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INSPECTION OF A PORTION OF A PROPELLER LEADING EDGE BY OBTAINING A CAST PLASTIC DUPLICATE

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A method for the inspection of full scale propeller leading edges that are not mathematically defined or that have been modified in the field is required to aid in defining the numerical coordinates of the leading edge contour. A method of obtaining an impression of a portion of a propeller leading edge is described herein. The method fixes a number of reference dimensions relative to the propeller. Subseq[illegible]t plastic castings taken from the impression may be inspected with the aid of these dimensional references. The unknown portion

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20. of the leading edge contour may then be defined and added to the numerical specification of the propeller.

Subject: Inspection of a Portion of a Propeller Leading Edge by Obtaining a Cast Plastic Duplicate

Abstract: A method for the inspection of full scale propeller leading edges that are not mathematically defined or that have been modified in the field is required to aid in defining the numerical coordinates of the leading edge contour. A method of obtaining an impression of a portion of a propeller leading edge is described herein. The method fixes a number of reference dimensions relative to the propeller. Subsequent plastic castings taken from the impression may be inspected with the aid of these dimensional references. The unknown portion of the leading edge contour may then be defined and added to the numerical specification of the propeller.

Acknowledgment: This work was performed in December of 1978 at the Charleston Naval Shipyard under the sponsorship of NAVSEA Code 05H, Subproject S0218012, Task 11719.

Table of Contents

List of Figures

INTRODUCTION

When a full scale propulsor blade must be modified in the field or when detailed inspections of a small portion of the blade are required, a method of duplicating that portion of the blade surface is required. Additionally, sufficient dimensional references must be available so that inspections of castings taken from the impression are meaningful and may be used to accurately re-define the propeller contour.

A recent effort accomplished these goals. A fixture was designed and fabricated that was attached to the propeller hub face. This fixture aided in setting the radial, circumferential and axial dimensional references. Markings on the blade surface, resulting from the manufacture of the propeller were also used to verify dimensions. A box designed to contain an elastic polyurethane casting resin was attached to the fixture so that sides of the box corresponded with known dimensions. Contours in the various sides of the box were fit to the blade surface and sealed to be leakproof. The liquid resin was poured and allowed to solidify on the propeller. Once removed from the propeller, a rigid casting resin was used to make a duplicate of the blade surface. Dimensions were transferred to the duplicate and inspections at known locations made. At one location, an inspected section was compared to a specified section and very good agreement obtained. The additional inspected contours were then added to the propeller specifications. All surface details and imperfections were found to be accurately transferred to the final cast duplicates.

DESCRIPTION OF THE DIMENSIONAL REFERENCE FIXTURE

The most important aspect of inspecting a propeller is to accurately maintain the dimensions relative to some known reference. To that end, a fixture was designed and fabricated which fixed all dimensions relative to the propeller hub face. Because the hub face is perpendicular to the axis of rotation, it was not necessary to have the propeller laying on a flat level surface.

Figure 1 shows the fixture schematically. A circular plate was bolted to the hub face. The diameter of the plate corresponded to a recessed area in the hub and provided for rotation of the fixture on the hub face, about the propeller centerline. An "I" beam was affixed to the circular plate. The bottom of the "I" beam provided an axial dimension corresponding to the location of the hub face. The beam centerline was aligned with a reference mark on the blade corresponding to the design radial reference line. The beam then provided fixed radial dimensions. A sliding fixture was attached to one flange on the "I" beam. The sliding fixture was set at a particular radial dimension. Finally, a plywood box was suspended from the fixture. The box was sufficiently deep to pass through the blade and form a casting box into which casting materials could be poured. The contour of the propeller could not be determined a priori, so during installation of the fixtures approximate contours were determined and cut into the intersecting sides of the casting box. The intersection of the blade and the box was sealed to be leakproof with a resilient putty.

The sides and the bottom of the casting box provided dimensions relative to the radial reference on the propeller. Figure 2 is a photograph of the main fixture.

CASTING PROCEDURE

Once the casting box was located and sealed, shoring was placed under it to prevent movement as approximately 100 pounds of resin are required to fill the box.

The blade and box were coated with a release agent in preparation for taking the impression. CONAP INC. CONATHANE TV-79 Liquid Polyurethane Casting Resin was mixed in two gallon quantities to assure uniform mixture. The resin was poured into the casting box and allowed to cure for about 24 hours. At this point the casting box was removed and discarded. The cured resin is somewhat elastic and was carefully removed from the blade surface. This task was accomplished by blowing compressed air between the blade and the impression to help break the bond between the two materials. Figure 3 shows the final impression. The square sides of the impression are used for dimensional references. Additional marks on the blade surface were transferred to the impression

CASTING THE DUPLICATE

After allowing the impression to cure for several weeks, it was placed inside a second plywood box of dimensions equal to the casting box. CONAP INC. CONATHANE UC-17 Liquid Polyurethane Casting Resin was poured into the space left by the blade and allowed to cure. Figure 4 is a photograph of the casting material in the mold after the box was removed. The rigid casting was then removed from the mold. Visual inspection showed that all known surface details had been transferred to the duplicate. Flats and marks on the duplicate could be used as dimensional references.

INSPECTING THE DUPLICATE

One method of inspecting airfoil sections is to use an airfoil inspection machine with a spark-gap follower. Typically, these machines produce a rectangular cross-section 3, 5 or 10 times size. They require a conductive blade surface to provide current to the spark-gap follower. Inspection of the cast duplicate described previously required carefully machining the casting into three pieces to allow each section to fit into the inspection machine. Each piece was coated with conductive silver paint to allow current flow. The final three times size inspections were digitized and numerically re-assembled to produce the required data.

One section on the blade and on the casting was well defined by the original blade specifications. A direct comparison of the final casting to the original blade specification was thus possible. Figure 5 is a comparison of these two sections. It could be seen that the sections are within tolerance. At this point it was felt that the data derived from the technique described in this report were adequate for use in improving the specifications of the propeller.

Summary

A method of duplicating a portion of a full scale propeller blade surface was derived. Dimensional references were maintained by use of special fixtures. A rigid plastic replica of the area of interest was produced at dockside with a minimum of support equipment required. Inspection of the plastic replica indicated that the method accurately reproduced the blade surface. Inspection of the replica produced data that could be used to improve the specifications of the propeller.

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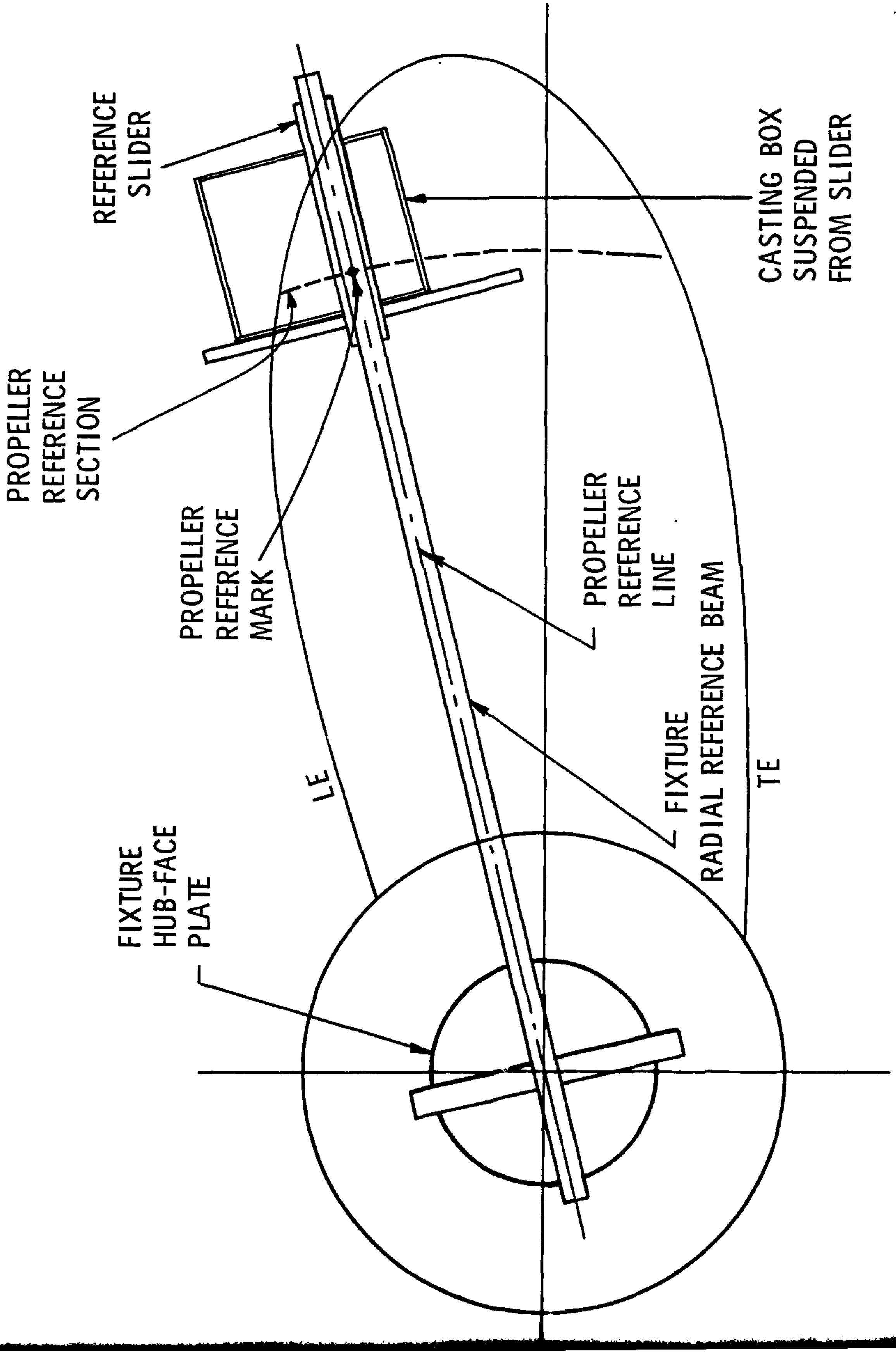

Figure 1. Drawing of Casting Fixture and Box Attached to Hub and Blade

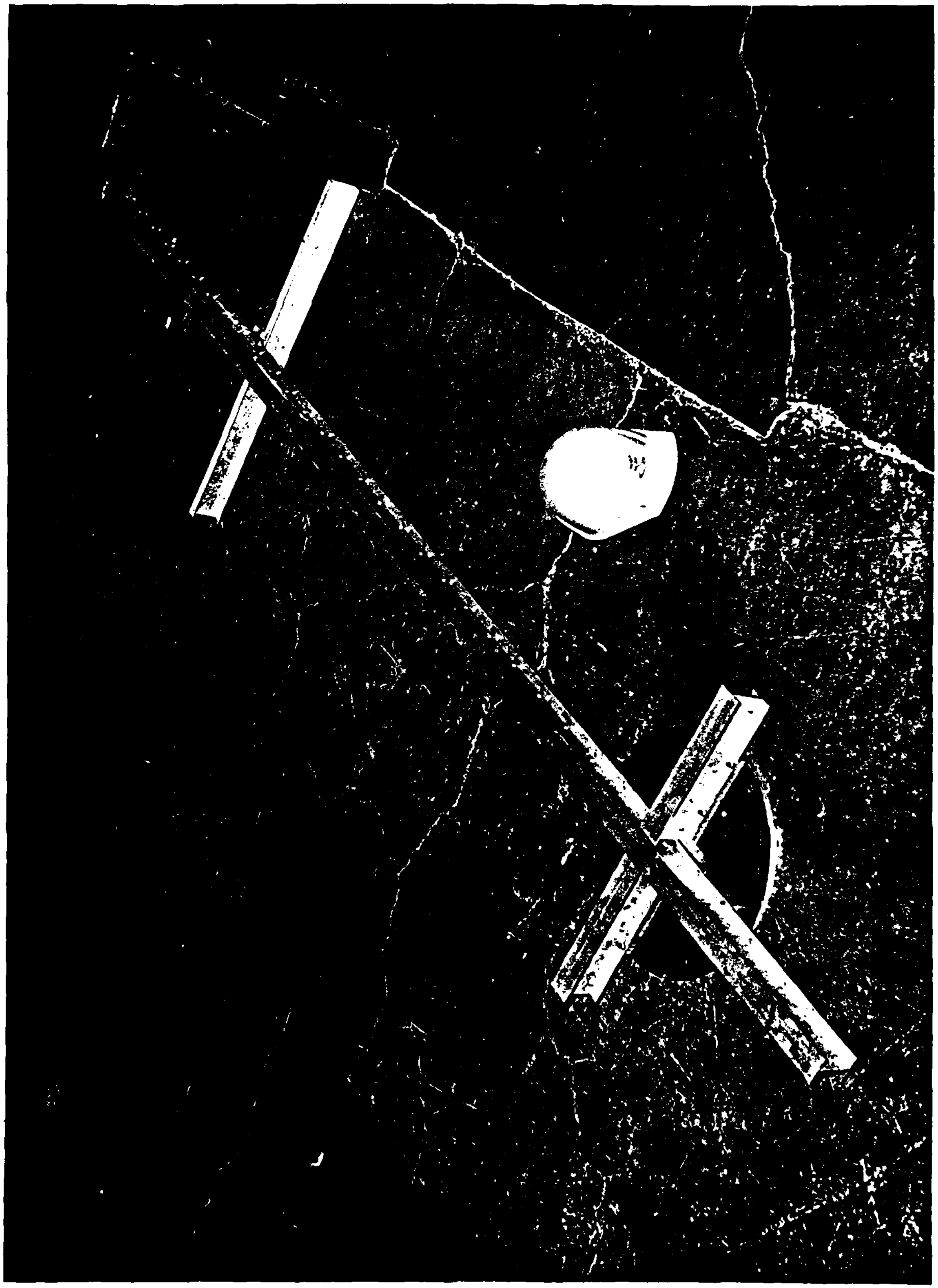

Figure 2. Photograph of Casting Fixture

Figure 3. Photograph [illegible]

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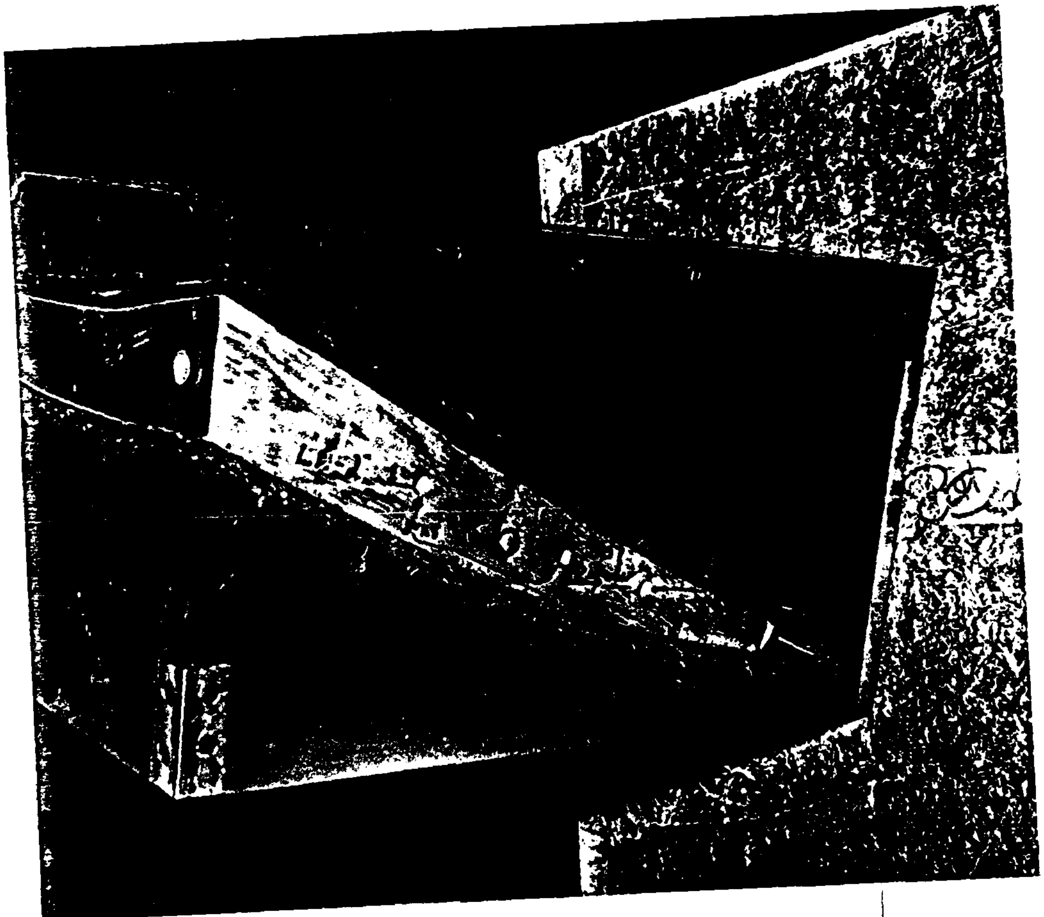

Figure 4. Photograph of Final Rigid Casting in Mold

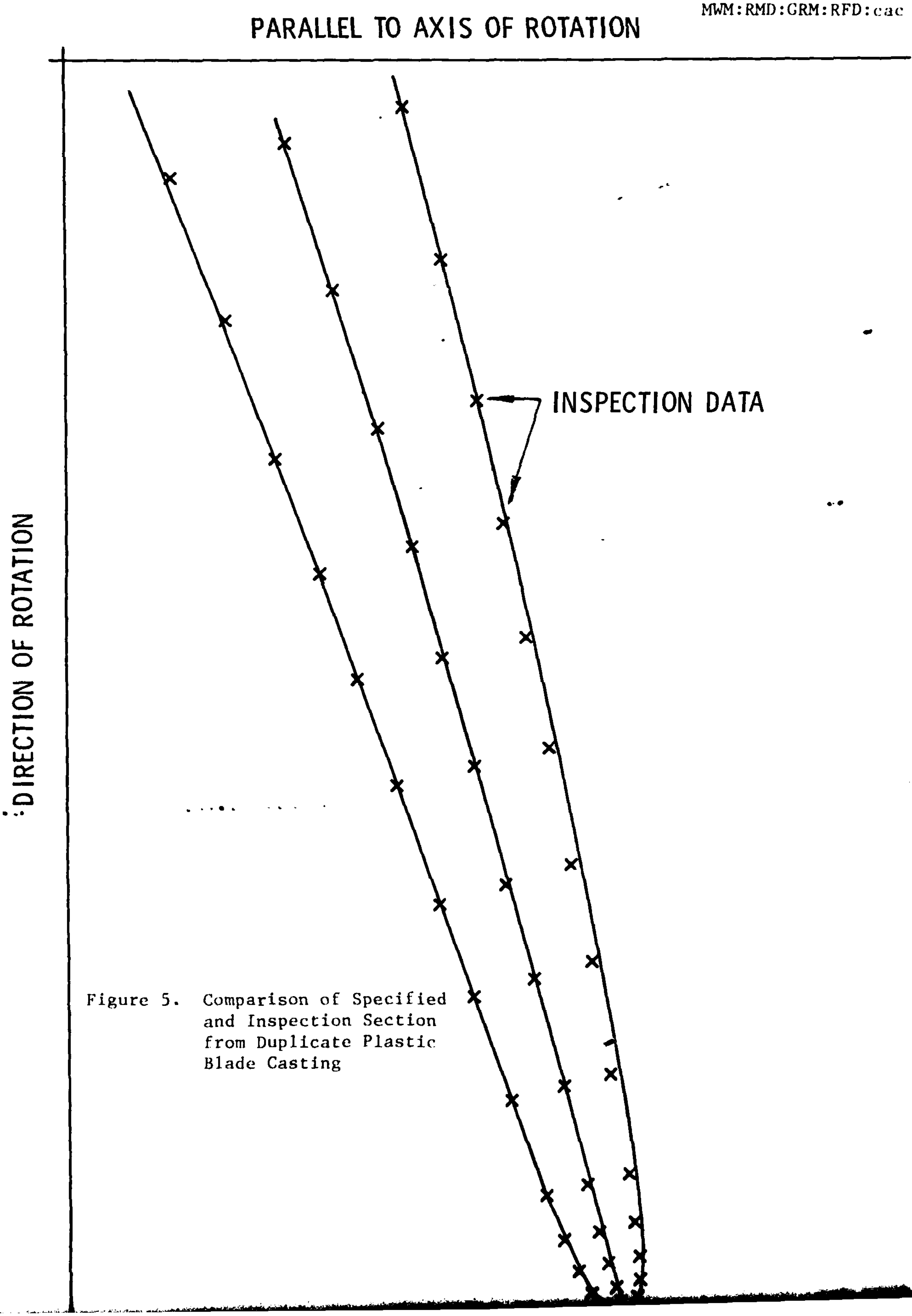

Figure 5. Comparison of Specified and Inspection Section from Duplicate Plastic Blade Casting

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