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CRANFIELD INSTITUTE OF TECHNOLOGY

# RADIAL INFLOW TURBINE STUDY

## SEVENTH INTERIM REPORT

by

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The radial inflow turbine is a primary component used both in small gas turbines and turbochargers. Better understanding of the flow processes occurring within the small passages of the machine could well result in the improved design of units. As most of the detailed aerodynamics is still ill-defined, a joint research project with the objective of improving our understanding has been instigated by Cranfield, the US Army and Turbomach (San Diego).

This document gives the seventh report on the project and describes progress and measurements taken.


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# PROGRESS REPORT

## PERIOD: 1.1.92 TO 29.2.92

As discussed in the last report, laser anemometry measurements are now under progress at various positions downstream of the rotor. The original design of both optical windows A and B (fig 1) had to be modified to overcome several unforeseen problems which occurred while the rig was operating.

Previous reports explain the problems caused by the icing of the window due to sub zero temperatures at the turbine outlet. This problem was solved by installation of electrical heaters at the turbine inlet far enough upstream not to disturb the flow. It was possible to maintain the turbine outlet temperature reasonably high so avoiding any condensation on the windows.

### Measurements at Window A

Laser anemometry results for the following running conditions have been obtained:

U/V = .64, .68, .70, .72 with PR = 3.0
U/V = .64, .68, .70 with PR = 3.5

Fifteen radial stations were selected to perform laser measurements at window A, fig 1. The separation between two stations was .125 inch (3.2mm). Laser measurements provided the velocity, flow angle and turbulent intensities at all measurement positions. In order to compare the laser results, a Cobra yawmeter probe has also been used after it was calibrated in a windtunnel (the details of which have already been included in previous reports). Cobra probe measurements were taken at approximately the same radial positions as the laser measurements.

Figs 2 and 3 give the laser anemometry and pressure probe results for pressure ratios of 3.0 at U/V = .64. Fig 2 gives the velocity variation along the radius of the duct at window A whereas fig 3 shows the swirl angle variation for different radial positions. Figs 4 and 5 show the results for the same window but at a different running condition (U/V = .64, PR = 3.5). Results for all the other running conditions have now been completed which will be presented in the final report.

## Measurements at window B

Results at the following conditions have now been completed for this window:

U/V = .64, .68, .70, .72; PR = 3.0
U/V = .64, .68, .70; PR = 3.5

Ten radial stations with a separation of 3.2mm were chosen in this case. Cobra probe results for all those positions have also been obtained.

Figs 6 and 7 give a comparison of laser anemometry measurements with those obtained by the Cobra probe for the same running conditions (U/V = 64, PR = 3.0) and approximately at the same radial positions. Results for the other running conditions have also been completed. Discussions on these results will be included in the final report.

## Measurement at the Inlet of the Turbine Rotor

It was also reported in the previous report that several schemes were under consideration to provide optical access for laser measurements at various positions at the turbine rotor inlet (between guide vanes and rotor). This task has been time consuming but is now completed. The details of the machining and the various positions at the inlet have not been given in this report and will be explained in the next report. Mirrors and optical windows suitable for this work have been obtained and the laser results will be undertaken in the near future.

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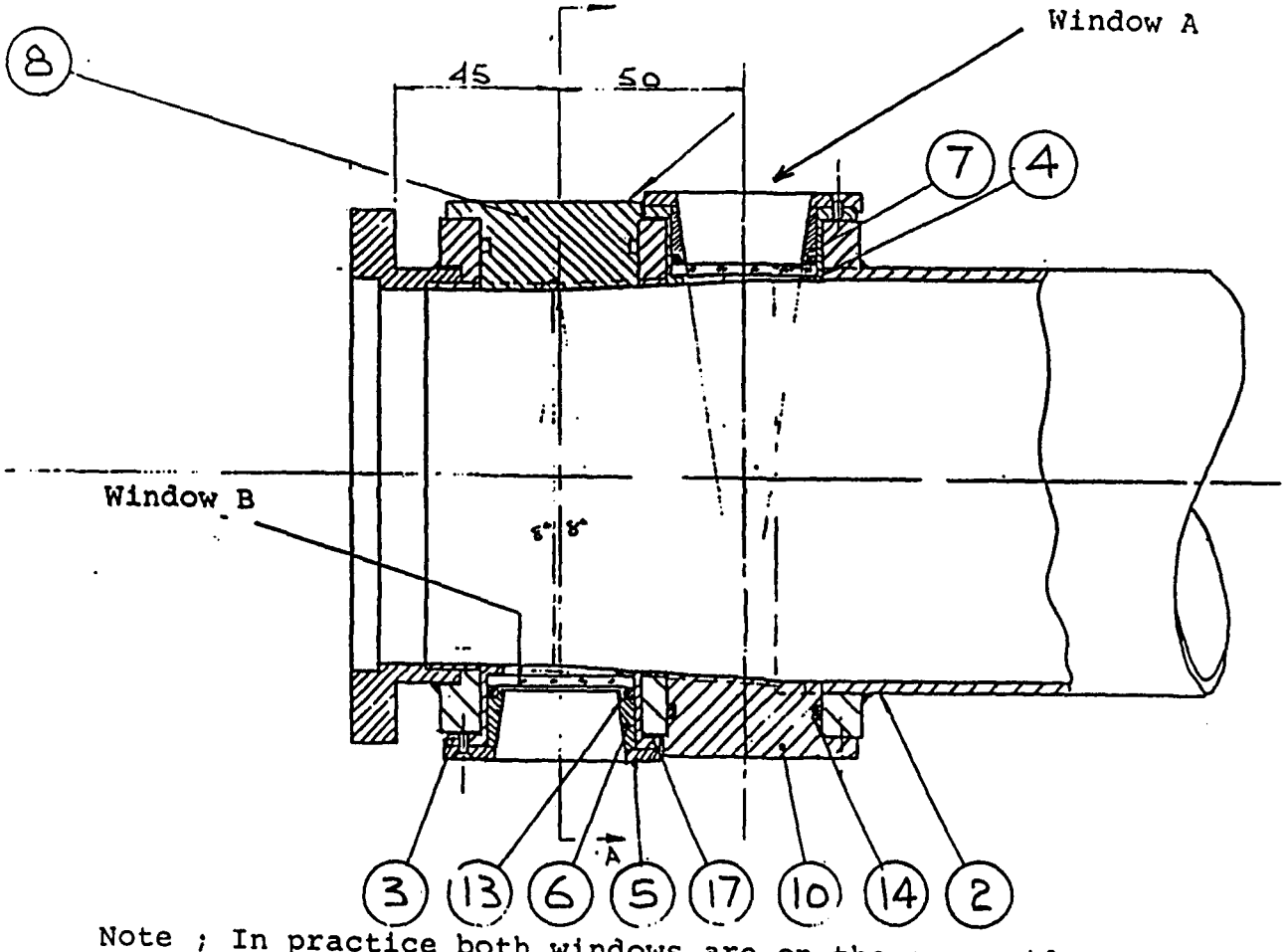
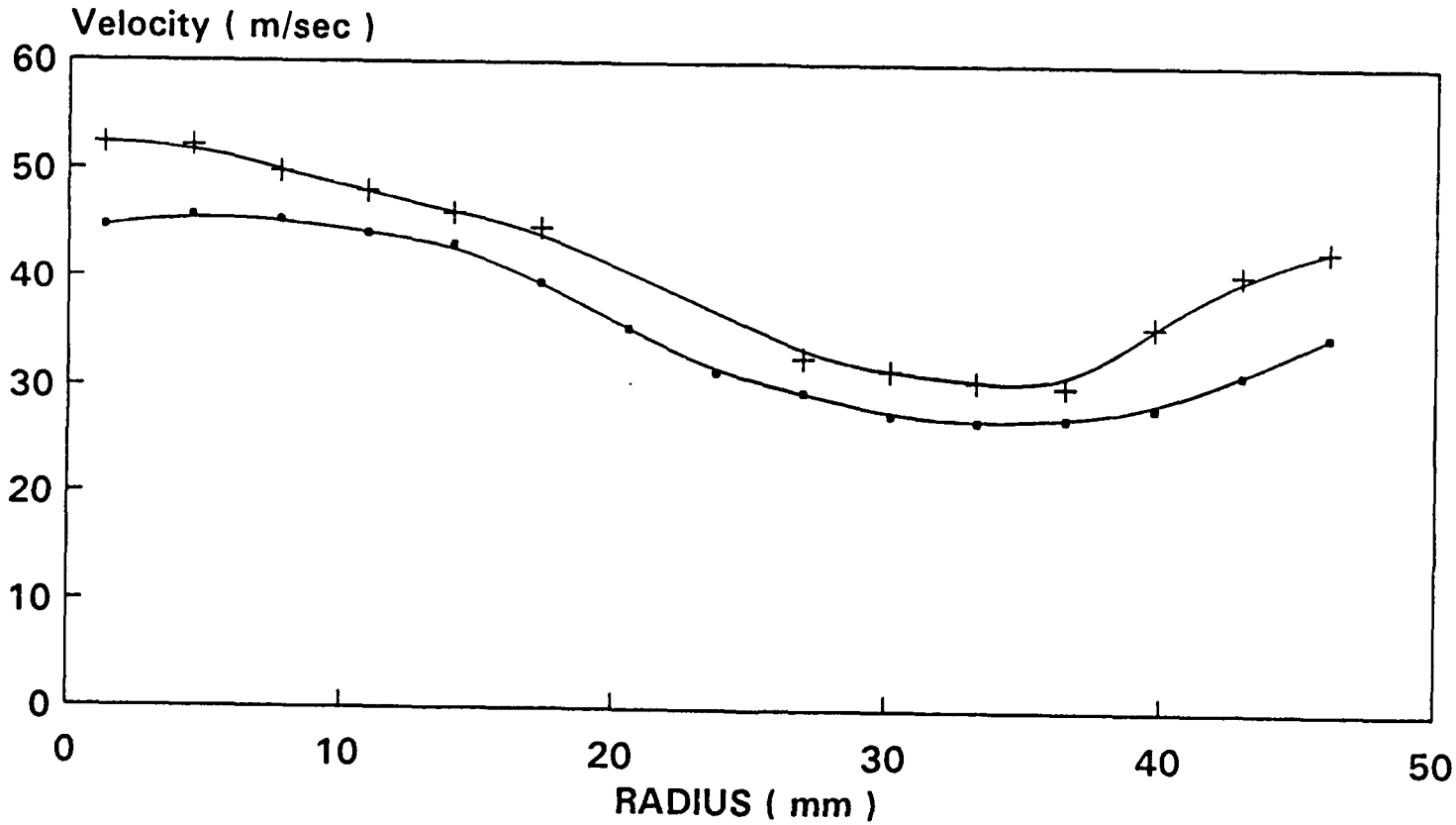



Note ; In practice both windows are on the same side.

FIG 1 ; WINDOWS FOR OPTICAL ACCESS

# CRANFIELD LA MEASUREMENTS

## Window A : PR = 3.0 : U/V = .64

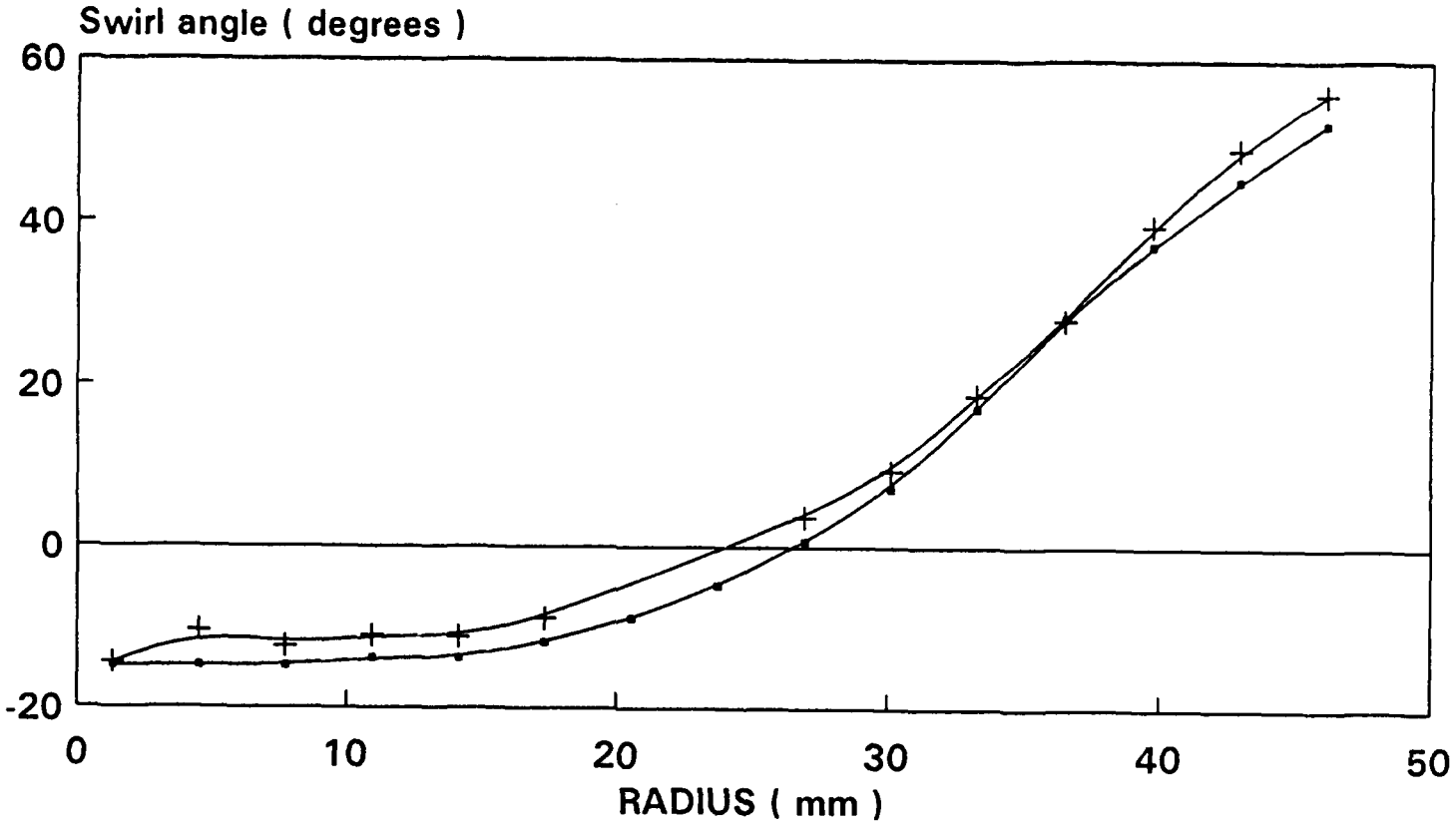



• Cobra + Laser

Figure 2

# CRANFIELD LA MEASUREMENTS

## Window A : PR = 3.0 : U/V = .64

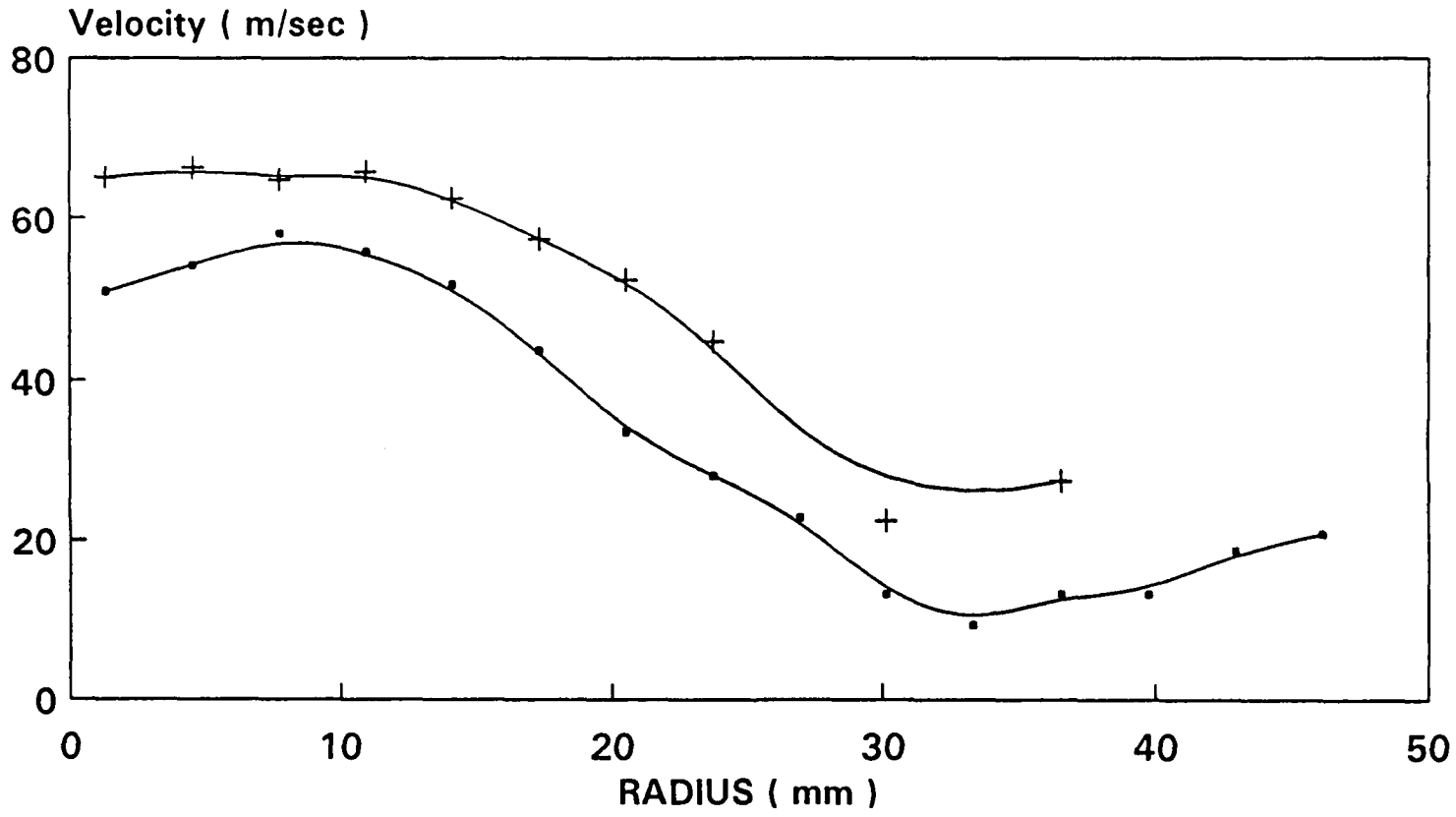



• Cobra + Laser

Figure 3

# CRANFIELD LA MEASUREMENTS

## Window A : PR = 3.5 : U/V = .64

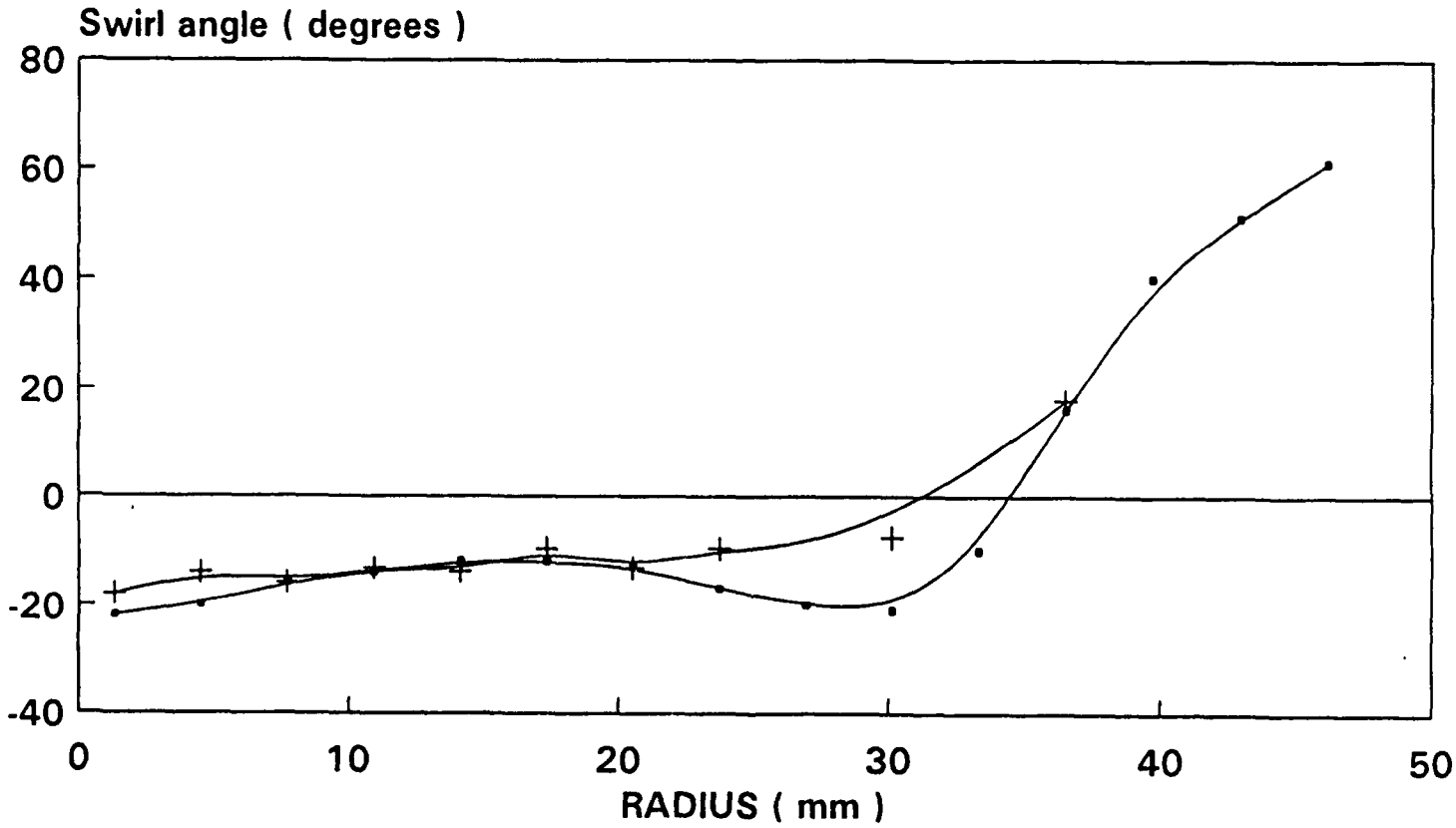



• Cobra + Laser

Figure 4

# CRANFIELD LA MEASUREMENTS

## Window A : PR = 3.5 : U/V = .64

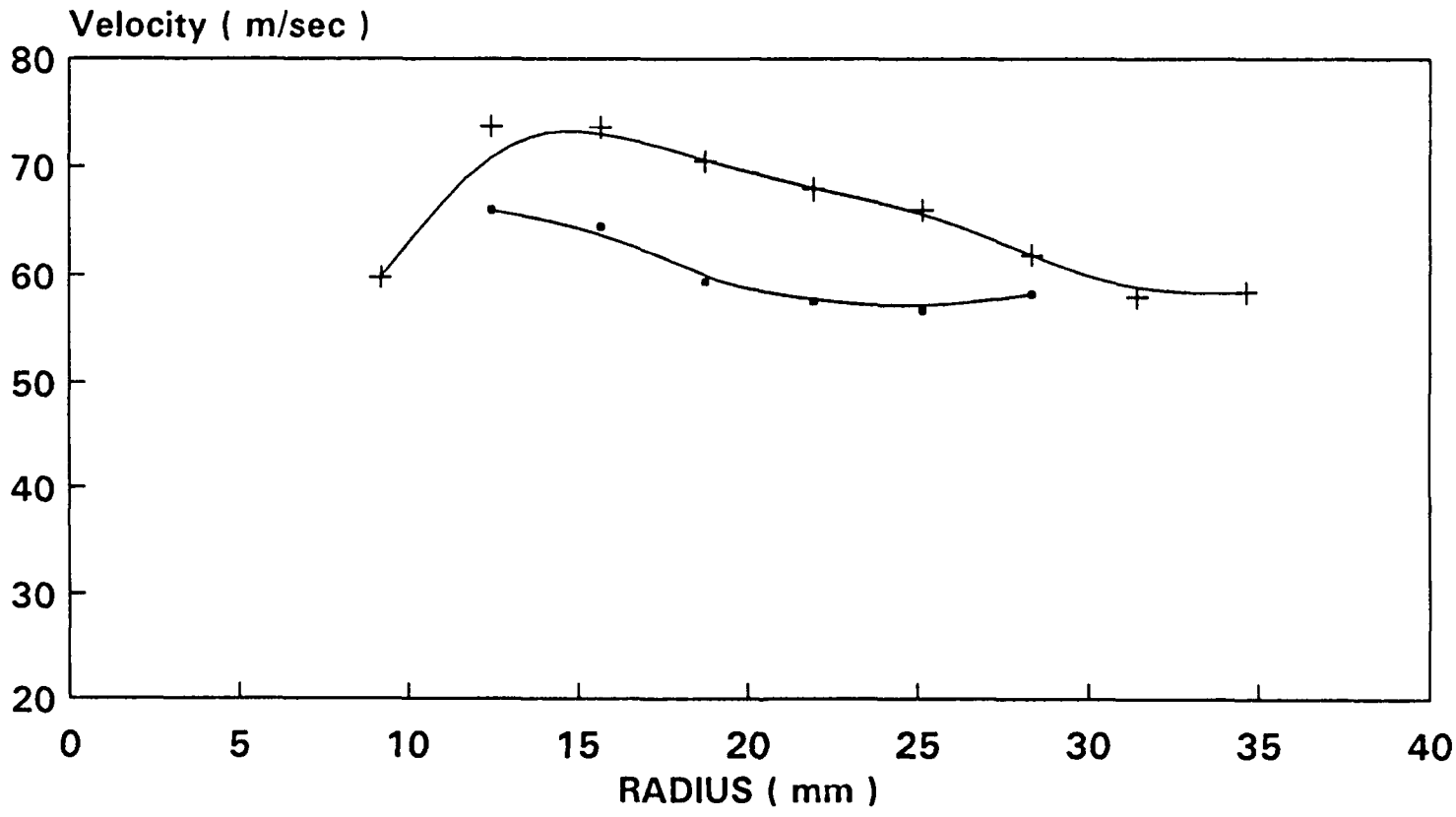



• Cobra + Laser

Figure 5

# CRANFIELD LA MEASUREMENTS

## Window B : PR = 3.0 : U/V = .64

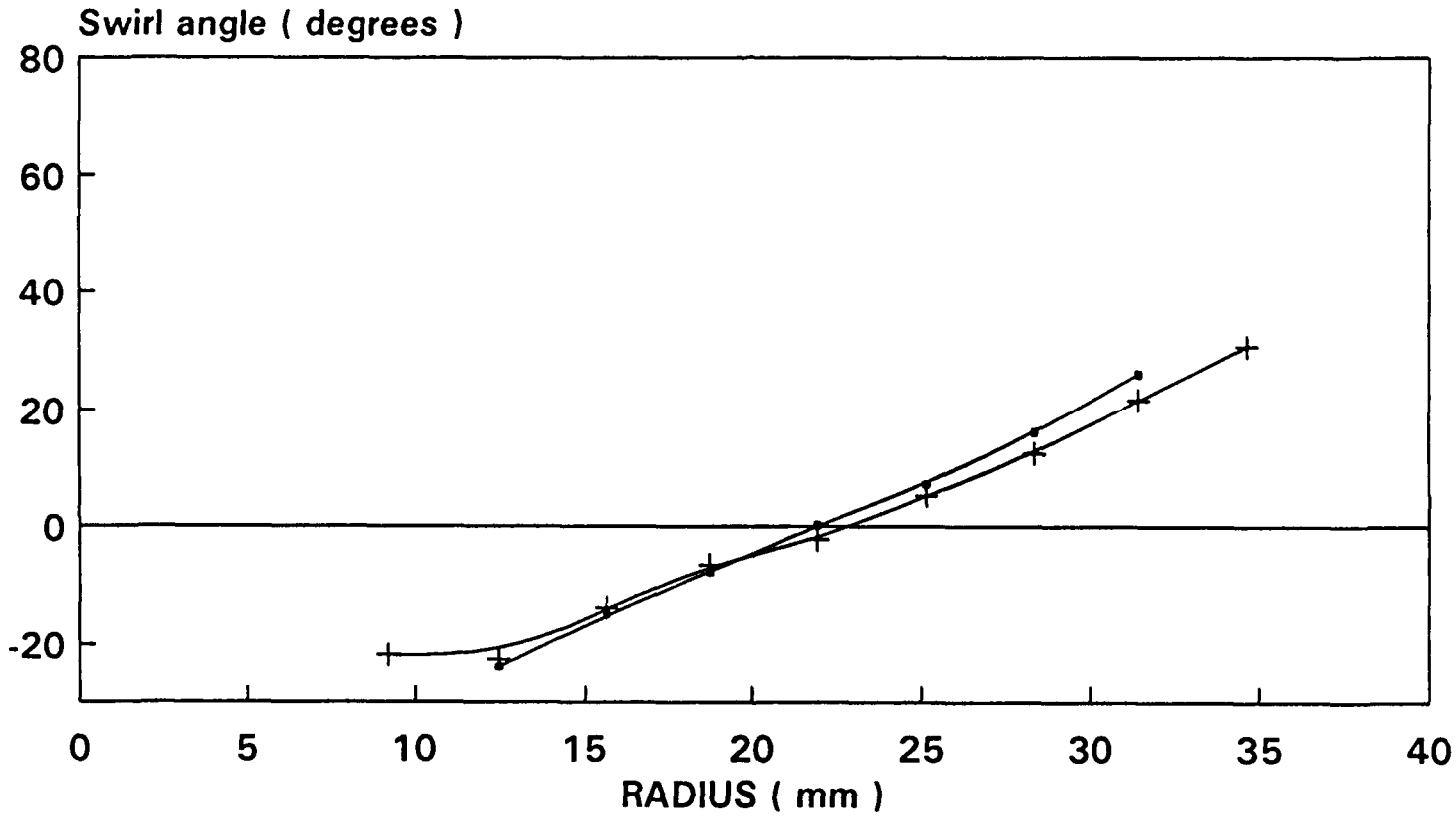



• Cobra + Laser

Figure 6

# CRANFIELD LA MEASUREMENTS

## Window B : PR = 3.0 : U/V = .64




• Cobra + Laser

Figure 7