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WEATHER BUREAU
Western Region

Salt Lake City, Utah

August 1969

High Resolution Radiosonde Observations

W. S. JOHNSON

Technical Memorandum WBTM WR-41

U.S. DEPARTMENT OF COMMERCE / ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

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A western Indian symbol for rain. It also symbolizes man's dependence on weather and environment in the West.

U. S. DEPARTMENT OF COMMERCE
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
WEATHER BUREAU

Weather Bureau Technical Memorandum WR-41

HIGH RESOLUTION RADIOSONDE OBSERVATIONS

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WESTERN REGION
TECHNICAL MEMORANDUM NO. 41

SALT LAKE CITY, UTAH
AUGUST 1969

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PREFACE

Standard radiosonde observations do not provide the resolution of detail in temperature and humidity profiles that is necessary in some investigations of the atmosphere or its effects on certain events. An example is the computation of refractivity profiles for investigation of tropospheric scatter, ducting, or attenuation of electromagnetic propagations. These environmental effects are very significant considerations in strategic communications, ballistic fire and control systems, space-positioning by radar, to mention a few.

Portions of the temperature and humidity traces are always missing in the standard radiosonde observation due to the normal switching of the commutator bar. In many instances rapid changes of one element are occurring while the other element is being transmitted. The radiosonde method is capable of better resolution of the temperature and humidity profiles than is normally provided from routine flights.

Modifications were made to the radiosondes, to the rawin GMD receiver and in procedures for extracting the meteorological data from the transmitted signals to obtain more data and to improve the accuracy of radiosonde observations. The modifications are not costly. Standard government in-stock items are used and the modifications can be done easily at the field station by the electronic technician and a radiosonde observer.

The application of this modified system probably is best utilized where detailed temperature and humidity information is required in the lower troposphere, although many flights have been tracked successfully to above 15 millibars.

This paper describes the instrumental and procedural modifications that were devised and have been in use for over one year by the Weather Bureau Office at Fort Huachuca, Arizona.

August 1969 W. W. Johnson

HIGH RESOLUTION RADIOSONDE OBSERVATIONS

I. INTRODUCTION

A method to obtain high resolution in the temperature and humidity profiles, particularly in the first 2000 feet above surface, by the radiosonde is described. The modifications to equipment use standard available items. The modifications provide a dual channel GMD telemetry system that gives nearly continuous recorder traces of both temperature and humidity, interrupted only for the high and low references. One channel carries temperature, the other carries humidity data. All other normal switching points on the commutator bar are used for positive data-altitude control.

The flight train consists of one 300-gram balloon, two standard parachutes and two standard 1680 MHz radiosondes strapped or tied together. One transmitter transmits only temperature and the other transmits only humidity, each on a separate frequency.

The receiver for one channel is the standard rawin GMD-1 () antenna and receiver drawer. The second channel is received through a small dipole and 30-inch reflector piggy-backed to the main antenna by the receiver drawer that is normally the spare to the GMD-1() set. Separate TMQ-5 recorders record the signals from each channel.

The advantage of this combination is that for a small additional cost over conventional soundings, considerably more information on temperature and humidity variations in the vertical is obtained with improved accuracy.

II. THE INSTRUMENT PACKAGE

The flight instrument package consists of two modified radiosonde modulators, MD-210/AMT-4B, with transmitters, FSN 6660-542-1964. One modulator is modified to transmit temperature only by cutting the lead from the hygristor at approximately three inches from the relay terminal board. The three-inch wire from the humidity terminal on the terminal board is soldered to the temperature terminal of the terminal board. The 2.4 meg. ohm <u>resistor is removed</u> from the humidity circuit, Figure 1.

In the humidity measuring instrument the lead from the thermistor is cut about three inches from the terminal board to the relay. The cut end of the three-inch wire is soldered to the humidity terminal of the board. The 2.4 meg. ohm <u>resistor remains</u> in the humidity cirucit, Figure 2.

These modifications give almost continuous recorder traces of both temperature and humidity. The only interruptions are the high and low references. Continuous traces can be obtained from surface to 1000 feet above surface by proper selection of instruments. The selection is made by comparing the current surface pressure with the calibration chart packaged with each modulator. Choose a modulator with low reference at a pressure just slightly higher than the current surface pressure. Then 1000 feet of continuous sounding can be obtained. Drift control is maintained through the layer by the references obtained at release (described in RELEASE PROCEDURES) and the next reference that will come in just above the thousand feet of ascent. Standard procedural instructions allow setting the commutator pin ± 3 contacts from the actual pressure contact and applying this correction throughout the flight. This simplifies the selection of instruments to obtain continuous traces in the low levels.

The relay is retained in the circuits of both instruments to obtain the normal switching points of each commutator contact on the recorder record. The long sweep of the recorder pen between humidity and temperature traces of conventional flights is eliminated. Instead, just a momentary kick of the recorder pen, about one ordinate down scale, is obtained. Both modulators send the normal switching points every one-half contact. The numerous pips thus produced on the recorder record at known pressures (from calibration chart) provide positive altitude control. The spacing of the pips is useful information on ascension rate changes.

The two transmitters are not modified, but the carrier frequencies are changed so that 15 MHz difference is maintained between the two. It is best ot use frequencies that are not multiples of the frequency difference or interfere with the two oscillator frequencies. No interference has been encountered using 1675 MHz for temperature and 1690 MHz for humidity. The frequencies are set on several transmitters at one bench session, setting all transmitters in one shipping carton to 1675 MHz and all those in a second shipping carton to 1690 MHz. The frequency is marked on the outside of each transmitter with a china-marking pencil. Several modulators are modified at the same time, one carton of modulators modified for temperature measurements and a second carton for humidity measurements. The low reference near the normal surface pressure for each modulator is marked on the outside of each modulator case. The modifications and frequency settings, four cartons in all, can be done in about two hours.

The standard ML-419/AMT-4 thermistor and the ML-476/AMT hygristor are used.

III. THE FLIGHT TRAIN

The two modified radiosondes are taped together, Figure 3, and a cord bridle is placed through the rings on the tops of the modulators to attach the train. The train consists of a 300-gram balloon, two standard paper parachutes and the two instruments taped together, Figure 4. The two parachutes are separated by 20 feet of cord with the upper parachute ten to twenty feet below the balloon and the instrument package 60 feet below the bottom parachute. The balloon is inflated to 3000 grams nozzle lift. This gives a relatively slow ascension rate of 500 to 600 feet per minute, thus partially compensating for the high time-constant of the sensors.

IV. GROUND RECEIVING EQUIPMENT

The signal from one transmitter is received and sent on to the TMQ-5 recorder through the rawin receiver system, GMD-1(). The signal from the other transmitter is picked up by a 30-inch parabolic reflector and dipole. This is a part of the Weather Bureau 1680 MHz radio test set listed in the Instrumental Equipment Catalog, page J5, WBSN J206-1-2-3. The auxiliary reflector and dipole are mounted on the right end section of the main GMD reflector, Figures 5 and 6. A bracket support for the auxiliary reflector is mounted between the center frame members of the GMD reflector and bolted to the end section using existing holes in the frame. Lightweight metal is used for the support to keep the weight to a minimum on the main reflector. The support is a 1/4-inch plate, 5 1/2 X 32 1/2 inches, which is just long enough to position the small reflector at the edge of the main reflector. The plate is cut to fit the bracket on the back of the small reflector and to allow the standard spare rawin mixer to be attached to the base of the dipole antenna. The spare oscillator and IF cables connect the mixer to the auxiliary receiver.

The auxiliary receiver is the spare receiver to the rawin set. A small table, just large enough to hold the spare receiver, is mounted on the housing of the GMD directly under the auxiliary antenna to keep the coaxial cables from the antenna to receiver as short as possible. With the auxiliary components mounted on the right side of the GMD (as veiwed from the control section of the housing), Figure 6, there is no interference to the use of the override controls on the left side. The auxiliary receiver is powered from the AC outlet on the face of the antenna control drawer using test cable CX 1493/J. The signal is also taken from this cable fitting at the receiver from pin D* and the grounding shield from pin C or F.

The signal input to the TMQ-5 recorder is to pin F and the grounding shield to pin D or E of plug P-601 in the back of the recorder. The 110V AC is supplied through pins A and B of this same plug.

*Pin designations are clearly indicated on equipment, but not discernable in Figure 6.

V. BASELINE CHECK PROCEDURES

Baseline check procedures are similar to those stated in the Federal Meteorological Handbook No. 3. A valid baseline consists of three temperature and four low reference traces for the temperature instrument and three humidity and four low reference traces for the humidity instrument. The two instruments should be baseline checked at the same time. This, of course, requires two baseline check boxes. One baseline check box can be used by baselining one instrument immediately after the other. After a valid baseline check has been completed, one temperature-humidity computer can be used.

VI. PRERELEASE GROUND CHECK

The commutator bar of each instrument is set to the surface pressure contact setting. Extreme care must be taken in making this setting because the only indication of the switching points is a slight kick of the recorder pen about one ordinate down scale.

A prerelease surface temperature and humidity check is made to assure that the radiosonde data agree with the surface temperature and humidity determined from the wet and dry bulb readings. It is most important that the radiosonde and the psychrometric measurements be taken at the same time at the same point in space. To assure this, an aspirated insulated shelter is used. Both radiosonde sensors and the psychrometer measure the same air stream through the shelter. Radiosonde readings must be within one-half degree Celsius and five percent relative humidity to be acceptable. Better than 95 percent of the radiosondes will meet these criteria. The prerelease check is a necessary procedure for detailed soundings. It eliminates the false superadiabatic lapse rates and inversions of temperature and the unrealistic humidity changes that frequently show on the traces in conventional soundings when the temperature and relative humidity of the first level reported is determined by surface instrumentation and the second reported level is measured by radiosonde.

VII. RELEASE PROCEDURES

Release is made immediately following the prerelease checks. Procedures for release are conventional with possibly one exception. The exterior ground and low reference leads on each radiosonde are joined together loosely by breaking the insulation on one lead and attaching the end of the other lead to the wire through the break in the insulation. They are simply held together by a flat piece of tape over the connection and pressed against the side of the case. A loop of string is passed through and two loops formed by the exterior connections and fastened to the observers wrist. With both recorders running, low reference is being recorded on both channels at this time. As the observer makes the release, the cord on his wrist breaks apart the loose connections on the radiosondes and both recorders begin simultaneously to record temperature on one, humidity on the other.

VIII. THE RECORDER RECORD

The chart speed is two inches per minute. Basically the same procedures as stated in Federal Meteorological Handbook No. 3 are used for the selection of significant levels. However, to refine the measurement of the variations of the temperature and relative humidity in the lower atmosphere, significant levels are taken when the recorder traces deviate from linearity by one-half degree Celsius or five percent relative humidity. Pressure contact values are determined, as in a normal flight, from the switching points. These are indicated on the recorder record by a momentary kick of the pen approximately one ordinate downscale at every one-half contact. The only interruption to the recording of the temperature and humidity profiles are the high and low references, Figures 7 and 8.

More levels than in a conventional sounding will be selected from the recorder record because of the nearly continuous traces of both elements and the criteria used in the selection of levels. The changes in ascension rate become quite apparent on the recorder record with a fast (two inches per minute) chart feed. By taking into consideration the apparent changes in the ascension rate, as shown by the spacing of the pressure contact pips, when selecting levels and with the large number of levels selected, a more exact profile of each element will be produced on the WBAN 31 () than can be obtained with normal observing techniques.

A special chart is used for detailed plotting of the lower portion of the sounding. It is simply the lower portion of the WBAN 31 (A) redrawn with the horizontal scale expanded 2:1 and vertical scale expanded 5:1. A time-pressure curve is drawn on the special chart using the horizontal scale as time in seconds since release and the vertical scale as pressure in millibars. The plotted points are the pressure values of each contact determined from the pips in the recorder record and the calibration chart versus the time in seconds since release, determined by scaling the recorder record which feeds at two inches per minute. The pressure of each significant level is from the T-P curve using time since release to the significant level in question. The thickness of each small layer is determined by the hypsometric formula using pressures at the top and bottom of the layer and the mean virtual temperature. The remainder of the procedures for working up the flight are as described in Federal Meteorological Handbook No. 3.

The two recorder records obtained from each flight, one for temperature and one for relative humidity, may be worked up independently or all levels may be entered on one recorder record. If winds aloft are also desired the control recorder tapes are retained and the winds computed in the normal manner.

IX. ADVANTAGES

Small-scale details in the temperature and humidity profiles are measured with standard radiosonde and GMD equipment. Fictitious surface-based superadiabatic lapse rates and inversions of temperature and unrealistic humidity changes near the surface are eliminated. The system eliminates recorder switching between temperature and humidity, therefore, the wear and maintenance of the TMQ-5 is practically eliminated and the response time of the recorder is of little concern. The small additional cost over conventional flights for an additional instrument and parachute and a little more gas in the balloon seems insignificant when compared to the expensive, sophisticated and sometimes cumbersome-to-use equipment employed in obtaining the same information. When only low-level temperature and humidity profiles are desired, the ground equipment is simply two each of omnidirectional dipoles, receiver drawers and TMQ-5 recorders. All these plus a power generator can be mounted easily in a 3/4 ton pickup truck for mobile operations.

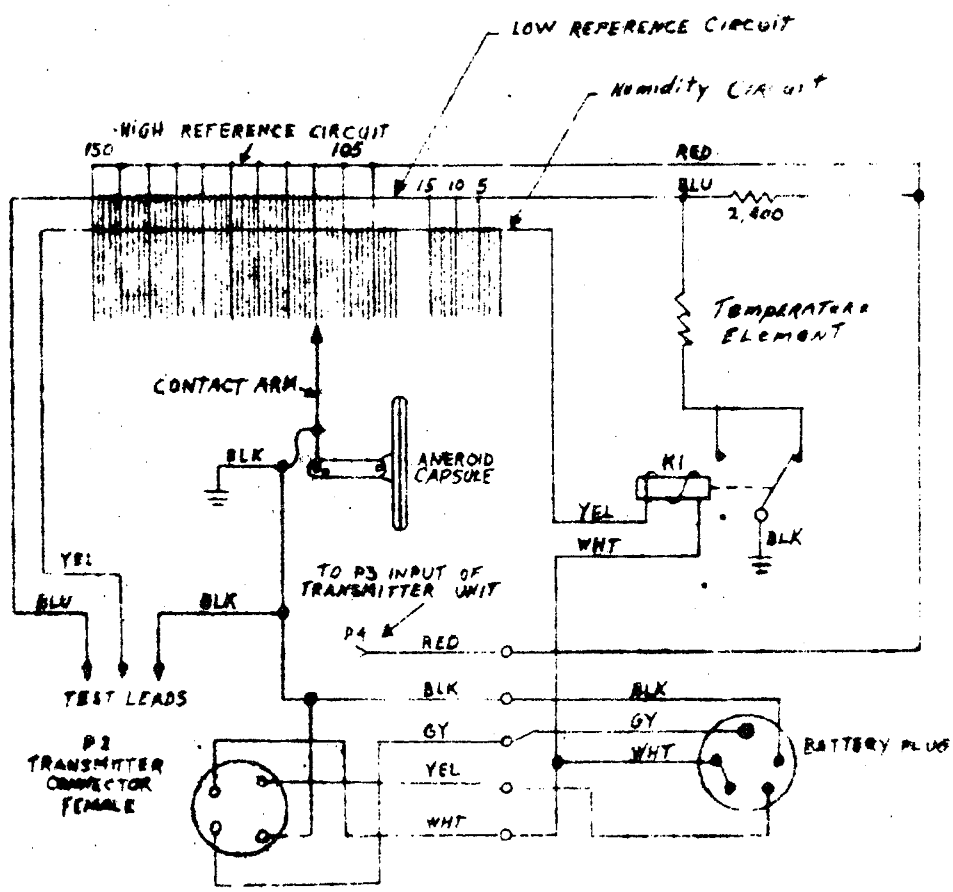

Figure 1 - Wiring Diagram of Modulator for Temperature Measurements

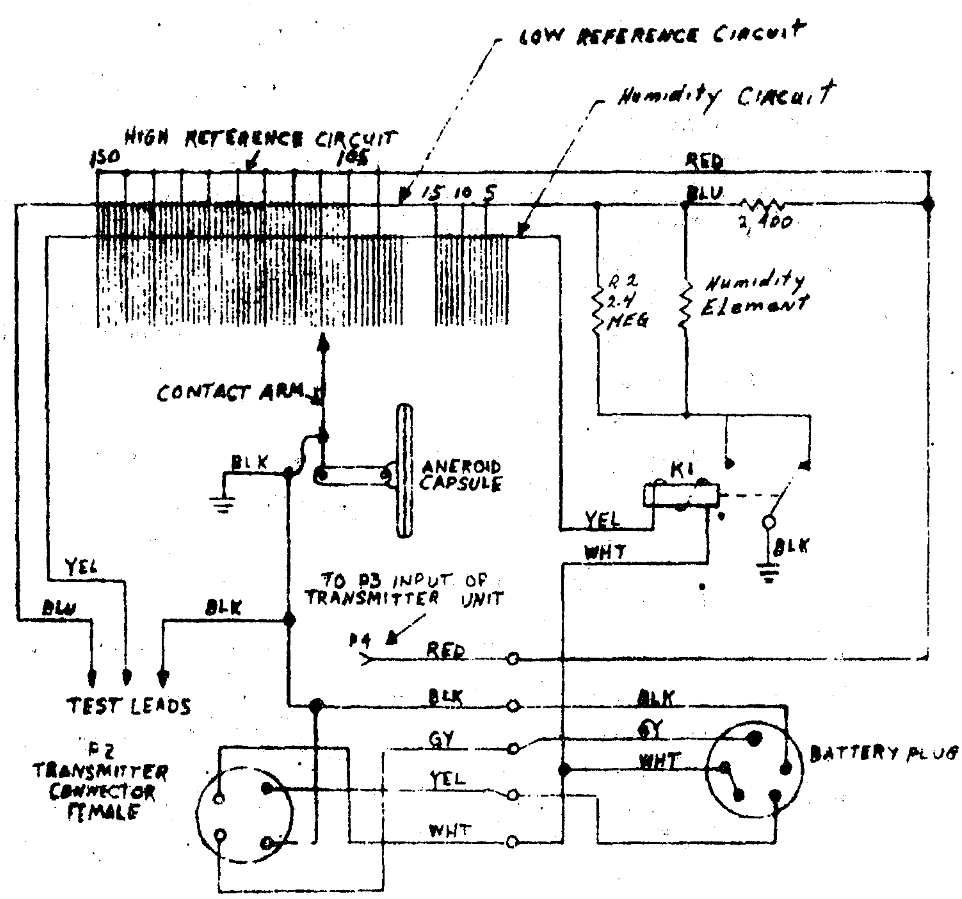

Figure 2 - Wiring Diagram of Modulator for Humidity Measurements

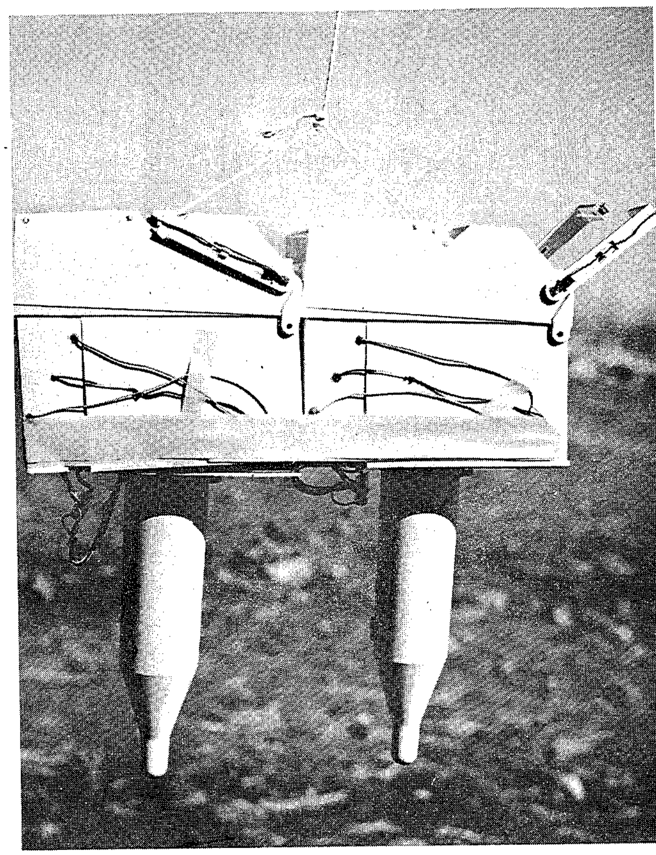

Figure 3 - Radiosonde Package
Ready for Flight

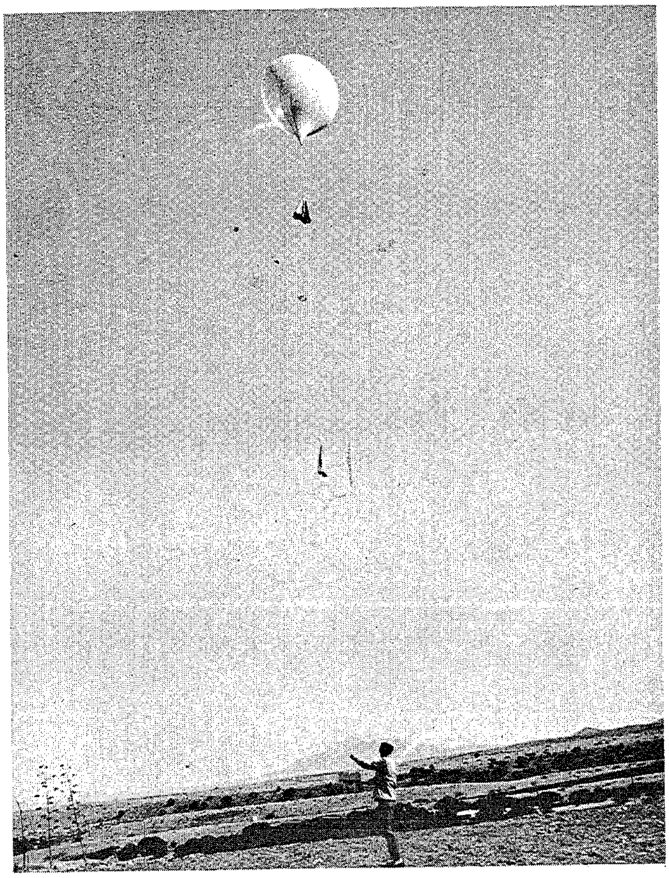

Figure 4 - The Flight Train

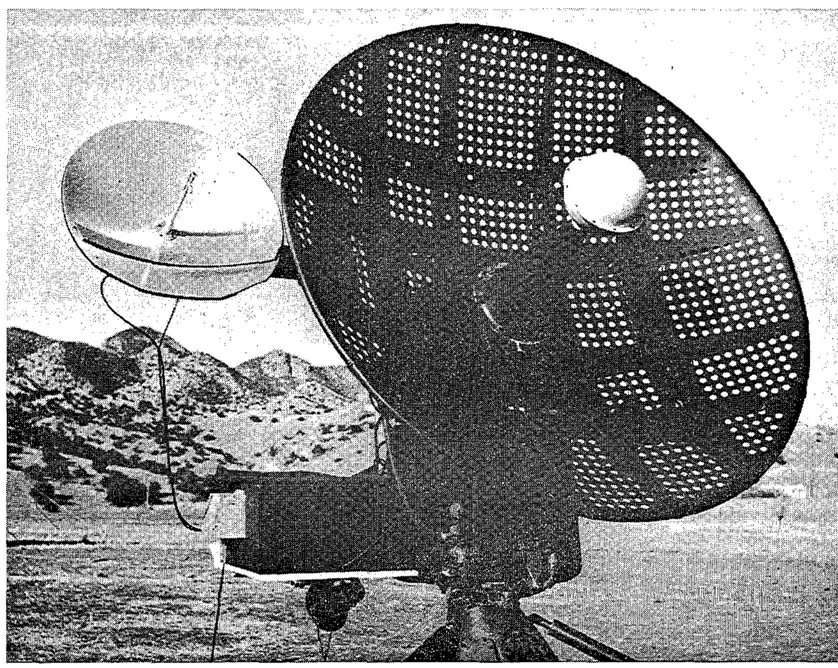

Figure 5 - The Antenna System

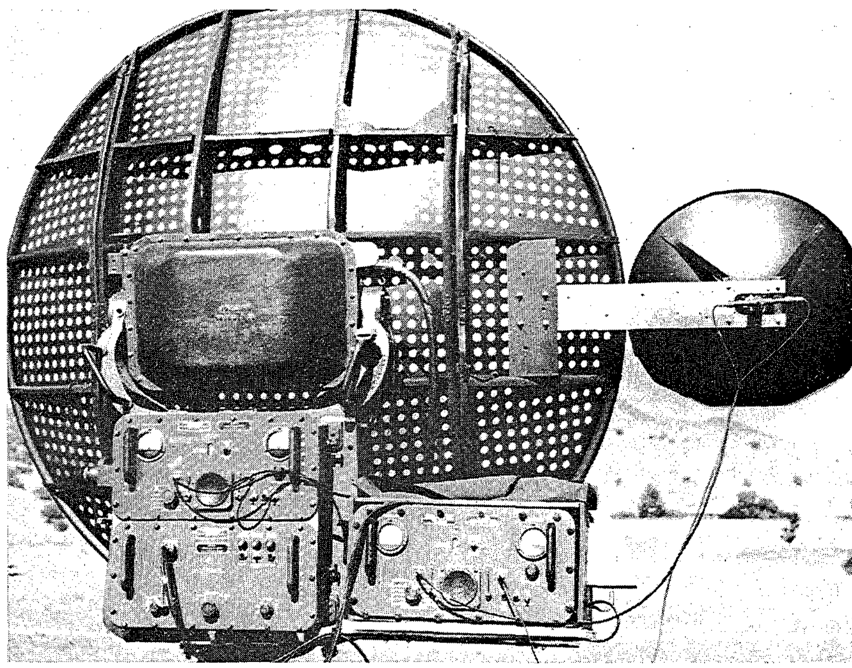

Figure 6 - Mounting of Antenna and Receiver

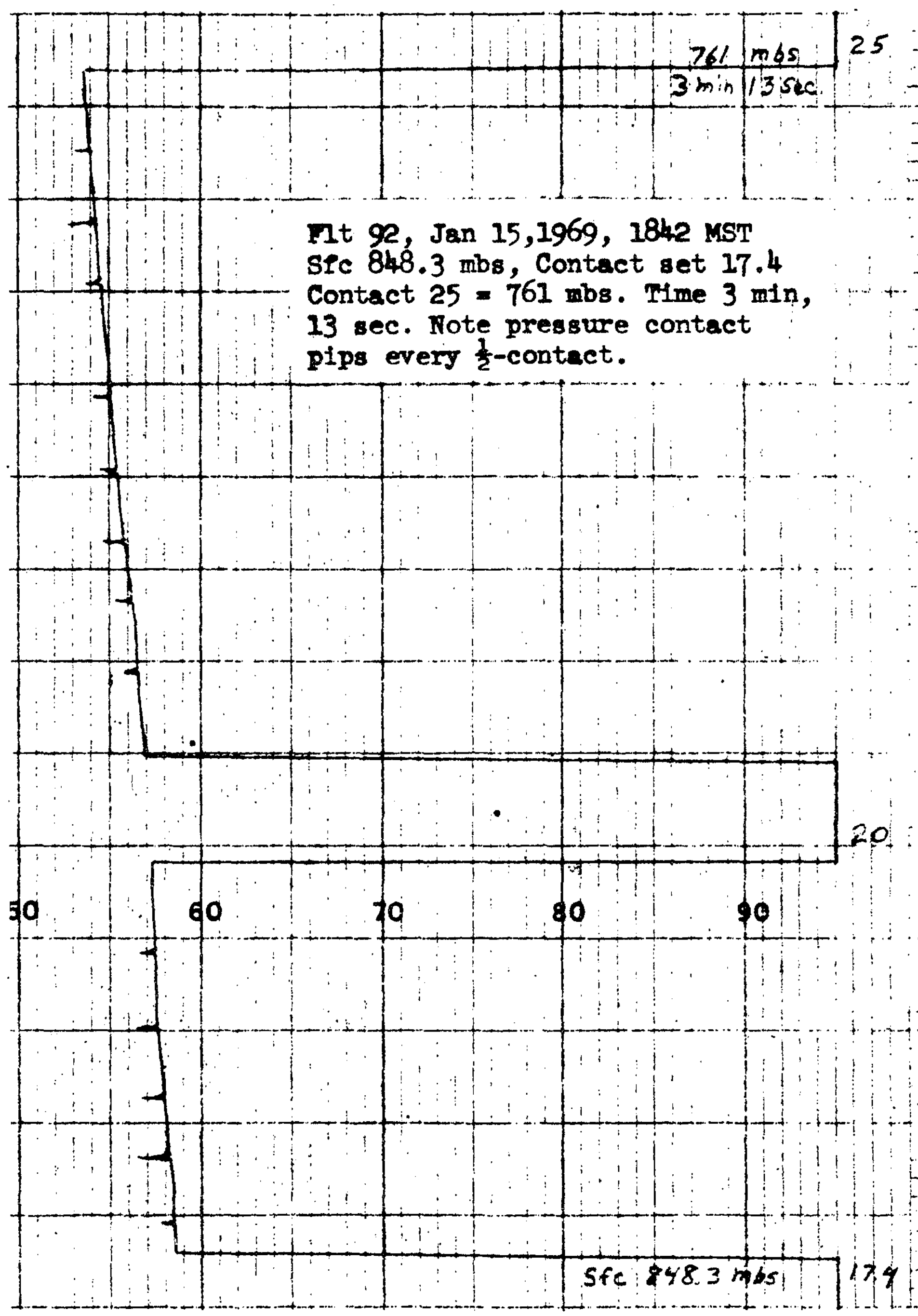

Figure 7 - Temperature Trace, Surface to 761 Millibars

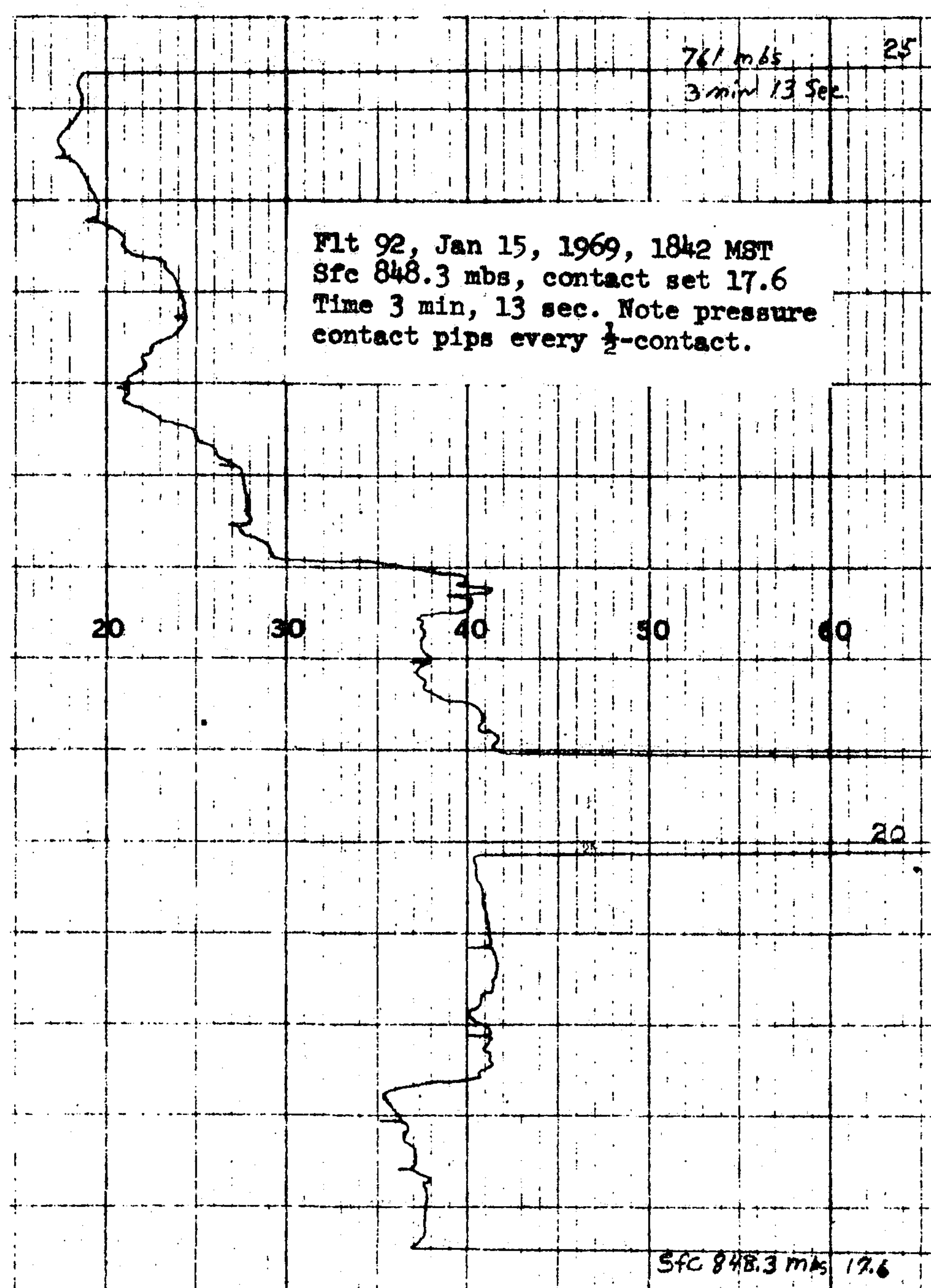

Figure 8 - Humidity Trace, Surface to 761 Millibars

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