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INFRARED CALIBRATION

AT

THE SPACE DYNAMICS LABORATORY
UTAH STATE UNIVERSITY

LOGAN, UTAH

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4880

- History
- Current Efforts
- Calibration Approach
  - Calibration Objectives
  - Low-background Calibration Chambers
  - Calibration Results

Recent Calibration Efforts at SDL/USU

* IBSS (Infrared Background Signature Survey)

  Radiometer

    30 detectors

    12-color filter wheel, 2.5 to 8.0 um

  Spectrometer

    Ebert-fastie grating, 2.5 to 24 um

    12 Detectors

* CIRRIS-1A (Cryogenic InfraRed Radiance Instrumentation for Shuttle)

  Post Flight

  Radiometer

    14 detectors

    8-color filter wheel, 2 to 24 um

  Spectrometer

    Michelson interferometer 2 to 24 um

    4 detectors

Recent Calibration Efforts, cont

* SPIRIT II (Spatial Infrared Rocketborne Interferometer Telescope)

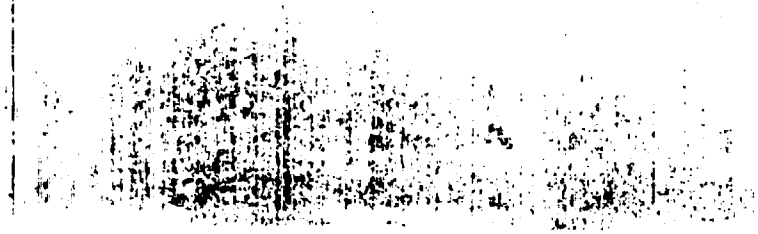
  Radiometer
  - 300 detectors
  - 6 colors, 6 to 30 um

  Spectrometer
  - Michelson interferometer 3 to 30 um
  - 6 Detectors

* SPIRIT III

  Radiometer
  - 4000 detectors
  - 5 colors, 6 to 30 um

  Spectrometer
  - Michelson interferometer, 3 to 30 um
  - 6 Detectors



Optical Calibration Objectives

1. Characterize each of the sensor responsivity domains
   - Linearity Responsivity
   - Absolute Responsivity
   - Spectral Domain
   - Spatial Domain
   - Temporal Domain

2. Design calibration experiments which characterize each parameter independently of the others

3. Calibrate the sensor in the mode that it will make measurements

Multiple source configurations required ⟶ Multi-function calibration chamber

SDL/USU Low-Background Calibration Chambers

* MIC-1
  (Multi-function Infrared Calibrator)

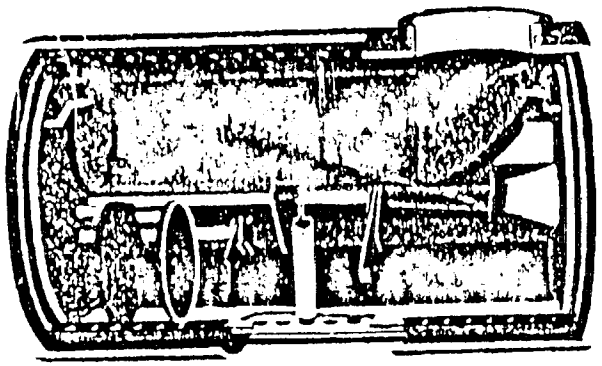
  6-inch circular exit pupil
  Developed on IBSS program

* MIC-2

  21-inch X 11-inch elliptical exit pupil
  Developed on SPIRIT II program

* MIC-3

  17.5-inch circular exit pupil
  Developed on SPIRIT III program



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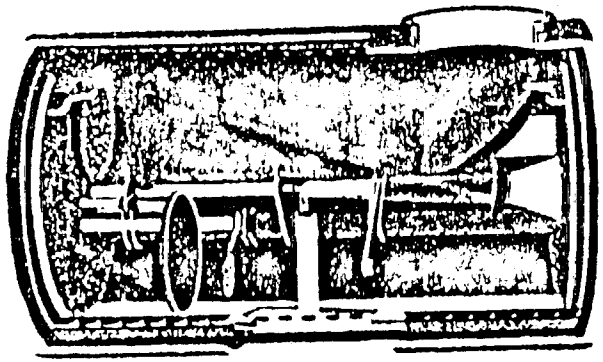

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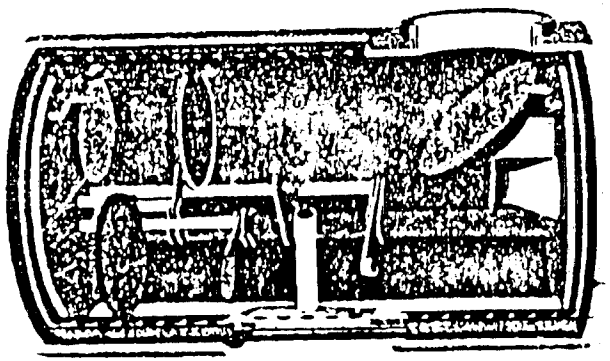

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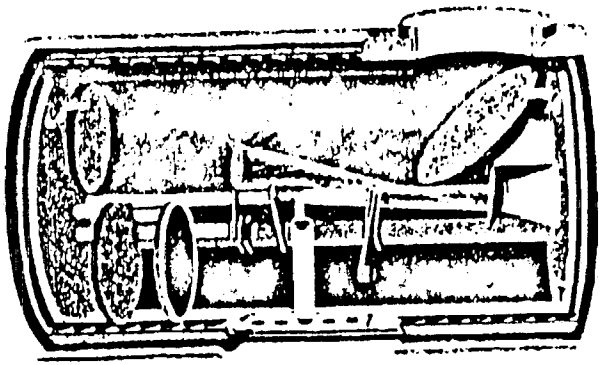

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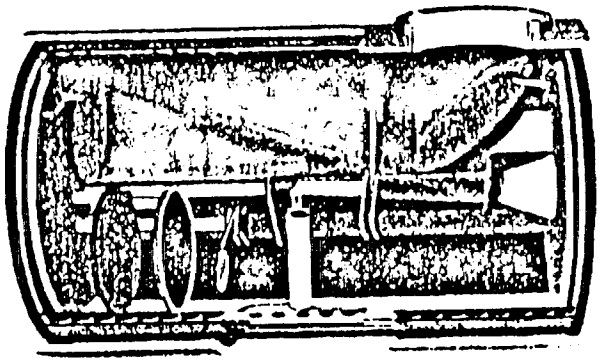


THE ILLUSTRATIONS SHOW THE BASIC OPTICAL CONFIGURATIONS OF THE CALIBRATOR AS FOLLOWS:

A. COLLIMATOR (POINT SOURCE)
B. SCATTER PLATE (DIFFUSE SOURCE) - for spectral calc - although signal.
C. EXTENDED AREA BLACKBODY
D. JONES SOURCE (NEAR, SMALL AREA SOURCE)
E. COLLIMATOR PLUS BACKGROUND

Optical Sources Provided by Multi-function Infrared Calibrators

* Collimator

  Full entrance pupil
  Partial field stop
  Size of point source depends on precision aperture in collimator focal plane

  Typical applications:
    Linearity for large field-of-view detectors
    Spatial domain characterizations
    Direct irradiance responsivity calibration
    Point source flat field

* Jones Source

  Partial entrance pupil
  Full field stop
  Flux throughput depends on precision aperture in calibrator

  Typical applications:
    Linearity for small field-of-view detectors
    Spectral domain characterizations
    Temporal domain characterizations
    Bench-mark (long-term repeatability) characterizations

Optical Sources Provided by Multi-function Infrared Calibrators, cont

* Scatter Source

  Full entrance pupil
  Full field stop
  Flux throughput depends on precision aperture in calibrator
  Flux throughput attenuated by scatter surface

  Typical applications:
    Relative spectral responsivity for spectrometers with large entrance pupils

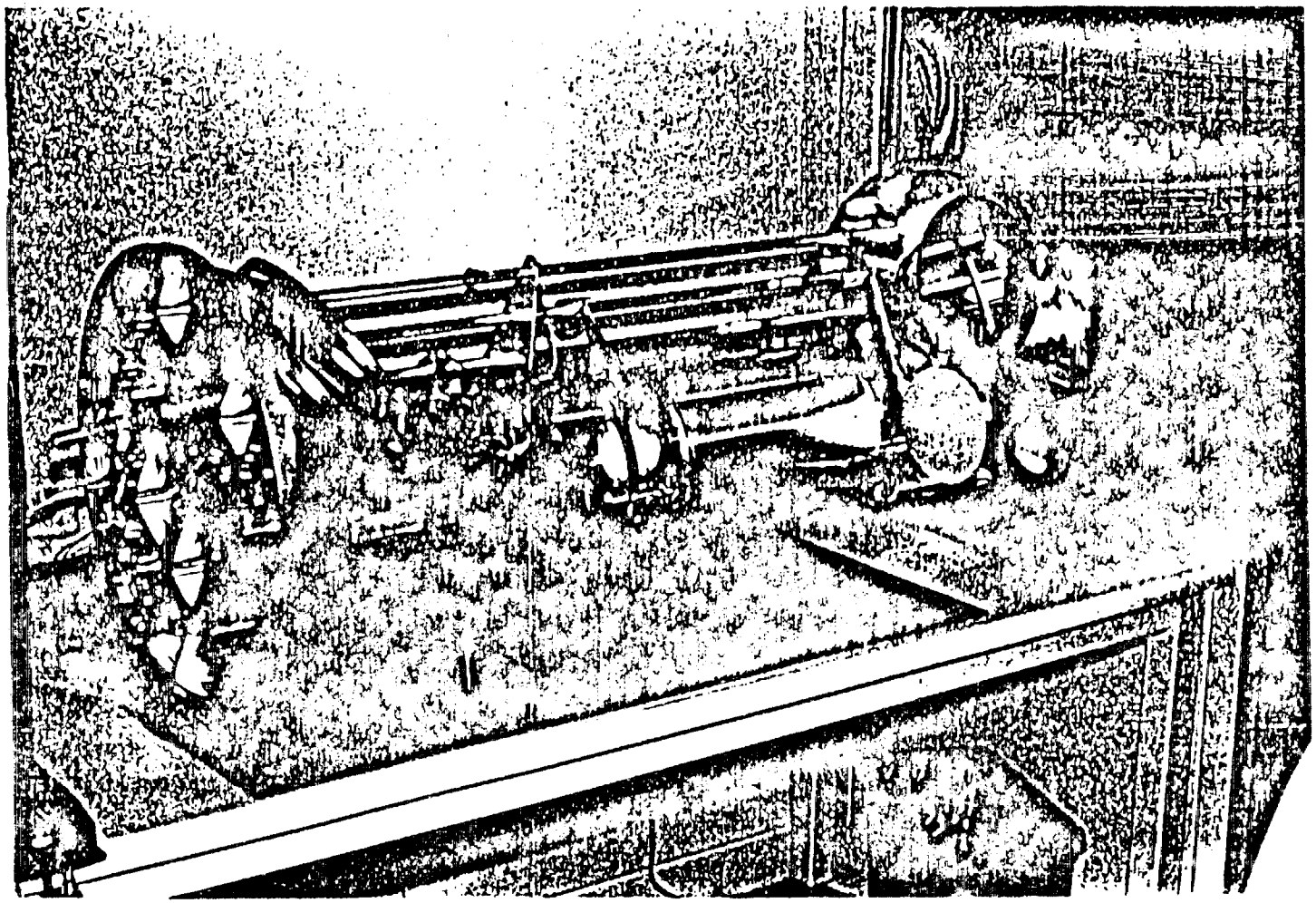
* Extended Source

  Full entrance pupil
  Full field stop

  Typical applications:
    Direct radiance responsivity calibration
    Extended source flat field

* Background Source

  Point source on background source



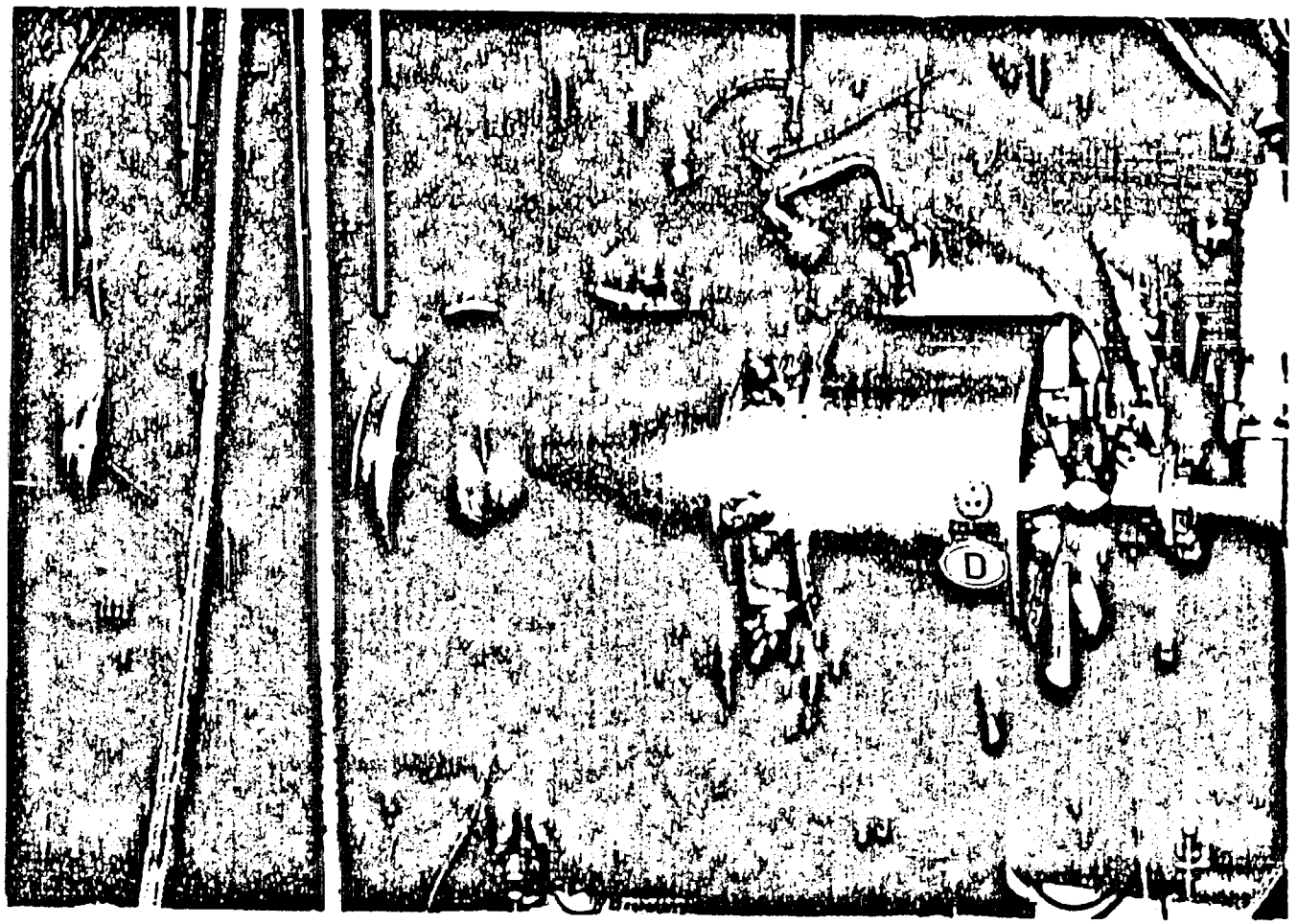
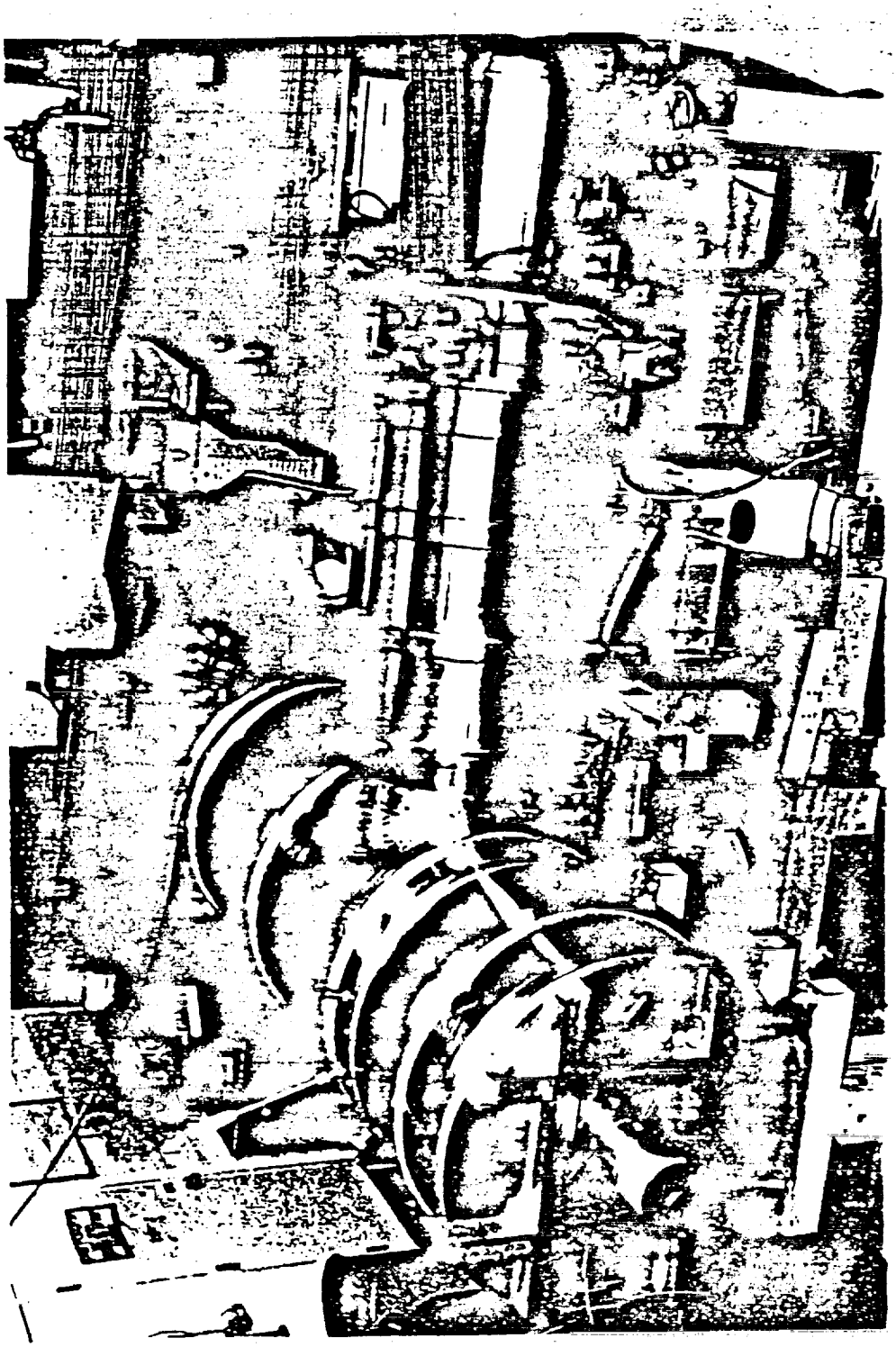


Figure 3 1-2. Photograph of the PCS mounted to the IBSS IR sensor during calibration.



SPIRIT III CALIBRATION CHAMBER

EXTENDED-AREA SOURCE

- 19.5 inch diameter blackbody simulator
- Flux on focal plane is proportional to aperture area
- Fills Full-Field and Full-Aperture of sensor under test
- Temperature Range — 25 Kelvin - 300 Kelvin
- Temperature Uncertainty — ±0.5 Kelvin (NIST traceable PRT)
- Emissivity — 0.99 ±1%

BACKGROUND SOURCE

- Near Small-Area source
- Used with the collimator to provide uniform background illumination with a point source
- **Single aperture**
- **Temperature Range — 20 Kelvin - 300 Kelvin**

EXTERNAL SOURCES for CALIBRATION CHAMBER

BLACKBODY SIMULATORS

• Temperature Ranges	
High Temperature	400 Kelvin - 1200 Kelvin
Low Temperature (Calibrated by NIST)	30 Kelvin - 400 Kelvin
Temperature Uncertainty	1 Kelvin
Emissivity	0.99 ±0.01

SPECTRAL SIMULATORS

• Monochromator	3 - 25 μm
• Absorption cells	Water, Methane, Polystyrene, etc.
• IR Laser	3 μm
• Michelson Interferometer	(5 cm^{-1} resolution)

SPIRIT III CALIBRATION CHAMBER

JONES SOURCE

- Near Small-Area source which illuminates the entire focal plane of the sensor
- Flux on focal plane is proportional to aperture area
- Effective Aperture sizes
  - Area dynamic range — 1024:1
  - Area resolution — 2:1
- Optical Filters
  - (Neutral Density) — 10%, 1%, & 0.1% Transmission
  - (Spectral) — 16 positions available

SCATTER SOURCE

- Fills Full-Field and Full-Aperture of sensor under test
- Flux on focal plane Is proportional to aperture area
- Apertures
  - Area dynamic range — 1024:1
  - Area resolution — 2:1
- Optical Filters — (Same as Jones Source

SPIRIT III CALIBRATION CHAMBER
(MIC3)

EXIT BEAM

• Geometry	17.5 inch circular
• Positioning:	
Full-Scale Two-dimensional travel	10 degrees (174 mrad)
Settability	4.1 μrad
Accuracy	±20.5 μrad

COLLIMATOR

• Focal Length	300 inches
• Apertures (11)	26.4 μrad - 0.833 mrad
Area dynamic range	1024:1
Area resolution	2:1
• MTF reticles and/or Scene Simulators (at focal plane of collimator)	11 positions available
• Optical Filters	
(Neutral Density)	10%, 1%, & 0.1% Transmission
(Spectral)	16 positions available

CONCEPT OF ASTER CALIBRATION REQUIREMENT

PRESENTED AT

5TH CAL/VAL PANEL MEETING

APRIL 7 TO 10, 1992

BOULDER, COLORADO

A. ONO

NATIONAL RESEARCH LABORATORY OF METROLOGY, MITI