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MINIATURE ACCELEROMETER-TRANSMITTER SYSTEM

STATUS REPORT

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INTRODUCTION

The NHTSA is sponsoring a program directed toward the development of a self-contained miniature accelerometer-transmitter package which can be implanted in a boxer's mouthpiece, and which will be worn under actual fight conditions. The record of linear and angular accelerations of the head thus obtained will be analyzed and correlated with observable physiological effects. The goal of these measurements is information defining human concussive threshold, with application to head injury criterion development and protective headgear design.

This program is being carried out under contract to the NHTSA by three organizations in a cooperative effort:

1. Konigsberg Instruments, Inc. (KI)
   - o Instrument design and development

2. National Bureau of Standards (NBS)
   - o Prototype evaluation
   - o Technical consultation

3. Science Applications, Inc. (SAI)
   - o Implementation study and recommendations
   - o Conduct of studies for packaging guidance
   - o interface with boxing community

PROGRAM STATUS

1. Instrument Design and Development

The present instrument concept is that of a self-contained module, containing the following functional elements:

- o Nine accelerometer array
- o Conditioning electronics (sample and hold, multiplex circuitry, analog to pulse width modulation circuitry)

- o RF transmitter
- o Antenna
- o Batteries (field replaceable sealed modules)

All of the above elements are contained within the boxer's mouthpiece; data is transmitted to ringside, where the following elements are located:

- o Receiver
- o Demodulator (including digitizer, D/A and filters)
- o Tape interface
- o Digital recorder
- o Analog recorder

"Quick-look" data will thus be available at ringside for verification of system operation; digital records will permit necessary instrument compensation and computation of corrected linear and angular accelerations to be performed off line.

Two prototype instruments, together with the ringside receiver and demodulator units, have been completed and delivered to the National Bureau of Standards for detailed evaluation.

Figures 1 and 2 document the appearance of one of the nine accelerometer array packages delivered to NBS. Figure 3 shows the accelerometer array and breadboard electronics module as supplied for test.

2. Instrument Evaluation

Evaluation at the Bureau of Standards is under way to determine instrument performance in the following areas:

Linear Acceleration (each accelerometer)	o Primary axis sensitivity o Transverse axis sensitivity o Amplitude linearity o Resolution o Effective interarm distance
Angular Acceleration	o Accuracy of computation o Resolution
General	o Error compensation strategy o Temperature sensitivity o Supply voltage variation sensitivity o Mouthpiece transfer function

Apparatus employed in the evaluation effort includes two high-precision linear shakers (Dimoff and Unholtz - Dickie Systems), a dual centrifuge, and (for angular acceleration performance evaluation) a dual spin axis table previously developed under NHTSA sponsorship. Special multipurpose fixturing,

shown in Figures 4 and 5, has been developed to adapt the accelerometer array packages to the various test fixtures.

The evaluation effort is just beginning, but preliminary linear performance data is becoming available. Sensitivity vs. frequency data for accelerometer No. 1 of each prototype unit is presented as Figures 6 and 7.

The decision to proceed to angular testing, utilizing the dual spin axis table, will be conditional upon favorable results from the linear test program. Instrument stability, linearity, and low transverse sensitivity will be key considerations in the decision to proceed to more detailed tests.

3. Implementation Study

A preliminary study by SAI directed towards determining the best way of utilizing the new instrument in the boxing ring under actual fight conditions is nearing completion. Specific tasks addressed in the feasibility study include:

- o Determination of subject and site selection criteria
- o Analysis of legal and liability issues
- o Development of experimental plans and protocols
- o Instrument packaging consultation

Results of the SAI study to date have been encouraging with respect to the likelihood of endorsement and cooperation of the professional boxing community.

Six states have been identified as offering an attractive combination of scheduled boxing events, knockout frequencies, and likelihood of endorsement. A formal presentation to the California State Athletic Commission has been made and preliminiary indications of cooperation have been forthcoming. Mockups of the projected instrument package will soon be evaluated by boxers in sparring trials, to provide final packaging guidance to KI. These trials will be conducted in a conservative fashion, under continuous medical supervision.

Future Activity

Successful application of the mouthpiece accelerometer-transmitter is presently contingent upon favorable outcome of the NBS evaluation effort and the SAI packaging acceptance study. The results of these efforts will be available early in 1980, and will permit final decisions to be made on the configuration and specifications of "production" instruments.

Acknowledgments

Acknowledgment and appreciation is extended to the dedicated and resourceful staff members of Konigsberg Instruments, NBS, and Science Applications, who have conducted the work described in this report. Specific acknowledgment is made to Eph Konigsberg, William Bubel, and Sergiu Silvian of KI; John Ramboz of NBS; and Dr. Donald Hausknecht of SAI.

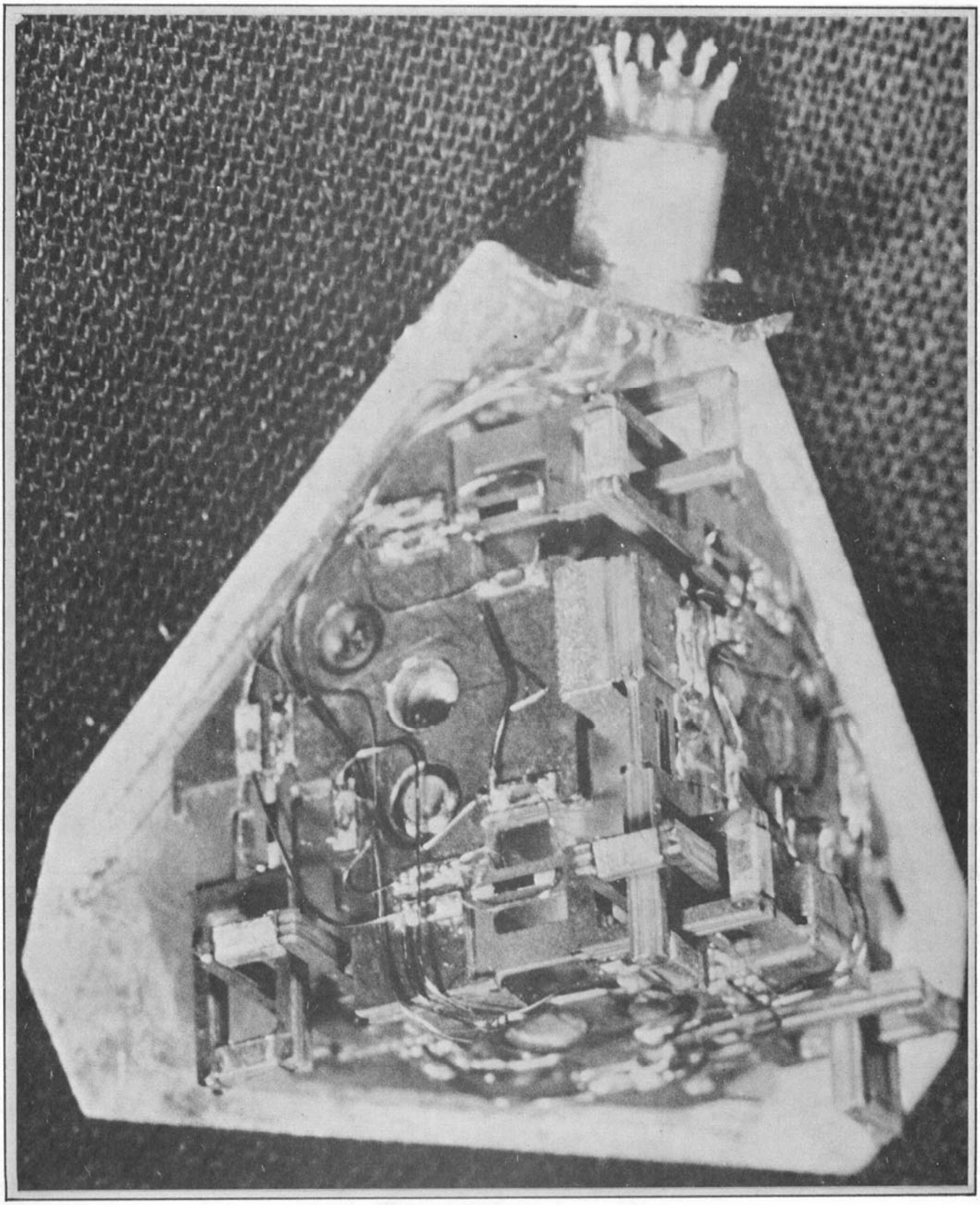

FIGURE 1, INTERIOR OF NINE ACCELEROMETER ARRAY PACKAGE

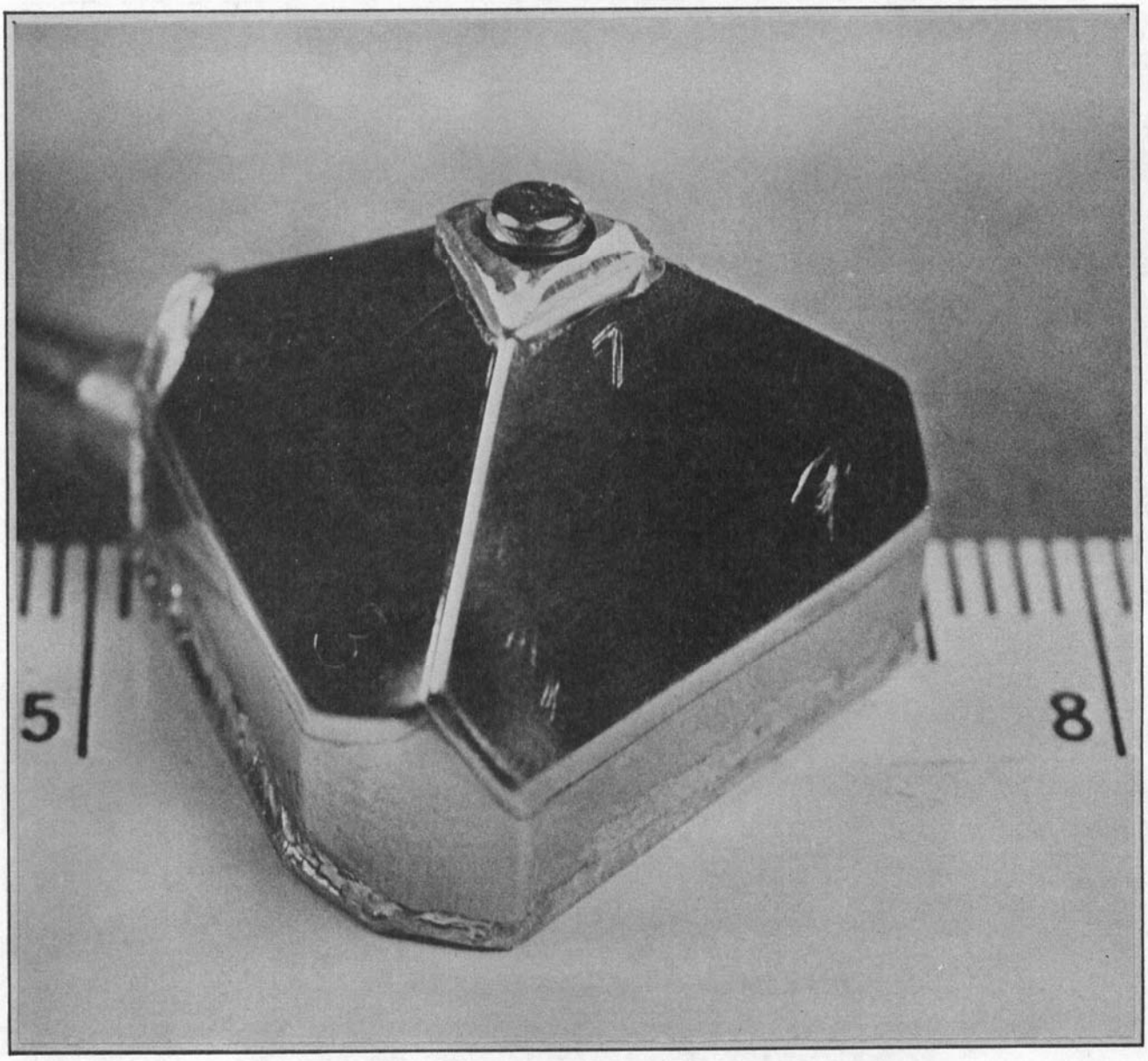

FIGURE 2, NINE ACCELEROMETER ARRAY PACKAGE

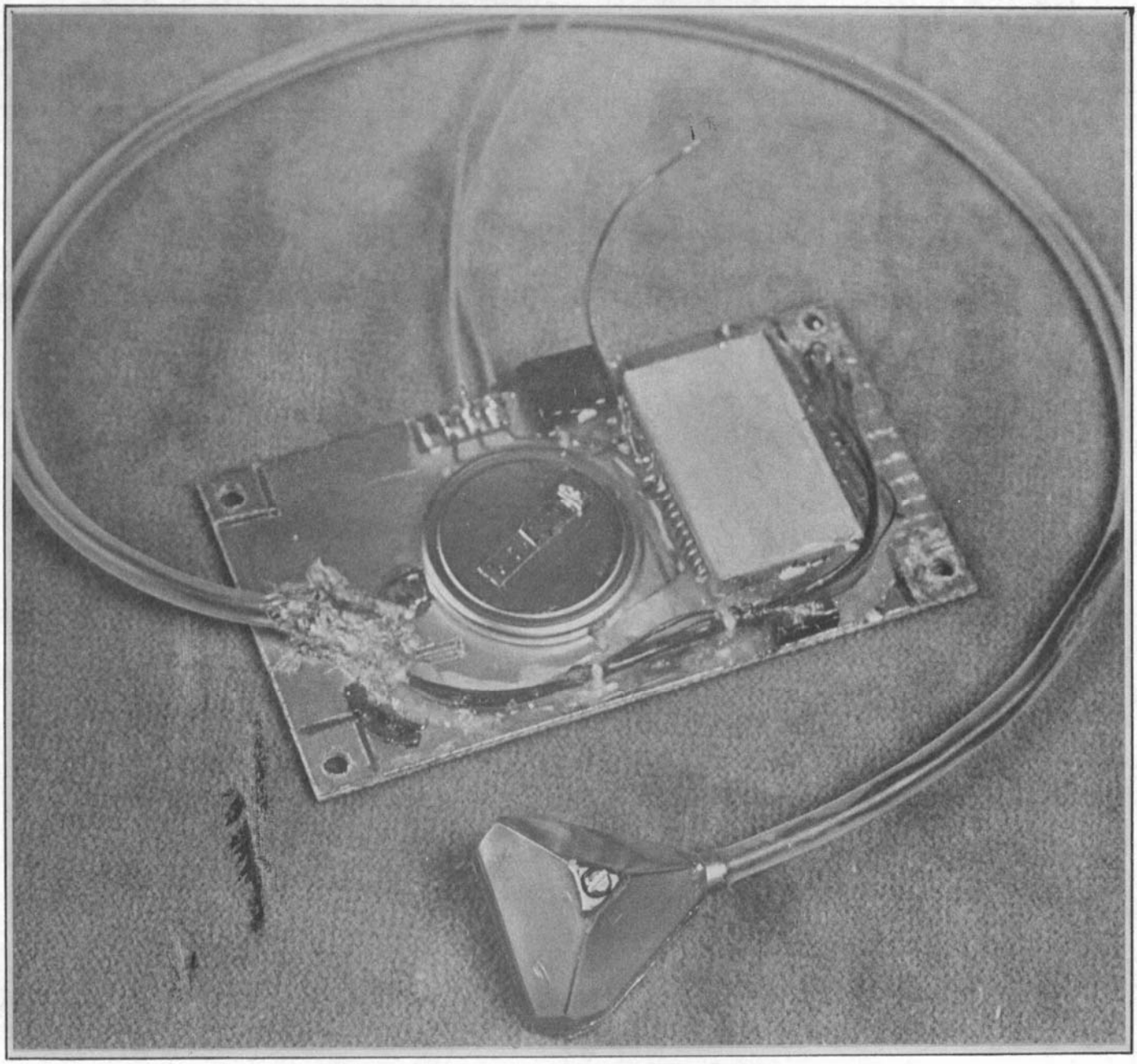

FIGURE 3, ACCELEROMETER ARRAY AND BREADBOARD ELECTRONICS

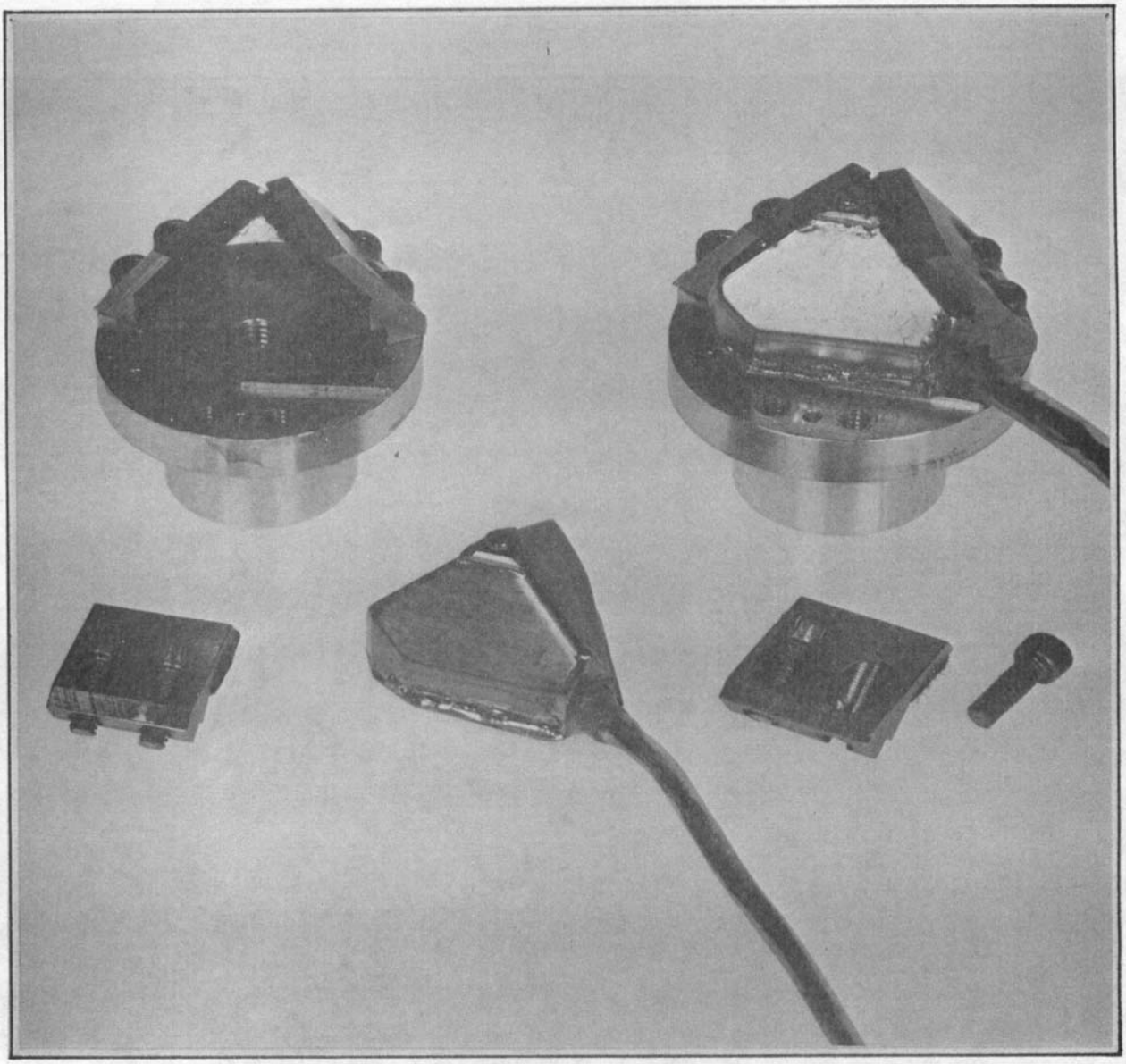

FIGURE 4, NBS FIXTURE FOR ACCELEROMETER ARRAY

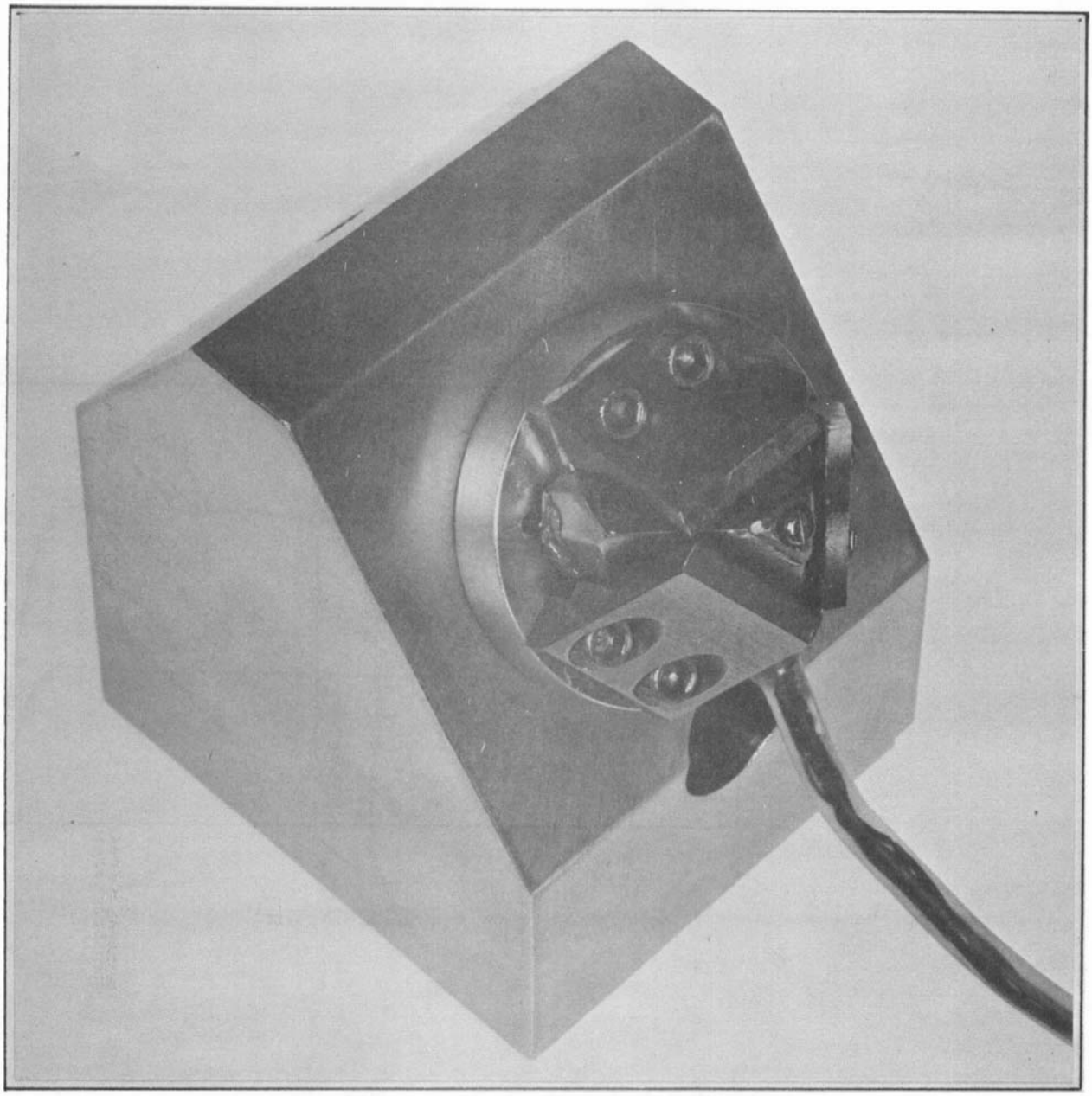

FIGURE 5, NBS FIXTURE FOR ACCELEROMETER ARRAY

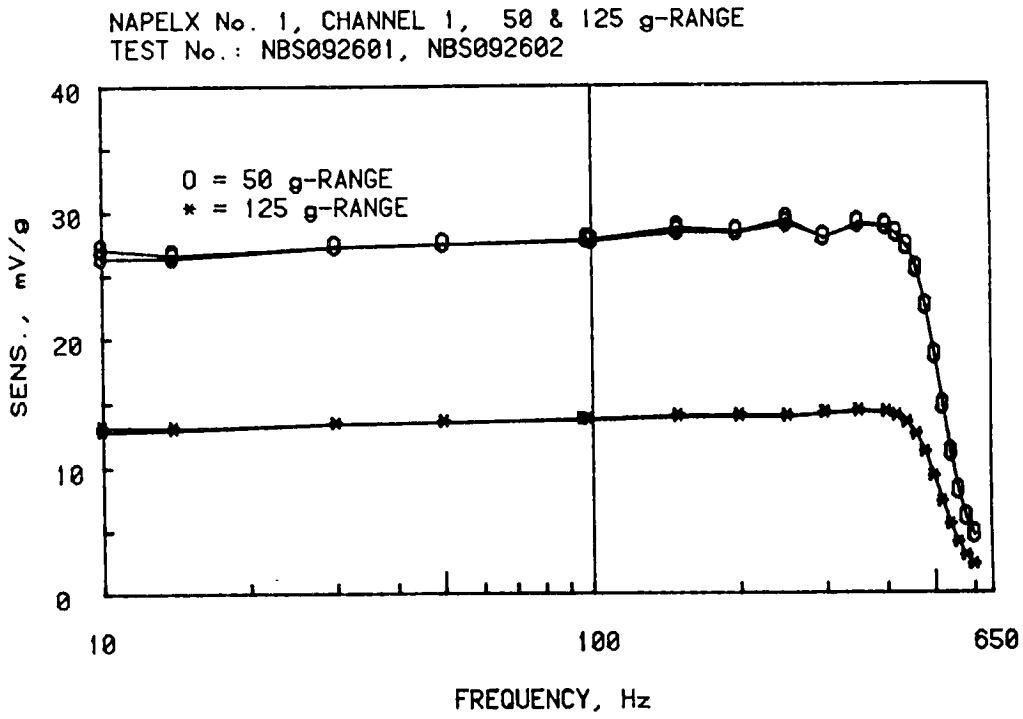

FIGURE 6, PRIMARY AXIS SENSITIVITY, S/N 1, CHANNEL 1

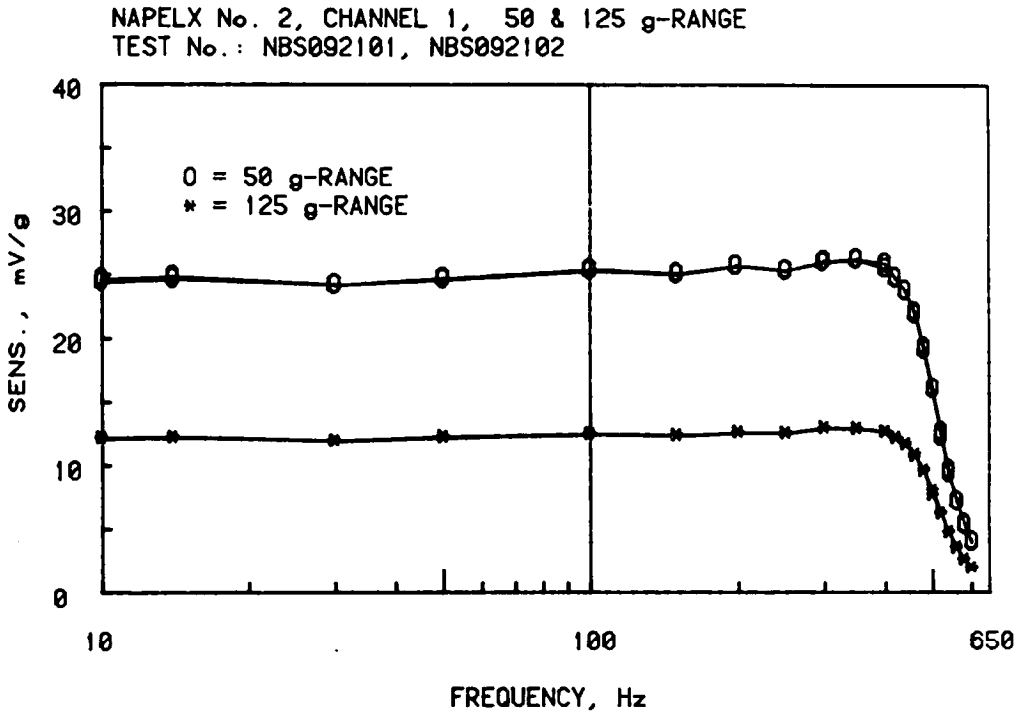

FIGURE 7, PRIMARY AXIS SENSITIVITY, S/N 2, CHANNEL 1