

AD-A008 284

A PROPOSAL FOR COMMUNICATION AND  
COMMAND CONTROL AIRBORNE RELAY

H. B. Davis

RCA Corporation

Prepared for:

Air Force Eastern Test Range

23 January 1974

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# RANGE MEASUREMENTS LABORATORY

ETR-TR-75-15

(RML)

A PROPOSAL FOR  
COMMUNICATION AND COMMAND CONTROL  
AIRBORNE RELAY

23 JANUARY 1974

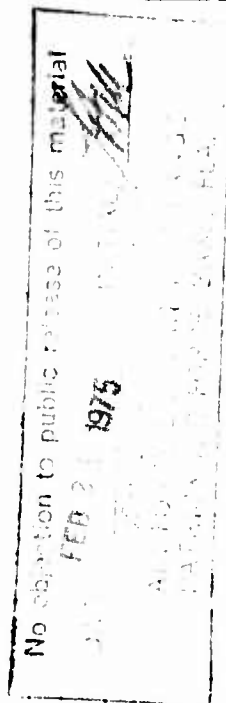
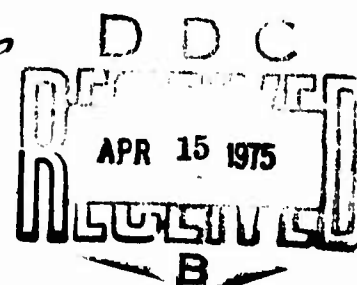
AIR FORCE EASTERN TEST RANGE

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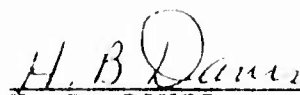
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A PROPOSAL  
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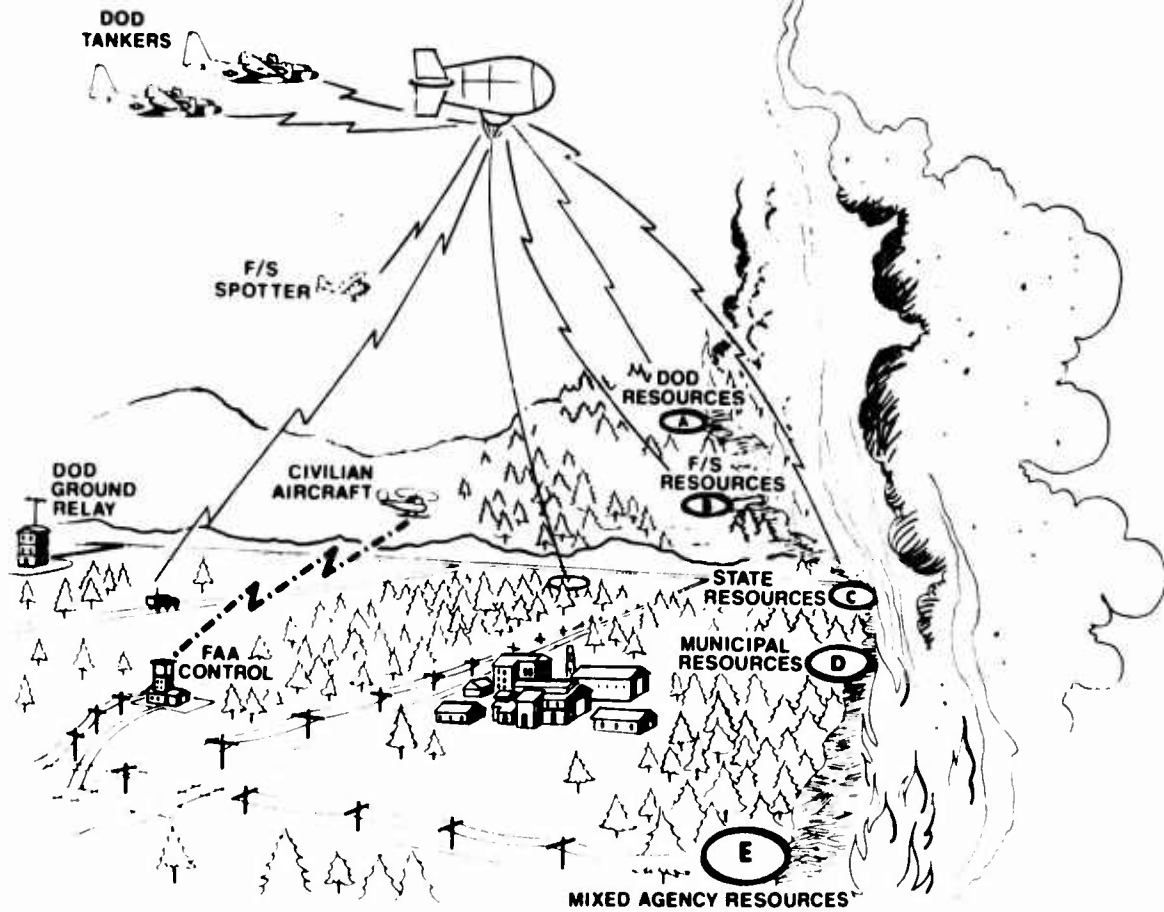
  
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RANGE MEASUREMENTS LABORATORY  
AIR FORCE EASTERN TEST RANGE  
PATRICK AIR FORCE BASE, FLORIDA

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# LARGE AREA FIRE



○ FIRE FIGHTING TEAMS

🚒 FOREST SERVICES MOBILE CONTROL

⋈ LAND LINES

⚡ RADIO LINKS

✓

## SECTION 1

### INTRODUCTION

#### 1.1 THE NEED FOR AN INTEGRATED AIRBORNE COMMUNICATION/COMMAND RELAY SYSTEM FOR FIRE SUPPRESSION OPERATIONS

The communication between fire fighting, rescue team, or other mobile emergency groups operating in remote forest areas of the United States has always been a major problem. Large forest fires are fought by a combination of agencies that may include Department of Defense, Forest Service, municipal, and county fire departments and state and civilian organizational elements. As many as 30,000 people, supported by quantities of logistic and fire fighting equipment, are required to contain and suppress large forest fires. The direction and control of this task force requires that information and orders flow quickly and clearly to the first-line fire fighting teams. Feedback information to central control is essential.

To provide a communication network for such emergencies, many areas have been spotted with radio command networks including fixed, mobile, and repeater stations. While a large geographical area is covered by these networks, there are many areas where only marginal communications are possible, and a number of areas are completely beyond range of the existing networks.

Where roads or trails do not permit vehicles, additional problems are found in attempting to maintain communication with groups operating with equipment which can be carried by one individual. Communication with these groups can be obtained only from particularly high elevations where absorption between the relay tower and the point is not excessive.

A system of balloonborne communication/command control relay stations could provide a significant improvement in completing emergency communication service or control in areas otherwise completely isolated from any other means of communication.

A balloon system offers significant advantages as a communication relay. The balloon system would have relatively low initial cost, minimal operating costs, and it would require only a small labor force to operate and maintain the equipment.

The frontispiece is a view of a large area fire with the various groups united in their fire fighting efforts. The advantages of a balloon relay for keeping all groups informed of the progress

on the fire line is readily apparent. The balloon provides a means of quickly establishing a communication relay line for voice, teletype, TV, or other purpose between the field groups and the control center.

The size of the balloon required for a specific purpose would be determined by the equipment weight, power requirements, and altitude requirements of the specific mission. The maximum benefit of balloon operation in mountainous terrain would be in the effect of altitude permitting communication to marginal or dead areas shaded by hills or other obstructions. Since UHF and VHF frequencies are normally limited by line-of-sight, elevation is therefore more important than the equipment power and range capability. Figure 1-1 shows such a relay situation.

## 1.2 THE APPLICATION OF TETHERED BALLOONBORNE EQUIPMENT FOR A COMMUNICATION/COMMAND CONTROL RELAY

The Range Measurements Laboratory (RML) of the Air Force Eastern Test Range (AFETR) has been engaged in a number of programs sponsored by the Advanced Research Projects Agency of the Department of Defense.

One of these programs was to research and develop an airborne television and communications relay system covering various frequencies and frequency ranges. The experience gained on these projects is directly applicable to the requirements of the Forest Service, NOAA, and other government agencies. Television relay from balloon platforms at distances greater than 100 miles has been achieved. Relay range is limited primarily by the elevation of the balloon. A view of the airborne package used on several airborne TV relay tests is shown in figure 1-2. A second balloon could be used for additional coverage. In this way the relay service may be extended to as much as 500 miles by using balloon to balloon relay.

A system such as described in this proposal could solve many of the existing problems of remote communication or control. The feasibility of such a system as herein proposed has been established at the Cape Kennedy Air Force Station. We therefore recommend that a three phased program be developed to demonstrate and evaluate the balloon relay communication concept. Phase I would be a small low cost short range relay demonstration; Phase II would demonstrate the long range capability; and Phase III would be an operational on site evaluation.

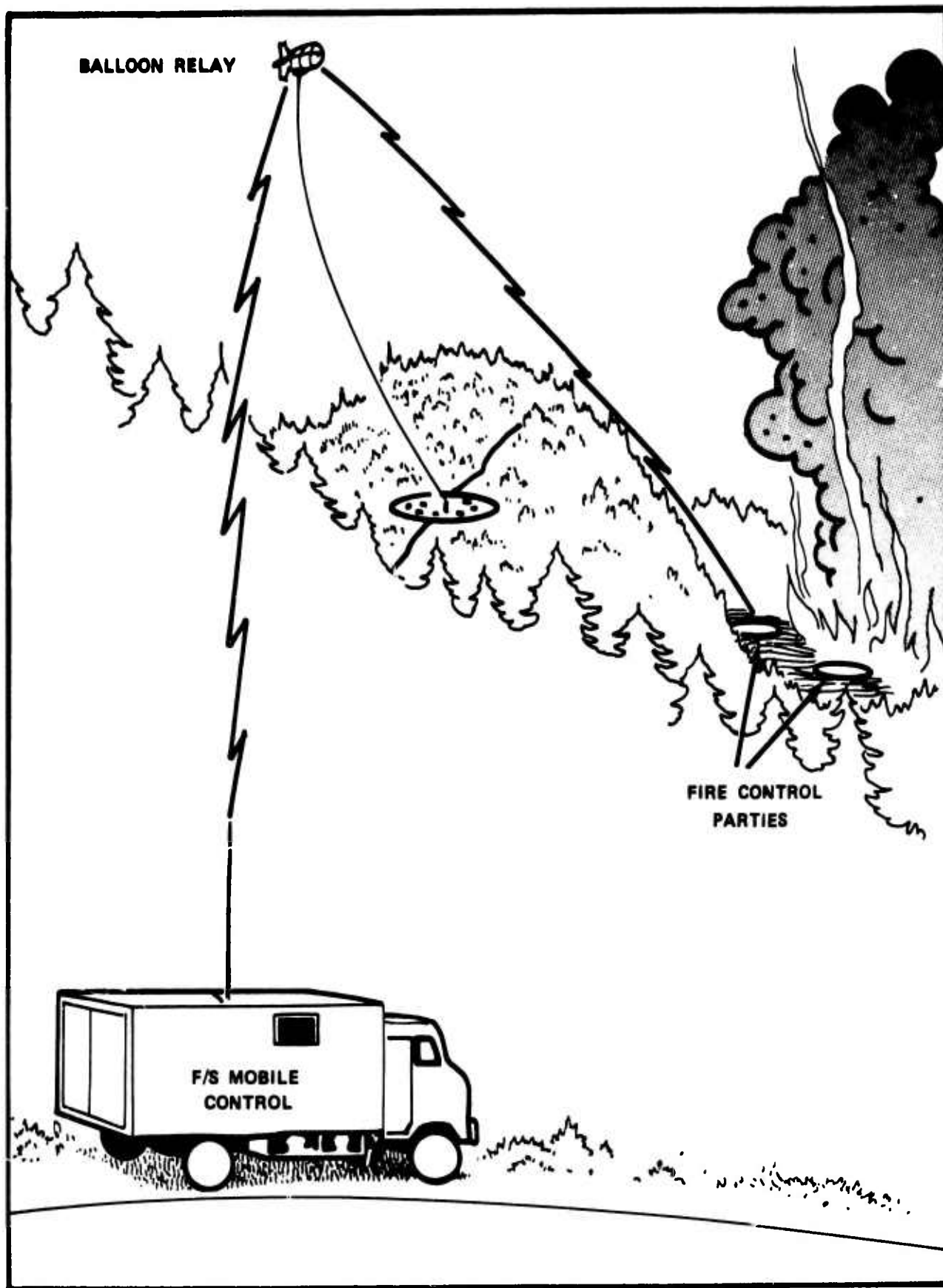


Figure 1-1.— Balloon Relay in Mountainous Terrain

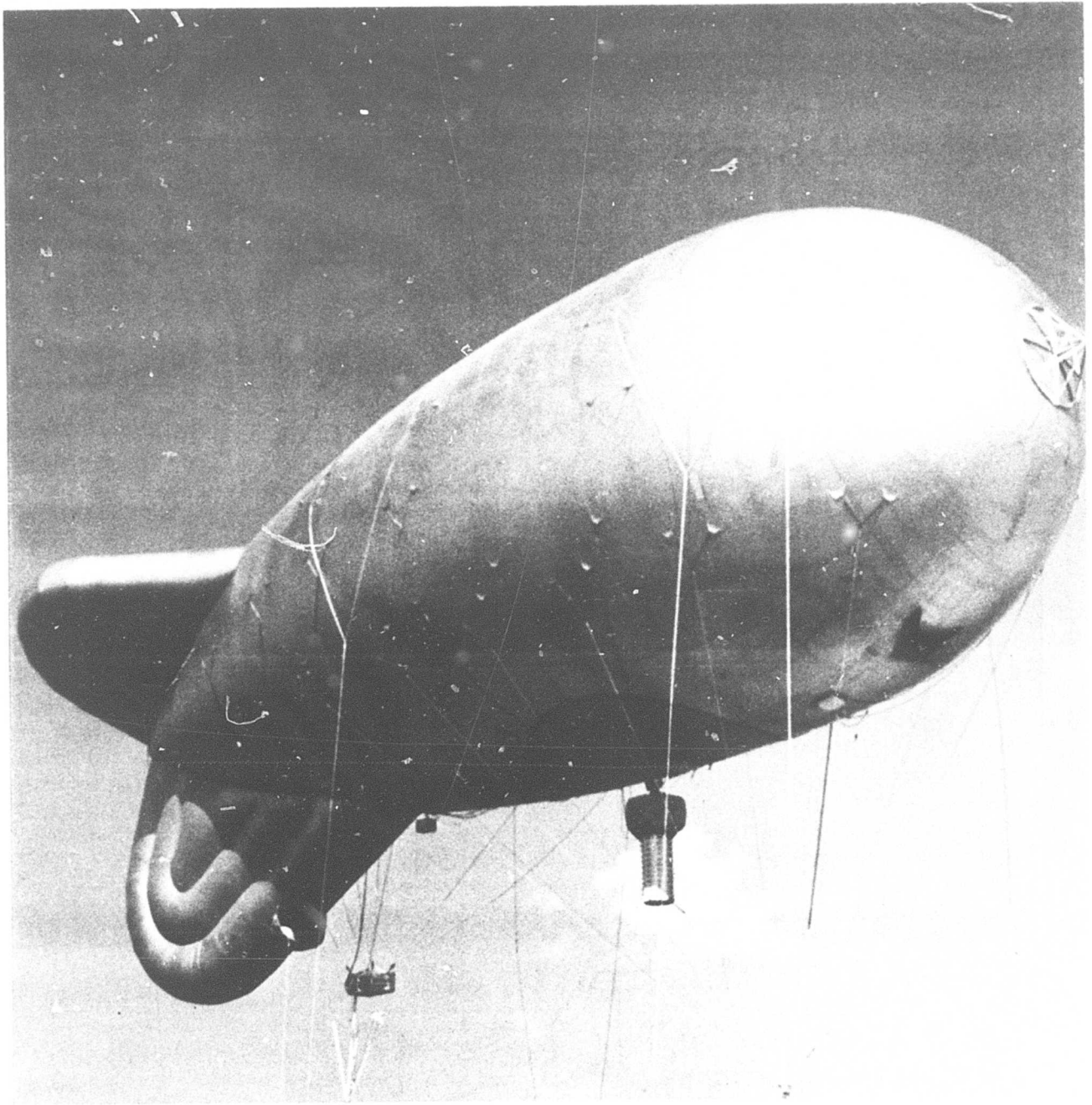


Figure 1-2. — Balloonborne Communication Package

SECTION 2  
PROJECT SUMMARY

2.1      SPECIFIC OBJECTIVES

Because of the wide range of requirements of the different services, the objectives have been divided into three phases. Phase I is a small, low cost balloon system which could lift a limited number of communication channels for short range relay. Phases II and III use a large, high altitude balloon system. The individual systems are described below.

2.1.1      Phase I: Feasibility Demonstration: Short Range Communication Relay Demonstration at CKAFS

1. Detect and relay voice communication two-way through a balloon system, one channel in each direction, at ranges up to or exceeding 30 miles.
2. Report results of the above tests with conclusions and recommendations after two weeks of testing at Cape Kennedy Air Force Station.

2.1.2      Phase II: Feasibility Demonstration: Long Range Command-Control Relay at CKAFS

1. Detect and relay both TV and voice signals in a specified frequency band at ranges greater than 100 miles by a balloonborne relay system.
2. Report results of the above tests with conclusions and recommendations after one month of testing at Cape Kennedy.

2.1.3      Phase III: On-Site Demonstration

1. Establish a balloon-relay system capability at a typical operating site selected by the interested agency. Operate and demonstrate the system.
2. Report results, conclusions, and recommendations.

## 2.2 OPERATIONAL CONCEPTS

### 2.2.1 Phase I: Short-Range Communications Relay Demonstration at CKAFS

The 5,300 cubic foot balloon (fig. 2-1) will be used to lift a lightweight package (airborne communication equipment available at CKAFS) to an altitude of 3,000 feet. Ground communication equipment will be installed in a mobile vehicle that will cruise in the Cape vicinity. The airborne system will relay two-way voice communications between the mobile vehicle and ground control. Ranges for the test will approximate 30 miles.

### 2.2.2 Phase II: Long Range Communication/Command Control Relay Demonstration at CKAFS

An existing DOD Family II D-7 tethered balloon system (fig. 2-2) with associated facilities and ground support equipment will be operated on a time shared basis with other projects at the Cape. The balloon system will be capable of attaining an altitude of 10,000 feet or more carrying a 1,000 pound payload requiring 4KW or less. Within these limits no balloon R&D is required. Repackaging of existing equipment and fabrication of some new equipment will be required.

For these tests the airborne electronics package will include an eight-sided antenna array with antennas on each face (fig. 2-3). A flux gate compass will be used to sense a change in balloon heading and switch to the optimum antenna face to transmit in the desired direction.

The basic system (originally developed for the TRIM LINE Project) is on hand and has demonstrated its ability to relay wide-band information such as television.

The TRIM LINE system is an electronic relay package weighing approximately 550 lb in the present configuration. This configuration can be changed to meet the mission requirements including the relay of frequencies in the 400 MHz, 2-3 GHz, 50 MHz, and 100 MHz areas of the spectrum. The balloonborne electronics frequency translates the frequency to C- or L-band and transmits it to a ground station where it is retranslated to the original frequency for feeding to the applicable receiver.

Bandwidth capabilities include the relaying of up to five television channels, 30 MHz (24-54 MHz) of VHF voice channels, one telemetry link (2-3 GHz) including Loran C data, and UHF command data. Individual mission requirements will dictate the equipment modification configuration.

A mobile land based communication link to cruise within a 100 mile radius will be used to demonstrate communications while existing TV stations will be used to demonstrate relay capability.

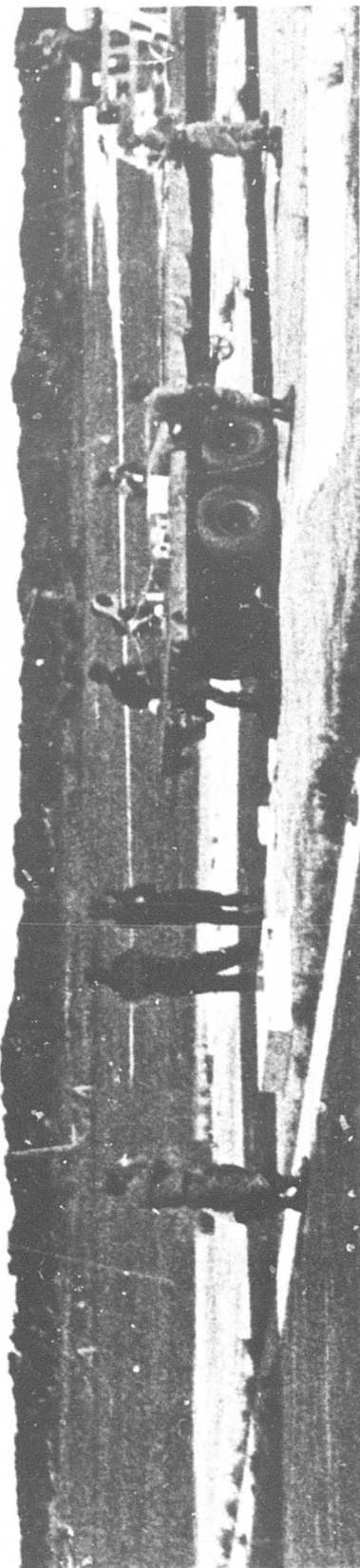
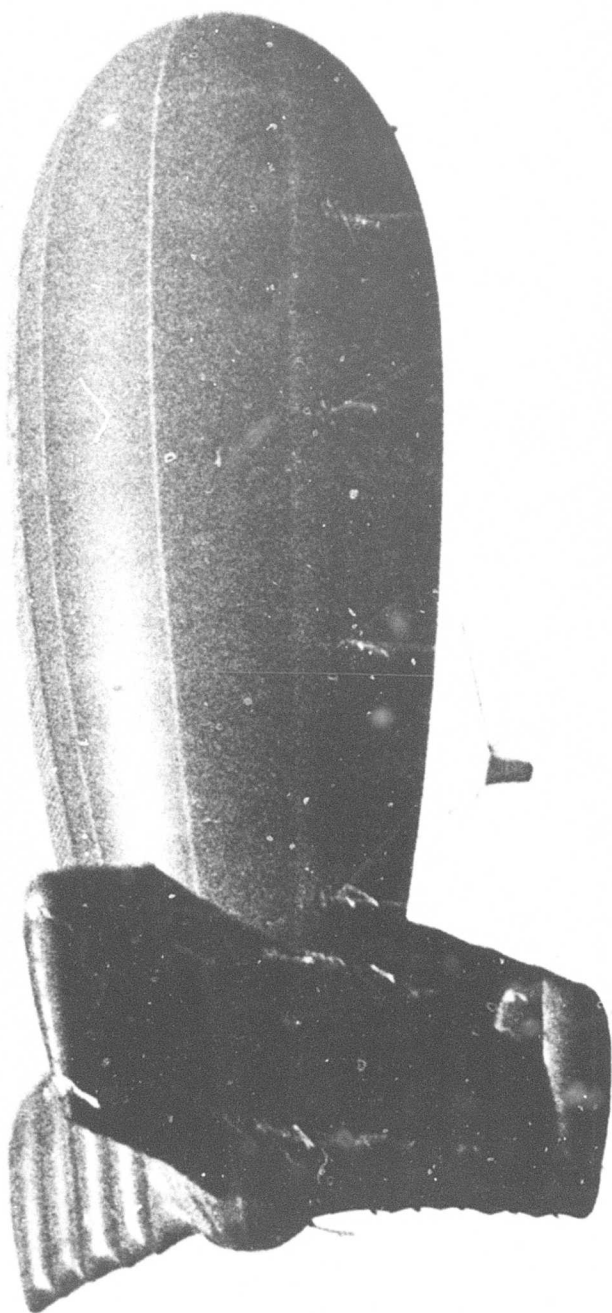


Figure 2-1. — Baidy Type Balloon

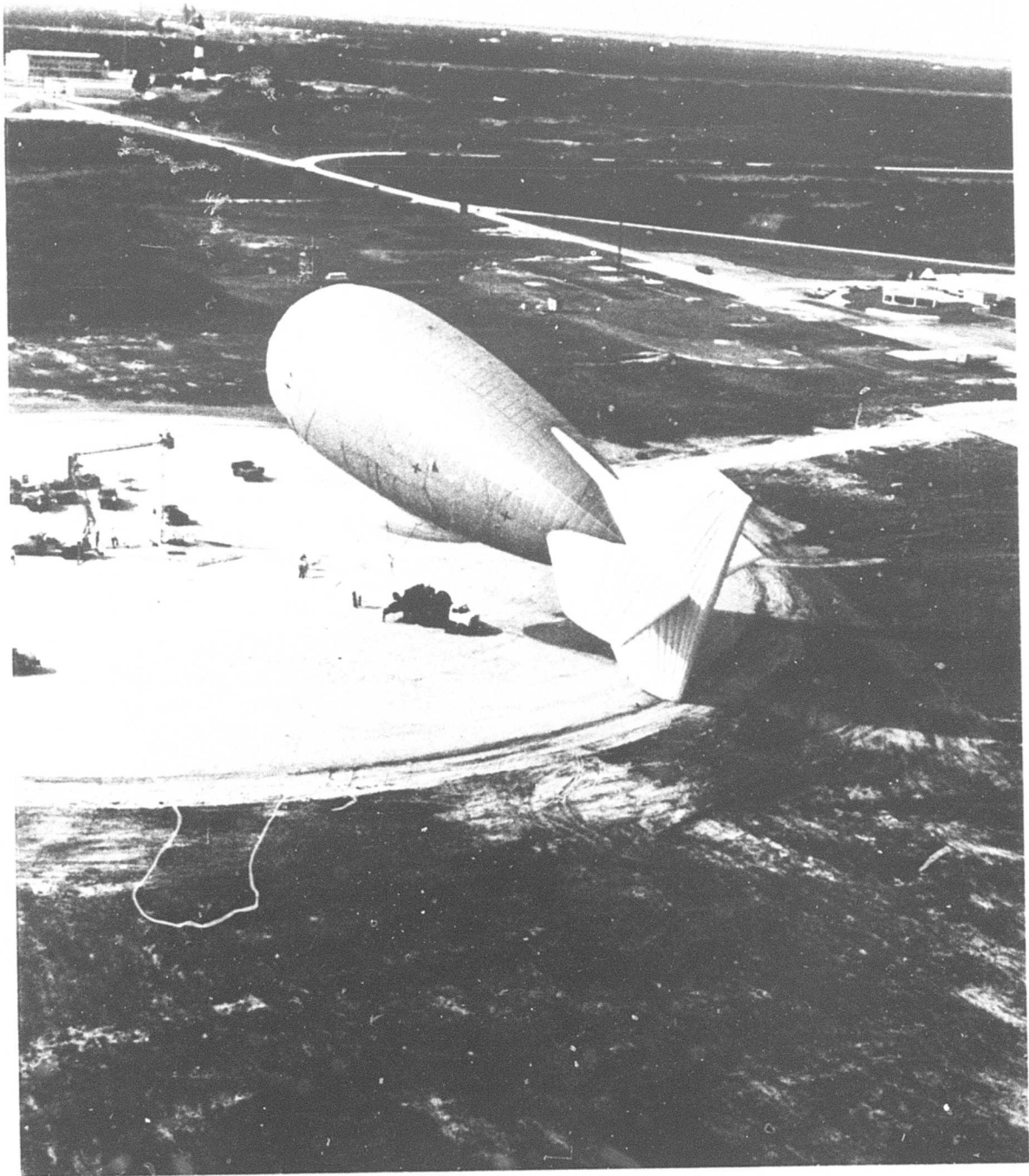


Figure 2-2. — Family II Balloon

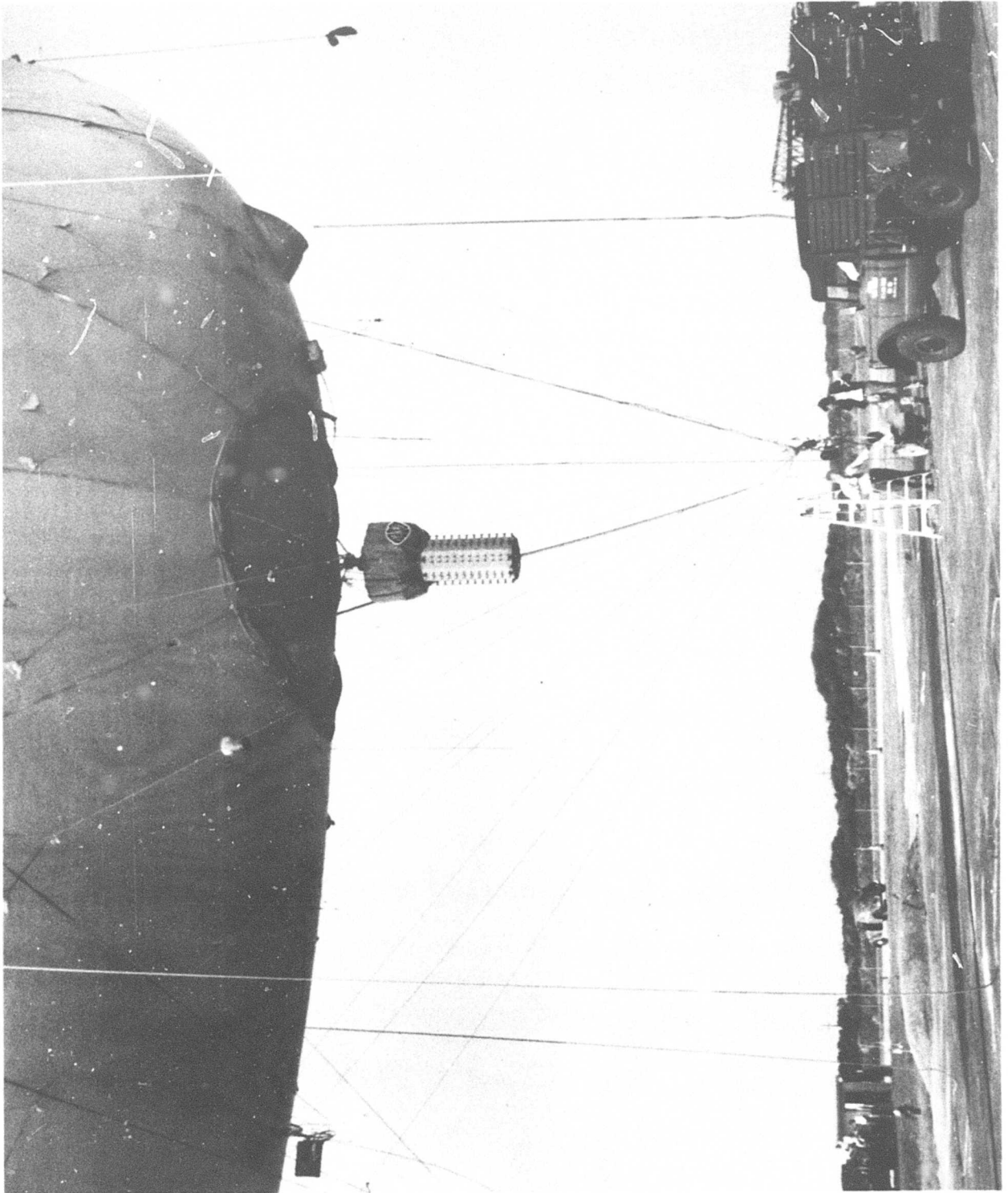


Figure 2-3. — Trim Line Communication Relay Package

### 2.2.3 Phase III: On-Site Demonstration

This phase will consist of operating the Phase II equipment in the normal environment where it is to be used.

### 2.2.4 Phase I: Operations

Flight operations for Phase I will start approximately 1 month after project approval. Tests will utilize existing equipment arranged to be flown by a 5,300 cubic foot balloon at Cape Kennedy. The flights will demonstrate the improved operations using the balloonborne equipment. With existing equipment, communication should be consistent between sites up to 30 miles or more apart.

Although the range specified in Phase I is limited, this range is by no means to be construed as the practical limits. The range specified was estimated considering the use of existing low power radio equipment. Optimized radio equipment, a larger balloon, and a lighter tether would permit increased altitude and a corresponding increase in range.

### Phase II

The Phase II will require a larger balloon (Family II) to carry the load. Flight operations will start approximately four months after payload contract approval. The balloon flights will be on a time shared basis with other tests at the Cape. Demonstration of both two-way voice communication and television relay will be presented.

Primary data will be collected to determine the consistency of signals and limit of range, considering fading, absorption or other anomalies. Progress reports will be issued monthly or at the completion of each major phase.

### Phase III

This portion of the project will consist of equipment demonstration in any selected area to show the advantages of such a system in mountainous country. Data similar to that of Phase II will be collected.

## 2.3 PROJECT MILESTONES

The estimated time required for each milestone period is shown on the following page.

# PROJECT MILESTONES

| ACTIVITY                       | MONTHS |   |   |   |   |   |
|--------------------------------|--------|---|---|---|---|---|
|                                | 1      | 2 | 3 | 4 | 5 | 6 |
| <u>PHASE I (CKAFS)</u>         |        |   |   |   |   |   |
| PREPARING BALLOON              | —      |   |   |   |   |   |
| PREPARATION OF EQUIPMENT       | —      |   |   |   |   |   |
| INTEGRATION WITH BALLOON       | —      |   |   |   |   |   |
| DEMONSTRATION FLIGHTS          |        | — |   |   |   |   |
| REPORTS                        |        | — |   |   |   |   |
| <u>PHASE II (CKAFS)</u>        |        |   |   |   |   |   |
| PREPARATION OF BALLOON         | —      |   |   |   |   |   |
| PREP OF RELAY EQUIPMENT        | —      | — |   |   |   |   |
| INTEGRATION WITH BALLOON       |        | — | — |   |   |   |
| DEMONSTRATION FLIGHTS          |        |   | — | — |   |   |
| REPORT                         |        |   |   | — | — |   |
| <u>PHASE III (REMOTE SITE)</u> |        |   |   |   |   |   |
| ORGANIZING                     | —      |   |   |   |   |   |
| PACKING                        | —      | — |   |   |   |   |
| MOVING (TRANSPORTATION)        |        | — |   |   |   |   |
| SETUP & CHECKOUT               |        | — | — |   |   |   |
| OPERATION & EVALUATION         |        |   | — | — |   |   |
| RETURN TO CKAFS                |        |   |   | — | — |   |
| FINAL REPORT                   |        |   |   | — | — |   |

## 2.4 COST ESTIMATE

|     | Phase                                               | Actions                                                                                                                                                             | Costs                                            |
|-----|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| I   | <u>CKAFS Demonstration</u><br>(available equipment) | Preparing balloon<br>Preparing equipment<br>Integration of System<br>Flight tests                                                                                   | \$10,000                                         |
|     |                                                     | Total                                                                                                                                                               | \$ 10,000                                        |
| II  | <u>CKAFS Demonstration</u><br>(TRIM LINE System)    | Preparation of<br>balloon<br>Preparation of<br>relay equipment by<br>contractor<br>(Westinghouse)<br>Integration of system<br>Flight test<br>Supplies/shop services | 2,000<br><br>30,000<br>5,000<br>20,000<br>15,000 |
|     |                                                     | Total                                                                                                                                                               | \$ 72,000                                        |
| III | <u>Remote Site Opera-<br/>tion</u>                  | Relay equipment opera-<br>tion and maintenance<br>Balloon operation and<br>maintenance<br>Facility activation<br>Transportation/supplies                            | 50,000<br><br>60,000<br>25,000<br>40,000         |
|     |                                                     | Total                                                                                                                                                               | \$175,000                                        |

APPENDIXES

- A. THE FAMILY II D-7 BALLOON SYSTEM
- B. RANGE MEASUREMENTS LABORATORY  
QUALIFICATIONS AND EXPERIENCE

## APPENDIX A

### THE FAMILY II BALLOON SYSTEM

The Family II 200,000-cu ft balloon is an aerodynamically shaped, single-hull, ballonet balloon with a cruciform stabilizer. The design includes several unique features to provide better stability, permit operations in high winds at altitude, and provide all-weather capabilities.

The hull is a Class C shape with a fineness ratio of 2.6. The overall fineness ratio of the balloon is 3.1. It is constructed of a urethane Dacron laminate material and designed to survive 90-knot winds at sea level. The ballonet, located within the hull, is pressurized by blowers which obtain air through chin scoops located on the lower portion of the hull.

The cruciform stabilizer, which is located much further aft on the hull than on conventional aerodynamic balloons, is pressurized by blowers for structural stiffness. Guy-wire bracing between the vertical and horizontal stabilizers provides additional structural stiffness. The vertical fin has a large fillet, or ventral fin, to provide additional stiffness to the hull which prevents buckling under extreme aerodynamic loads. The cruciform configuration was selected for this design because it provides the same aerodynamic stability with more structural rigidity than a Y-configuration of equal planform area.

The balloon is designed to carry approximately 1,000 lb of useful payload in the blister-shaped housing beneath the hull. Power generation equipment is carried external to the blister enclosure, and weighs 520 lb.

The blister is designed to reduce aerodynamic drag and to protect the payload. The payload is attached directly to the balloon using a payload ring which is laced to the hull. Tethering is by a single cable attached to the confluence point beneath the balloon. Ground handling equipment for this large balloon system is based on proven techniques developed for handling manned blimps. The basic ground equipment consists of a portable mooring mast set in place with ground anchors, a gondola attached to the underside of the balloon, and line-handling winches. When moored, the nose of the balloon is secured to a rotating latch on the mast, and the balloon is free to weathercock into the wind. The gondola

provides the proper weight-and-balance and acts as a restraint to protect the balloon from ground damage. The main balloon tether-cable winch is mounted on a self-propelled truck, which also has smaller winches for ground handling lines. The mooring mast and its attendant ground anchor drive system are also unitized on a self-propelled truck. This provides total mobility for the balloon ground handling system.

The balloon itself can be relocated from site-to-site without the necessity for deflation. In tests conducted at Cape Kennedy Air Force Station, the balloon was successfully towed over 20 miles of sandy terrain with a standard D-8 bulldozer. It was also towed from site-to-site by helicopter to confirm tactical mobility. Complete specifications for the balloon are shown in figure A-1.

The Family II balloon is shown leaving the mooring mast in figure A-2. This balloon may be required for larger relay system weighing in the 1,000 pound category.

For setting up a new or temporary balloon site, a portable mooring mast is used. Figure A-3 shows the truck used for transporting and setting up the portable mooring mast. The mast in place before the truck is separated is shown in figure A-4. The same truck is used to set the tower anchors. Figure A-5 shows the portable mast in place and ready for use. Figure A-6 shows a typical balloonborne power supply.

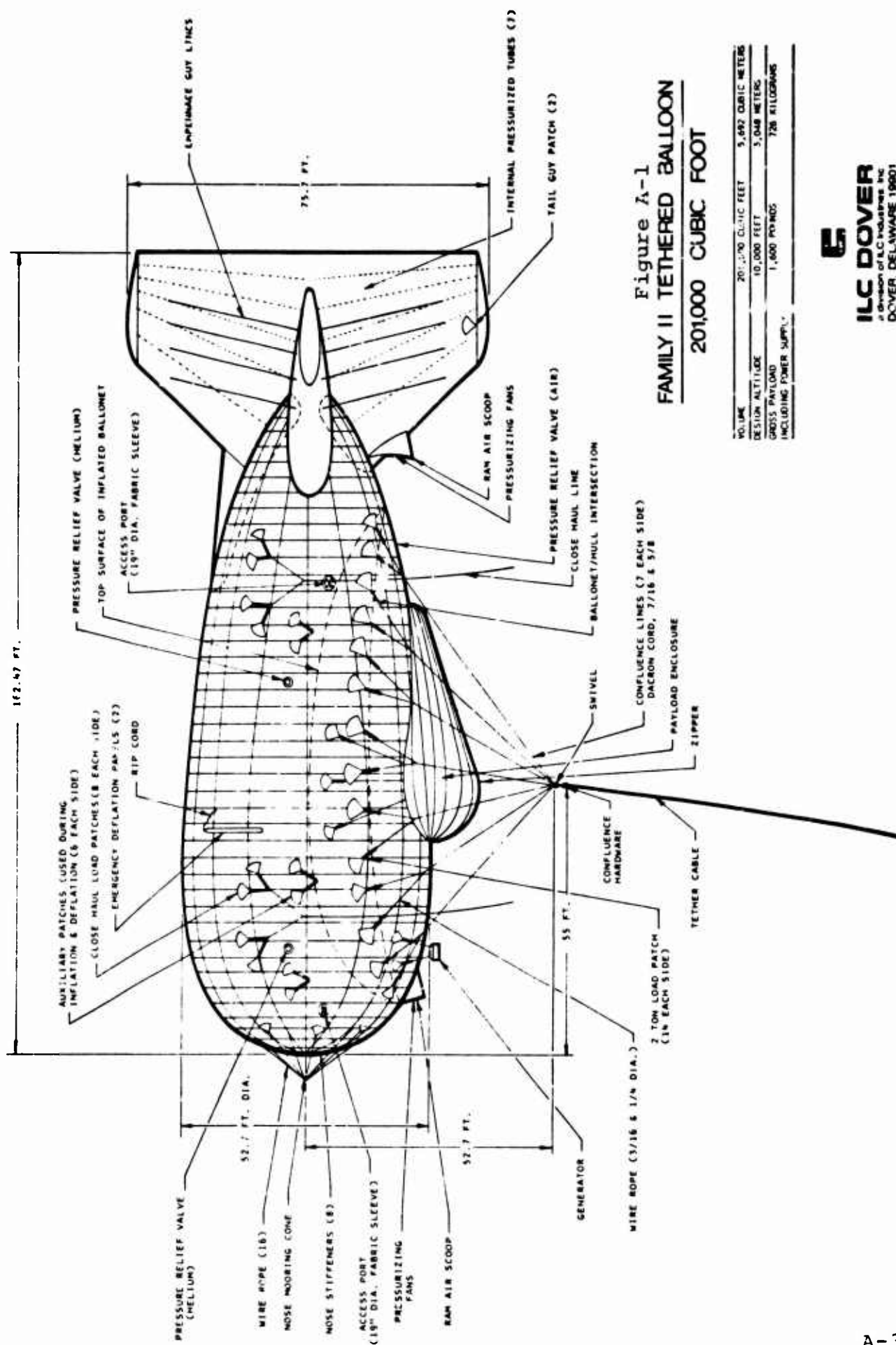


Figure A-1  
FAMILY II TETHERED BALLOON  
201,000 CUBIC FOOT

|                                      |                    |                    |
|--------------------------------------|--------------------|--------------------|
| VOLUME                               | 201,000 CUBIC FEET | 5,692 CUBIC METERS |
| DESIGN ALTITUDE                      | 10,000 FEET        | 3,048 METERS       |
| GROSS PAYLOAD INCLUDING POWER SUPPLY | 1,600 POUNDS       | 728 KILOGRAMS      |

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Figure A-2. — Family II Balloon Leaving Mooring Mast

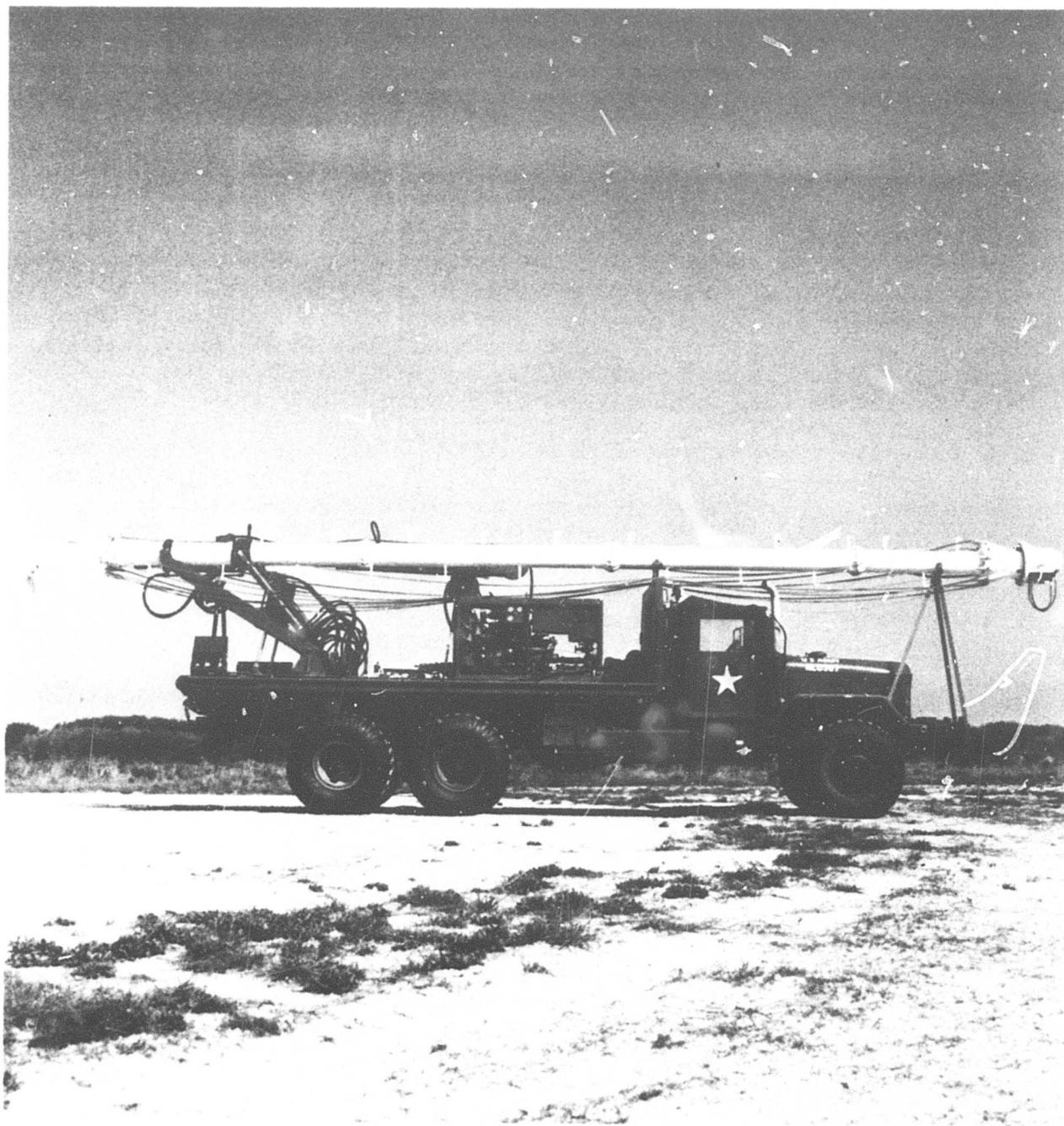


Figure A-3. — Truck with Mooring Mast



Figure A-4. — Mooring Mast Set In Place by Truck

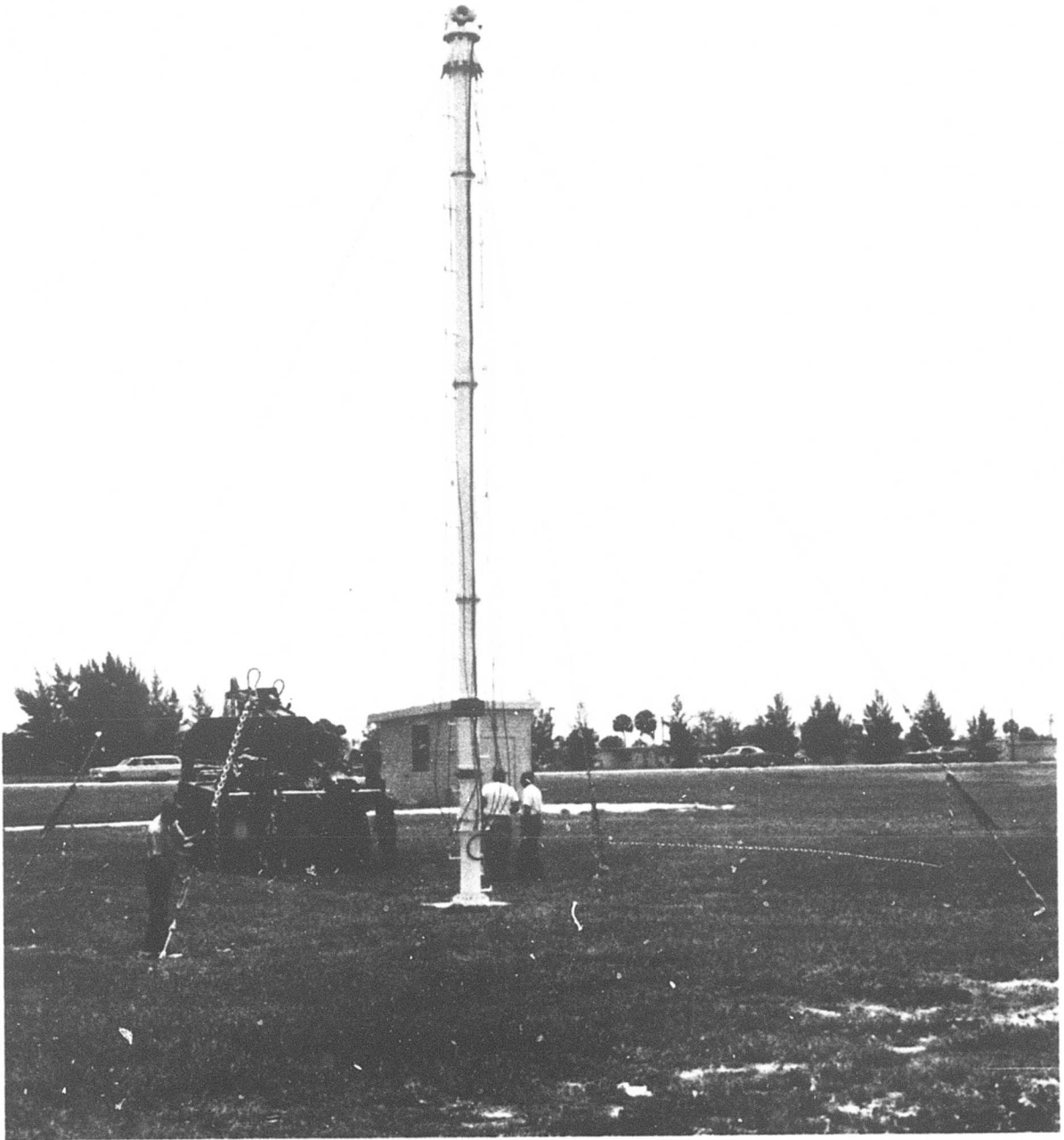


Figure A-5. — Mooring Mast for Temporary Balloon Site

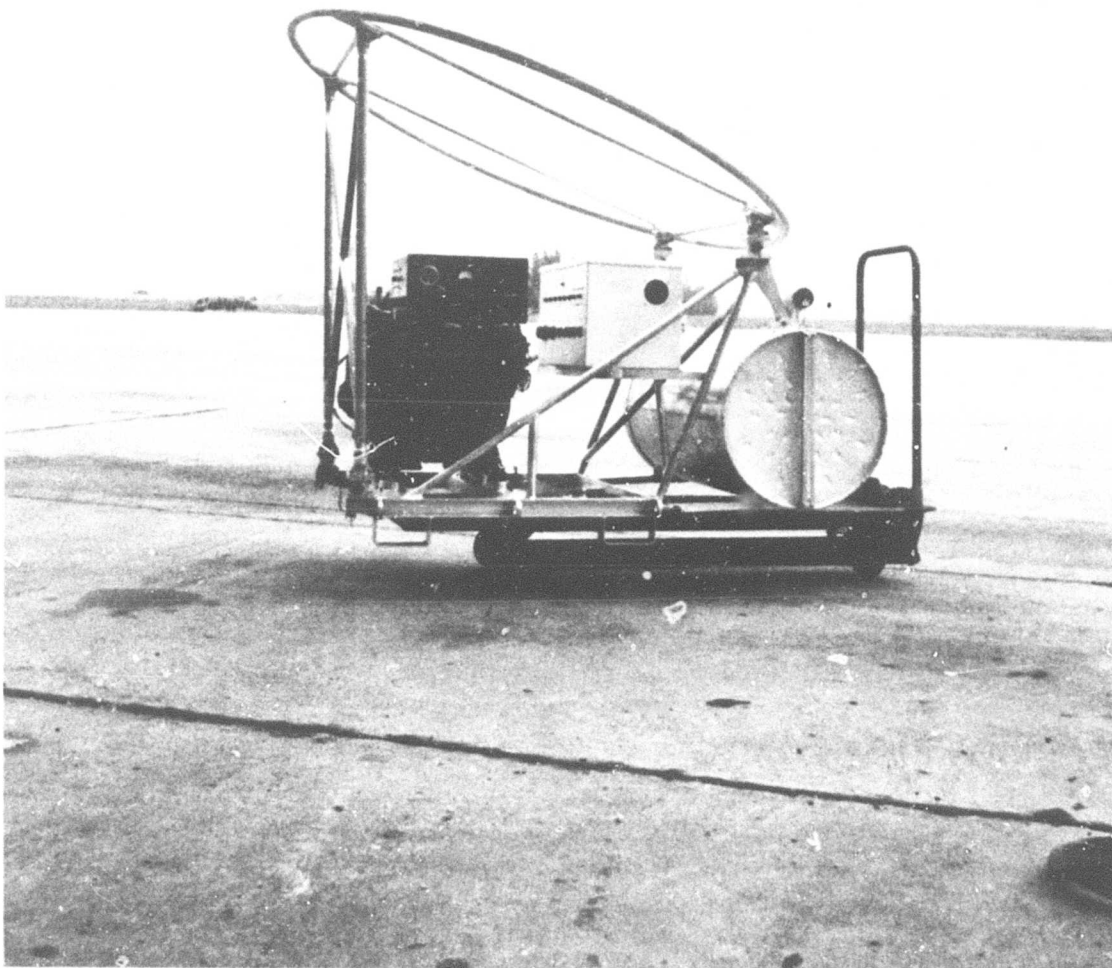


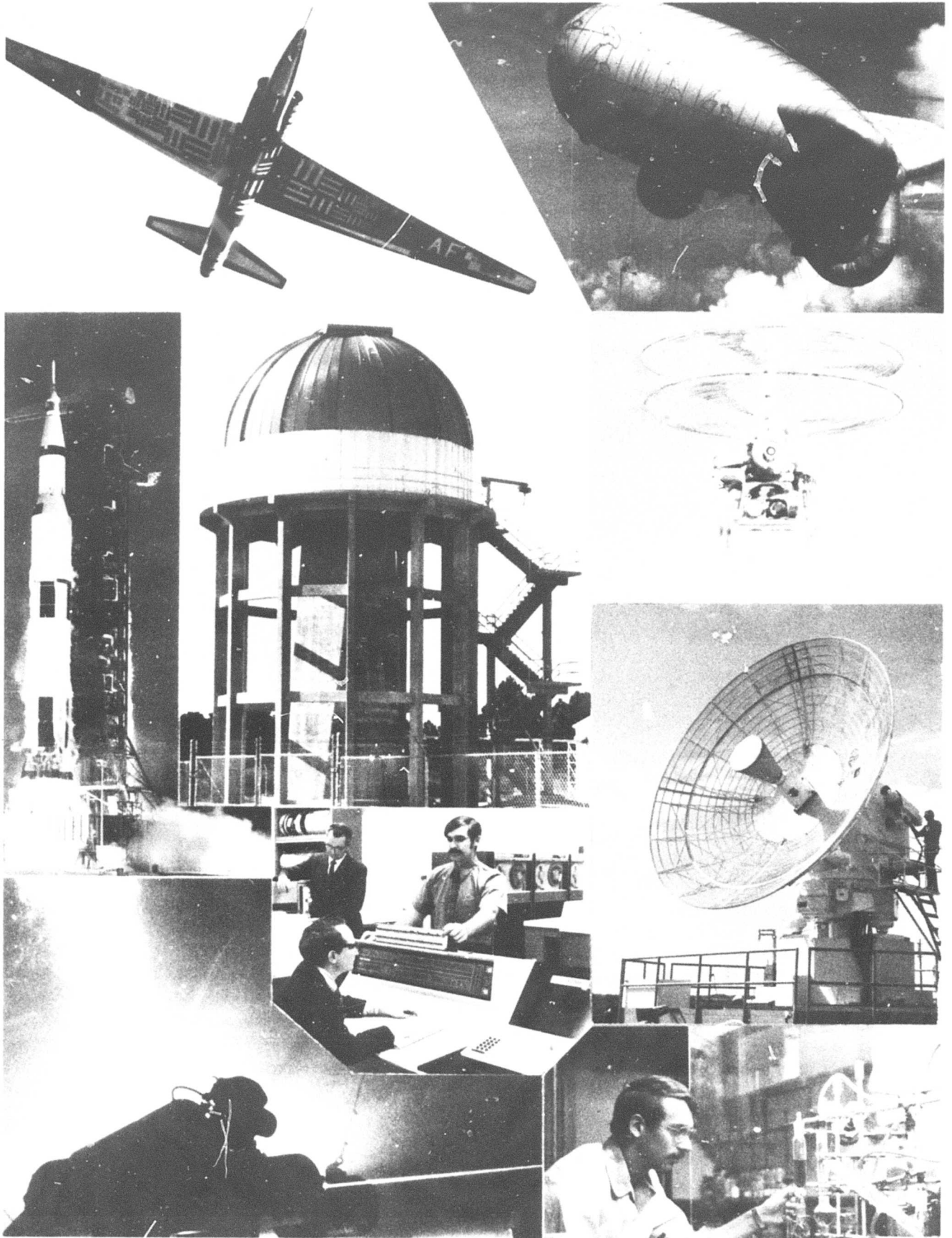
Figure A-6. — Balloonborne Power Supply

APPENDIX B

RANGE MEASUREMENTS LABORATORY  
QUALIFICATIONS AND EXPERIENCE



Range Measurements Laboratory Qualifications and Experience



Typical RML Projects



From the rear, the Range Measurements Laboratory presents this aspect. The 0.13 On-Axis Radar is prominent in the foreground, while the dome for the associated OVER/UNDER Telescopic System is at left, rear. Air conditioned with filtered air, the Laboratory building has been designed and built to accommodate large, high-precision optical systems and for optical research. There are many enclosed work areas equipped with seismic mass floors which are vibration isolated with active Barry air suspension units.

## MESSAGE FROM THE DIRECTOR



The RANGE MEASUREMENTS LABORATORY is a unique organization. Officially established at Patrick Air Force Base, Florida in January 1966 as part of the Air Force Eastern Test Range, the Laboratory had a modest beginning with a staff of 11 persons engaged in only one project.

The Laboratory is engaged in many projects, some of relatively large scale. On these projects, the Laboratory staff is augmented as necessary by Range Contractor personnel from Pan American World Airways, Inc., and RCA Service Company.

The Laboratory operation began in one building at Patrick Air Force Base. Today, the Laboratory occupies and uses space in Buildings 981 and 986 at Patrick Air Force Base; Hangar C and Launch Site Complexes 1, 2, 3, and 4 at the Cape Kennedy Air Force Station (CKAFS); and an operating test site at Malabar, Florida.

The Range Measurements Laboratory (RML) has been assigned the general mission to perform in-house investigations and to analyze the effects of various physical phenomena and instrumentation associated with missile and space vehicle testing. In addition, the Laboratory has the mission to perform special tasks for such scientific government agencies as Advanced Research Projects Agency (ARPA), North American Air Defense Command (NORAD), and Aerospace Defense Command (ADC).

Because of the technically wide-ranging nature of the projects assigned to the Laboratory, it has been necessary to assemble a technical staff of great versatility and experience. The scientific areas covered by these staff members include the following technical areas and others:

|                        |                  |                   |
|------------------------|------------------|-------------------|
| Electronics            | Photo Chemistry  | Mathematics       |
| Project Management     | Telemetry        | Data Transmission |
| Computers              | Sensor Platforms | Servomechanisms   |
| Inertial Stabilization | Aerodynamics     | Optics            |

Electro-Optics

Physics

Astro-Physics

Pyrotechnics

Rocketry

Mechanics

Astronomy

Radar

Assigned projects have required the exercise of all of these disciplines. The assigned staff members perform all the steps of hardware and system implementation beginning with the original concept, through design and fabrication, to field testing and system turnover to the final customer. As a result, the Laboratory has developed the staff skills and physical facilities to perform significant work in the following fields:

1. Advanced optics, including absolute optical measurements, interferometry, and analyses of optical imaging and image tracking technology
2. Radar and tracking analysis, including reentry and measurements analysis
3. New systems concepts and analysis
4. Photo/chemical techniques and analysis
5. Electronic systems
6. Tethered lighter-than-air platform research and operation
7. Image restoration and analysis
8. Associated computer systems applications
9. Advanced television techniques, including low light level, pulsed operation, and absolute measurements
10. Sophisticated mechanical design, development, and fabrication of maximum performance tracking mounts for large aperture, diffraction-limited telescopes
11. Implementation and operation of three complex, computer-controlled tracking centers utilizing the most advanced optical and electronic equipment and techniques

12. Studies and development of measurement techniques relating to photographic emulsions and electron image tubes
13. Advanced laser technology

In addition to this Laboratory capability, a tremendous technical resources capability exists within the local Cape Kennedy and Brevard County area that is available to, and has been used by, the Laboratory. Some of the more important of these resources are:

RADAR. - The Air Force Eastern Test Range (AFETR) has a network of precision C-band instrumentation radars which have been strategically located to track missiles and artificial satellites for test and development. This radar network reaches from Cape Kennedy on the Florida coast to Ascension Island in the South Atlantic, some 5,000 miles away. With a 0.4 degree beamwidth, these hydrostatic bearing tracking radars have an inherent precision of 0.1 milliradian, making them among the world's most accurate tracking radar systems.

This radar network is supplemented by two advanced design radars, modified at the Range Measurements Laboratory under ARPA sponsorship to incorporate the On-Axis tracking techniques developed by Laboratory personnel. The first ARPA On-Axis radar is installed and operational at Grand Bahama Island, 150 miles southeast of Cape Kennedy. The second On-Axis radar is installed at RML and is used by Laboratory personnel as a test bed to develop new and advanced radar technology.

This combination of radar systems provides a test and development laboratory facility for ground, suborbital, and orbital work unequalled anywhere in the United States. This test range facility was used very heavily to support the Have Faith and Meteor projects.

TELEMETRY. - Instrumentation of the AFETR to support missile test and space flight programs has resulted in the existence of a complex and sophisticated telemetry complex. This complex, together with the telemetry center (Tel 4) and the associated antennas and data links, again provides a 5,000-mile-long test area with complete telemetry coverage. The facilities of the telemetry complex have been used in the Laboratory balloon programs and on other projects.

COMPUTERS. - Although RML has significant computer capability, should the need arise the AFETR has two CDC 3600 computers at the Cape Real Time Computer Center. Additionally, there are IBM 360's at the Technical Laboratory Data Center for large batch data reduction. The Laboratory has used the CDC 3600's extensively in the early development of the On-Axis technology, but now employs its own Xerox Data Systems (XDS) Sigma 7 and Sigma 5 computers.

COMMUNICATIONS. - Inherent in the AFETR instrumentation network is an excellent data transmission and communications system including HF, VHF, single sideband, and microwave equipment. Redundant circuitry and data links insure reliability.

METEOROLOGY. - Supporting the Eastern Test Range operations is a comprehensive meteorological instrumentation complex. AFETR weather stations at CKAFS and downrange through Ascension Island furnish accurate and timely weather information needed by the Range and the Range Users to schedule tests and to analyze metric performance data. The routine AFETR weather stations observational program includes rawinsonde, pilot balloon, and surface observations. Three stations also provide routine rocketsonde observations. Rocket, rawinsonde, wiresonde, and surface observations are also made on special test support schedules for Range Users and for hurricane warnings.

ENGINEERING SUPPORT. - The AFETR employs Pan Am and RCA to operate and maintain the range instrumentation. As a result, there is a large, well qualified staff of engineers and technicians available to assist the Laboratory as required. In the past four years, the Laboratory has used an average of 35 man-years of this talent in the areas of mechanical, electrical, electro-optical, and optical engineering. These technical people are, for the most part, the same engineers who designed and implemented the AFETR from its early beginnings. They represent what is probably the most experienced technical group in range engineering technology that is available in the world.

SHOP SUPPORT. - The Range Contractor (Pan Am/RCA) has well-equipped shops that have excellent capabilities in mechanical, sheet metal, electrical, electronics, electro-optics, and optics fields. In addition, the Base Aircraft Shops can support very large machine shop jobs. The Laboratory has been able to obtain 98 percent of its shop support right here at Patrick Air Force Base.

DRAFTING. - The Laboratory relies heavily upon the Range Contractor's experienced and competent design and drafting department for most project requirements.

OPERATING LOCATIONS. - One of the unique features of this geographic location is the currently established Airspace Danger Warning Restricted Areas. Established for missile launches and testing, this location provides several areas where the Laboratory can conduct tests which might be hazardous to aircraft or commercial air traffic. By activating the warning area through FAA, all nontest aircraft are excluded from the area. RML presently uses three such areas.

FLORIDA INSTITUTE OF TECHNOLOGY (FIT). - This young, but well-staffed and highly regarded technical university is located in Melbourne, Florida, some 11 miles from the Laboratory. Many of the major disciplines covered, such as physics, electronics, mathematics, and oceanography are of interest and use to the Laboratory.

Following is additional information on the applicable technical capability and experience of the Laboratory.



WALTER H. MANNING, JR,  
Director, Range Measurements Laboratory

## SENSOR PLATFORMS BRANCH (ENLP)

Consisting primarily of DOD personnel trained in such diversified fields as aerodynamics, electronic engineering, physics, and electro-optics, the Sensor Platforms Branch provides engineering for advanced balloon platforms and field engineers for operating the various field sites of the Laboratory.

A large portion of the Branch's work is involved in developing advanced balloon technology. Utilizing state-of-the-art techniques in materials analysis, stability analysis, and computer techniques, the Branch is currently developing a large tethered-balloon system that will carry 750 pound payloads to altitudes of 12,000 feet. Using approximately 3/4-inch diameter polyester tether cable and a 45,000 pound winch, the system is designed to fly in winds up to 90 knots at the surface of the earth.

The Laboratory's tethered-balloon site, located at Cape Canaveral, can moor two 84,000-cubic foot balloons, one 200,000 cubic foot balloon, and several smaller balloons simultaneously. Various payloads such as radar, communications, relays, and high resolution optics have been flown on these platforms. In 1968, the first tandem tethered-balloon flight in the United States was performed by the Sensor Platforms Branch of the Laboratory. In this initial flight, a payload of 800 pounds was flown to an operational altitude of 13,800 feet.

The Family II balloon system, described in detail in appendix A, is shown moored on the launch pad.

In addition, the Branch directs Laboratory efforts where quick-reaction efforts are required to develop systems swiftly for evaluation and deployment at remote sites. Included in these tasks is the responsibility for providing field engineers to train the ultimate users of these Laboratory developed systems. Some of these systems have been field tested in Southeast Asia and similar jungle environment locations.

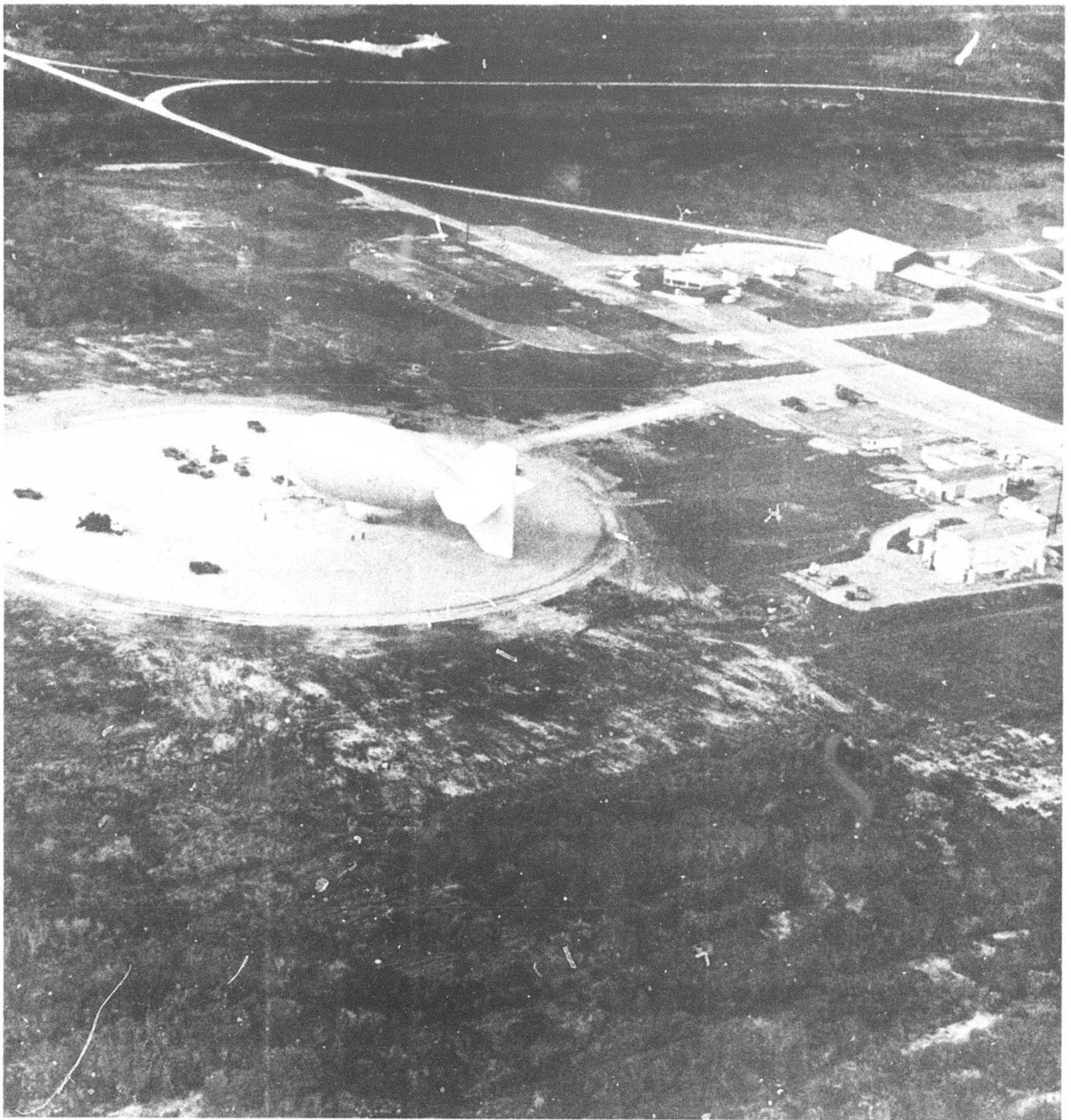
A 25-foot Langley Research Center tethered aerodynamic balloon was constructed by NASA. It was used in a series of tow tests at Langley AFB for formulating a set of theoretical equations to determine the stability boundary limits of tethered balloons in flight. This balloon was used subsequently in an ARPA/NASA combined program for a further investigation to determine the stability of tethered aerodynamic balloons. Tow tests were

accomplished at Cape Kennedy Air Force Station by the Range Measurements Laboratory to refine stability equations and computer programs. The balloon is constructed of thin nylon with an inside helium barrier of saran. The tail is made of saran and balsa wood construction and is detachable so that some tow tests may be conducted without a tail section. Flight instrumentation is included on this 670 cubic foot balloon and its accompanying tow test vehicle.

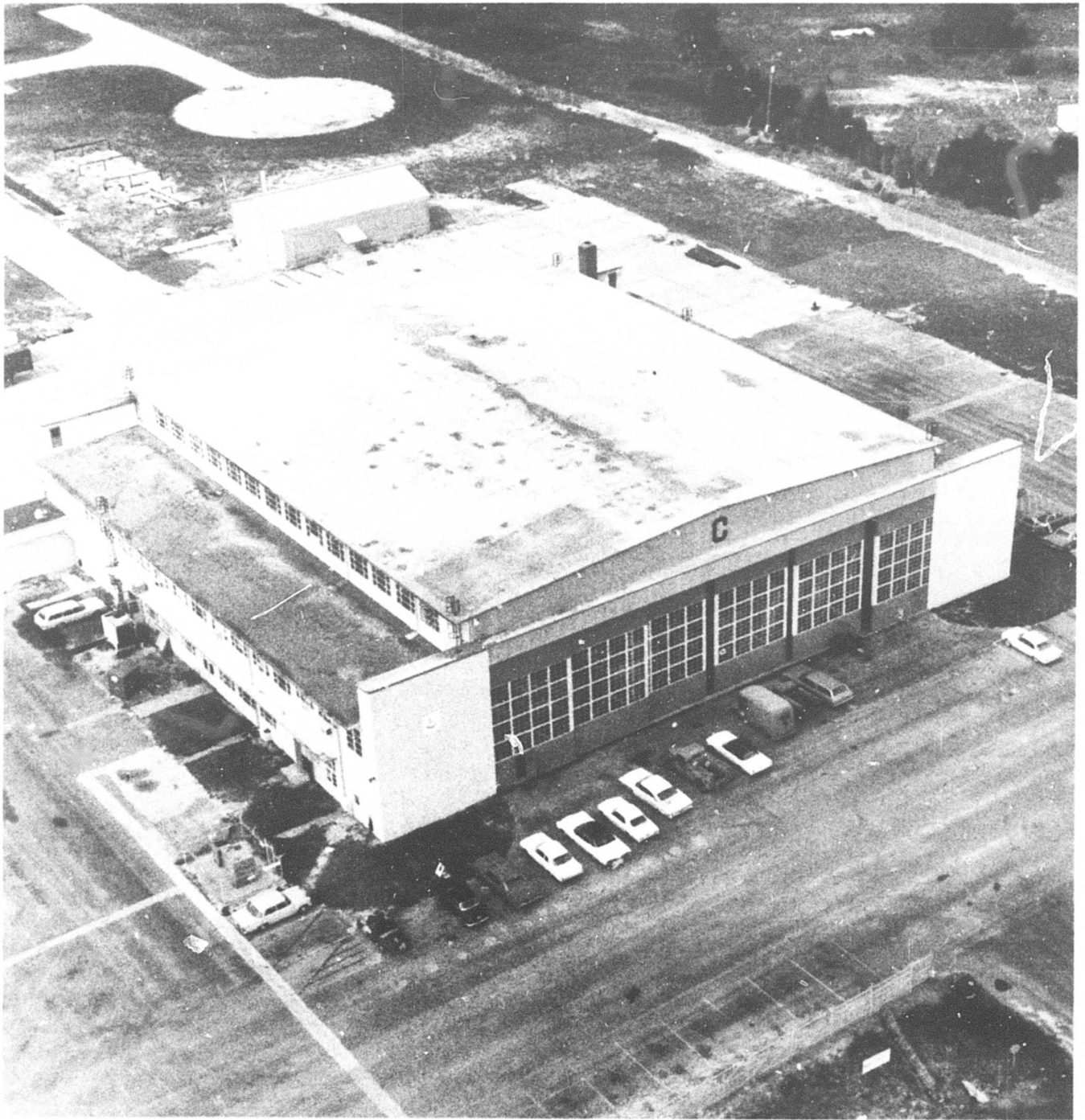
The 5,300 cubic foot balloon, built by G. T. Schjeldahl Company, has been used over the past several years by the Range Measurements Laboratory in conducting various test and experiments at altitudes up to 5,000 feet. This balloon which can lift approximately 100 pounds was instrumental in measuring random balloon motions in tethered flight status. In this series of experiments, the balloon was instrumented with accelerometers, wind velocity gauges, and associated equipment which measured balloon motions at tethered altitudes between 500 and 5,000 feet on daylight and nighttime missions.

This balloon was also used as an aerial platform for conducting a research product which measured atmospheric electro-potential energy in both clear air and cloud conditions. Electro-potential measurements as high as 50,000 volts were obtained in some of these experiments. In addition both positive and negative charges of surrounding clouds were sensed.

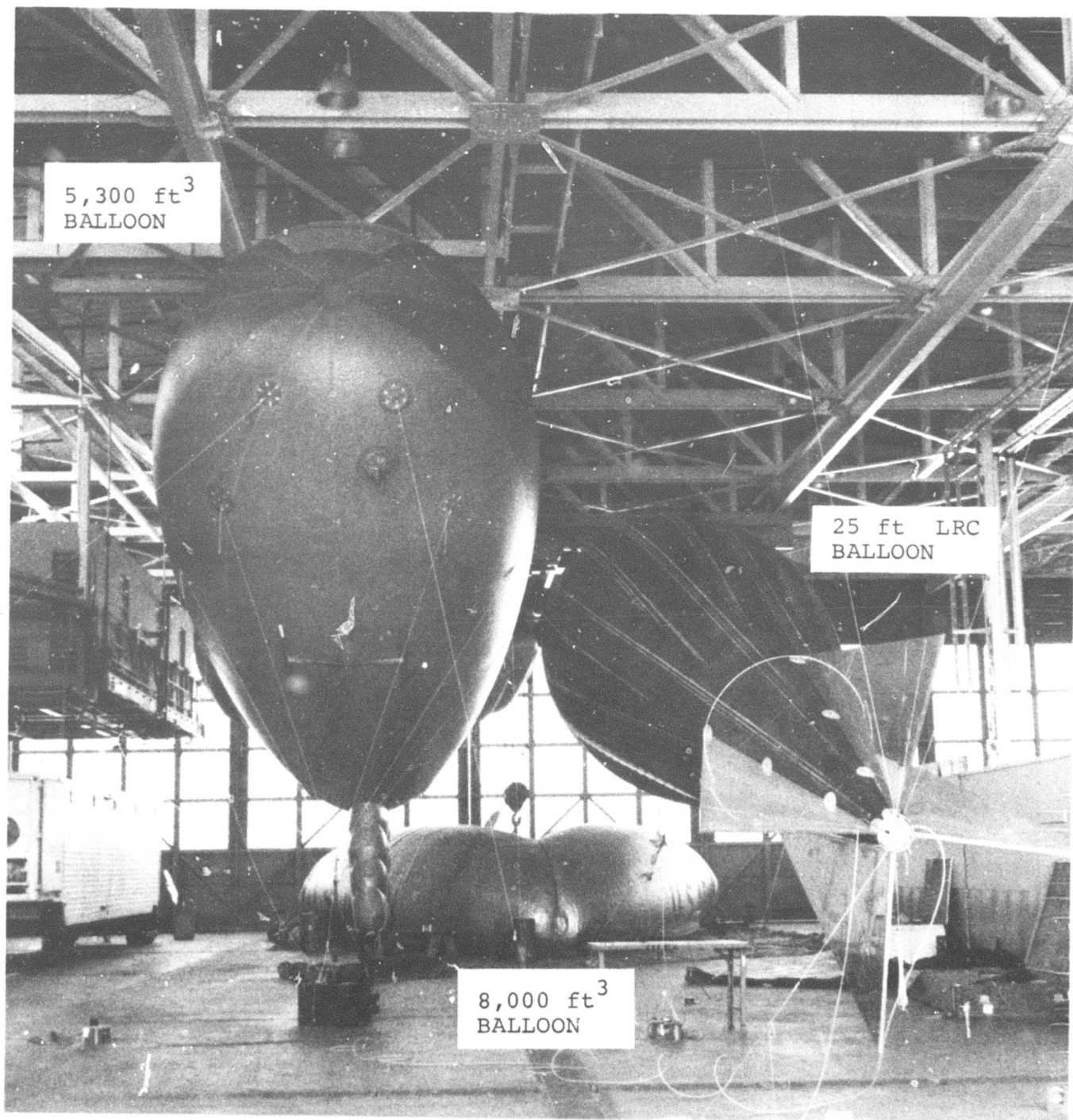
In the background of the illustration is a 8,000 cubic foot Goodyear V-balloon on the floor of the hangar. Tests were made with this balloon for NASA and the Army. These tests measured its lateral stability under moderate wind conditions and at altitudes up to 7,000 feet.



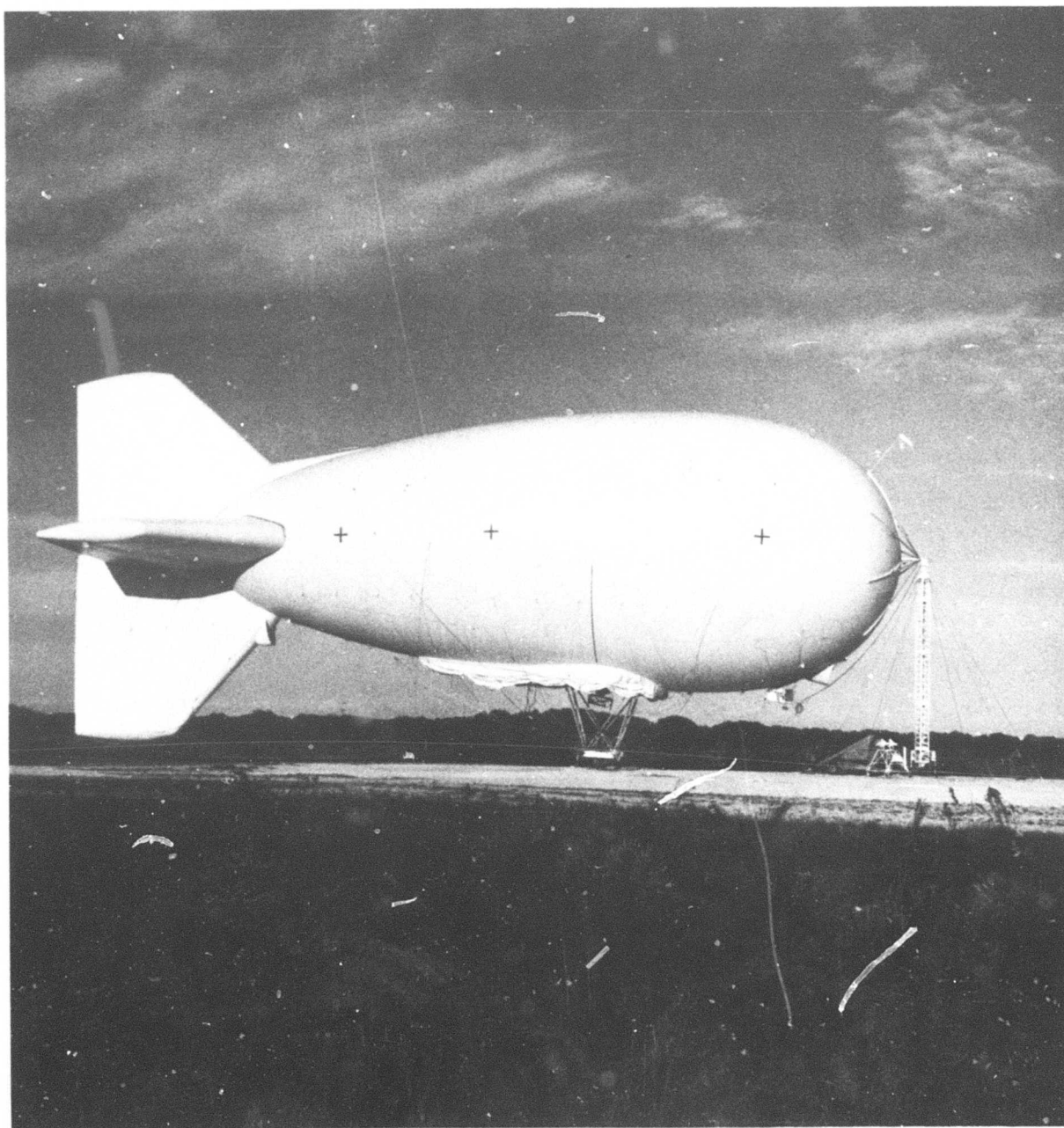
Family II Balloon on Pad at CKAFS



Hangar C at Cape Kennedy, has 7,000 Square Feet of office and shop space for engineers and technicians and 20,000 square feet of hangar floor space. Here small balloons are stored and equipment is assembled and modified. More than 20 acres of space adjacent to the hangar is used for flying small balloons.



Balloons at Hangar C



Family II 200,000 cu ft balloon moored to semipermanent mooring tower on prepared launch site. The mooring gondola is seen underneath the balloon. The protective windscreen is furled to allow ready access to the payload mounting ring.

## TELEMETRY

Each balloon is equipped with sensors to monitor the system "state of health." This information is transmitted via P-band to the telemetry van which was designed and built by the Laboratory.

Flight parameters are monitored in this telemetry van in real time during all flights and are recorded for post-flight analysis.

The parameters monitored are:

- Helium pressure
- Ballonet pressure
- Helium temperature
- Emergency descent valve status
- Tether line tension
- Power supply voltage and frequency
- Wind velocity
- Pitch and roll

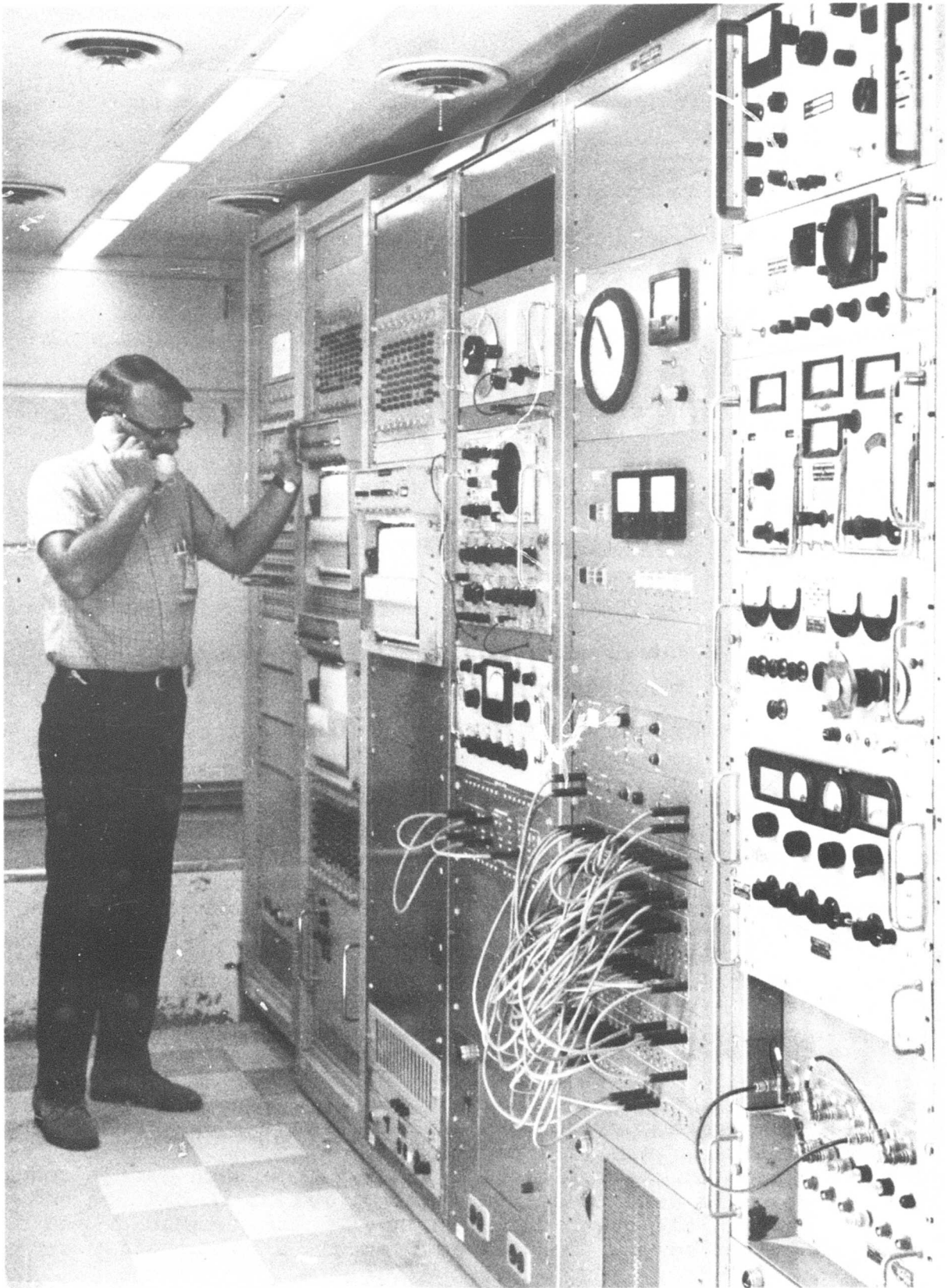
## CENTER OF BALLOON OPERATIONS

Operations are conducted from the control van and are monitored visually through the viewing window. Communications to aircraft, boats, on-site stations, land vehicles, and the Eastern Test Range are centralized in this location.

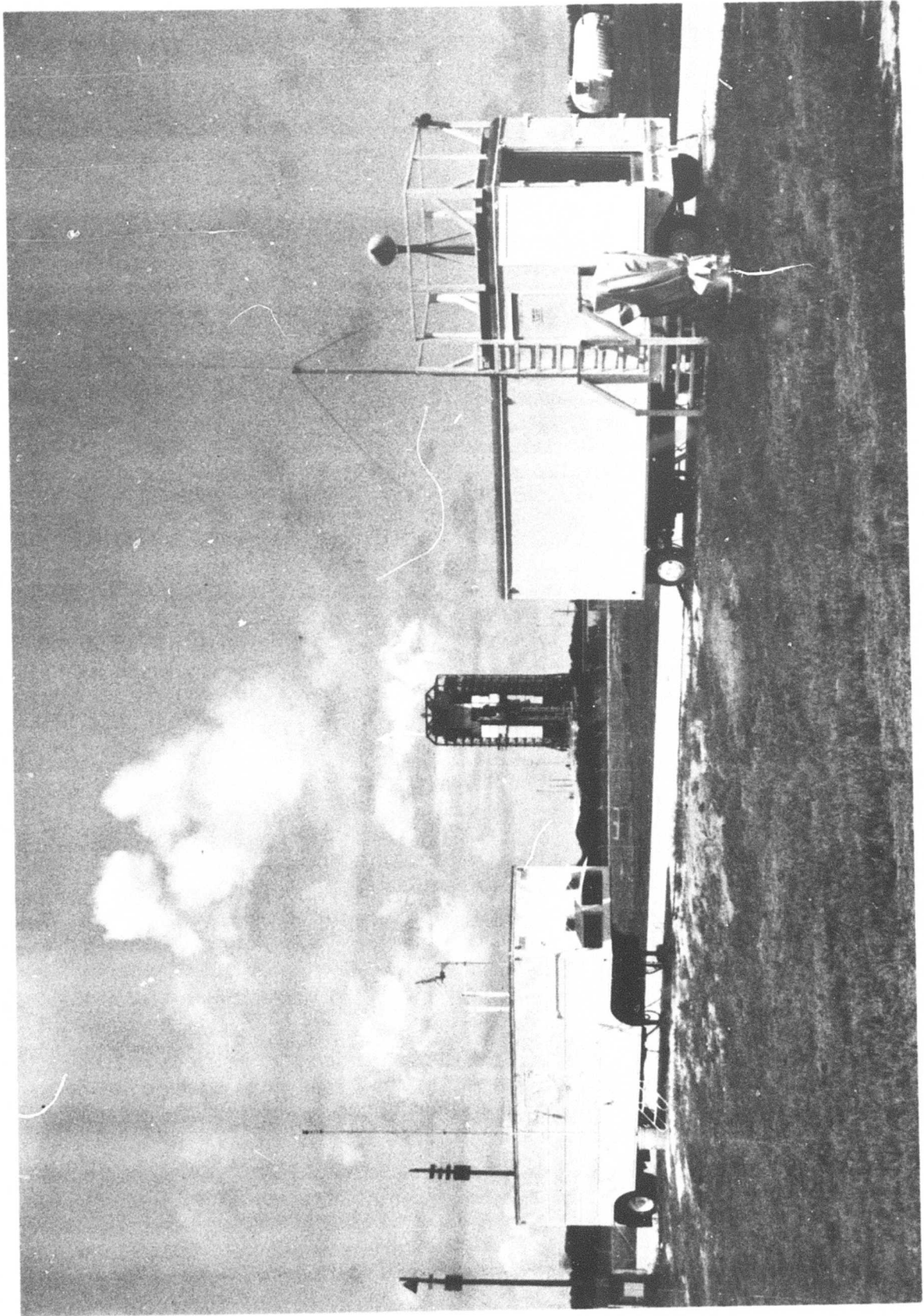
The Command/Control system is also operated from the Operations Control Van.

## COMMAND/CONTROL SYSTEM

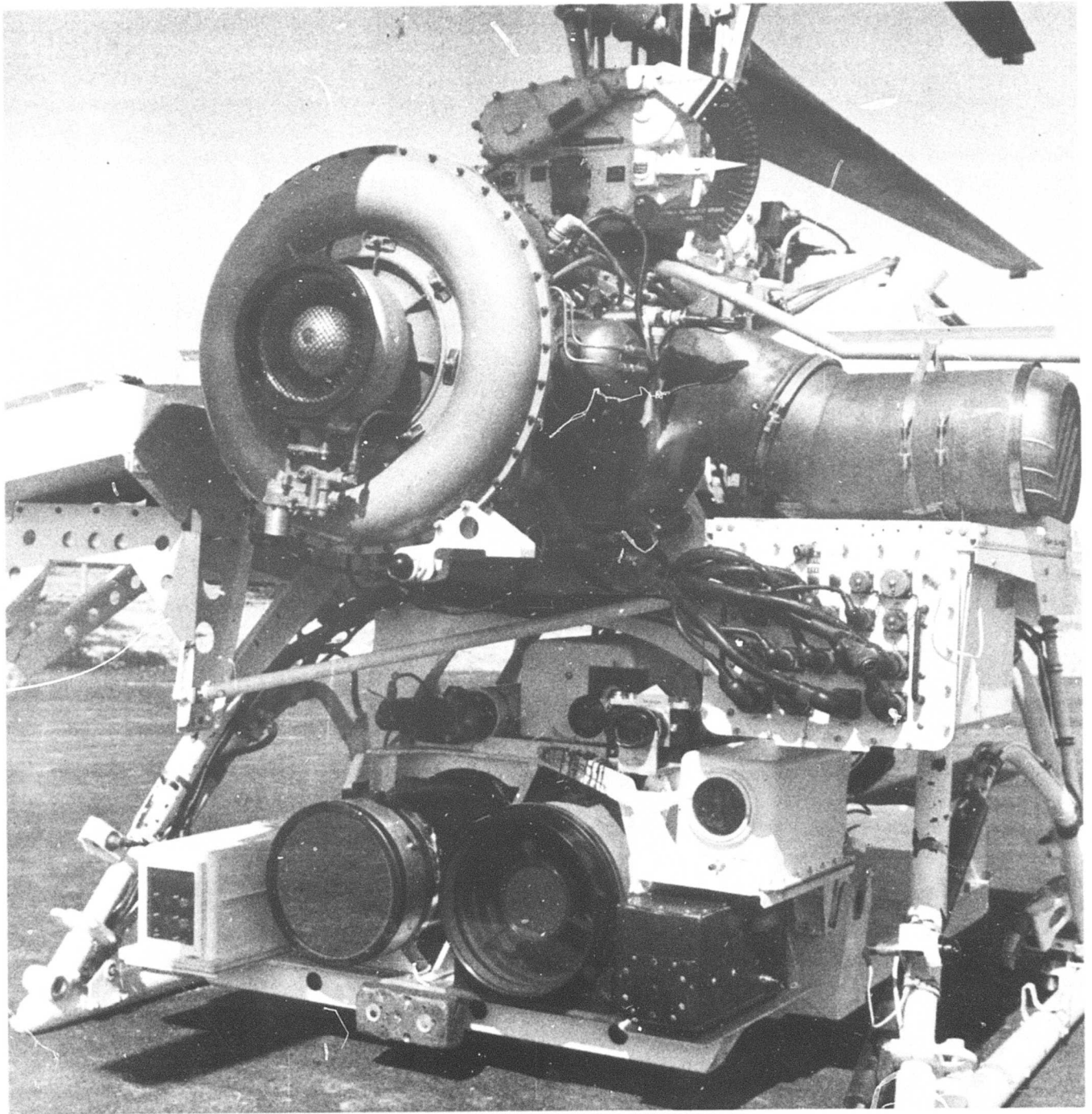
Each balloon system is equipped with redundant 10-channel command transmitters/receivers capable of activating remote control functions on the balloon. Typically, one such remote control function is used to activate helium valves to control balloon descent in the event of breakaway. Spare command channels can be used for sensor "on-off" activation, drop mechanism command, etc.



Telemetry Van, Interior View



Telemetry Van on Left, Command Control Van on Right



Laboratory personnel designed, built, operated, and tested this multipurpose electro-optical sensor package for use on the remotely controlled helicopter. The time from initial go-ahead to the successful maiden flight was only 6 months, a small fraction of the time customarily required for such systems.

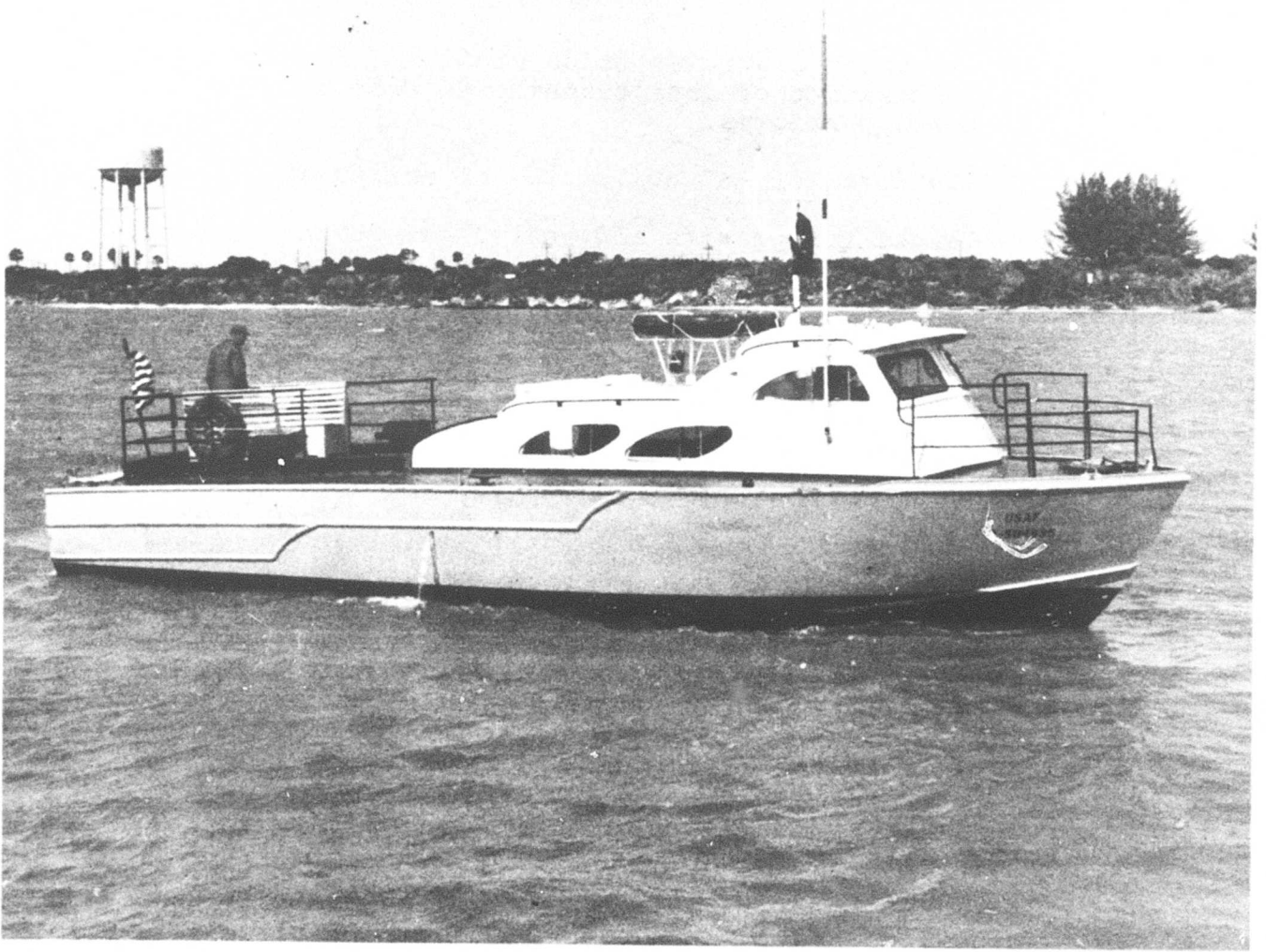
A 41-foot boat is under the operational control of the Laboratory and is dedicated to its support. It is equipped with HF radio and has facilities for mounting additional communications or other equipments. A davit for recovery operations has been installed. A depth finder and winch are to be installed soon. This boat is used as an:

1. Off-shore instrumentation station for the acquisition of data transmitted from airborne platforms.
2. Platform for R&D evaluation of equipment/systems.
3. Target for passive and active detection systems.
4. On-station recovery service during frequent off-shore, airborne instrumentation missions.

#### VESSEL PARTICULARS FOR USAF 41-FOOT BOAT

P-50-1935

|                    |                                                                    |
|--------------------|--------------------------------------------------------------------|
| Type:              | Cruiser, twin propeller                                            |
| Length, overall:   | 41 ft                                                              |
| Length, waterline: | 38 ft                                                              |
| Beam:              | 12 ft, 6 in                                                        |
| Beam, molded:      | 13 ft                                                              |
| Draft:             | 3 ft, 6 in                                                         |
| Depth, molded:     | 6 ft, 7 in                                                         |
| Bottom             | Vee (Steel Hull)                                                   |
| Net tonnage:       | 15 (approximately)                                                 |
| Engines:           | 6071M Marine Diesels<br>(Serial Nos. 6A-108206 and<br>6A-108207)   |
| Built:             | September, 1963                                                    |
| Built by:          | Breaux's Baycraft, Inc.<br>P. O. Box 296<br>Loreauville, Louisiana |
| Hull number:       | 657                                                                |



41-Foot Sensor Platforms Support Boat