United States Patent

[11] 3,576,070

[72] Inventor **John T. Parsons**
205 Wellington, Traverse City, Mich. 49684

[21] Appl. No. **823,433**
[22] Filed **May 9, 1969**
[45] Patented **Apr. 27, 1971**

[54] **WARPAGE MINIMIZING PROCESS FOR MACHINING METAL CASTINGS**
4 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **29/558,** 29/156.8, 29/527.6
[51] **Int. Cl.** **B23p 13/04**
[50] **Field of Search** ..... 29/558, 156.8, 156.8 (P), (Sheet Digest); 29/557, 23.5, 527.6, 173

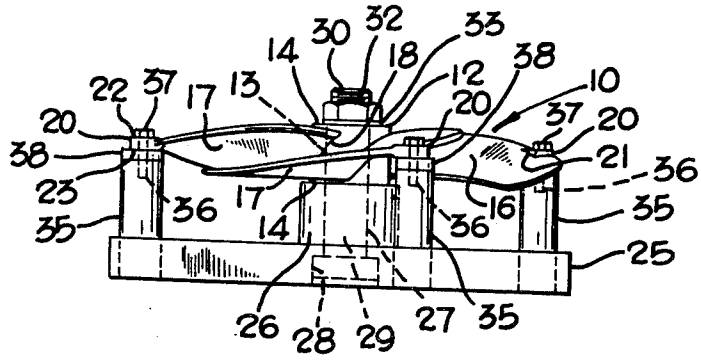
[56] **References Cited**

UNITED STATES PATENTS

3,002,266	10/1961	Lynn et al.	29/156.8
3,130,481	4/1964	Ahlen	29/527.6X
3,295,190	1/1967	Parsons	29/156.8
3,345,727	10/1967	Komarnitsky	29/557X

Primary Examiner—John F. Campbell
Assistant Examiner—Victor A. DiPalma
Attorney—Jerome A. Gross

ABSTRACT: A process of machining metal castings to minimize warping, especially useful in manufacturing propellers. When the casting is mounted for machining its shallow parts are restrained from warping out of alignment. After machining and while still so restrained, the more critical portions, for example, those near the roots of propeller blades, are machined to contour, then shot peened. The peening hardens the machined surface, increasing its bending resistance, to minimize warping when the casting is released from restraint.



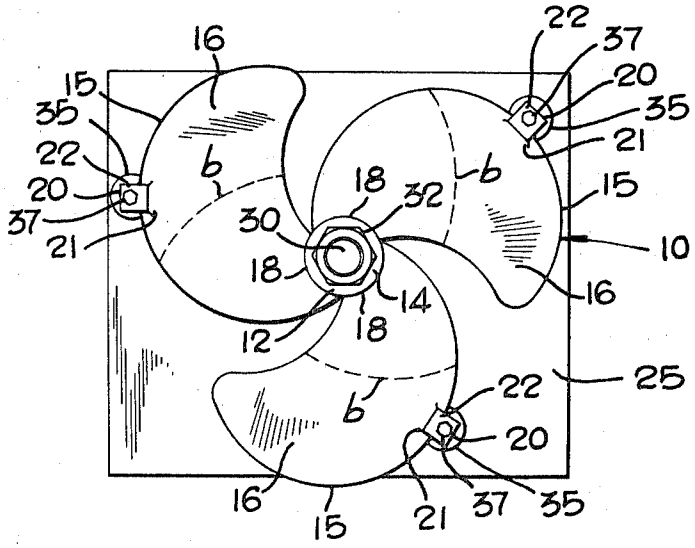


FIG. 2

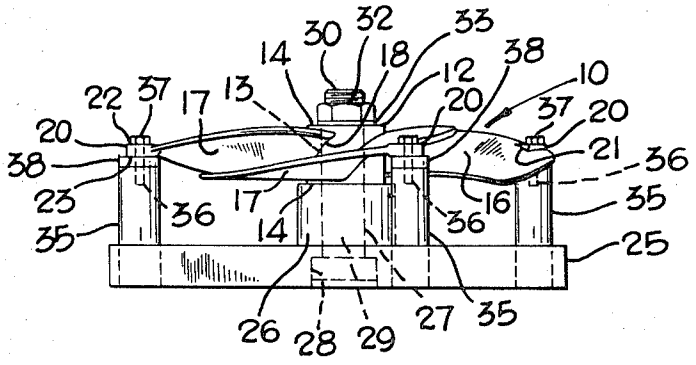


FIG. 1

Inventor
JOHN T. PARSONS

By Jerome A. Gross
Attorney

WARPAGE MINIMIZING PROCESS FOR MACHINING METAL CASTINGS

BACKGROUND OF THE INVENTION

The present invention relates to a process for machining castings and minimizing the warping attendant to machining portions thereof having relatively slender or shallow cross sections. It has particular application to the machining of propeller castings. In such castings, warpage of the blade portions adjacent to and outboard of the roots may cause severe deflection of the tips from their intended plane of rotation.

A principal cause of such warpage during machining is the uncontrolled release of some of the stresses locked in on cooling of the casting. Typically, when cast metals cool, they shrink. However their outer surfaces solidify sooner than the portions inwardly thereof, and cool to ambient temperature more quickly. As the surfaces solidify, they first assume a relatively unstressed length commensurate with the volume of the still molten metal at the interior. As the interior continues to cool, it solidifies; then, as its temperature lowers to ambient temperature, the interior tends to shrink further. Such further shrinkage of the solidified interior is resisted by the previously cooled surfaces, resulting in compression stresses in the surfaces and tensile stresses in the interior. If the casting is shallow its shape when cooled is in part dependent upon the balance of such compression and tensile stresses.

In such a situation, machining the surface removes some of the material in compression, disturbing this balance of stresses. Considering a shallow section, if this balance is disturbed more on one side than on the other, the casting will bend or warp.

One aspect of this problem is reviewed in my prior U.S. Pat. No. 3,295,190 dated Jan. 3, 1967, entitled "Method of Machining Metal Castings for Screw Propellers and the like." That patent sets forth a method of machining propeller blades which is suitable if machining pressures are light or if the outer portions of the propeller blades are of sufficient thickness to require no support during machining. In contrast, the present invention provides for rigidly restrained, undeflecting support of shallow casting portions during machining, and minimizes their warpage when released from such restraint.

SUMMARY OF THE INVENTION

Summarizing generally and without limiting the scope of invention, the present process is best applied to metal castings of relatively shallow cross section, that is, those having portions defined principally by two opposed surfaces spaced from each other more closely than their width. Typical are the blades of a marine propeller. Utilizing the present process, the casting is mounted and aligned and restrained in position for machining one of such opposed surfaces, for example, the convex blade surfaces of a propeller casting. While maintaining such restraint, such an opposed surface is machined to contour, and is then peened, as by shot peening. The peening increases the bending resistance of the metal at the machined surface, to compensate in part for the bending resistance of the metal removed by machining. The casting is then released from restraint, and mounted, aligned and restrained in position for machining its other surface or set of surfaces; in the example mentioned, the opposite blade surfaces. After such machining, such new machined surfaces are similarly peened; and the casting is then released from restraint. The peening of the opposed surfaces, while restrained from warping, affords them added resistance to bending out of the alignment in which the casting has been restrained. This added bending resistance lessens the warpage which would otherwise occur on release from restraint.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view of a marine propeller casting mounted aligned in position for machining the concave surfaces of its blade.

FIG. 2 is a plan view thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Typical of the castings for which the present process has been devised is the casting generally designated **10**. As cast, it includes a hub portion **12**, which in the machining process is first drilled to provide an axial bore **13** which establishes a plane of rotation. To mount the casting **10** for machining, it is also necessary to provide the hub **12** with end faces **14**, machined precisely perpendicular to the bore **13**.

Projecting from the hub **12** are three blade portions **15**. Each blade has two sets of surfaces, a concave surface **16** shown uppermost in the drawings and a convex surface **17** opposite thereto. Along the outer edges of each of the blade portions **15**, positioned approximately on a radial line from the hub axis extending through the blade root juncture **18**, is an integral restraint pad portion **20**, thicker than the blade portion **15** and having fillets **21** merging with its upper and lower surfaces **16**, **17**.

A somewhat simplified mounting fixture is shown schematically in FIGS. **1** and **2**. On a heavy base plate **25** is a cylindrical hub mounting platform **26**. The base plate **25** and hub mounting platform **26** have a central bore **27** and the base plate **25** has a counterbore **28**, holding a large central mounting bolt **29** whose upper end **30** is threaded to receive a mounting nut **32** and washer **33**, by which the hub **12** of the propeller casting **10** is mounted.

Outboard along the base plate **25**, spaced at equal angular and radial distances from the bore **27**, are rigid blade restraint posts **35**, positioned to restrain and support the machining pads **20** of the blade portions **15**. In the simple embodiment illustrated, each has a central vertical tapped bore **36** to receive a restraint bolt **37**. Bored spacers **38** may be provided on each of the posts **35**, of such thickness as may be required to provide the desired planar alignment of the restraint pads **20**.

In preparing a casting preliminary to machining its blade portions **12** to contour, after boring the hub **12** and providing its upper and lower faces **14**, each restraint pad portion **20** is machined to provide upper pad surfaces **22** in planar alignment with each other, and lower surfaces **23** similarly aligned. Restraint bores **24** are drilled through each of the pads **20** at precisely equal radial distances from the bore **13** and at equal angular distances from each other.

The casting **10** is then mounted by its hub portion **12** as shown in the drawings, in position for machining one of its two sets of blade surfaces, for example, its concave surfaces **16**. The blade portions **15** are secured in desired alignment by inserting the bolts **37** through the restraint bores **24** and bolting securely to the posts **35**, using spacers **38** to hold to desired planar alignment. The upper outer surfaces of the hub and the upwardly presented set of blade surfaces **16** are then machined to final contour either entirely or at least at and outboard of the root junctures **18**.

As stated earlier of this specification, such machining removes the surface metal which, by virtue of differential rates of cooling and other factors, is likely to be stressed in compression; and the result of the removal is to disturb the balance of stresses, as might typically tend to cause the blade portions **15** to warp upwards. The bolts **37** hold the restraint pad portions **20** so as to counteract this tendency to bend upward. The most critical region for such upward bending of each blade is that commencing at the root juncture **18** and extending outboard roughly halfway to the outer blade edges, for example, to the dashed line *b*. If warping curvature in this region can be minimized, such curvature nearer the tip portions will cause no serious deflections.

Therefore, after such machining I shot peen the surfaces so machined. Conventional shot peening apparatus, which propels shot against the machined surface portion, serves to harden the surface. With the blade portion held restrained from warping such hardening increases the bending resistance of the peened surface portion, to lessen its tendency to warp upward and thus to compensate in part for the effects of machining.

The restraint bolts **37** are then released, and the large nut **32** removed, freeing the partially machined casting to warp as much as it will. The casting **10** turned over and again bolted in place on the hub mounting platform **26**. Spacers **38** of approximate thickness are utilized to fix planar alignment of the pads **20**, and the restraint bolts **37** are again tightened, so that the unwarped desired alignment for machining is restored. The second set of blade surfaces **17** is them machined, at least those portions at and outboard of the blade root junctures **18** approximately to the line *b*, and such surface portions are peened to afford them additional bending resistance. Finally the casting is released from restraint. Any warpage which previously appeared will be found to be substantially offset by such second machining and peening under restraint. The pads **20** and their fillets **21** are cut off, and the edges marking the intersections of the blade surfaces **16**, **17** are finished, as well as those other portions of the casting which may require finishing.

The blade casting **10** is typical of metal castings at least part of which include cross sections defined by outer surfaces comprised principally of two opposed surfaces spaced more closely than their width. By machining the surface of such a casting portion while restraining it from warping out of alignment, and peening the machined portion without releasing the restraint, there results a substantial degree of compensation for the unbalance in stresses which accompanies the removal of metal during machining of the surfaces.

Utilizations other than on marine propellers will be apparent to those familiar with the problems of machining metal castings.

I claim:

1. For purpose of minimizing warping, the process of machining a metal casting at least part of which has a cross section defined by an outer surface comprised principally of two opposed surfaces spaced more closely than their width, comprising the steps of:

mounting the casting aligned in position for machining and restraining it from warping out of such alignment, then machining at least a portion of said opposed surfaces, and peening at least a portion of the surfaces so machined, whereby to increase the bending resistance of the peened surface portion; and then

releasing the casting from such restraint.

2. The process defined in claim **1**, wherein the step of peening is performed by propelling shot against such machined surface portion.

3. For purpose of minimizing warping, the process of machining a metal casting at least part of which has a cross section defined by an outer surface comprised principally of two opposed surfaces spaced more closely than their width, comprising the steps of:

mounting the casting aligned in position for machining one of said opposed surfaces, and restraining it from warping out of such alignment, and then, while maintaining such restraint against warping;

machining at least a portion of one of said opposed surfaces, and peening at least a portion of the surface so machined, then mounting the casting aligned in position for machining the other of said opposed surfaces and restraining it from warping out of such alignment, and then while maintaining such restraint against warping;

machining at least a portion of the other of said opposed surfaces and

peening at least a portion of such machined surface, whereby increased bending resistance at the peened surface portion compensates in part for the removal by machining of compressed metal at the outer surface of the casting.

4. The process of machining metal propeller castings, comprising the steps of:

mounting the casting by its hub portion in position for machining one set of its blade surfaces and securing its blade portions in desired alignment therewith;

machining said set of blade surfaces at and outboard of the root junctures of the blade portions;

peening the surfaces so machined, releasing the casting from such restraint; then

mounting the casting alignment in position for machining the other set of its blade surfaces and restraining its blade portions in the same desired alignment therewith;

machining said other set of blade surfaces at and outboard of the root junctures of the blade portions;

peening the surfaces so machined; and

releasing the casting from such restraint.