cut in by a drill or formed by suitable cores used in the mold when the die is made of cast metal. Shallow grooves **20** are cut lengthwise in the bottom of the die, as shown, and other grooves **21** from front to rear. The width and depth of the grooves should be kept small as, for example, .003 to .010 inch to prevent portions of a rubber pad or diaphragm to be described from being pressed into them and damaged. Below the top of the die a hole **22** from 0.30 to .120 inch in diameter is drilled through the side of the die opposite each hole **19** for a purpose to be described.

The die is shown associated with a forming press having a heavy plate **23** on which the die rests and which is elevated by means not shown against the bottom of a semi-cylindrical metal container **24** filled with water supplied by a pipe **25**. The container has semi-circular metal ends, not shown. Across the bottom of the container extends a flexible rubber diaphragm **26** normally of the shape shown in FIG. 2, a metal strip **27** extending clear around the edge of the diaphragm and being vulcanized thereto, this strip having threaded holes to receive the ends of securing screws **28** which extend through container **24**. The extreme end or edge **29** of the diaphragm rests against the inner face of the container and is pressed against this face by the fluid pressure in the container to seal the joint and prevent any fluid leakage at the joint. A continuous metal strip **30** extends around the lower end of the container and is secured to its inner face, this strip resting on support plate **23** and preventing any portion of diaphragm **26** from being forced between the bottom face of container **24** and plate **23** by the high pressure in the container while forming. A rectangular rubber pad **31** from ½ to 1 inch thick is preferably placed on sheet **18**, this pad extending for a substantial distance beyond the entire edge of the sheet as shown. This pad protects the diaphragm **26** from being cut or otherwise damaged by the sharp edge or any burrs on sheet **18** during the forming. It will be understood, however, that the presence of pad **31** is not necessary to practice the invention as it may be omitted and the diaphragm **26** come in direct contact with the top of sheet **18**.

To effect the forming table **23** with die **10** and sheet **18** thereon are raised to the position shown in FIG. 2 and pump **32** started to pump water from a source (not shown) into container **24**. As the pressure increases the major portion of diaphragm **26** moves down compressing pad **31** and causing the entire edge portion of the pad to move down and bend sheet **18** against the curved portions **11** and **17** of the die. The pressure first forces outer portion **33** of the diaphragm into firm sealing contact with plate **23** (see FIG. 2) so that a large volume of air is entrapped between plate **23**, die **10** and diaphragm **26**. As the pressure in the container is increased, portions of the diaphragm closer to the die are successively pressed into contact with plate **23** and also the edge portion of pad **31** is pressed against this plate, as illustrated in FIG. 3. This action would progressively increase the pressure of the entrapped air in space **34** (FIG. 3) in the absence of die cavities **19** until the edge portion **35** of pad **31** could not move any closer to die **10**. It will be seen that in this extreme position, the lower portion of

sheet 18 is not in contact with die 10 with the result that the sheet has not been formed to the shape of the die. The provision of the cavities in the die and the holes 22 and grooves 20, 21 permits this entrapped air to move into cavities 19 and the portion 35 of pad 31 to continue moving in until it has pressed the entire lower portion of sheet 18 against the die when the operation is complete and the sheet has been formed to the desired shape. Since the cavities 19 are connected together by grooves 20, 21 the air pressure in them will be substantially equalized at all times. The die metal disposed between the several cavities 19 provides a set of short vertical columns which give adequate support to the top portion of the die.

When the forming is complete, pump 32 is reversed to withdraw some of the water and the pump stopped when diaphragm 26 has resumed its initial shape, as shown in FIG. 2. Table 23 is now lowered and the formed sheet removed from the die.

While the invention has been illustrated in a press in which a rubber member is pressed against the sheet being formed by hydraulic pressure, it is also adapted for use in a press wherein pressure is applied to the rubber by confining it in a rigid hollow box and lowering the box over a pedestal as disclosed in U.S. Patent to H. E. Guerin No. 2,190,659.

Having thus described my invention, what I claim as new and useful and desire to secure by Letters Patent is:

1. A rigid forming die for use with a supporting base and a flexible mat to conform a sheet of metal to the exposed face of the die in response to pressure applied through the mat to the opposite surface of the sheet and to the support surface of the base, said die having a generally flat bottom face disposed in face adjacency to said support surface of the base, a top face and a peripheral side face connecting said top and bottom faces, said unformed sheet being projected beyond the edges of said top face and said mat being projected beyond the edges of said unformed sheet, said projection of said unformed sheet being less than the height of said peripheral side face, the interior of said die being provided with a plurality of spaced apart cavities each terminating in said bottom face and the top of each cavity being a substantial distance below said top face, said die closely adjacent said bottom face being provided with a plurality of passages connecting said cavities and at least one passage terminating in one of said cavities and said side face whereby air entrapped between said mat, said support surface, and said peripheral face of the die may escape into said cavities.



2. A rigid forming die as set forth in claim 1, in which at least one side of the die at a level substantially below the tops of said cavities is provided with additional passages terminating in said cavities and side face.

3. A rigid forming die for use with a supporting base and a flexible mat to conform a sheet of metal to the exposed face of the die in response to pressure applied through the mat to the opposite surface of the sheet and to the support surface of the base, said die having a generally flat bottom face disposed in face adjacency to said support surface of the base, a top face and a peripheral side face, a portion of which is convexly curved, said unformed sheet being projected beyond the edges of said top face and said mat being projected beyond the edges of said unformed sheet, said projection of said unformed sheet being less than the height of said peripheral side face, the interior of said die being provided with a plurality of spaced apart cavities each terminating in said bottom face and the top of each cavity being a substantial distance below said top face, the bottom face of said die being provided with shallow, narrow grooves interconnecting all said cavities and also additional narrow, shallow grooves terminating in some of said cavities and said side face whereby air entrapped between said mat, said support surface, and said peripheral face of the die may escape into said cavities.


**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 208,097 | House | Sept. 17, 1878 |
| 1,157,213 | Forsyth | Oct. 19, 1915 |
| 2,156,889 | Wiley | May 2, 1939 |
| 2,290,149 | Chesney | July 21, 1942 |
| 2,418,393 | Bridgens | Apr. 1, 1947 |
| 2,422,979 | Pecker | June 24, 1947 |
| 2,442,338 | Borkland | June 1, 1948 |
| 2,492,131 | Burger et al. | Dec. 27, 1949 |
| 2,669,209 | Hoffman | Feb. 16, 1954 |
| 2,734,474 | Golbert | Feb. 14, 1956 |
| 2,735,390 | Engel | Feb. 21, 1956 |
| 2,762,395 | Lamb | Sept. 11, 1956 |
| 2,781,016 | Livermont | Feb. 12, 1957 |
| 2,825,385 | Allen | Mar. 4, 1958 |
| 2,969,758 | Howlett et al. | Jan. 31, 1961 |

OTHER REFERENCES

"The Use of Rubber for Producing Sheet Metal Parts." Aero Dig., Nov. 1940, pp. 129, 130, 133.