



# THE BLACK VAULT

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February 8, 1967

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Dear [redacted]

Enclosed is a short Progress Report of our work  
to date pursuant to [redacted]

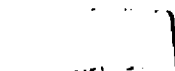
Very truly yours,  
[redacted]

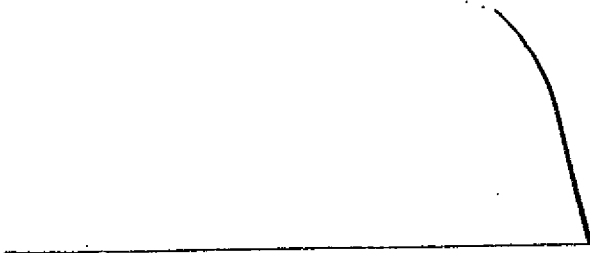
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2/14/67*



FOURTH PROGRESS REPORT

February 8, 1967

Contract No. 



PROGRESS REPORT - 1 January to 31 January 1967

I. PIEZOELECTRIC CRYSTALS

Several PZT 5-B series connected ceramic bimorphs have been obtained from Clevite. A test rig was built to allow electrical and mechanical measurements on these ceramic crystals. The test rig allows a thin rectangular crystal to be mounted cantilever fashion; i. e., clamped at one end with the rest of the element suspended in air. A stop was machined to allow the free far end of the crystal to be depressed only .020". For the 1.7" by .7" crystal which has been subjected to test this amount of deformation represents a strain of about  $2 \times 10^{-4}$  which is 20% of the expected fracture strain and sufficient to produce a peak voltage transient of 15 volts. The experimentation with this crystal has been concerned with establishing the transient or ringing characteristics. Electrical voltage output is monitored on an oscilloscope and the crystal is set in (decaying) oscillation by depressing the end to the stop with a piece of plastic and then sliding the plastic off the end of the crystal. Oscillation at 150 cps occurs with an approximately exponential amplitude decay at a time constant of 80 milliseconds (with a 10 meg electrical load). This time constant can be interpreted as equivalent to saying that the system has a Q of 39 with an electrical open circuit. As the resistance connected to crystal is decreased the Q is lowered and the oscillation dies out faster. A lumped constant electromechanical model of the crystal was used to develop expressions for total system Q and total electrical power delivered to the load resistor as functions of external load resistance. The optimum resistance was thus calculated and when a resistor of this value is connected to the test crystal, Q and voltage decrease to values within the experimental error ( $\approx 5\%$ ) of the calculated values. According to our calculations the maximum efficiency of energy

conversion is 50% with a pure resistive load of the optimum value and the quantity of power for a 20% strain is 20  $\mu$  Joule per square inch of crystal area for each transient mechanical excitation. Since the actual load presented by an electronic package will not be a pure resistance the actual conversion efficiency will be less than 50%. Our previously assumed value of 20% efficiency still appears a reasonable one.

In the remaining contract time work will continue to establish the design requirements of a piezoelectric energy converter.

## II. EMG SOURCE RESISTANCE

Our consultants have determined that the most promising electrode materials are platinum, gold, stainless steel, and tantalum. 3 mil diameter wires of all four metals have been ordered. The stainless steel and platinum (90% P<sub>T</sub> 10% IR) wires have been received already Teflon coated. When the other wires arrive they will be Teflon coated by a local company. Our animal experiment consultant is expected to begin work immediately using the materials on hand with laboratory rats as the experimental subjects.