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LSSA LARGE AREA SILICON SHEET TASK

CONTINUOUS LIQUID FEED CZOCHRALSKI GROWTH

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QUARTERLY REPORT

October - December 1977

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract NAS7-100 for the U.S. Department of Energy (DOE).

The JPL Low-Cost Silicon Solar Array Project is funded by DOE and forms part of the DOE Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays.

siltec

MENLO PARK, CALIFORNIA

January 1978

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CONTINUOUS LIQUID FEED CZOCHRALSKI GROWTH

Siltec Report No. 0140-0080

QUARTERLY REPORT

October - December 1977

By

Walter Torbet

January 1978

SILTEC CORPORATION
Menlo Park, California

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INTRODUCTION

Siltec's contract with JPL is to develop a crystal growing process and required equipment which will use the well-proven Czochralski (CZ) technique in combination with a continuous liquid feed system (CLF). This system is intended to provide pulling capabilities in excess of 100 kilograms of silicon from each furnace setup. The basic concept is sketched in Figure 1 (Appendix B) and consists of four major elements:

1. Crystal Growth Chamber and Pull Mechanism
2. Polycrystalline Charge Melt-down Chamber
3. Liquid Silicon Transfer Assembly
4. Transfer Rate Control System

The principle of operation involves continuous (or semi-continuous) melt-down of polycrystalline silicon material in the charge melt-down chamber and replenishment of the crystal growth crucible via a liquid transfer assembly.

The continuous liquid feed concept offers the following significant advantages:

1. High crystalline quality associated with CZ techniques is expected, assuring high efficiency solar cells.

2. The process is based on well-developed CZ technology with low associated risk of program failure.

3. Polycrystalline charge meltdown chamber can accept material in a variety of forms, including power, pellets, and billets.

4. Manufacturing costs associated with silicon container materials and energy use can be kept at a low level with a continuous growth cycle.

The equipment requirements of this work cannot be met within the confines of an existing Siltec furnace. Therefore, a new furnace will have to be designed and built before the process development work can begin. This quarter's work has been on the design layouts of such a furnace.

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TECHNICAL DISCUSSION

It is to be expected that the transport tube will have design problems. Therefore, this tube will be made as short as, and as direct as, possible. This implies that the two crucibles, melt-down and growth, should be located adjacently. This feature has been included in the layouts of the furnace by the enclosing of the crucibles in a siamese chamber.

A tentative design was determined for the transport tube assembly:

1. The transport tube will be thick wall SiO_2, about 2.5 cm. outside diameter.

2. The heating will be by graphite resistance heaters, per Drawing No. 0140-0020 (see Figure 2, Appendix B).

3. The heaters will be assembled to the SiO_2 tube by wrapping with SiO_2 woven tape. This serves both to assemble the heaters and to electrically insulate them.

4. A layer of graphite woven tape will be wrapped over the SiO_2 tape, to shield the SiO_2 from the alkalis in the insulation of Step 5.

5. The wrapped tube will be potted to a thickness of about 1-1/2 cm. in fire-brick mortar. The mortar will serve not only as insulation but also to provide structural rigidity and strength, to separate and electrically insulate the heater bus bars, and to provide the attachment of the bulkhead flange.

6. Temperature measurements will be by thermocouples buried in the slots of the heater segments.

This construction will yield a tube assembly with about a 9 cm. outside diameter. The anticipated diameter of the growth crucible is therefore 30 cm.; crystal diameter plus twice this tube diameter plus a clearance allowance. The design layouts allow for up to 40 cm. diameter crucibles.

TECHNICAL DISCUSSION (Continued)

Many components from the current Siltec furnace design have been incorporated into the design layouts. Major items include:

1. Crystal lift and rotate carriage
2. Crucibles lift and rotate carriage
3. Automatic diameter control assembly
4. Crucible temperature control assembly

A first attempt was made to detect a melt level with a reflected laser beam. The attempt failed due to excessive deflection of the beam by surface rippling of the molten silicon.

A current model Siltec furnace has been moved into the Engineering Lab to expedite future such experiments.

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CONCLUSIONS AND RECOMMENDATIONS

No conclusions or recommendations may be drawn from the work in the first quarter.

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NEW TECHNOLOGY

No new technology has been developed on this program during this quarter.

PROJECTION OF ACTIVITIES

The long lead fabrication items of the CLF furnace are believed to be the mainframe and the crucible chamber. Design work will be completed for these two items. Components, such as the crystal and crucible carriages from current Siltec furnace that are to be utilized, will be placed on order.

Experiments with melt level control will continue, and experiments with elements of the molten silicon transport tube will commence.

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APPENDIX A

Summary of Characterization, Design, and Economic Analysis Data

There was no data generated during this quarter to analyze.

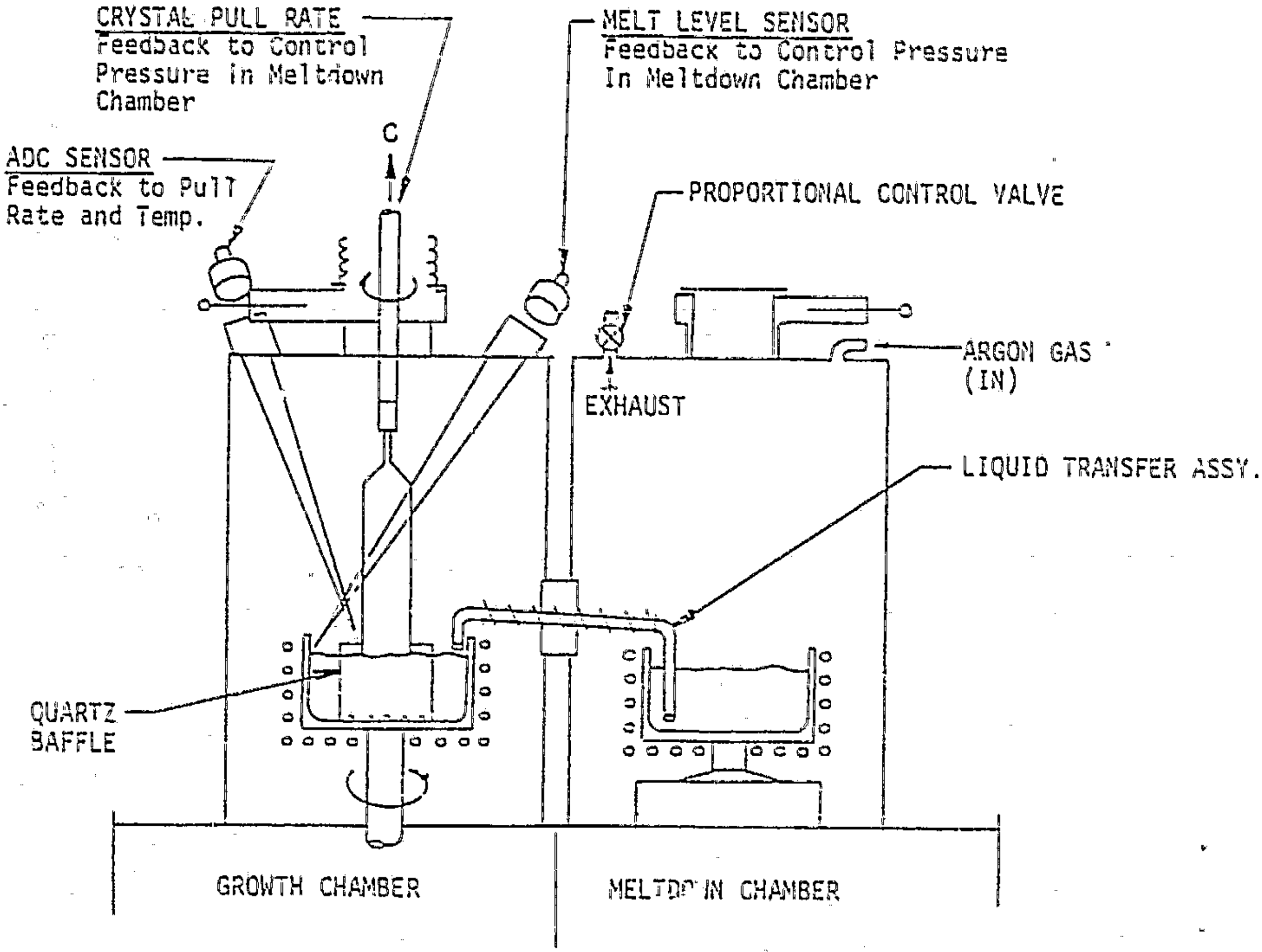

Figure 1: Liquid Transfer Crystal Growth System

APPENDIX B

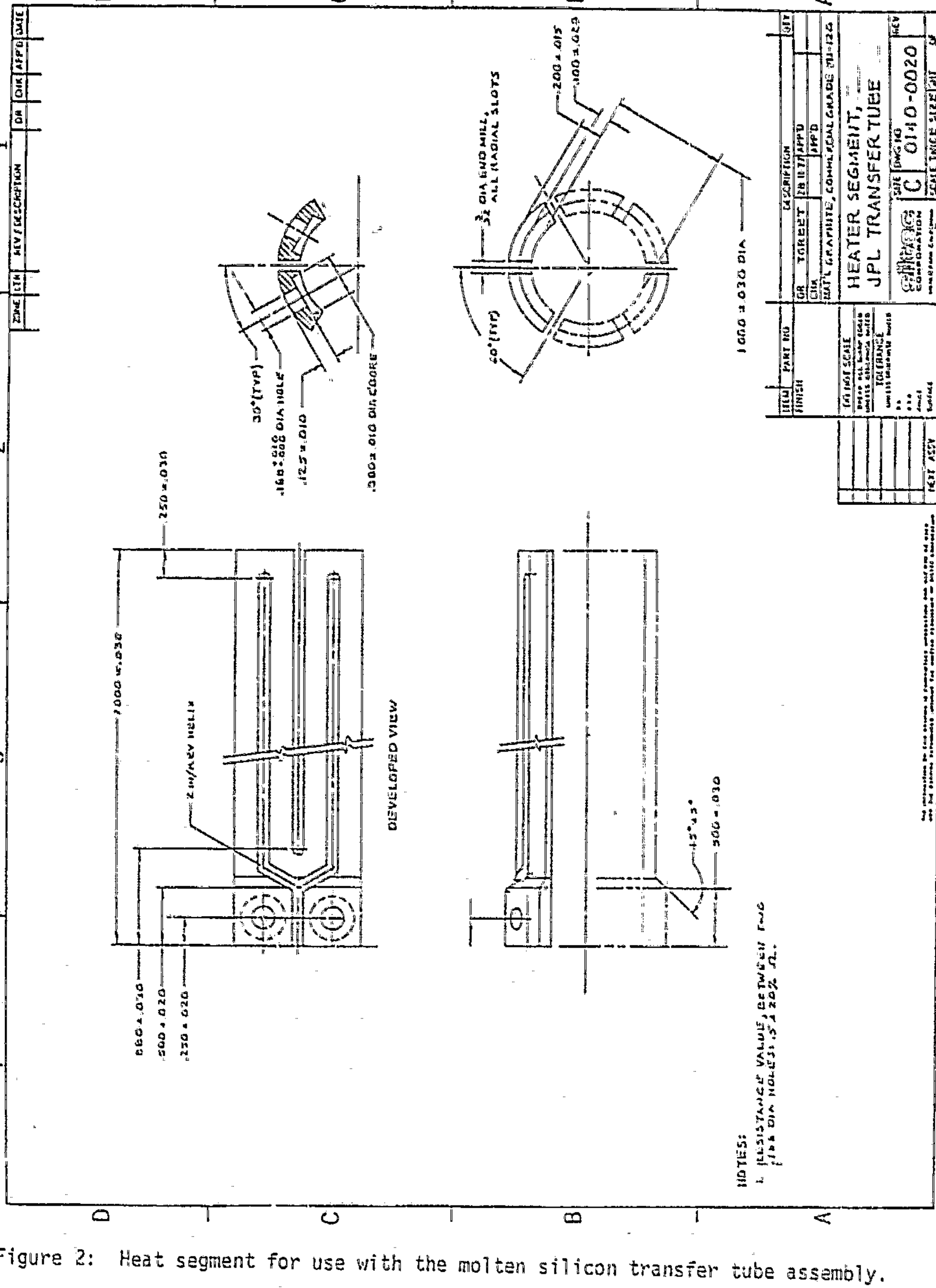

Figure 2: Heat segment for use with the molten silicon transfer tube assembly.

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APPENDIX C

Program Plan

Since this Program Plan has not been submitted as of the date of this report, an "update" is not included.