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RESEARCH AND DEVELOPMENT

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"A Cryocooler for High Acceleration Applications"

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## 1.0 PROBLEM IDENTIFIED AND ACTION TAKEN

As described in detail in the previous quarterly report, the decision was made to use stainless steel spacers and copper plates for the heat exchangers to be constructed in this effort. This decision was based on new calculations that showed that a more dependable, easier to construct exchanger is possible using copper plates and stainless steel spacers rather than the initially proposed niobium plates with glass ceramic spacers. Ordering of the materials for the spacers and plates has been delayed due to newly obtained test results at ACE, Inc. These tests have been conducted on the bonding of similar plate and spacer materials. The tests were conducted with copper spacers manufactured using the Modified Jelly Roll process (MJR), rather than the stack and draw method. The MJR process resulted in copper plates with rectangular holes having a hydraulic radius of 16 microns and an aspect ratio of approximately 3. Although the shape of the holes in the MJR is different from those that will result from the stack and draw process, the bonding properties of the two type plates should be similar. Here are a few of the findings that relate to this effort:

- 1). Although the Cu-Ag braze material used to bond the copper plates to the spacers has a melting point of  $780^{\circ}\text{C}$ , heating to  $850^{\circ}\text{C}$  is required to assure proper wetting of the plate material.
- 2). At the  $850^{\circ}\text{C}$  temperature mentioned in 1., part of the silver in the braze tends to boil off. Thus, it was observed that as much as 0.5 microns of braze material may flash off during the bonding process. A braze thickness of 1.0 mil seems to be optimum.



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- 3). Plates made as thin as 5 mil do not bond satisfactorily. Plates of this thickness come out dished due to the Electronic Discharge Milling (EDM) slicing process. Plate thickness should be kept above 10 mils.
- 4). Alignment notch(es) in the plates should be thoughtfully provided, since tests show that uniformity of the plate-spacer stack is critical to good bonding.

The overall conclusion based on these tests is that copper plate/steel spacer heat exchangers are technically feasible, if the guidelines mentioned in (1) - (4) are observed. We can now order our plate and spacer material with confidence.

## 2.0 WORK DONE DURING THE REPORT PERIOD

The work will be reported in the current areas of effort:

### 2.1 Order Long Lead Time Equipment and Materials

Equipment for the contractor-owned heat exchanger manufacturing facility is now complete. The Leybold-Heraeus sputtering system has now been installed and tested. A sample of 400 mesh Ag-Cu brazing powder and brazing paste has been ordered from Lucas-Milhapt, Inc. These products are designed for vacuum brazing processes and should allow formation of 1 mil thick braze joints.

## 2.2 Design Test Facility

All designs for the basic support hardware (gas panel, dewar supports and mounting plates) have been finished. Designs for the test cryostat hardware are nearing completion.

## 2.3 Construct Test Facility

Construction of the gas handling panel for the system is complete. Mounts and supports for the dewar are complete and in place. The contractor-owned Gifford-McMahon cryocooler is mounted in a suitable dewar and has been tested.

## 2.4 Other Related Work

As mentioned in 1.0, information gained in plate/spacer bonding tests has been correlated in the design parameters for the spacers and plates needed in this program. Feasibility of bonding copper plates to stainless steel spacers has been demonstrated.

## 3.0 WORK PLANNED FOR THE NEXT REPORT PERIOD

During the next report period the materials for the heat exchanger plates will be ordered and construction will begin on the support cryostat.