TROPICAL WIND, ENERGY CONVERSION, REFERENCE LEVEL EXPERIMENT (TWERLE)

Status Report (For Period Ending 15 August 1973)

On the 19th of January 1973, a TWERLE test flight was recovered about 1,000 miles south of Buenos Aires. This was flight number 257152F, launched from Christchurch on 13 November 1971, and flew for 434 days.

The GHOST package and parts of the balloon have now been received in Boulder. This is the longest duration balloon that has ever been recovered.

1. TWERLE Balloon Platform (TBP) weight budget (Revised 9 July 1973)

Sub-System	Weight (Grams)
TSP - Solar Panel	180
TAN - Antenna	150
TCD - Cutdown	57
TDE - Data Encoder	150
TTX - Transmitter/Osc.	315
TTS - Temperature Sensor	20
TPS - Pressure Sensor	190
TRA - Radio Altimeter	150
TFR - Rigging	150
	1362

2. The following summaries indicate the present status of each sub-system:

Balloon (TBN-100)

The production contract was signed with the G. T. Schjeldahl Co., Northfield, Minnesota to provide the TWERLE superpressure balloons. Production drawings have been received from the vendor, are being reviewed and marked up prior to return to GTS. The polyester (Celanar) film is on order and laminating should start during August. The assembly of the balloons is scheduled to get under way during September.

Solar Panel (TSP-200)

Approximately 350 individual solar panels have been fabricated to date. We have about 15,000 more solar cells to be delivered from Spectra Labs. A test fixture has been designed and built to test the output from a complete panel. The solar cell supplier has been requested to provide a calibrated cell with each shipment. We are planning to have a complete panel calibrated by Spectra Labs, to evaluate our production units.

A test flight was launched from the NCAR Marshall site on 10 July 1973 to evaluate the performance of the TWERLE Solar Power Supply. Several problems developed during and after the flight, centering on the data transmitter and calibration curves. The data was not conclusive enough to evaluate the solar power supply, so another test flight is planned in about three weeks.

Antenna (TAN-300)

Two hundred and twenty of the support structures for the TWERLE antennas have been fabricated.

It has been decided to fabricate the antenna by the Type "A" technique, i. e., using a template to cut the foil into the special pattern and then fasten with adhesive to the mylar substrate.

Cut-down (TCD-400)

All the magnetometer coils have been fabricated, with 65% of the coils tested. The Kapton printed circuit material has created a slight delay in completing the cut-down interconnection assembly. This problem is expected to be solved within the next three weeks.

Data Encoder (TDE-500)

Prototype boards have been fabricated, tested, and approved for production. Final assembly is under way.

Transmitter (TTX-600)

A sub-contract was signed with the Ball Brothers Research Corp., Boulder, Colorado on 27 July 1973 for fabrication of the TWERLE transmitter and stable oscillator. All parts are now on order. The major problem is still with location of a satisfactory crystal manufacturer. The C.T.S. Knights Co. has not delivered test units to the University of Wisconsin that meet the TWERLE specifications (series resistance too high).

Temperature Sensor (TTS-700)

We have received 210 calibrated bead thermistors from Veco. The assembly of 200 TTS circuits has been completed. The acceptance tests have been performed on twenty-five completely calibrated sensor assemblies.

Pressure Sensor (TPS-800)

During the University of Wisconsin's design review in June, the procedures outlined for calibration were reviewed and modified to reduce the total time consumed during these steps.

Seven bids were received on 25 July 1973, in response to the invitation for bids. The low bidder was Boulder Scientific Research & Development Laboratories, Boulder, Colorado. This sub-contract is now under review by the NSF. As soon as the go-ahead is received from NSF, the TPS contract will be signed and work started on the assembly. All of the electronic, and most of the mechanical parts have been ordered by UCAR to expedite the fabrication process.

Radio Altimeter (TRA-900)

The fabrication of the radio altimeter is under way by the Meeda Corporation.

The current delivery schedule is:

100 each	- 31 December	1973	- Christchurch site
100 each	- 31 January	1974	- Pago Pago site
120 each	- 31 March	1974	- Ascension site
120 each	- 30 April	1974	- Ghana site.

3. TWERLE Flight Operations (TFO)

This portion of the TWERLE program is presently on schedule, with plans progressing satisfactorily for all sub-systems, as described in the following summary:

Launch Sites:

A response has been received through the Dept. of State from the government of New Zealand approving the TWERLE program at Christchurch.

At a meeting with Dr. Chapin, Dept. of State, on 19 July 1973, site development plans for Accra, Ghana were discussed and an inquiry was sent to the American Embassy in Accra.

Mobile Launcher (MOL-200):

The first launcher chassis has been delivered and the superstructure installed. It is now undergoing field tests and deployment evaluations at the UCAR field site south of Boulder.

The other two launcher chassis are scheduled for delivery during August. The new launch table has been designed and fabricated, and is now ready for interface testing with the launcher. These tests are scheduled for August.

Launch-Assembly Shelters (LAS-100):

Plans have been completed for the LAS at each site. All sites except Christchurch will use a pre-fabricated steel structure manufactured by Stran-Steel Corporation, Houston. At the Christchurch site, the required space will be added to the present launch building, using local materials and contractors.

The Stran-Steel structures will be ready for shipment to the three tropical sites in early October.

Ground Test Sets (GTS-700):

The other IRLS/Bip receiver has now been modified and is operating at NCAR.

The first GTS was used during the interface tests made at Texas Instruments in mid-June. (See test report attached.)

The remaining GTS's are being fabricated at UCAR and the University of Wisconsin for use at the launch sites.

A prototype of the LAS test stations is now assembled at UCAR and final equipment and wiring is being designed along with the necessary test procedures.

4. A progress report from the University of Wisconsin is also included in this report.

TWERLE TRANSMITTER AND ENCODER

TEST BOX CHECKOUT WITH RAMS RECEIVER

E. Litchfield and J. Afanasjevs went to Texas Instruments, Dallas, Texas, to check out the transmitter and encoder test box against the RAMS receiver. The person in charge at TI was Dr. John DuBose. Testing was carried out by Jim Quarfoot (designer of PLL's) and Bob Westmoreland. Jim Coates made an appearance from time to time and seemed well versed in the technical aspects of the data processing.

The equipment brought by E. Litchfield from NCAR was very well packed and was transported by car to Dallas. The equipment was unloaded and assembled into a test rack brought from NCAR.

One item that was missing was the cover for the transmitter test box. E. Litchfield had constructed a very useful display which gave transmitter ID codes and data output of each encoder. These display panels will be incorporated into each of the site test systems.

After about a 1/2 hr warmup, the tests were begun. The first test was the measuremnt of RF power output of each of the transmitters at the bulkhead, with all variable attenuators set to zero.

Results: (measured with HP 411A)

Transmitter #	P_{out} dBm
1	-27
2	-27
3	-28
4	-27.5
5	-28
6	-29
7	-27.5
8	-28

There seemed to be an unaccounted for power loss of about 9 dBm in the system.

Transmitter output	(600 MW nominal)
	+ 28dBM
Fixed attenuator	- 30dB
Power Combiner	- 17dB
P_{out} Calculated	- 19dBM
P_{out} Measured	- 28dBM ave.

After about an hour of warm-up, the output frequencies of the transmitters in CW mode were checked using a HP computing counter. Note that transmitters #2 and #7 have been interchanged (at NCAR?).

Results:

Transmitter #	Frequency
1	401,187,398
2	401,188,463
3	401,188,047
4	401,190,055
5	401,186,878
6	401,187,532
7	401,213,134
8	401,210,940

Transmitters #2 and #8 had trouble locking. #2 had a loose connector (NOTE: for flight we will have to find a good way to keep the miniature RF connectors tight). The buffer coil on #8 had to be retuned to obtain lock. Probably the core moved during shipment. (We must use the core locking washers or varnish for flight.)

In general, the frequencies measured seem about 200Hz lower than when the transmitters were shipped from U.W. to NCAR. In addition, #5 has a large drift (frequency decreasing) compared to the other 7 units. Maybe we have a bad crystal in #5.

The system was checked using RAMS and proved to work fine. The RAMS received the correct ID codes, the correct frequencies within $\pm$ 2Hz and the correct pre-wired data.

Jim Coates showed concern about frequency shifting of the transmitter due to different data streams. His concern proved to be unnecessary. Tests using a single transmitter and different data streams showed that the received frequency differed by no more than 2Hz. RAMS accuracy is $\pm$ 1Hz.

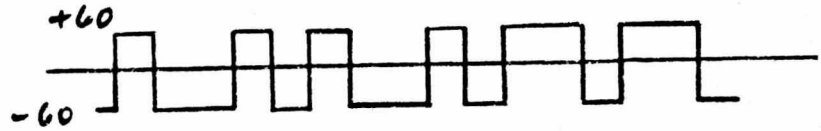
The above test was made with transmitter #1 and with transmitter #6. Transmitter #1 had a good modulation setting (-58.7°, +60.7°) and transmitter #6 had a poor setting (-56.2°, +66.1°). No difference was observed in the output frequency or data for the two transmitters.

Jim Quarfoot designed the PLL's for operation of 56° to 66°. This leaves margin for noise and doppler shift. If the combined modulation goes above +90° or below -90°, we get one less or one more cycle and a frequency shift. Too small a modulation (both angles symmetric) results in a reduced output from the loop.

The case of asymmetry is more complex since it results in a dc level shift which is dependent on the data stream.

NORMAL DATA STREAM

DC LEVEL



ASYMMETRIC DATA STREAM

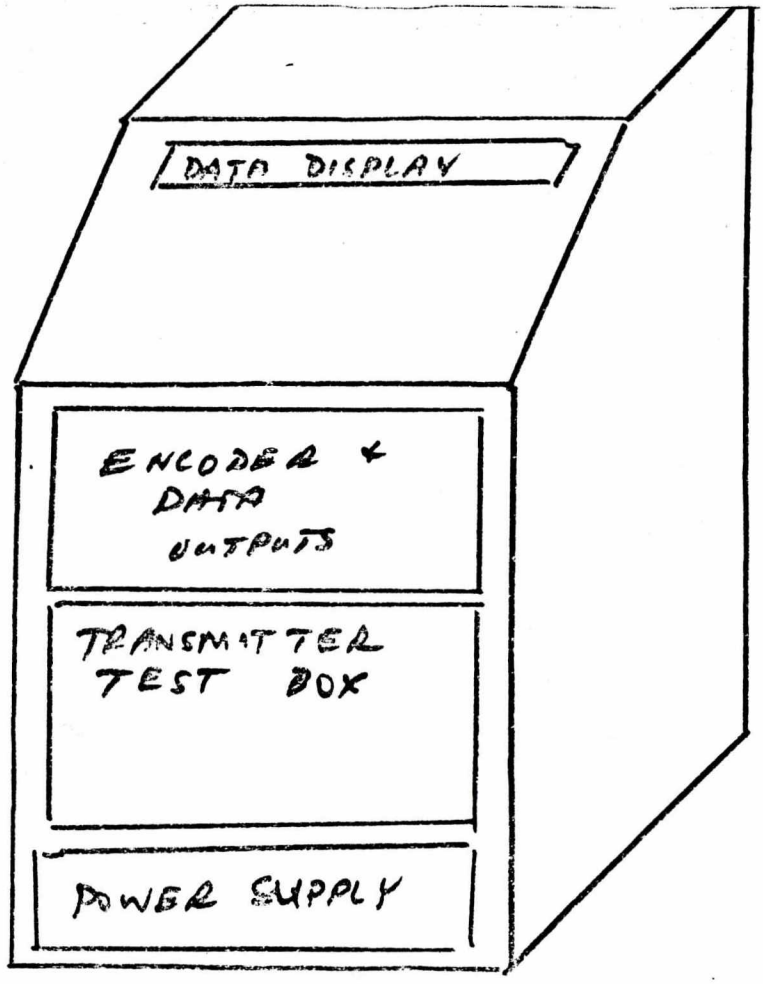
DC LEVEL

The dc level wanders around depending on the actual data stream.
Conclusion: The symmetry requirement is more important.

The only real problem that was encountered was the excessive RF leakage from the TWERLE test box. The cover for the test box might have helped some but the RAMS receiver is so sensitive that we still would have trouble. Short of reworking the entire transmitter test box (lengthy and expensive) the obvious solution seems to separate the receiver and the transmitters by a distance sufficient to block out the leakage.

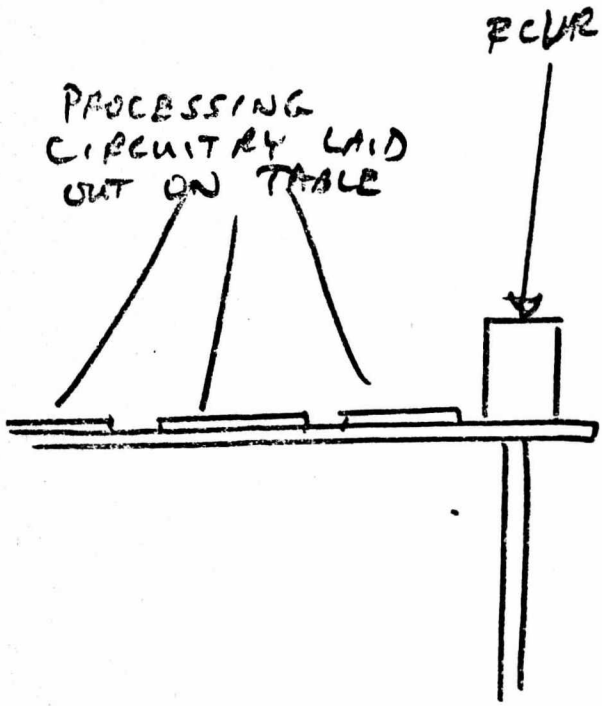
Signed _____
Juris Afanasjevs

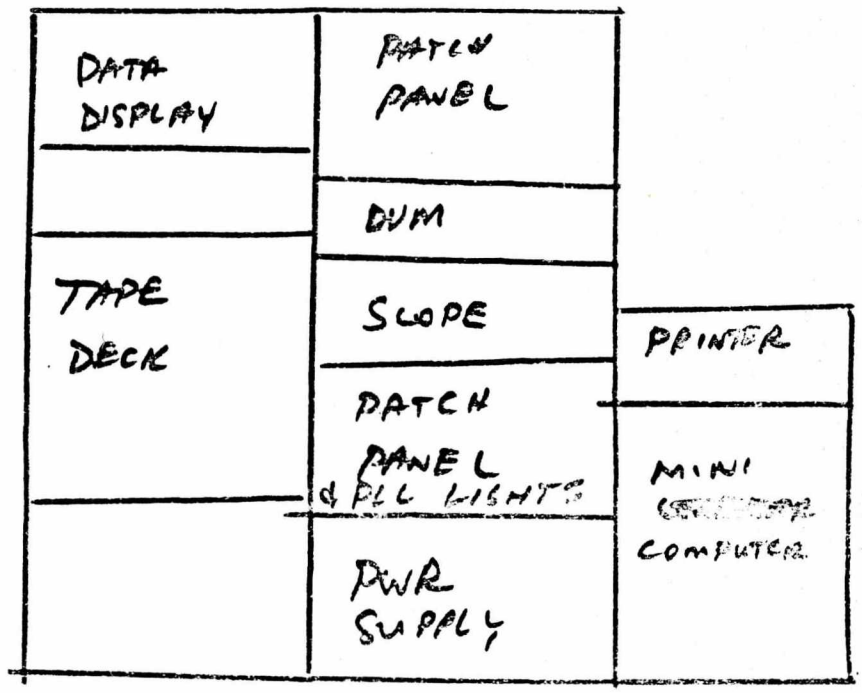
19 June 1973



NEAR TEST RACK

TI TEST SETUP





T W E R L E

TROPICAL WIND, ENERGY CONVERSION, REFERENCE LEVEL EXPERIMENT

Technical Progress Report

for the period

28 April 1973

to

15 July 1973

Space Science and Engineering Center
The University of Wisconsin
1225 West Dayton Street
Madison, Wisconsin 53706

T W E R L E

Technical Progress Report

1. A bidder's meeting on the TWERLE transmitter and stable oscillator (TTX) was held on 12 June 1973 at Madison, Wisconsin. A revised transmitter and stable oscillator manufacturing manual was presented at this time. Items which received special notice were:

   a. parts to be supplied by NCAR

   b. time schedule for delivery of the first 10 systems and the 440 systems afterward

   c. procurement problems on items no longer available from original manufacturers

A guided tour of the UW TWERLE labs provided the bidders with a chance to see working prototypes of the transmitter and stable oscillator.

2. A TWERLE technical coordination meeting between UW and NCAR was held on 14 June 1973. The NCAR personnel present were W. Kellogg, V. Lally, E. Lichfield, J. Tefft, and D. Waltman. Technical discussion was concentrated on the TWERLE pressure transducer (TPS). A revised testing schedule was worked out for the pressure transducer. This schedule should result in reduced costs and a reduction of the burden on the manufacturer's test equipment.

3. A revised version of the pressure sensor (TPS) manufacturing manual was sent to NCAR on 15 June 1973.

4. Quotes on TWERLE crystals from CTS Knight Inc. and Bliley Electric Co. were transmitted to NCAR for action.

5. On 18 and 19 June, J. Afanasjevs (UW) and E. Lichfield (NCAR) went to Texas Instruments, Dallas, to check out the TWERLE transmitter and encoder test box against the RAMS receiver. The tests were successful. RF leakage from the test box was excessive and caused some problems.

6. The second UW solid antenna prototype and the NCAR flexible antenna prototype were tested by Ball Brothers, Boulder, Colorado, and were found to match within 0.5 dB at low angles of elevation. The new antenna has better gain and better axial ratio than the earlier prototype.

S. Ellington performed pathloss calculations based on the new antenna parameters.

7. Several different white paints were tested to determine which would be suitable for TWERLE package protection. The white lead paint, previously specified, is no longer available and is illegal to manufacture. Suitable substitutes have been found.

8. A test program is being run by D. Gauthier to select the best adhesives/solvents for joining the pressure sensor bubble. Adhesives used in other parts of the TWERLE system, TTX and TPS, are also being checked for environmental integrity.

9. Work is progressing on the 4 pressure test systems to be used at the launch sites.

10. On 5 and 6 July N. Levanon and R. Oehlkers went to NCAR to aid in the evaluation of the bids for the TWERLE transmitter and stable oscillator.

11. An alternative for the discontinued HP quad bridge, used in the transmitter, has been found and tested.

12. A successful prototype of the transmitter launch site test system has been constructed. This system has resulted in a significant simplification in the phase angle measurement. This will enable a simple pre-launch adjustment of the phase modulator.

5. Tethered Tests of TWERLE Flight System (TFO-002)

On August 9, 1973 two successful TWERLE system tests were performed at the UCAR Marshall site.

The first test consisted of hanging a complete electronic flight-train from an eighty foot wooden pole (See Figure 1). The TSP powered the system and data was received through a rigid antenna (See Figure 2), and the GTS located in a building about 1,000 feet away.

Table 1 is the data received during the pole-mounted test. A resistor was installed in the temperature and pressure sensor, since the actual sensors would be off-scale during this type of test. The altimeter was too near the ground to lock properly, but was searching as designed during the tests.

Figures 5 and 6 show the flight train suspended from the tethered Kytoon during the second series of tests. The spacing of the components and package configuration is representative of the final system design.

Table 2 is the same type of data as received during the first test. The balloon was tethered at an altitude of about 1,000 feet above the ground.

TABLE 1

TWERLE FLIGHT TRAIN TETHER TEST

9 August 1973

TETHER ON POLE

Received Telemetry Data						
ID Code	Frame synk	Altimeter Readout	Pressure Temp.	Pressure	Air Temp.	Comments
/	/	001	163	246	101	
/	/	253	163	246	101	
/	/	030	163	246	101	
/	/	016	163	246	100	
/	/	005	163	246	101	
/	/	011	163	246	100	
/	/	022	163	246	101	
/	/	015	163	246	101	
/	/	025	163	246	101	
/	/	027	163	246	101	
/	/	037	163	246	101	
/	/	025	163	246	101	
/	/	031	163	246	100	
/	/	029	163	246	101	
		SYSTEM TAKEN DOWN				

pointed at inflatin shelter

TABLE 2

TWERLE FLIGHT TRAIN TETHER TEST

9 August 1973

TETHER ON TETHER BALLOON

Received Telemetry Data						
ID Code	Frame synk	Altimeter Readout	Pressure Temp.	Pressure	Air Temp.	Comments
/	/	022	163	246	101	
6 ft	/	023	163	245	101	
/	/	021	163	246	101	
/	/	023	162	246	101	
08:25	/	024	163	246	101	
/	/	020	163	246	101	
/	/	035	163	246	101	
/	/	020	163	246	101	
/	/	039	163	246	101	
/	0110	102	163	246	100	
/	/	000 alt. removed	163	246	100	
/	/	000	163	246	101	
/	/	000	163	246	100	
/	/	000	163	246	100	
/	/	000	163	246	101	
/	/	000	163	246	100	
/	/	000	163	246	101	
/	/	000	163	246	101	
/	/	000	163	246	101	
/	/	000	163	246	101	
/	/	000	163	246	101	
/	/	000	163	246	100	
/	/	000	163	246	101	
MISSED						

continued . . .

TABLE 2

TWERLE FLIGHT TRAIN TETHER TEST

9 August 1973

TETHER ON TETHER BALLOON (page 2)

Received Telemetry Data						
ID Code	Frame synk	Altimeter Readout	Pressure Temp.	Pressure	Air Temp.	Comments
/	/	000	162	246	101	
/	/	000	163	246	101	
/	/	000	163	246	101	
/	/	000	163	246	100	
/	/	000	163	246	101	
/	/	000	164	246	101	
/	/	000	163	246	100	
/	/	000	163	246	101	
/	/	000	163	246	100	
/	/	000	163	246	101	
/	/	000	163	246	101 w/ 20DB 1W.	ant.
/	/	000	163	246	101	
/	/	000	163	246	101	
/	/	000	163	246	100	
/	/	000	163	246	101	
/	/	000	163	246	100 30 DB	
/	/	000	163	246	101 40 DB	
/	/	000	163	246	101 40 DB	

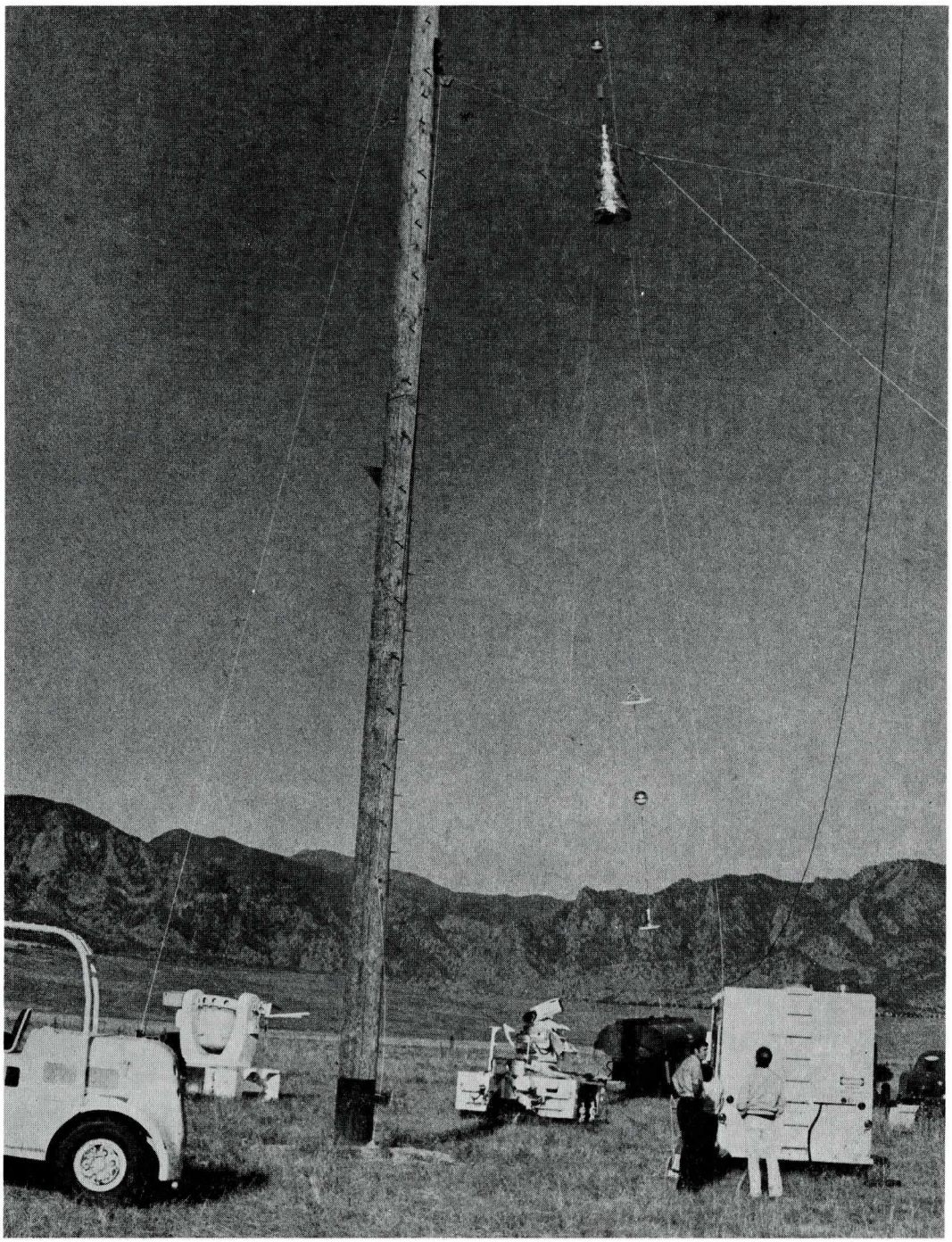


FIGURE 1 - POLE-MOUNTED TEST IN PROGRESS

FIGURE 2 - RIGID-TWERLE RECEIVING ANTENNA NEAR GROUND STATION

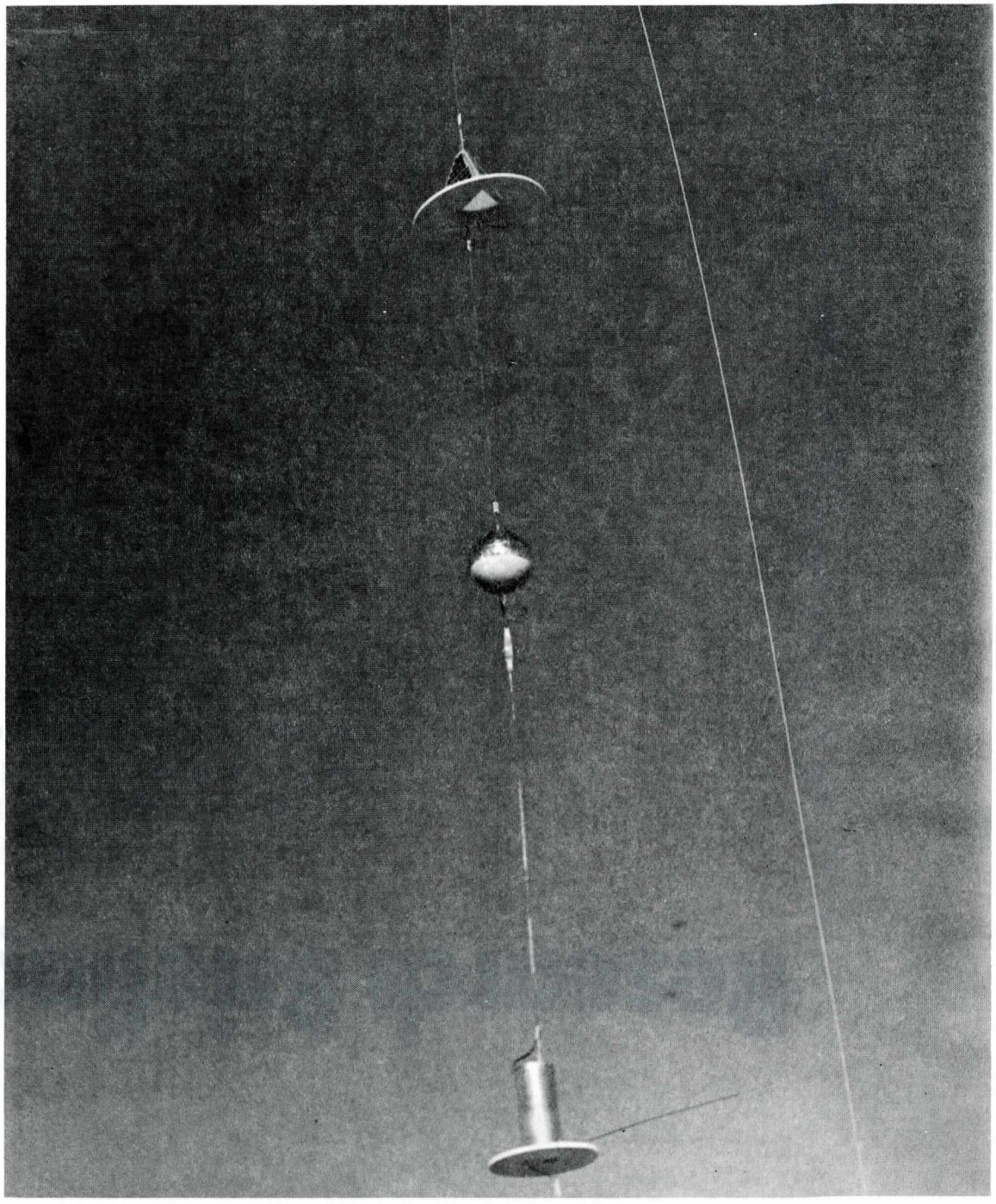


FIGURE 3 - POLE MOUNTED TEST - SOLAR POWER SUPPLY (TSP), PRESSURE SENSOR (TPS), DATA ENCODER (TDE) AND TEMPERATURE SENSOR (TTS)

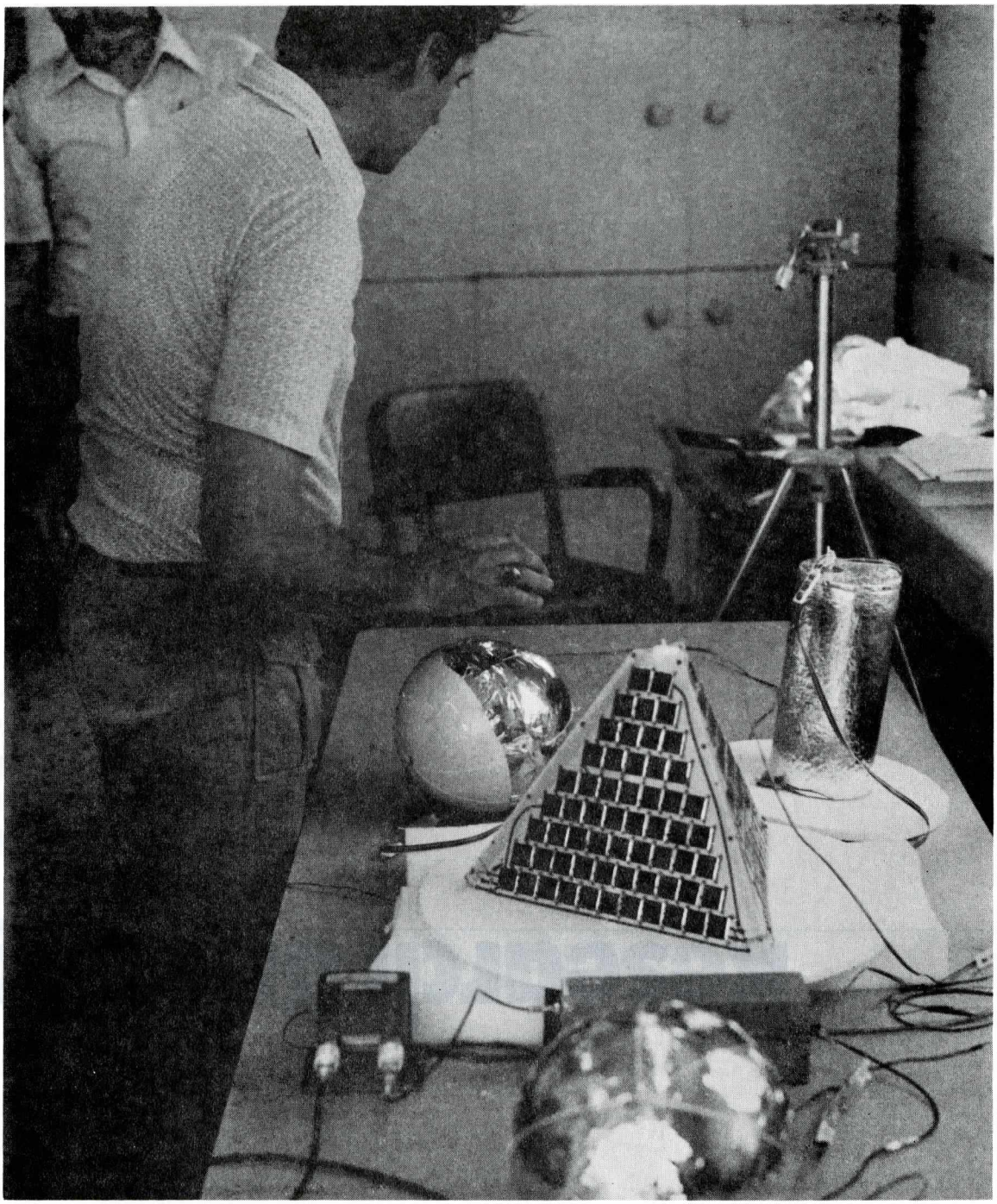


FIGURE 4 - TEST UNITS ON BENCH DURING TETHERED TESTS

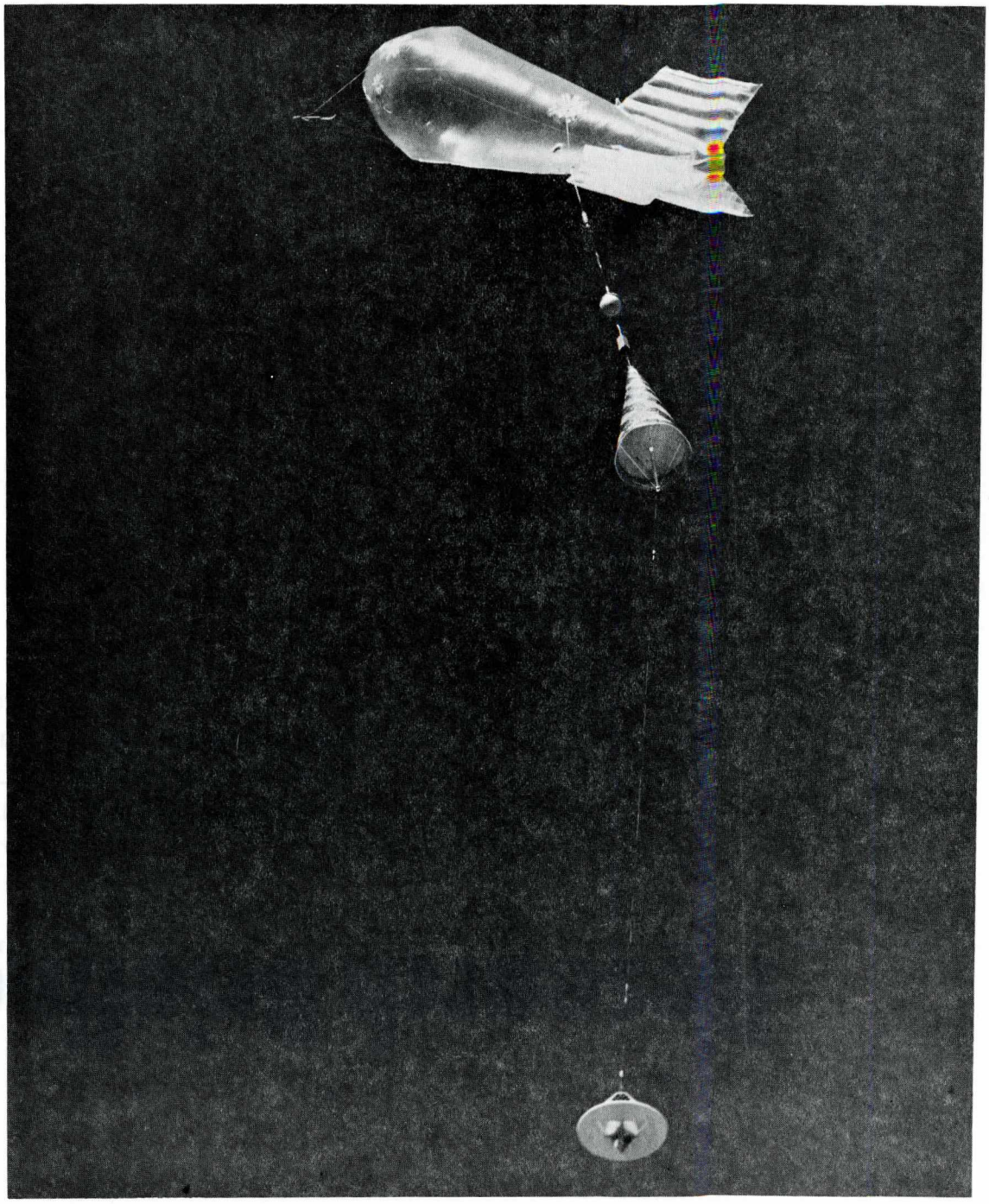


FIGURE 5 - TETHERED KYTOON SUPPORTING THE TWERLE FLIGHT ELECTRONICS

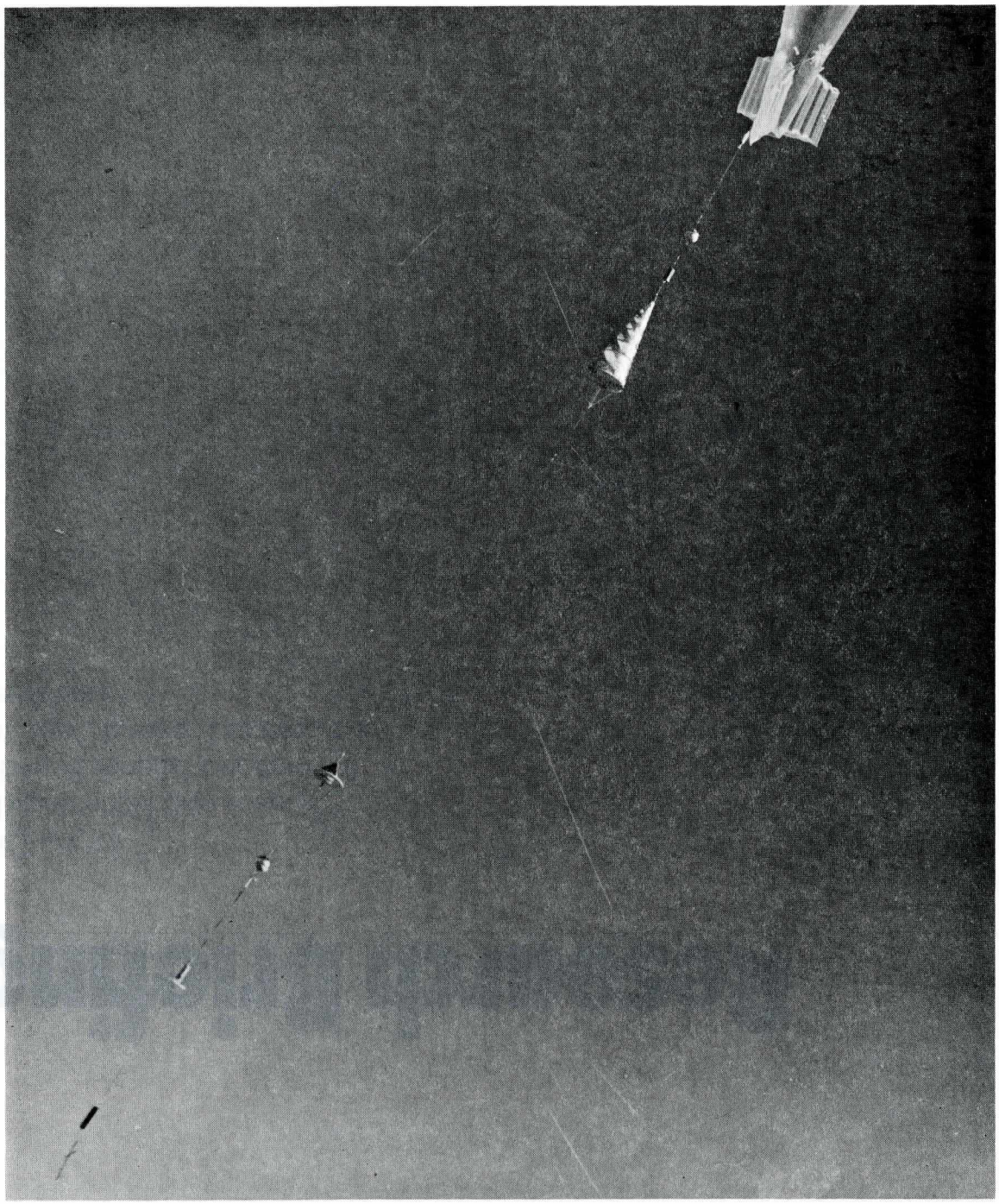


FIGURE 6 - KYTOON SUPPORTING TWERLE FLIGHT ELECTRONICS