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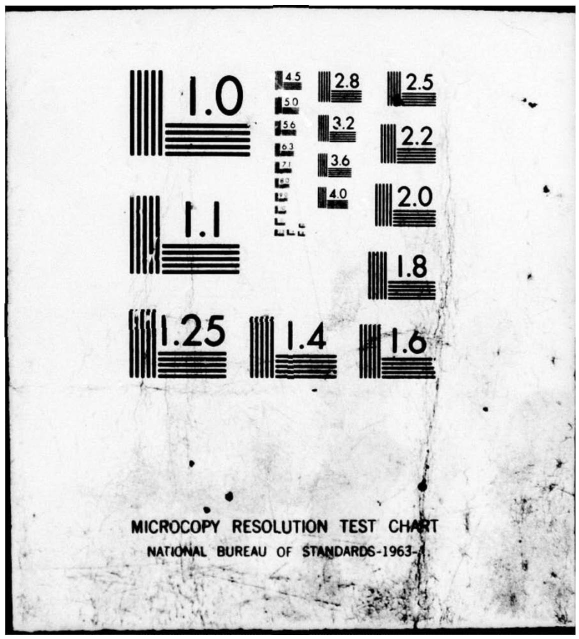
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MOST Project -4

LEVEL II

NORTH STAR RESEARCH AND DEVELOPMENT INSTITUTE
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MOST Project -4

LEVEL II

FINAL REPORT

on

A UNIQUE UNDERWATER SOUND TRANSDUCER

Project No. NR 185-504

Contract No. Nonr-4992(00)

31 Jul 68

7p.

to

OFFICE OF NAVAL RESEARCH
Washington, D. C.

NORTH STAR RESEARCH AND DEVELOPMENT INSTITUTE
3100 38th Avenue South, Minneapolis, Minnesota 55406
July 31, 1968

FINAL REPORT

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A UNIQUE UNDERWATER SOUND TRANSDUCER

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NORTH STAR RESEARCH AND DEVELOPMENT INSTITUTE
July 31, 1968

The purpose of this project was to develop a sensitive wide-band sonar detector utilizing the semiconductor piezojunction effect. The energy of a sonar signal incident on a flexible diaphragm is converted to electrical energy by applying the acoustically produced "signal" to the base-emitter junction of a transistor. The output current of the transistor is directly proportional to the force applied to the base-emitter junction and is linear over a significant portion of the force-output current characteristics.

The accomplishments on this project were:

1. Design and construction of a special apparatus for use in applying a force to the base-emitter junction of a transistor. The apparatus was used to determine the relationship between applied force and transistor characteristics. Various types of commercial transistors -- NPN and PNP, planar and planar epitaxial -- were tested for stress sensitivity.

2. Development of transistor equivalent circuits that contain stress-sensitive elements. Using the equations and equivalent circuits developed, we have derived a general expression for stress sensitivity in piezojunction devices. The equation shows that device sensitivity is directly proportional to the circuit load resistance,

the D.C. collector current, and current gain of the transistor; the sensitivity is inversely proportional to the absolute temperature of the device. The expression applies to any piezojunction device, provided that the material is silicon, the force is applied perpendicular to the junction area, the stress level exceeds 10^{10} dynes per square centimeter, and the entire emitter-base junction is uniformly stressed.

3. A technical paper. A portion of our work, including the analytical results of item 2 above, was described in a paper published in Solid State Electronics, March 1967.

4. Means for measuring the frequency response of piezojunctions at high frequencies. The specially designed laboratory apparatus was modified to increase its frequency response by the design of an improved stylus - electro mechanical arrangement. The modification enabled the apparatus to make time-varying junction force-output current characteristics to over 100 KHz. Frequency response measurements were performed on the emitter-base junction of the GE 2N2108 transistor. Frequency response from 6 KHz to over 100 KHz was obtained.

5. Investigation of signal coupling schemes and frequency response of piezojunction transducers. Special attention was given to mechanical response at ultrasonic frequencies. Several signal coupling schemes were investigated, since a unique scheme is required for a uniform wide-band frequency response. A tent-type diaphragm arrangement that couples the sonar signal energy to the piezojunction by means of a rigid stylus was selected as the superior configuration.

6. Design, fabrication, and testing of several piezojunction transducers. Frequency responses above 40 KHz were obtained with relatively straight forward transducer design.

7. Design and construction of an underwater testing apparatus and a more rugged piezojunction transducer. The apparatus was designed

for tests at 12, 26, 76, and 100 KHz. Program funding did not permit underwater tests to be performed on the current model of our piezo-junction transducer.

INDEX OF TECHNICAL REPORTS

The following is a list of technical reports submitted to the Office of Naval Research on Contract No. Nonr 4992(00) and Project No. NR 185-504.

1. First Monthly Letter Report. July 15, 1965.
2. Second Monthly Letter Report. August 16, 1965.
3. First Quarterly Status Report, September 15, 1965.
4. Fourth Monthly Letter Report. October 15, 1965.
5. Fifth Monthly Letter Report. November 12, 1965.
6. Second Quarterly Status Report. December 15, 1965.
7. Annual Report. January 13, 1966.
8. Monthly Letter Report. February 15, 1966.
9. Third Quarterly Status Report. March 15, 1966.
10. Monthly Letter Report. April 15, 1966.
11. Monthly Letter Report. May 16, 1966.
12. Fourth Quarterly Status Report. June 14, 1966.
13. Monthly Letter Report. July 15, 1966.
14. Monthly Letter Report. August 15, 1966.
15. Quarterly Status Report. September 15, 1966.
16. Monthly Letter Report. October 14, 1966.
17. Monthly Letter Report. November 11, 1966.
18. Monthly Letter Report. December 15, 1966.
19. Annual Report. January 12, 1967.
20. Monthly Letter Report. February 10, 1967.
21. Monthly Letter Report. March 14, 1967.
22. Monthly Letter Report. April 11, 1967
23. Monthly Letter Report. May 12, 1967.
24. 12 Month Status Report. June 14, 1967.
25. Monthly Letter Report. March 6, 1968.
26. Monthly Letter Report. April 2, 1968.
27. Monthly Letter Report. April 30, 1968.
28. Monthly Letter Report. June 10, 1968.

INDEX OF TECHNICAL PUBLICATIONS

1. Mattson, R. H., Yau, L. D., and DuBois, J. R. "Incremental Stress Effects in Transistors", Solid-State Electronics, 10, 241-251, 1967.