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**FEASIBILITY INVESTIGATION OF
GROWING GALLIUM ARSENIDE SINGLE CRYSTALS
IN RIB² J FORM**

NSF GRANT GI-43093

July 1, 1974 - December 30, 1975

\$164,000 ADL

60,000 MIT

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at the
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ABSTRACT

An eighteen month program was initiated July 1, 1974 to determine the feasibility of producing GaAs single crystal ribbons suitable for solar cell substrates. Constrained, encapsulated molten zones are passed through rectangular polycrystalline feed material to form single crystal ribbons. The objective of this program is to grow 10 cm x 1 cm x 0.1 cm single crystals by a process that is amenable to continuous growth.

During the past six months, two methods have been used to establish passage of a molten zone through ribbon GaAs feedstock; direct coupling with rf to the GaAs and constrained zone-melting in B_2O_3 sealed graphite boats. Establishment of a narrow molten zone by direct rf coupling to GaAs was shown to be limited by the large skin depth required for heating GaAs as compared to the desired ribbon thickness.

Polycrystalline GaAs ribbons have been grown in graphite boats by passage of a wide zone through B_2O_3 -encapsulated feed-stock, confined by a quartz cover plate. Failure to remove the encapsulant above its glass transition temperature, however, resulted in cracking of the ribbons on cooling to room temperature. In order to study the crucial zone melting step in isolation from the encapsulation steps of the continuous process, a horizontal constrained-zone melting apparatus made from graphite was used in which a boron oxide moat serves only as a sealant to suppress arsenic vaporization. Melt zones were passed through 5 and 10 cm long samples of GaAs ribbon feedstock. By controlling the heat flow in the graphite boat and controlling the zoning rate, large grained, single phase polycrystalline samples with directional solidification and good thickness control were achieved. Arsenic vaporization was effectively suppressed at the melting point of GaAs ($1240^\circ C$) by the B_2O_3 moat and 3 atmospheres of pressure.

A vertical constrained-zone-melting apparatus with a B_2O_3 moat seal, rf heating, and water cooling on the bottom will be used to control the heat flow and temperature patterns required for growth of single crystal ribbons. These conditions will then be adapted to a continuous growth process.

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Dr. John Haggerty
Wilson Menashi

RIBBON GROWTH OF GALLIUM ARSENIDE

NSF Grant GI-43093

A.D. Little, Inc.

July 1, 1974 – December 30, 1975 (18 Months)

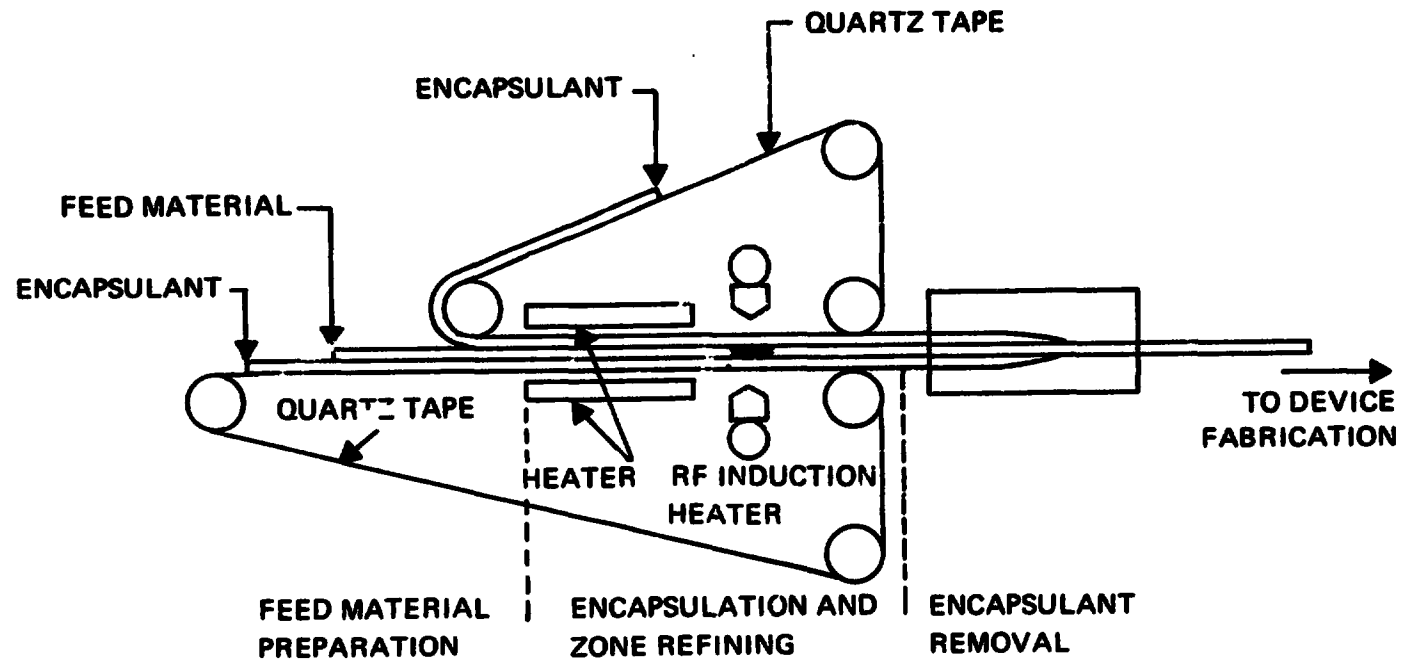
\$ 164,000 ADL

\$ 60,000 MIT (Crystal Characterization)

Dr. Joan Berkowitz, Principal Investigator

PROJECT OBJECTIVES

- **To grow and characterize GaAs substrate ribbon single crystals
10 cm long x 1 cm wide x 0.1 cm thick**
- **To develop designs for a continuous growth experimental
apparatus**

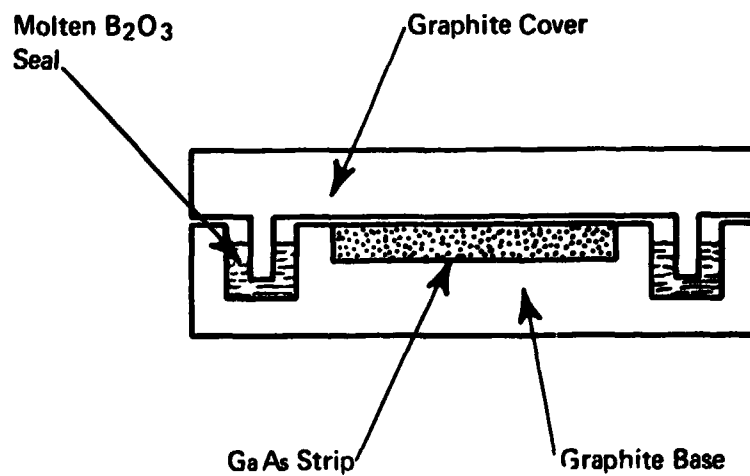


ACTIVITY DURING THE LAST 6 MONTHS

Tests with Direct Coupling
Horizontal Confined Growth
Characterization of Specimens
Vertical Confined Growth

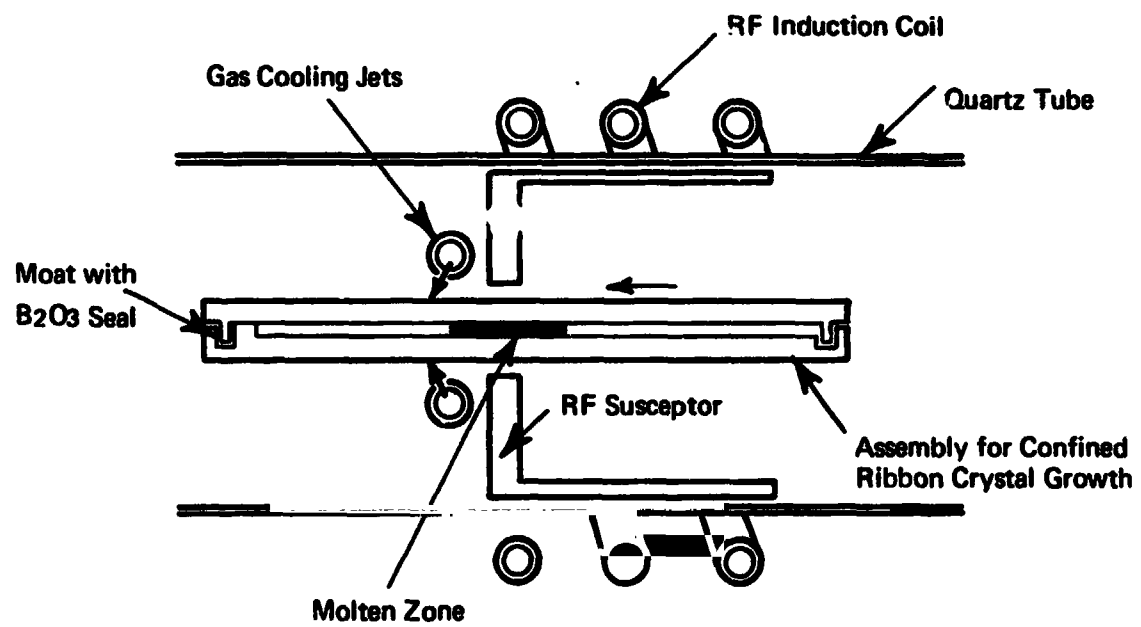
DIRECT COUPLING

Temperature Limit of 900°C
Skin Depth for RF Heating is Greater
Than Crystal Thickness
GaAs Spalled by B₂O₃ in Direct Contact



HORIZONTAL CONFINED GROWTH

Constraint of the Molten Zone
 B_2O_3 Does Not Contact the GaAs
GaAs Does Not Wet the Graphite

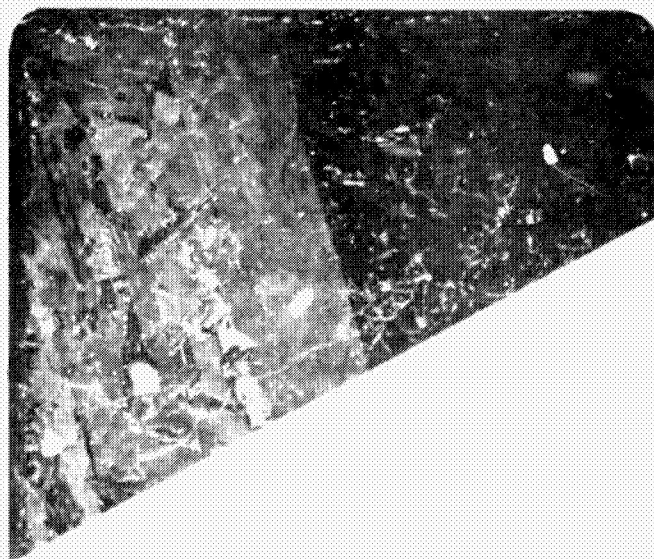




1.3 cm

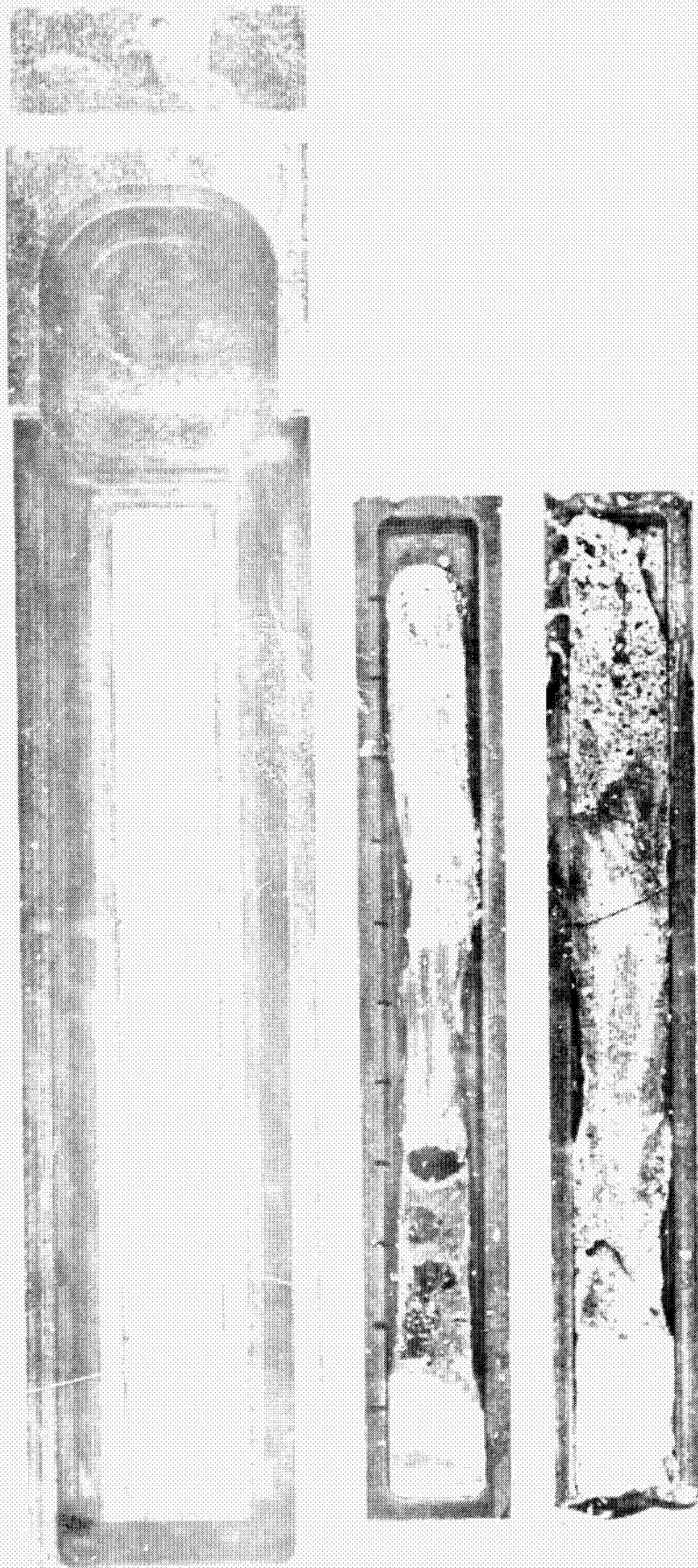


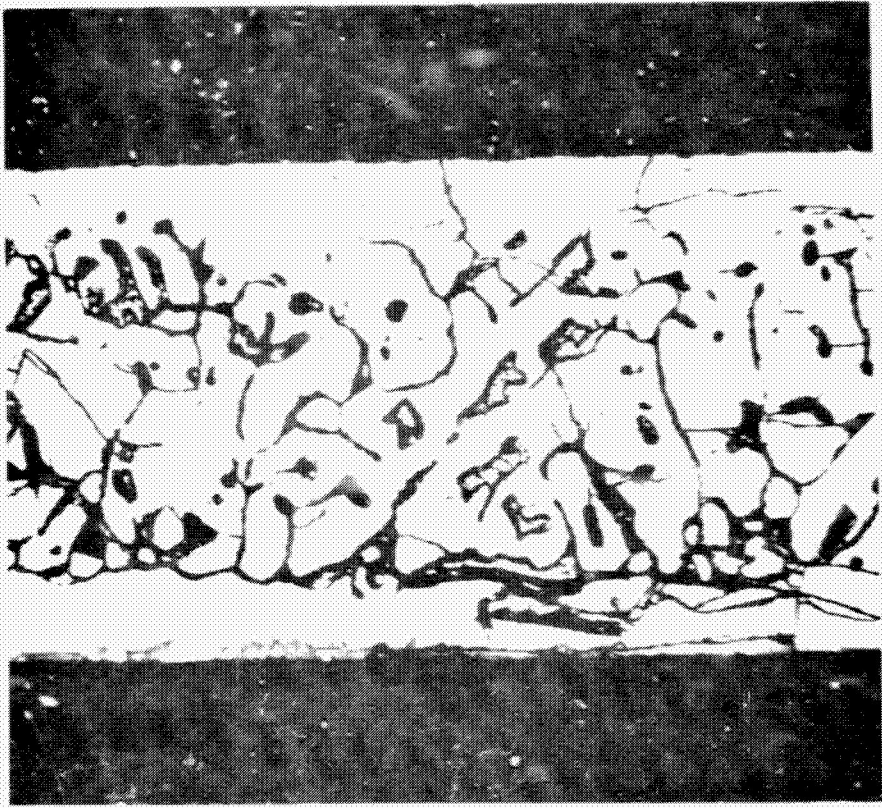
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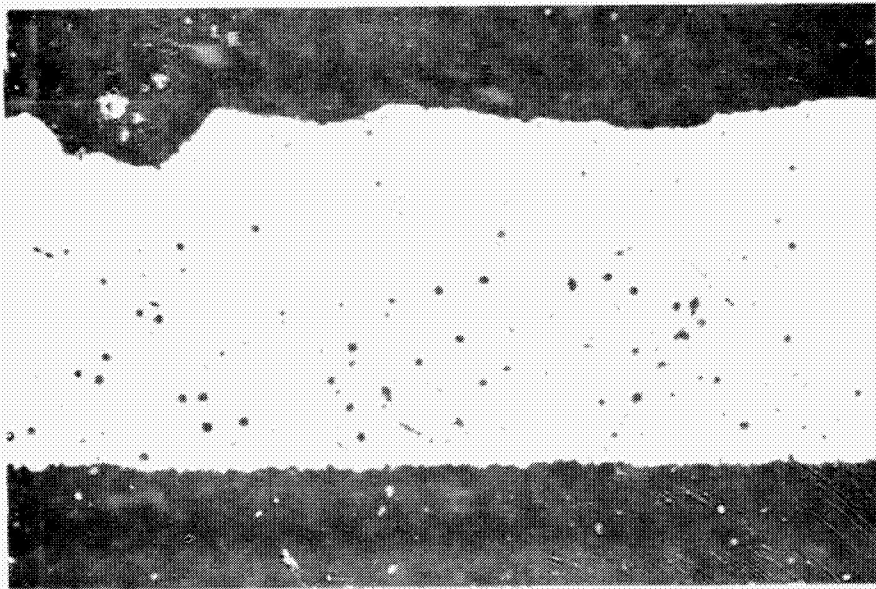
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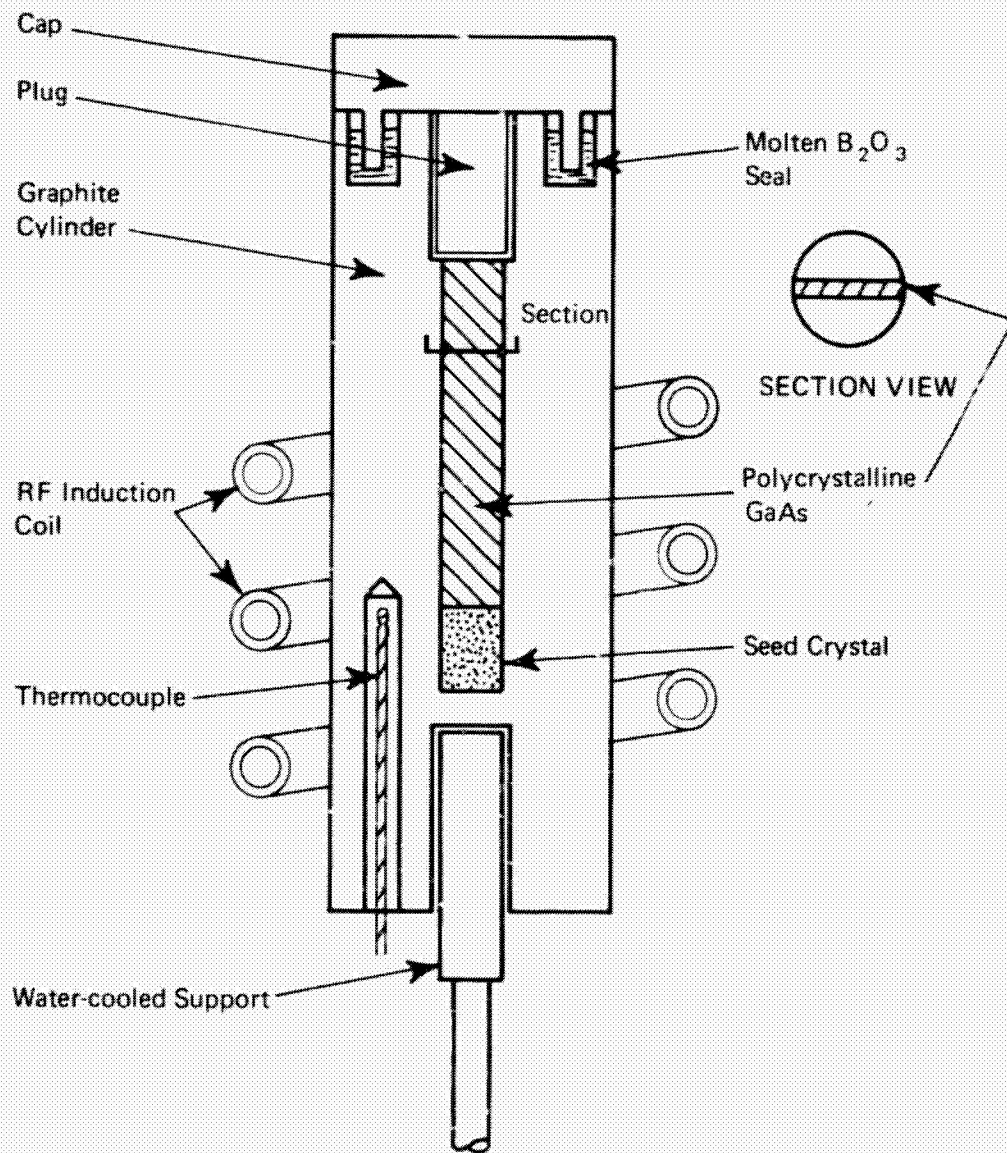




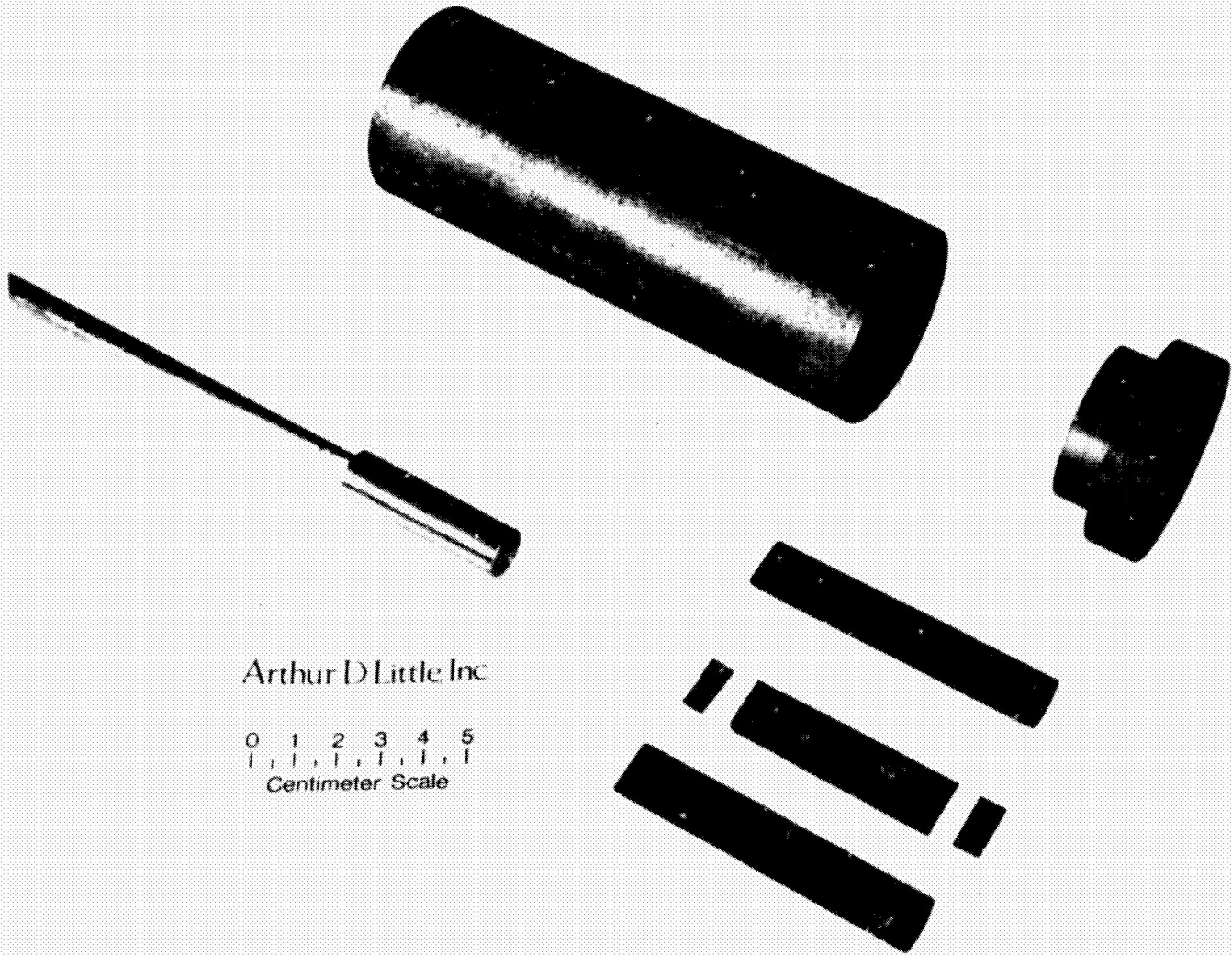
1.7 mm



1.3 mm

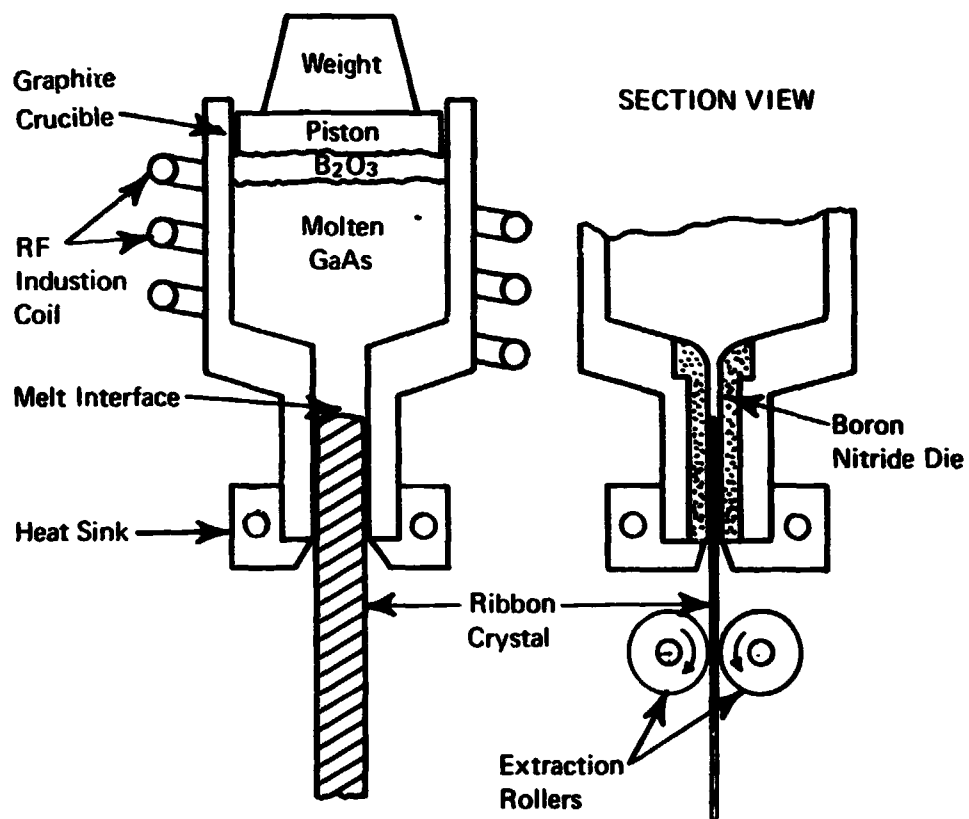


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Centimeter Scale



SUMMARY OF KEY RESULTS

- **Confined Melt Zone**
- **Directional Solidification**
- **Control of Arsenic Vaporization**
- **Single Phase Polycrystalline Material**

PLANNED ACTIVITY FOR THE NEXT 6 MONTHS

- **Experiments with Vertical Confined Growth**
- **Physically Characterize Crystals**
- **Design Continuous Growth Apparatus**

PLANNED RENEWAL REQUESTS – Jan. 1976 – July 1977

- **Construction of Experimental Continuous Growth Apparatus**
- **Optimization of Process with Respect to Energy and Cost**
- **Solar Cell Development and Characterization**