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A Preliminary Evaluation of the Cricketsonde Rocket System

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Abstract

Test flights of the Cricketsonde rocket were conducted by AFCRL to determine the operational feasibility of this low level meteorological rocket system. Designed as an inexpensive reliable and safe method for obtaining meteorological data up to 3,000 ft. altitude; the Cricket employs a cold-type propellant and a 403 mc radiosonde telemetry package which is ejected at apogee and descends by parachute. Flight results indicate that the Cricketsonde has a good potential as an operational system. Problem areas relating to its optimum use are explored.

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1. INTRODUCTION

Two series of Cricketsonde rocket flights (Figure 1) were made in October through December 1963 at Otis AFB, Mass., to determine the operational feasibility of this low level meteorological rocket sounding technique. The Cricketsonde flight vehicle was designed and developed by Texaco, Inc., Richmond, Va., to provide an inexpensive, reliable and safe method of making meteorological measurements of temperature, pressure and relative humidity to an altitude of approximately 3,000 ft. The complete system includes a launcher (Figure 2), rocket vehicle, telemetry package and parachute recovery system. The telemetry package (Figure 3), essentially a small radiosonde, was designed by the Friez Instrument Division of the Bendix Corporation. The flight units for these tests were made available to AFCRL by the Bureau of Naval Weapons (FAME).

2. PROPULSION SYSTEM

The rocket employs a cold carbon dioxide propellant in the following manner. The propellant chamber is first partially filled with acetone. Liquid CO_2 is then pumped into a pressure of 400 psi and is dissolved in the acetone (Figure 4). The binary composition is used here to control the thrust and prolong the thrust duration.

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Figure 1. The Cricketsone Rocket: the Payload Section, Parachute and Timer Section, Propellant Tank and Nozzle Assembly

Figure 2. Cricketsonde Launcher

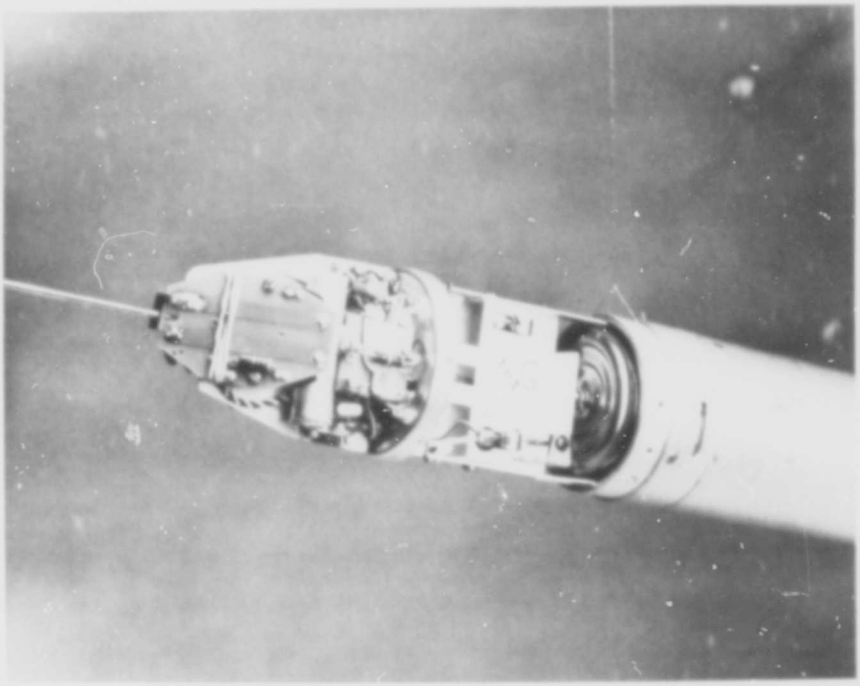
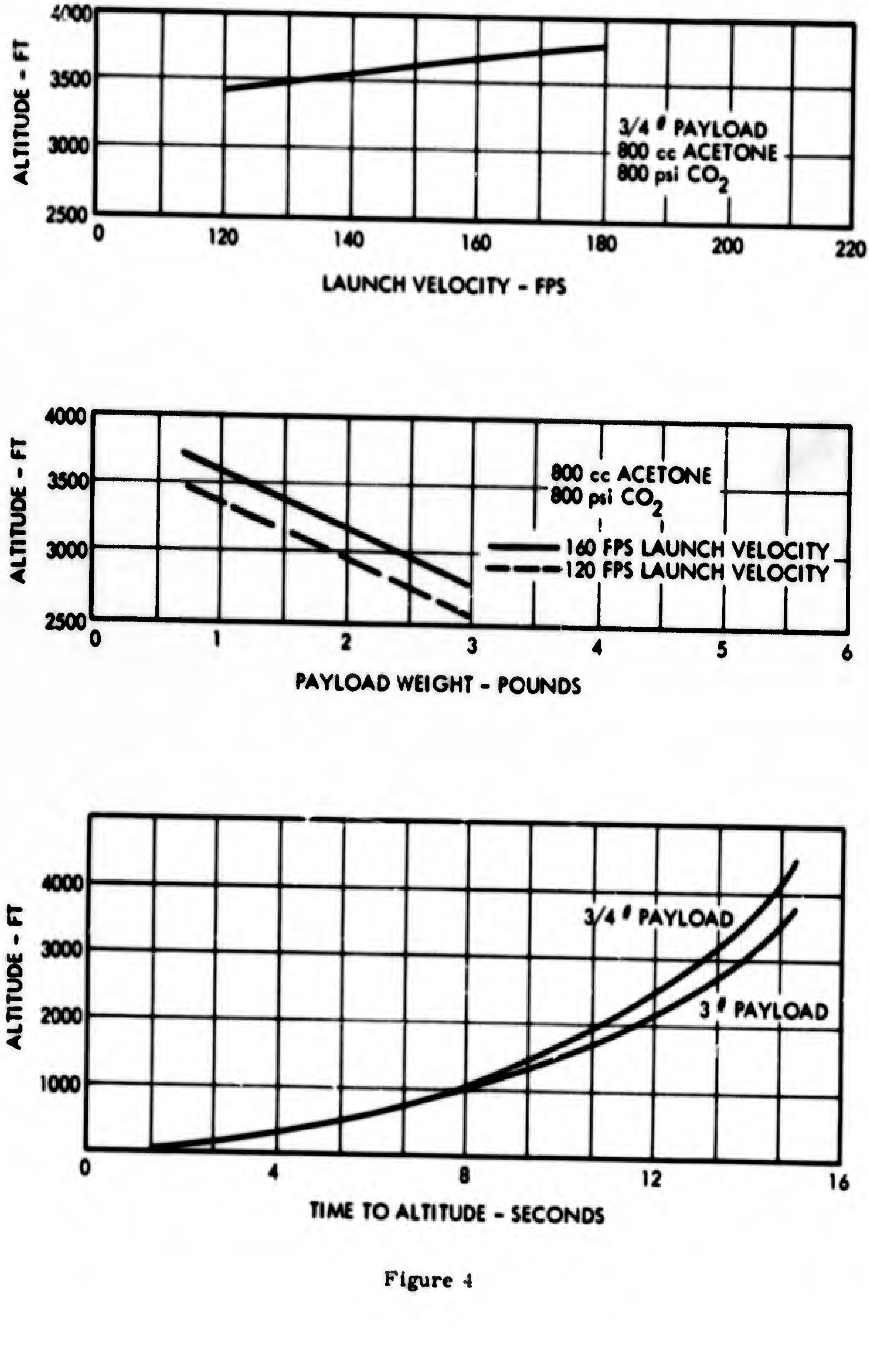


Figure 3. The Cricketsonde Rocket; The Telemetry Package



4000
3500
3000
2500
ALTITUDE - FT
0
120
140
160
180
200
220
LAUNCH VELOCITY - FPS
3/4 # PAYLOAD
800 cc ACETONE
800 psi CO2
4000
3500
3000
2500
ALTITUDE - FT
0
1
2
3
4
5
6
PAYLOAD WEIGHT - POUNDS
800 cc ACETONE
800 psi CO2
160 FPS LAUNCH VELOCITY
120 FPS LAUNCH VELOCITY
4000
3000
2000
1000
ALTITUDE - FT
0
4
8
12
16
TIME TO ALTITUDE - SECONDS
3/4 # PAYLOAD
3 # PAYLOAD

Figure 4

Additional gaseous CO_2 is fed into a chamber below the breech and released by a special valve at launch time to impart a high muzzle velocity to the rocket for stability purposes.

After the rocket is charged, it is loaded, tail first, into the breech. A plug with a valve is used in the nozzle to charge the rocket with CO_2 and to close off the nozzle prior to launch. The launch chamber under the breech is loaded with gaseous CO_2 under pressure, and a launch tube is added to the breech. At launch, a valve is released allowing pressure from the launch chamber to expel the rocket. The rocket ordinarily reaches 180 fps by the time it leaves the launch tube (Figure 4). The valve at the nozzle orifice provides a seal in the breech to transmit the thrust of the launch chamber pressure to the rocket. As the rocket leaves the launch tube, this valve (plug) drops off allowing the rocket fins to deploy and the rocket charge to be released through the nozzle. This discharge lasts two seconds, imparting 75 g's to the rocket (Figure 5). Normal peak velocities reach 550 fps for a 3/4 pound load (Figure 4).

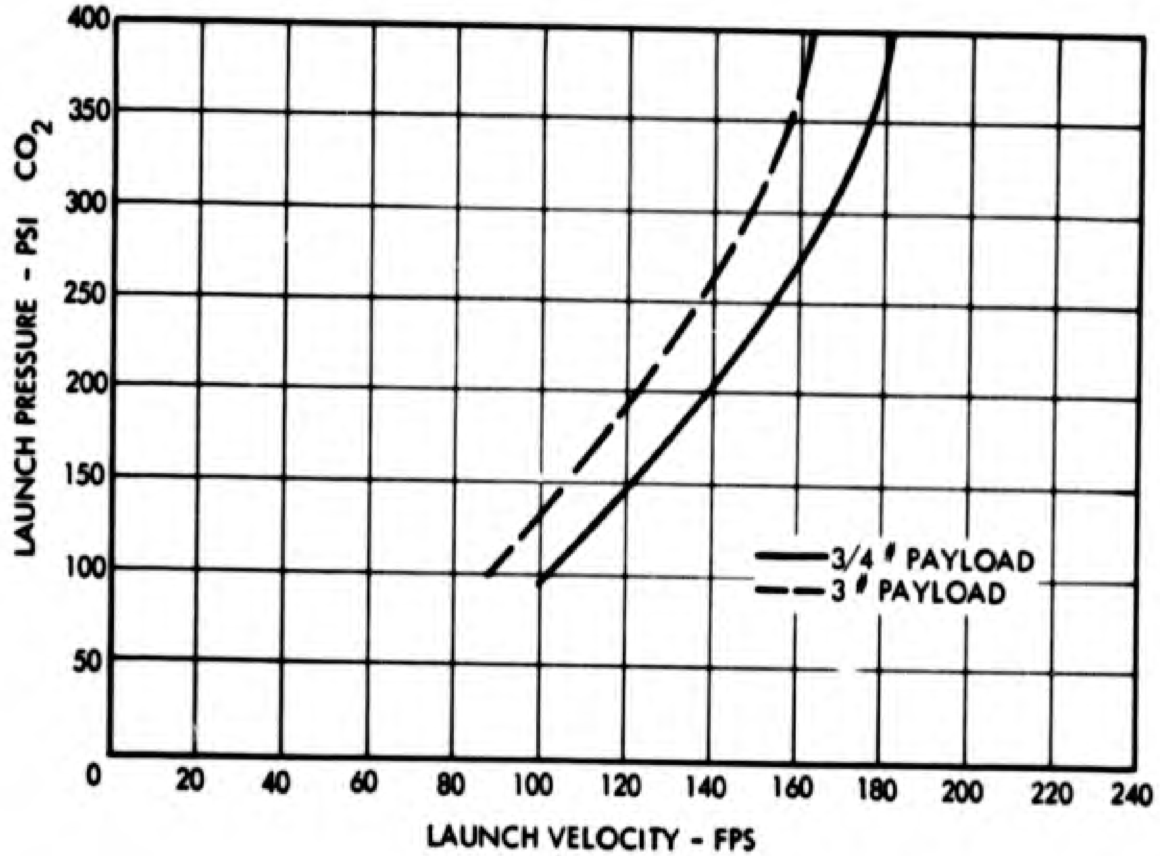
After "burnout" the instrument coasts to apogee. The time required for the rocket to achieve peak altitude is about 13-14 sec. with a 3/4 pound payload. A timer mechanism opens the parachute compartment at a preset time after launch. A five-foot diameter parachute is then deployed, with the rocket descending at a rate of about 600 fpm to impact, with only slight likelihood of damage to itself or to any surrounding objects.

3. TELEMETRY

The telemetry package includes a transmitter, blocking oscillator, pressure switch, and battery, all contained within the nose section.

The package transmits a record of pressure, temperature and humidity of the atmosphere through which it passes. A multivibrator is used to switch temperature and humidity sensors into the circuit. The baroswitch over-rides the multivibrator to give pressure readings. The transmitter is designed to operate in the 403 mc meteorological band. The entire payload including battery weighs 3/4 pound. The total weight of the fueled rocket is 5-1/2 pounds.

The temperature and humidity sensors are mounted in a vented housing and are exposed to the atmosphere by attachment to the parachute lanyard. The temperature sensor is a standard ML-419 element and the humidity sensor a standard ML-476 carbon element. A sample of data is obtained every 30 feet on descent. An aneroid type baroswitch is employed. During flight, pressure points are obtained for each 500 feet of altitude. The sonde operates from a water activited battery (Ray-O-Vac BSC5).


LAUNCH PRESSURE - PSI CO_2
400
350
300
250
200
150
100
50
0
20
40
60
80
100
120
140
160
180
200
220
240
3/4 # PAYLOAD
3 # PAYLOAD
LAUNCH VELOCITY - FPS

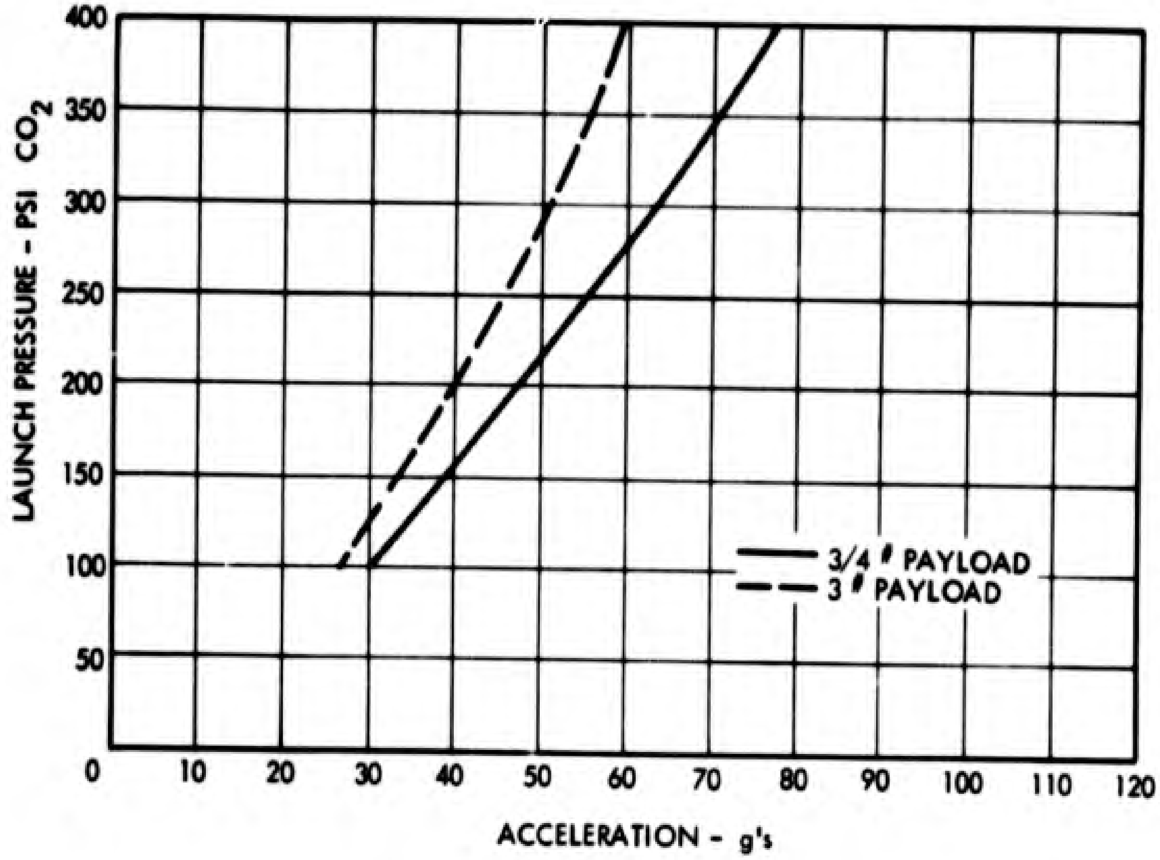

LAUNCH PRESSURE - PSI CO_2
400
350
300
250
200
150
100
50
0
10
20
30
40
50
60
70
80
90
100
110
120
3/4 # PAYLOAD
3 # PAYLOAD
ACCELERATION - g's

Figure 5

The rocket incorporates the latest mechanical design features wherein the instrument package is fastened in the nose section prior to calibration of the baroswitch unit. An access door is provided for insertion of the water activated battery without the necessity of removing the entire nose cone.

The ground receiving system consists of a manually operated antenna, receiver, recorder and power generator, as shown in Figure 6.

4. FLIGHT TEST RESULTS

The Cricketsonde flight tests were conducted at Otis Air Force Base, Cape Cod, Mass., in two separate series.

The first series of flight tests were to determine altitude capabilities and dependability of meteorological sensors under typical field use. Eight (8) flights were made, all performing satisfactorily. (See Table 1.) Wind conditions were rather severe, with velocities up to 35 to 40 knots encountered. However, five units were recovered.

The second group of flight tests were set up to evaluate the potential for reusability of the Cricketsonde. Twenty-eight (28) flights were made using four different vehicles. (See Table 2.) One rocket was launched successfully eleven times. Data were obtained on all flights.

Telemetering lasted for approximately six (6) minutes, as the parachute descended at a rate of about 500 ft./min. (Figures 7 and 8.) The temperature and humidity data were reduced in a manner similar to that employed in standard radiosonde operations, utilizing special charts prepared by Bendix-Friez. (Figure 9.)

Pressure values are obtained using a ten point calibration chart. The pressure points over-ride the temperature and humidity measurements and occur approximately every five (5) seconds (500 feet of altitude).

5. CONCLUSIONS

As previously stated, these flights were made to determine the operational feasibility of the Cricketsonde technique. Without question, the feasibility of the system was shown. Loading and launching were performed without any problems, despite the fact that untrained operators were handling the equipment. As for the payloads, they were completely satisfactory electronically and all flights produced usable data. The complete system was demonstrated to be operable with a minimum of two personnel, a launcher operator and a receiving equipment operator.

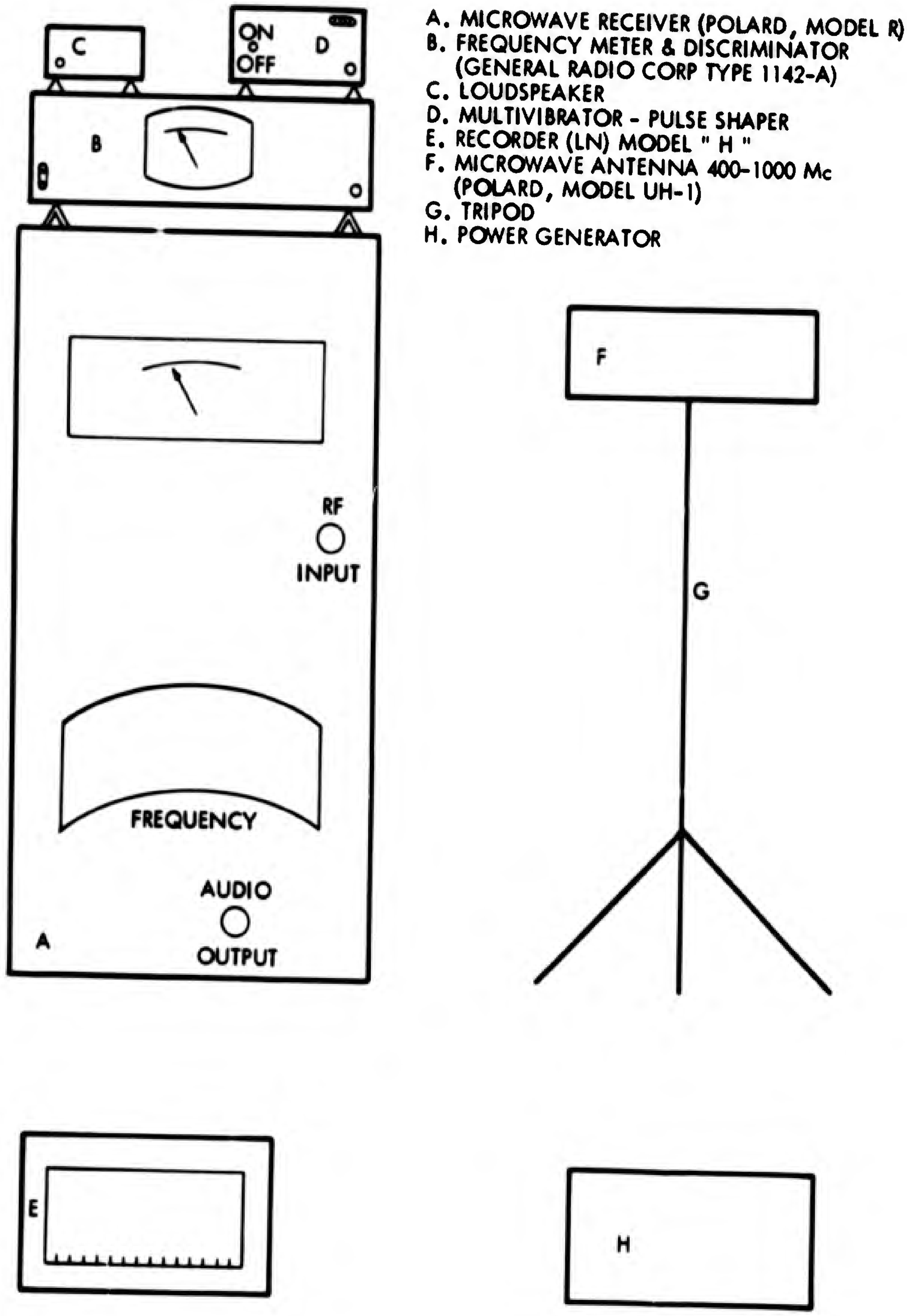


Figure 6. Ground Receiving System

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TABLE 1

Flight No.	Time EST	Baroswitch No.	Rocket Motor No.	Calculated Altitude from Baroswitch Data (feet)	Approx. Descent Time (min)	Avg. Descent Rate (ft/min)	Avg. Time to Max. Altitude (sec)
1	1000	116	823	3,261	4.9	609	14
2	1200	94	819	3,209	4.9	609	14
3	1230	73	815	3,002	5	609	14
4	1300	118	822	3,330	5	609	14
5	1349	89	789	2,808	4.5	609	14
6	1430	107	845	3,386	5	609	14
7	1445	102	824	3,300	5	609	14
8	1504	101	816	3,199	4.8	609	14

TABLE 2

Rocket Motor Number	Number of Flights	Number of Baroswitch	Avg. Maximum Altitude (Feet)	Avg. Time to Max. Altitude (sec.)
815	11	75	3,000	14
818	8	112	3,300	14
822	7	118	3,300	14
823	2	116	3,200	14

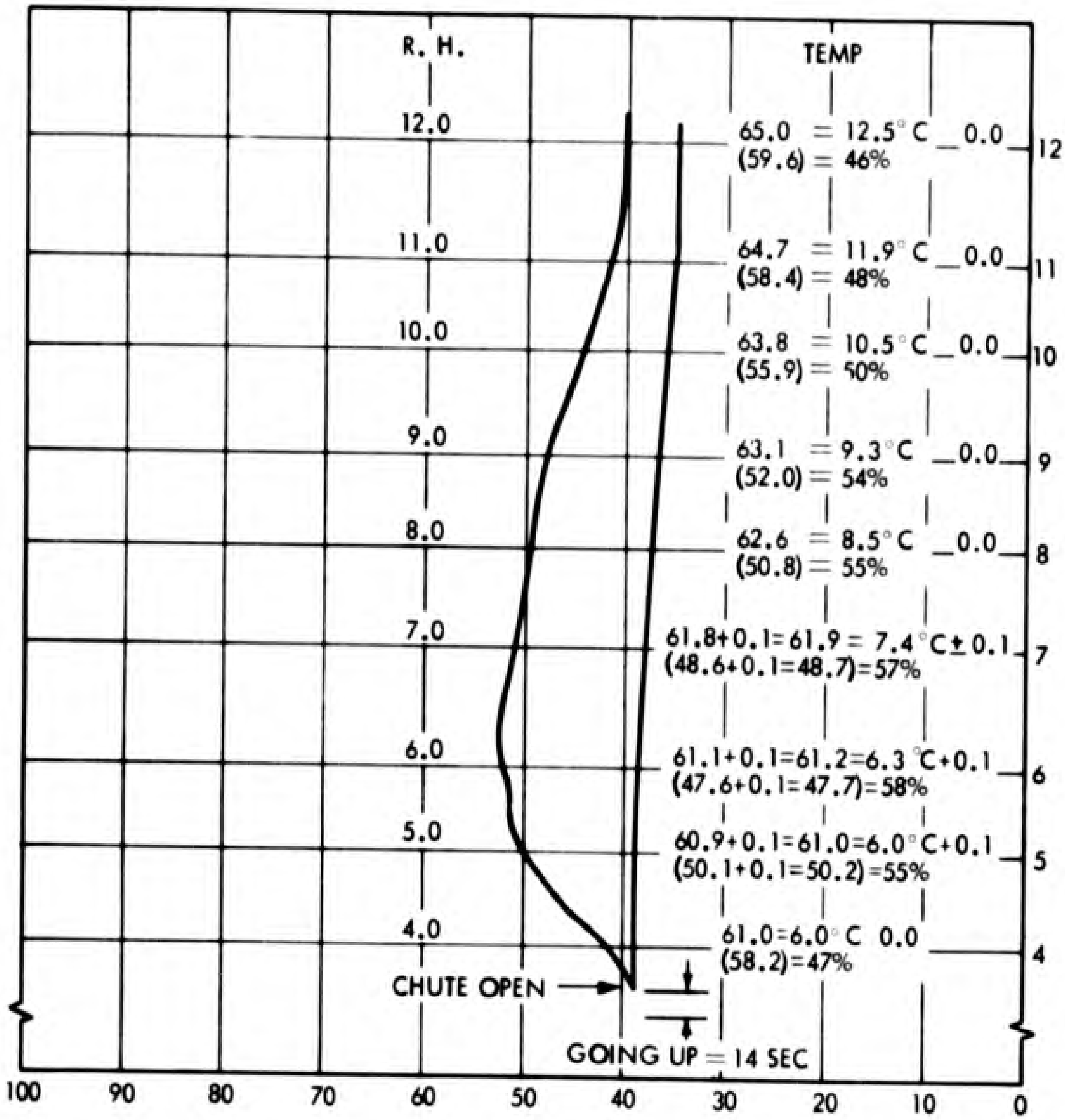

Figure 7. Flight Record, Flight #6

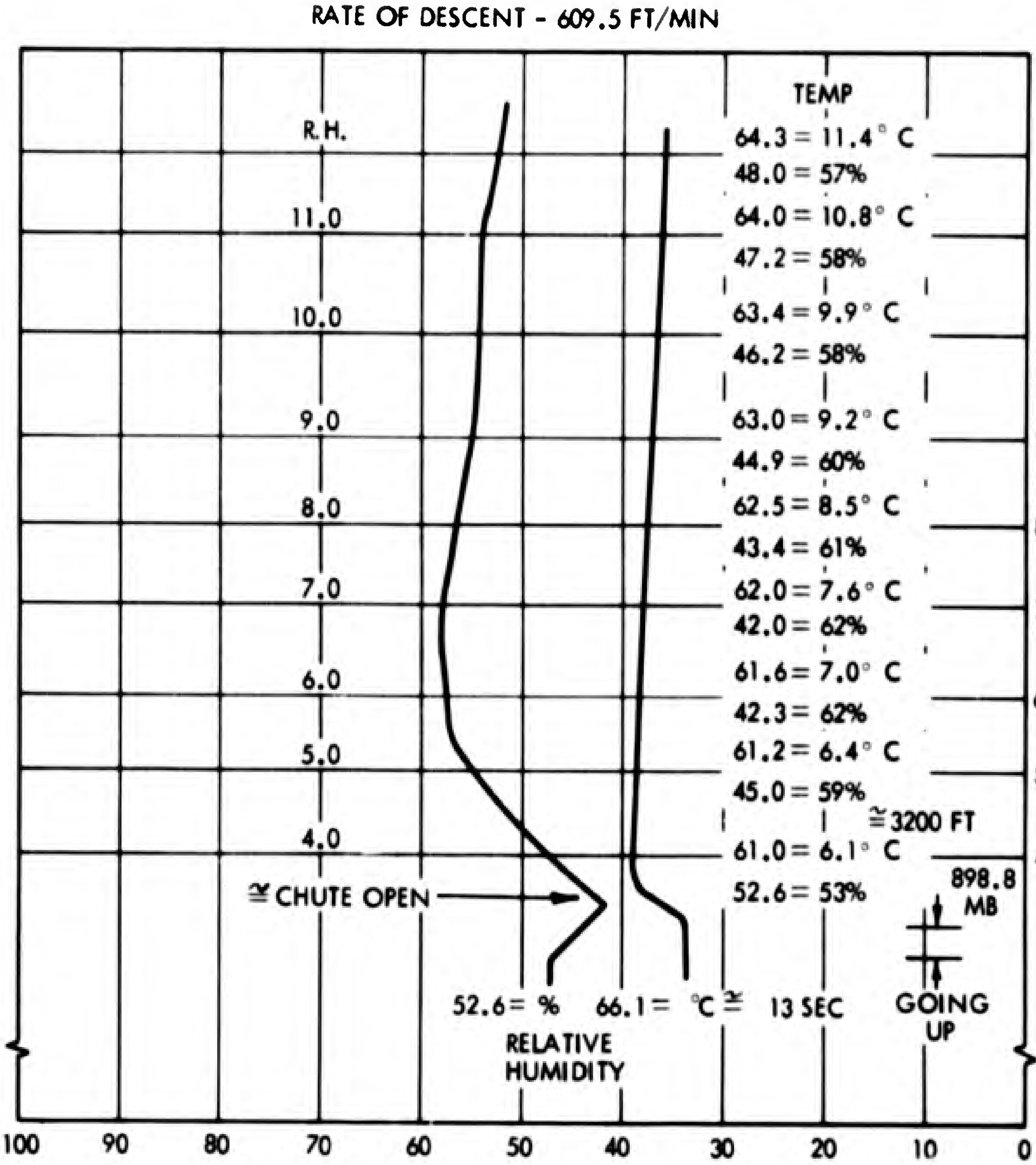

Figure 8. Flight Record, Flight #8

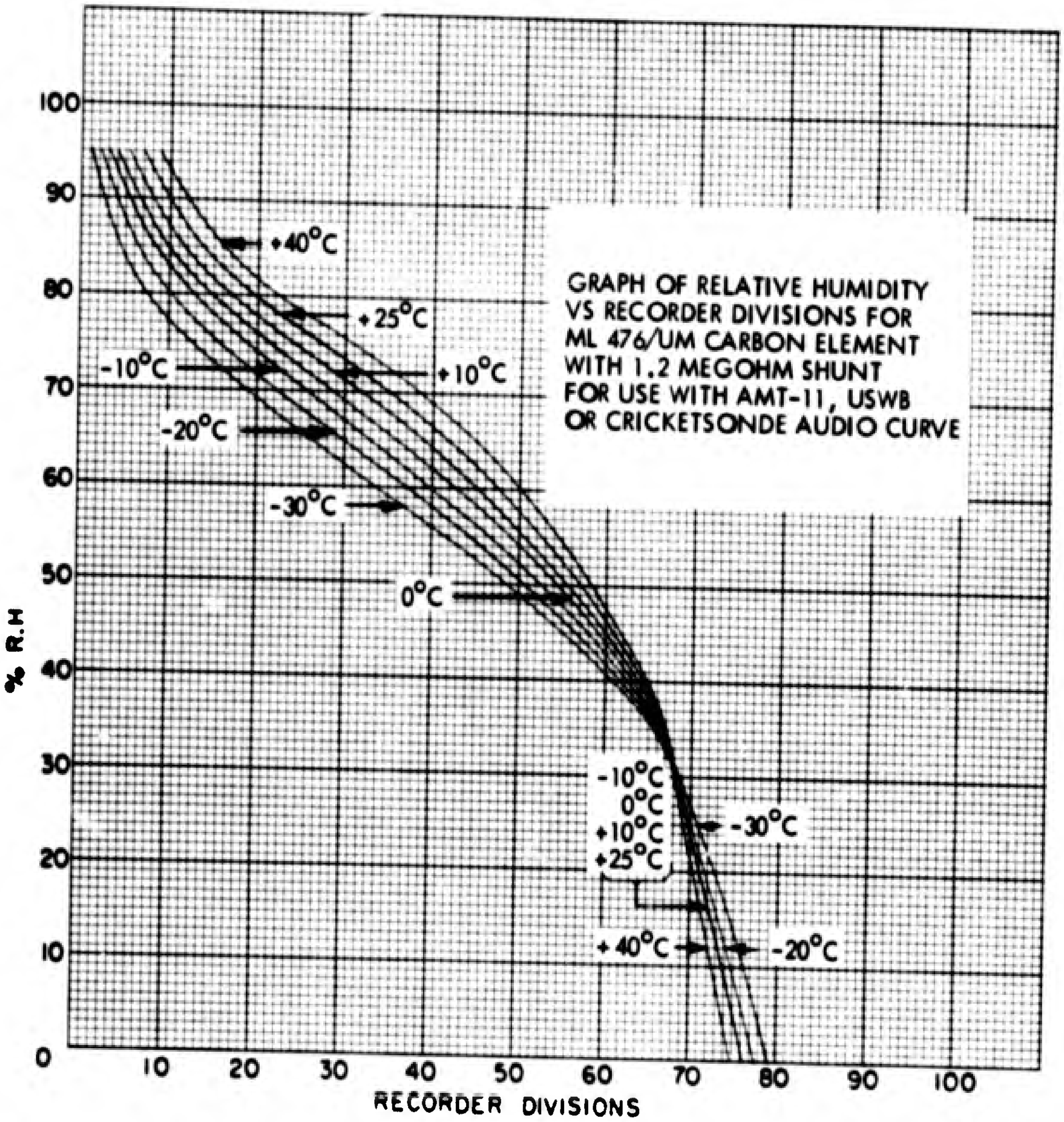
GRAPH OF RELATIVE HUMIDITY
VS RECORDER DIVISIONS FOR
ML 476/UM CARBON ELEMENT
WITH 1.2 MEGOHM SHUNT
FOR USE WITH AMT-11, USWB
OR CRICKETSONDE AUDIO CURVE
+40°C
+25°C
-10°C
+10°C
-20°C
-30°C
0°C
-10°C
0°C
+10°C
+25°C
-30°C
+40°C
-20°C
% R.H
0
10
20
30
40
50
60
70
80
90
100
RECORDER DIVISIONS

Figure 9

Other techniques for obtaining the same type of data are captive systems, such as the wiresonde and radiosondes, using light-weight sondes and small slow-rising balloons. While no comparison flights were made it appears that the Cricketsonde could potentially satisfy certain operational low level sounding requirements as a substitute for the flight expendables used in other systems.

As far as cost is concerned the Cricketsonde is estimated by the contractors to cost approximately $80 in quantity procurement. This breaks down to about $35 for the vehicle and $45 for the payload. If each unit were to be used ten times, the cost per shot would be in the order of $8. Experience has shown that reusable Crickets require a new battery and occasionally a new temperature or humidity element, thus a unit cost figure of $10 is more realistic. The fuel required for each Cricket launch is very nominal in cost, under 50 cents.

Some problem areas are inherent in the current Cricketsonde system, although none appear to be insoluble. A real operational system, for example, should transmit on 1680 mc and have a capability for automatic wind sensing, be it through the use of a transponder or other technique. There should also be an add-on capability for other possible sensors, such as a refractometer. The recovery feature, which is economically mandatory, could be less than satisfactory in nighttime flights. The same would apply to coastal launches, or launches in swampy or heavily wooded areas. However, experienced personnel could probably offset the recovery problem somewhat by judicious selection of the launch angle to take advantage of the upper air winds. Finally, although the Cricket propulsion method is advertised as a "safe" one, certain precautions must be taken by the personnel. A fair amount of real estate, probably up to ten (10) square miles, would be required for routine operations, allowing for an occasional propulsion or parachute failure.

Acknowledgments

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