July 24, 1962 D. J. CLARKE ETAL 3,045,327

FABRICATION OF BLADES FOR COMPRESSORS, TURBINES AND THE LIKE

Filed March 4, 1957 2 Sheets-Sheet 1

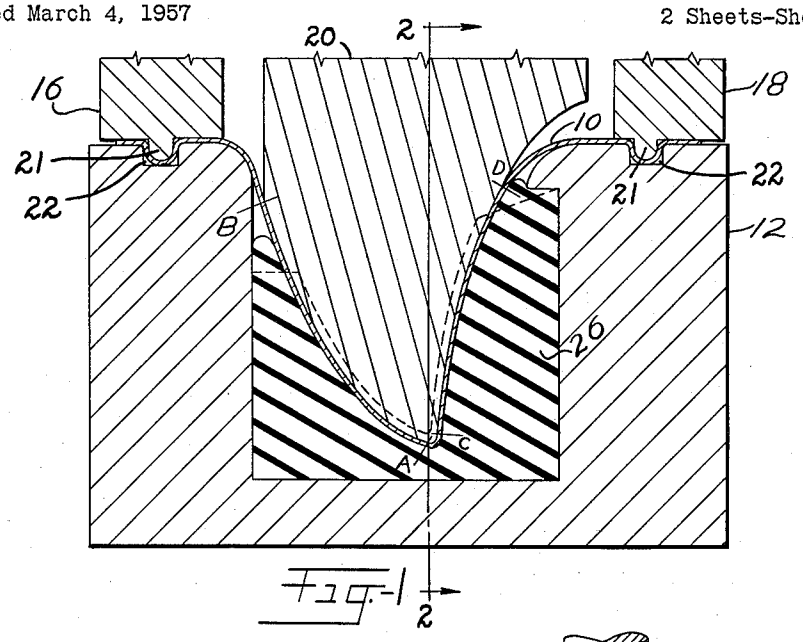


Fig. 1

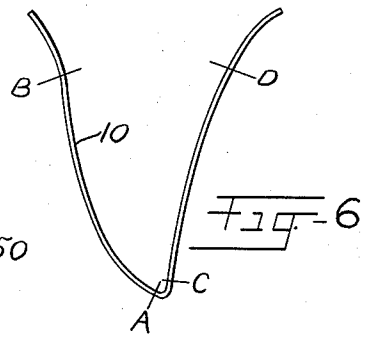


Fig. 6



Fig. 4

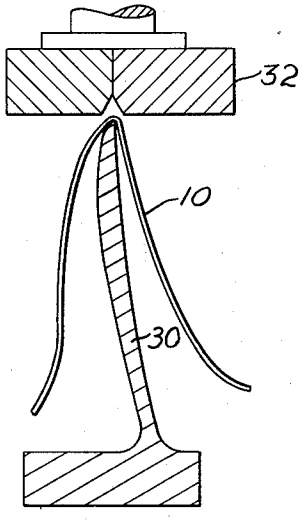


Fig. 7

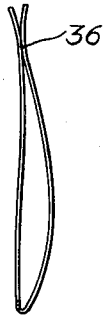


Fig. 8

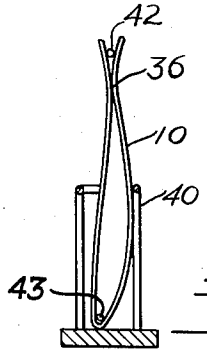


Fig. 9

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FABRICATION OF BLADES FOR COMPRESSORS, TURBINES AND THE LIKE

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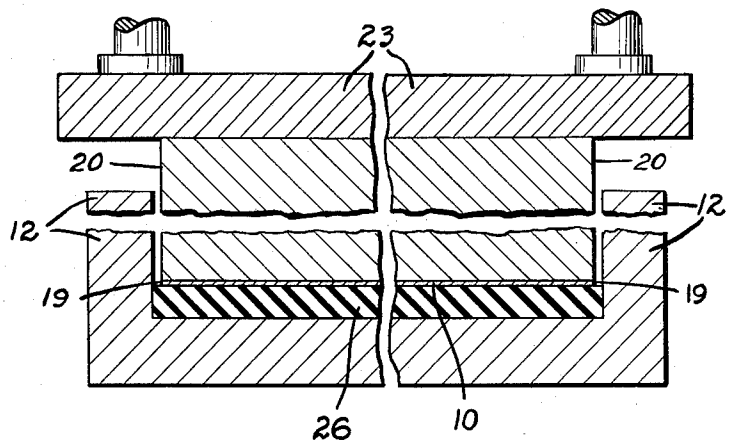


Fig-2

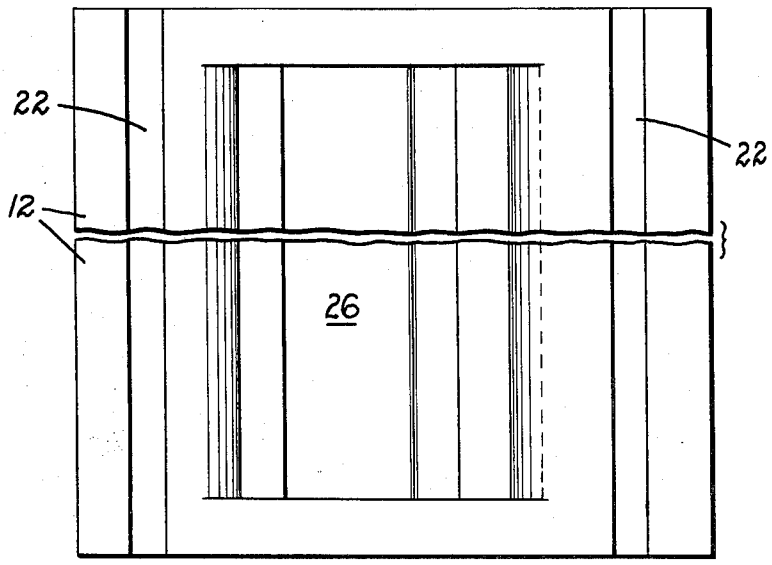


Fig-3

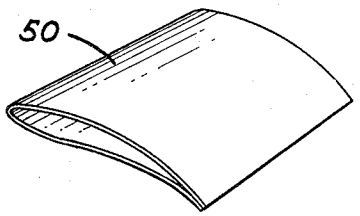


Fig-5

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FABRICATION OF BLADES FOR COMPRESSORS, TURBINES AND THE LIKE

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8 Claims. (Cl. 29—156.8)

This invention relates to hollow blades for rotary fluid machines adapted to exchange force with a fluid.

The object of the invention is to provide a simple and highly satisfactory process of fabrication for forming such blades with accurately shaped airfoil surfaces and in the absence of fixtures so that the finished blades are largely free of internal warping or distorting stresses.

Other objects will appear from the following description, the accompanying drawings and the appended claims.

The above objects are accomplished by the means illustrated in the accompanying drawings in which—

FIG. 1 is a cross section of a die assembly for stretch-forming a blade blank;

FIG. 2 is a sectional view through the die on the line 2—2 of FIG. 1;

FIG. 3 is a plan view of the lower die prior to the introduction of the blank thereinto;

FIG. 4 is an end elevation of a blade made by the process of the subject invention;

FIG. 5 is a perspective view of the finished blade;

FIG. 6 is a view of a blade blank as formed by the die assembly;

FIG. 7 shows the blade blank of FIG. 6 in relation to the folding die and mandrel;

FIG. 8 shows the blade blank after folding and fixing together along its trailing edge; and

FIG. 9 shows the blade blank loosely supported in a brazing rack.

Referring now to the drawings a flat sheet metal blank 10 is placed on the die box 12 and gripped tightly along its side edges by the hold-down pads 16 and 18 leaving its ends 19 free. The pads move down against the blank with the male die 20 under the action of pressure applying means 23 allowing substantially free movement of the side edges of the blank in the initial movement. Toward the latter part of the closing movement the beading 21 on the hold-down pads enters grooves 22 of box 12 and creates a drag load on the blank as it is drawn into the die by the descending male die 20. The drag load is preferably of sufficient magnitude to impose on the blank a tensile stress exceeding the yield stress or elastic limit of the material.

A cushion 26 of rubber or like elastomeric and deformable material and in the shape of a female die with a central recess is placed within the die box by which it is laterally confined, the die being of a shape to create an interference with the male die at some distance from the limit of the male die descent. The shape of the recess in the female die is approximately that of the finished surface of the blade, but it need not be as accurately formed as the male die. Also as shown the walls of the female die are more closely spaced than the final blade walls. The action of the rubber cushion forces the stretched blank to lie against the male die while the blank is being stretched. The cushion initially occupies the position shown in dotted lines, and is deformed to the position shown in section in FIG. 1 under the action of the male die.

The male die has contours AB and CD corresponding to the contours of the finished blade between these same letters, FIG. 6. Only the portion from A to C is not precise and is not such as to result in the finished blade

contour in that area. As shown in FIG. 1 the contour AC has a greater radius of curvature than that desired for the nose of the blade.

The blank is removed from the die and box and has the shape shown in FIG. 6 after the hold-down pieces of the blank are cut off. It is next placed over the mandrel 30, FIG. 7 where it is pressed upon by the die 32. This action reduces the radius of curvature of the nose of the blank to the selected contour desired.

The mandrel is preferably slightly thinner than the blade inwardly of its nose portion so that when the blank is removed from the mandrel the rear portions of the blank just touch as shown in FIG. 8. The blank is fixed preferably by spot-welds 36 spaced along its trailing edge or rear portion. It is then placed in a rack 40 with braze material 42 in the trough at the aft end. The recess at the nose may also be filled by solder 43.

The brazing operation preferably is done in a furnace. The blank is next sheared along the blade span just forward of the trailing edge spot welds. The sheared edges are then deburred finishing the blade 50 to the shape shown in FIG. 4.

The blade envelope in the condition shown in FIGS. 8 and 9 is substantially free of internal strains over its entire extent tending to cause deformation in use, particularly those normal to the surface of the blade, and when heated to brazing temperatures will retain its selected contours with great accuracy without any fixtures to restrain the contours while the blade is in the furnace or otherwise being heated. That is, the contours and general shape of the blade are free of forces from fixtures over a major portion of its chordwise contours or over a major portion of its area.

Fixtures for establishing contours would tend to warp and distort a blade. Furthermore they are expensive to recondition and maintain with the proper accuracy. Greater accuracy and lower costs are achieved by the process of this invention which does not require such fixtures.

While the method herein described, and the form of apparatus for carrying this method into effect, constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to this precise method and form of apparatus, and that changes may be made in either without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A press for forming blades for compressors, turbines and the like from a sheet metal blank comprising a die box adapted to receive said metal sheet thereon, a deformable cushion in said die box having a recess the walls of which are the approximate shape of the desired surface contours of said blade, means for laterally confining said cushion, a male die adapted to move against said blank supported on said die box to press said blank into said recess, said male die having the shape of the finished surface contours of said blade over substantially the entire extent thereof, means for restraining the sides of said blank to cause the stretching of the material thereof during the action of said male die leaving the ends of said blank free, and means for advancing said male die on a working stroke to force said blank into said recess in pressure contact with said cushion while undergoing stretching to cause said blank to assume the shape of said male die leaving said blade walls substantially free of internal stress.

2. A press for forming blades for compressors, turbines and the like from a sheet metal blank comprising a die box adapted to receive said metal sheet thereon, a deformable cushion in said die box in the shape of a female die having a recess the walls of which are the approximate shape of the desired surface contours of said

blade, means for laterally confining said cushion, a male die adapted to move against said blank supported on said die box to press said blank into said recess, said male die having the shape of the finished surface contours of said blade over substantially the entire extent thereof, means for restraining the sides of said blank to cause the stretching of the material thereof during the action of said male die leaving the ends of said blank free, and means for advancing said male die on a working stroke to force said blank into said recess in pressure contact with said cushion while undergoing stretching to cause said blank to assume the shape of said male die leaving said blade walls substantially free of internal stress.

3. A press for forming blades for compressors, turbines and the like from a sheet metal blank comprising a die box adapted to receive said metal sheet thereon, a deformable cushion in said die box in the shape of a female die having a recess the walls of which are the approximate shape of the desired surface contours of said blade, means for laterally confining said cushion, a male die adapted to move against said blank supported on said die box to press said blank into said recess, said male die having the shape of the finished surface contours of said blade over substantially the entire extent thereof, means operable during the latter part of the stroke of said male die for restraining the sides of said blank to cause the stretching of the material thereof leaving the ends of said blank free, and means for advancing said male die on a working stroke to force said blank into said recess in pressure contact with said cushion while undergoing stretching to cause said blank to assume the shape of said male die leaving said blade walls substantially free of internal stress.

4. A process for fabricating blades for compressors, turbines and the like comprising placing a sheet metal blade blank over a recess in a female die of laterally confined deformable elastomeric material, having the approximate shape of the desired surface contours of said blade, advancing an accurately shaped male die having the shape of the finished surface contours of the blade over substantially the entire extent thereof against said blank to force said blank into said recess, and holding the edges of said blank to cause stretching of the metal thereof beyond its elastic limit while leaving the ends of said blank free, the elastomeric material causing the stretched blank to lie against and conform closely to said male die during said stretching operation.

5. A process for fabricating blades for compressors, turbines and the like comprising placing a sheet metal blade blank over a recess in a female die of laterally confined deformable elastomeric material having the approximate shape of but spaced more closely together than the desired surface contours of the finished blade, advancing an accurately shaped male die having the shape of the finished surface contours of the blade over substantially the entire extent thereof against said blank to force said blank into said recess, and holding the edges of said blank to cause stretching of the metal thereof beyond its elastic limit while leaving the ends of said blank free, the elastomeric material causing the stretched blank to lie against and conform closely to said male die during said stretching operation.

6. A process for fabricating blades for compressors, turbines and the like comprising placing a sheet metal blade blank over a recess in a female die of laterally confined deformable elastomeric material having the approximate shape of the desired surface contours of said blade, advancing an accurately shaped male die having the shape of the finished surface contours of the blade over substantially the entire extent thereof against said blank to force said blank into said recess, and holding the edges of said blank during the latter part only of the stroke of said male die to cause stretching of the metal thereof beyond its elastic limit while leaving the ends of said blank free, the elastomeric material causing the stretched blank to lie against and conform closely to said male die during said stretching operation.

7. A process for fabricating blades for compressors, turbines and the like comprising placing a sheet metal blade blank over a recess in a female die of laterally confined deformable elastomeric material having the approximate shape of the desired surface contours of said blade, advancing an accurately shaped male die having the shape of the finished surface contours of the blade over substantially the entire extent thereof against said blank to force said blank into said recess, holding the edges of said blank to cause stretching of the metal thereof beyond its elastic limit while leaving the ends of said blank free, the elastomeric material causing the stretched blank to lie against and conform closely to said male die during said stretching operation, reducing the radius of curvature of the nose of said blade and securing the trailing edges of said blade together while retaining the same surface contours.

8. A process for fabricating blades for compressors, turbines and the like comprising placing a sheet metal blade blank over a recess in a female die of laterally confined deformable elastomeric material having the approximate shape of the desired surface contours of said blade, advancing an accurately shaped male die having the shape of the finished surface contours of the blade over substantially the entire extent thereof against said blank to force said blank into said recess, holding the edges of said blank to cause stretching of the metal thereof beyond its elastic limit while leaving the ends of said blank free, the elastomeric material causing the stretched blank to lie against and conform closely to said male die during said stretching operation, reducing the radius of curvature of the nose of said blade and securing the trailing edges of said blade together while retaining the same surface contours by brazing said trailing edges with said blade surfaces substantially unconfined.

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