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BEND-STRETCH METHODS OF FORMING HEAVY FAN BLADES

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Fig. 1.

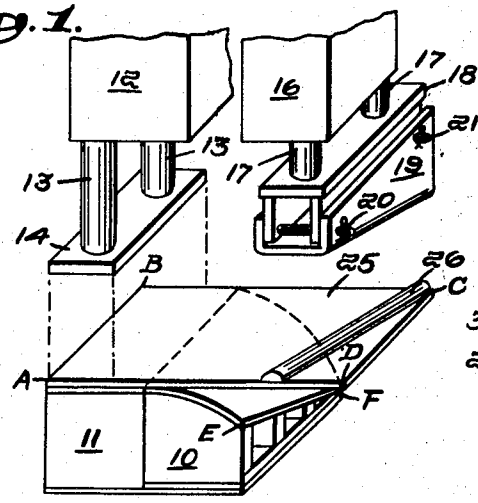


Fig. 3.

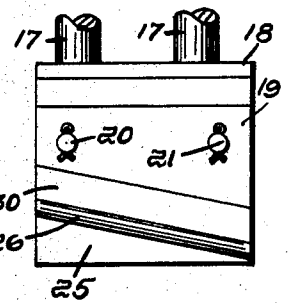


Fig. 2.

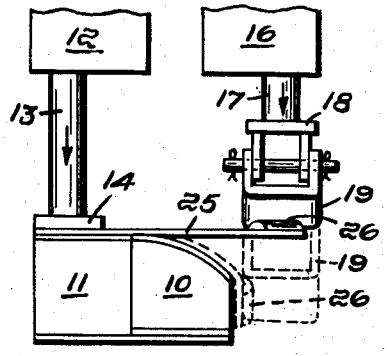


Fig. 4.

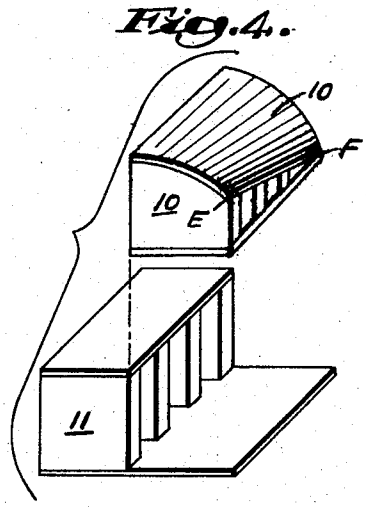


Fig. 5.

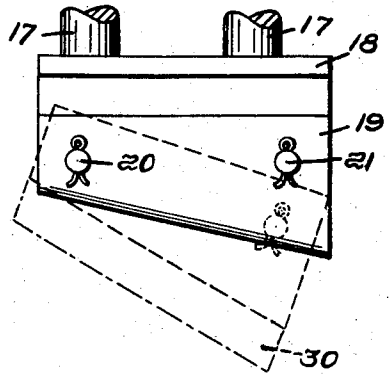
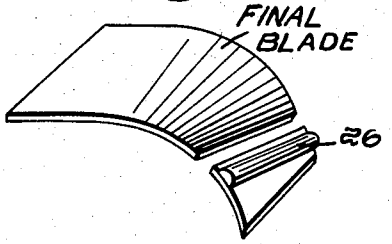


Fig. 6.



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BEND-STRETCH METHODS OF FORMING HEAVY FAN BLADES

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2 Claims. (Cl. 29—156.8)

This invention relates to methods of formation of curved plates such as curved fan blades from flat metal blanks.

For heavy duties, fan blades of thick metal having flat radially extending portions and having other portions formed in conical or modified conical segments such as conoidal are desired. Heretofore, such blades have been formed by forging or by using dies. Forging does not maintain the desired thickness due to the hammering involved, and dies are large, cumbersome and expensive.

This invention uses the well-known principle of stretch-forming of metal in a novel method. In conventional stretch-forming methods, clamps are attached to each end of the material being handled, and the clamps are then caused to move in such a manner as to draw the material around a form having the desired shape. In certain cases only one clamp has been caused to move, the other clamp being fixed. Attaching movable clamps to thick section metal plates which are heated to 1800° F. or more for easy forming is very difficult as clamping pressure cannot be maintained due to cooling shrinkage. This invention eliminates the need for a movable clamp.

In one embodiment of this invention, a blade blank is prepared for forming by outlining the desired blade pattern upon one of the surfaces, following which a semi-cylindrical bar of steel is welded along its flat diametral surface to the blank adjacent an edge of the blade layout. To form a blade, the blank is then heated to about 1800° F., and then placed upon a clamp surface adjacent a form having a substantially conical surface. The edge of the blank opposite the one near the semi-cylindrical bar is clamped to the clamp surface. A ram having a flat bar contacting surface is moved against the semi-cylindrical rod and exerts pressure on it to bend the blank over the form. Preferably, the flat bar contacting face of the ram is set at an angle, which may be a 15° angle to the bar, at the start of the bending of the form, remaining set at this position until the end of the blank to be bent to an arc of the smallest radius has been bent to the approximate shape of the form at its end, at which time the ram surface will have been in line contact with the bar. At this point the first step of the bend-stretch operation will have been completed. Then the bar contacting face of the ram is re-set to give the proper taper, which may be a 30° angle, and the ram is moved further downwardly until the bar contacting face of the ram is in line contact with the bar completing the second step of the bend-stretch operation. For some blades the semi-circular bar may then be burned off or cut off leaving the desired blade.

For other blades further bend-stretching may be required, in which case, at the end of the second step of the bend-stretch operation, the ram is retracted to permit a metal block to be placed between it and the bar, following which the ram is moved downwardly against the block to further bend-stretch the blade blank in a third step.

An object of this invention is to improve the quality of curved fan blades bent from thick metal plates.

This invention will now be described with reference to the annexed drawings, of which:

Fig. 1 is a partial perspective view of one embodiment of a machine for the practice of this invention, showing a blade blank in position on a form with the blank clamp and the ram retracted;

Fig. 2 is a partial end elevation of the machine showing the blank clamp and the ram in blank contacting position for the start of a bend-stretch operation, and showing by dashed lines the portions of the blank and ram at the end of a bend-stretch operation;

Fig. 3 is a partial side elevation showing the ram raised from the position shown by the dashed lines of Fig. 2 so as to permit a block to be placed between it and the bar on the blank for further bend-stretching of the blank;

Fig. 4 is an exploded perspective view of the form and the blade clamp base;

Fig. 5 is a side elevation of the blank bending portion of the ram showing its 15° taper position in solid lines, and its 30° taper position in dashed lines, and showing in dash-dot lines the block which may be used; and

Fig. 6 is a view of a finished blade with the blade blank portion having the semi-circular bar thereon spaced from the blade.

A form **10** having its upper surface curved to provide the desired shape for the curved portion of a blade is positioned alongside a blade blank base **11** which has a flat upper surface merging with the upper surface of the form. A conventional air or hydraulic press **12** has a pair of pistons **13** attached at their lower ends to a flat blade clamp plate **14**, the plate **14** being parallel to and aligned with the flat upper surface of the base **11**.

Another conventional air or hydraulic press **16** has a pair of pistons **17** attached at their lower ends to a support **18** to which a ram **19** is attached. The inner portion of the ram **19** is pivoted about an inner pin **20** to the support **19**, and its outer portion is secured to the support **19** by an outer pin **21**. The ram has a flat lower surface but has sides which are tapered from its front or inner end to the back or outer end, and at the start of a bend-stretch operation is set by the location of pin **21** in an upper hole in the support **18**, so that its flat lower surface has about a 15° taper, or in other words extends at an angle of about 15° to the horizontal. Later in the operation, as will be described later, the ram would be re-set by relocation of the pin **21** in a lower hole in the support **18** so that as shown by the dashed lines of Fig. 5, its flat lower surface is at about an angle of 30° to the horizontal.

A rectangular metal block **30** may be placed between the ram and the bar for providing a greater degree of bend-stretching than is provided by the ram alone.

The inner or front end of the form **10** is curved in an arc of smaller radius than its outer or back end so that blades having conically or substantially conically shaped surfaces such as surfaces of conoids, can be formed over the form.

In preparation for the forming operation, a rectangular blade blank **25** has a semi-cylindrical bar **26** welded thereto and which is so placed on the blank that its front or inner end is nearer the base **11** than its back or outer end is when the blade is in position on the base **11** and form **10** as shown by Fig. 1. The ram **19** is so positioned that it extends over the semi-cylindrical bar **26** so that it contacts the latter continuously during the period the ram is moved downwardly by the press **16** to form a blade. The ram has sufficient width to maintain its contact with the bar as the latter is displaced sideways during the bending operation.

Operation

In operation, a proposed blade blank **25** with a semi-cylindrical bar **26** therein is heated to about 1800° F., and then is placed upon the base **11** and form **10** as shown by Figs. 1 and 2. The press **12** is then operated to move the clamp plate **14** against the upper surface of that portion of the blade blank between the plate **14** and base **11**, clamping that portion of the blade blank in position. The ram **19** would previously have been set so that its rod contacting surface has a taper of about 15°, as previously described. The ram is moved downwardly by the press **16** until the front end AD of the blade is bent downwardly to the approximate shape of the form **10** at its inner or front end, at which time the ram is in line contact with the bar. The ram is then raised, and reset by relocation of the pin **21** so that its lower surface has the increased taper as shown by the dashed lines of Fig. 5, and is then brought down again to complete the blade forming.

As the ram descends it picks up line contact with the semi-cylindrical bar as the blade blank bends downwardly, and at the bottom of the strike is in full line contact with the bar, the blank being stretched to the exact blade form.

An analysis of the process shows that the final line of blade contact with the form **10** is a straight line E—F. A projection of this line to the outer surface of the blade is also a straight line, but the plane in which this projected line lies is twisted from end to end (not less than through a 90° angle). As the axis of the semi-cylindrical rod **26** lies in this plane, the rod twists from one end to the other, but the pressure line on the face of the rod remains a straight line which allows the blade to be stretched to the form uniformly. A semi-cylindrical ram contacting rod is the only shape that will provide this characteristic.

Other shapes than semi-cylindrical can be used with less accuracy of blade form if the welded on, ram contacting section is pressed to the point of complete separation from the blade. Where it is undesirable to strip the welded on ram contacting section from the blade during the bending operation, the welded on section must be semi-cylindrical.

What we claim as our invention, is:

1. A method of forming a fan blade to have a flat inner portion and a substantially conical outer portion from a flat blade blank, which comprises welding the flat diametral portion of a semi-cylindrical bar to the outer portion of the blank adjacent its outer edge, heating the blank, placing the heated blank with its inner portion on a flat clamp surface, with its outer portion spaced from a form having a substantially conical surface merging with said flat clamp surface, and with said bar between said conical surface and a flat ram surface; clamping the inner portion of the blank to the clamp surface, applying pressure to the bar to bend-stretch the outer portion of the blank against the form with said ram surface which is at an angle to the adjacent surface of the bar at the start of the application of pressure but which extends in line contact with the bar when the outer portion of the blank has been partially formed to the form, stopping the application of pressure by the ram surface after it has made line contact with the bar surface, adjusting the ram surface until it is again at an angle to the adjacent surface of the bar, again applying pressure with the ram surface to continue the bend-stretching of the blank until after the ram surface is again in line contact with the bar surface, and removing the bar and the adjacent outer edge portion of the blank from the blank.

2. A method of forming a fan blade to have a flat inner portion and a substantially conical outer portion from a flat blade blank, which comprises welding the flat diametral portion of a semi-cylindrical bar to the outer portion of the blank adjacent its outer edge, heating the blank, placing the heated blank with its inner portion on a flat clamp surface, with its outer portion spaced from a form having a substantially conical surface merging with said clamp surface, and with said bar between said conical surface and a flat ram surface, clamping the inner portion of the blank to the clamp surface, applying pressure to the bar to bend-stretch the outer portion of the blank over the form with said ram surface which is at an angle to the adjacent surface of the bar at the start of the application of pressure but which extends in line contact with the bar when the outer portion of the blank has been partially formed to the form, stopping the application of pressure by the ram surface after it has made line contact with the bar, adjusting the ram surface until it is again at an angle to the adjacent surface of the bar, again applying pressure with the ram surface to continue the bend-stretching of the blank until the ram surface is again in line contact with the bar, again stopping the application of pressure by the ram surface, placing a metal block between the ram surface and the bar, again applying pressure through the block by the ram surface against the bar to further bend-stretch the blank, and removing the bar and the adjacent outer edge portion of the blank from the blank.

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