Dec. 29, 1970 R. M. POTTER 3,550,422

CREEP-FORM TOOLING

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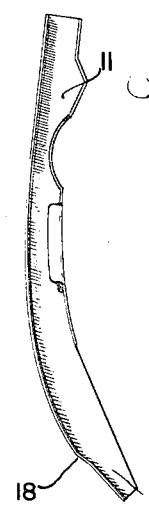


Fig. 2

Fig. 3

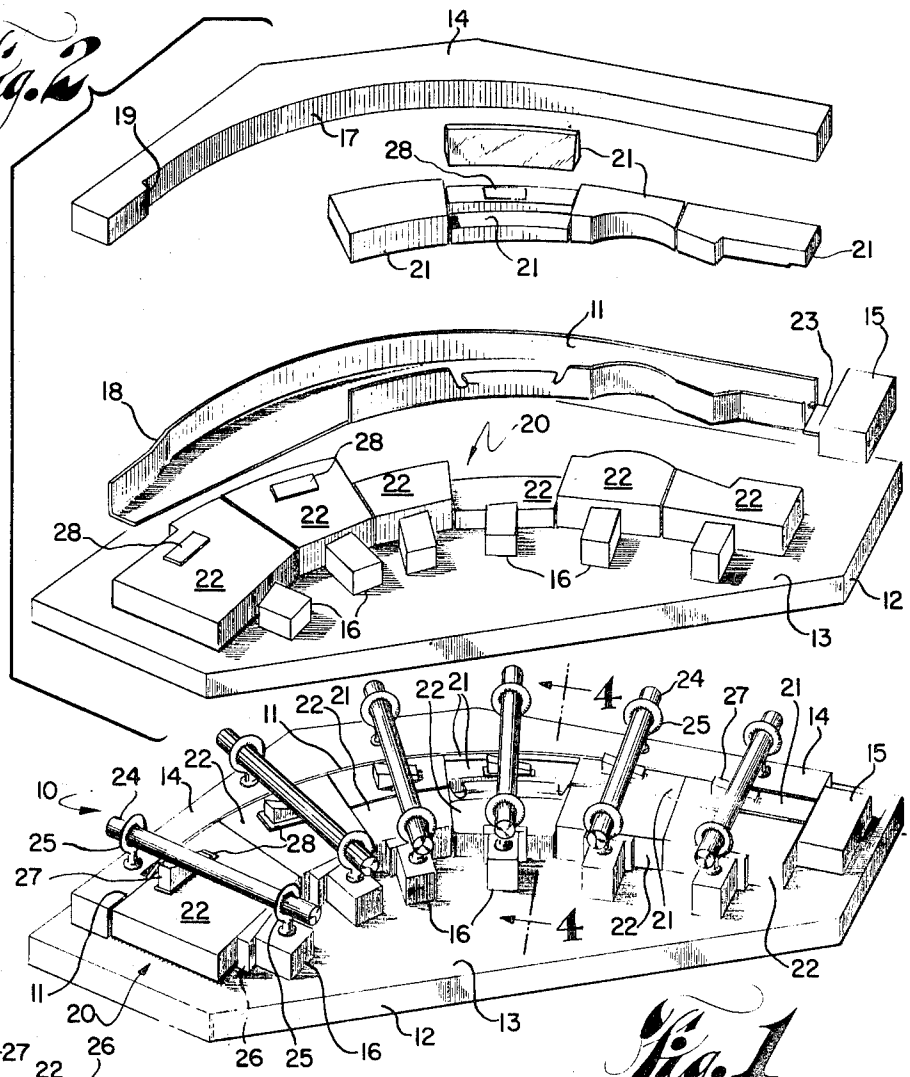
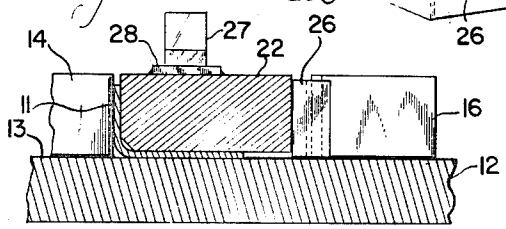
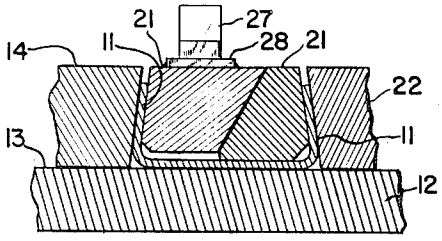


Fig. 5

Fig. 1





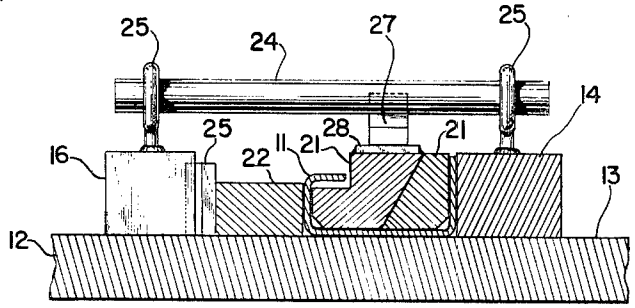


Fig. 6

Fig. 4

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CREEP-FORM TOOLING

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ABSTRACT OF THE DISCLOSURE

Tooling for creep-forming flanged intermediate sheet metal details is provided with contour-control block elements that are particularly located and restrained on a base member and that function to obtain improved dimensional tolerance characteristics in the resulting parts as they are conventionally processed at elevated temperatures and without requiring subsequent special thermal treatment or special metal rework steps. The invention is especially important with respect to the manufacture of aircraft structural parts from both stretch-formed and press-formed flanged intermediate details made of conventional ultra-high-strength alloy steel, precipitation-hardening alloy steel, or titanium alloy sheet metal materials.

BRIEF SUMMARY OF THE INVENTION

A tooling assembly for creep-forming flanged sheet metal intermediate details is provided with a base member having a base reference surface and with stationary contour-control block elements fixedly secured to the base element to establish a side reference surface and an end location surface. Either a press-formed or stretch-formed flanged sheet metal intermediate detail is located in the tooling on the base reference surface, preferably with the detail shrink flange or stand-up flange, as applicable, in contact with a stationary contour-control block element side surface and with the detail end nearest a severe joggle or offset feature in contact with a stationary contour-control block element end surface provided for reference purposes. Insert block elements are provided in the assembly at each detail double-flanged (channel) longitudinal region of significantly different configuration, if any. An articulated relatively movable side pressure block is positioned on the base member with a separate block element for and located at each one of the detail longitudinal regions of significantly different configuration. Backup block elements, preferably one for each relatively movable side pressure block element, are fixedly secured to the base member in spaced-apart relation to the side pressure block elements and cooperate with side wedge elements that are subsequently installed intermediate each different backup block/side pressure block element combination. Similarly, top wedge elements cooperate with eyebolt and crossbar means secured to the fixed contour control side block elements and backup block elements to develop vertical restraint within the assembly; a crossbar element is normally provided for, and is centered with its longitudinal axis transverse to, each detail longitudinal region of significantly different configuration. Afterwards, the included detail is loaded in critical longitudinal regions at ambient temperature to a stress level above approximately 33,000 p.s.i. by shock-loading each of the different side and top wedge elements. The essentially totally contacted detail is then subjected to the conventional temperature-time history required for accomplishing creep-forming in the tooling assembly. The resulting creep-formed part thereby obtains improved dimensional tolerance characteristics without requiring any subsequent special thermal treatment or special rework steps.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the tooling of this invention with a press-formed double-flanged sheet metal intermediate detail assembled therein for creep-forming;

FIG. 2 is an exploded perspective view of the principal tooling elements and the part detail illustrated in FIG. 1;

FIG. 3 is a plan view of the sheet metal detail of FIGS. 1 and 2;

FIG. 4 is a sectional view taken at line 4—4 of FIG. 1;

FIG. 5 is a sectional view taken at line 5—5 of FIG. 1; and

FIG. 6 is a sectional view similar to FIG. 5 but showing an alternate form of insert block means for a sheet metal intermediate detail of different flanged configuration.

DETAILED DESCRIPTION

The tooling of this invention is referenced generally as **10** in FIG. 1 and is provided for creep-forming the double-flanged sheet metal part intermediate detail designated **11** to final dimension. Part **11** is normally previously press-formed in a conventional hot-form hydraulic press or the like to develop the illustrated representative intermediate formed configuration. However, and generally because of alloy characteristics, the intermediately-formed configuration of the detail only closely approaches the finally-desired part dimensions from a forming tolerance standpoint. Also, and alternatively, the detail designated **11** may be a conventional stretch-formed structural angle part with a single stand-up flange and a base flange that is either a shrink or stretch flange.

As shown in the drawings, tooling **10** in-part is comprised of a rigid base member **12** (normally fabricated of low carbon steel) having web reference surface **13**. In most applications reference surface **13** is planar in the regions that support detail **11** but may be provided with other contoured or stepped surface configurations that substantially match the configuration of the corresponding web or flange surface of the contacting intermediate detail in its finally-desired form.

Tooling **10** includes block elements **14** and **15** that provide a side reference surface and an end reference surface, respectively, and also spaced-apart wedge backup block elements **16**, all fixedly secured to base **12** by welding or other fastening means. Element **14** may be fabricated in one piece or in several sections, generally not less than 18" in length, for convenience; if made in sections the end-abutting relation between adjacent sections of means **14** should not exceed approximately .010". The vertical surface **17** of block element **14** is provided with a contour that essentially matches the contour finally desired in the corresponding flange of detail **11**. Depending on the manner whereby detail **11** is formed to its intermediate configuration, surface **17** will essentially correspond to either a shrink flange in a press-formed part or the standup flange of a stretch-formed angle part. Such flanges are normally at right angles to the detail web or base flange. In areas where a joggle such as **18** (FIG. 3) occurs in the adjacent detail flange, surface **17** is preferably provided with a square-step notch such as **19**. The step should start at the joggle tangent point and should accommodate the joggle depth. Element **15** contacts and locates the end of detail **11** and is preferably positioned to be at the detail end that is nearest the most severe detail joggle or offset feature.

Tooling **10** further includes articulated side pressure block **20** and the various insert block elements designated **21**. Block elements **21** each have cross-sectional dimensions that substantially correspond to the desired final interior dimension of detail **11** at the longitudinal region double-flange. The opposed vertical faces of each block element **21** will contact the adjacent interior faces of up-

standing opposed flanges of part **11** and are therefore also provided with vertical face contours that correspond to the finally-desired flange contours. As shown in FIGS. 4 and 6, particularly insert blocks **21** may be split lengthwise and on a diagonal to facilitate insertion and removal relative to a detail return flange feature. Also, particular insert blocks may be provided with step features to accommodate some forms of return flange, see FIG. 4. Side pressure block **20** is supported by base member **12** in the apparatus assembly and is articulated in a manner whereby each separate element **22** has a vertical face that contacts and corresponds to an adjacent exposed flange face of a detail longitudinal region of significantly different contour. Normally the thickness of blocks **14**, **20**, and **21** is selected in each instance so that the block upper surface is approximately ¼" above the upper edge of each adjacent flange. Also, the ends of blocks **14**, **20**, and **21** at the ends of detail **11** are preferably sized to each extend a minimum ½" beyond the end of the detail. In the case of the block elements adjacent the reference end of detail **11**, it is preferred to provide a clearance step (**23**, FIG. 2) in location block **15** so that the adjacent end of part **11** will be properly located and restrained during creep-forming. Block **15** then also functions to locate and restrain the adjacent ends of insert block **21** and an element **22**, see FIG. 1.

In order to develop vertical restraint for part **11** during subsequent creep-forming, assembly **10** is further provided with rigid crossbar or clamp rod elements **24** that each cooperate with a pair of eyebolt elements **25**. As shown in the FIG. 1 illustration, each eyebolt element **25** is secured to contour control block **14** or to a wedge backup block **16**.

After part **11** is properly located in assembly **10** in contacting relation to fixed contour-control block elements **14** and **15** and after insert blocks **21** and the elements **22** of side pressure block **20** have been installed in position, the desired detail stress loading is developed by the forced insertion of side wedge elements **26** and top wedge elements **27** into the position shown in FIG. 1. To assure proper location of the top wedge elements to avoid tipping, metal pads such as **28** may be welded to the upper surface of various of block elements **21** or **22**, see FIG. 5.

When assembling apparatus **10** to accomplish the creep-forming of intermediate detail **11** it is necessary that wedge elements **26** and **27** be shock-loaded to provide the proper level of pre-form stresses in detail **11**. For this purpose I prefer that such wedge elements be driven in a direction pointing toward block **15** as shown in the drawings by sledge hammer action and sufficiently to induce a stress above approximately 30,000 p.s.i. minimum in all areas of detail **11** that are to be creep formed.

Creep-forming is then accomplished by placing the assembled tool **10** and detail **11** in a heated oven environment or the like and maintaining the stressed detail conventionally at a prescribed temperature for sufficient time. In the case of precipitation-hardening AM350 alloy steel, for example, temperature-time history of 850° F. for one hour during tempering is generally satisfactory. In the case of titanium alloy details, a temperature of approximately 1000° F. may be preferred for one hour. H–11 ultra-high-strength steel details may involve as many as three tempering sequences each utilizing a temperature of 1025° F., for example, for three hours. If lower tensile properties, such as 260,000 to 280,000 p.s.i. are desired in the resulting part, the tempering thermal processing may utilize a temperature of 1040° F.

After creep-forming has been accomplished the tooling and part are cooled normally to ambient temperature and the part removed following removal of the various wedge elements and movable side block and insert block elements. The resulting part has form dimensional tolerances of typical aircraft quality and does not require subsequent special thermal treatments or special reworking to eliminate defects. In addition to providing parts that have improved form dimensional properties, the invention provides parts that are free of cracks and the like thus contributing to significantly reduced rejection rates in comparison to the part rejection rate associated with conventional tooling.

I claim:

1. A tooling assembly for creep-forming an elongated flanged intermediate sheet metal detail at elevated temperatures into a part having a final configuration with longitudinal regions of significantly different flange contour and with an upstanding contoured flange that is substantially at right angles to a base contoured flange in at least one of the part final configuration different longitudinal regions, comprising:

(a) rigid base means having a reference surface substantially corresponding to said part final configuration base contoured flanged and contacting said sheet metal detail at said base means reference surface,

(b) side reference block means fixedly secured to said base means, having a reference surface substantially corresponding to said part final configuration upstanding contoured flange, and contacting said sheet metal detail at said side reference block means reference surface,

(c) end reference block means fixedly secured to said base means, having a reference surface located relative to said side reference block means reference surface at an end of said part final configuration, and contacting said sheet metal detail at said end reference block means reference surface,

(d) articulated side pressure block means relatively movable with respect to said base means, having a different articulation element for each one of said part final configuration different longitudinal regions, having articulated pressure faces corresponding to said part final configuration upstanding contoured flange, and base contoured flange, and contacting said sheet metal detail at said articulated pressure faces,

(e) backup block means fixedly secured to said rigid base means in spaced-apart relation to each of said side pressure block means articulation elements,

(f) restraint means vertically fixed relative to said rigid base means and located in positions over and spaced-apart from each one of said side pressure block means different articulation elements, and

(g) wedge means having a different wedge element installed intermediate each backup block means and side pressure block means articulation element combination and intermediate each restraint means and side pressure block means articulation element combination of said articulated side pressure block means,

said wedge means elements being force-loaded to conform said intermediate sheet metal detail at ambient temperatures to said part final configuration and to stress said intermediate sheet metal in all areas to be creep-formed to a level above approimately 30,000 p.s.i.

2. The invention defined by claim **1**, wherein said wedge means elements are each provided with wedge included angle in the range of approximately 5° to 10°, said wedge means elements being force-loaded in the assembly with the apex of each said wedge included angle adjacent to said end reference block means.

3. A tooling assembly for creep-forming an elongated flanged intermediate sheet metal detail at elevated temperatures into a part having a final configuration with longitudinal regions of signicantly different flange contour and with opposed upstanding contoured flanges substantially at right angles to and joined by a base contoured flange in at least one of the part final configuration different longitudinal regions, comprising:

(a) rigid base means having a reference surface substantially corresponding to said part final configuration base contoured flange and contacting said sheet

metal detail at said base means reference surface,

(b) side reference block means fixedly secured to said base means, having a reference surface substantially corresponding to one of said part final configuration opposed upstanding contoured flanges, and contacting said sheet metal detail at said side reference block means reference surface,

(c) end reference block means fixedly secured to said base means, having a reference surface located relative to said side reference block means reference surface at an end of said part final configuration, and contacting said sheet metal detail at said end reference block means reference surface,

(d) articulated insert block means relatively movable with respect to said base means, having a different articulation element for each one of said part final configuration different logitudinal regions with opposed upstanding contoured flanges, having articulated opposed pressure faces corresponding to said part final configuration opposed upstanding contoured flanges, and contacting said sheet metal detail at said articulated opposed pressure faces and at said base contoured flange,

(e) articulated side pressure block means relatively movable with respect to said base means, having a different articulation element for each one of said part final configuration different longitudinal regions, having articulated pressure faces corresponding to the other of said part final configuration opposed upstanding contoured flanges, and contacting said sheet metal detail at said articulated pressure faces,

(f) backup block means fixedly secured to said rigid base means in spaced-apart relation to each of said side pressure block means articulation elements,

(g) restraint means vertically fixed relative to said rigid base means and located in positions over and spaced-apart from each one of said insert block means and said side pressure block means different articulation elements, and

(h) wedge means having a different wedge element installed intermediate each backup block means and side pressure block means articulation element combination, intermediate each restraint means and insert block means articulation element combination,

and intermediate each restraint means and side pressure block means articulation element combination of said articulated block means,

said wedge means elements being force-loaded to conform said intermediate sheet metal detail at ambient temperatures to said part final configuration and to stress said intermediate sheet metal in all areas to be creep-formed to a level above approximately 30,000 p.s.i.

4. The invention defined by claim **3**, wherein said wedge means elements are each provided with a wedge included angle in the range of approximately 5° to 10°, said wedge means elements being force-loaded in the assembly with the apex of each said wedge included angle most adjacent to said end reference block means.

5. The invention defined by claim **3**, wherein the part final configuration opposed upstanding contoured flanges have a closing relationship with respect to each other in at least one part final configuration longitudinal region of significantly different flange contour, said articulated insert block means having articulation element at said one part longitudinal region that is comprised of two longitudinal portions, one of said insert block means articulation element longitudinal portions contacting a wedge means element and being spaced-apart from said sheet metal detail base flange and supported by the other of said insert block means element longitudinal portions along an inclined surface.

6. The invention defined by claim **3**, wherein said part final configuration opposed upstanding contoured flanges comprise a shrink flange and an opposed stretch flange, said side reference block means reference surface substantially corresponding to said part final configuration upstanding contoured shrink flange.

References Cited

UNITED STATES PATENTS

3,060,564	10/1962	Corral	72—342
3,094,160	6/1963	Walton et al.	72—342

LOWELL A. LARSON, Primary Examiner

U.S. Cl. X.R.

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