April 26, 1966 E. B. KOLT 3,247,549

VACUUM FORMING DIE CONSTRUCTION

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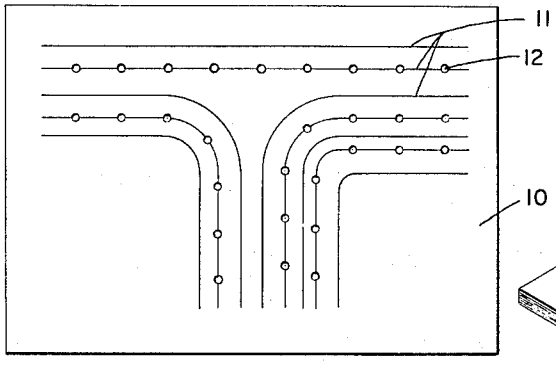

Fig. 1

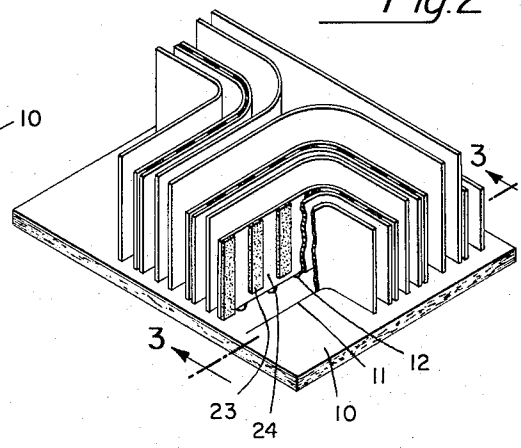

Fig. 2

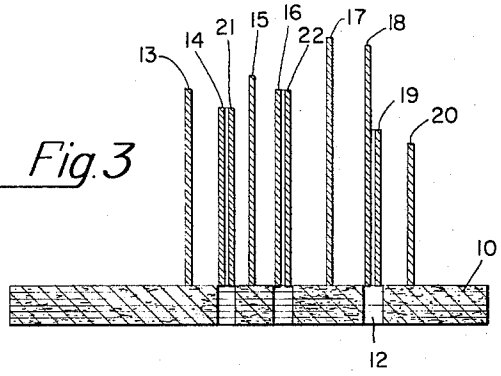

Fig. 3

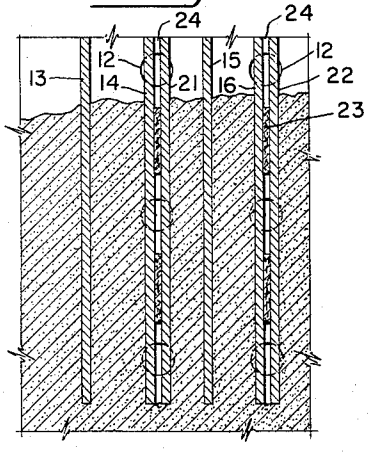

Fig. 5

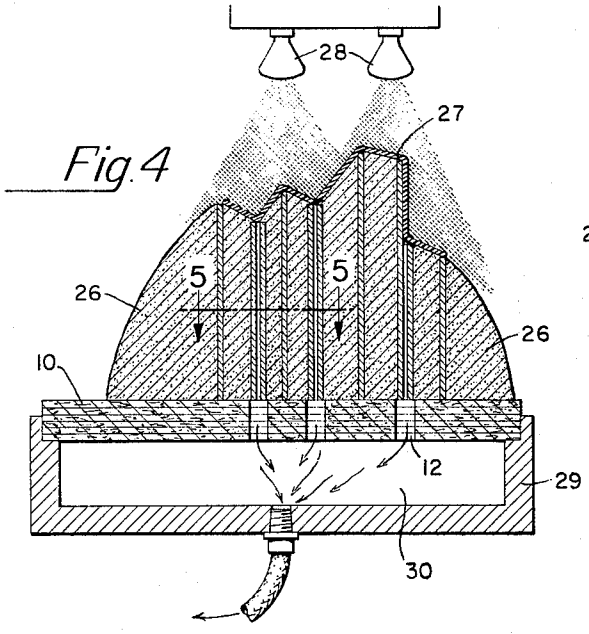

Fig. 4

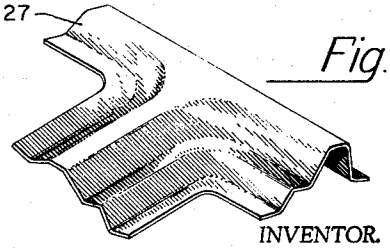

Fig. 6

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VACUUM FORMING DIE CONSTRUCTION

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This invention relates to a new and improved vacuum forming die structure employed in the production of panel configurations. More particularly the accurate, simplified structure is produced with less time and cost than prior art structures.

During the development of an automobile body all the sheet metal parts are first constructed in the form of a prototype model to facilitate engineering studies of the problem of forming, welding and assembling in sequence the sheet metal panels. These prototype models further permit analysis of stress concentrations as well as cost and weight analysis. It has become a standard practice in the automotive industry to make these prototype models from plastic sheets employing vacuum forming techniques.

Heretofore the processes and dies employed for vacuum forming plastic sheets have necessitated patterns and/or casting molds made by highly skilled pattern makers.

It is a general object of the present invention to provide a vacuum forming die which may be made without machining parts and surfaces, without the necessity of patterns or molds and which may be constructed accurately and economically by semi-skilled labor.

A principal object of this invention is to provide a new and improved structure for vacuum forming thermo-plastic sheet material.

A further object of the present invention is to provide an accurate vacuum forming die made directly from drawings without the necessity of patterns or casting molds.

A more specific object of the present invention is to provide a novel vacuum forming die structure having a plurality of bent or formed templates of constant height along the length of the templates as an integral part of the vacuum forming die.

The above and other novel objects and features of the invention will be apparent from the following description and accompanying drawing in which:

FIG. 1 is a plane view of the base support having contour lines drawn thereon;

FIG. 2 is a perspective view of the base support showing templates mounted on the contour lines;

FIG. 3 is a section in elevation taken at lines 3—3 of FIG. 2;

FIG. 4 is a cross-section taken through a finished vacuum forming die shown mounted on a vacuum box under heat lamps to illustrate forming of a thermo-plastic sheet;

FIG. 5 is a section in plane view taken at lines 5—5 of FIG. 4;

FIG. 6 is a perspective view of a portion of a thermo-plastic sheet formed by the novel die shown in FIG. 4.

In accordance with the preferred embodiment of the present invention there is provided a vacuum forming die structure having a base support plate; a plurality of contour lines representative of constant elevation are drawn thereon; a plurality of rectangular sheet metal templates are cut into strips of predetermined height corresponding to contour line elevation and then bent to coincide in shape with the two-dimensional contour lines on the base support plate; duplicate templates are prepared for some of the contour lines, the duplicate pairs are combined as a unit to form breather templates provided with a thin spacer to separate them creating an air space therebetween. Vents are made in the base support along the contour lines and the templates are mounted on the base support plate, then a plastic material is placed into the voids between templates and smoothed to the desired contour. The plastic is then hardened to provide a completed vacuum forming die.

Base support **10** of FIG. 1 has drawn thereon a plurality of contour lines **11** preferably representative of lines of constant elevation. However, it may be advantageous to select character lines of varied elevation. Some of the contour lines have apertures **12** through the base support **10** spaced along the contour lines. Since the contour lines **11** are representative of constant elevation they are not necessarily spaced parallel one to another as could occur if character lines are employed.

A plurality of templates is prepared by cutting strips to a predetermined height in a shear press. The preferred thin sheet metal templates **13** to **20** vary in height as shown in FIG. 3, but are uniform in height along their individual length. Duplicate templates **21** and **22** are prepared for some of the contour lines as will be explained hereafter. The rectangular shaped sheet metal strips or templates **13** to **22** are bent to coincide with respective ones of the contour lines **11**. Pairs of templates **14** and **21**, and **16** and **26** are bent to conform to the same contour line. The duplicate pair of templates are nested one against the other with a thin spacer **23** separating them. Flexible adhesive tape has been successfully employed for this purpose. The spacers **23** are arranged in a manner to provide an air space **24** extending from the bottom to the top of the templates. Thus, the combined templates with the spacers interposed therebetween become a composite unit of parallel plates referred to hereinafter as a breather strip. The breather strips are mounted on the base support plate in coincidence with the contour lines **11** having apertures **12** spaced therealong. The remaining templates are mounted on the base support coincident with their respective contour lines **11**.

As now arranged, the breather strips have air spacers communicating directly with the apertures or vents **12**. A plastic material **25** is placed into the voids between adjacent templates and/or breather strips. Since the top of the templates are representative surface contour lines it is extremely simple to smooth the plastic material between templates either as a straight line or in conformity with a general sloping contour indicated by the spacing and height of the templates. No special tools or skills are required to achieve a high degree of accuracy in smoothing the plastic material to form a die surface. This is especially true if contour lines are selected skillfully. As shown in FIG. 4 an excess of plastic material is employed as a shoulder or support **26** to give stability to the vertically aligned templates.

The breather strip formed by templates **14** and **21** occurs at the inner corners of the contour surface. Similarly, the breather strip formed by templates **16** and **22** also occurs at the concave inflection point or inner corner of the die surface. The breather strip formed by templates **18** and **19** occurs at an inner corner or side shoulder of the die surface. Thus, the breather strips are placed at air pockets of the die surface. After the plastic material has hardened to form a vacuum molding die a thermo-plastic sheet **27** heated by heat lamps **28** can be molded directly over the die surface. As shown in FIG. 4 base support **10** has been placed onto a vacuum box **29**. A vacuum is applied to the plenum **30** of the vacuum box from a suitable source. The application of a vacuum will cause the heat softened thermo-plastic sheet to conform to the exact contours of the die surface. When the heat source is removed the thermo-plastic sheet will harden, resulting in a vacuum formed sheet **27**. The illustrated sheet is the center or B-post of a uniside structure of an automobile body.

The invention employing breather strips and vented supports has been illustrated with constant elevation contour lines and formed rectangular templates and/or templates representative of selected character lines.

It is to be understood that the invention can be accomplished by using various combinations of the templates, contour lines and vent means within the scope of the present invention which is only limited by the terms of the appended claims.

What is claimed is:

1. A device for vacuum forming a sheet of thermoplastic material to a three-dimensional surface comprising:
- a flat base,
- a plurality of two-dimensional curved contour lines on said flat base representative of lines of constant elevation of the forming face of the apparatus,
- a plurality of apertures through said flat base coinciding with and spaced along said contour lines,
- a plurality of breather strips mounted on said flat base in coincidence with said contour lines, said breather strips comprising
- a pair of closely spaced parallel plates, each of uniform height along their respective length having upper edges coinciding with said three-dimensional surface,
- spacer means separating said pair of parallel plates and providing an air space connecting said apertures with said three-dimensional surface,
- and a hardenable plastic material interconnecting adjacent plates of different breather strips, said plastic material being shaped and hardened to conform to said three-dimensional surface.

2. A device as set forth in claim 1, wherein said spacer means comprises strips of adhesive tape of lesser thickness than said plates of said breather strips.

3. A device as set forth in claim 1, which further includes a plurality of single width plates mounted on contour lines intermediate said breather strips.

4. A device as set forth in claim 3, wherein one of said pairs of parallel plates of a breather strip is of a height different from the other of the pair.

5. A vacuum forming die comprising,
- a flat base support,
- a plurality of two-dimensional curved contour lines on said base support, representative of character lines of the die surface,
- apertures in said base support on said contour lines,
- a plurality of formed thin, flat template strips vertically mounted in coincidence with said two-dimensional curved contour lines on said base support, the upper edges of said templates being in coincidence with the three-dimensional vacuum forming surface,

- spacer means,
- breather strips comprising a parallel pair of said thin flat templates separated by said spacer means to provide an air space therebetween,
- and a hardenable plastic material connecting adjacent strips, said plastic being formed to a three-dimensional vacuum forming die surface.

6. A vacuum forming die made by the method comprising the steps of:
- laying out a plurality of contour lines on a base support representative of predetermined height of the die surface,
- cutting a plurality of original templates from sheet material each having a width representative of a height of one of said contour lines,
- cutting a duplicate template for some of said contour lines,
- forming all said templates to conform to their respective contour lines,
- mounting said templates on said base support coincident with said respective contour lines,
- separating said duplicate template from its original template by thin spacers interposed therebetween to provide an air space between the duplicate and the original templates,
- providing vent means in said base support connected to said air space,
- applying between the templates a hardenable plastic material to interconnect said base support and said templates as a unit,
- forming said plastic material to conform to said predetermined height and to form said die surface,
- and hardening said plastic to provide a vacuum forming die.

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