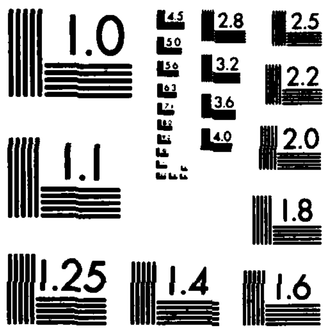
AD-A142 608 TECHNICAL SUPPORT FOR MICROWAVE EXPERIMENTS ON THE EYE LENS(U) SCIENCE APPLICATIONS INC MCLEAN VA ELECTRO-OPTICS TECHNOLOGY DIV N C WYETH OCT 82 SAI-168-030-026 DAMD17-80-C-0057 — 1/1

UNCLASSIFIED — F/G 6/18 — NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD__________

(Report Number)

TECHNICAL SUPPORT FOR

MICROWAVE EXPERIMENTS ON THE EYE LENS
SUBTITLE:
INTERFEROMETRIC MEASUREMENT OF EYE LENS

MOTION UNDER MICROWAVE PULSE EXPOSURE

Annual Report for Period
September 1, 1981 - October 31, 1982

N. Convers Wyeth
October 1982

Supported by
U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Fort Detrick, Frederick, Maryland 21701

Contract No. DAMD17-80-C-0057

Science Applications, Inc.
McLean, Virginia 22102

Approved for public release; distribution unlimited.

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Technical Support for Microwave Experiments on the Eye Lens - Subtitle: Interferometric Measurement of Eye Lens Motion Under Microwave Pulse Exposure	5. TYPE OF REPORT & PERIOD COVERED Annual Report (September 1, 1981 - October 31, 1982)
	6. PERFORMING ORG. REPORT NUMBER 168-030-025
7. AUTHOR(s) N. Convers Wyeth	8. CONTRACT OR GRANT NUMBER(s) DAMD17-80-C-0057
9. PERFORMING ORGANIZATION NAME AND ADDRESS Electro-Optics Technology Division, Science Applications, Inc., 1710 Goodridge Dr., McLean, Virginia 22102	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62771A.3E162771A805.00.015
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, Maryland 21701	12. REPORT DATE October 1982
	13. NUMBER OF PAGES 9
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Laser interferometry
Microwave cataractogenesis

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A research program at Walter Reed Army Institute of Research (WRAIR) is concerned with the mechanism by which microwave exposure produces cataracts in the eye lens. Science Applications, Inc. (SAI) is supporting WRAIR personnel in system design, equipment assembly, and operation of experiments to measure the physical effects in the eye lens as it is subjected to microwave pulses of varying peak power levels. This report describes an ongoing project using a laser interferometer and rat eye lens in vitro. The experiment is presently in the data collection phase, with no firm conclusions yet drawn.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SUMMARY

A research program at Walter Reed Army Institute of Research (WRAIR) is concerned with the mechanism by which microwave exposure produces cataracts in the eye lens. Science Applications, Inc. (SAI) is supporting WRAIR personnel in system design, equipment assembly, and operation of experiments to measure the physical effects in the eye lens as it is subjected to microwave pulses of varying peak power levels. This report describes an ongoing project using a laser interferometer and rat eye lens in vitro. The experiment has detected motion of the eye lens surface, but has not yet differentiated between bulk motion of the lens and deformation.

Table of Contents

1. INTRODUCTION AND BACKGROUND

The causal relationship between excessive microwave exposure and the subsequent development of cataracts in the eye lens is well documented. Present safety standards are specified in terms of maximum average power level and duration of exposure. There remains the question of whether the peak power occurring within a given average power exposure has any additional effect on cataract production; if it does, the safety standards should be rewritten to take account of this. The physical mechanism by which the radiation triggers subsequent cataract formation is also not well defined.

A research program at the Walter Reed Army Institute of Research (WRAIR) is addressing these issues and using optical techniques to measure the physical effects in the eye lens as it is subjected to microwave pulses of varying peak power levels. Science Applications, Inc. (SAI) has supported WRAIR personnel in system design, equipment assembly, and operation of an experiment to detect physical deformation of an eye lens induced by microwave pulses using laser interferometric techniques. This experiment has detected motion of the eye lens surface, but has not yet differentiated between bulk motion of the lens and deformation.

2. MEASUREMENT SYSTEM

The design and evolution of the optical measurement system was described in the previous annual report. The system configuration has undergone several modifications since its initial conception; the present design is shown in Figure 1. The arrangement is a simple Michaelson interferometer with a focusing lens to allow relatively undistorted wavefronts to be reflected from a small area of the eye lens. The eye lens is immersed in saline during the measurements; this approximates its situation in vivo.

The interferometer reference mirror is mounted on a calibrated piezo-electric translator which moves the mirror along the reference beam axis in proportion to the voltage applied to it (1.875 nm/volt). With a known amplitude of motion thus imposed on the reference mirror (typically at 1 kHz), it is simple to calibrate the detector output in terms of the displacement it represents for a given fringe pattern. This calibration is then directly applicable to the eye lens signal during a microwave exposure.

The superposition of the reference and object beams on the observing screen produces an interference pattern in a one centimeter diameter circle (the expanded beam size). The width and orientation of the light and dark fringes can be changed by adjusting the angular position of the reference mirror. The full pattern can not be adjusted to all light or all dark, indicating that the converging wave fronts were not exactly aligned with the lens surface. However a highly symmetric pattern of concentric rings with a fairly large central spot is obtainable as shown in Figure 2a.

The active area of the photodiode is a square of dimension 0.5 mm. The best motion signals are obtained when the interference fringes are adjusted as shown in Figure 2b, i.e., arcs of small curvature and constant width roughly equal to the detector size.

The light paths of the interferometer are shielded against thermal air currents. However net heating of the saline/lens medium by the microwaves

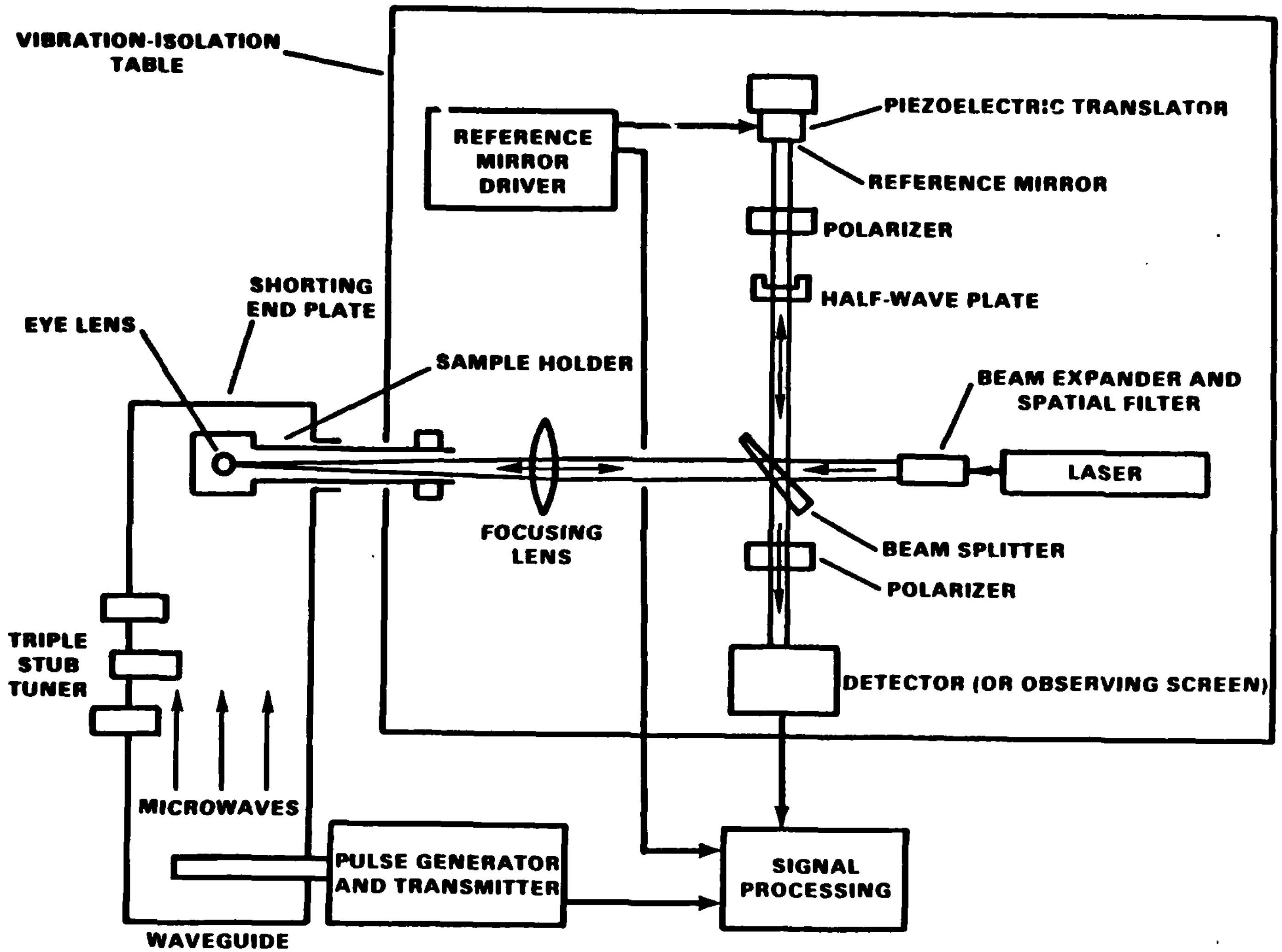


Figure 1. Schematic Diagram of the Interferometer System.

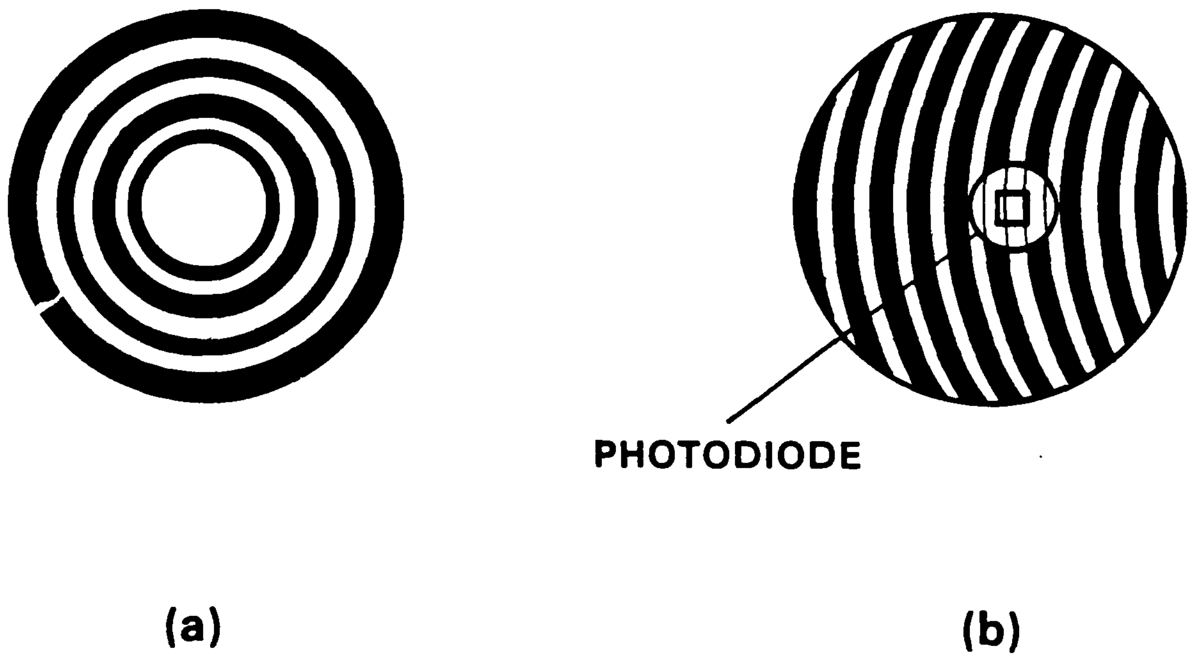


Figure 2. Interference Patterns: (a) Adjusted for highest symmetry; (b) Typical pattern used for motion measurement, with detector size and position shown.

and residual air path effects causes a slow drifting of the interference pattern during an exposure run. When the system is being used to measure motions of less than one fringe width, this drift causes a continuous shift in the intensity variation seen by the detector because the detector aperture is of the order of a fringe width. This is manifest as a varying of the detector AC output down through zero to full inversion (180° phase shift) and back again (a zero level signal would occur when the fringe width and position relative to the detector were such that the part of the fringe intensity distribution moving off the aperture during the vibration cycle was exactly compensated by the part moving onto the aperture). By running the piezo-electric reference mirror oscillator during an exposure experiment it is possible to monitor the effects of this unwanted drift and correct for it in the signal processing as described next.

The photodiode output is amplified to line levels and fed into the various signal processing stages. In a typical run, the microwave transmitter is pulsed at 10 pps and the detector signal stored in a signal averager which was triggered by the transmitter pulse. If the reference mirror oscillation frequency and the transmitter pulse rate are incommensurable, the reference mirror signal is averaged to zero over many pulses along with any other random noise, leaving only those signals correlated with the microwave pulse. However the aforementioned signal inversion drift would tend to cause even these desirable signals to average to zero. Therefore the reference oscillator signal in the fringe motion is observed in real time on an oscilloscope triggered by the piezo-electric translator driver, and the signal averager is activated only when the fringe pattern position is in the proper (chosen) phase. In this way, although the fringe pattern continues to drift during a data run, only signals with a consistent phase are recorded and averaged.

The averaged fringe motion data is stored in digitized form in the signal averager and displayed on a CRT screen. Figure 3 shows the typical appearance of the data. Each point shows the digitized value stored in a channel of the signal averager after averaging 512 signals. The time between channels (sampling interval) is 40 microseconds, and not

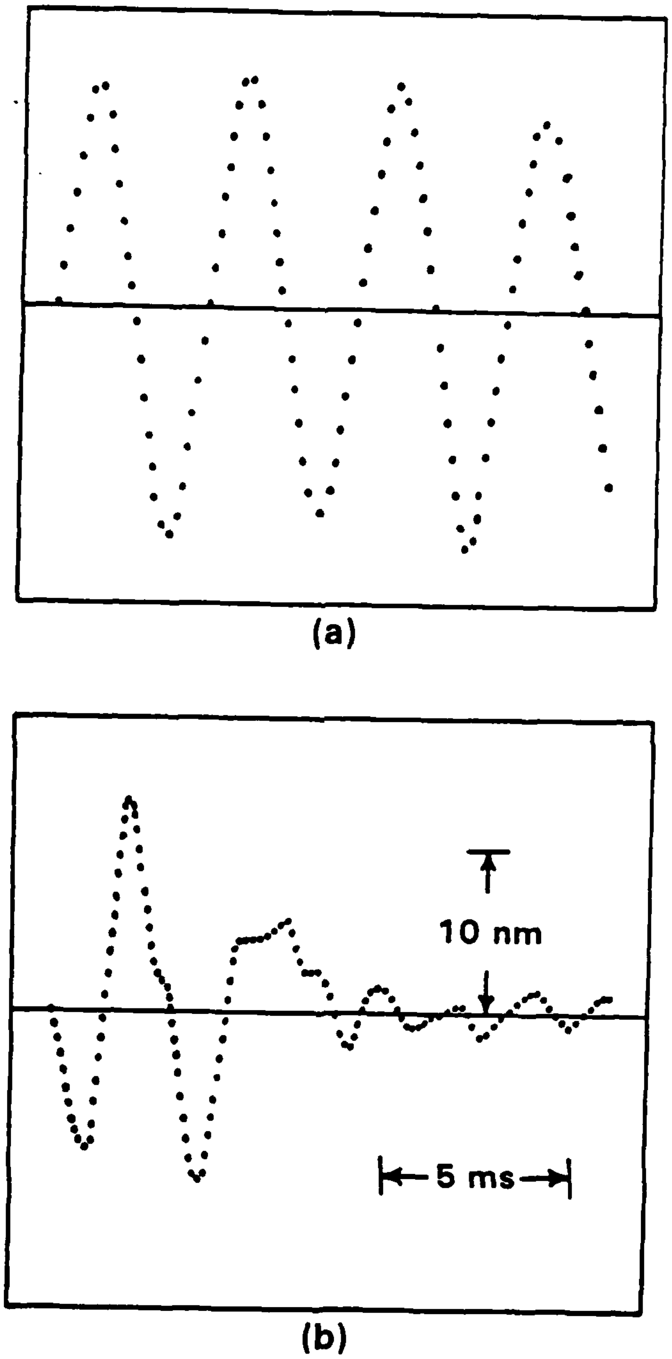


Figure 3. Recorded Output from Signal Averager: (a) Calibrated 2 nm motion (at 1 kHz) of reference mirror (no eye lens motion); (b) Typical eye lens motion signal.

all channels are shown in these adaptations from the CRT display. Figure 3a shows the signal recorded for a calibrated 2 nm motion (at 1 kHz) of the reference mirror and stationary eye lens. The system resolution after signal averaging is clearly excellent at this level. Figure 3b shows a typical signal from an eye lens exposed to a microwave pulse. The 10 nm scale calibration shown was derived from reference mirror signals similar to Figure 3a.

After difficulties were encountered in obtaining reflections from eye lenses during the first experiments, P. Brown (WRAIR) tested several chemical treatments and came up with a short immersion in dilute HCl which causes the eye lens surface to give a suitable reflection for interferometry under saline. Comparison of the movements observed with treated and untreated lenses shows very little change if any in the response to the microwave pulse. Thus the acid treatment does not appear to change the mechanical properties of the lens significantly. However further experience in aligning the system and improvements in the focusing lens holder have made it possible to obtain eye lens reflections fairly consistently. Therefore the acid treatment was abandoned as an unnecessary complication.

3. EXPERIMENTAL RESULTS

During the past year, over a dozen rat eye lenses have been exposed to pulsed microwave irradiation, and the motion of a point on the lens surface was recorded using the interferometer. All lenses showed detectable motion of order 10 nm (see Figure 3b). Previous experiments with glass "eye lenses" had shown motion originating through microwave interaction with the sample chamber and/or its contents. The rat eye lens motion observed was very similar to the glass lens motion. Thus it is unlikely that microwave interaction with the lens itself is the main source of movement, since the glass is non-absorbing. Motion could be imparted to the lens through the supporting pedestals or through waves in the saline.

By bouncing the laser beam off of the pedestal, some movement of the supporting element was detected. This motion was made significantly smaller by damping the pedestal and sample chamber walls using an acoustically absorptive material (see Figure 4). The motion of a glass lens was changed by this damping but retained a significant displacement, indicating that the primary source of the motion detected was pressure waves generated in the saline and impinging upon the immersed lenses.

Several other experiments investigating the eye lens motion tend to confirm the idea that the motion originates in the saline. The amplitude and frequency of the observed motion are independent of whether the lens is resting on one supporting pad or held between two pads (top and bottom). Moreover, the amplitude of the movement varies with the position of the lens within the sample holder, indicating that the induced wave pattern within the saline may be complex; for example, waves of differing nature may originate from any number of the chamber walls. These in turn may depend upon the particular microwave mode pattern set up in the waveguide. However the nature of the motion showed no change with waveguide tuning other than the expected scaling of amplitude with the quality of the coupling to the sample chamber.

The dependence of the motion amplitude on peak power and energy per pulse was examined. The amplitude was found to vary linearly ($\pm$ 10%) with

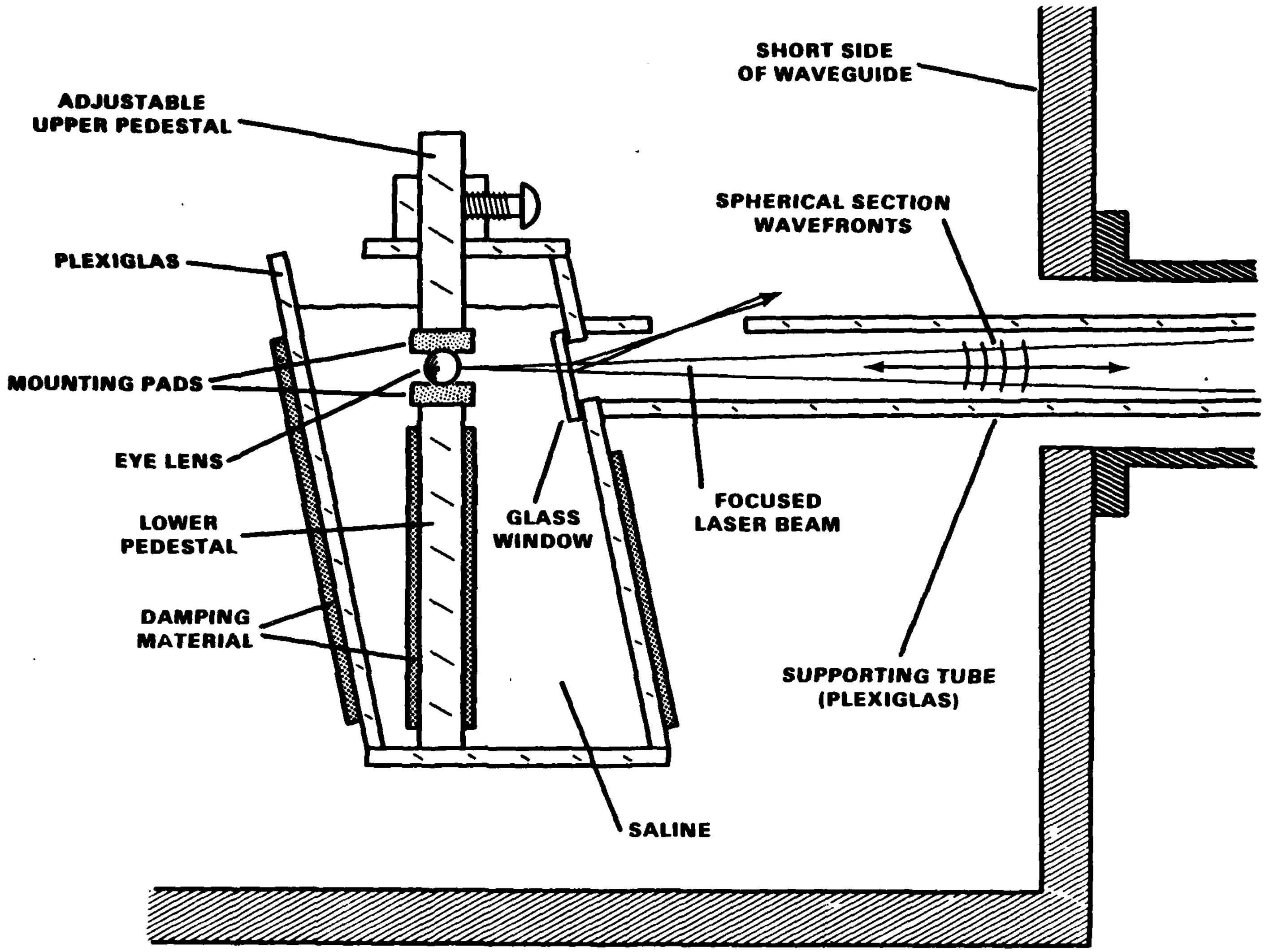


Figure 4. Diagram of Sample Chamber Design.

the energy per pulse and was not dependent on peak power (with energy constant). This agrees with the accepted theories of thermo-acoustic transduction (T.A.).

In this connection the theoretical work of Lin[1] and of Gournay[2] on the T.A. effect was reviewed. Where they disagreed, the work of Gournay was found to be correct. A scoping calculation was done using reasonable values for the elastic constants of the lens tissue to predict whether the lens could move without deforming in response to the T.A. pressure wave which is the putative cause of the observed motion. This calculation indicated that the diameter of the lens could change by 20% or more of the observed motion amplitude (i.e., by 2 nm or more) in a mode in which the transverse dimension would simultaneously increase (Young's modulus).

Since the original calculations under this project indicated that high frequency (> 100 kHz) resonances might be excited in the eye lens, an effort was made to detect such motion. A high speed tape deck was used to record data during an experiment, and the tape was then played back at a slower speed into the signal processing equipment. This increased the effective bandwidth of the signal averager to around 300 kHz and thus extended the search for T.A. motion of the lens to higher frequencies. However no motion at these higher frequencies was seen.

4. PLANNED CONTINUATION OF THIS WORK

The question of bulk (rigid) motion versus elastic deformation should be addressed in the next set of measurements. A pair of small dielectric mirrors was purchased for use in a planned experiment to reflect back to the interferometer a laser beam which has bounced off the eye lens surface at a grazing angle. This will be an attempt to measure the T.A. motion at more than one point on the eye lens.

A full program of additional studies including pressure measurements, theoretical analysis of T.A. waves, and birefringence measurements has been submitted in a follow-on proposal.

REFERENCES

1. J. C. Lin, Microwave Auditory Effects and Applications, pp. 99-134, Charles C. Thomas, Springfield, Illinois (1977).

2. L. S. Gournay, J. Acoustical Soc. of Amer., 40, 1322 (1966).

END

FILMED

8 84

DTIC