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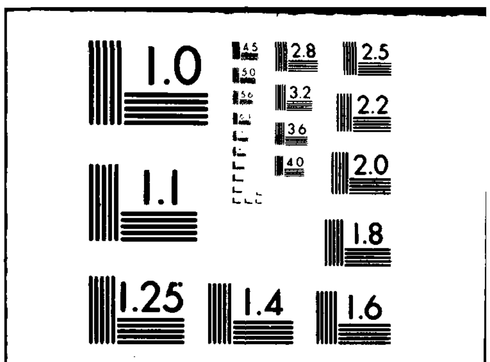

MICROCOPY RESOLUTION TEST CHART

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

Completion of construction of the loading device frame, tubes and speciment holders; development of suitable heating and cooling systems for the tubes; development of a method to measure the (small) displacements applied to the specimen by the loading device; determination of the amount of light needed in the crack opening recording method.

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Progress Report No. 2 on

TIME-DEPENDENT FRACTURE PROCESSES RELATING TO SERVICE LIFE PREDICTION OF ADHESIVE JOINTS AND ADVANCED COMPOSITES

F49620-77-C-0051

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October 7, 1977

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ABSTRACT

The work done since the last report has consisted of:

a) Completion of construction of the loading device frame, tubes and specimen holders.

b) Development of suitable heating and cooling systems for the tubes.

c) Development of a method to measure the (small) displacements applied to the specimen by the loading device.

d) Determination of the amount of light needed in the crack opening recording method.

This report describes the details of items (b), (c) and (d).

Heating and Cooling Systems

Following construction of the loading frame, tests were made to determine the most suitable methods for heating and cooling the tubes.

It was found that the current needed for the resistance heating method proposed was too high to be practical. We therefore decided to use mica band heaters clamped to the outside of the tubes and provide the heating via conduction. It is planned to use three 500 watt band heaters on each tube to give a heated length of five inches. The heaters have been on order for four months and delivery is anticipated within a week.

Using water to cool the tubes resulted in too slow a contraction rate. Cooling is now provided by spraying liquid nitrogen on the inside of the tubes over a five inch length as shown in fig. 1. This provides a contraction of .001" in 60 seconds, corresponding to a 3% strain across a 0.030" thick bond. According to calculations, the heaters should provide an equal expansion rate.

Measurement of Displacements Applied to Specimen

The measurement was first attempted using an L. V. D. T. and also a photonic sensor. In both cases, the problem of drift occurred. In view of the long-time nature of the experiments, it is desirable that the drift be minimized. To this end, an optical interference scheme employing a Mach-Zehnder interferometer has been developed. (See fig. 2)

The interference pattern produced is a series of light and dark fringes in concentric circles. As the mirrors (fig. 2) are moved closer together a given fringe moves towards the center, where it then disappears. The opposite occurs for the mirrors moving apart. Two photodiodes are placed in the image plane of the pattern, one at the center of the pattern and the second slightly off-center. The amplified signal of the central diode drives a counter and the phase difference between the two amplified diode signals is used to determine the direction of motion of the mirrors. Fig. 3 shows the output of the diodes as recorded by a chart recorder.

The mirrors are attached to the specimen in the form of two interferometers, one measuring normal displacements and the other tangential displacements. Each count on the counter corresponds to a movement of $\lambda/2$ of the mirrors, where λ is the wavelength of the He Ne laser light used. This corresponds to a resolution of 1.25×10^{-5} inches. If maxima and minima are counted instead of zero crossings (as the counter does) a resolution of $6{\cdot}25 \times 10^{-6}$ inches can be obtained.

The output will be recorded for data reduction and also used as a feedback to control the heating and cooling systems.

We had planned to build a circuit to supply the logic in the control loop. However, recent discussions with J. P. L. personnel who specialize in the microprocessor field gave us the idea that off-the-shelf, pretested modules added to a basic microprocessor would do the job with greater certainty. This would save time as compared to designing, constructing and testing our own logic circuitry. The microprocessor could then also be used for data acquisition and on-line reduction purposes, greatly decreasing the time spent reducing the data which would otherwise have to be chart recorded. The rates of data acquisition are slow enough that this can be done without difficulty with such a system.

A capacitance probe with micro-inch resolution and extremely low drift has also been investigated as an alternative to the Mach Zehnder device. Price considerations ($4K) may, however, eliminate it as a choice.

Crack Opening Recording Method

The exposure time needed for photographic recording of the unbond interference pattern with the short developmental specimens described in the first progress report was one second. The specimens proposed for the study will be of the order of ten times longer. This will increase the exposure time. Further losses in illumination will be incurred due to the need for additional beam steering devices in the present set-up. It is estimated that, using the present 15 milliwatt laser light source, exposure times of the order of five seconds will now be required. This will not be fast enough to capture photographically some fracture events. A more powerful laser is needed.

The more powerful laser would also allow simulatneous recording of the interference pattern by a photodiode array which, coupled to a microprocessor unit, would greatly facilitate data reduction.

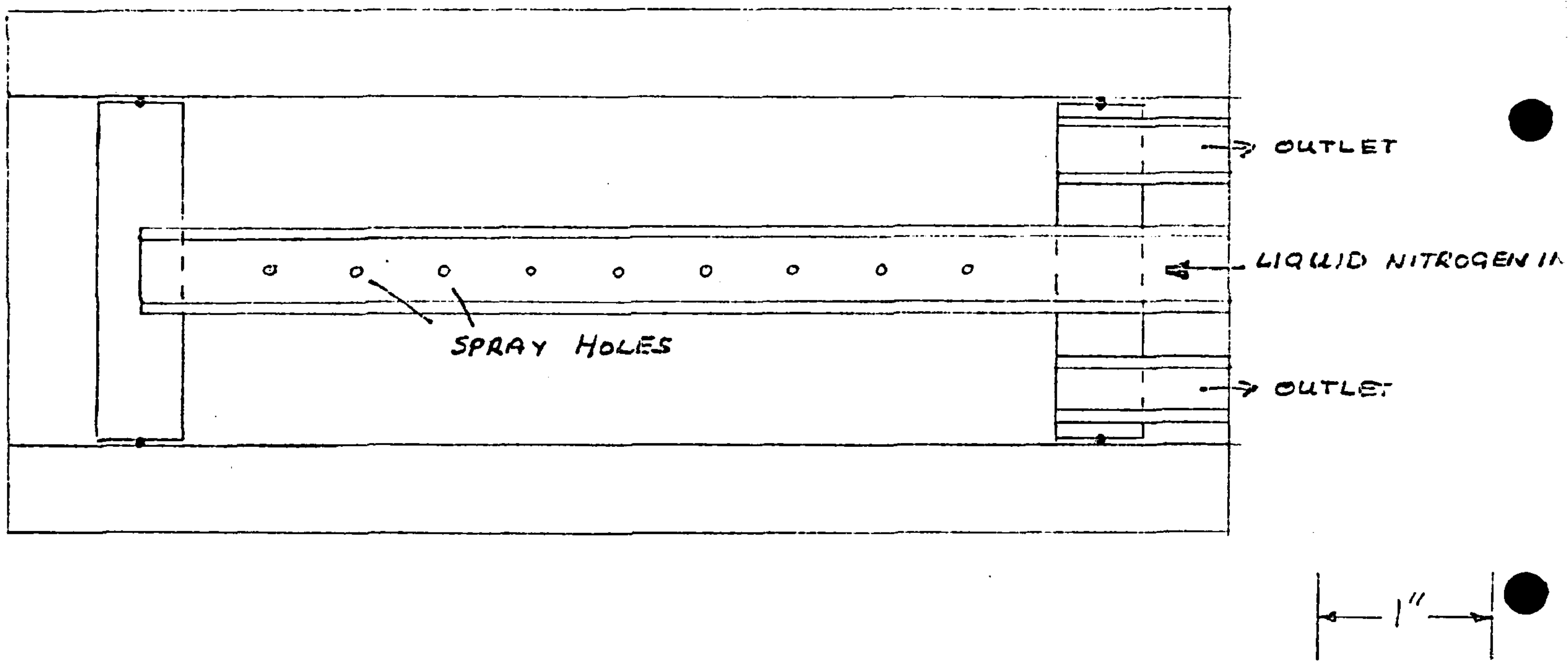

FIG 1 CROSSECTION of a PORTION of a TUBE SHOWING the COOLING ARRANGEMENT

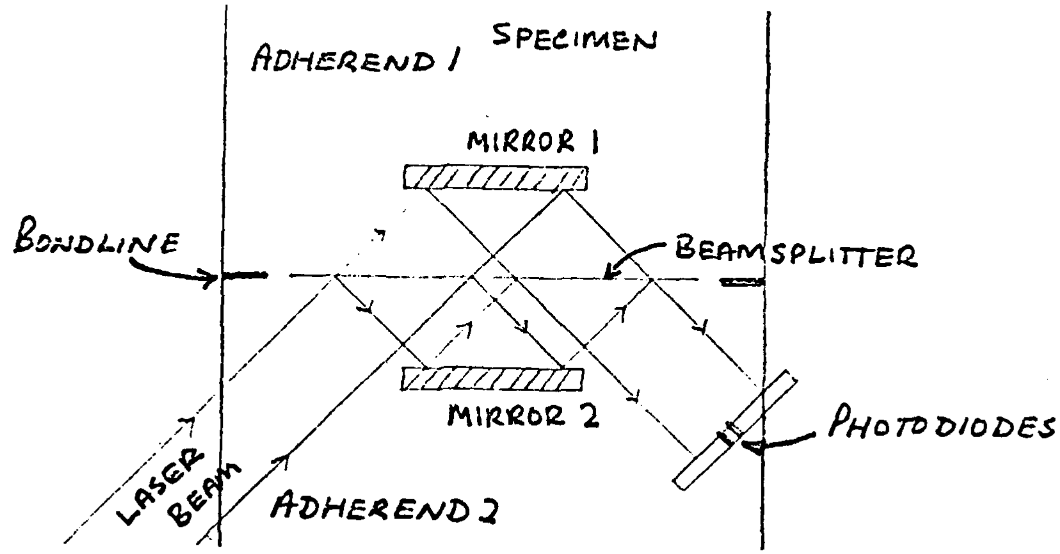

FIG. 2 MACH ZEHNDER INTERFEROMETER.

Mirror 1 is mounted on adherend 1 and mirror 2 and the beamsplitter on adherend 2. This mirror arrangement measures displacements normal to the bondline.

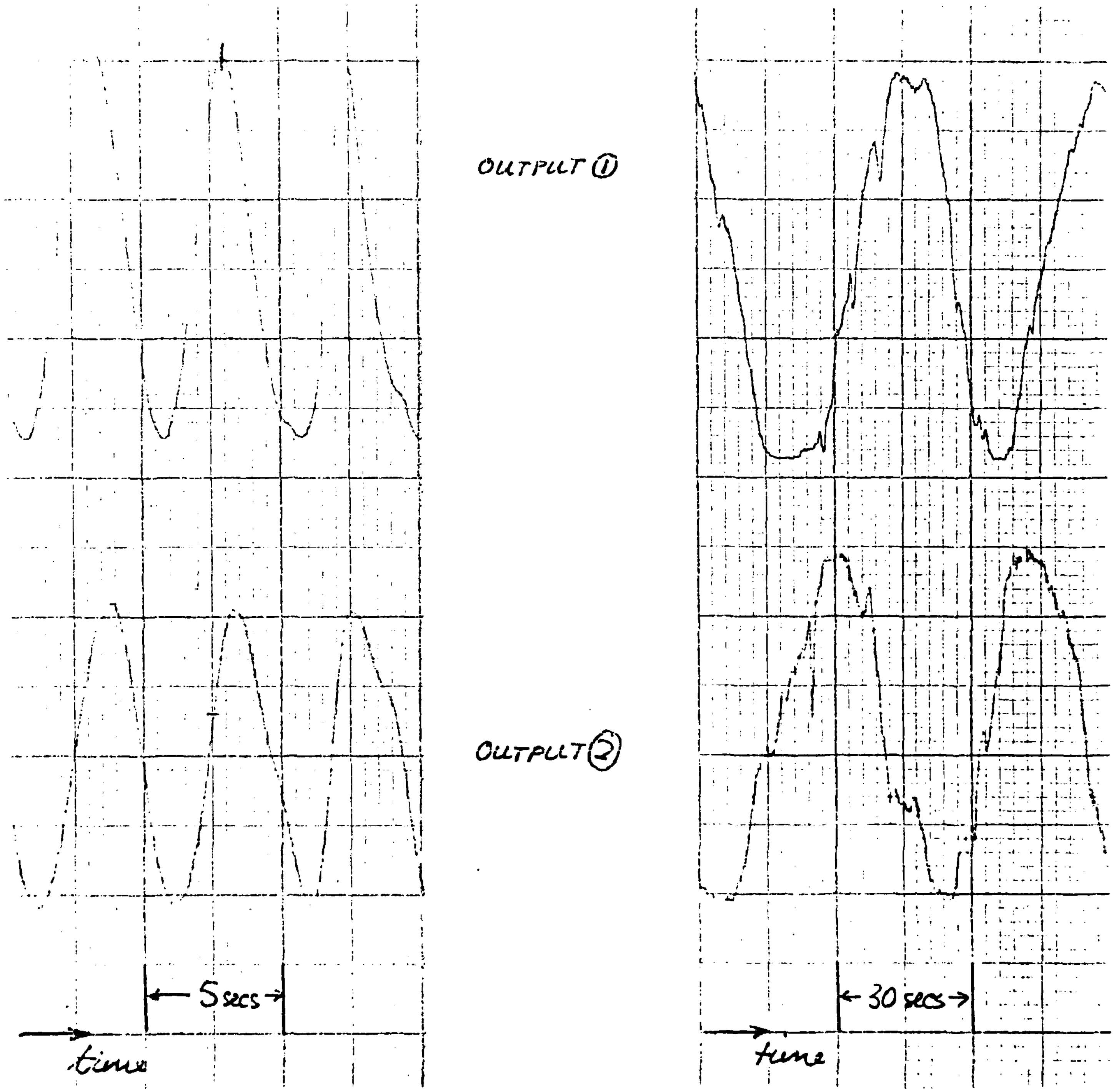

FIG 3 PHOTODIODE OUTPUT

a) Liquid nitrogen cooling, output ① leads outputs ②, mirrors

b) Ambient heating, output ② leads output ①, mirrors

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