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EVALUATION OF ACOUSTIC EMISSION FROM REVERSIBLE ACOUSTIC STRESSES USING PHASE SENSITIVE METHODS

FINAL REPORT, No. 1

D. N. Beshers
J. T. Kuo

July 18, 1975

U. S. ARMY RESEARCH OFFICE

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

It has been shown that a number of acoustic signals of potential utility may be emitted by a solid when subjected to high amplitude stresses at kilohertz frequencies.

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This grant was a small follow-on grant to permit the completion of the work begun under grant DA-ARO-D-31-124-72-G117, which ran from February 21, 1972 to February 20, 1974. The present grant ran from February 21, 1974 to February 20, 1975. The final report covers both grants.

The technical accomplishments were of two kinds, some rather bold pioneering work which jumped well ahead of the state of the art to demonstrate the feasibility of our ideas, and some patient systematic fill-in of the background necessary if we are ever to bring these ideas to practical utility.

Under the first category, we detected in several materials, including metals and rocks, very high frequency signals emitted during vibration at 22.5 hKz at amplitudes so high that plastic deformation occurs in many materials. In copper single crystals we attributed these signals to dislocations racing back and forth across the specimen at the speed of sound. In rocks the interpretation was not so clear. Signals of this type depend on details of the specimen, which makes them hard to reproduce.

We therefore turned to a more systematic approach: building up our knowledge of internal friction in deformed materials and our knowledge of internal friction at very high amplitudes. We made three contributions in this area:

(1) A review of internal friction in deformed metals at low temperatures, including the Bordoni peak and related phenomena, showing how these peaks are related to the state of internal stress of a metal.

(2) A study of internal friction in brass associated with the operation of Frank-Read sources, and also a study of the modulus defect associated with the formation of slip bands as a result of source operation.

(3) The development of techniques for observing harmonics generated in high amplitude steady-state vibration. These harmonics are correlated with the operation of Frank-Read sources and the formation of slip bands through the data acquired under (2) above. These harmonics are a reproducible form of the high frequency signals mentioned in the last paragraph, so we gave considerable attention to establishing their nature and character.

We made only preliminary attempts to give a quantitative account of the harmonics: just enough to assure ourselves that the data were indeed valuable and when finally interpreted would give valuable information about dislocation dynamics in cyclic deformation.

In sum, we have made some observations of unusual acoustic emission from reversible acoustic stresses, and showed how to put the study of these emissions on a sound footing. We have now received a grant from the National Science Foundation to pursue these observations further.

The papers published under this grant include:

"Twinning of Zn and Sn during Ultrasonic Deformation", by M.C. Jon, D.N. Beshers, and W.P. Mason, Journal of Applied Physics 45, 3716 (1974).

"Acoustic Emission Caused by Large Alternating Strains", by W.P. Mason, D.N. Beshers, M.C. Jon and J.T. Kuo, Ultrasonics 13, 128 (1975).

"Plastic Deformation and Internal Friction", by D.N. Beshers and R.J. Gottschall, Proc. of the 5th International Conference on Ultrasonic Attenuation and Internal Friction; the conference was held August 1973, and we are assured that the proceedings have now gone to press.

"Acoustic Emission Produced by Large Alternating Stresses", by W.P. Mason, Proc. of 10th Anniversary Meeting of the Society of Engineering Science; the meeting was held November 1973 and we are assured that the proceedings have now gone to press.

The larger part of this grant went to support M.C. Jon in his doctoral thesis.

The scientific personnel involved in the two grant were: Senior personnel, W.P. Mason, D.N. Beshers, and J.T. Kuo; Graduate students, M.C. Jon, M.Y. Bora, C.C. Law, and R.J. Gottschall.

The principal graduate student on this project was M.C. Jon, who completed a thesis for the degree of Doctor of Engineering Science entitled "An Ultrasonic Study of Microplasticity in Alpha Brass" in January, 1975. The other graduate students were involved only peripherally in this project, giving assistance with specimen preparation, calculations, etc. A small amount of technical support was made to

Gottschall for his D. Eng. Sc. thesis on "...Damping in Cu-Ni Crystals... at Low Temperatures and High Strain Amplitudes" completed in May, 1975. The Bora (M.S.) and Law (D. Eng. Sc.) theses were on stress relaxation.