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DEVELOPMENT OF FIBER-BASED LASER ANEMOMETER FOR SSME APPLICATION

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SUMMARY

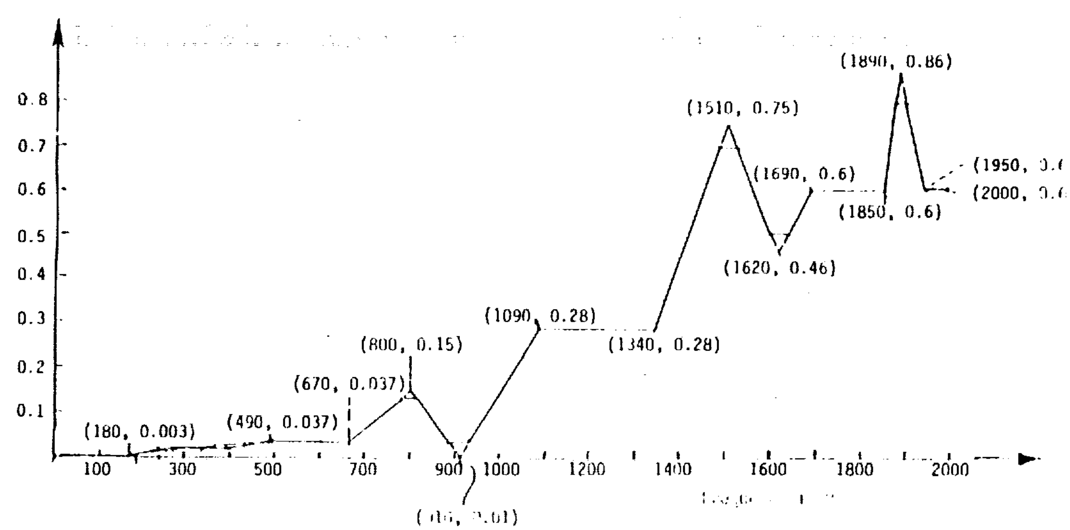
During the past twenty years, laser Doppler anemometry has become an important non-intrusive diagnostic tool. It has been used for detailed and accurate measurement of fluid flows in wind tunnels, air-breathing engines, rocket motors, shock tubes, etc. A recent study by Rocketdyne for NASA identified laser anemometry, using a compact optical head, as a feasible diagnostic instrument for the SSME Model Verification experiments. PRi is presently under contract from NASA Lewis to develop and deliver such a laser anemometer system. For this application, it is desired to place the laser at a remote distance from the engine, and use single mode polarization preserving fiber optics for the transmission of the laser light to and from the measurement head. Other requirements for the instrument include:

1. Two simultaneous components
2. Flow velocity: -300 to 300 m/s
3. Flow angle: 0 to 360°
4. Severe vibration and temperature environments as specified
5. Measurement resolution: 1 mm (normal to the flow)
6. Optical probe dimensions: 25 mm diameter; 15 cm length
7. Total run time: 500 seconds
8. Accuracy: 5% velocity magnitude, 3 degree in angle

Analytical and experimental tools are being used to develop the technologies required for the laser anemometer. These include finite element analysis of the optical head and vibration tests for various optical and mechanical components. Design of the optical head and the fiber optic connectors are driven by the temperature and vibration requirements for the measurement environment. Results of the finite element analysis and the vibration tests of the components are included. Conceptual design of the fiber optic launcher and the optical probe has also bee complete. Detailed design of the probe as well as the fabrication and assembly of the components is in progress.

It is anticipated that the anemometer will be fabricated and its performance evaluated through a series of vibration and environmental tests before the delivery of the optical system to NASA for further evaluation.

Vibration Power Spectral Density



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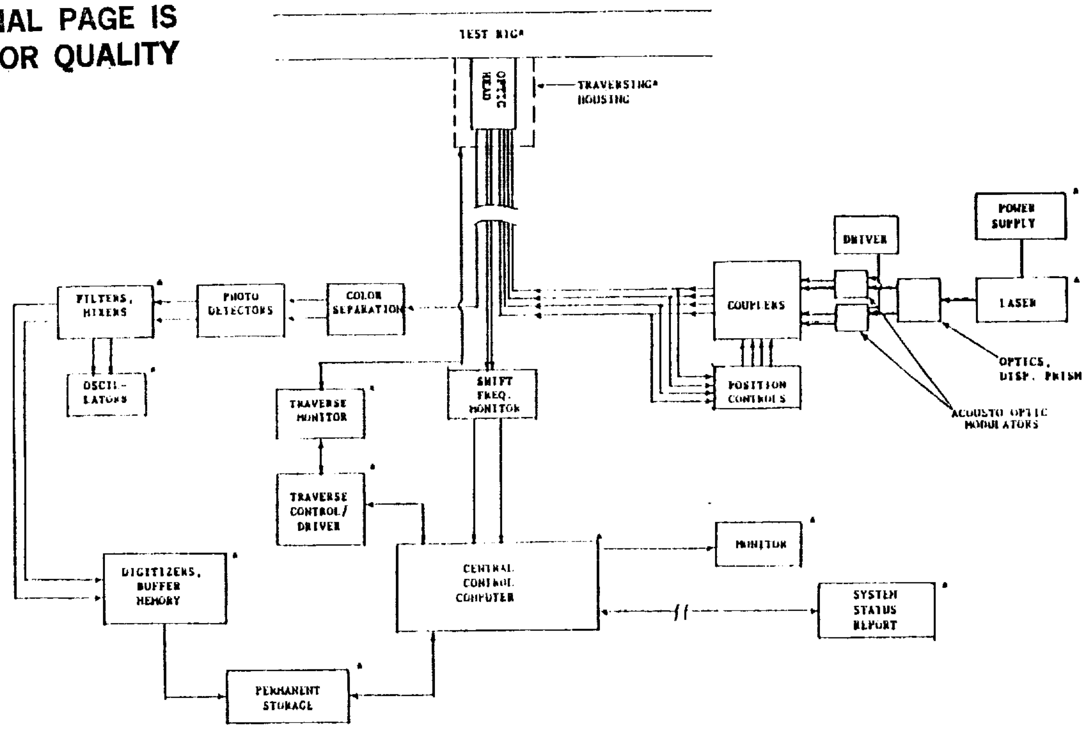
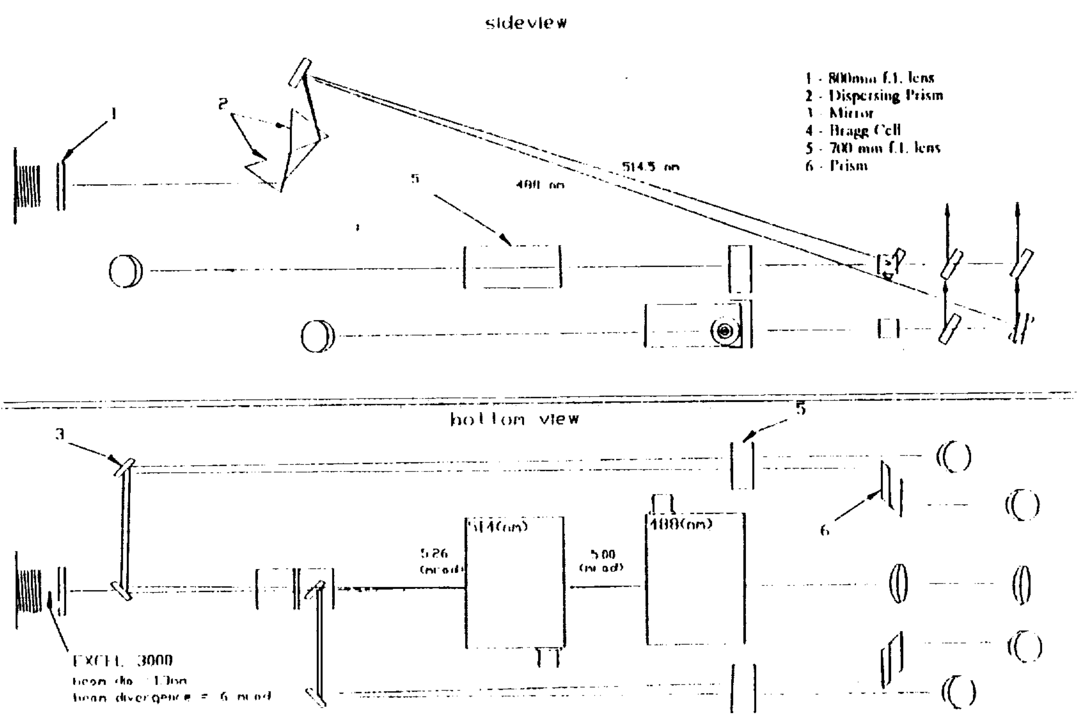
Component System Diagram



*Not included in the deliverables.

Optical Configuration of the Source System



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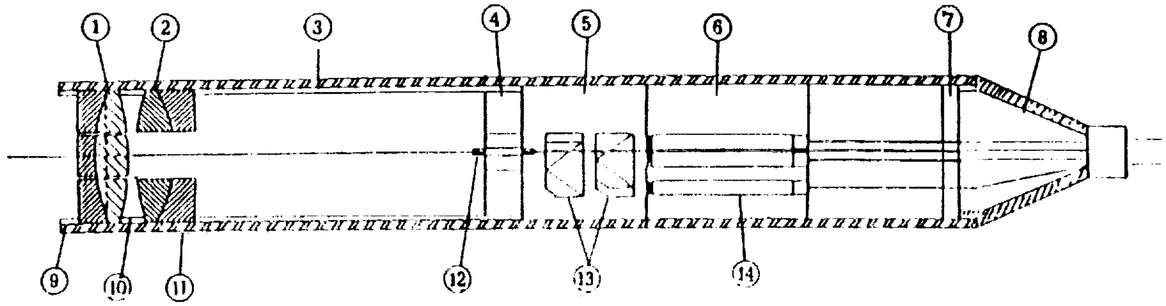
Optical Head Design



Description

1. Transmitter Lens
2. Focus Lens
3. Spacer
4. Receiver Fiber Stage
5. Prism Carrier
6. Collimating Lenses Alignment Assembly
7. Spider Ring
8. Backshell
9. Cap
10. Spacer
11. Shell
12. Receiver Fiber
13. Prism
14. Feedback

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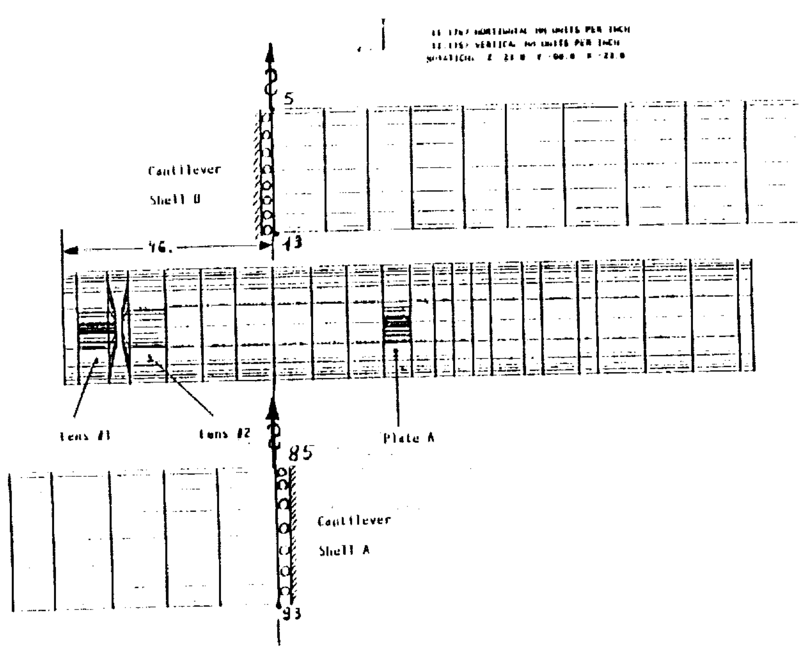
Division of the Probe into Two Cantilevers for Independent Analysis



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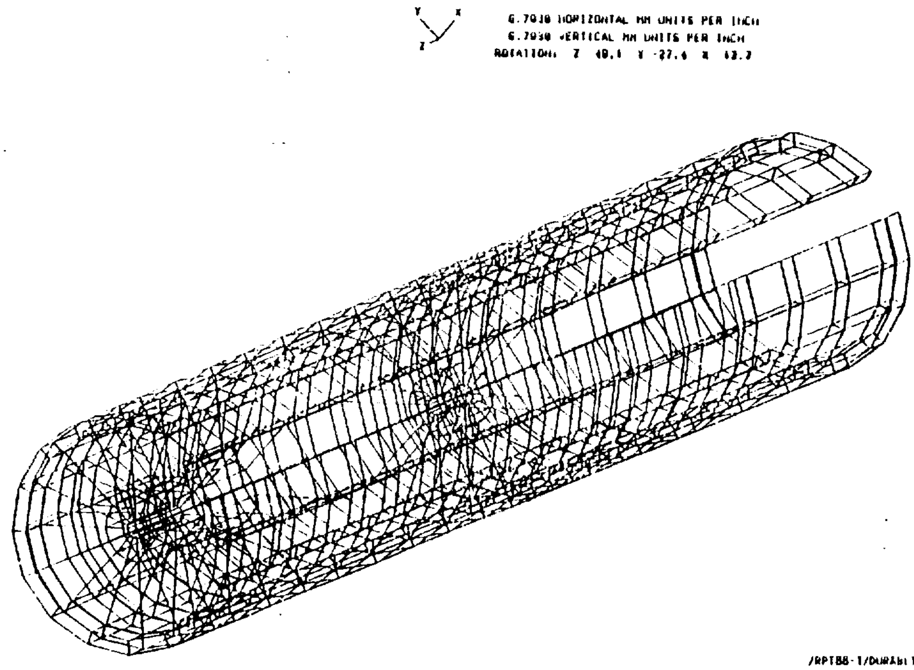
Finite Element Model of the Probe, Including the Lenses and Fiber Holders



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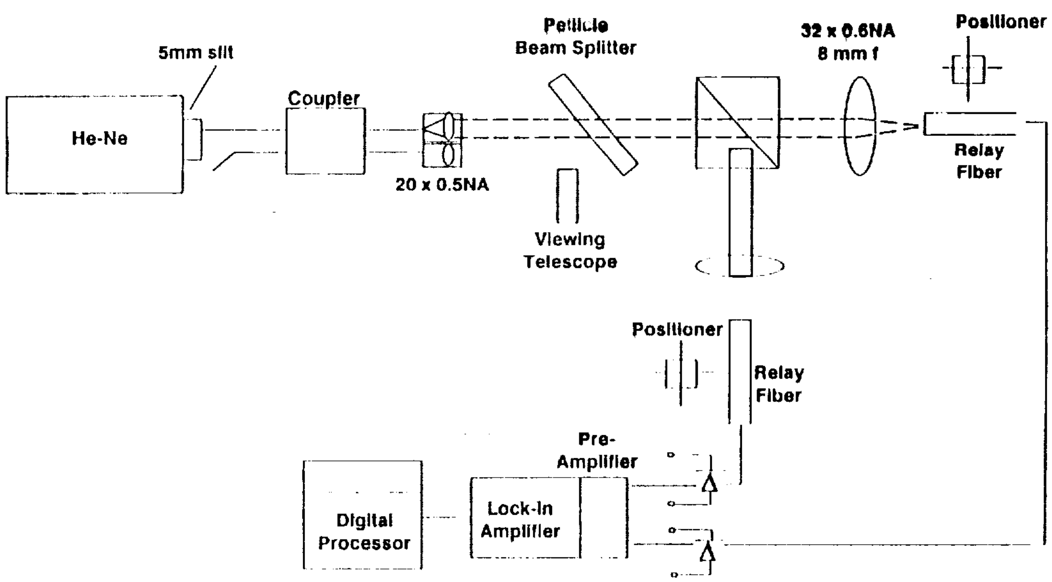
Beam Quality Test Set-Up



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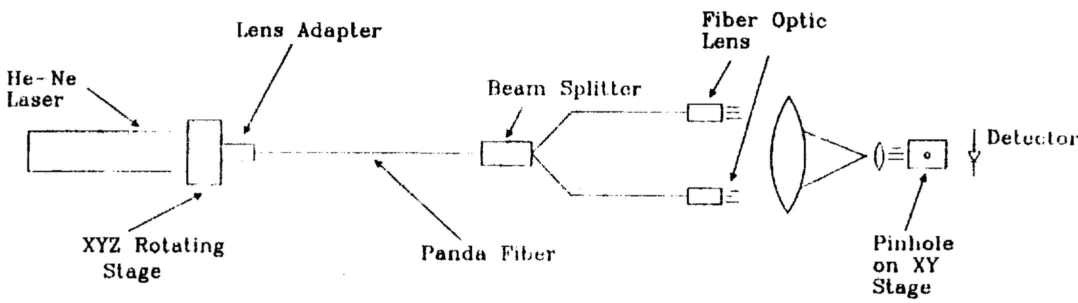
Fiber Vibration Test Setup



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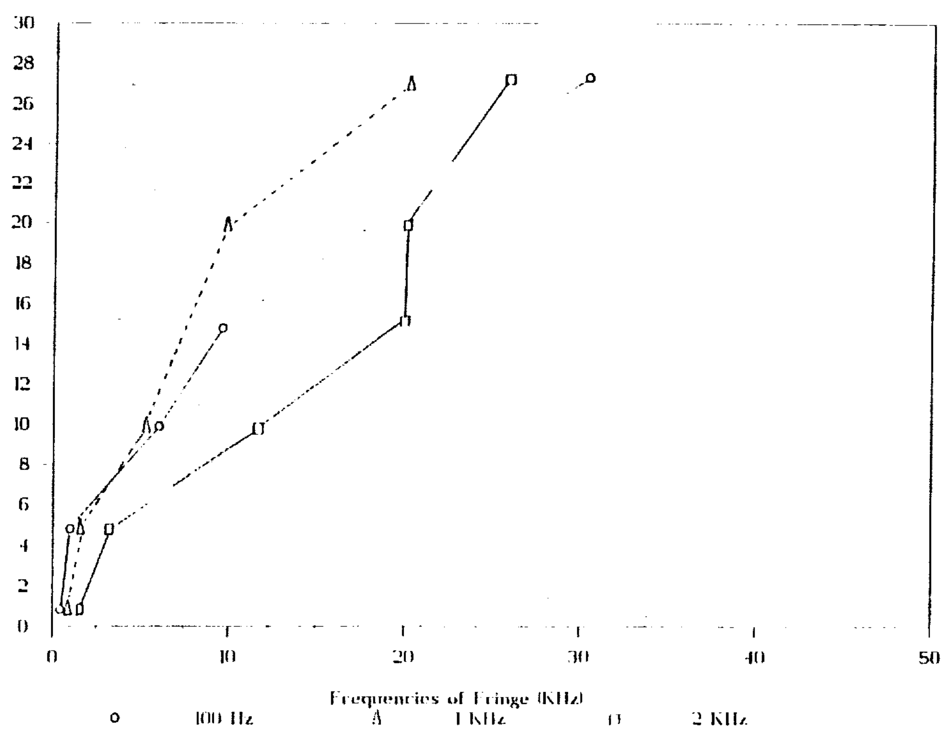
Vibration Test (Single Cable)



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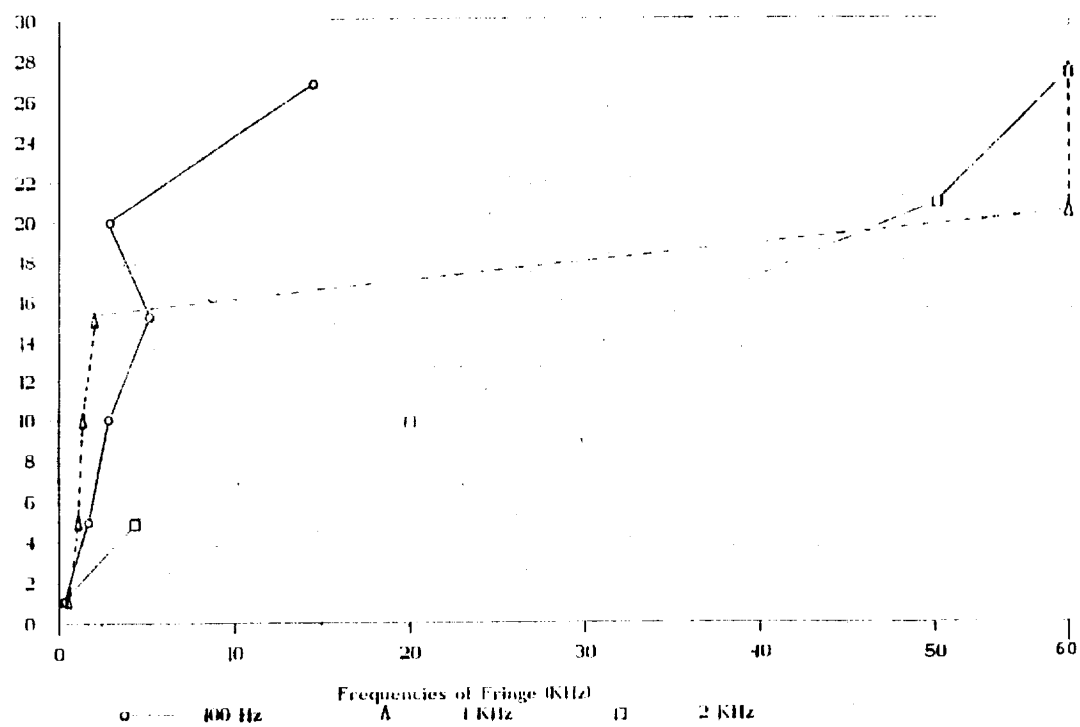
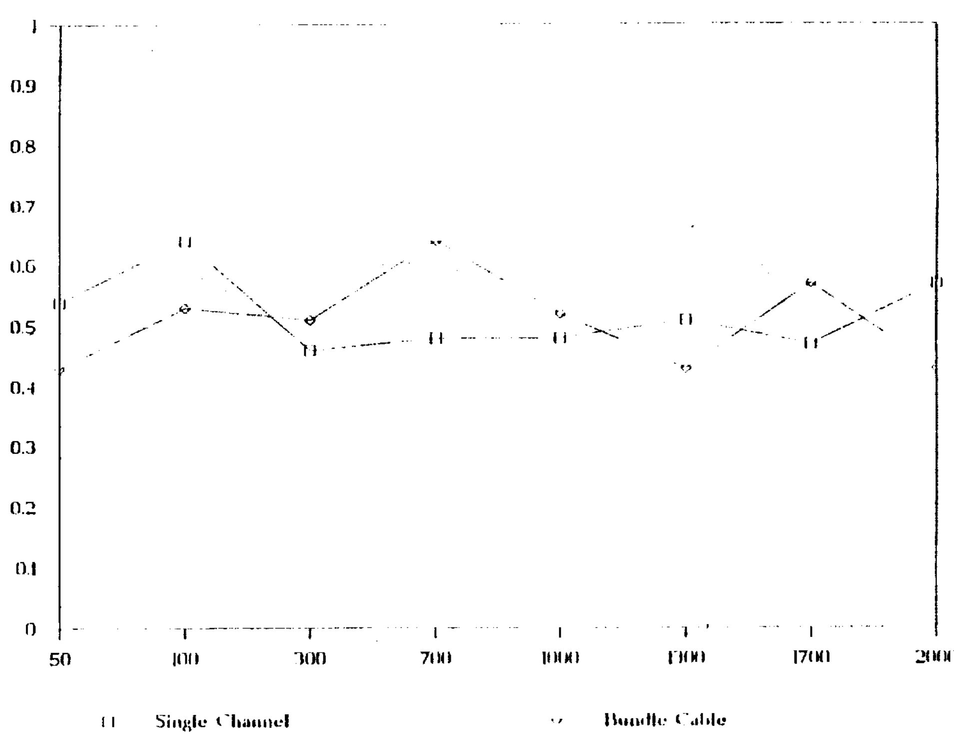
Vibration Test (Bundle Cable)



Visibility vs Cable Vibration Frequency



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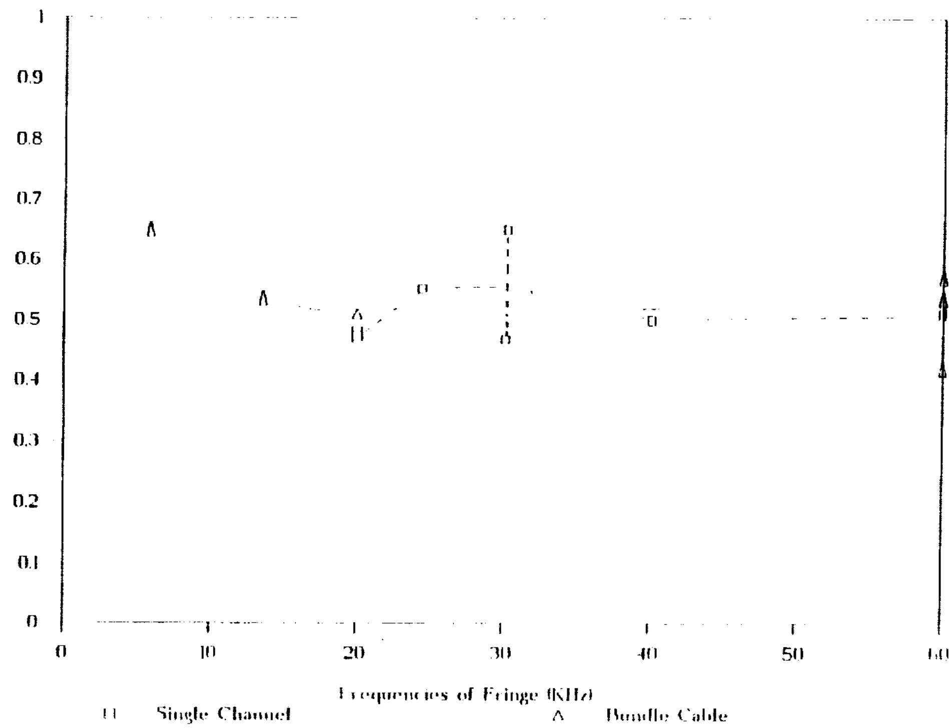
Visibility vs Frequencies of Fringes



Cable Vibration Frequency vs. the Frequency of the Fringes at 27 G