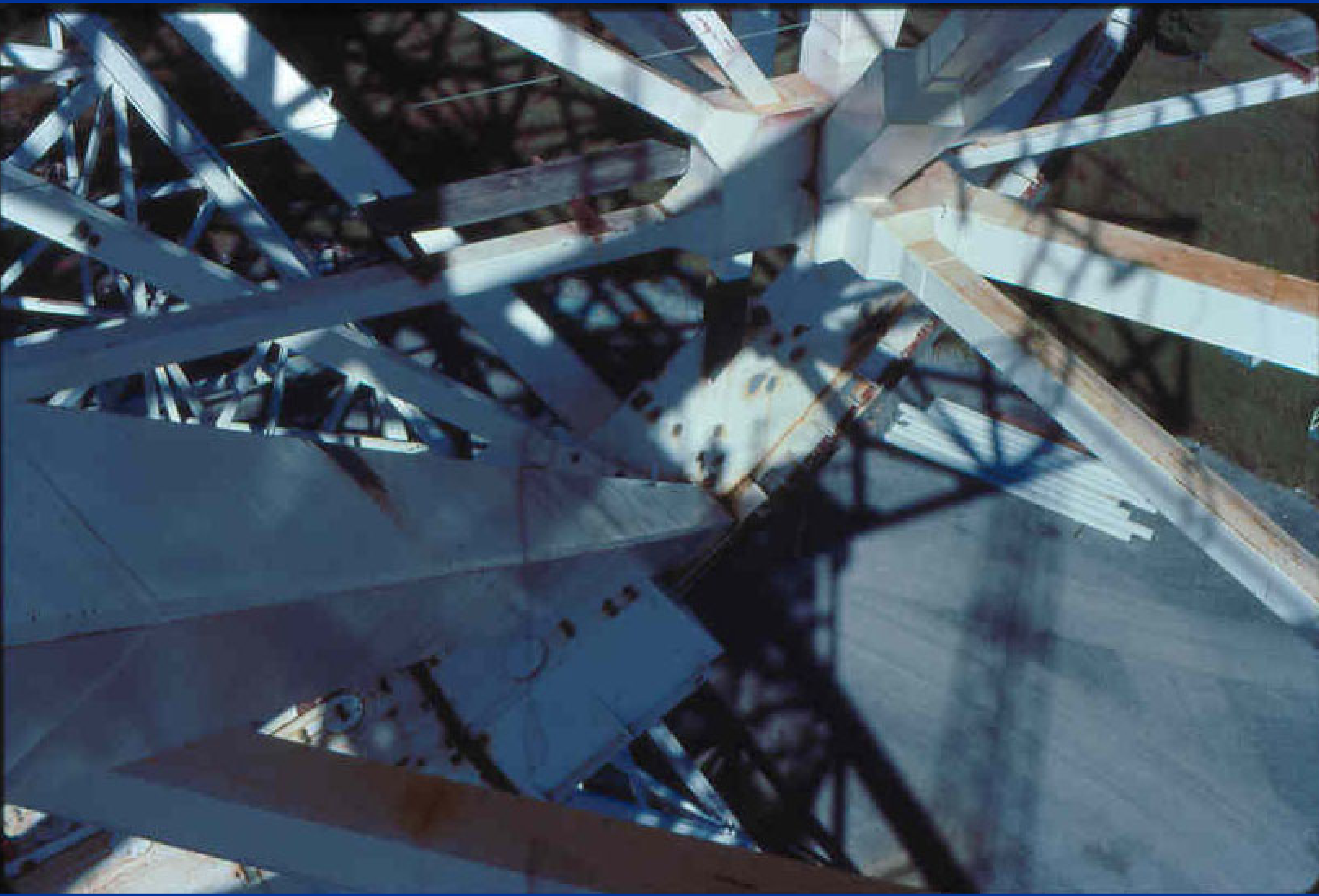
DRAFT

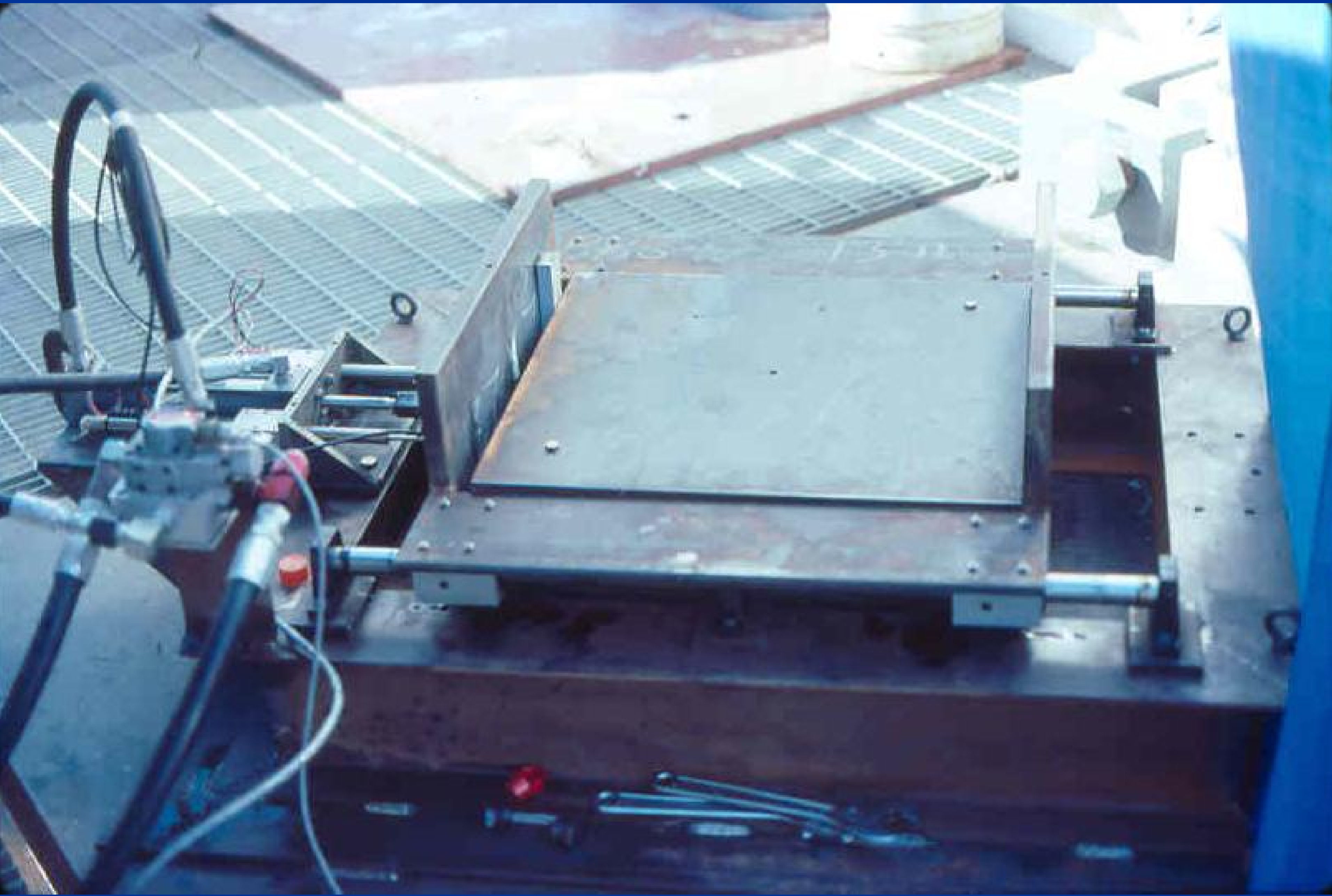
John Payne

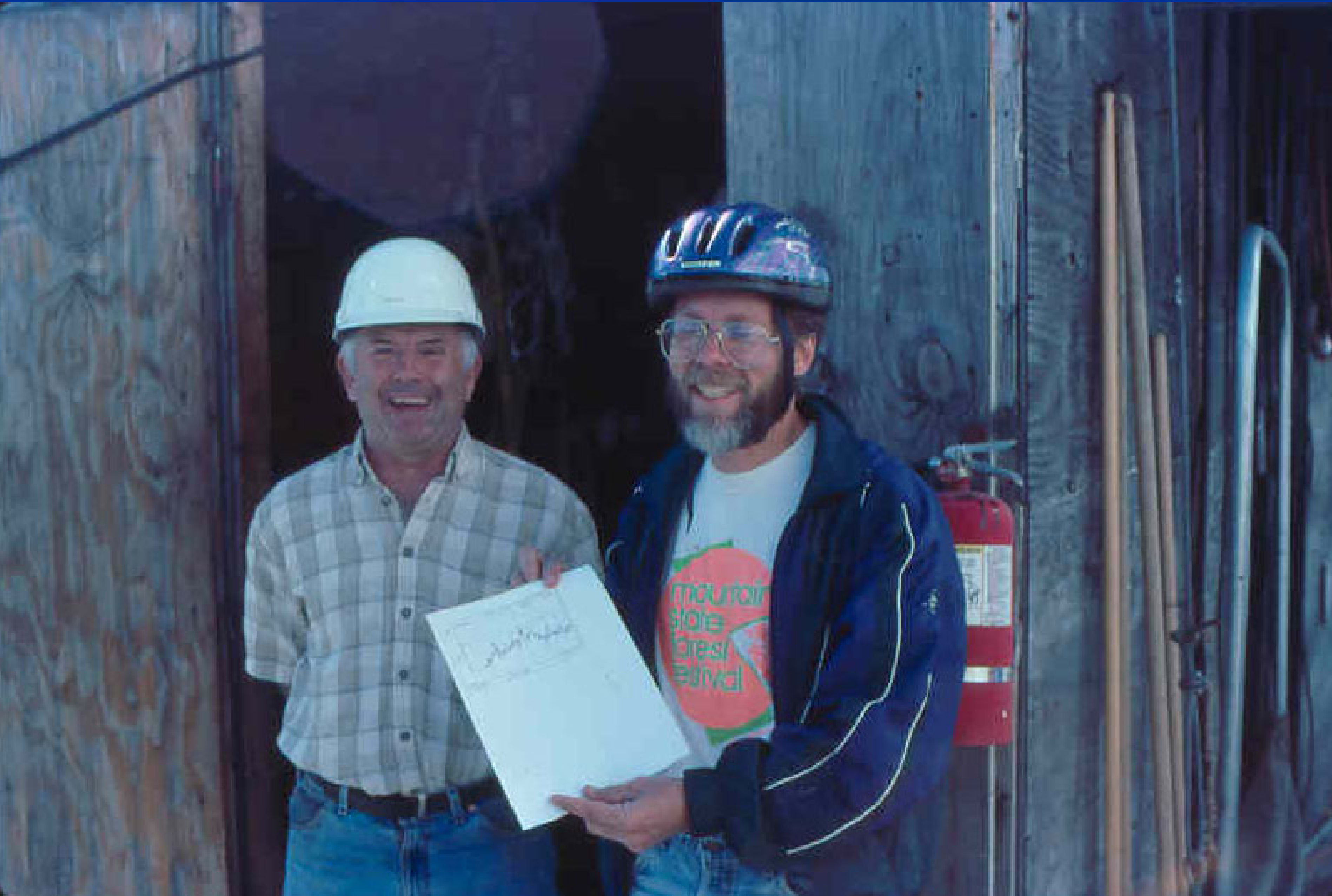
A tribute to the
GBT experimental work

10/26/2006

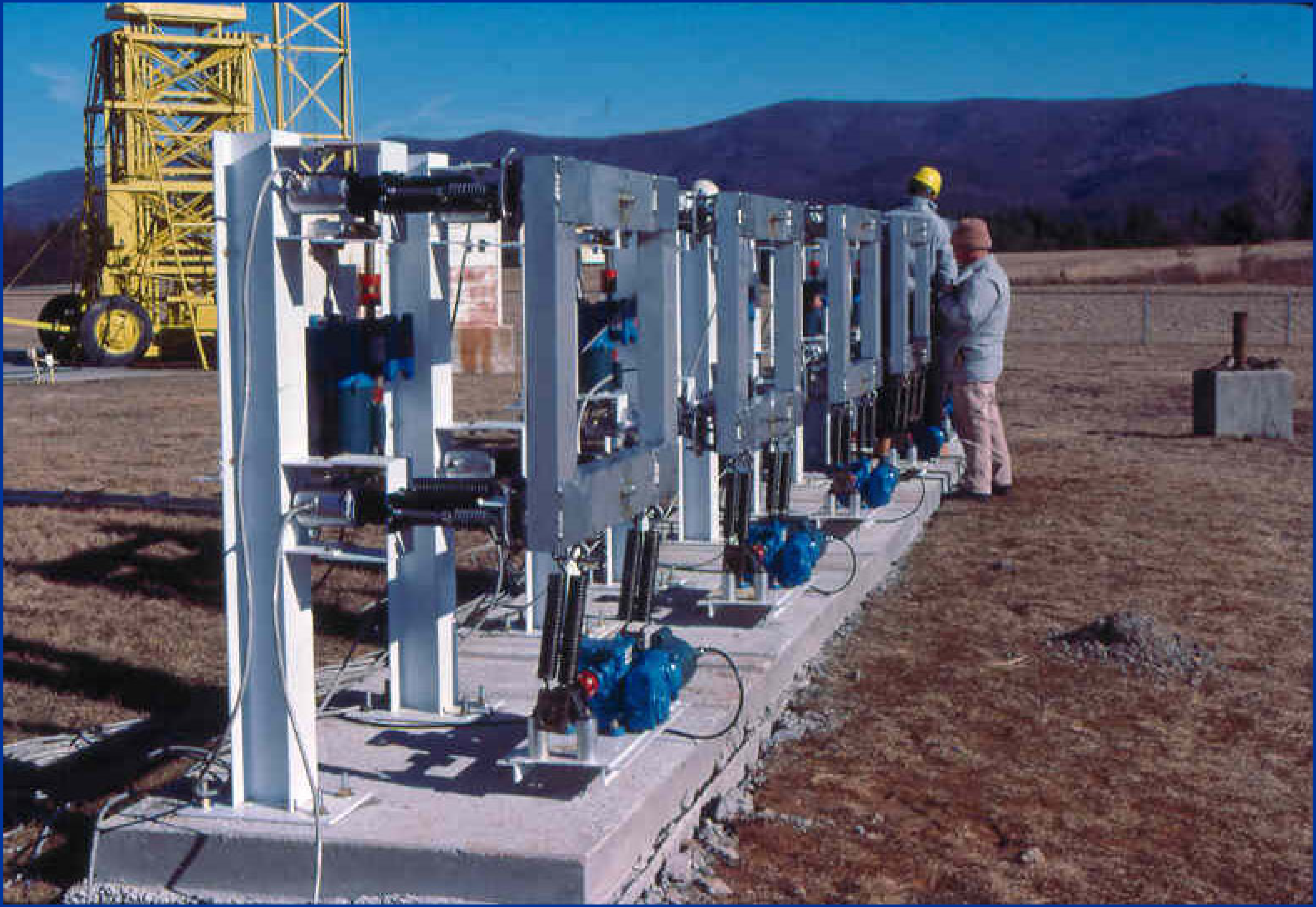
GBT NATURAL FREQUENCY

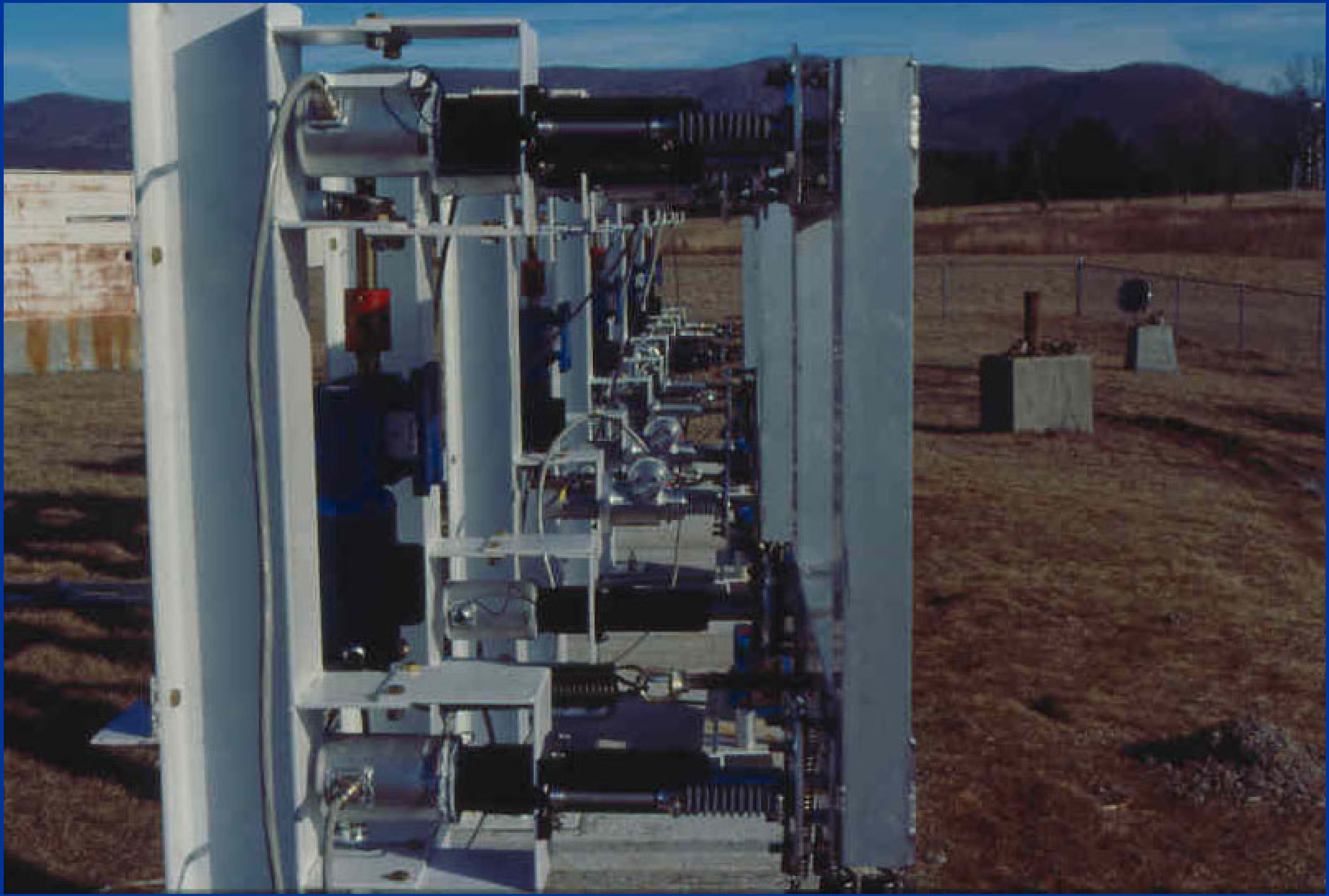






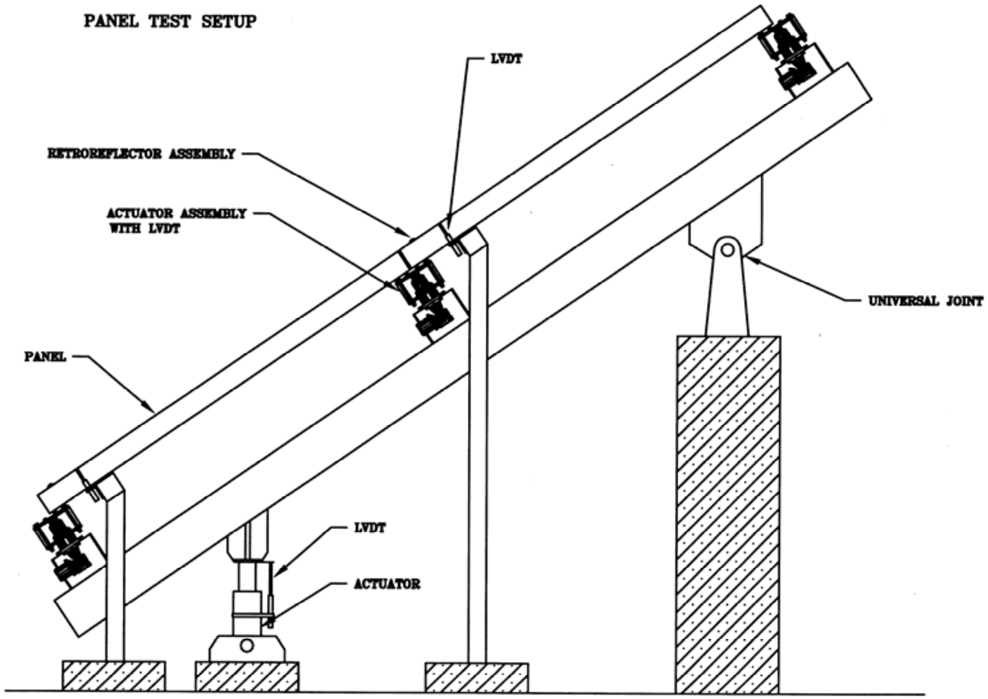
ACTUATORS





PANELS

PANEL TEST SETUP



AS005 FILE: ACTIVE SURFACE
KEYS: PANEL SETTING

NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

MEMORANDUM August 26, 1992

To: Bob Hall, Lee King
From: J. Payne, D. Parker
Subj: Setting the panels on the GBT

Introduction

The initial setting of the panels on the GBT will consist of setting the panel to panel heights at each actuator. In order to avoid repeated setting of the surface, it is highly desirable that this setting be done just once, with sufficient precision for high frequency operation of the GBT. Due to the fact that we are using the same mold for several tiers of panels, panel edges along a radius will be offset by up to 200 microns. In order not to degrade the overall surface precision, this initial panel to panel setting should be accurate to around 25 microns. In this note we describe a suitable instrument for measuring and recording the relative panel heights at each actuator.

The Instrument

A sketch of the proposed tool is shown in Figure 1.

A shaft, screwed onto the actuator, provides a reference for a jig that slides over the shaft. A step in the shaft permits location of the jig. A tapered shaft (in the manner of a screwdriver blade) fits between the panel gaps in order to locate the jig in rotation around the shaft. Four electronic dial indicators mounted to the jig make contact with the reference points on the panel. A suitable indicator is a Mitutoyo 534-182-1 (data sheet attached). This indicator has a range of 12.7 mm, a resolution of 1 micron, a visible display and an SPC output. The indicator is battery powered, with a battery life of 500 hours. Assuming a separation between the indicators of approximately 15 cm, the angle of the actuator extension shaft with respect to the surface tangent needs to be known to an accuracy of around one arc minute to limit errors in setting to less than 25 microns. Gravity is a convenient reference to use here. In the radial direction, the angle of the surface tangent with respect to gravity is known for each actuator position. In the circumferencial direction, horizontal is a convenient reference plane.

The accuracy required of the tilt measurement (better than 1 arc minute) precludes the use of a large dynamic range "digital protractor". A suitable inclinometer is manufactured by Schaevitz, a LSRP-14.5, which has a range of ± 14.5 degrees. A series of wedges will be needed to maintain the radial inclinometer within its range for the outer parts of the reflector. This simple option has been chosen over a servo controlled platform which, while more elegant, would be more bulky and complex.

A block diagram illustrating the various components is shown in figure 2. All components are battery operated, and a data sheet on a typical hand-held computer is attached. A convenient (but certainly not necessary) means of identifying each actuator would be a bar code transfer on the reflector surface. The operator would read the bar code after installing the tool. The correct actuator tilts would be stored in the computer, along with the correct digimatic indicator readings. Corrections to these readings would then be computed on the basis of the tilt deviations. A reading for "adjustment screw #1" could then be displayed on the screen. The operator would adjust #1 until the reading is zero and move on to #2. After the setting process is complete, all four digimatic readings are stored, along with the tilt readings to be recovered later in a lab-based PC. It should be noted that with this procedure not only are the panels set with high precision with respect to one another, but the relationship between the corner cube (when installed) and the panels is now known to a high precision. This, theoretically at least, permits the setting of the surface using the laser rangefinders.

One issue that needs to be settled is the deformations resulting from the weight of the operator(s) in the vicinity of the actuator. We can include a "strobe" option that will permit the operator to stand some distance away and remotely initiate readings.

Cost of Tool

Four digimatic indicators ($350 each)		1400
One inclinometer stack		2400
One hand held computer		1700
One digital/analog interface		500
Miscellaneous		1000
	Total	$7000

We are proceeding with construction of such a tool, and it should be finished in 2 months.

JP/ss

cc: F. Crews
M. Barkley
D. Hogg
J. Lockman

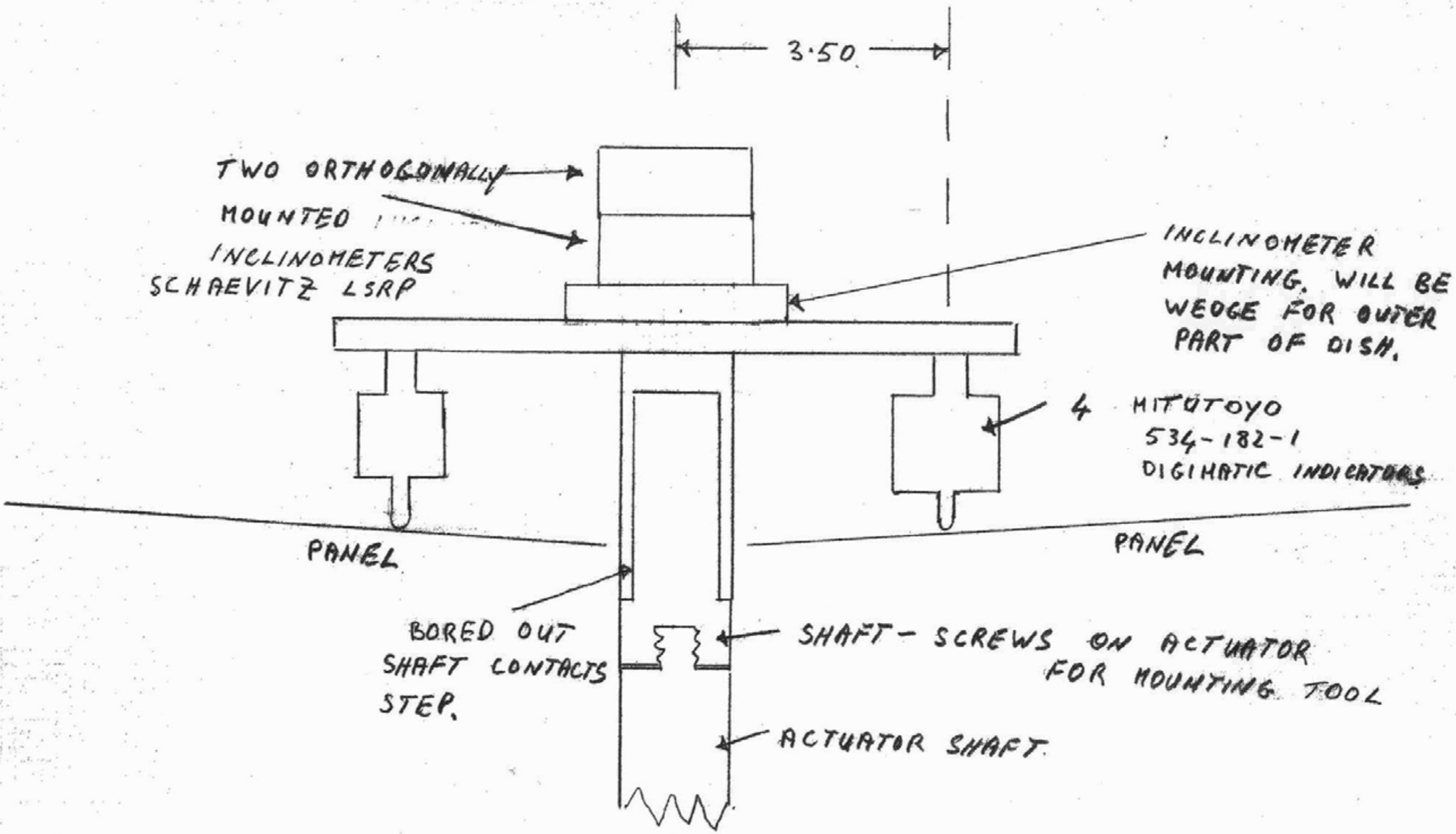


FIG 1 - SKETCH OF TOOL - SIDE VIEW.

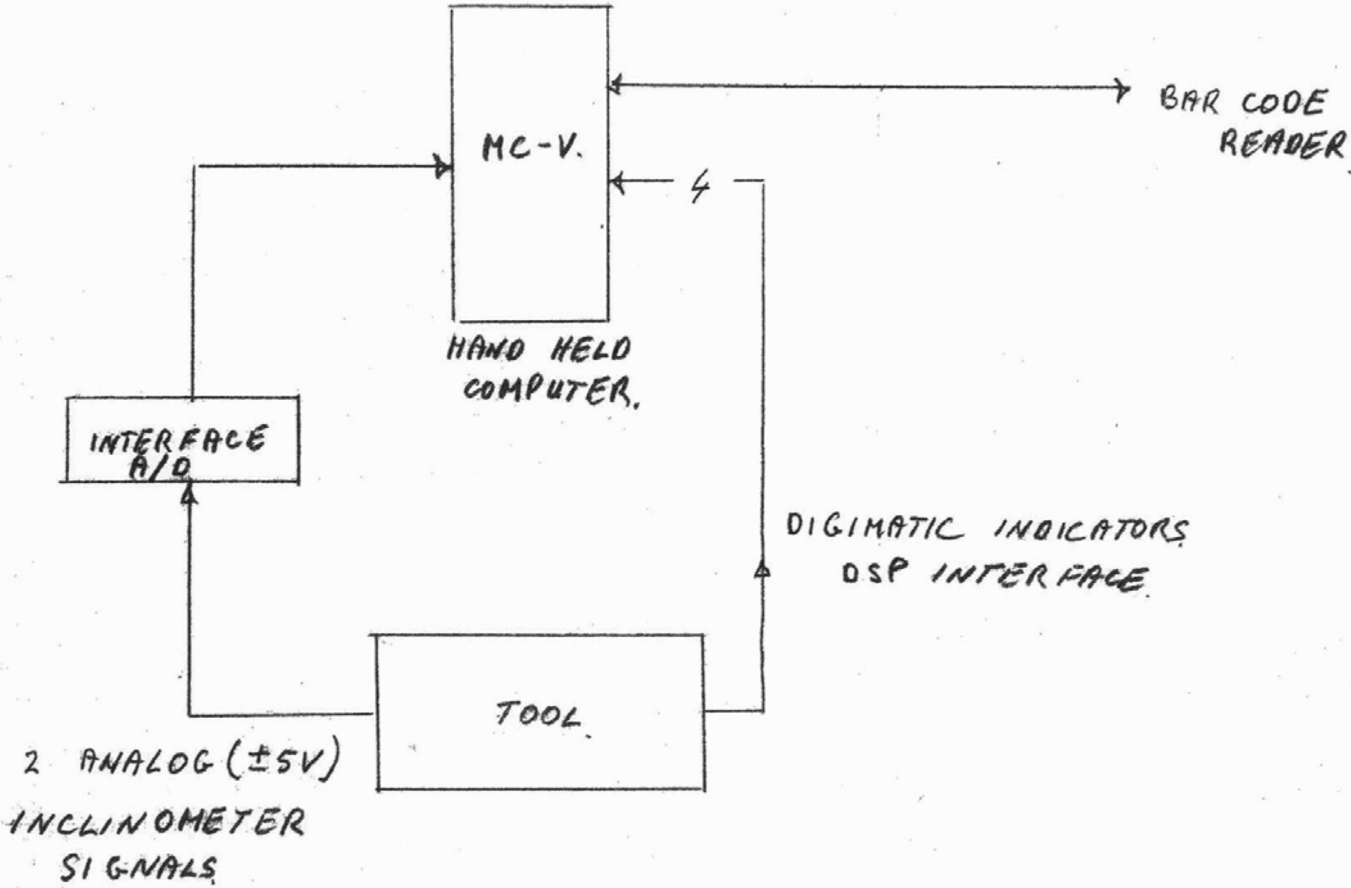
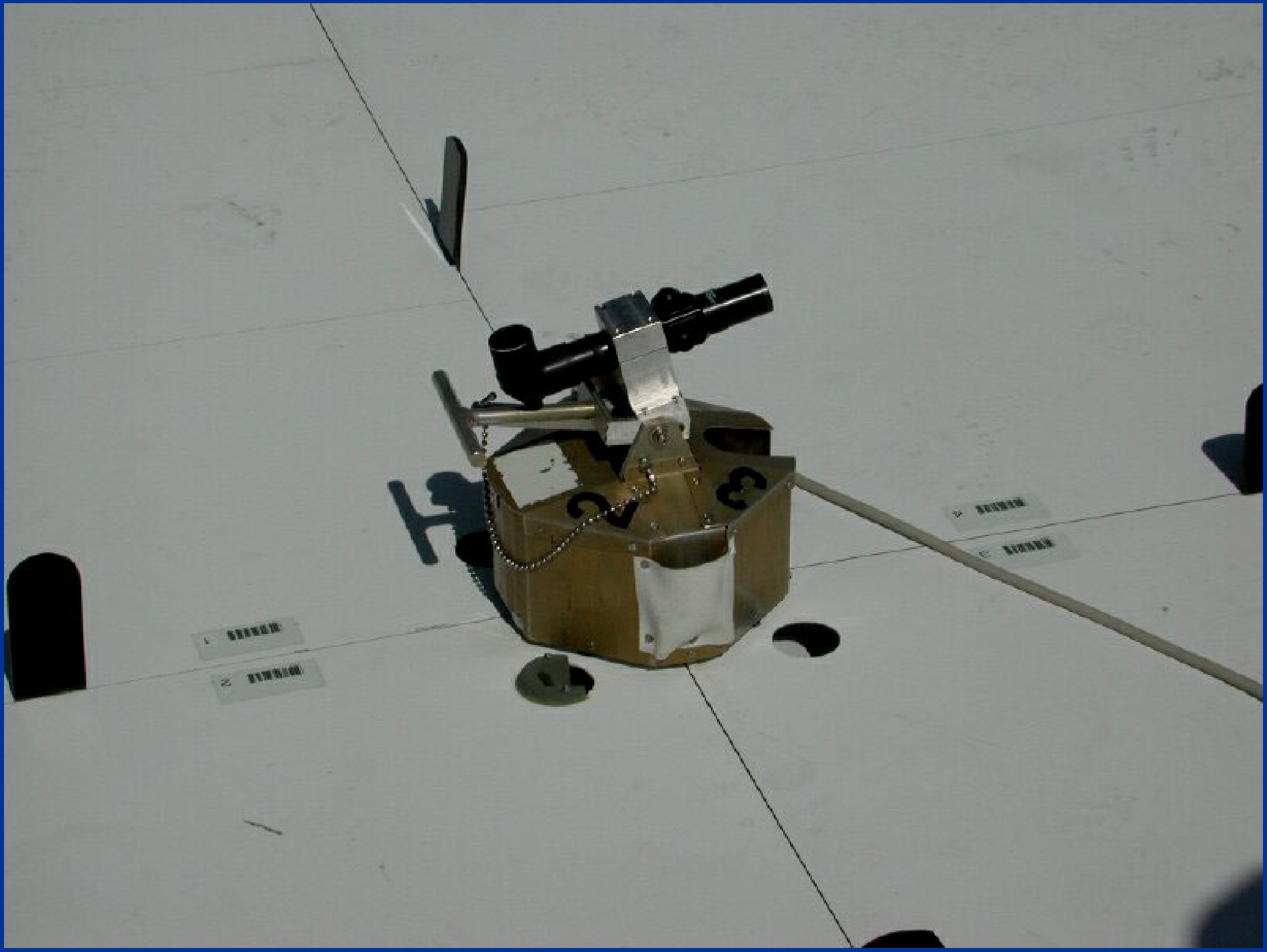


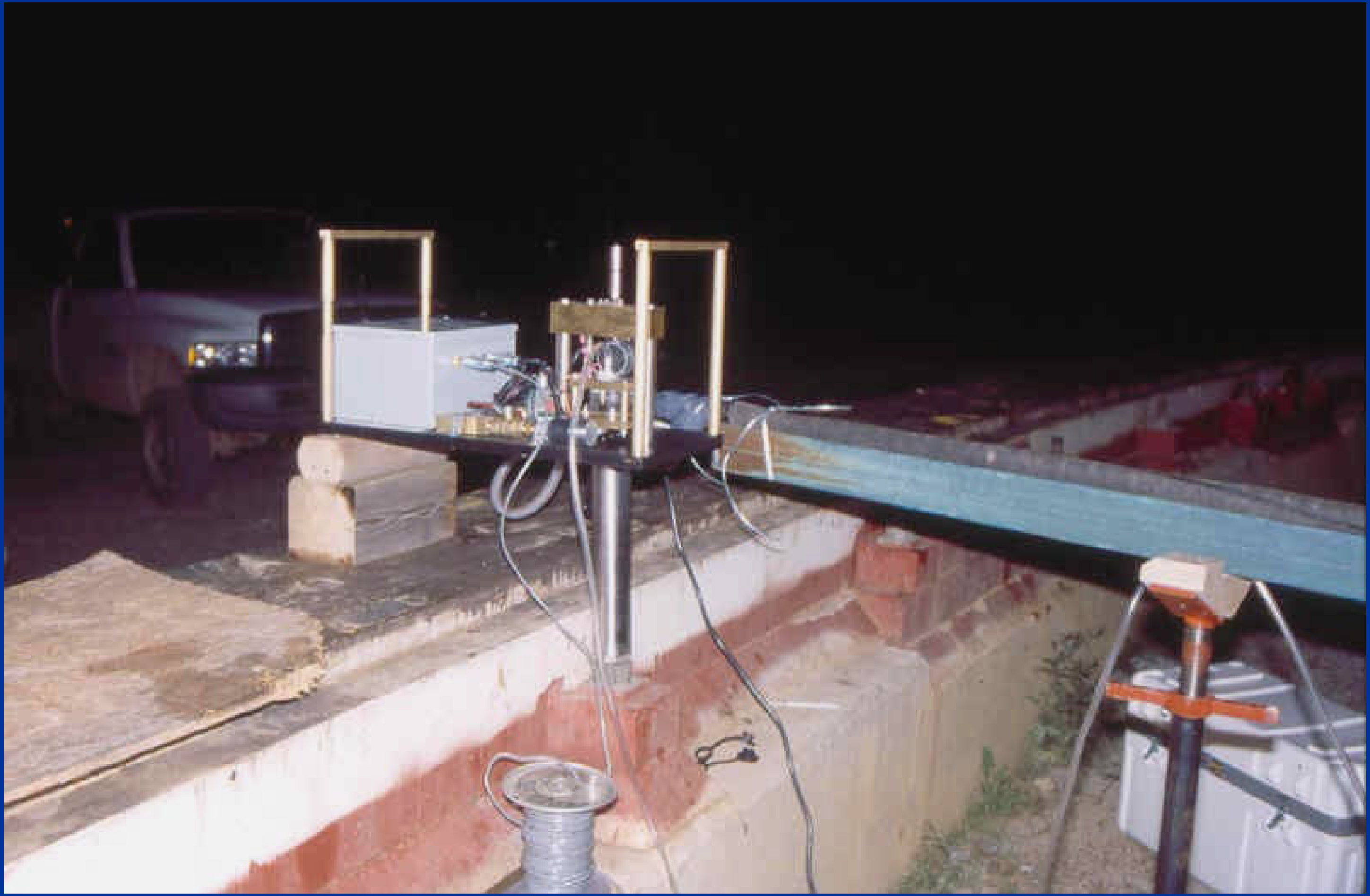
FIG. 2 INTERCONNECTIONS


A=
B=
C=
D=
B
A




Corner Setting Mid-Range Results
Frequency
600
500
400
300
200
100
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Inches * 0.001

HYDROSTATIC LEVEL



140 FOOT EXPERIMENT

DERICK DEFLECTION

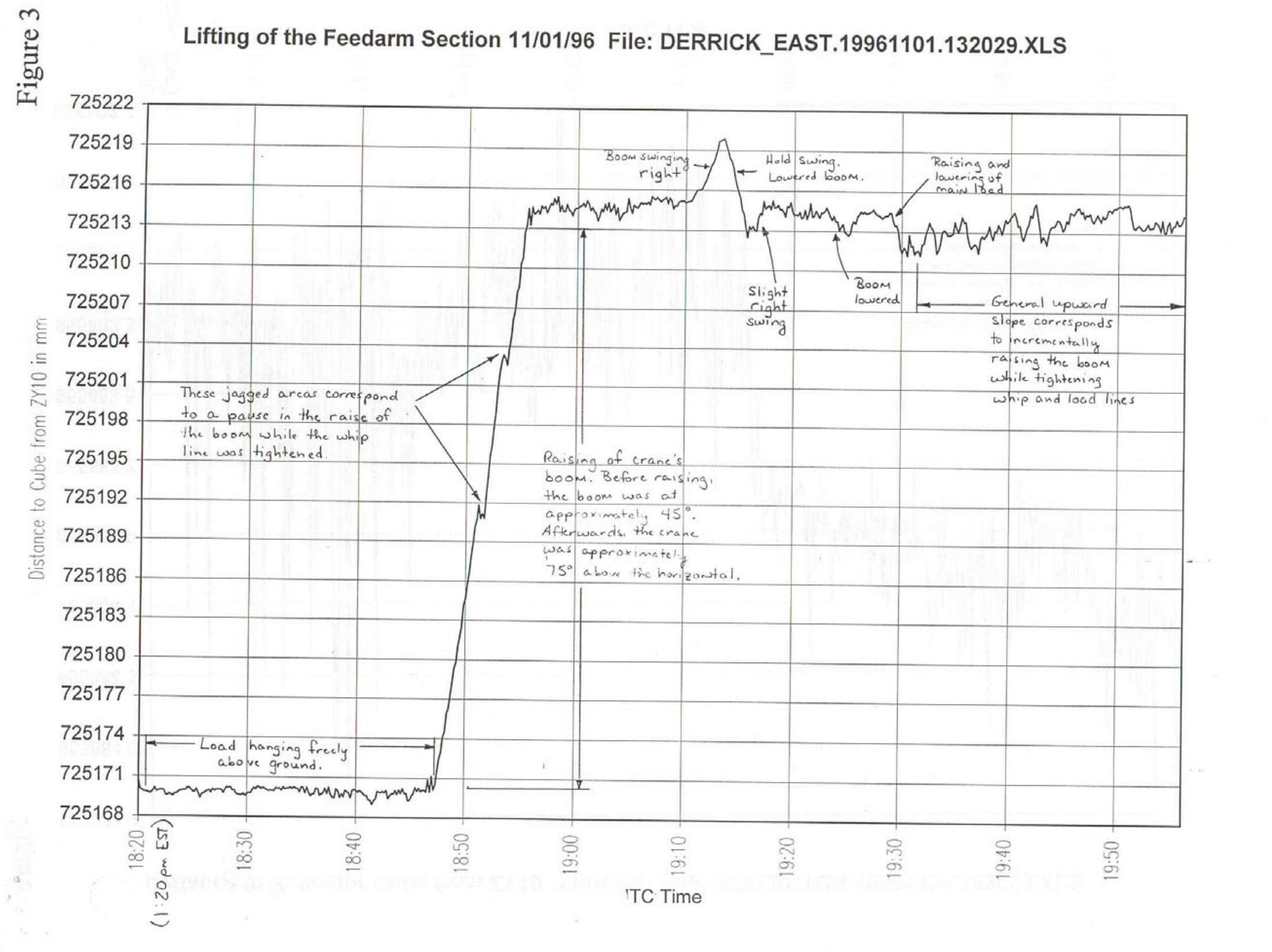
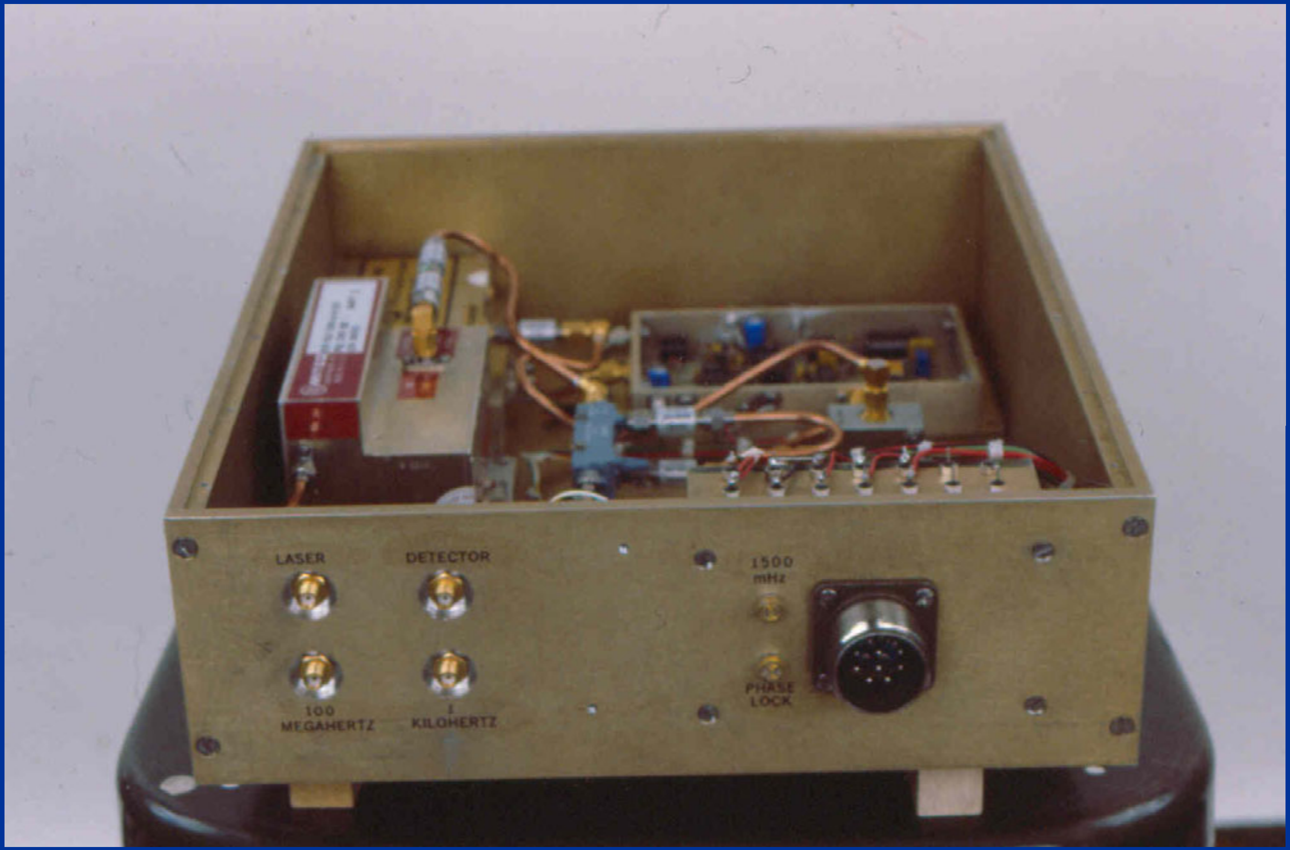
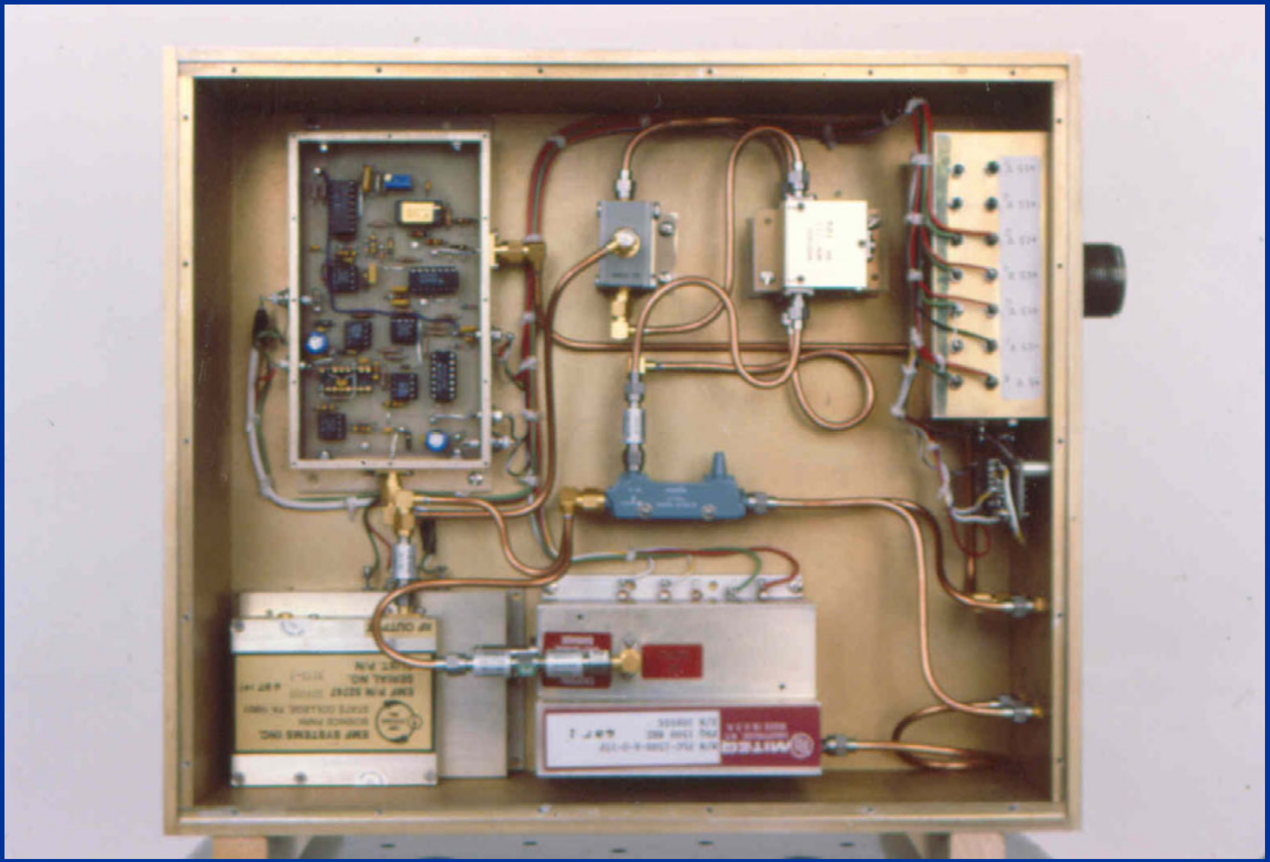


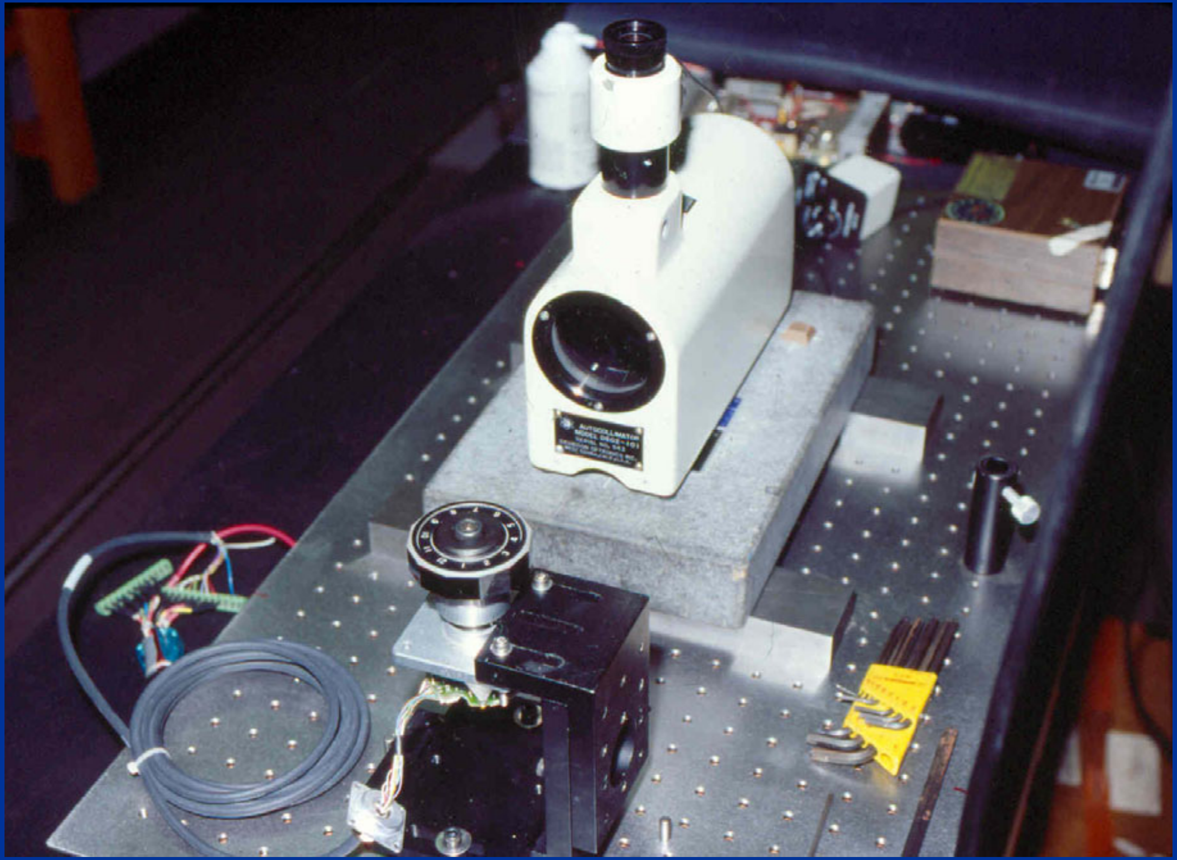
Figure 3
Lifting of the Feedarm Section 11/01/96 File: DERRICK_EAST.19961101.132029.XLS
Distance to Cube from ZY10 in mm
UTC Time
725222
725219
725216
725213
725210
725207
725204
725201
725198
725195
725192
725189
725186
725183
725180
725177
725174
725171
725168
18:20
(1:20pm EST)
18:30
18:40
18:50
19:00
19:10
19:20
19:30
19:40
19:50
Boom swinging right
Hold swing. Lowered boom.
Raising and lowering of main load
Slight right swing
Boom lowered
General upward slope corresponds to incrementally raising the boom while tightening whip and load lines
These jagged areas correspond to a pause in the raise of the boom while the whip line was tightened
Raising of crane's boom. Before raising, the boom was at approximately 45°. Afterwards, the crane was approximately 75° above the horizontal.
Load hanging freely above ground.

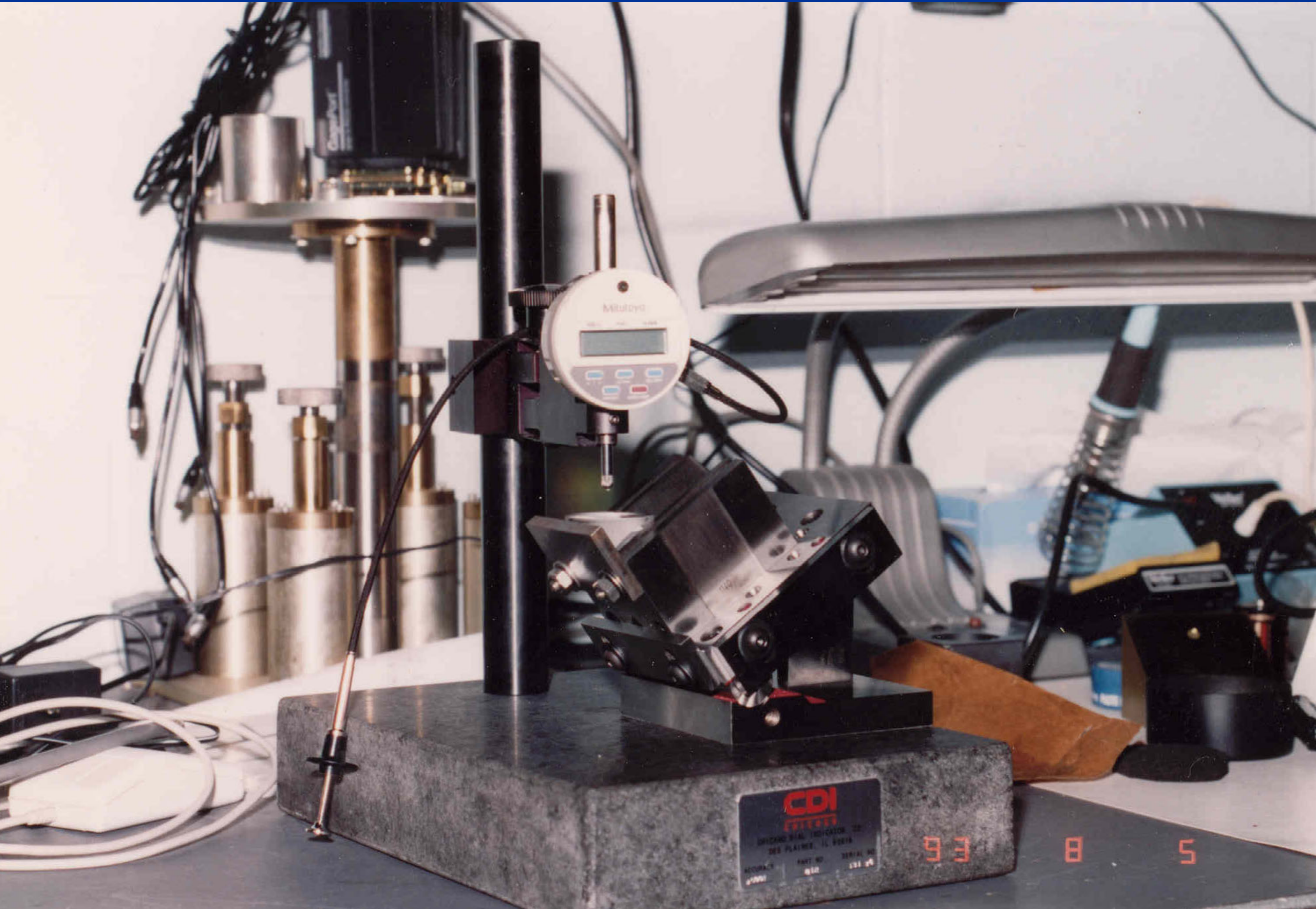
OSCILLATORS

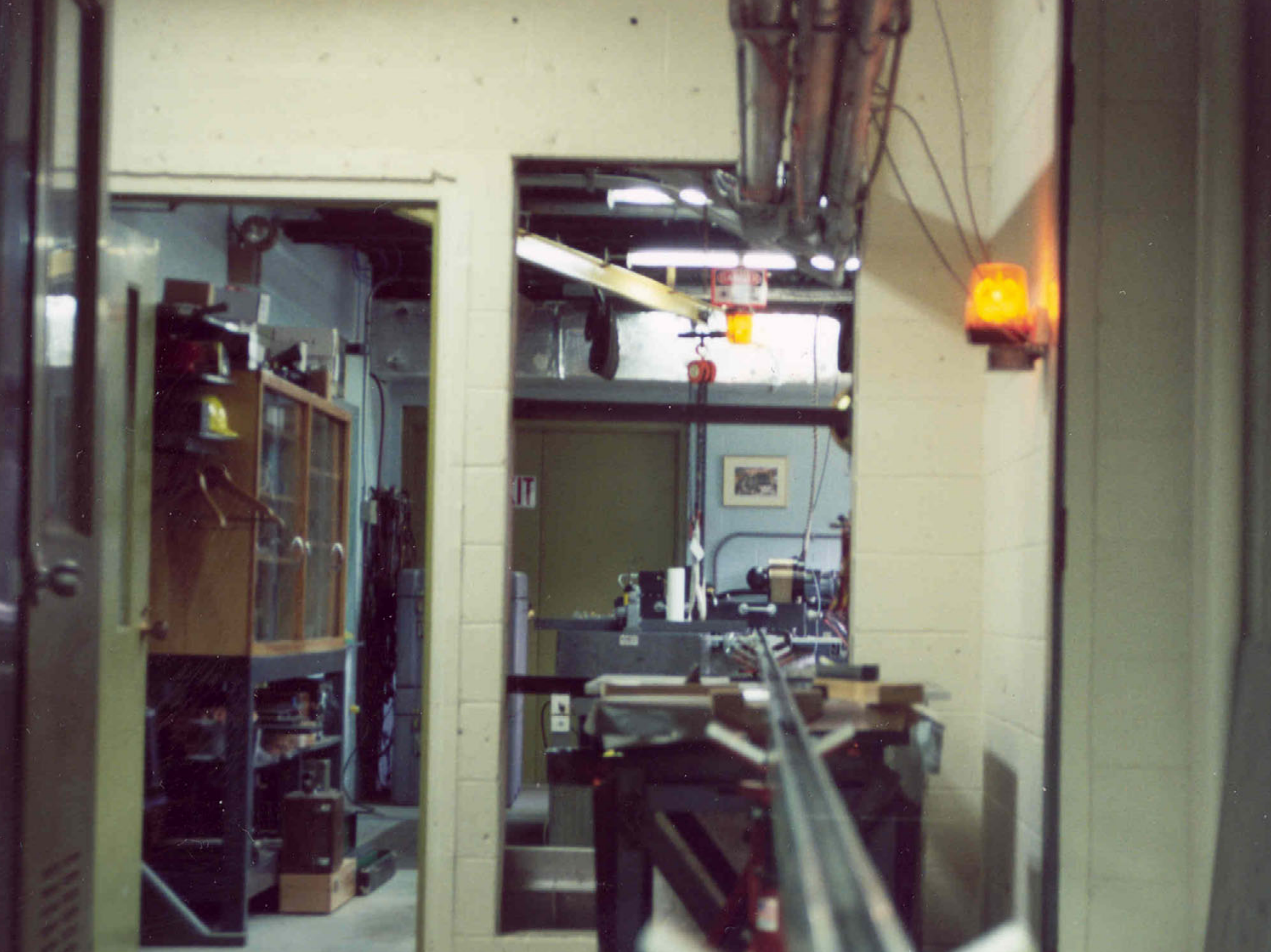

LASER
DETECTOR
100
MEGAHERTZ
1
KILOHERTZ
1500
mHz
PHASE
LOCK

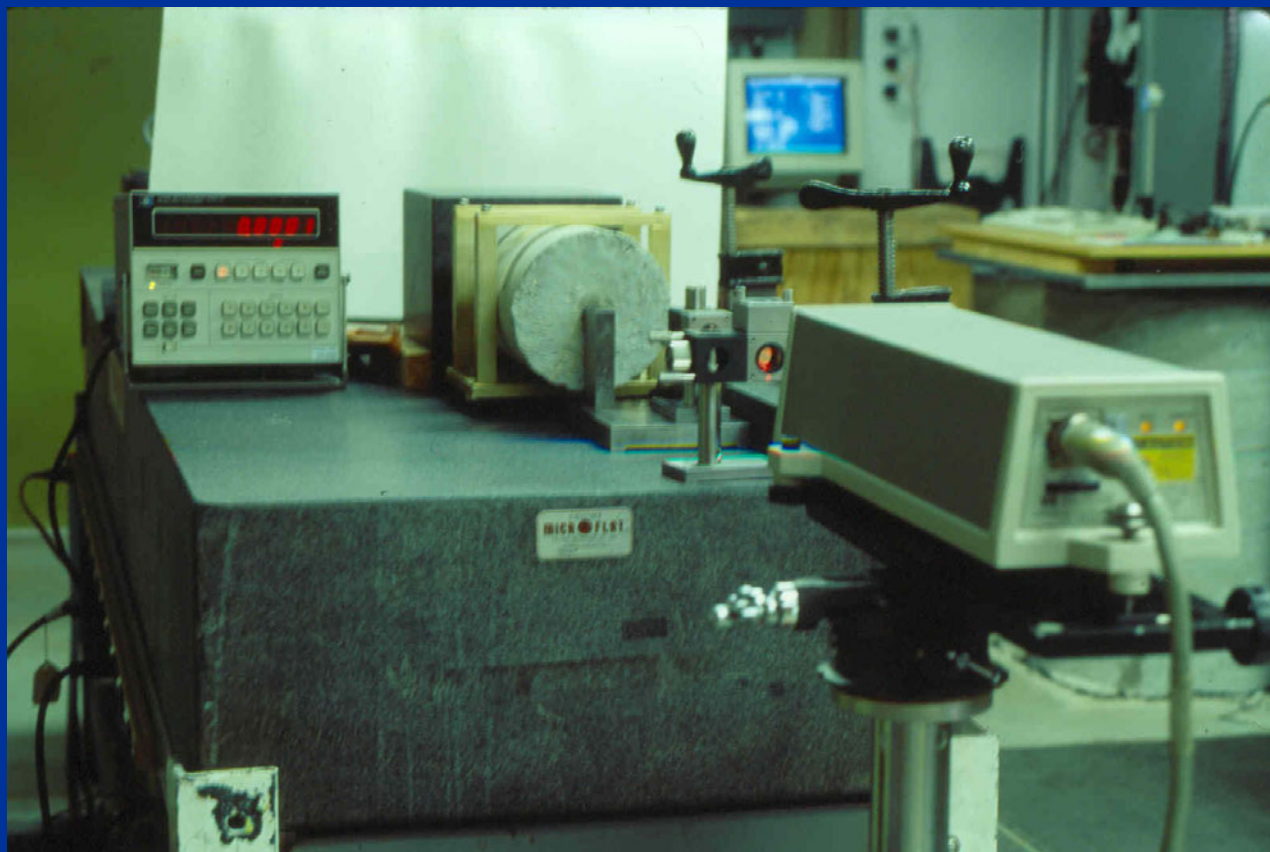


METROLOGY LAB


AUTOCOLLIMATOR

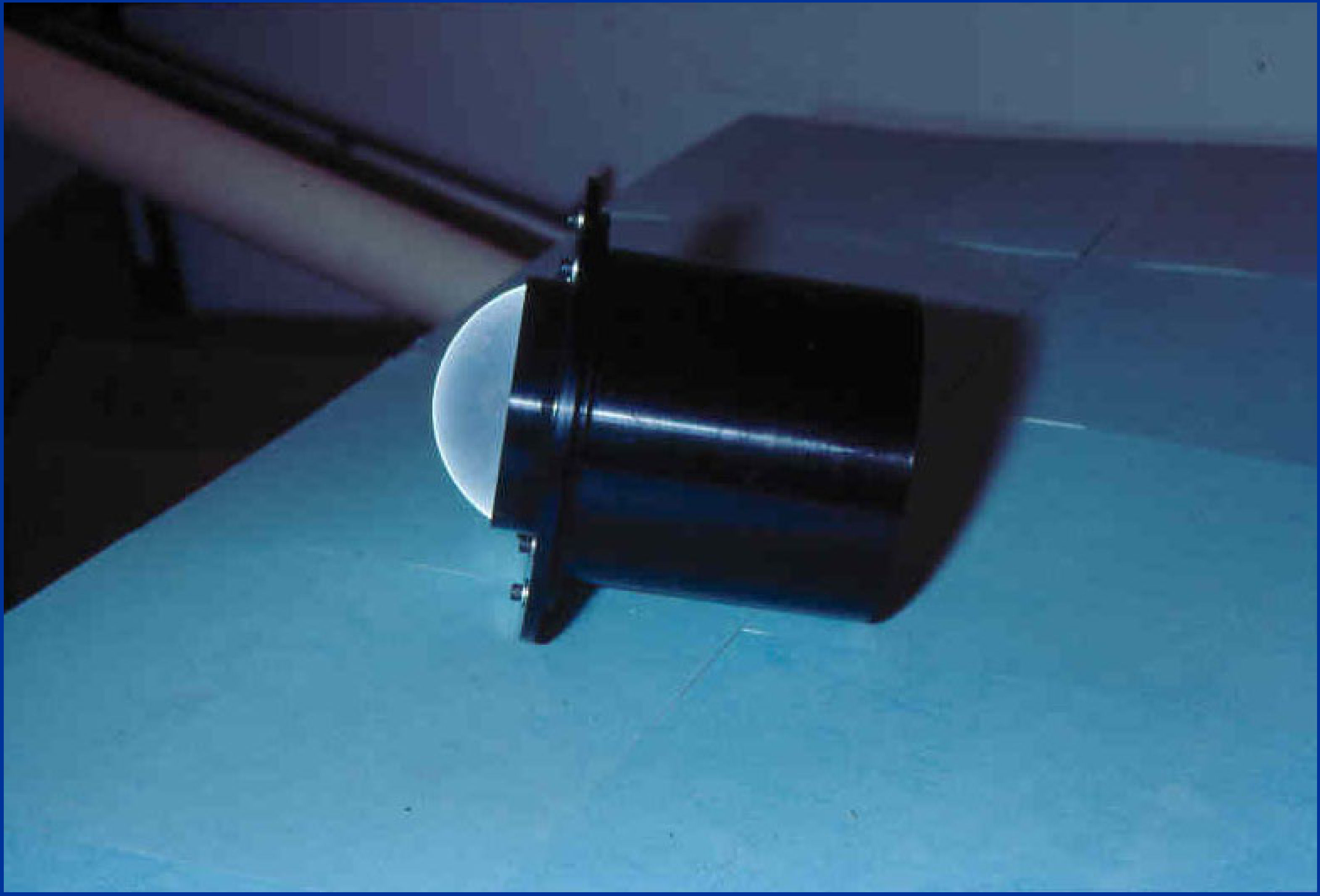

Mitutoyo
CDI
93 8 5





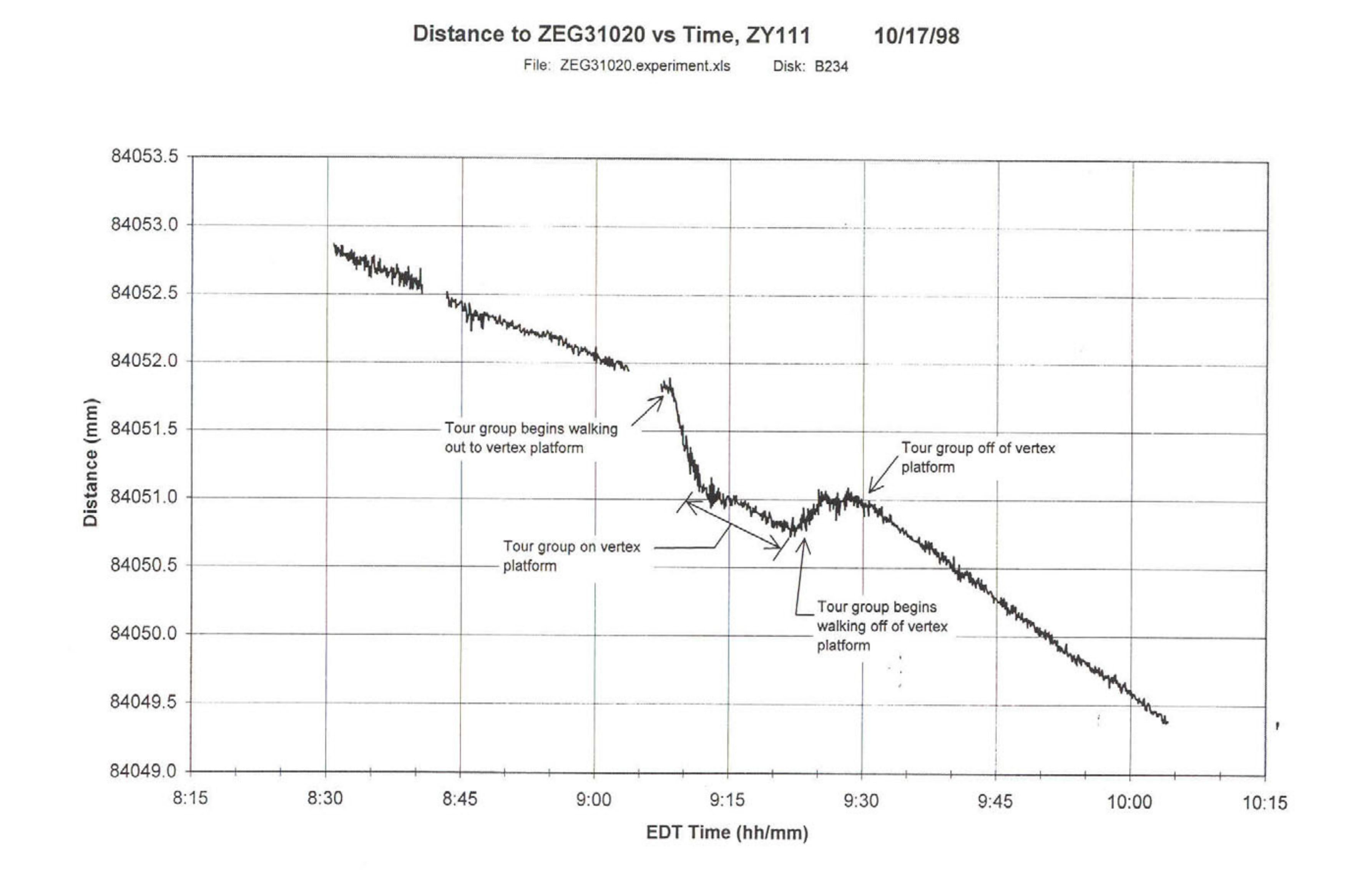
GeoSAR

RETROREFLECTORS



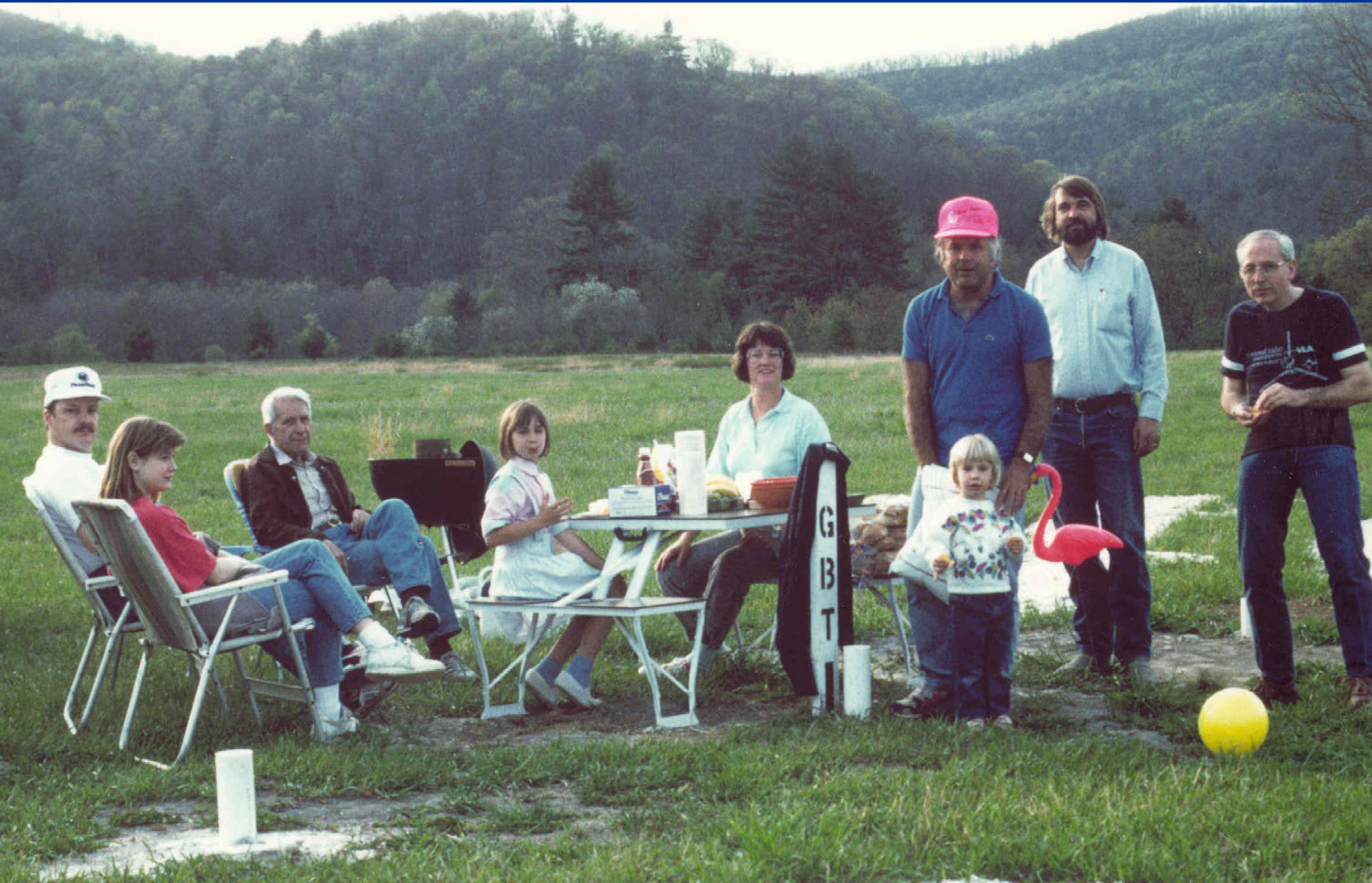
AUTOCOLLIMATOR

HORIZONTAL FEED ARM DEFLECTION BY ADVISORY COMMITTEE

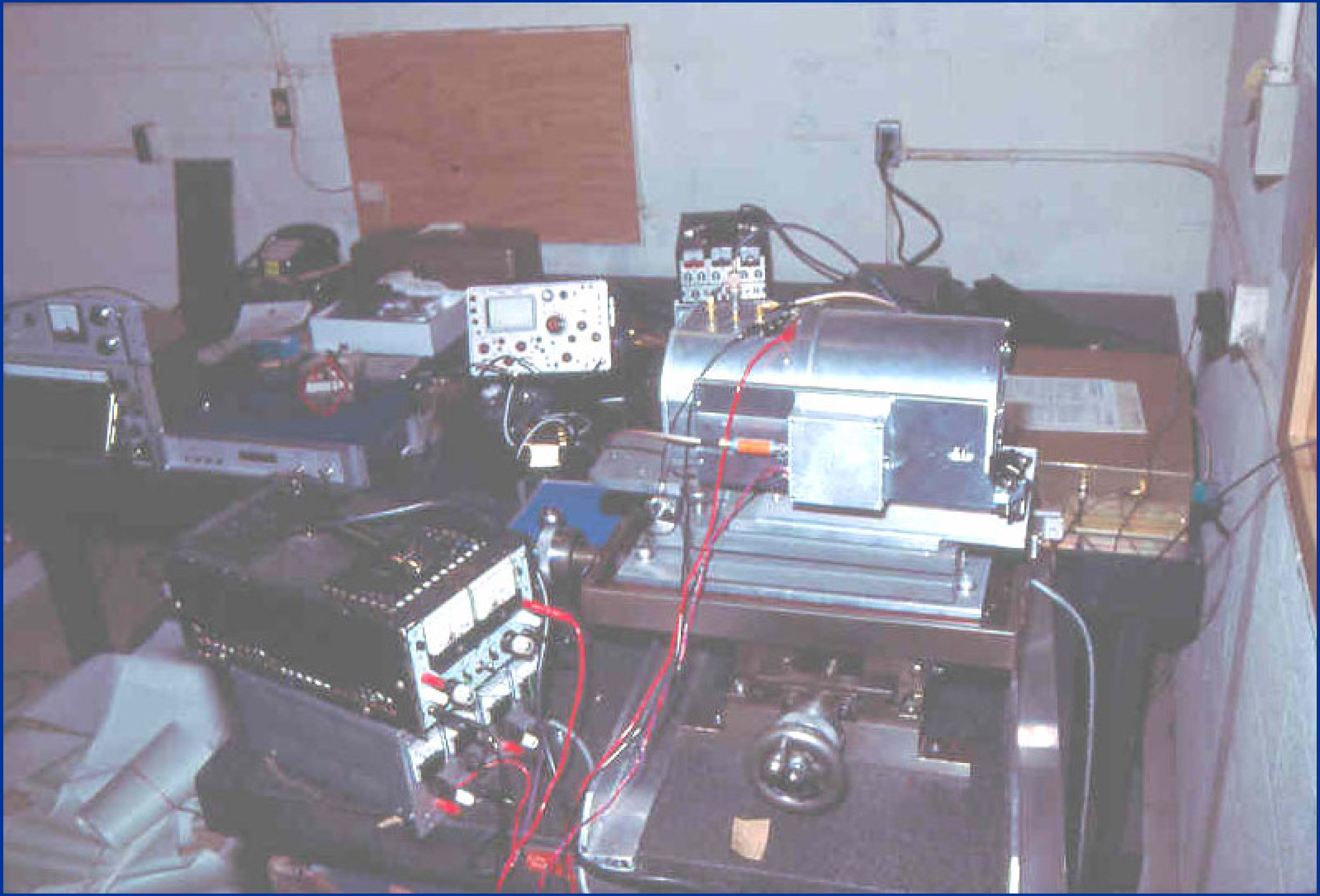


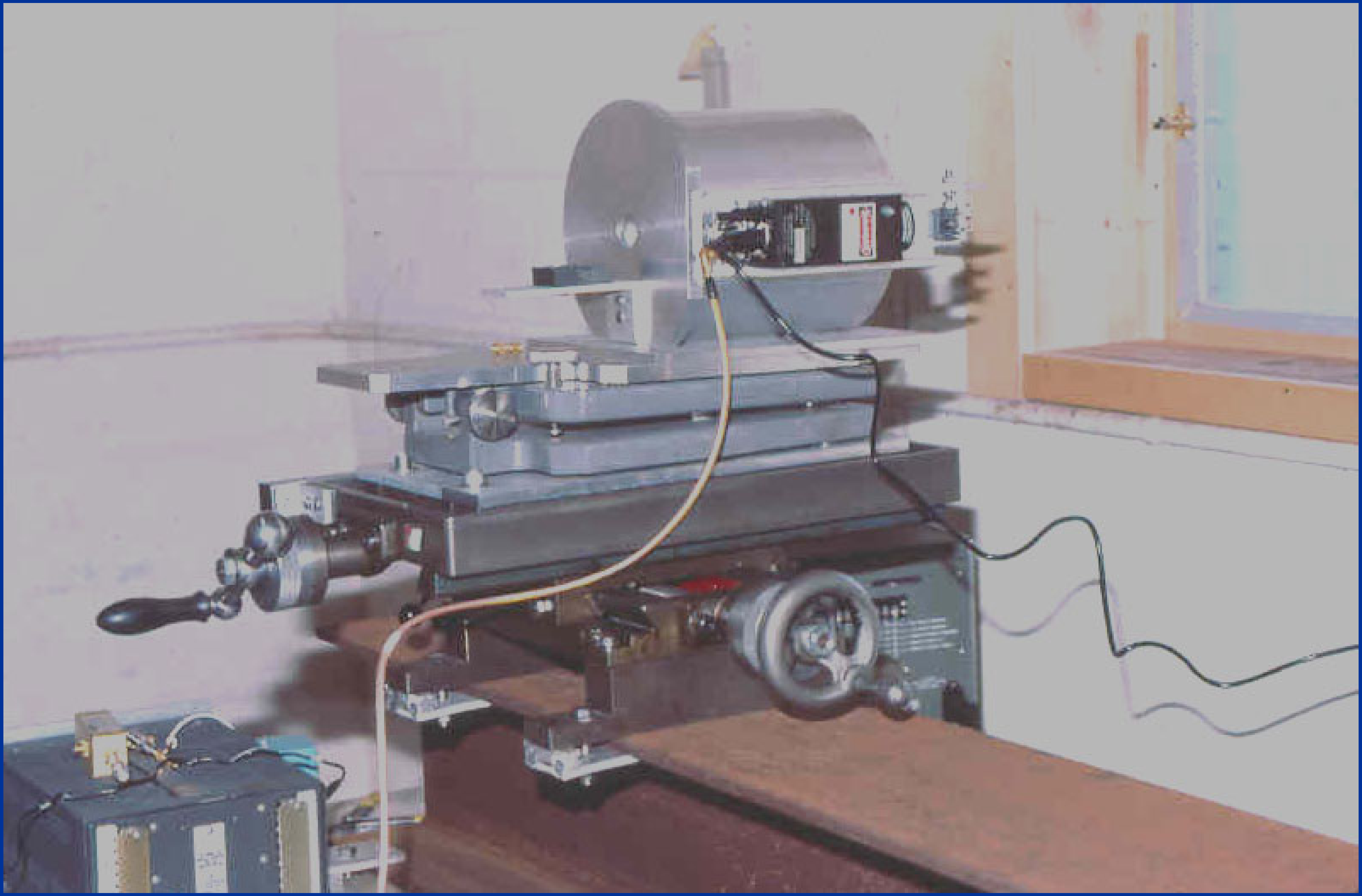
Distance to ZEG31020 vs Time, ZY111 10/17/98
File: ZEG31020.experiment.xls Disk: B234
Distance (mm)
84053.5
84053.0
84052.5
84052.0
84051.5
84051.0
84050.5
84050.0
84049.5
84049.0
8:15
8:30
8:45
9:00
9:15
9:30
9:45
10:00
10:15
EDT Time (hh/mm)
Tour group begins walking out to vertex platform
Tour group on vertex platform
Tour group off of vertex platform
Tour group begins walking off of vertex platform

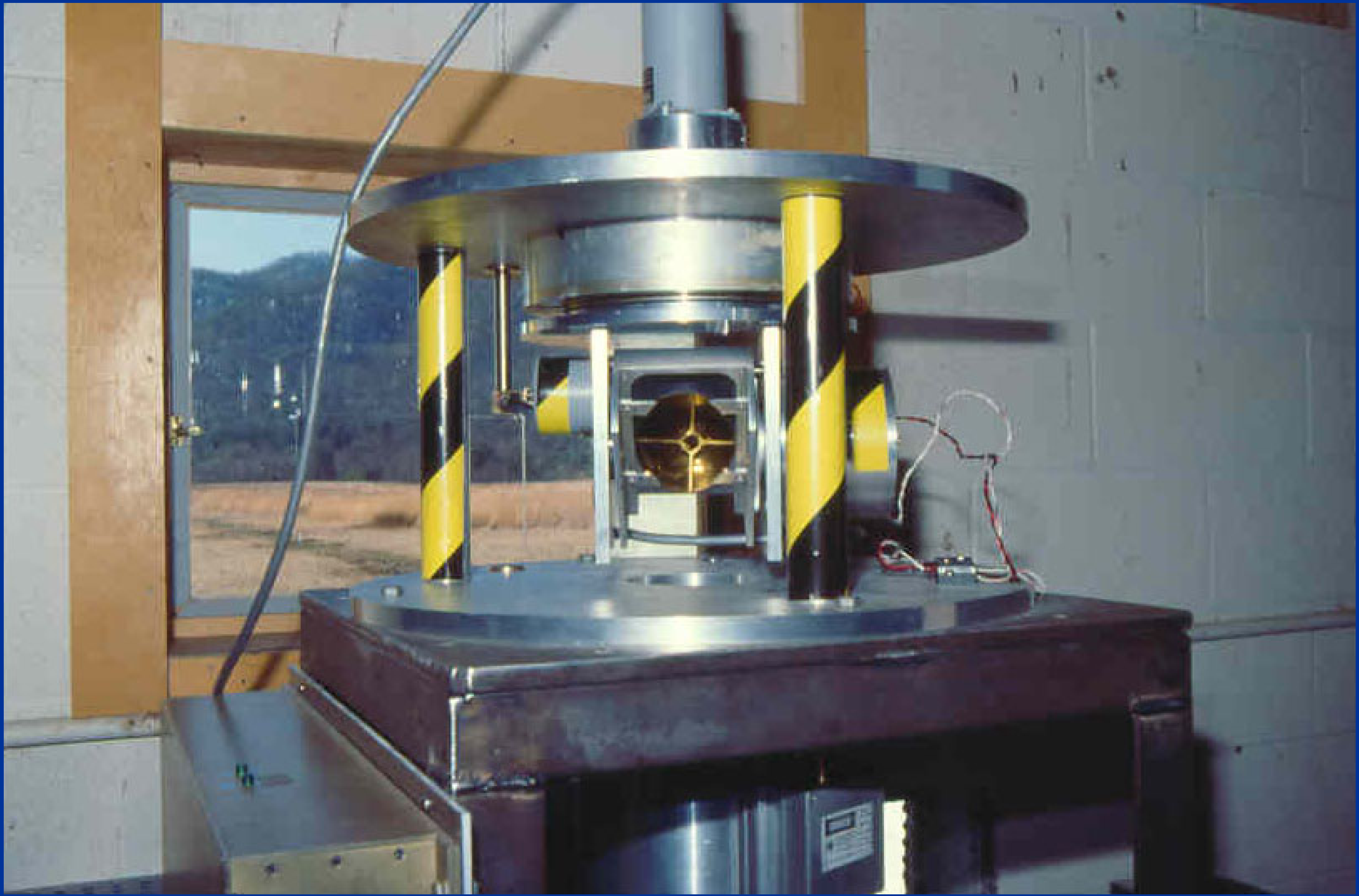
METROLOGY GROUP

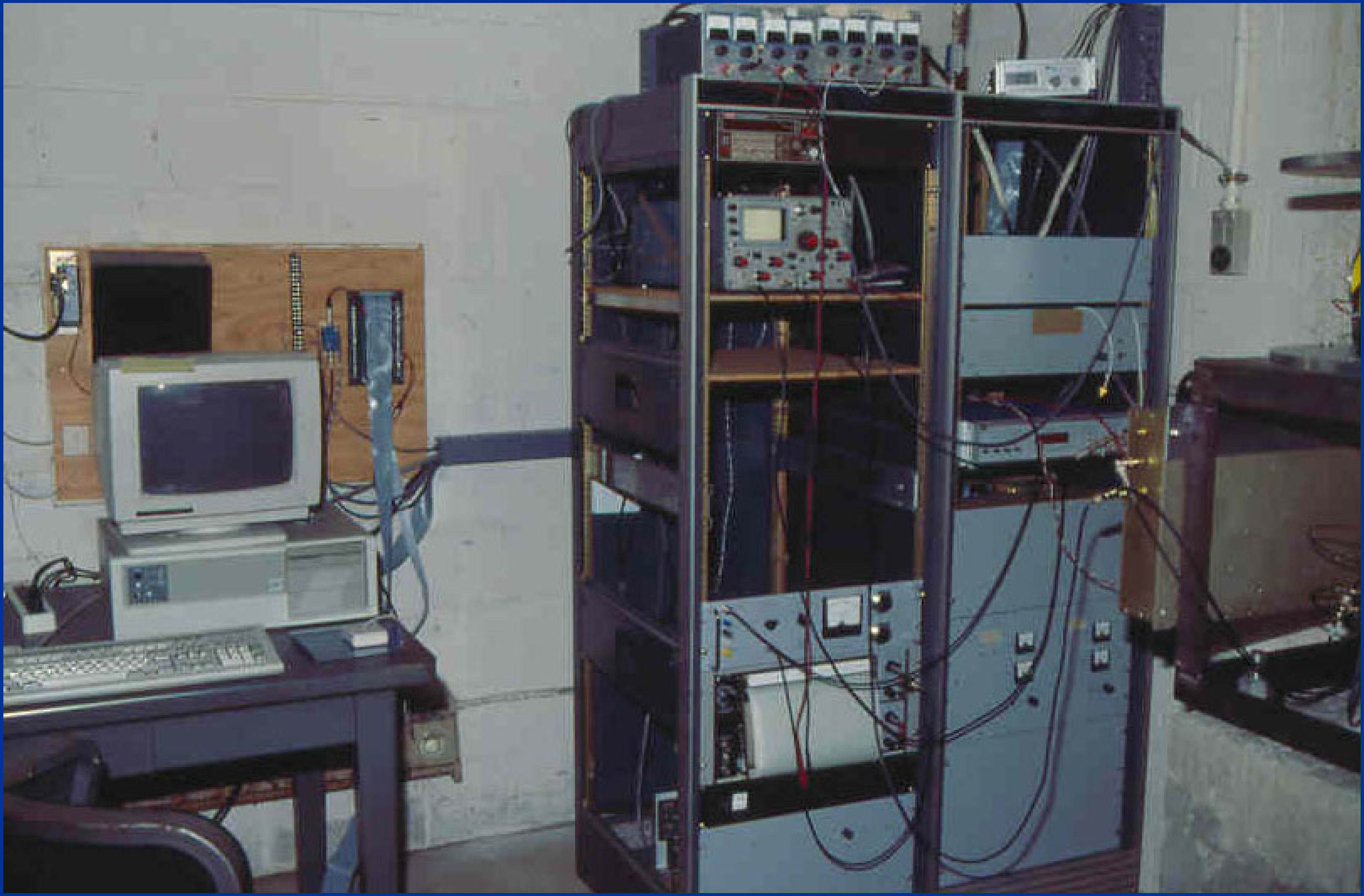

GBT

RANGER R&D









US005455670A

United States Patent [19]

Payne et al.

[11] Patent Number: 5,455,670

[45] Date of Patent: Oct. 3, 1995

[54] OPTICAL ELECTRONIC DISTANCE MEASURING APPARATUS WITH MOVABLE MIRROR

[75] Inventors: **John M. Payne**, Tucson, Ariz.; **David H. Parker**, Arborvale, W. Va.; **Richard F. Bradley**, Stanardsville, Va.

[73] Assignee: **Associated Universities, Inc.**, Washington, D.C.

[21] Appl. No.: **68,543**

[22] Filed: **May 27, 1993**

[51] Int. Cl.[6] **G01C 3/08**; G01C 3/00; G01B 11/26; G01B 11/24

[52] U.S. Cl. **356/5.1**; 356/3.11; 356/141.1; 356/152.2; 356/152.3; 356/376; 356/2

[58] Field of Search 356/1, 4, 5, 141.1, 356/152.2, 152.3, 376, 3.11, 5.1, 2

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,809,477	5/1974	Russell	356/5
4,274,736	6/1981	Balmer	356/5
4,457,625	7/1984	Greenleaf et al.	356/1
4,560,271	12/1985	Fumio	356/5
4,810,088	3/1989	Karning et al.	250/342

OTHER PUBLICATIONS

J. M. Payne; Rev. of Scientific Instr.; vol. 44, #3; Mar. 1973; p. 304.

J. M. Payne et al.; Rev. of Scientific Instr.; vol. 63, #6; Jun. 1992; p. 3311.

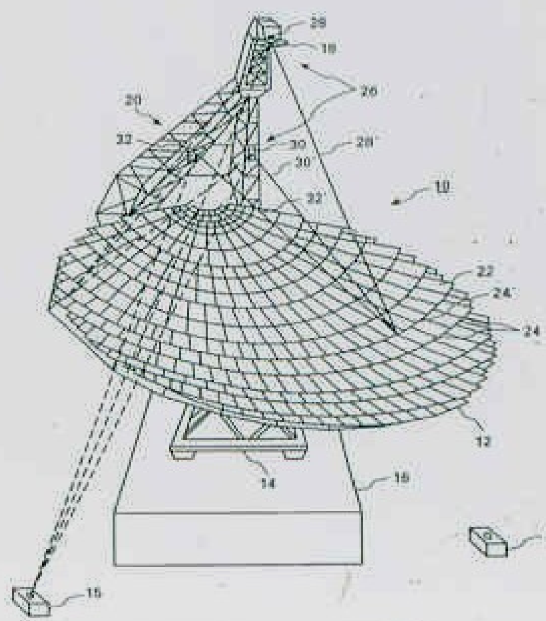
Primary Examiner—Stephen C. Buczinski

Attorney, Agent, or Firm—Margaret C. Bogosian

[57] **ABSTRACT**

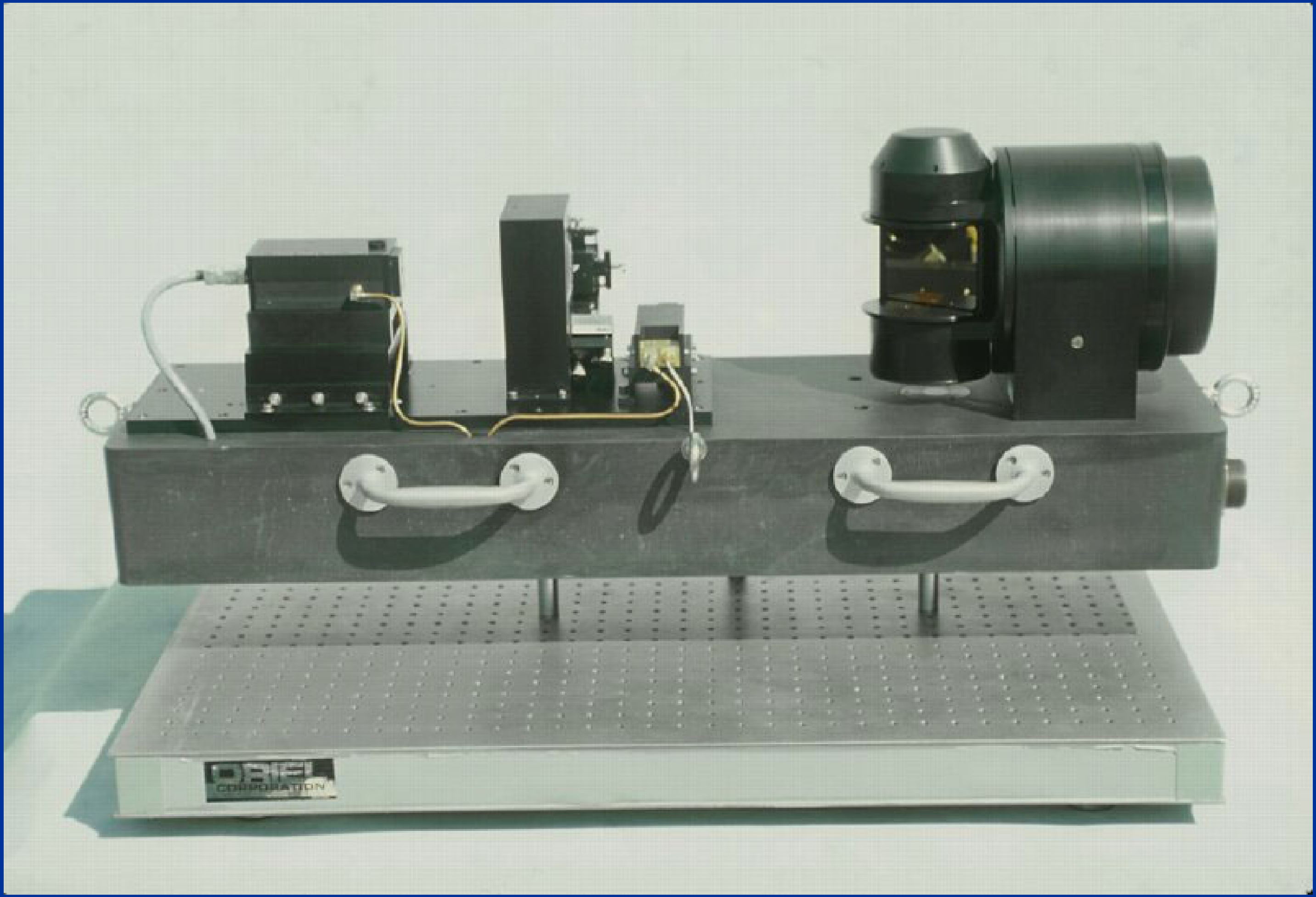
A rangefinder system employs three laser rangefinders for determining three dimensional coordinates, each rangefinder using a steerable mirror for aiming the rangefinder beams at a series of retroreflectors. The beams are modulated at 1.5 GHz. The system includes a signal at an offset frequency of 1 kHz for phase detection. A digital phase detector under control of a local computer, as is the mirror, computes phase difference which is used to measure the distances to the retroreflectors. Correction is made for zero point phase drift of the circuit of each rangefinder and a benchmark reference to a distant retroreflector corrects for atmospheric effects on the measurements. A central computer directs the implementation of the tasks of the local computers of each rangefinder and computes and displays trilateration computation results made from the three rangefinders. The system can measure the distance to five different points per second with ranges up to 120 m at all accuracy of about 50 μm.

32 Claims, 14 Drawing Sheets



RANGER CONSTRUCTION


Mack



SUBREFLECTOR

Other areas of interest

- Servo/stiction
- Performance measurement program
- Powder paint deformations
- Active damper for feed arm
- Quadrant detector
- Holography problems
- Tertiary mirror
- Wheel taper measurements