TR 1556

THUNDERSTORM RESEARCH INTERNATIONAL PROGRAM

TRIP - 77

REPORT TO MANAGEMENT

November 1977

TECHNICAL SUPPORT DIRECTORATE

TITLE/APPROVAL PAGE

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TR 1556

STANDARD TITLE PAGE

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16. Abstract

This report contains a summary of the 1977 Thunderstorm Research International Program (TRIP 77) studies conducted at the NASA John F. Kennedy Space Center.

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KSC FORM 16-272 (5/72)

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SECTION I

BACKGROUND

TRIP 77 was a follow-on to the 1976 research program known either as Thunderstorm II or TRIP-76. The 1976 research period was from June 15 to August 13 and the 1977 period was about the same.

The significant difference in 1976 to 1977 was the ability of most of the experimenters to arrive early, set up their instruments and then remain at KSC longer in an active data collection mode. (Unfortunately, inclement weather for 1977 was not as good as for 1976, but there were many good data days that are noted in Attachment B. The sites selected by the experimenters are shown in Attachment A. Fifty-five (55) different sites were selected for the investigators' instrumentation. These sites did not include the KSC field mill location; however, it did consider the twenty-five (25) rain buckets installed at the KSC field mill sites.

All of the investigators identified in Attachment C did submit letters identifying their support requirements, scientific objectives, numbers of personnel expected, etc. All these requirements were converted into security clearances, PRD/RD entries to Special Projects Document 081 Annex H. Approximately fifty pages of PRD/RD documentation had to be revised and/or new pages prepared.

SECTION II

SUMMARY OF OPERATIONS

I. OPERATIONS

The Technical Support (TS) Program Coordinator held a daily operations' briefing at 0900 in room 4296 of the Operations and Checkout Building (M7-355), KSC. During this period, the KSC Weather Office, mainly Mr. Gulick of NWS-NOAA, gave a post analysis of the previous day's weather, followed by the day's forecast and an outlook on weather conditions for the following day. The normal NOAA weather charts were used, complemented by the latest GOES satellite pictures, the latest rawinsonde sounding (usually taken at 0905Z) and the computer-derived thunderstorm probability forecasts associated with the sounding.

Following the weather briefing, discussions were held on what the experimenters had accomplished, and their plans for that day. The TS representative then scheduled the daily activity with KSC and the USAF, who in turn obtained our FAA flight clearance to perform aircraft operations over KSC and CCAFS.

II. RESOURCES

For TRIP 77, the following resources were provided to the investigators (all are John F. Kennedy services, except those noted with an asterisk(*) which were provided by USAF SAMTEC-1, AFETR & PAFB):

A. Field Mill data - magnetic tapes (3), hard copies contours.

B. Lightning detection and ranging (LDAR).

C. WSR72X Weather Radar. 33mm and polaroid photographs of scopes.

D. Daily weather summary.

E. *Rawinsonde data printouts. 2 daily.

F. NASA-6 airborne field mill data.

G. Photographic services (processing and dark room).

H. Wide-band and 3kHz data quality wire pairs.

I. Electrical power (KSC/CCAFS).

J. Loan pool services.

K. Equipment calibration.

L. Office space.

M. Telephone services in office spaces.

N. *Aircraft support at PAFB.

O. *Operational space at PAFB.

P. *Weather Information Network Display System (WINDS) data.

Q. GOES satellite photographs.

III. AIRCRAFT OPERATIONS

During the TRIP 77 experimental period, the following aircraft flew various data gathering sorties:

Aircraft	Arrived	Departed	User(s)
NASA-6 (C-45)	15 June	7 Sept *	KSC, NOAA-ERL
NRL Navy S2D (USN)	5 July	29 July	USN, NOAA-ERL
Schweitzer 845A (ONR)	24 June	9 July	NMTMT/U Of Manchester
Bellanca Viking	18 July	29 July	MIT
Learjet Model 24B (NASA-705)	17 July	7 Sept *	NASA (JSC/KSC), USAF
T39B Saberliner (USAF)	4 Aug	30 Aug	USAF

*The NASA Learjet and the C-45 provided standby meteorological (lightning and thunderstorm reconnaissance) support for the Voyager launches.

Another interesting facet of the aircraft operations was the direct and nearby lightning strike simulations that were made on the TRIP 77 lightning configuration of the NASA 705 Learjet. Both capacitor banks of 200kV peak voltage and a Marx generator were used. These tests were conducted in Hangar 800 at Patrick Air Force Base with the gracious consent of the Base Operations Staff.

IV. PRINCIPAL INVESTIGATORS

Nineteen agencies (government/university) participated in TRIP 77. Seventeen of these experimenters were outside agencies, two were from the J. F. Kennedy Space Center and one participant operated from off-site. All experimenters and their scientific objectives are identified in Attachment C. At the peak of the measuring activity, eighty-two (82) visitors were supporting the program, excluding the KSC cadre. Attachment D of this report identifies the experimenters' equipment (in situ). Views of the various aircraft that participated in TRIP 77 are also included. All guests and visitors who attended TRIP 77 activities are shown on Attachment E.

V. WEATHER FORECASTING & SUPPORT

The KSC Weather Office provided daily weather briefings (5 days/week) to all experimenters and the necessary consultation services during the day. The office operated from 0630 to 2000, to provide overall coverage and data acquisition, particularly during thunderstorm periods which were normally from noon on. The

The Weather Office also supported some weekend operations, when predictions indicated a possible active weather day for Saturday or Sunday. The Weather Office staff was supplemented by the services of Sgt. James Murray (on loan from Detachment 11, 2nd Weather Squadron, Patrick Air Force Base, Florida) as a weather radar operator. NOAA arranged the employment of a summer student and we were fortunate to obtain graduate meteorologist Russell Stark. The services of these two individuals were invaluable, particularly for data acquisition and documentation during active storms and subsequently in the preparation of daily weather summaries dissemination to the experimenters.

VI. LAUNCH SUPPORT

From the 15th of June to the 7th of September, the services of NASA-6, the NASA 705 Learjet and T-39B Saberliner provided standby meteorological support for the following expendable vehicles/scientific satellite missions:

Geosynchronous Operational Environmental Satellite (GOES-B) (U.S.)	16 June
Geosynchronous Meteorological Satellite (GSM) (Japan)	14 July
High Energy Astronomical Observatory (HEAO-1) (U.S.)	12 Aug
SIRIO (Italy)	25 Aug
Voyager 2 (U.S.)	20 Aug
Voyager 1 (U.S.)	7 Sep

VII DEPARTURE DEBRIEFINGS

Each experimenter was personally interviewed by the Program Coordinator and Mr. Durrett of the KSC Lightning Committee. General comments were very favorable of the exceptional cooperative support provided by the J. F. Kennedy Space Center personnel. Many experimenters lauded the response time to accomplish their request, and the excellent weather briefings that were conducted. The KSC data was extremely useful to the majority of the experimenters. Data provided were:

A. Hard copies of field mill contouring.

B. Daily weather summaries.

C. WBAN-10 hourly weather observations from Cape weather station.

D. Printout of rawinsonde soundings.

E. Hard copies of LDAR plots.

F. WSR72X Radar Data (film & summaries).

A survey was made of all those principal investigators present to determine the interest for a TRIP 78. Eight investigators indicated an interest in returning to KSC for one more year of operational data, four expressed a maybe in returning for various reasons, and only one declined because of reassignment of duties. Other experimenters plan to gather data elsewhere in the U.S.

SECTION III

RECOMMENDATIONS

I. KSC management support the follow-on studies of the Thunderstorm Research International Program 1978 (TRIP-78) funding estimated at $100,000.

II. The New Mexico Tech rain gauges remain installed for data purposes to support rain rates at KSC for the year 1978. (Some data will be useful for MSBLS rain attenuation studies.)

III. Maintain some operational capability of field mill data measurement system and the LDAR equipment for CY 1978.

SECTION IV

ACKNOWLEDGEMENTS

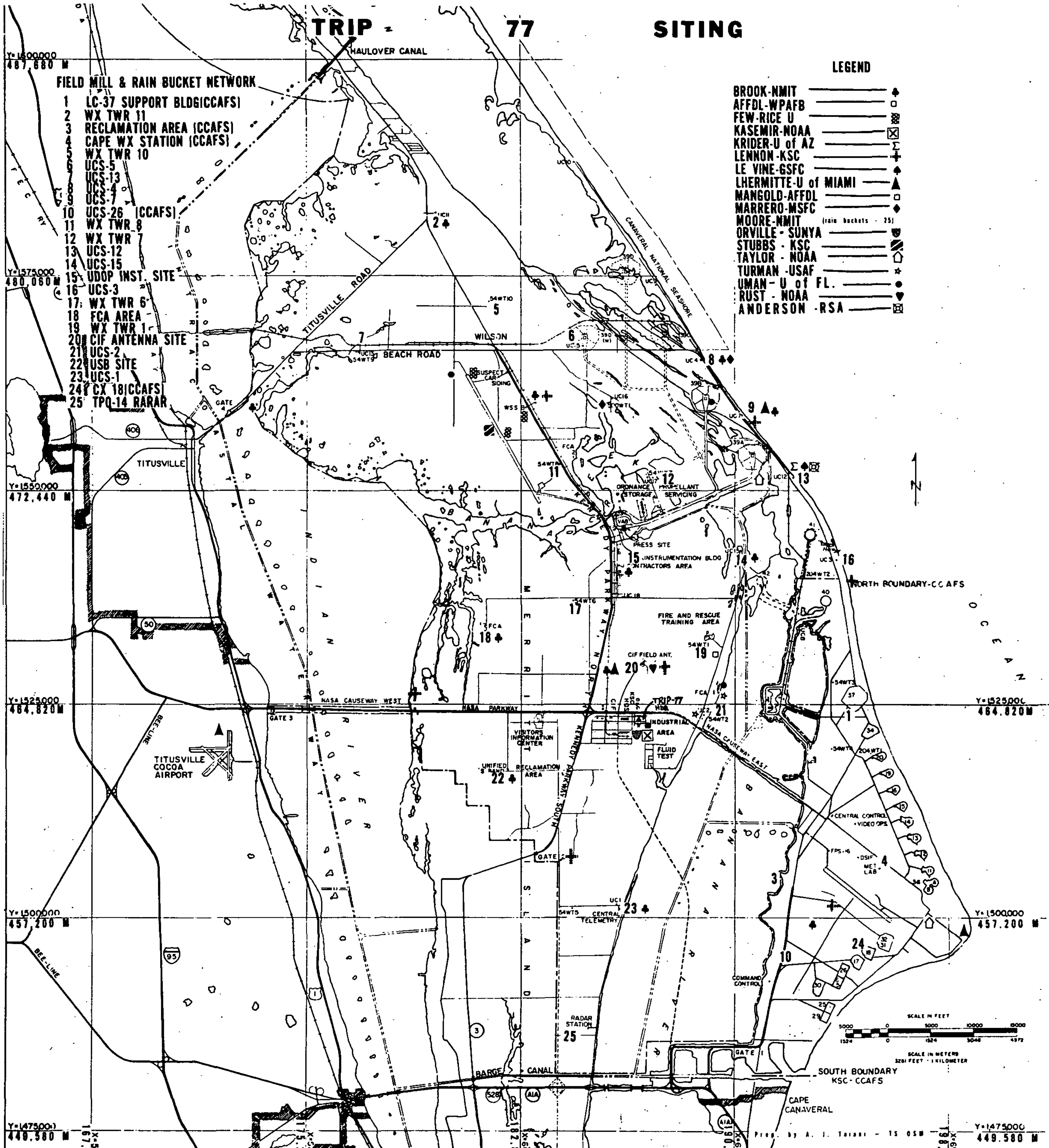
I. The Federal Aviation Agency (ATC Miami and Air Traffic Group-PAFB) for their favorable waivers for ballooning over KSC and their special air traffic control considerations to the experimental aircraft used during this period.

II. The Air Force Eastern Test Range (AFETR) Detachment 1 and Patrick Air Force Base (PAFB) for their cooperation in Range and Base support.

III. Those personnel at J. F. Kennedy Space Center who exhibited such a cooperative attitude in supporting the scientists. Some of those services which should be recognized are timing, communications, measuring, utilities and supply. The scientists in their debriefings acknowledged your wonderful cooperation.

IV. The NOAA personnel in the KSC Weather Office for their outstanding forecasting, data gathering and dissemination of data and weather information.

V. Mrs. Joan Bellamy, who provided the necessary gal-Friday support to the Program Coordinator and to the multitude of experimenters and visitors who passed through the Operations and Checkout Building during TRIP 77.



ATTACHMENT A

SIGNIFICANT DATA COLLECTION DAYS (1977)*

DAY	DATE	START TIME (GMT)	STOP TIME (GMT)
168	17 June	1632 2009	1836 2200
171	20 June	1640 2005	1725 2200
172	21 June	1704	1948
173	22 June	1927	2200
178	27 June	1728	1920
180	29 June	2039	2150
181	30 June	1719	1930
182	1 July	1634	2150
186	5 July	1432	1800
188	7 July	1929	2039
189	8 July	1800	2105
194	13 July	1200	2200
196	15 July	1700	1814
203	22 July	1722	1939
208	27 July	1843	2150
213	1 Aug	2002	2300
215	3 Aug	1658	1843
217	5 Aug	1855	1930
220	8 Aug	1840	0047 (9th)
224	12 Aug	1440	1700

*Data Day - More than one experimenter collected data.

EXPERIMENTERS AND SCIENTIFIC OBJECTIVES

EXPERIMENTER	OBJECTIVES
Arabian, D. A., Code W/A NASA Lyndon B. Johnson Space Center Houston, TX. 77058 (713) 483-6233	a. Investigate various categories of thunderstorms in the vicinity of KSC utilizing an instrumented Learjet. b. Conduct simulated lightning ground test utilizing the Learjet and electrostatic source provided by AFFDL, Wright-Patterson AFB, Ohio.
Baum, Robert Lt. USAF AF Flight Dynamics Laboratory/FES Wright Patterson AFB, OH 45433 (513) 255-5196/5439	a. Obtain magnetic field measurements of the nearby lightning environment from an airborne platform. b. Obtain measurement of skin currents and induced transients within the aircraft while operating in a lightning environment. c. Obtain a correlation between airborne and ground lightning test measurements. d. Make electrostatic field mill measurements over the Cape Kennedy network for calibration of the ground network.
Brook, Marx Dr. Research & Development Division New Mexico Institute of Mining & Technology Socorro, NM 87801 (505) 835-5611	a. Location of lightning charge "centers" from time-resolved multistation electric field change measurements, and correlation of these results with storm physical structure as determined by multi-Doppler radar measurements of wind field, fast scanning radar measurements of cloud reflectivity, and in-cloud measurements of cloud microphysical and electrical structure. Also, correlation of the charge center results with the results obtained from LDAR, the electric field mill network, and lightning channel reconstruction using thunder measurements. b. Study of the evolution of cloud reflectivity structure using a fast scanning X-band surveillance radar. Measurement of reflectivity intensification rates and the relationship between echo intensification and lightning occurrence, correlated with the raingage network measurements. c. Lightning fine structure measurements using a moving film lightning camera, and, as time permits, wideband electric field and radiation measurements.

EXPERIMENTER (CONT'D)	OBJECTIVES (CONT'D)
Few, Arthur A. Jr. Dr. Dept. of Space Physics & Astronomy Rice University Houston, TX 77001 (713) 527-8101 X3601	a. Obtain data on the location and orientation of all major lightning channels both inside and outside the cloud throughout the time development of marine air-mass thunderstorm at KSC. b. Obtain data on the location and geometry of the charged cloud regions supplying change to each lightning flash in the KSC thunderstorms studied. c. Obtain data on nature and explanation of the infrasonic emissions from thunderclouds associated with electrical discharges. d. Obtain vertical profiles of temperature and corona currents inside thunderclouds. e. Correlate acoustic methods of lightning and source location with electromagnetic and multi-station electrostatic techniques. f. Correlate electric fields inside thunderclouds with fields measured at the surface and on aircraft outside the thunderclouds. g. Correlate regions of lightning activity and charge generation with thunderstorm dynamical data and with the thunderstorm microphysical data.
Kalafus, Rudolph M., Dr. Code TSC-521 Transportation Systems Center Cambridge, MS. 02142	(See Marrero, P. J. for objectives).
Kasemir, Heinz W., Dr. NOAA Environmental Research Laboratories Boulder, CO. 80302 (303) 499-1000 X6249	a. Using aircraft, determine the electric field and space charge distribution inside electrified convective clouds in the Florida area, and correlate the charge centers with meteorological parameters.
Krider, E. P., Dr. Institute of Atmospheric Physics University of Arizona Tucson, AZ 85721 (602) 884-1329	a. Study the overall evolution of lightning activity at the NASA Kennedy Space Center using the KSC field mill network and other sensors. The frequency of lightning discharges, the fraction of cloud-to-ground discharges, the fraction of discharges containing continuing currents, and the number of return strokes in cloud-to-ground discharges all will be measured as a function of time during summer storms.

EXPERIMENTER (CONT'D)	OBJECTIVES (CONT'D)
	b. Study the physical characteristics of lightning stepped-leader and return stroke currents using fast time-resolved measurements of the electric and magnetic fields produced by discharges at KSC. This experiment is part of a joint multi-station experiment with Dr. Martin A. Uman and his group at the University of Florida. Return stroke propagation speeds will be measured photoelectrically, and these speeds will be used to test models of how return stroke currents propagate up the leader channels.
	c. Study sources of atmospheric radio noise in the HF and VHF bands using time-resolved electric field measurements with correlated sferics records.
Lennon, Carl NASA, Code IN-TEL-12 John F. Kennedy Space Center Kennedy Space Center, Fl. 32899 (305) 867-4068	a. LDAR, a Lightning Detection and Ranging System, will be operated at KSC. The space-time history of the lightning discharge process will be mapped by measuring the time of arrival (at 6 receiving stations) of lightning produced RF pulses in the 30 to 50 MHz frequency range. 1. To locate electrically active areas of a cloud and map the space-time history of the electrical discharges. 2. To determine the physical relationahip between electrically active areas and rain areas of a cloud. 3. To detect and locate lightning strikes to ground. 4. To gather additional evidence that the observation that VHF radiation ceases just prior to the step leader making contact with the ground and resumes after the return stroke has been established. 5. To map lightning ground strike locations relative to electrical active portion of the cloud.
LeVine, David, Dr. NASA Code 982 Goddard Spaceflight Center Greenbelt, MD 20771 (301) 982-4059	a. The general purpose of this research program is to examine the structure of waveforms radiated from lightning for characteristics which are indicative of storm type. In particular, to determine whether or not tornado bearing storms can be identified on the basis of the RF radiation associated with the storm system. b. The specific objective at KSC will be to collect waveforms at frequencies from HF-UHF in conjunction with other monitoring of the lightning in order to associate the RF structure of the lightning with physical parameters of the lightning flash and with the dynamics of the storm.

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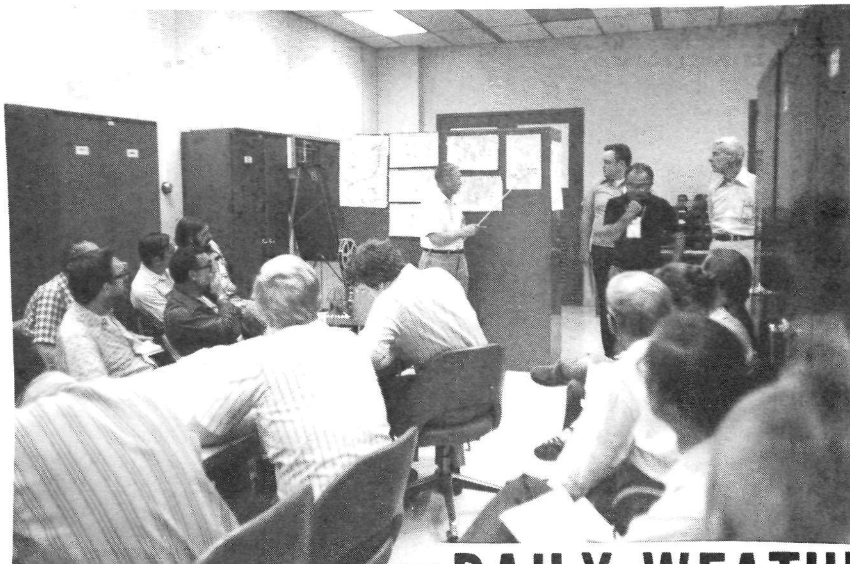
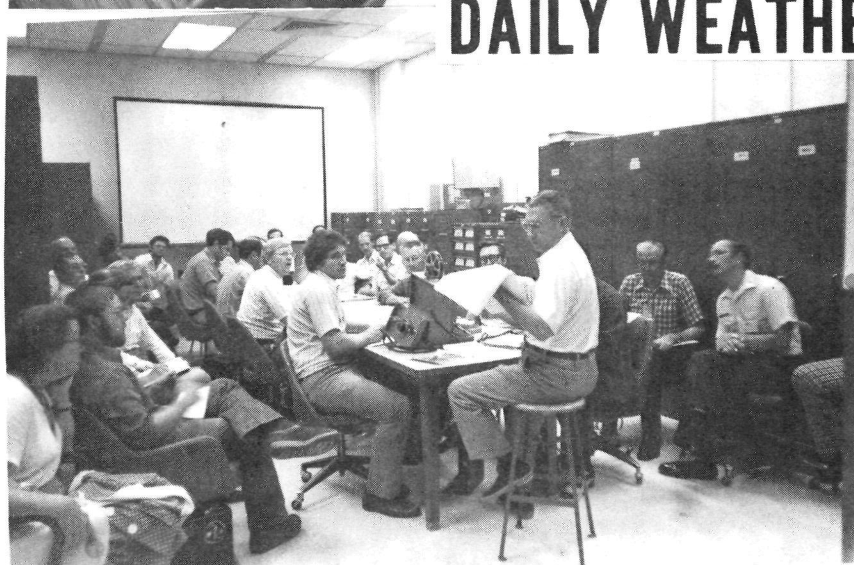
EXPERIMENTER (CONT'D)	OBJECTIVES (CONT'D)
Lhermitte, Roger, Dr. School of Marine & Atmospheric Science Div. of Atmospheric Science University of Miami P. O. Box 249115 Coral Gables, Fl. 33124 (305) 350-7491	a. Study of the three dimensional structure of motion and radar reflectivity fields inside thunderstorms. Special attention will be given (but not limited to) to the study of strong updraft or downdraft observed by the system inside convective storms as related to the distribution and evolution of electric charges in the storms, or the occurence of lightning, which will be observed.
Mangold, Vernon A.F. Flight Dynamics Laboratory/FE5 Wright-Patterson AFB, OH 45433 (513) 255-5196/5439	a. Flight evaluation of a lightning detector instrument package (Stormscope). Test bed will be a T-39-B aircraft equipped with a new digital weather radar (Bendix RDR-1300) and transient digitizer system (WP-2222) for evaluation of the Stormscope. b. A ground station will evaluate a newly developed narrowband UV optical densitometer system & ground testing of optical charges in air density (wind) and/or rainfall as a function of lightning activity. c. Laser triggering of natural lightning using a high peak power laser (4×10^8 watts) and suitable optics for triggering and/or providing a convenient path for lightning discharge.
Marrero, Peter J. NASA Code EC32 George C. Marshall Space Flight Center Marshall Space Flight Center, AL 35812 (205) 453-1597	a. Utilize a Pulsed Laser Doppler System to prove the feasibility to measure the gust from velocities in the non-precipitous regions of a storm and measure the associated wind phears. The goal is to collect data on the penetration of the CO_2 laser beam into the storm and compare this data with standard wind anemometers on a tower, weather and doppler radars.
Moore, Charles B., Prof. Department of Physics New Mexico Institute of Mining & Technology Socorro, NM 87801 (505) 835-5423	a. Characterization of 'sea coastal' thunderclouds. b. Study of relations and differences between electric fields at the earth's surface with those within active thunderclouds. c. Study of precipitation formation and development in Floridian thunderclouds with special attention given to the precipitation in warm regions of the cloud. d. Determination of charge and electric field distributions aloft in developing Floridian thunderclouds. e. Cooperative study of relations between rainfall and lightning over KSC.

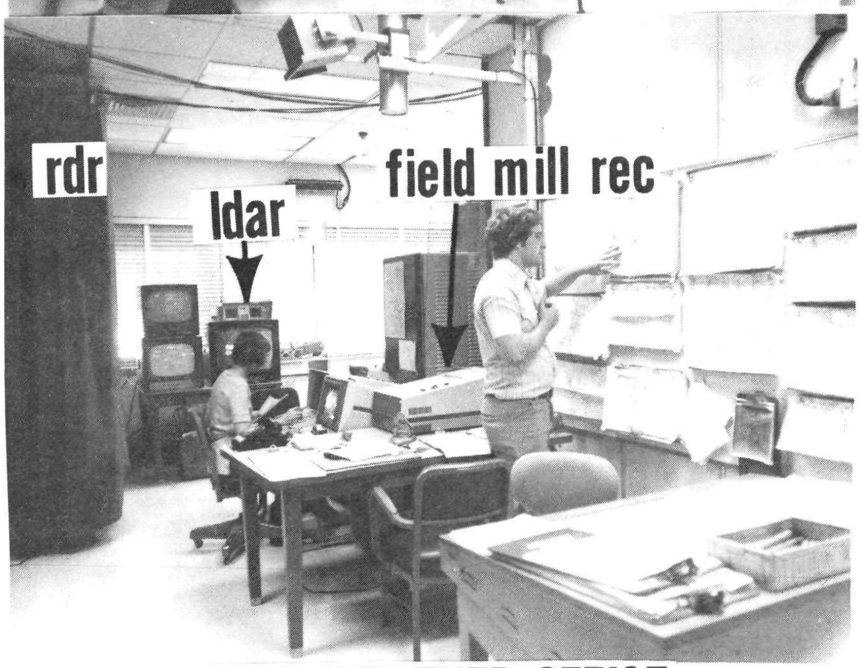
EXPERIMENTER (CONT'D)		OBJECTIVES (CONT'D)
Nanevicz, J. Dr. Stanford Research Institute Menlo Park, CA 94025 (415) 326-6200 X2609		See Arabian for objectives.
Orville, Richard, Dr. Dept. of Atmospheric Science State Univ. of N.Y. @ Albany 1400 Washington Ave. Albany, N. Y. 12222 (518) 457-5151	a.	Measure the return stroke velocities near the ground and simultaneously record the electric and magnetic fields (Uman, Drider). From these data it may be possible to calculate the electric current flowing in cloud-to-ground return strokes in the first few tens of microseconds.
Panofsky, Hans, Prof. College of Earth & Mineral Sciences The Penna. State Univ. University Park, PA. 16802 (814) 865-0478/79	a.	Evaluate WINDS data to compute patterns of divergence and convergence and compare the strength of these fields with lightning frequency. The hypothesis is that strength of convergency is a measure of thunderstorm activity.
Poehler, Horst, Dr. RCA - Mail Stop 620 John F. Kennedy Space Center Kennedy Space Center, FL. 32899		See Lennon for objectives.
Rust, David, Dr. Nat'l. Severe Storms Lab. NOAA - ERL 1313 Halley Circle Norman, OK 73069 (405) 329-0388	a.	An S-band radiometer will be used on a narrow-beam, steerable antenna to measure the radiation from clouds and thunderstorms. The major objective of this program is to ascertain whether the presence of cloud electrification can be detected in this way. If this is possible, an attempt will be made by collaborating with other investigators to determine those electrical processes or conditions that resulted in remote detection. Of particular interest are electric fields at the ground and aloft, precipitation and lightning. In addition, the radiometric data will be correlated with radar data.
Stahmann, James NASA-PRC John F. Kennedy Space Center Kennedy Space Center FL. 32899 (305) 867-3407		See Stubbs for objectives.

EXPERIMENTER (CONT'D)	OBJECTIVES (CONT'D)
Stubbs, Donald NASA Code DL-NED John F. Kennedy Space Center Kennedy Space Center, FL. 32899 (305) 867-4548	a. Lightning Triggering at KSC: The basic rationale for triggering lightning at the John F. Kennedy Space Center (KSC) is to control lightning and increase the number of strokes to a structure in a known time frame to quickly verify the lightning protection of the structure and associated ground support equipment (GSE) with natural lightning. In addition, natural lightning currents could be used to verify the lightning protection of flight hardware and other components, and even full-scale aerospace vehicles. Natural lightning possesses high voltage and energies not available from simulators, and this makes it very useful for final verification testing of the lightning protection of large structures, or components that include composite materials.
Taylor, William, Dr. National Severe Storms Lab. NOAA-ERL 1313 Halley Circle Norman, OK 73069 (405) 329-0388	a. Field measurements of the spacetime history of intracloud discharges superimposed on Doppler radar motion fields and precipitation structure. b. Inference of discharge characteristics from observed quantities. c. Contribute to knowledge of physical processes acting in charge separation and discharge.
Turman, Bobby N., Capt. USAF Code TFE Hdq. 1035th Technical Operations Group Patrick AFB, FL. 32925 (305) 494-2924	a. To measure indirectly time-dependent optical travamission properties of clouds using two ground stations, separated by one km.
Uman, Martin, Dr. Dept. of Electrical Engr. College of Engineering University of Florida Gainesville, FL. 32611 (813) 392-0911	a. Basic objective is to measure return-stroke current waveshapes by operating fast electric and magnetic field antennas at KSC and Gainesville. b. Operation of two TV systems to accumulate information on Lightning location, time of occurrence, strokes per flash, etc.

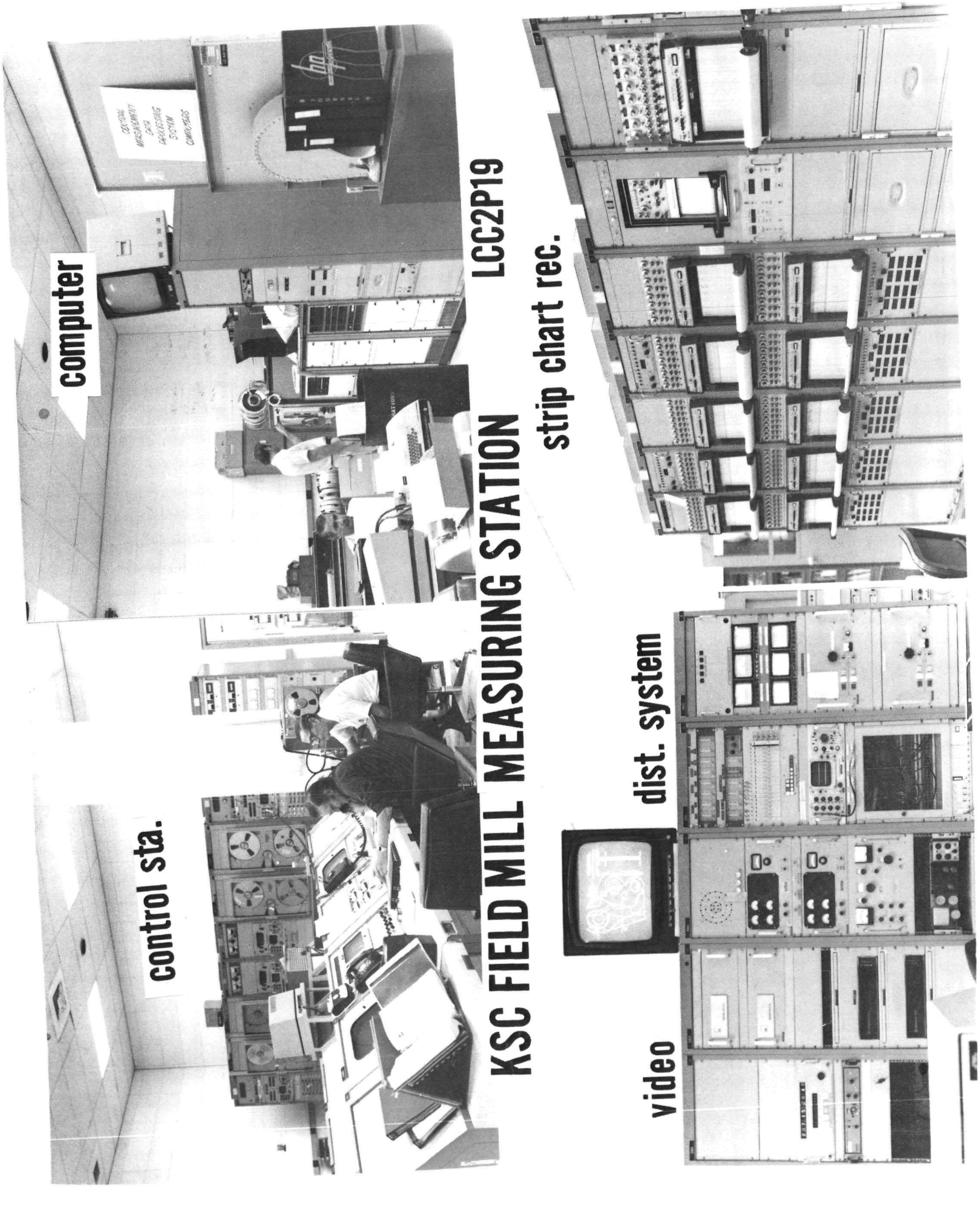




DAILY WEATHER BRIEFING
NWS - NOAA



KSC WEATHER OFFICE


computer
LCC2P19
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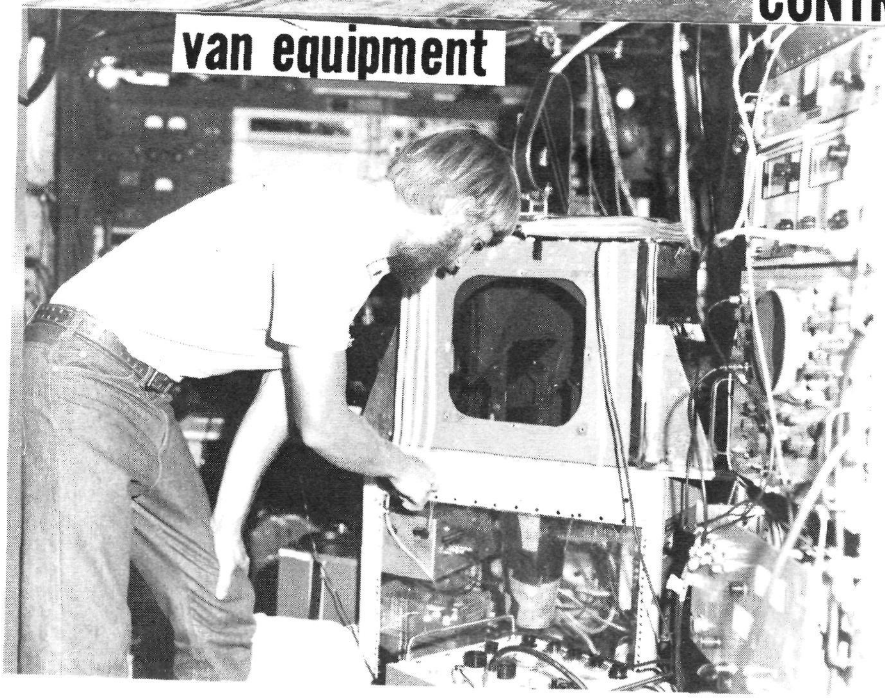
KSC FIELD MILL MEASURING STATION
control sta.
dist. system
video

RED BALL RADAR/SUPPORT TRAILERS

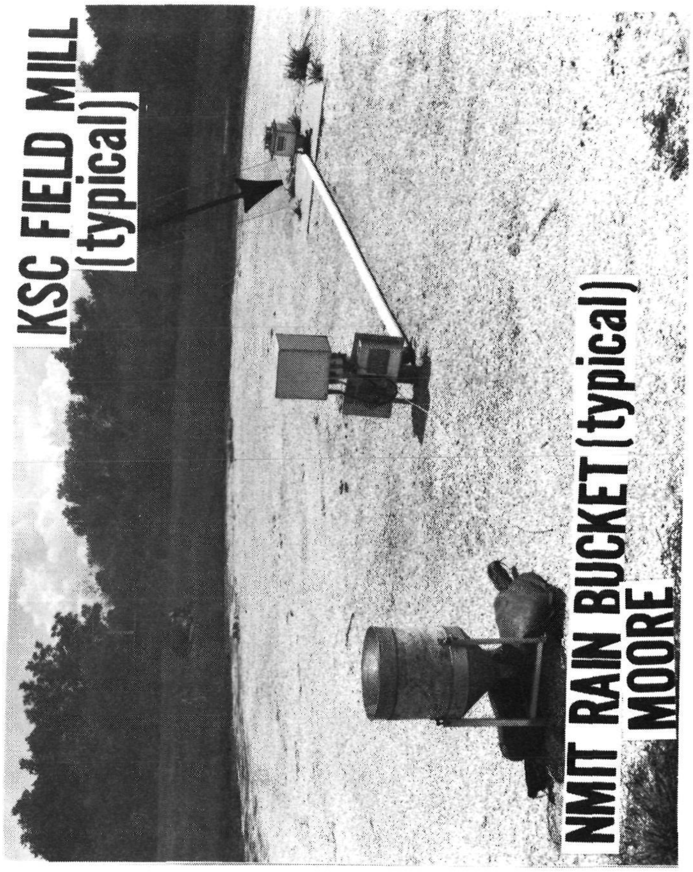
CONTRACTOR'S ROAD

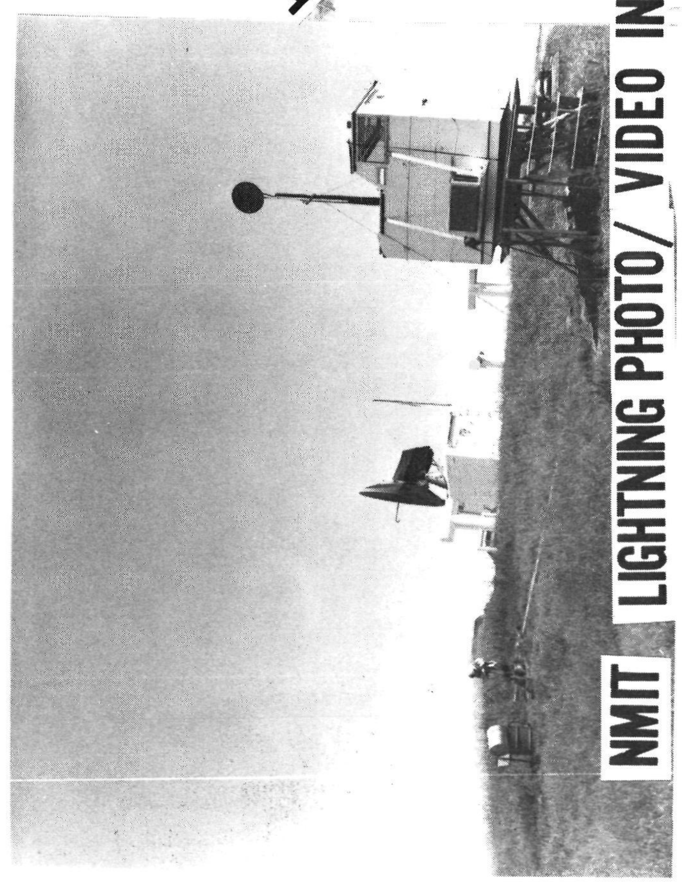


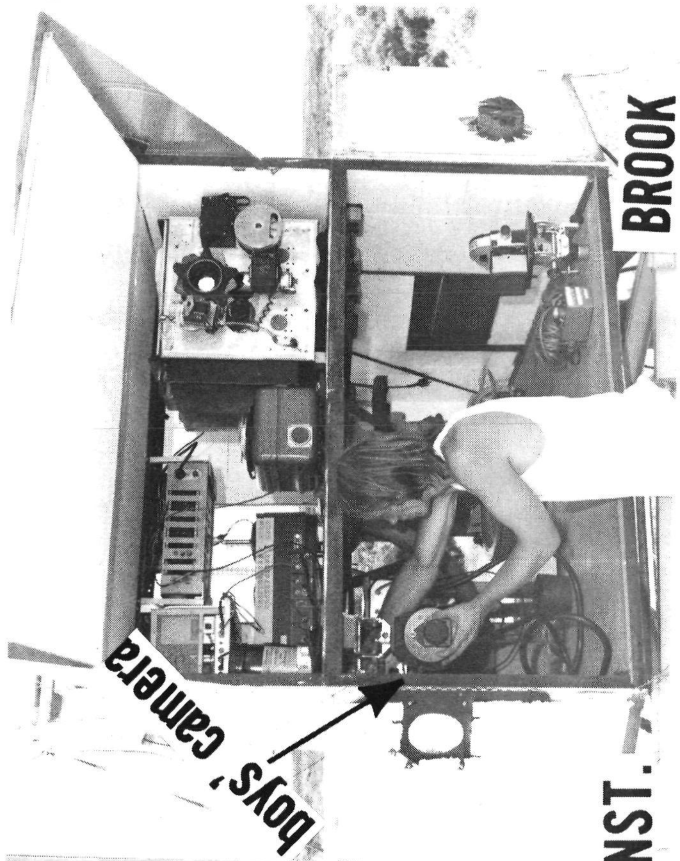
BROOK

NEW MEX. INSTITUTE OF MINING & TECHNOLOGY

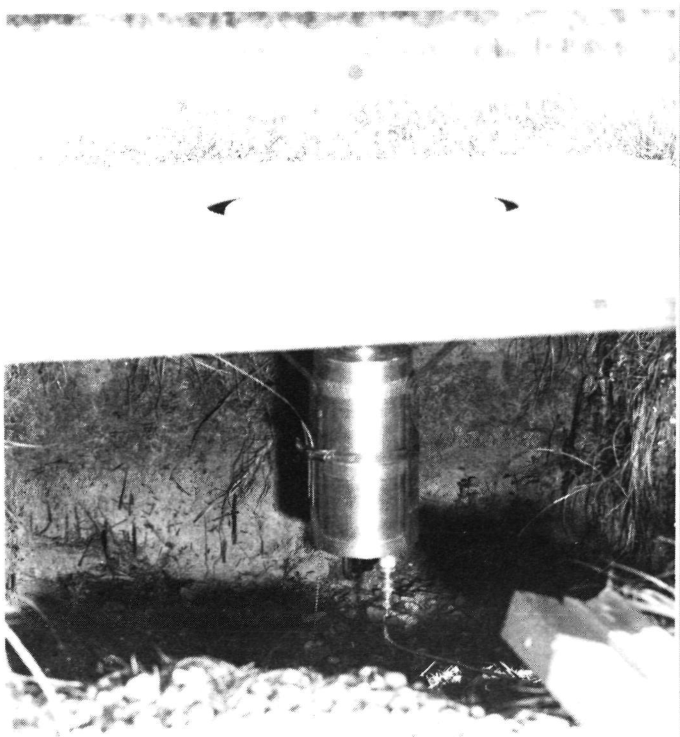

LDAR
LENNON
RECORDING/COMPUTING STA.


KSC FIELD MILL
(typical)
NMIT RAIN BUCKET (typical)
MOORE

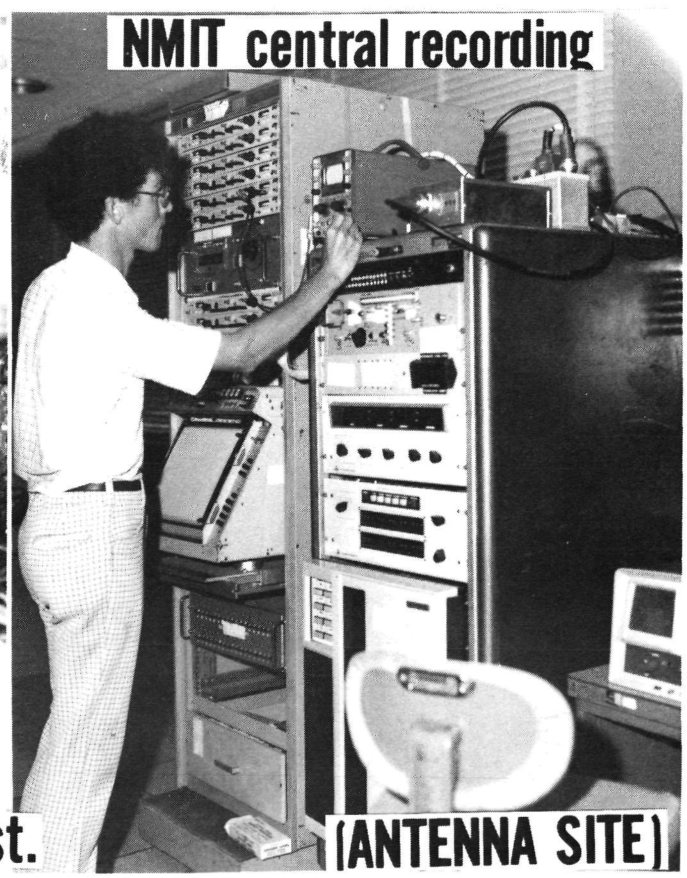

NMIT LIGHTNING PHOTO/ VIDEO INST.


BROOK
boys' camera

NMIT field change meas. inst.typical)



NMIT field change calibration inst.



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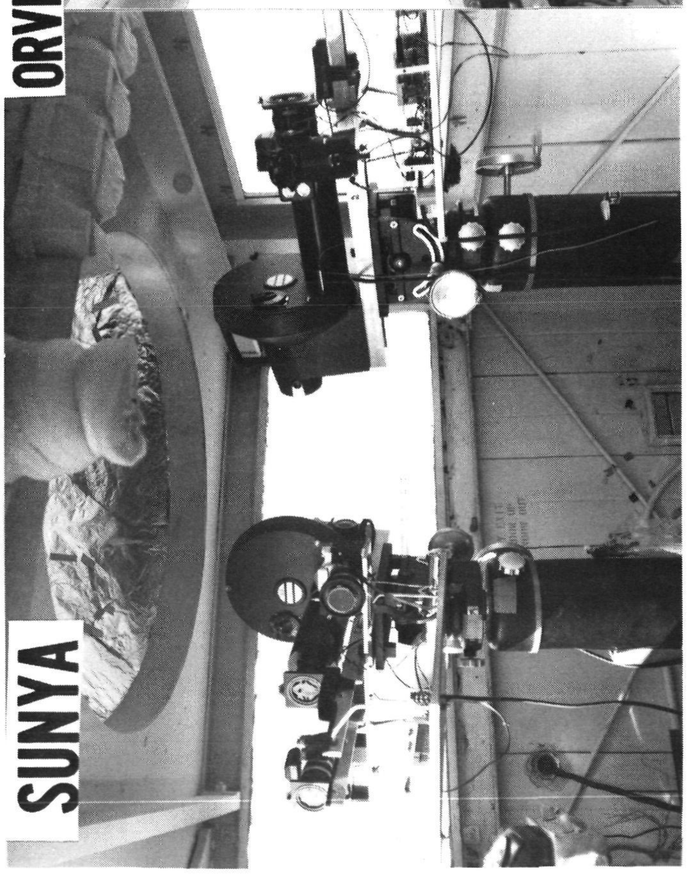
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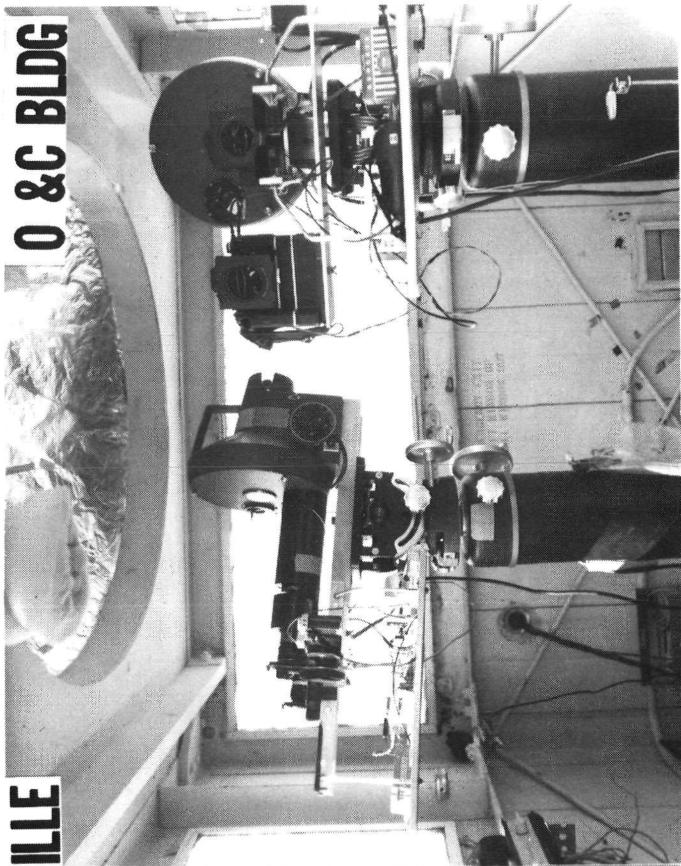
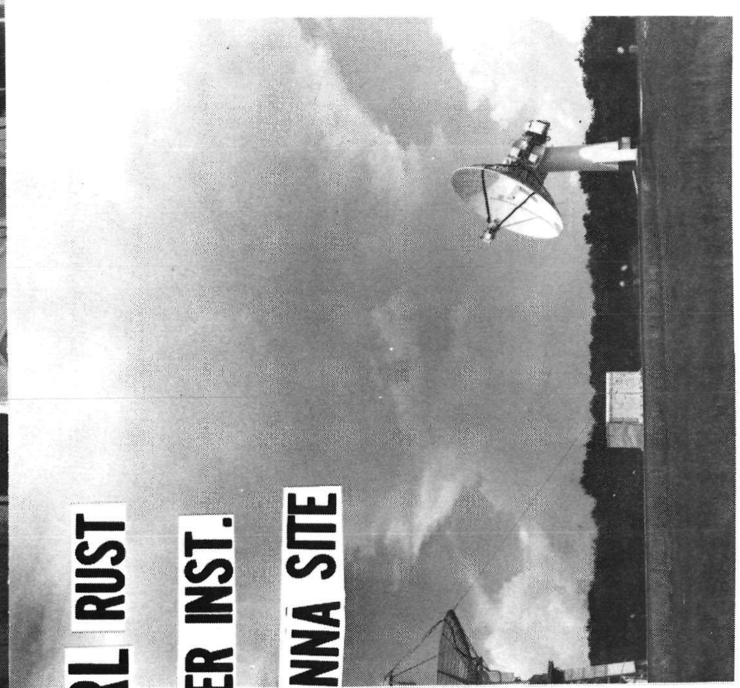
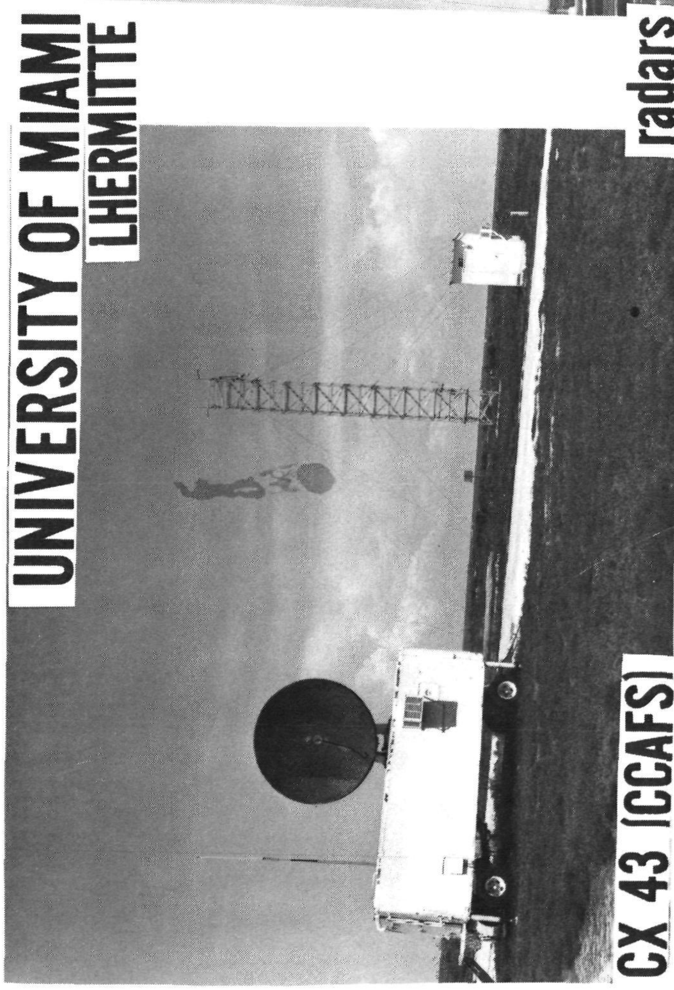

ORVILLE
O &C BLDG


NOAA ERL RUST
RADIOMETER INST.
CIF ANTENNA SITE


radiometer controls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radars
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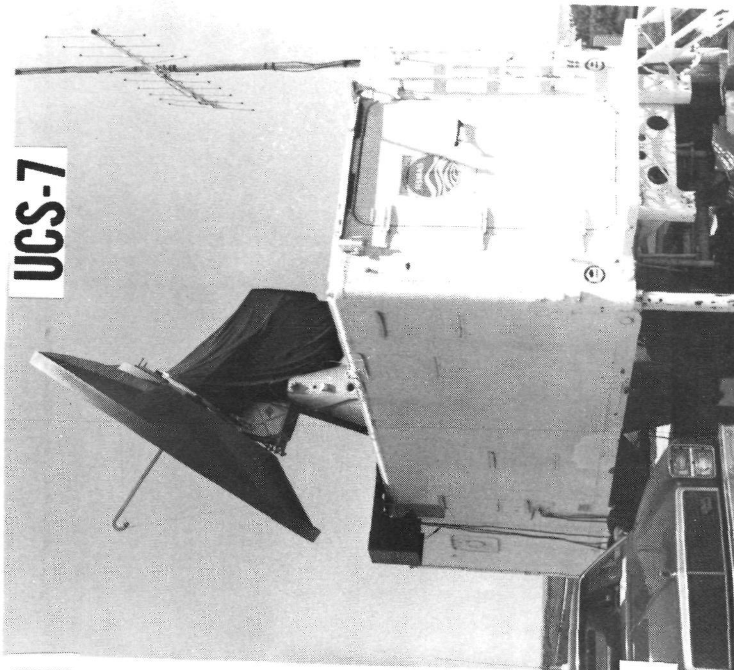
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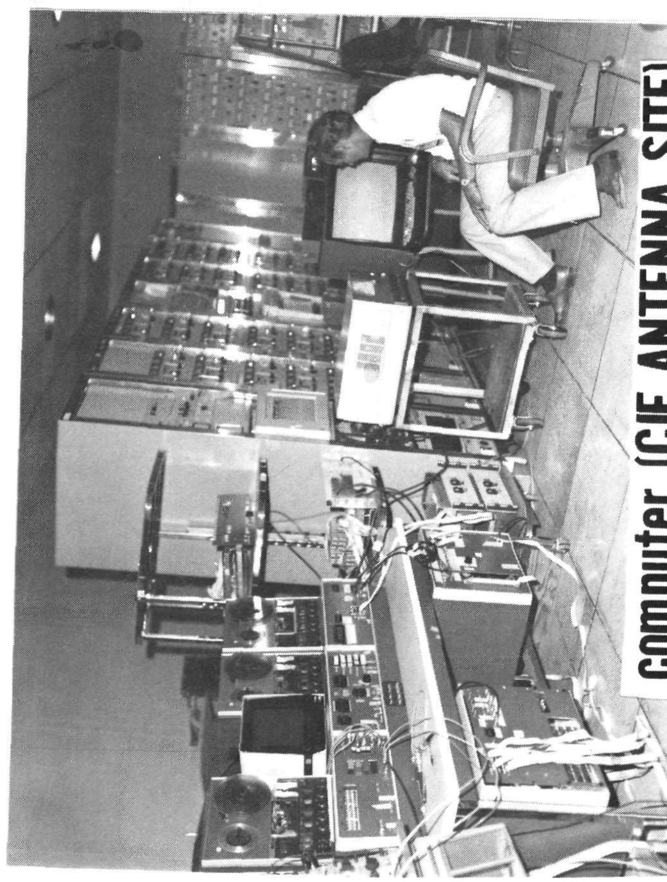
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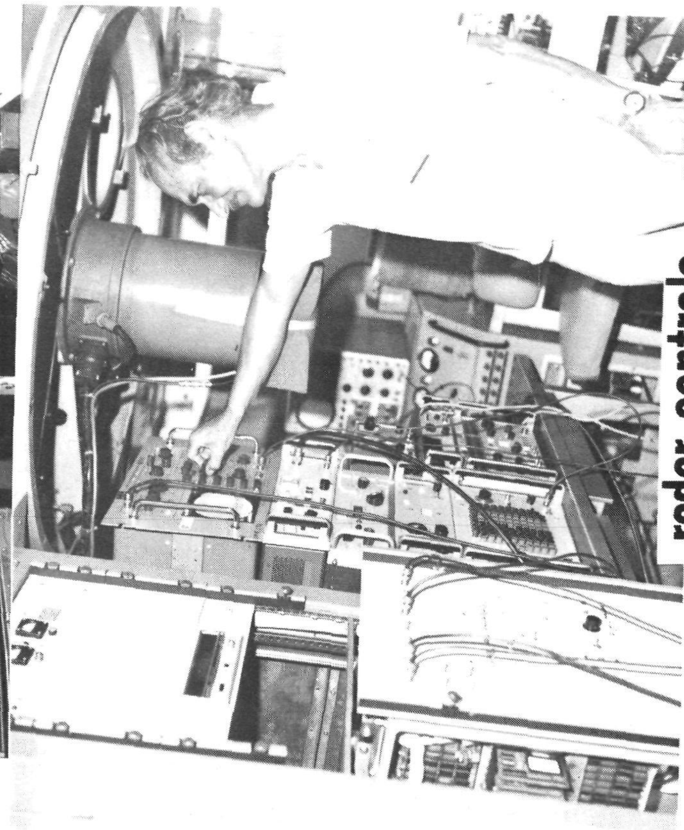
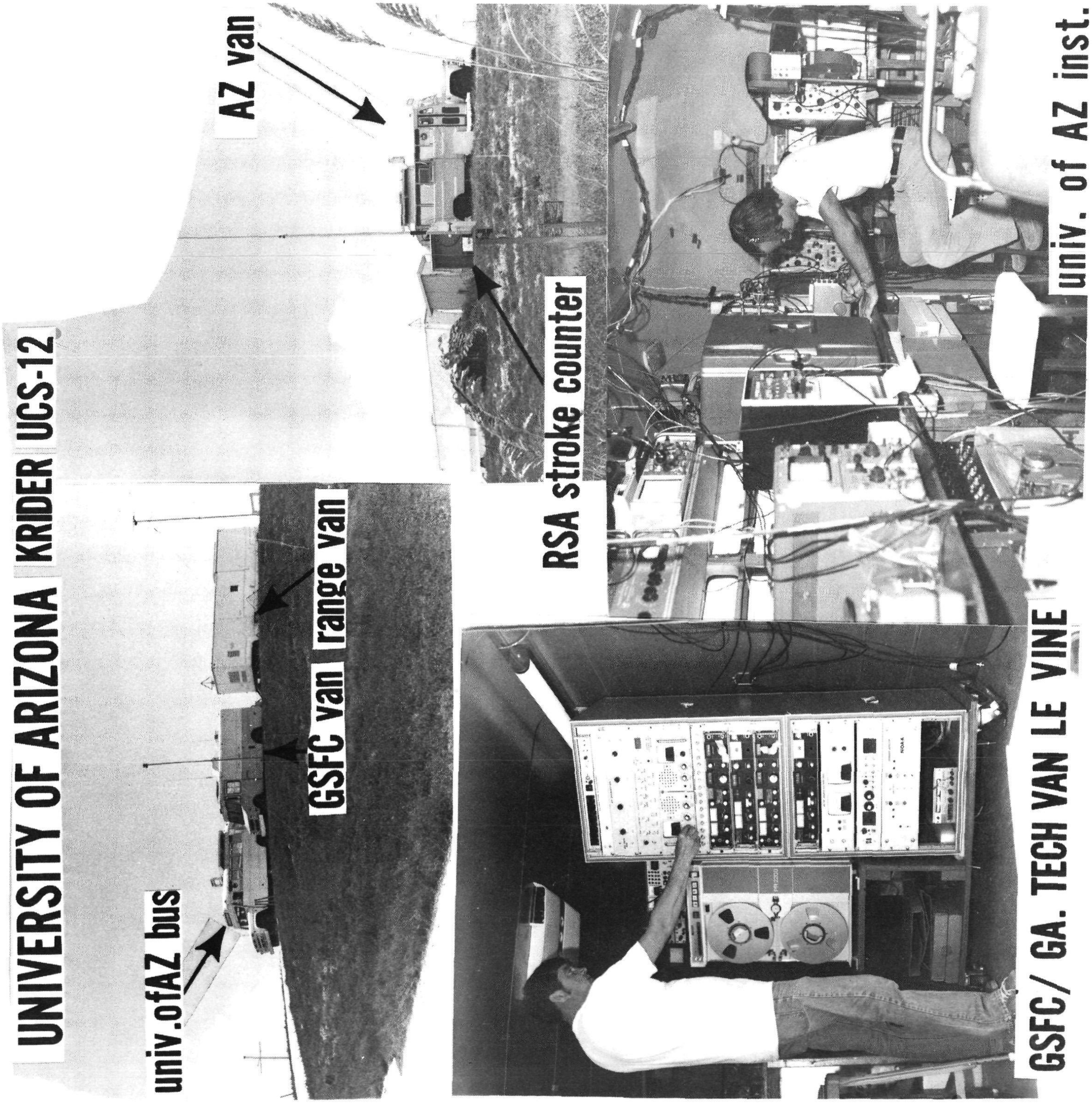
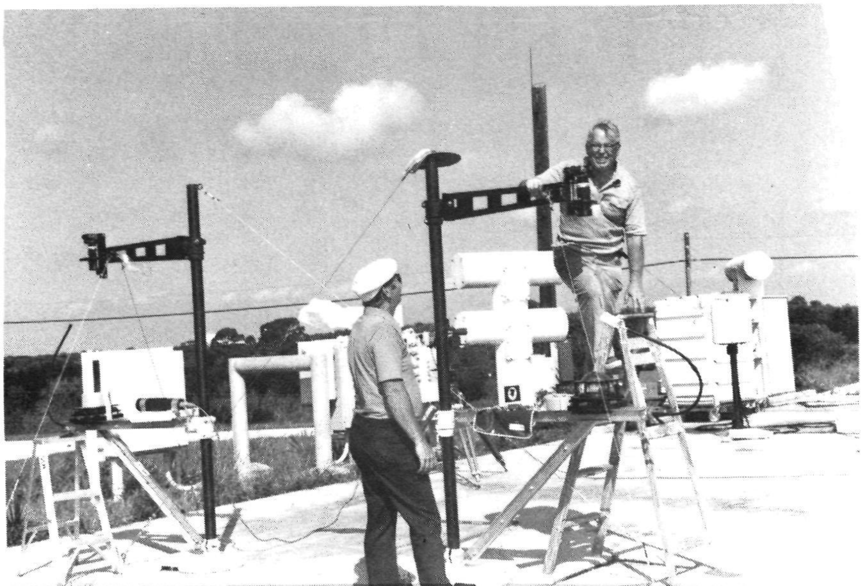
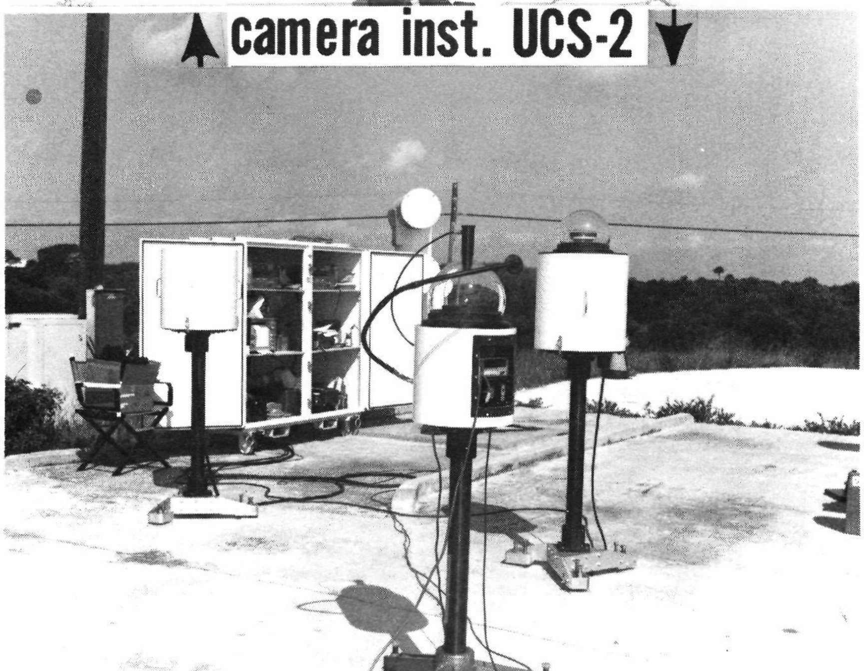

radar controls


UNIVERSITY OF ARIZONA KRIDER UCS-12
univ.ofAZ bus
GSFC van
range van
AZ van
RSA stroke counter
GSFC/ GA. TECH VAN LE VINE
univ. of AZ inst.

AFTAC PAFB

THURMAN

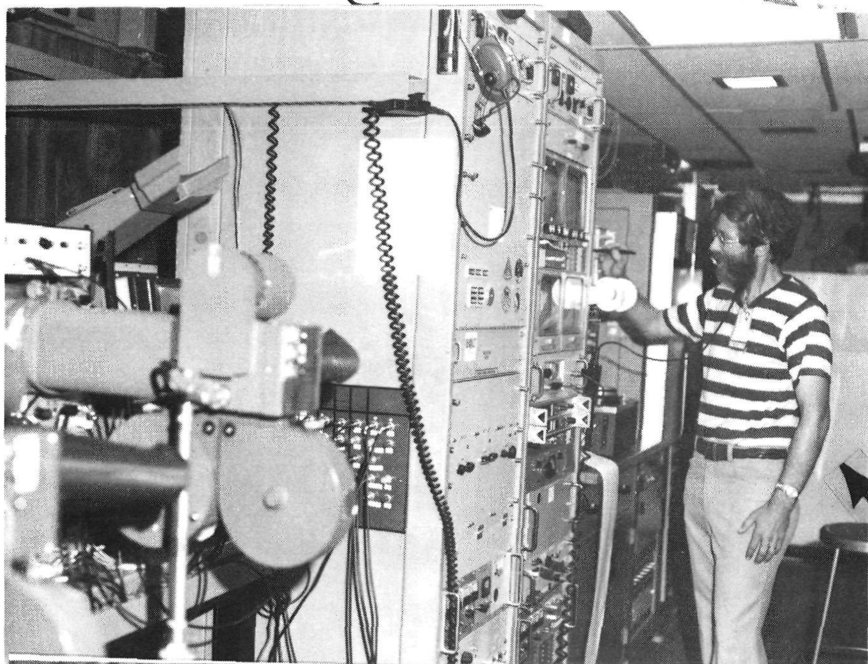


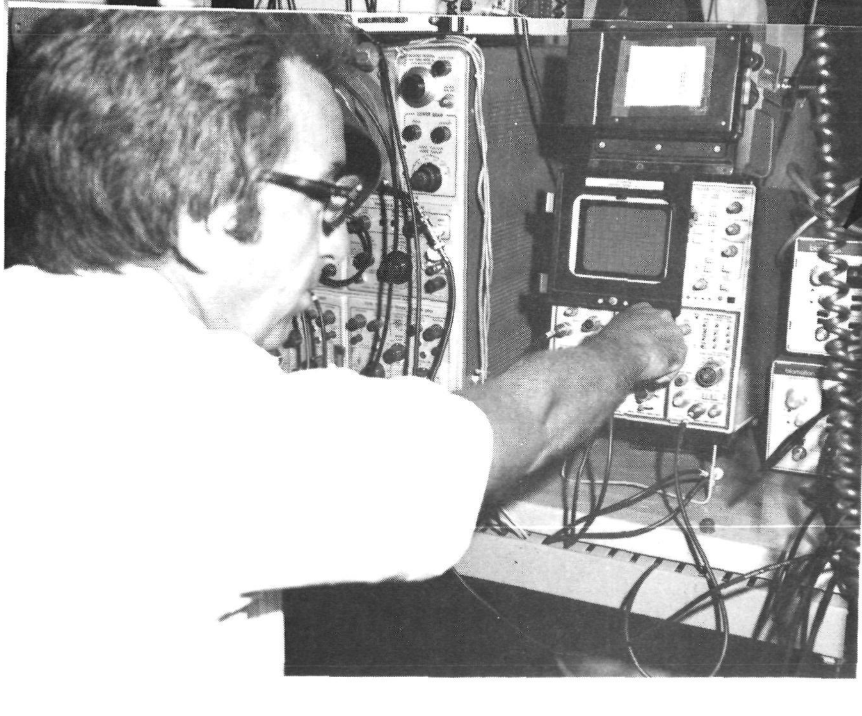


UNIVERSITY OF FLORIDA

UMAN

van @ FCA-2

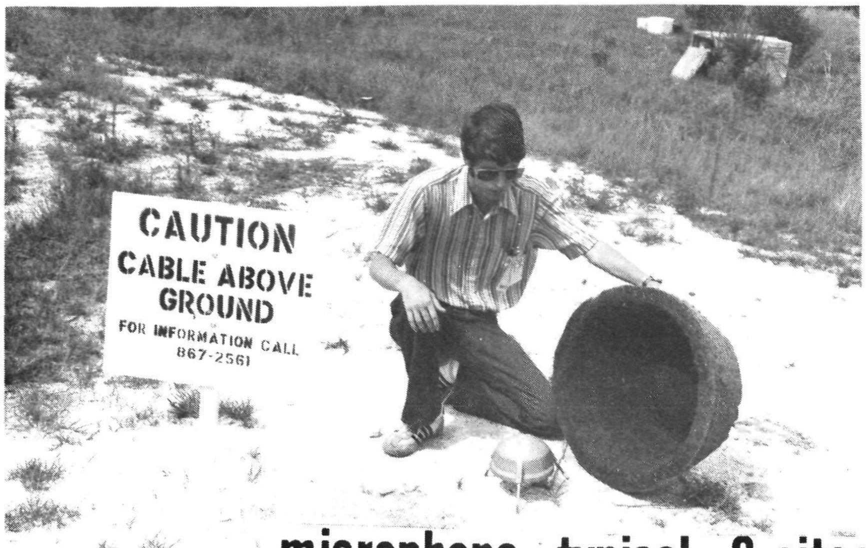




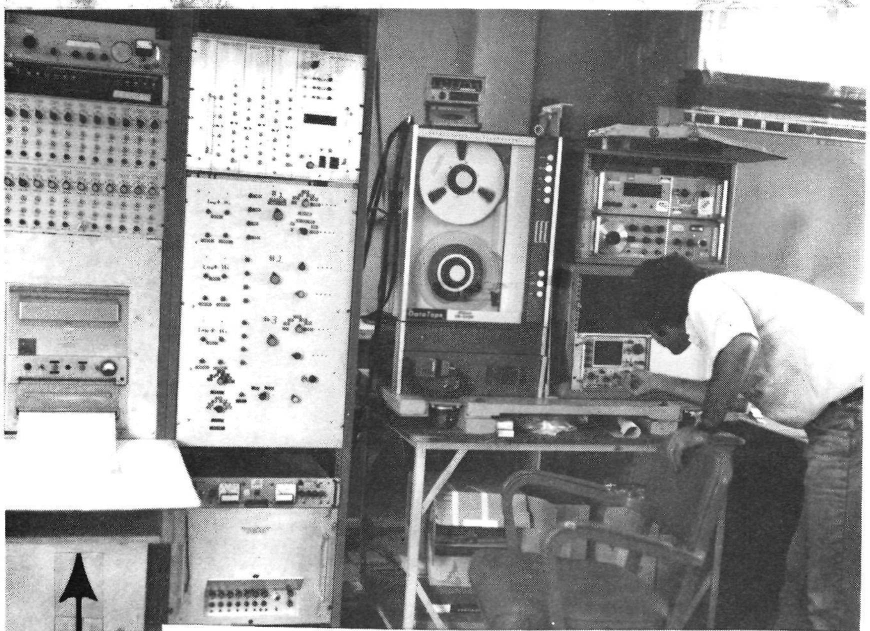
recording inst.

RICE UNIVERSITY

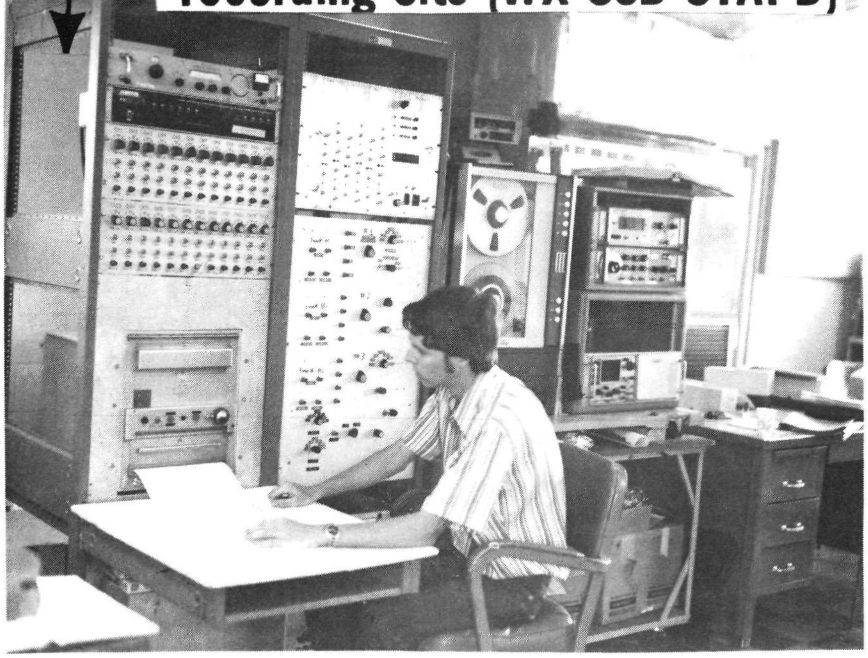
FEW



microphone typical—3 sites

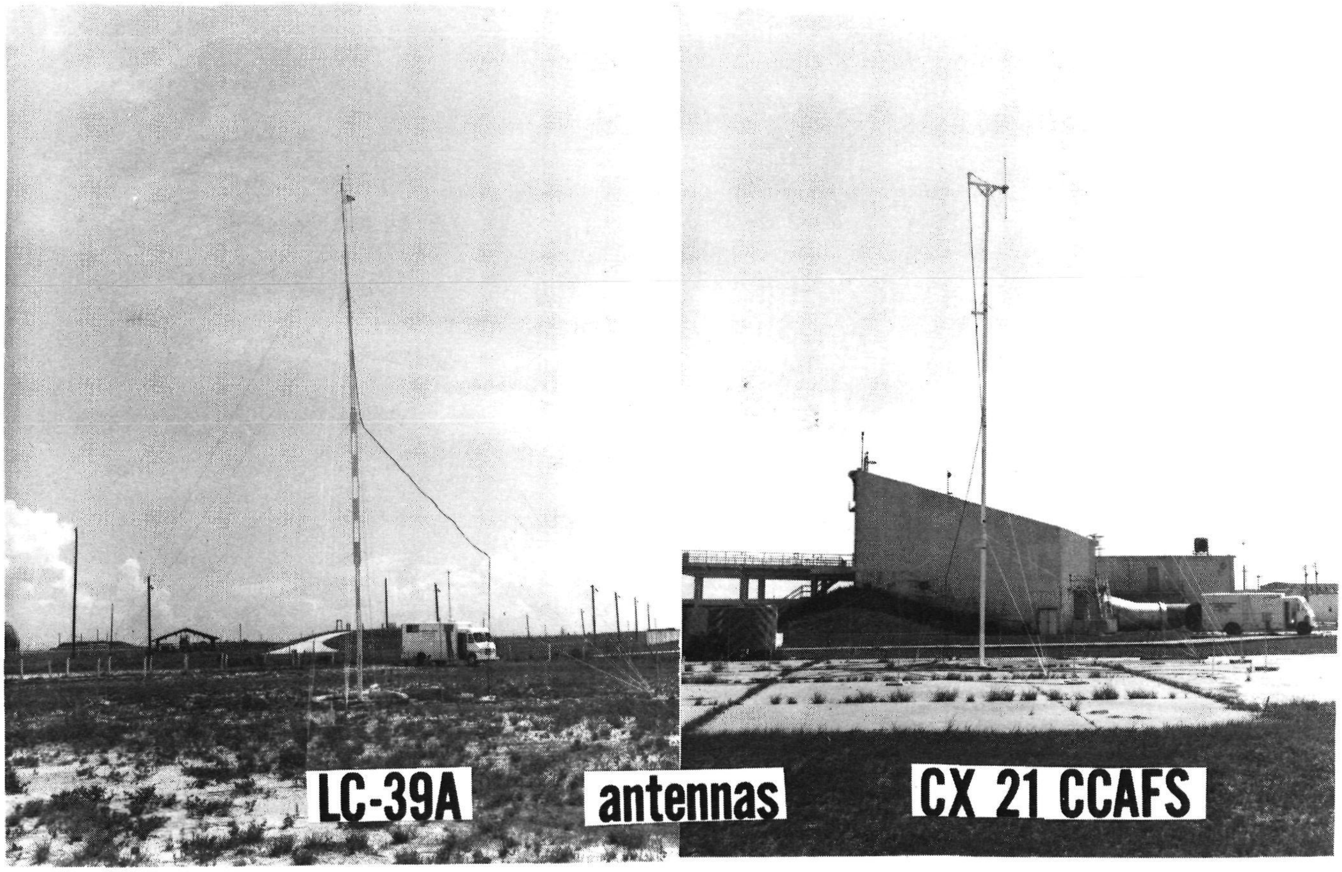


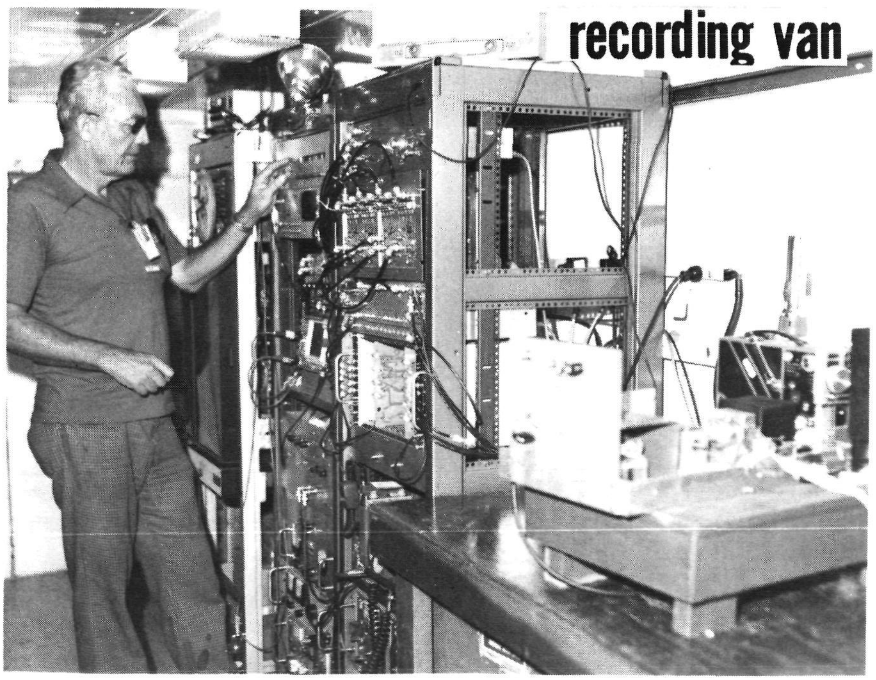
recording site (WX SUB STA. B)



NOAA ERL

TAYLOR



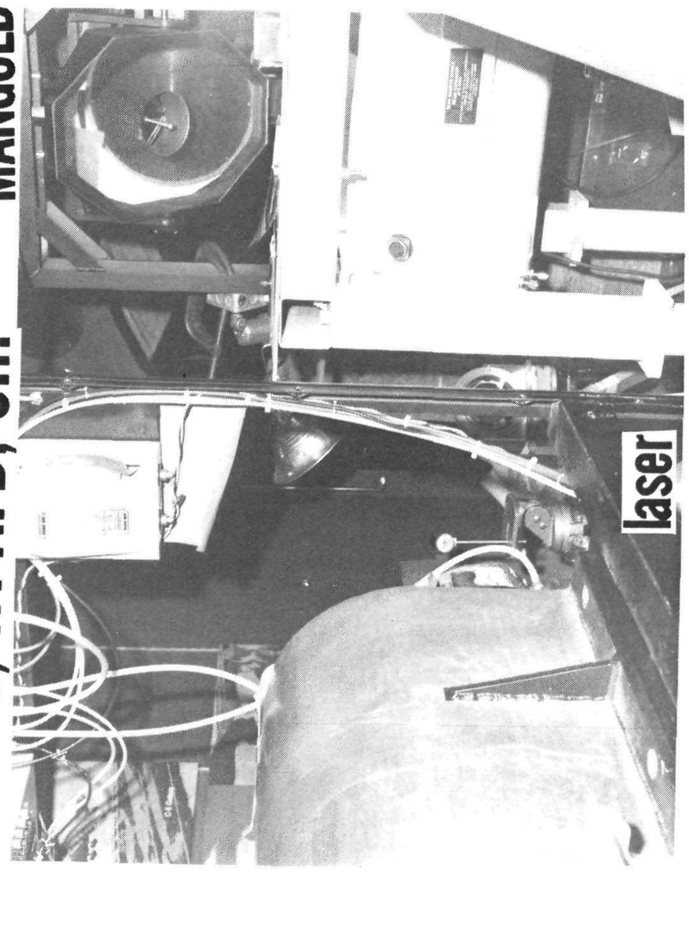


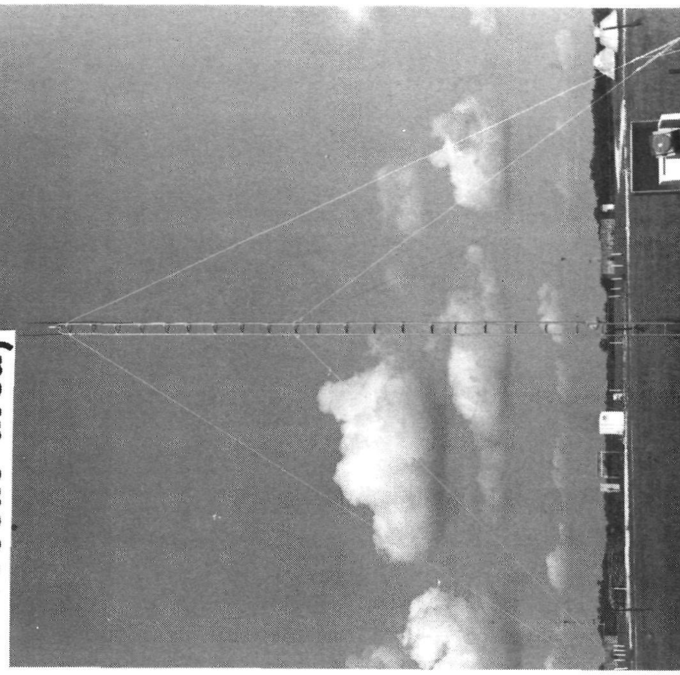
storm scope/laser control van

stormscope vans laser

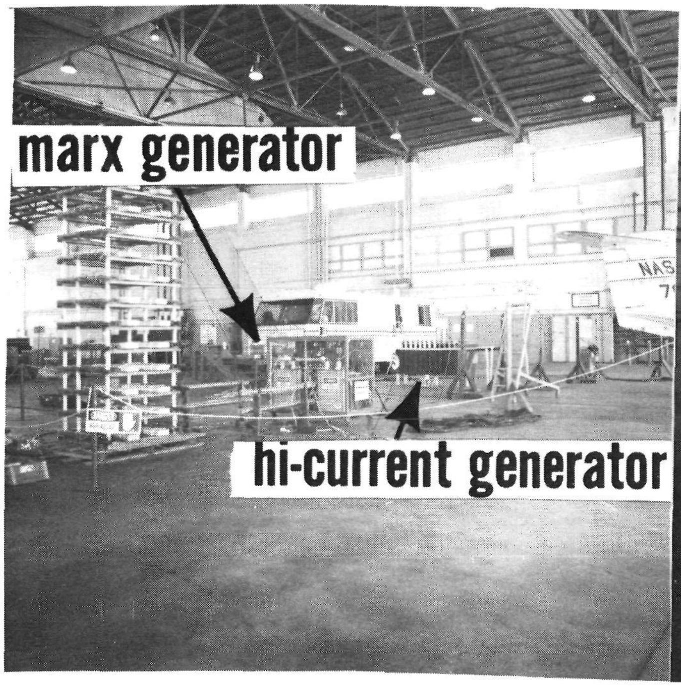
AFFDL, WPAFB, OH.

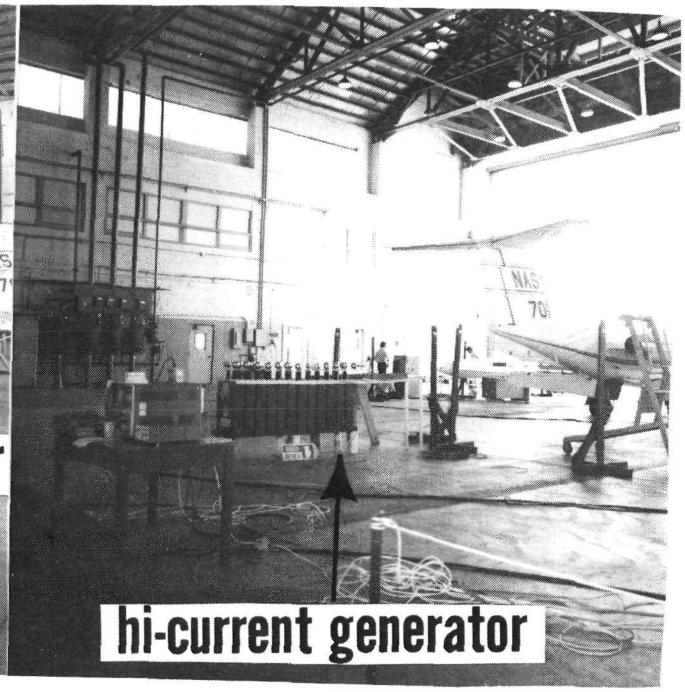
MANGOLD (fire & rescue area)



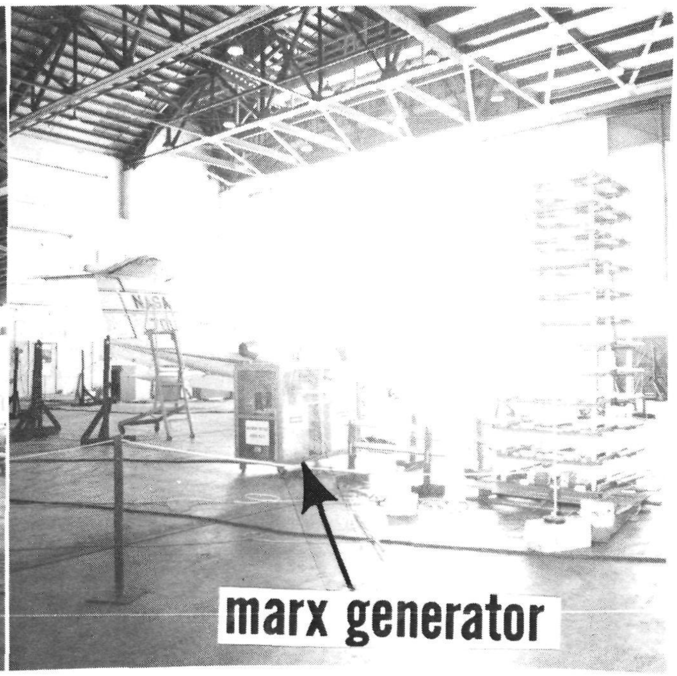


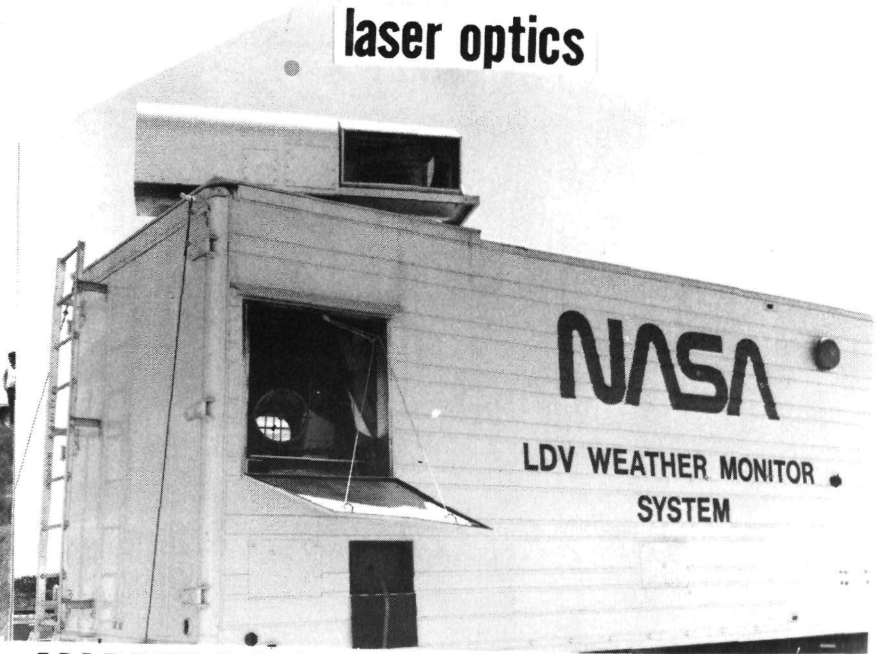
grounding tower &laser reflector





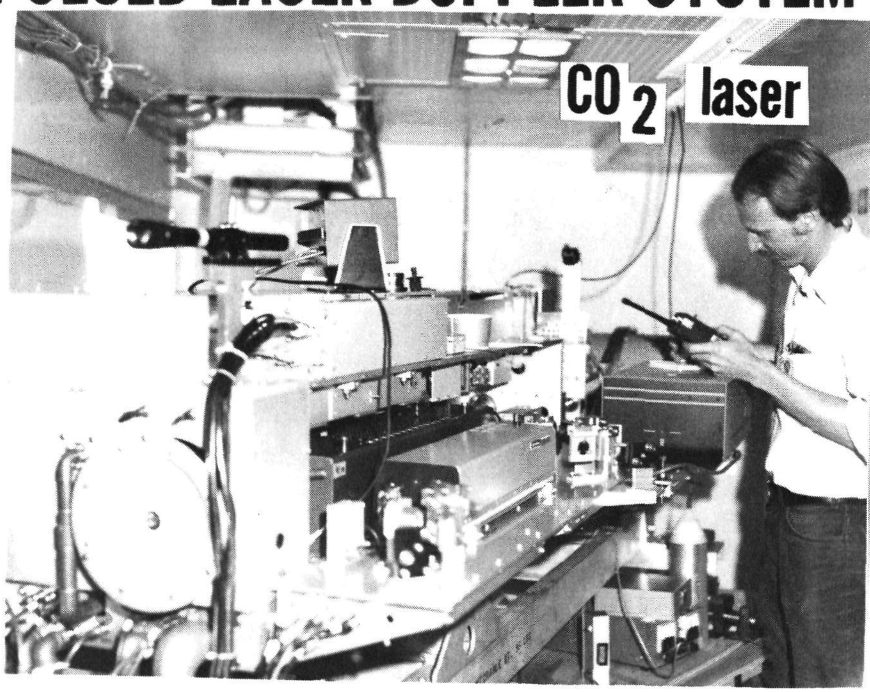
LIGHTNING A/C STRIKE TEST JSC-NASA/MANGOLD
hgr. 800 PAFB

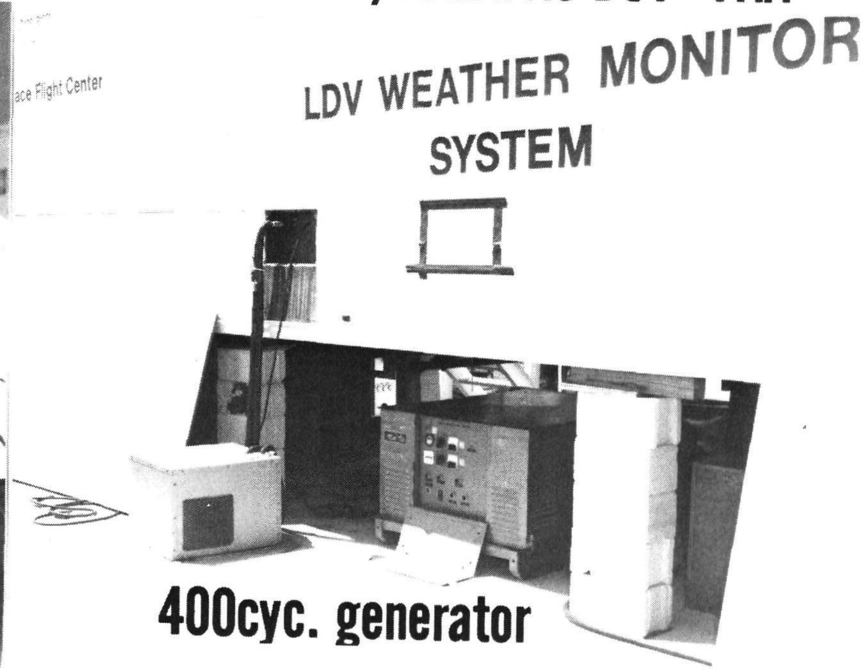




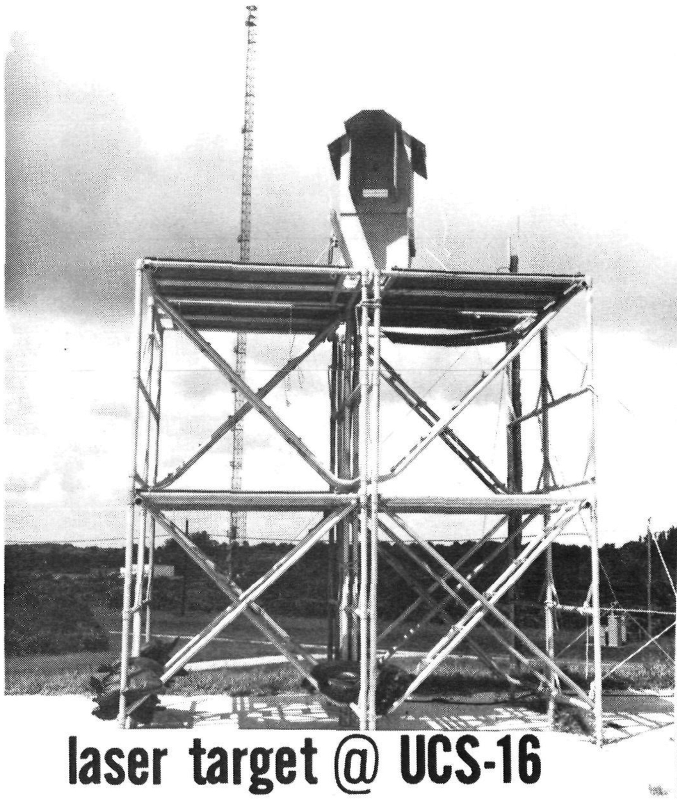
PULSED LASER DOPPLER SYSTEM

MARRERO-MSFC/KALAFAS-DOT—FAA





PULSED LASER DOPPLER SYSTEM



laser target @ UCS-16

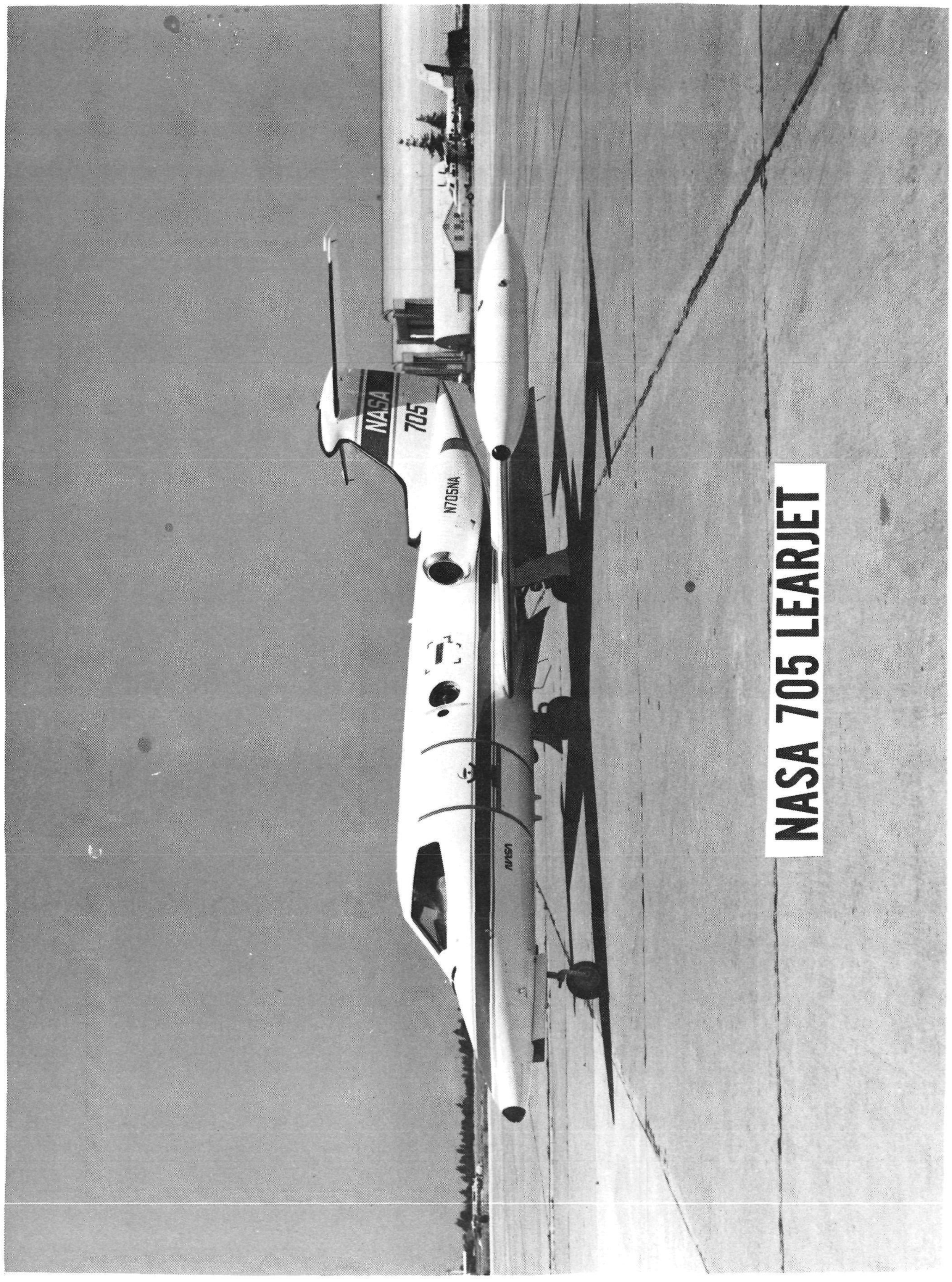
wind recording eq.
@ 150 meter tower

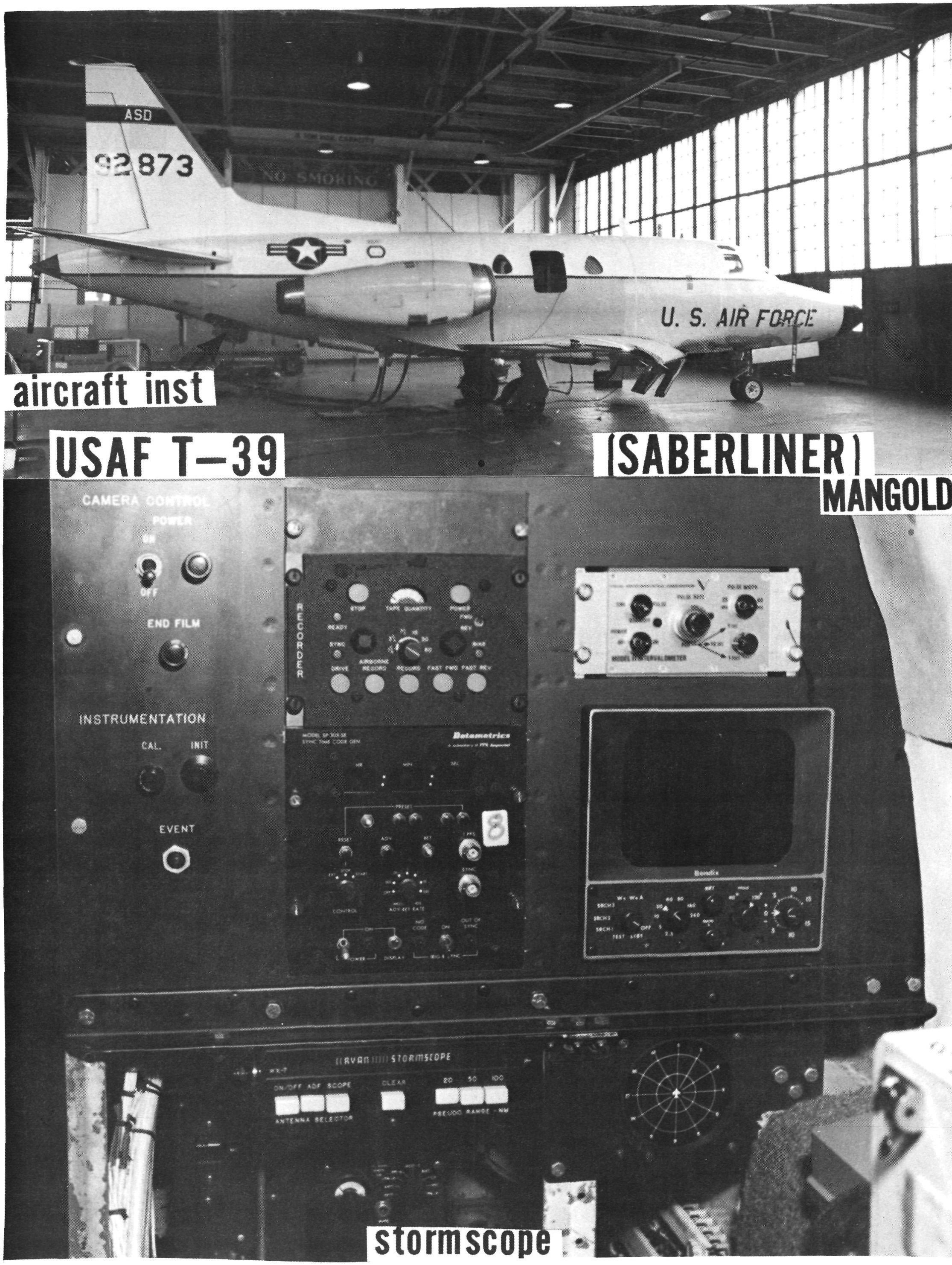
interior recording inst.

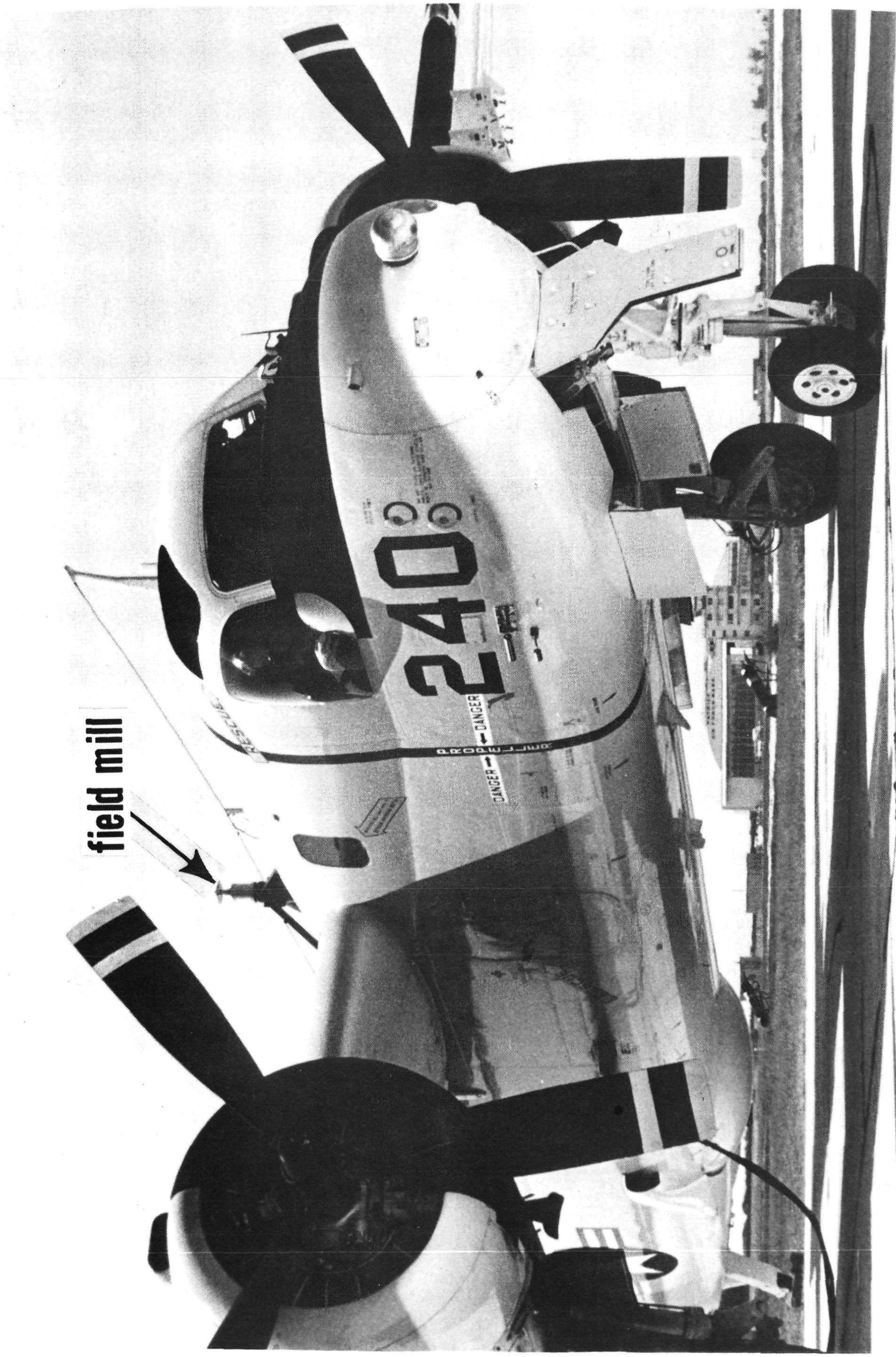
hanger 751

NASA-6


KSC BALLOON LIGHTNING TRIGGERING
STUBBS/STAHMANN
orbiter landing facility
triggering rocket
balloon system


NASA 705 LEARJET
NASA
705
N705NA

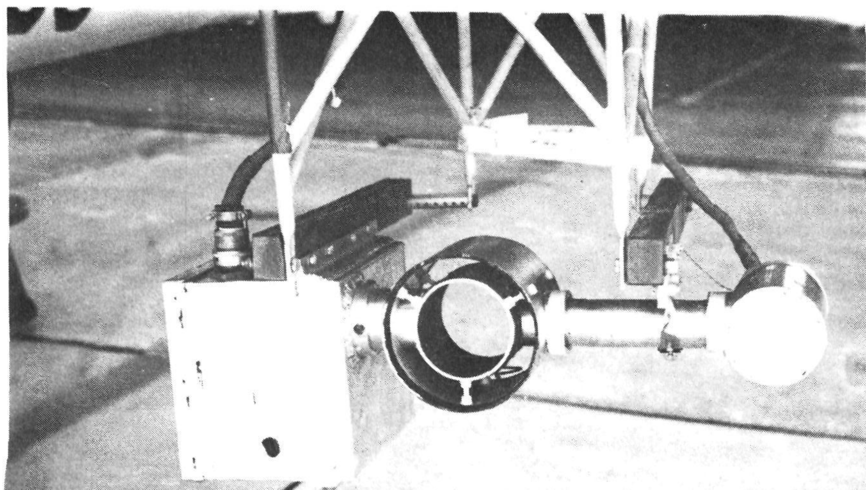

aircraft inst
USAF T-39
(SABERLINER)
MANGOLD
ASD
92873
U. S. AIR FORCE
CAMERA CONTROL
POWER
END FILM
INSTRUMENTATION
CAL.
INIT
EVENT
RECORDER
stormscope



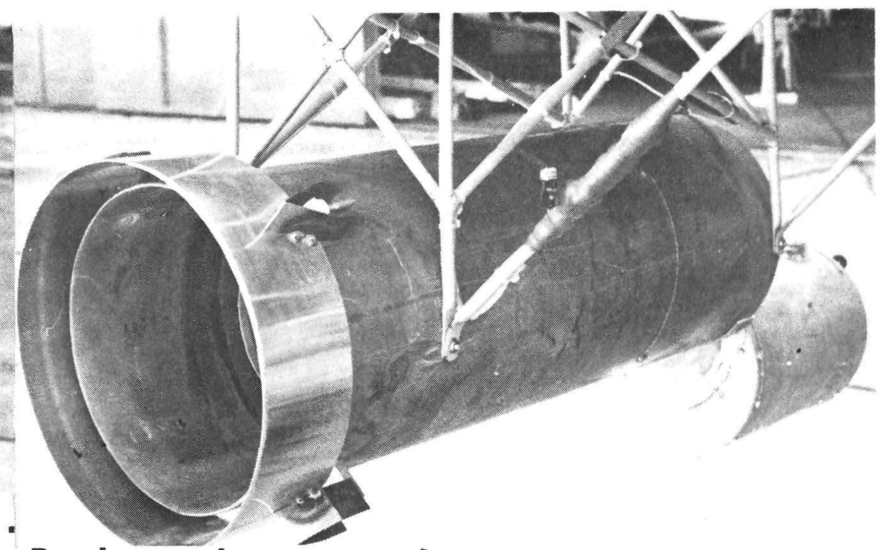
USN S2D Naval Research Lab. KASEMIR

ONR SCHWITZER 845A

NEW MEX. INSTITUTE OF MINING & TECHNOLOGY MOORE



Rain carried space chg. eq.
MOORE/CHRISTAN



Rain drop size eq.
LATHAM/ILLINGWORTH

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	Dates
Anderson, Ralph, Dr. Council for Scientific & Industrial Research National Electrical Engineering Research Institute P. O. Box 395 Pretoria, 0001 South Africa	7/19-28/77
Andra, Claude Establissement D'Etudes ETDE Recherches Meteorologiques (EERM) Meteorologie Nationale 73-77 Rue De Sevres 92100 Boulogne, France	7/6/77
Arnold, Roy, Dr. University of Mississippi Oxford, Mississippi	7/6-8/77
Berger, Karl, Dr. (Consultant) GSTAD STR 31 CH 8702, Zollikon, Switzerland	7/19-28/77
Blair, James National Geographic Society 17th & M Streets, N.W. Washington, D. C. 20036	8/1-11/77
Boulay, Jeal Louis Office National D'Etudes et de Recherches AerosPatiales (ONERA) 92320 Chatillon, France	7/27-28/77
Chin-Shan-Chiu Institute Atmospheric Sciences South Dakota School of Mines & Technology Rapid City, South Dakota 57701	7/14-20/77
Dowling, James U. S. Naval Research Laboratory Washington, D. C. 20375	8/1-2/77

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Fitzgerald, Donald R, Dr. Air Force Geophysics Laboratory Hanscom Field, Maine 01731	7/27-8/5/77
Hopkins, Margret L. Univeristy of Wisconsin Department of Meteorology & Space Science 1225 W. Dayton Street Madison, Wisconsin 53706	6/16-8/3/77
Horton, Richard U. S. Naval Research Laboratory Washington, D. C. 20375	8/1-2/77
Latham, John, Dr. University of Manchester Manchester, M60, 1QD, United Kingdom	6/26-7/8/77
Markson, Ralph, Dr. Measurement Systems Laboratory Department of Astronautics & Aeronautics Massachusetts Institute of Technology Cambridge, Massachusetts 02139	7/19-29/77
Marrino, Clifford, Dr. National Center of Atmospheric Research P. O. Box 3000 Boulder, Colorado 80303	7/19-22/77
Pearce, Jeffery University of Colorado Boulder, Colorado 80303	8/1/77
Ruhnke, Lothar, Dr. U. S. Naval Research Laboratory Code 8320 Washington, D. C. 20036	7/7-15/77

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Serafin, Robert J, Dr. National Center for Atmospheric Research P. O. Box 3000 Boulder, Colorado 80303	7/18-22/77
Taillet, Joseph Office National D'Etudes et de Recherches AerosPatiales (ONERA) 92320 Chatillon, France	7/27-28/77
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