(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 190 640**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 86101065.0

(22) Date of filing: 27.01.86

(51) Int. Cl.⁴: B 21 D 26/02

(30) Priority: 04.02.85 GB 8502772

(43) Date of publication of application:
13.08.86 Bulletin 86/33

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

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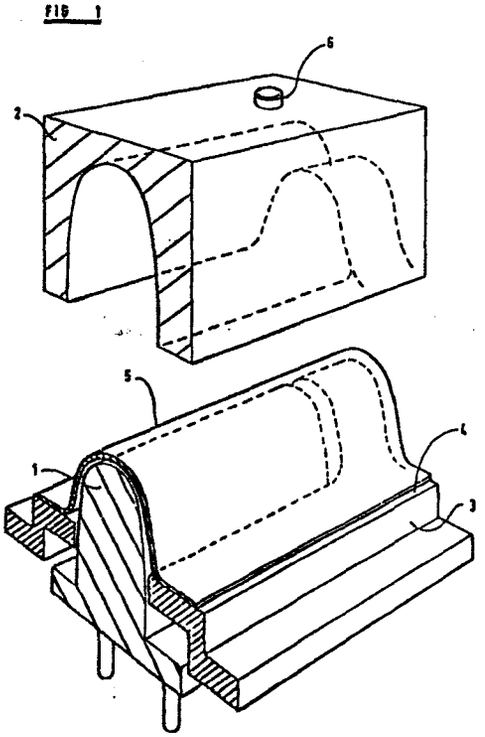
(54) Pressing contoured shapes.

(57) A process for forming superplastically deformable sheet metal into contoured shapes, especially complex saddle shapes having compound curvature, utilises the technique of pressure forming in combination with a forming tool with the sheet metal in condition for superplastic deformation. A preform of superplastically deformable sheet metal is first formed and then sealed to a pressure box. A forming tool is engaged with the preform face external of the pressure box and, under conditions for superplastic deformation, the sheet metal is pressure-formed into conformity with the forming tool. Apparatus for performing the process is also disclosed.

Fig 1



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Pressing Contoured Shapes

THIS INVENTION concerns the pressing of contoured shapes in sheet metal, using the technique of superplastic forming.

There are many available techniques for pressing contoured shapes from sheet metal. However the pressing of saddle-section shapes, especially in workpieces of extended length, is difficult to accomplish, particularly when configurational accuracy and/or a high surface finish is required for both surfaces of the product, and especially when the product is also required to have compound curvature. The reason for this is that techniques employing matched male and female press tools involve drawing of the sheet material and also involve the application of a variable, non-isostatic, pressure in the direction of the thickness of the sheet material in the closed condition of the tools. Accordingly, vacuum/pressure forming techniques, and techniques involving the use of relatively flexible diaphragms engaging one surface of the workpiece and subject to fluid pressure to force the workpiece against a tool, have been developed. An object of the present invention is to provide a process and equipment for pressing contoured shapes from sheet metal that avoids various disadvantages of the known techniques.

In its broadest aspect the present invention provides a process for the superplastic forming of sheet metal into contoured shapes, comprising establishing a preform of superplastically deformable sheet metal; sealingly securing the periphery of said preform in a pressure box and, with the preform at a temperature appropriate for superplastic forming, engaging said preform with a forming tool to support the face of the preform external of the pressure box; and applying fluid pressure to said pressure box to effect superplastic deformation of the preform into conformity with the forming tool.

Preferably said forming tool is a male tool and is thrust into engagement with the preform to accomplish a preliminary forming of the latter, e.g. to accomplish partial stretch-forming of the preform. This procedure is especially desirable when a preform of single curvature is to be formed to a final product having compound curvature

The process may be applied to the forming of any superplastically deformable sheet metal, for example, titanium and titanium alloy sheet, and stainless steel sheet.

The invention is especially applicable to the production of extended, non-linear, saddle-section shapes, such as erosion shields for helicopter rotor blades having leading edges that exhibit spanwise non-linearity.

In carrying out the process of the invention, a suitable preform of the sheet metal to be formed is constructed, using hot or cold forming techniques as appropriate to the metal and to the preform shape required. The preform is then, if necessary, heated to the required temperature for superplastic forming either in situ adjacent to the pressure box or externally in a pre-heating chamber such as an infra-red oven. If external pre-heating is employed, the pre-heated preform, at the forming temperature, is transferred to the pressure box and secured therein.

The preform is next engaged by the forming tool and then is superplastically deformed into conformity with the configuration of the tool, by causing the preform to move towards the tool by the application of fluid pressure to the pressure box.

The invention also provides apparatus for performing the process thereof. Thus in another aspect the invention provides apparatus for forming sheet metal, comprising a pressure box and means for sealingly securing the periphery of a superplastically deformable sheet metal preform therein; a forming tool for engaging the face of the preform external of the pressure box; and means for applying fluid pressure to said pressure box to effect superplastic deformation of the preform into conformity with the forming tool.

A typical embodiment of apparatus in accordance with the invention is illustrated in the accompanying drawings, in which:

FIGURE 1 is an exploded, semi-diagrammatic, perspective view of the principal components of the apparatus;

FIGURE 2 is a diagrammatic transverse sectional view of the apparatus at a first stage in the operation thereof;

FIGURE 3 is a corresponding view at a second stage; and

FIGURE 4 is a corresponding view at the conclusion of the operation.

The apparatus shown in the drawings comprises an essentially rigid male forming tool 1 adapted to be mounted directly or indirectly on a lower platen of a suitable press (not shown). A pressure box 2 of a configuration providing clearance over the tool 1 is carried by the upper press platen (not shown) so as to be movable into position over the tool 1 and be held by the press, to retain the tool 1 and pressure box 2 in fixed relative positions during a forming operation.

The apparatus further comprises a clamping frame 3 that has a sealing surface 4 complementary to the periphery of the pressure box 2 and serves to sealingly secure the periphery of a sheet metal preform in the pressure box 2.

In use of this apparatus, a preform 5 is first fabricated to the arched shape illustrated in Figures 1 and 2, for instance by heating a sheet of the required metal to a suitably high temperature and deforming the sheet by simple pressing. The preform 5 is then introduced into the pressure box 2 and clamped in place by means of the clamping frame 3. The preform is raised to an appropriate temperature either before being introduced into the pressure box 2, or while in situ therein, e.g. by radiant heating. Figure 2 illustrates the apparatus components and the preform configuration at this stage in the operation.

The forming tool 1 is then thrust upwardly, by the press, into engagement with the preform 5 to effect a preliminary shaping of this, by a stretch-forming procedure that is effective to make the crest of the arch shape of the preform match the crest of the tool 1. Figure 3 illustrates the apparatus components and the preform configuration at this stage in the operation.

Thereafter, with the preform supported by the tool 1, gas under pressure is fed to the pressure box 2 through inlet 6 to deform the remainder of the preform 5 into exact conformity with the configuration of the tool 1. This deformation utilises the superplastic properties of the sheet metal so that upon subsequent release of gas pressure and removal of the formed product from the tool 1 and pressure box 2, the product will retain the configuration of the tool 1 without spring-back. Figure 4 illustrates the apparatus components and the configuration of the preform at the conclusion of this operation.

The temperature required in the forming operation depends upon the metal of the preform. In the case of titanium sheet, a forming temperature of about 930°C is appropriate to develop the required superplasticity.

The features disclosed in the foregoing description, in the following claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

CLAIMS

1. A process for the superplastic forming of sheet metal into contoured shapes, characterised by the steps of: establishing a preform of superplastically deformable sheet metal; sealingly securing the periphery of said preform in a pressure box and, with the preform at a temperature appropriate for superplastic forming, engaging said preform with a forming tool to support the face of the preform external of the pressure box; and applying fluid pressure to said pressure box to effect superplastic deformation of the preform into conformity with the forming tool.

2. A process according to claim 1, further characterised in that said forming tool is a male tool.

3. A process according to claim 2, further characterised in that said forming tool is thrust into engagement with the preform to accomplish preliminary forming thereof.

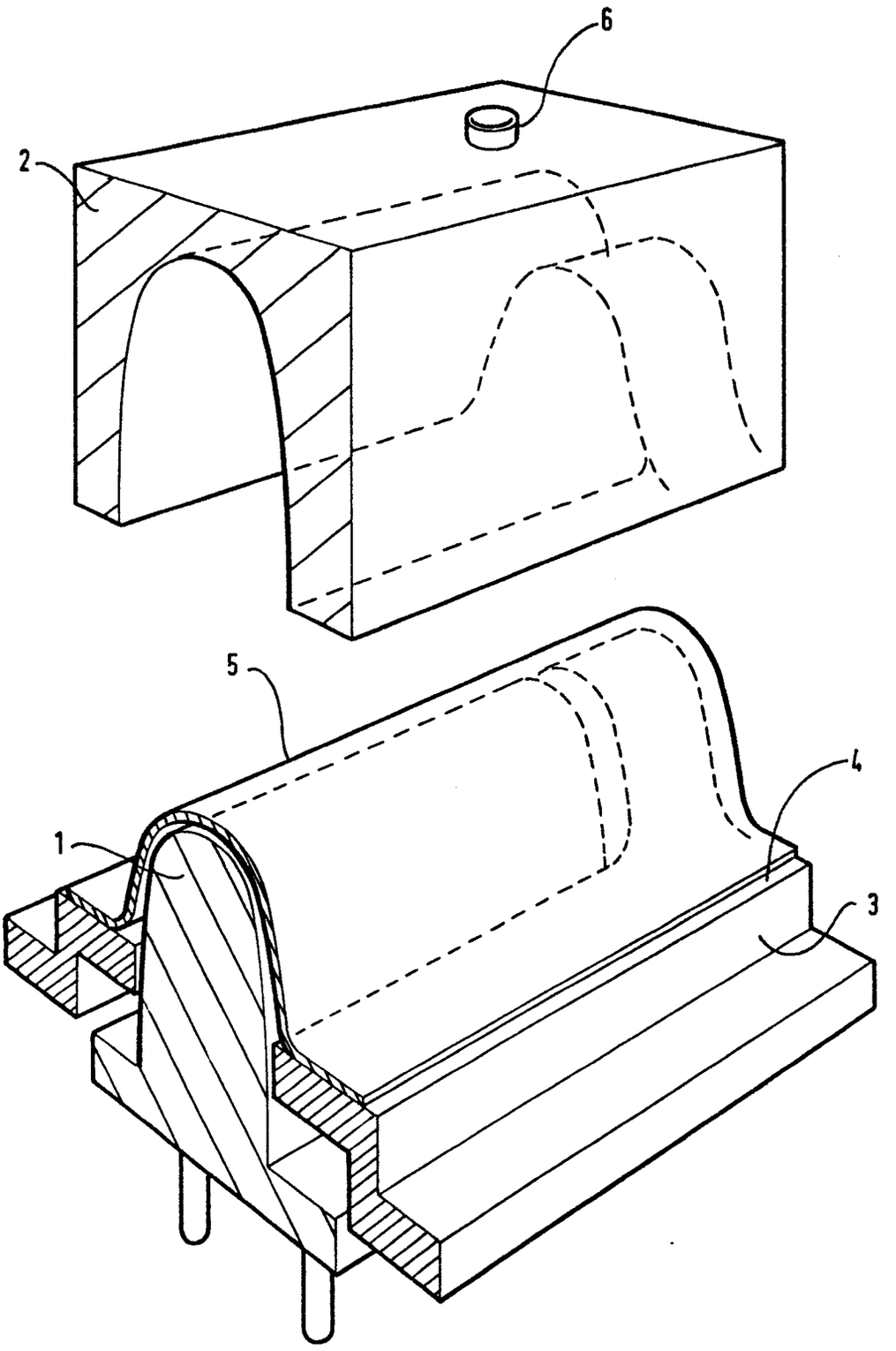
4. A process according to claim 3, further characterised in that said forming tool is thrust into engagement with the preform to accomplish preliminary stretch-forming thereof.

5. Apparatus for forming sheet metal, characterised by a pressure box and means for sealingly securing the periphery of a superplastically deformable sheet metal preform therein; a forming tool for engaging the face of the preform external of the pressure box; and means for applying fluid pressure to said pressure box to effect superplastic deformation of the preform into conformity with the forming tool.

6. Apparatus according to claim 5, further characterised in that said forming tool is a male tool.

7. Apparatus according to claim 6, further characterised by press means for thrusting said male tool into engagement with the preform to accomplish forming thereof.

FIG 1



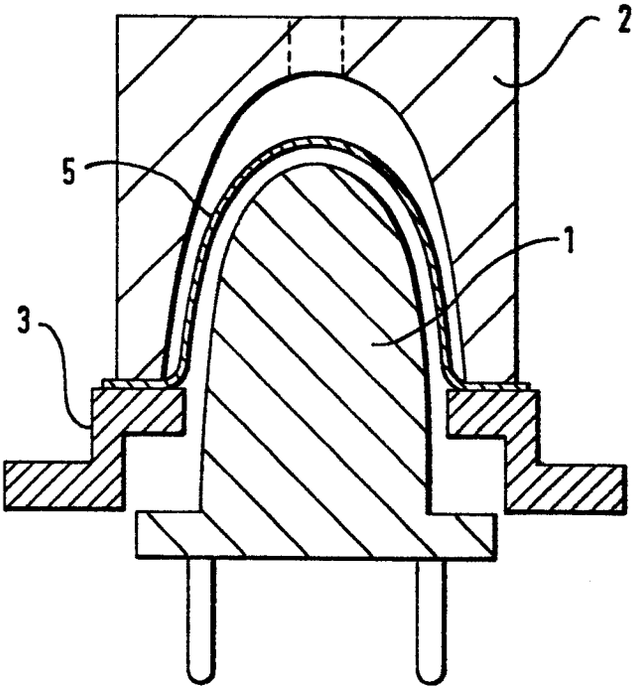


FIG 2

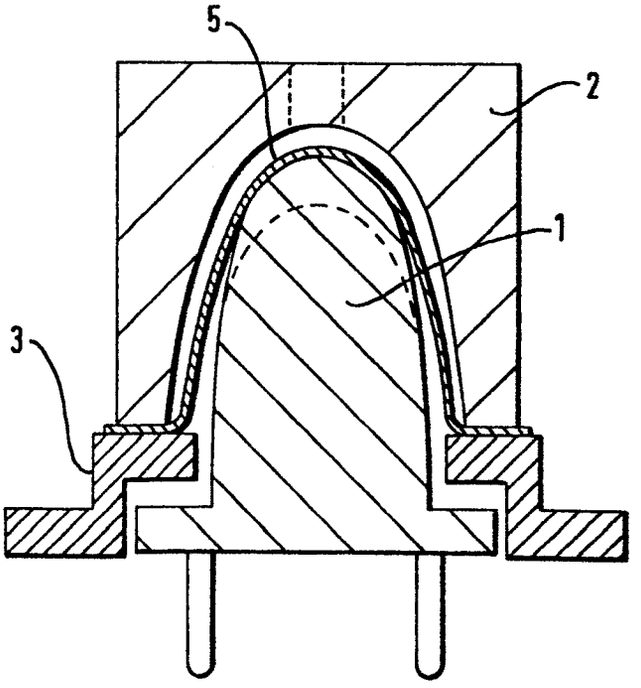


FIG 3

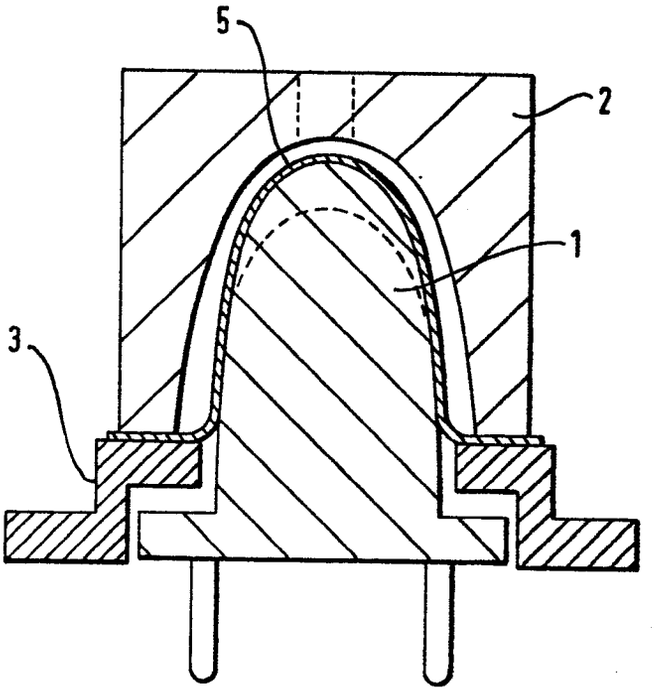


FIG 4