N91-21368

CONTAINERLESS EXPERIMENTATION IN MICROGRAVITY WORKSHOP

ABSTRACT

HIGH TEMPERATURE ACOUSTIC AND HYBRID MICROWAVE/ACOUSTIC LEVITATORS FOR MATERIALS PROCESSING: PROGRESS REPORT

M. Barmatz

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109

The physical acoustics group at the Jet Propulsion Laboratory has developed a single mode acoustic levitator technique for advanced containerless materials processing. This technique was successfully demonstrated in ground-based studies to temperatures ≈ 1000 °C in a uniform temperature furnace environment and to temperatures > 1500 °C using laser beams to locally heat the sample. At this time, we are evaluating microwaves as a more efficient means than lasers for locally heating a positioned sample. Recent tests of a prototype single mode hybrid microwave/acoustic levitator successfully demonstrated the feasibility of using microwave power as a heating source. The potential advantages of combining acoustic positioning forces and microwave heating for containerless processing investigations will be discussed and results of ground-based acoustic, microwave, and hybrid microwave/acoustic studies will be presented.

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MARTIN BARMATZ

JPL

JANUARY 18, 1990

PRESENTATION OUTLINE

- HIGH TEMPERATURE SINGLE MODE ACOUSTIC LEVITATOR
  - ISOTHERMAL ENVIRONMENT ($\leq$ 1000 °C)
  - LASER BEAM HEATING ($\approx$ 1500 °C)
  - VIDEO TAPE
- HYBRID MICROWAVE/ACOUSTIC LEVITATOR
  - ADVANTAGES OF MICROWAVE HEATING
  - DEVELOPMENT PROGRAM
  - TEMPERATURE FEEDBACK CONTROL
  - PROTOTYPE HYBRID
  - POTENTIAL SCIENCE AREAS

MICROWAVE/ACOUSTIC

RESEARCH TEAM

DR. M. BARMATZ - MICROWAVE/ACOUSTIC PHYSICIST

DR. J. WATKINS - MICROWAVE/ACOUSTIC PHYSICIST

MR. J. STONEBURNER - ACOUSTIC PHYSICIST

DR. H. JACKSON - THEORETICAL PHYSICIST

DR. C. SHIPLEY - SCIENTIFIC PROGRAMMER

MR. G. AVENI - ACOUSTIC SCIENTIST

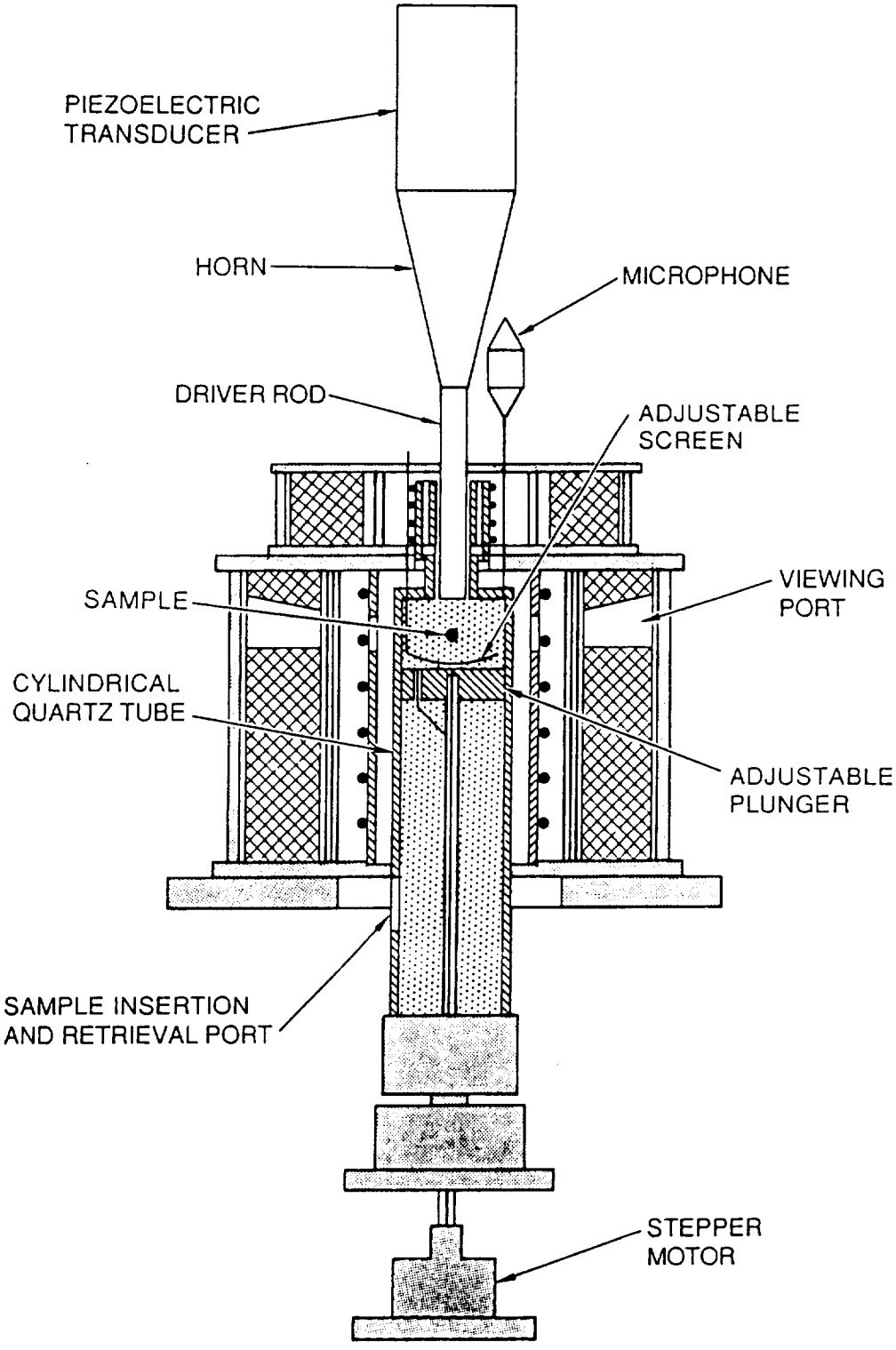
MR. C. HAGENLAGER - PROGRAMMER

MR. R. ZANTESON - MACHINIST

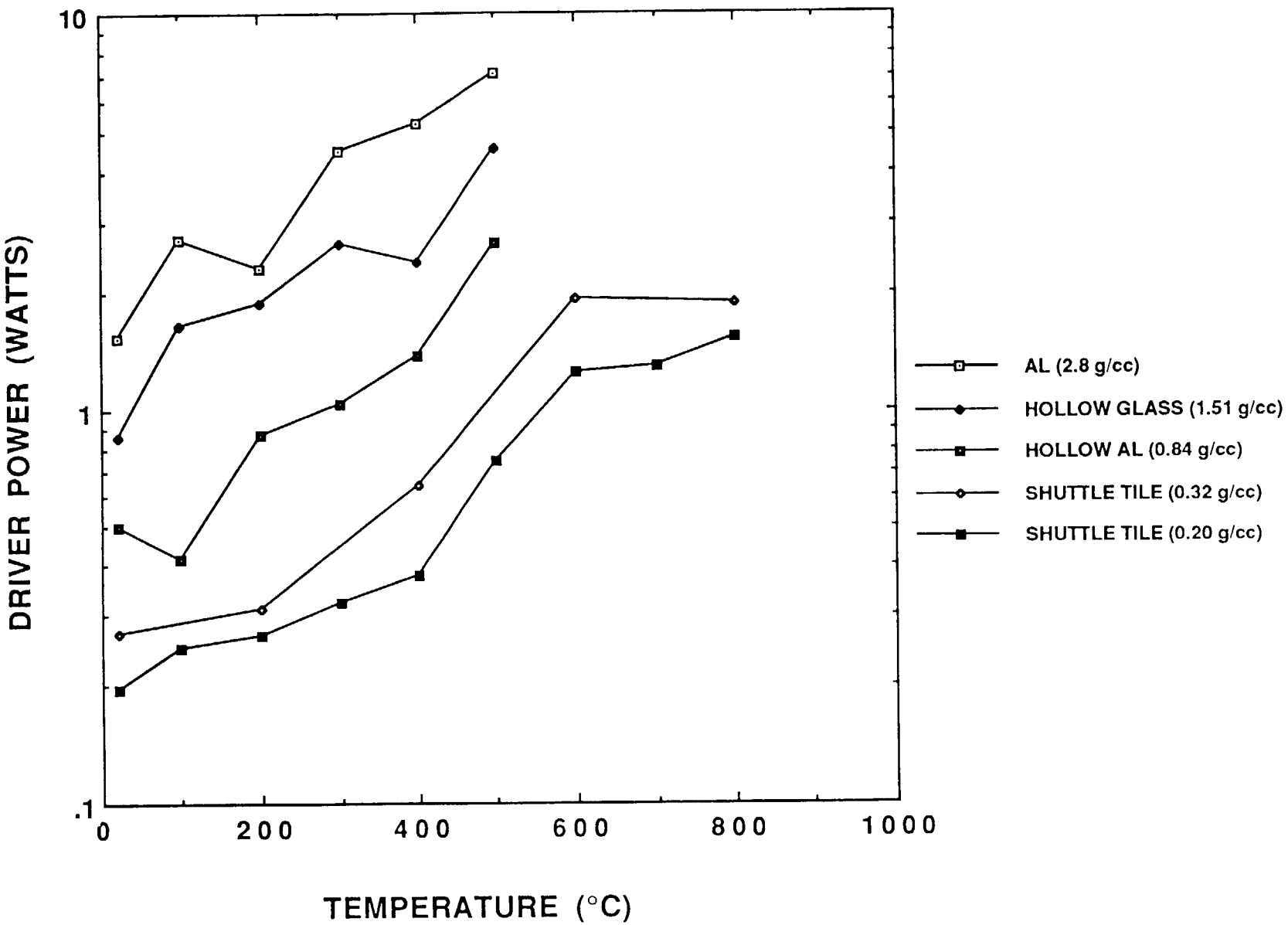
HIGH TEMPERATURE SINGLE MODE ACOUSTIC LEVITATOR

- CYLINDRICAL SINGLE MODE POSITIONER
  - FIXED FREQUENCY 20 KHZ DRIVER
  - (011) MODE EXCITATION
- ISOTHERMAL FURNACE (1000 °C)
- 100 WATT NEODYMIUM-YAG LASER - DUAL BEAM
  - ≈ 3 mm DIAMETER SHUTTLE TILE SAMPLE
- NON-CONTACT TEMPERATURE MEASUREMENT
  - QUANTUM LOGIC LASER PYROMETER

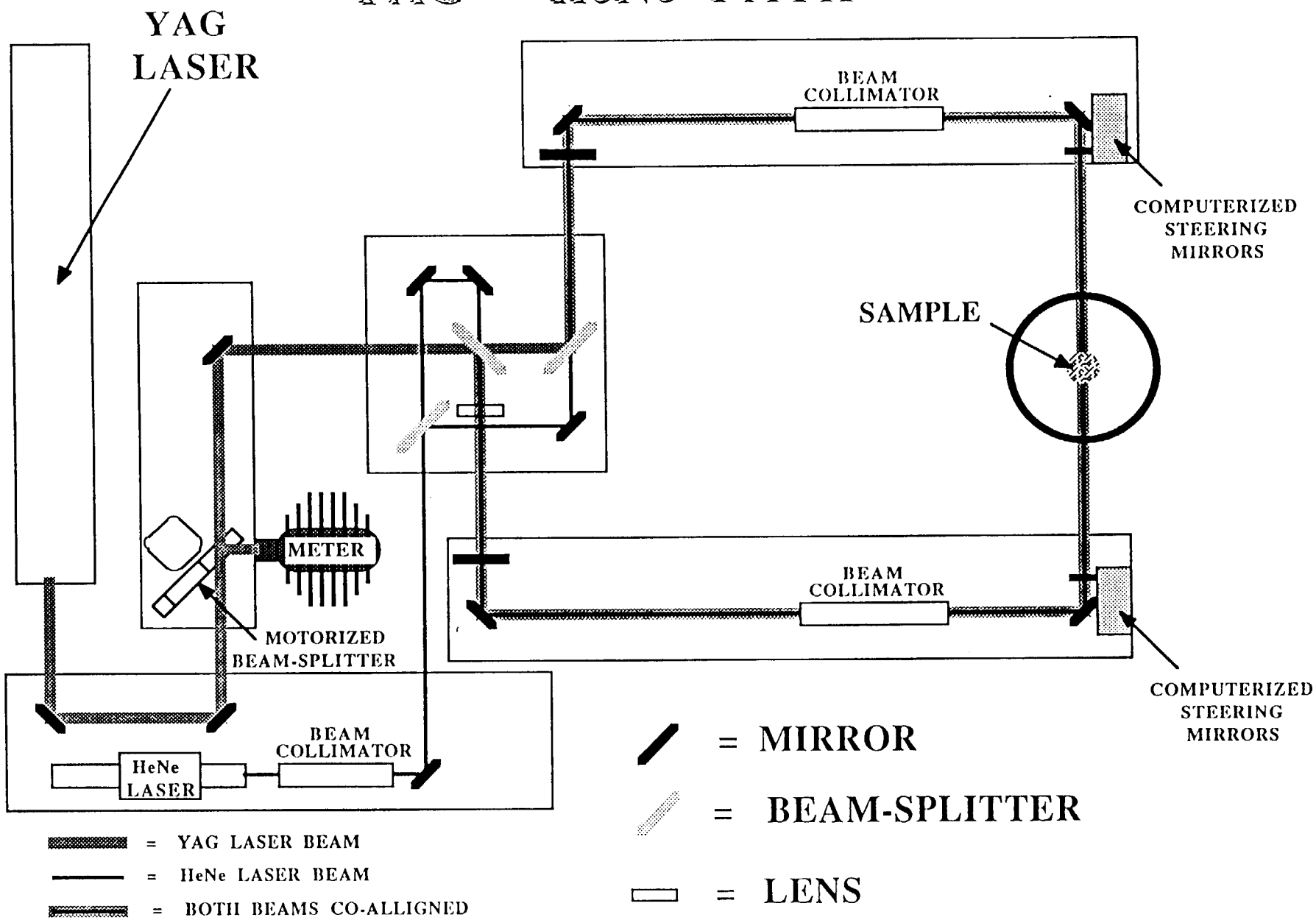
HIGH TEMPERATURE SINGLE MODE ACOUSTIC LEVITATOR

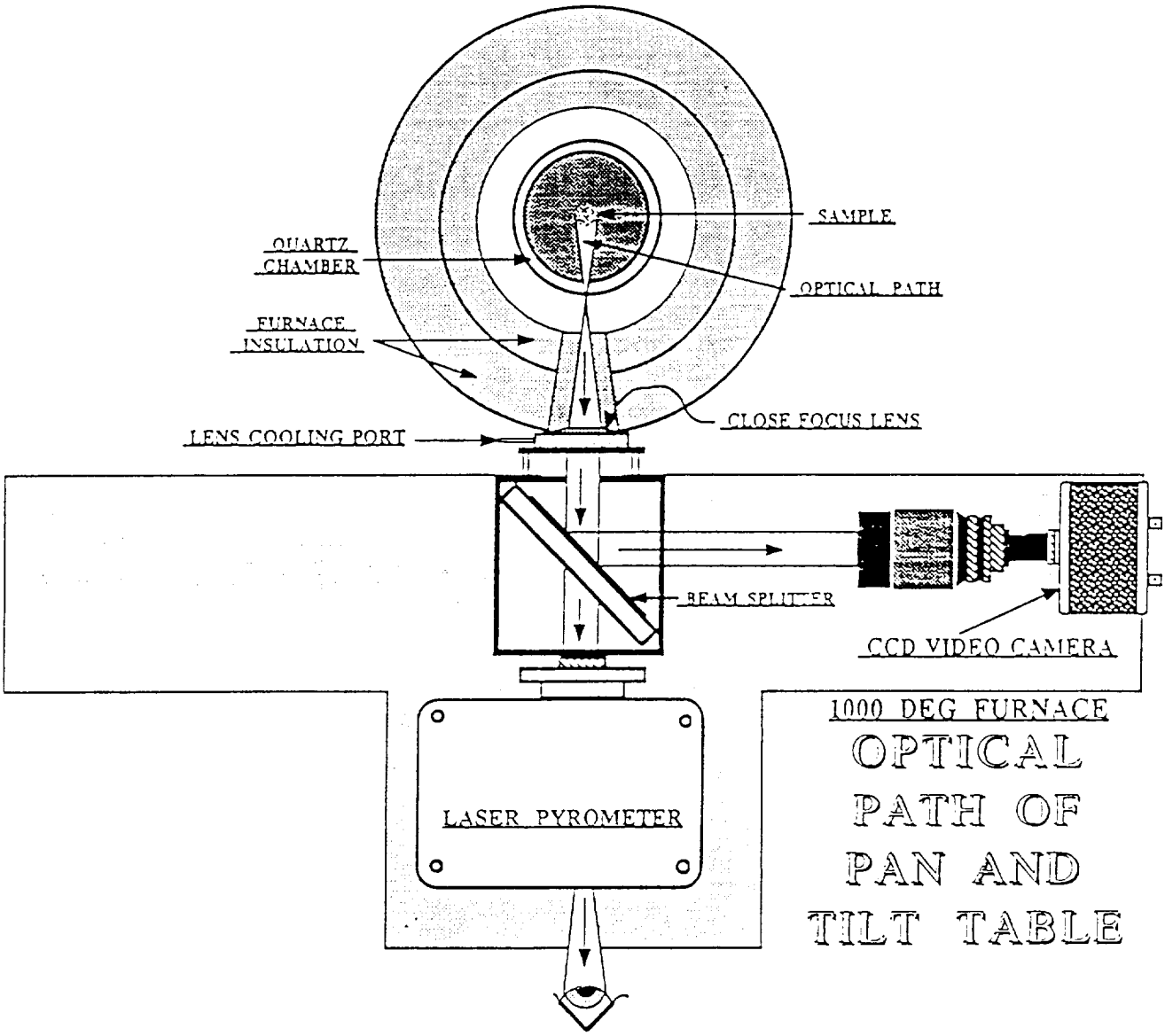


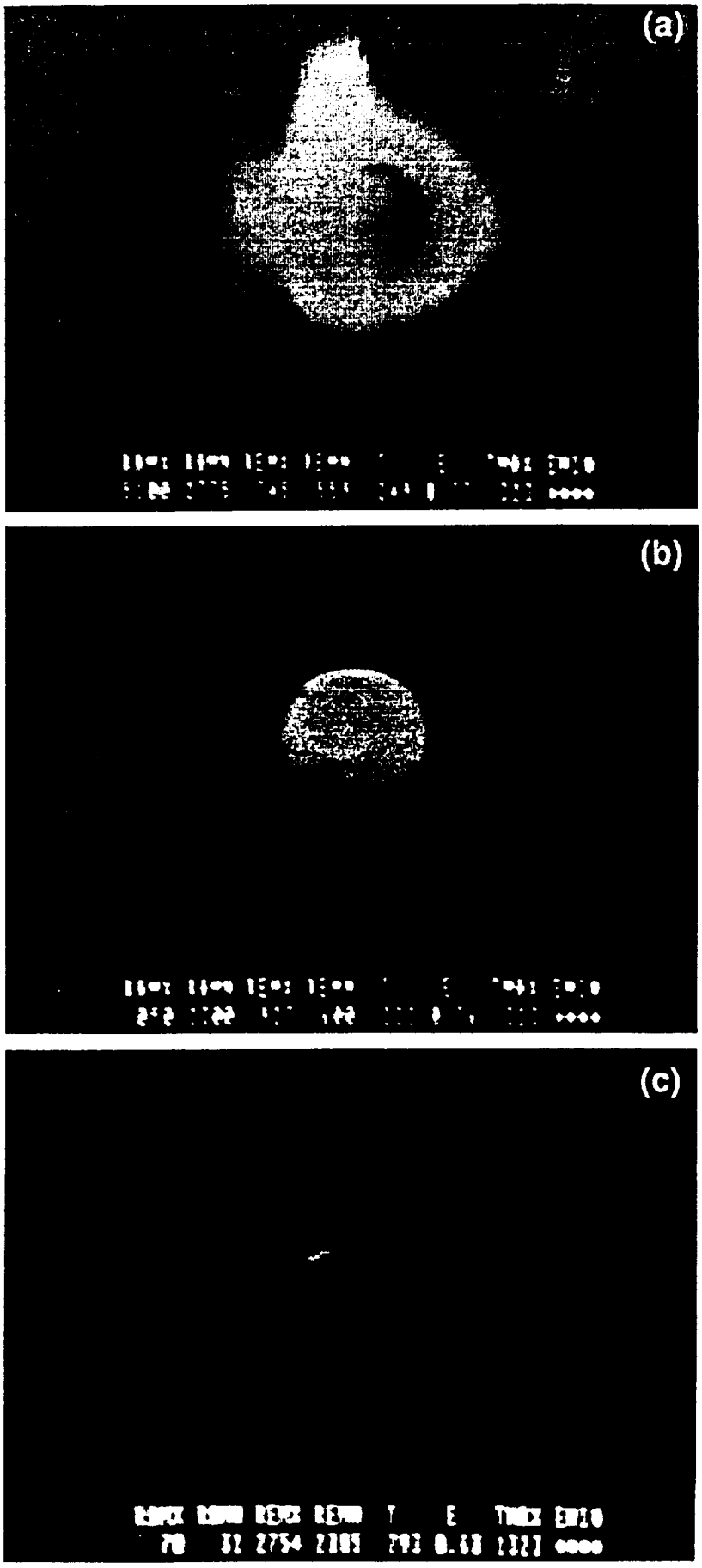
DRIVER POWER VS TEMPERATURE



YAG - HeNe PATH




SAMPLE
QUARTZ CHAMBER
OPTICAL PATH
FURNACE INSULATION
CLOSE FOCUS LENS
LENS COOLING PORT
BEAM SPLITTER
CCD VIDEO CAMERA
1000 DEG FURNACE
LASER PYROMETER
OPTICAL PATH OF PAN AND TILT TABLE



MICROWAVE/ACOUSTIC HYBRID LEVITATOR

MICROWAVE HEATING ADVANTAGES

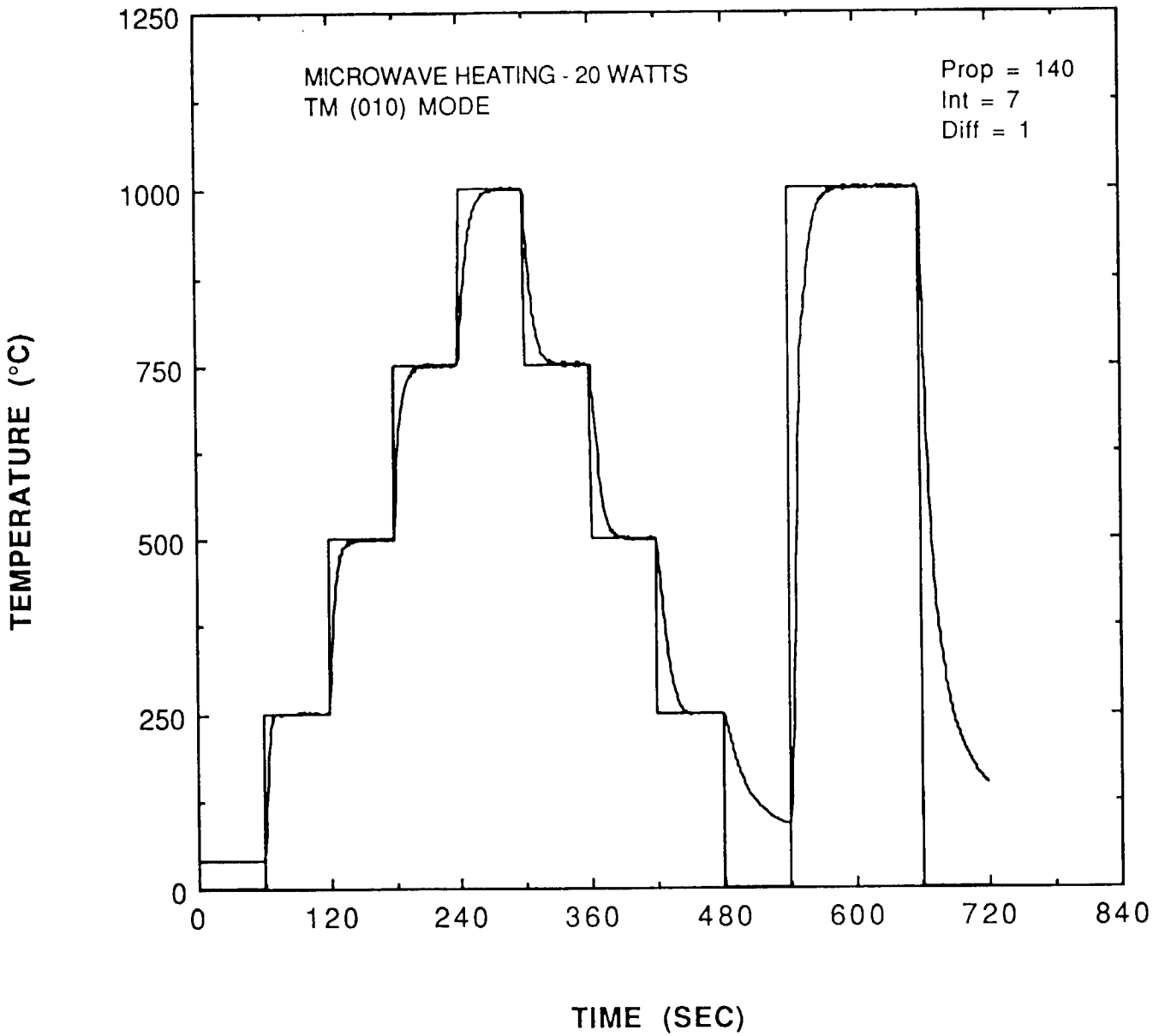
- EFFICIENT POWER CONVERSION COMPARED TO LASERS AND ARC LAMPS
- SMALL, LIGHT WEIGHT POWER SYSTEM
- VOLUMETRIC SAMPLE HEATING IS POSSIBLE
- SAMPLE POSITIONING IS NOT CRITICAL
- FAST CONTROLLABLE HEATING OF SAMPLE
  QUICK RESPONSE TIME
- COLD CHAMBER WALLS ⇒ QUICK CONTROLLABLE COOLING - TEMPERATURE CONTROLLED PROCESSING
- SELECTIVE HEATING OF SAMPLE COMPONENTS
- POSITIONING OF HOT AND COLD SAMPLES SIMULTANEOUSLY (DROP COALESCENCE)

MICROWAVE/ACOUSTIC HYBRID LEVITATOR

DEVELOPMENT PROGRAM

- EVALUATE MICROWAVE HEATING CONCEPT APPLIED TO CONTAINERLESS PROCESSING
  - MODEL - ABSORPTION OF A SPHERE
  - MODEL - TEMPERATURE PROFILE WITHIN SPHERE - INVERTED TEMPERATURE PROFILE (HOTTEST IN CENTER)
  - TEMPERATURE FEEDBACK CONTROL
  - MATERIALS CHARACTERIZATION - DIELECTRIC CONSTANT
    - GLASSES (LEAD BORATE - 900 °C)
    - CERAMICS (ZEOLITE - > 1100 °C)
  - DEMONSTRATE HYBRID LEVITATOR CONCEPT
    - PROTOTYPE - 20 KHZ (ACOUSTIC) LEVITATION - 10 WATTS (MICROWAVE)
    - HIGH POWER HYBRID - 1KW MICROWAVE SOURCE

TEMPERATURE CONTROL OF ALUMINA SILICATE



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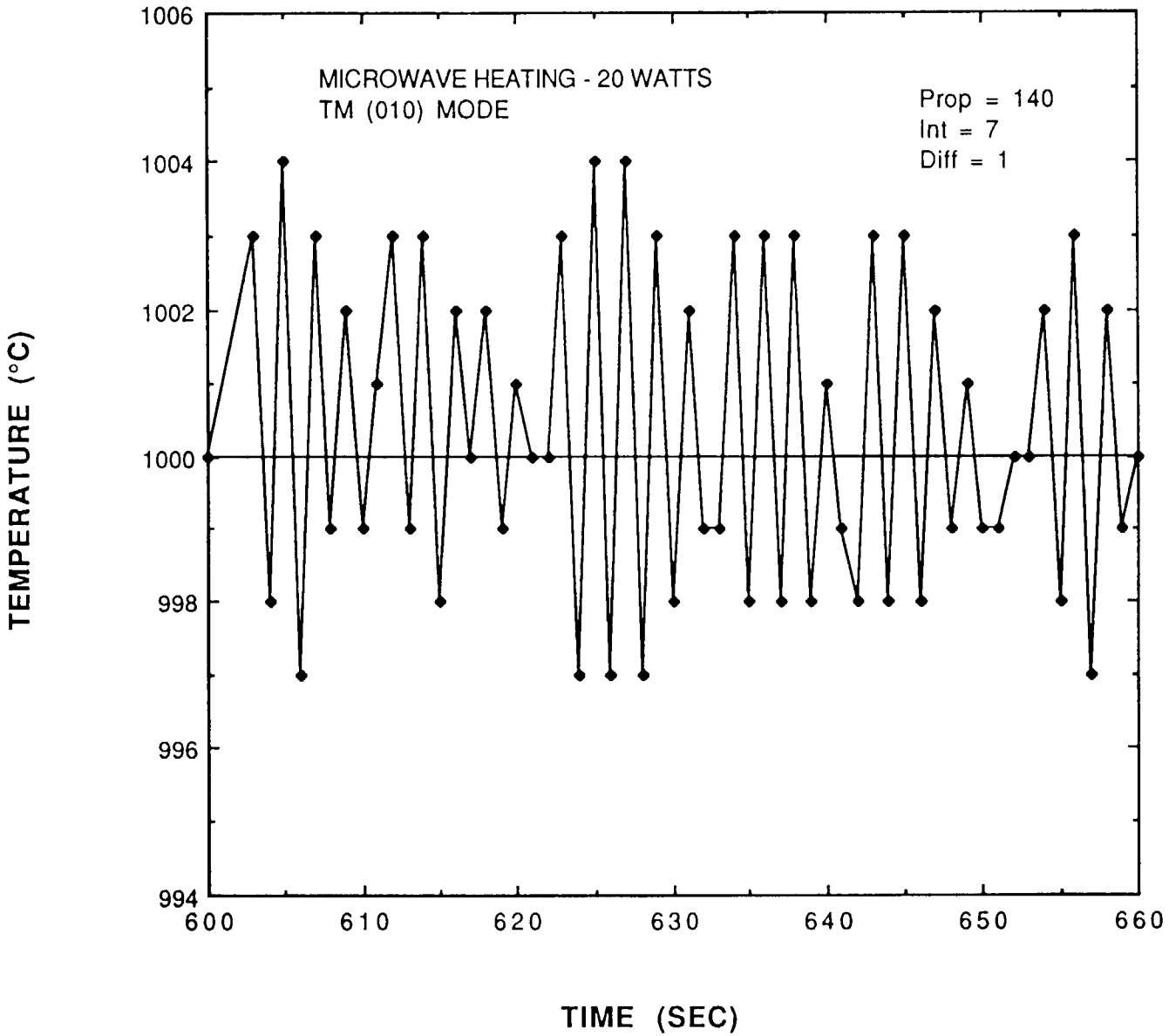
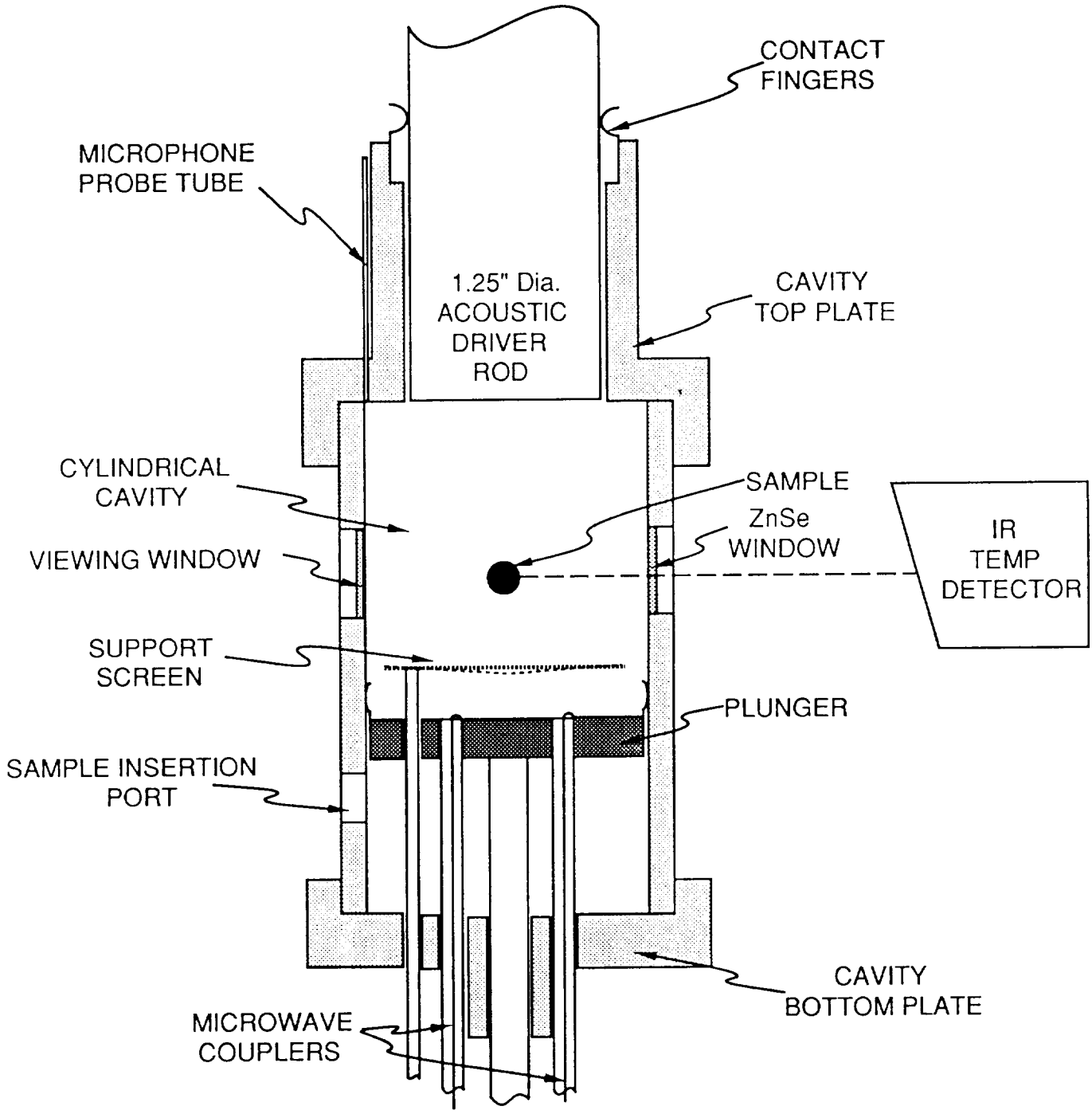


MICROWAVE / ACOUSTIC HYBRID LEVITATOR

PIEZOELECTRIC DRIVER - SINGLE MODE POSITIONER



MICROWAVE/ACOUSTIC HYBRID LEVITATOR

POTENTIAL SCIENCE AREAS

- TEMPERATURE CONTROLLED PROCESSING
  - QUICK HEATING AND COOLING
  - PHASE TRANSFORMATION STUDIES
  - GLASS AND CERAMIC MATERIALS SYNTHESIS
  - TEMPERATURE MODULATION STUDIES
- ENHANCED MATERIALS PROCESSING DUE TO INVERTED TEMPERATURE PROFILE
  - UNIQUE ANNEALING OR ZONE REFINING
- NON-CONTACT THERMOPHYSICAL PROPERTIES MEASUREMENTS
  - SPECIFIC HEAT, DIELECTRIC PROPERTIES