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NRL Report 5966

AUTOMATIC WEATHER STATION (GRASSHOPPER)

PART 1 - DESIGN AND MODIFICATIONS 1955-1961

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August 13, 1963

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CONTENTS

ABSTRACT

Weather information is frequently required from critical areas where routine meteorological observations are not made or can be made only at considerable expense. As part of a continuing program to develop means for obtaining meteorological data from remote or inaccessible regions, an automatic weather station (Grasshopper) has been developed which is capable of telemetering data from a 15-watt (input to the final) transmitter over distances of hundreds of miles every six hours for several months. The initial models were air deliverable, but in 1959 NRL removed the parachute capability to make it a manual-delivered land station. Present models of this station contain sensors for wind direction, wind speed, air temperature, and barometric pressure.

The station transmits in international Morse code in three-letter groups at a word rate of 17 groups per minute which is satisfactory for monitoring by conventional receiving equipment. The received Morse code is converted to weather data by calibration charts supplied with each station. The accuracy of the transmitted weather data is equivalent to a manned station. In addition to the meteorological variables, the station sends its identifying call.

Commercially available equipment was used in design and manufacture whenever possible to take advantage of lower costs, easier replacement of parts, and greater reliability.

PROBLEM STATUS

This is an interim report on one phase of the problem; work is continuing on this and other phases.

AUTHORIZATION

NRL Problem A03-11
Project FASS-00-005/652-1/F003-02-04

Manuscript submitted May 8, 1963.

AUTOMATIC WEATHER STATION (GRASSHOPPER)

PART 1 - DESIGN AND MODIFICATIONS
1955-1961

INTRODUCTION

Automatic weather station AN/GMT-1(XG-1) (better known as "Grasshopper"), developed by the Navy Electronics Laboratory, San Diego, California, and modified by the Naval Research Laboratory, is now a reliable instrument for obtaining weather information from inaccessible regions. Two models have evolved from NRL's development: (a) parachute-type, expendable, automatic weather station (AN/GMT-1(XG-1)), (development essentially complete as reflected in 1956 models), and (b) presently used manually erected reuseable automatic weather station (development in progress since 1958). Models are now being tested and evaluated in antarctic regions by NRL-trained personnel as part of Operation Deepfreeze. Performances in previous seasons have given good results and as a result of these field trials and other tests, continuing design modifications are being made to make the Grasshopper a better weather reporting instrument.

Although the outward appearance of the Grasshopper has not changed materially, NRL has redesigned or substituted new parts for most of the internal components of the Grasshopper, based on laboratory testing and field evaluation. These include the transducers, coding system, transmitter, power supply, clock, pneumatic system, legs, and structure. A prime example of NRL modifications was the substitution of two barometric pressure transducers in place of the seven used in the original model, and in the future, only one will be required.

HISTORICAL BACKGROUND

1950-1952

The first Grasshopper (parachute-type) was originally developed by NEL, and two well-engineered experimental prototypes (Fig. 1) were completed in 1950 (1). These models were shipped to the U.S. Naval Air Test Center, Patuxent, Maryland, for evaluation tests. When the evaluation tests (2) had been completed, the Grasshoppers were shipped to NRL. After a preliminary examination where one was found to be extensively damaged and the other in fair condition, the Grasshoppers were placed in storage awaiting further directions.

1955-1961

In early 1955, the Grasshopper (NEL No. 1) in fair condition was removed from storage and repaired where possible with fixed substitutes. It was then placed in limited operation to acquaint personnel in the Automatic Systems Section of NRL with this type of coding system, code transmission, code receiving, data collection, and data analysis. Subsequent to a visit to NRL by Bureau of Aeronautics (now Bureau of Naval Weapons) personnel in June 1955, a request was made for a reworked model for Task Force 43 in Operation Deepfreeze, 1956 season.* Task Force 43 wanted some means of obtaining

*The season referred to by Operation Deepfreeze is dated one year in advance.

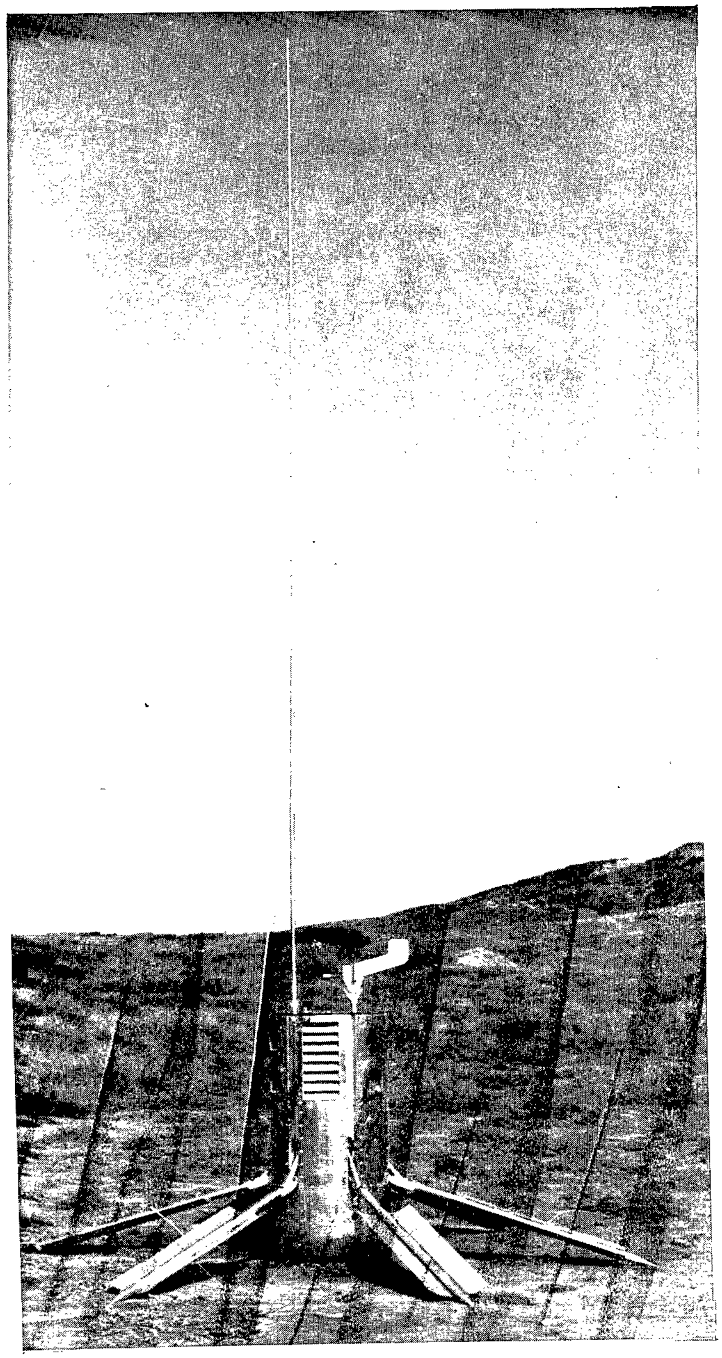

Fig. 1 - Parachute-type expendable automatic weather station AN/GMT-1(XG-1) as received from NEL

meteorological information from the antarctic polar icecaps in order to schedule air delivery of cargo to advanced bases and Grasshopper offered the potential to meet this requirement.

The request for the reworked Grasshopper was confirmed the middle of July 1955 with delivery scheduled as soon as possible but no later than Oct. 24, 1955. The project was undertaken because of the extreme urgency for the need of a station of this nature on the 1956 antarctic expedition and despite shortcuts which had to be made because of insufficient personnel, the reworked and modified Grasshopper (Fig. 2) was delivered to Task Force 43 on Oct. 24, 1955 with a complete set of calibration charts.

Plans were then made to manufacture nine Grasshoppers for use in the Antarctic during the 1957 season with the U.S. Naval Avionics Facility, Indianapolis, Indiana, as manufacturer. In January 1956 NRL undertook to supply the following to NAFI:

1. A Grasshopper (NEL No. 2) reflecting all the changes made on NEL No. 1 from NRL engineering studies, recommendations from Refs. 1 and 2, and special requests from Task Force 43.

Fig. 2 - Grasshopper modified and in assembly jig ready for shipment to Task Force 43, Oct. 1955

2. A complete set of modified drawings showing all the modifications made on the Grasshopper (NEL No. 1).

3. Consultative service, performance demonstrations, photographic aids, and manufacturing assistance with delivery of the Grasshopper and the modified drawings by Mar. 1956.

The drawings were delivered by Feb. 17, 1956, and the modified Grasshopper reflecting all the design changes considered pertinent for this special operation, on Mar. 8, 1956. NRL furnished consulting services and manufacturing assistance to NAFI and the new Grasshoppers (NAFI Nos. 2-9) were delivered in time for Operation Deepfreeze 1957. NAFI No. 1 was retained at NRL as a pilot model.

No attempt was made to place any Grasshoppers in operation during the 1958 and 1959 seasons and all existing units were shipped to Norfolk, Virginia.

In Feb. 1959 a conference was held with Lt. Knowles of Task Force 43 and Mr. Smith of the National Science Foundation to determine the program necessary to place Grasshoppers in operation for the 1960 season. The program evolved included the following:

1. The air delivery system was discarded as it was a disadvantage at Deepfreeze.

2. The stations were modified so they could be manually delivered with helicopter or weasel, making maintenance and recovery easier.

3. The Grasshopper was modified so that it has an extended life for reuse at various sites over several seasons rather than being expendable after one operation.

4. The modified Grasshopper was treated as an experimental piece of equipment instead of an operational unit.

5. Two Navy technicians with a background in electronics were trained at NRL as well as Mr. Leroy M. Allison from National Bureau of Standards on the complete operation of the Grasshopper.

6. The monitoring conditions at Deepfreeze were improved with the acquiring of a Collins crystal calibrated radio receiver and a McElroy Morse code recorder especially for Grasshopper monitoring and servicing.

7. The operating life of the station was extended to 120 days by making provisions for connecting an external auxiliary battery pack.

8. A vibrator system was installed on the barometric pressure transducer to improve the accuracy to 1-1/2 mb.

9. Transmitters were modified to use a frequency of 2720 kc instead of 4223 kc previously used because it was felt that better reception could be expected from this frequency.

10. Stations were tested and calibrated to operate through temperature range of -30°F to +40°F, considered the summer temperature extremes at Deepfreeze.

11. As shown in Table 1 the stations available to work with, NAFI Nos. 3 and 6 were reworked at NRL with the help of the technicians assigned for training at NRL. NAFI Nos. 5 and 8 were shipped directly to Deepfreeze, then modified with kits supplied by NRL. A new wiring schematic drawing accompanied the stations (Drawing E-2573, sheet 3). Two Grasshoppers (NAFI Nos. 5 and 8) were placed in operation very successfully during the

Table 1
Survey of Grasshoppers

Serial Number	Current Status
NEL 1	Lost in the antarctic
NEL 2	Structure used at NRL to evaluate engineering design changes
NAFI 1	Modified for Scott Island, 1961
NAFI 2	Lost in the antarctic in 1956-57 or disposed of as not serviceable
NAFI 3	Installed on Cape Palmer, 1960, not recovered
NAFI 4	Lost in the antarctic in 1956-57 or disposed of as not serviceable
NAFI 5	In service in the antarctic
NAFI 6	In service in the antarctic
NAFI 7	Lost in the antarctic in 1956-57 or disposed of as not serviceable
NAFI 8	Returned to NRL for overhaul, 1962
NAFI 9	Lost in the antarctic in 1956-57 or disposed of as not serviceable

1960 season. NAFI Nos. 3 and 6 arrived late in the season and saw limited service at McMurdo; however, No. 3 was installed on the Thurston Peninsula to operate during the winter season.

Plans were made early in 1960 by Deepfreeze to repeat the procedure which had been used to make the previous season successful. Two Navy technicians were trained and Mr. Allison of NBS was given a refresher course on the modified Grasshopper (manually delivered station). For training purposes Grasshopper NAFI No. 1 was used. NAFI Nos. 5, 6, and 8 were used with success this season. NAFI No. 3 was not available because late in the 1960 season it was placed on Cape Palmer off the Thurston Peninsula by a helicopter from the USS GLACIER and an expedition to this region has not been undertaken since. One code mechanism was returned to NRL for overhaul and repair and by the end of the season another had to be returned. This meant that two stations were operable at the end of the season with some of their components giving difficulty because they had been used beyond their design life.

In 1961 Deepfreeze requested a modified Grasshopper for use on Scott Island (Fig. 3) similar to the 1959 and 1960 models. This is a small island halfway between Christ Church, N.Z. and McMurdo Station and is exposed to ocean spray and ice most of the time. Since NAFI No. 1 was at NRL undergoing modification and testing, it was selected for use on Scott Island. The coding system was overhauled and a clock-converter system was added to allow the Borg hour-hand-wiper clock to be used on the top deck. This station was used for training three Navy electronic technicians. The station was shipped on Oct. 2, 1961,

Fig. 3 - Scott Island

with calibration charts and a clock-converter kit to modify another station at McMurdo Station. The code mechanism and anemometer sent to NRL were overhauled and returned on Dec. 19, 1961. NAFI Nos. 5 and 8 along with No. 1 were used mostly this season because No. 6 was in need of repairs. At the end of the season the code mechanism in No. 8 was not operating properly; therefore, this station was returned to NRL for overhaul.

MODIFICATIONS (1955-1956)

From NRL engineering studies of the recommendations made by the Navy Electronics Lab (1), Naval Air Training Center (2), and the requirements of Task Force 43 in Operation Deepfreeze, the following modifications were evolved in design to make the Grasshopper an air-delivered, expendable automatic weather station capable of operating for 60 days. It must be realized that all the recommendations were not investigated, because either they did not apply or time did not permit. A revised list of drawings is given in Appendix A.

Transducers

Wind-Direction Transducer – The original wind-direction transducer as received was damaged and had a number of defects. For these reasons and the questionable value of a magnetic compass in the polar region, a new transducer was used. The new wind direction transducer is coupled to the vane of the wind speed transducer. These transducers are located as shown in Fig. 4 on the top deck of the Grasshopper in about the same relative position as the original one. The wind vane is connected to the movable arm of a 0 to

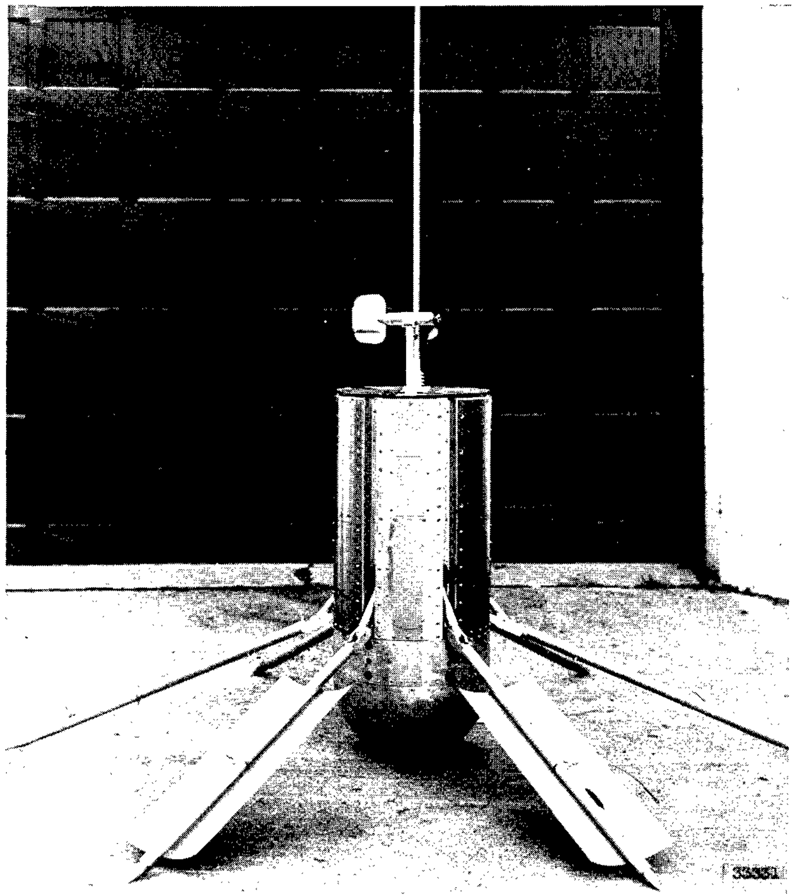

Fig. 4 - Modified Grasshopper showing new anemometer

2000 ohm minitorque potentiometer which in turn gives the direction in degrees with respect to a reference line. The reference line is a painted fluorescent fire-orange stripe on the top and sides then continuing on to two adjacent legs forming the tail of an arrow. This reference line is visible for photography from the air and determining a fix from the aircraft's instruments. This fix is then used to translate the transmitted data. When used with this system, the wind-direction transducer has an accuracy of ±2 degrees.

Wind-Speed Transducer – For a number of reasons it was found necessary to replace the wind-speed transducer. Most of these reasons are outlined in Ref. 2. The search for a commercially made unit to be adapted to the Grasshopper was not successful. The approach was to develop a special wind speed transducer which is shown in Figs. 5 and 6. This wind-speed transducer (anemometer) has a 6-inch-diameter, 8-blade impeller driving a salient radial 4-pole magnet. The rotary force displaces a drag cup against the restoring torque of a spring. The displacement results in a rotary movement which is coupled to the movable arm of a 0 to 2000 ohm microtorque potentiometer. The flat spiral spring provides a restoring force on the drag cup, which is coupled to the potentiometer, against the force of the rotating magnet. The spring must be adjusted to restore the drag cup to a fixed stop and the low torque potentiometer to its starting point. Further loading of the spring against the stop determines the wind speed at which the instrument will start indicating. The maximum speeds this anemometer will indicate is 50 to 150 knots and the minimum is 2 to 3 knots. The spring length or the magnet strength can be altered at assembly to give the desired maximum wind speed. For the Grasshopper

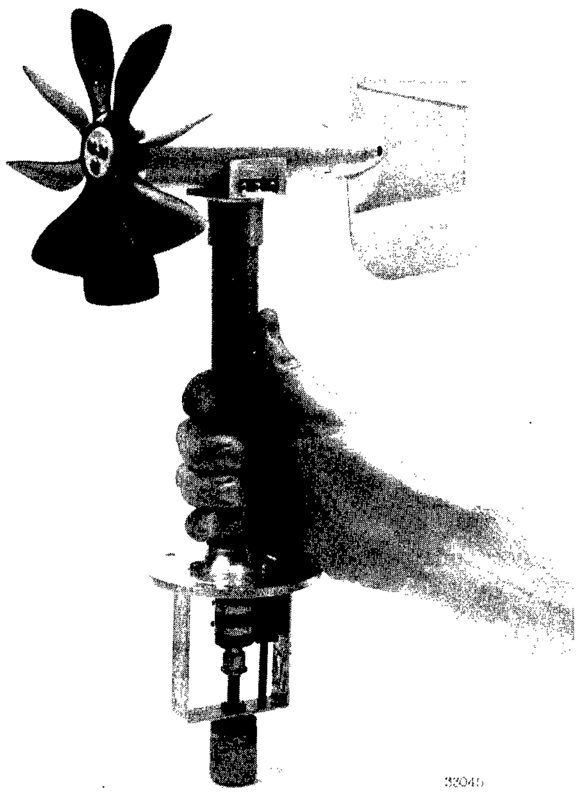

Fig. 5 - NRL anemometer

the range selected was 3 to 5 knots minimum and 80 knots maximum. The alignment of the drag cup with respect to the revolving magnet is accomplished with a low-friction jewel. The impeller to magnet shaft is supported with two stainless steel precision miniature ball bearings. All parts are lubricated with low temperature instrument oil. The impeller is directed into the wind by a streamlined vane. This instrument head with vane is supported on a pedestal. A vertical shaft through the pedestal connects to a 0 to 2000 ohm minitorque potentiometer which indicates the wind direction. The instrument head has a versatile feature in that it plugs into the supporting pedestal. At the base of this pedestal two slip rings provide the necessary electrical connections for the wind speed. A small clip on one leg of the Grasshopper holds the vane of the anemometer to prevent damage to the instrument until the station is erected. Then it pulls free, allowing the vane to point the impeller into the prevailing wind. Results from NBS wind tunnel tests Ref. (3) are shown in Fig. 7. When tested at -20° F in the wind tunnel, the error was ±1 knot at 20 knots. At 80° F the accuracy was within ±1 knot over a range of 3 to 80 knots. Shock tests indicated the unit would tolerate accelerations greater than 50 g without damage.

Temperature Transducer - The originally designed bimetal temperature transducer was used. The spiral bimetallic coil was made heavier and as a result a low-torque rugged minitorque potentiometer could be used. With this arrangement the unit was more rugged with an accuracy better than 1°F and the hysteresis effect was kept to a minimum. As a result of sealing the Grasshopper to keep out blowing snow, the temperature indicated

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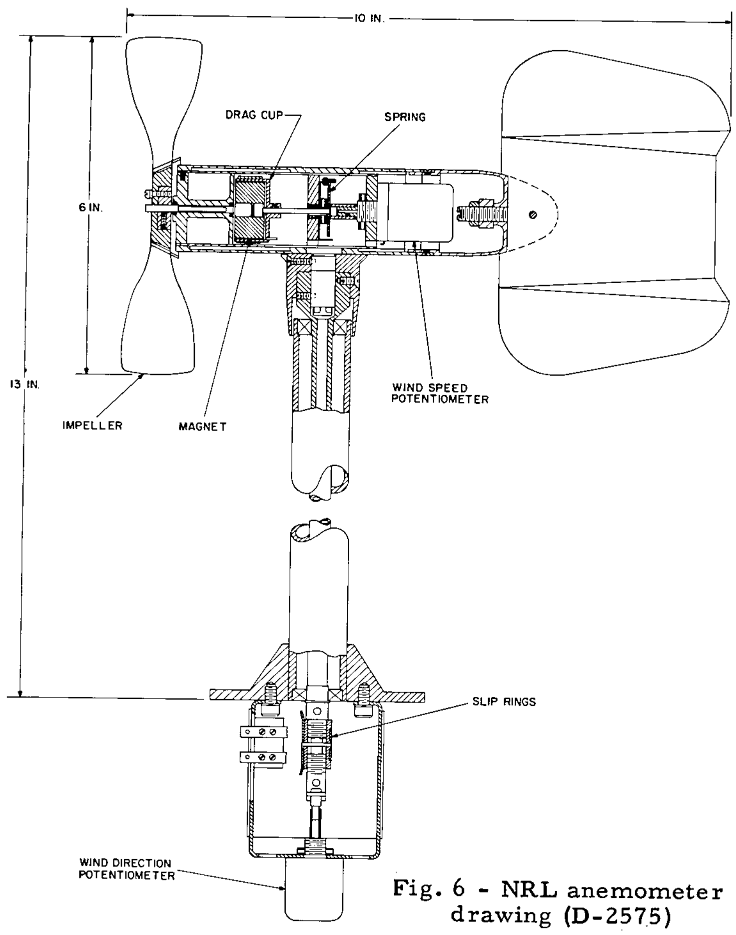


Fig. 6 - NRL anemometer drawing (D-2575)

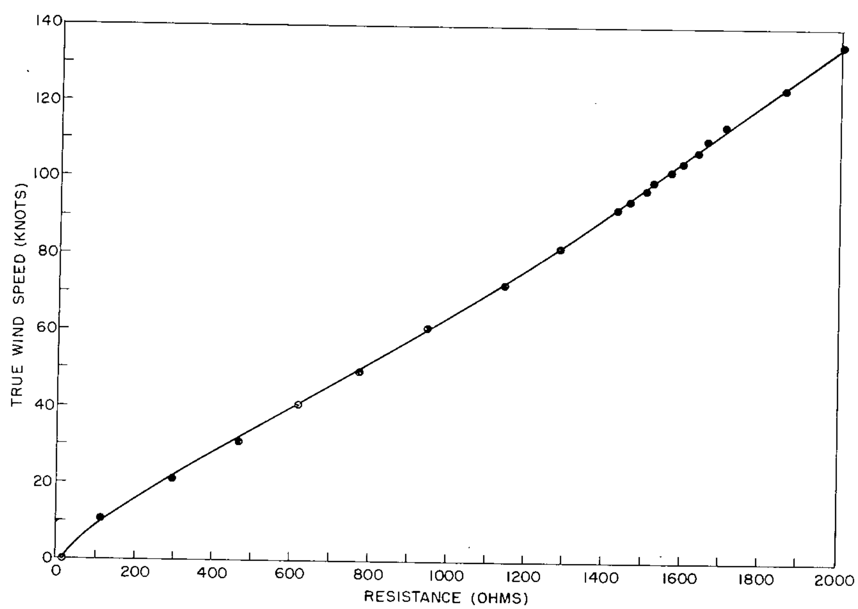


Fig. 7 - NRL anemometer, wind tunnel test results at NBS

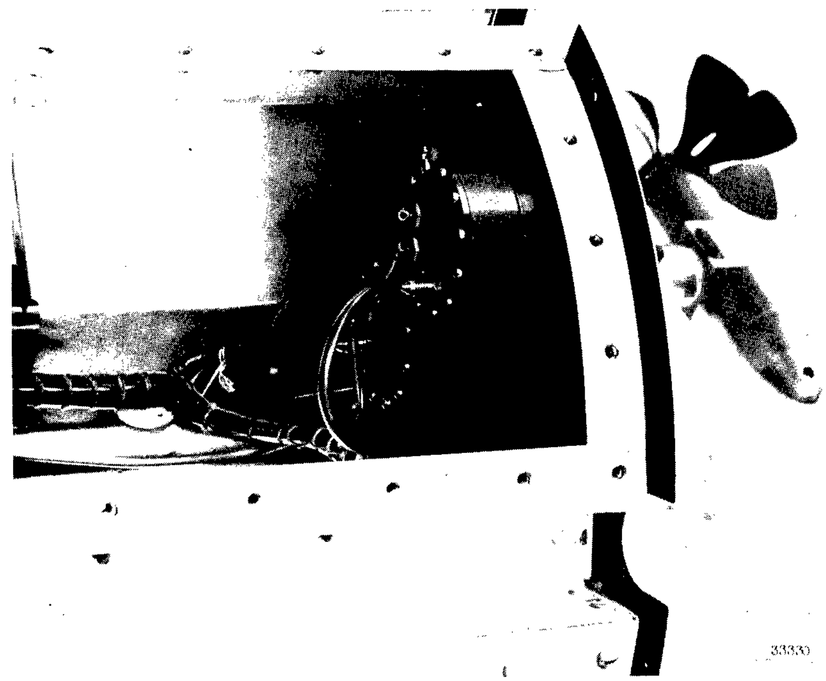


Fig. 8 - Barometric pressure transducers mounted in Grasshopper

by the temperature transducer when the sun was shining was 8 to 15 degrees high. This was because all the ventilation in the station was blocked off. However, it was decided to use the temperature transducer under these conditions because it was thought that this effect would not be noticeable in the antarctic.

Barometric Pressure Transducers – There were a number of reasons for desiring one or even two units to replace the set of seven plug-in pressure transducers furnished with the original design Grasshopper. Some of these reasons were reduced costs and simplified operational problems. Another disadvantage for this operation was the awkwardness in selecting the proper pressure transducer without knowing the altitude of the actual operating site.

Barometric pressure transducers from a number of commercial sources were considered. Several were purchased and evaluated. When it became apparent that one unit could not be used to cover the desired range of 690 to 1040 mb and maintain a 1-mb resolution, two units were selected. Each of these two pressure transducers covered different ranges with overlaps of 70 mb and connected to separate channels. One of the channels is referred to as barometric pressure high range and the other barometric pressure low range. The high range is transmitted over the original pressure channel and the low range is transmitted over the original relative humidity channel. The transmitted barometric pressure from the channel that appears to be applicable is used.

High Range – Of the units tested, a rugged compact capsule-type barometric pressure transducer (Giannini 47146B-A-1.2/1.5-20) was selected for the high range that would accommodate elevations up to 5000 feet. This model, has a range of 12 to 15 psi (approximately 830 to 1040 mb). The resistance of the unit is 0 to 2000 ohms with a minimum of 200 turns of wire on the potentiometer. This pressure transducer is shown in Fig. 8 mounted to the top deck inside the Grasshopper with its twin, the low range. This transducer has a 1-mb resolution and the accuracy throughout its range is ±1-1/2 mb. The

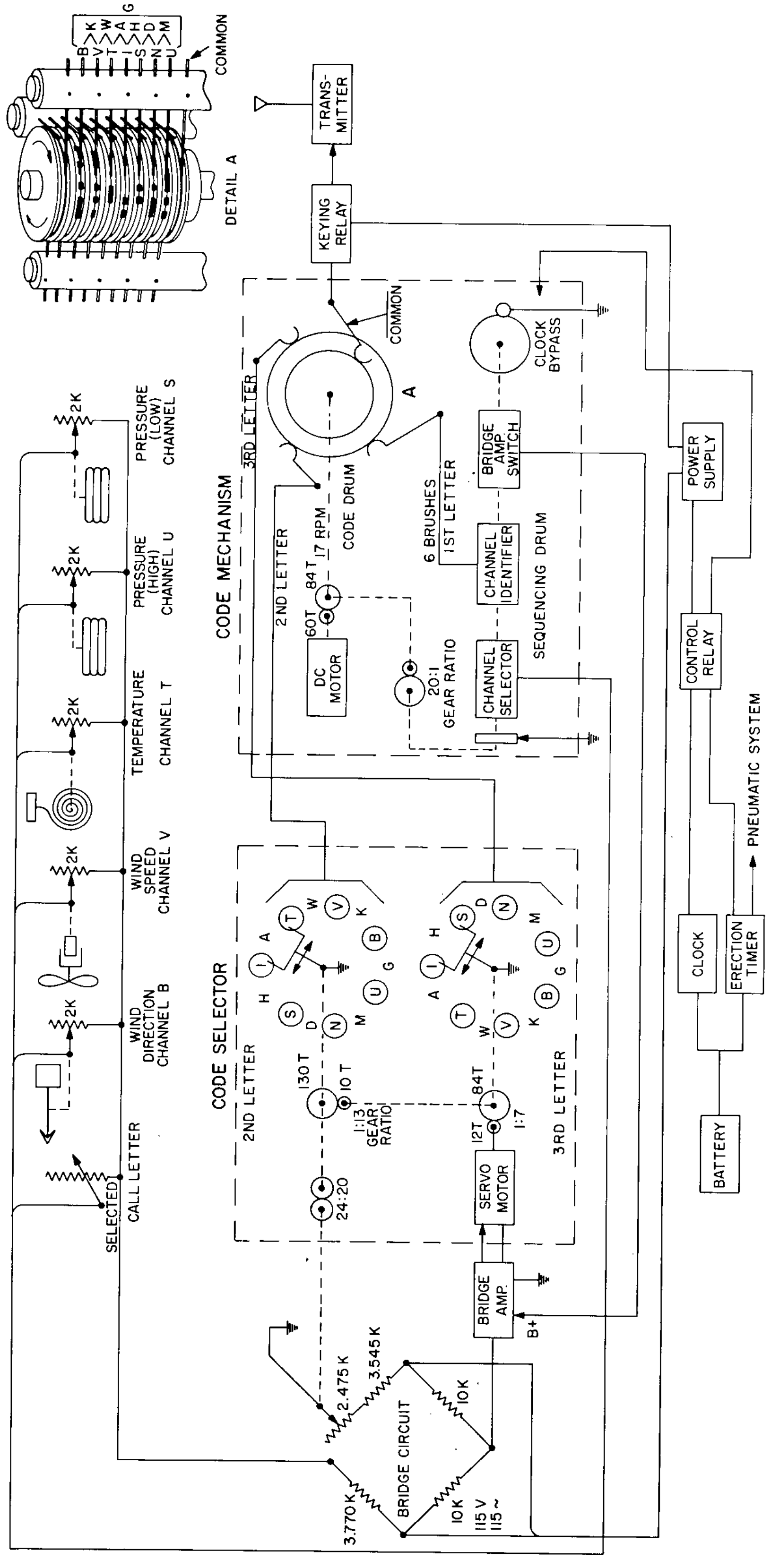


Fig. 9 - Grasshopper code system block diagram

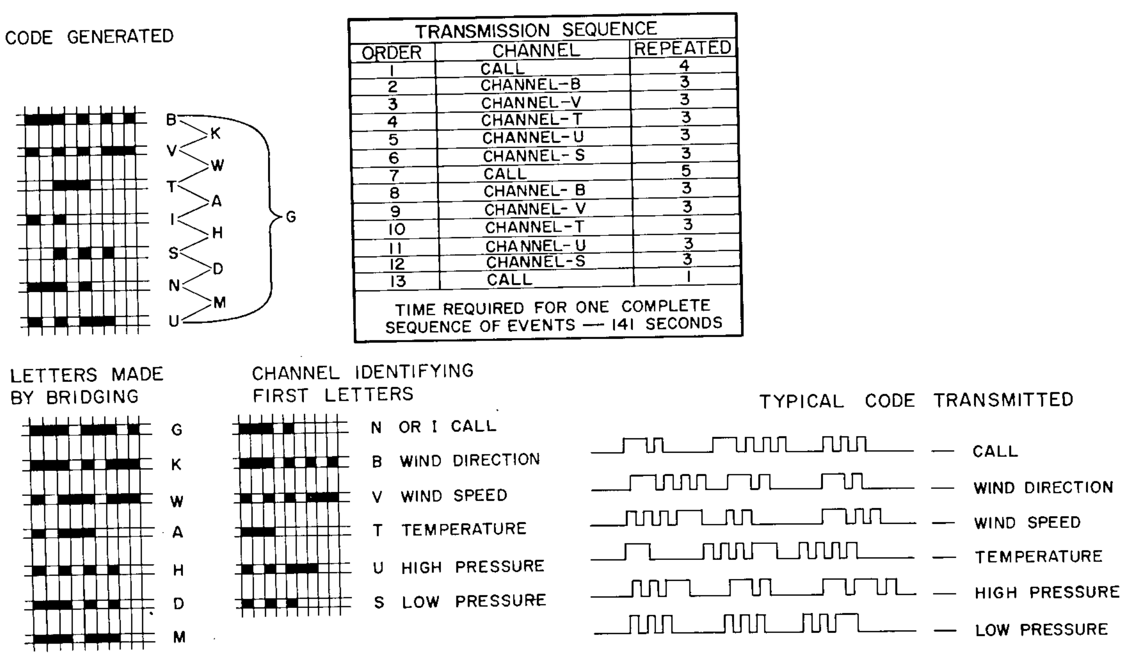
temperature correction is in the neighborhood of ±2 mb for the range -20°F to +80°F. The shock characteristics of this unit are satisfactory for shipping, parachute opening, and ground impact.

Low Range – The relative humidity transducer was omitted from the modified Grasshopper for this special operation, not due to difficulty experienced with it but because another channel was needed for the low range barometric pressure transducer. This channel was selected because the measurement of relative humidity near and below freezing temperatures is very difficult and a suitable transducer to do this was not available. Therefore, the information received from this channel at the Antarctic would be of little value so the low range barometric pressure transducer, for which there was a specific need, was substituted on this channel.

The low range barometric pressure transducer (Giannini 47146B-A-1/1.3-20) selected would accommodate elevations up to 10,000 feet and with the exception of range it is the same as the high range transducer. This model has a range of 10 to 13 psi (approximately 690 to 900 mb). The resistance of this unit is 0 to 2000 ohms with a minimum of 200 turns of wire on the potentiometer. The accuracy, resolution, and other conditions are the same as described on the high range unit.

Code Mechanism System

To help understand the code system, a block diagram of the coding system is shown in Fig. 9. The transmission sequence, code generated, and typical code received on tape recorder are shown in Fig. 10.



TRANSMISSION SEQUENCE

ORDER	CHANNEL	REPEATED
1	CALL	4
2	CHANNEL-B	3
3	CHANNEL-V	3
4	CHANNEL-T	3
5	CHANNEL-U	3
6	CHANNEL-S	3
7	CALL	5
8	CHANNEL-B	3
9	CHANNEL-V	3
10	CHANNEL-T	3
11	CHANNEL-U	3
12	CHANNEL-S	3
13	CALL	1
TIME REQUIRED FOR ONE COMPLETE SEQUENCE OF EVENTS — 141 SECONDS		

Fig. 10 - Code generated, transmission sequence, and typical code arrangement transmitted

Code-Letter Selector – The code-letter selector mechanism consists of seven contact buttons in two separate circles. The two-prong wiper on each switch is geared together at a 13 to 1 ratio. When this unit was tested at low temperatures, the phenolic plate which supports the brass buttons contracted more than the brass buttons (due to the difference in their thermal coefficient of expansion) thereby leaving the buttons protruding above the phenolic. This left a sharp shoulder on which the delicate wipers could hang and bend out of alignment. Once this occurs, the code selected is of little value. This was repaired by soldering a 1/8-diameter-silver-pancake contact to each prong of the wipers. The round contact allowed the wiper to ride up over the sharp shoulder. In addition, the buttons were rhodium plated to prevent oxidation. It should be mentioned that units made like this are good for 60 days or longer but will have to be given a periodic overhaul if extensive operation is required because wear will cause "flats" on the buttons and the code selected may be in error. Another condition prevalent at low temperature was a microfilm of ice which formed on the button contacts. The wipers would not cut through this film because the contact pressure was very light. To eliminate moisture condensing on the buttons and then freezing into a thin layer of ice a light coat of DC 5 compound was placed in the path of the wipers.

Channel-Sequence Selector – The sequence-selector drum as received was made of cast methyl methacrylate. This drum was cracked, crazed, and distorted from previous climatic exposure when received. This drum was recast using the more recently developed cast epoxy. The contacts were also rhodium plated to eliminate oxidation. The contacts were given a light coat of DC 5 compound to control condensation. The brushes on this unit were pointed, thus easily bent anytime the drum was turned backward the slightest amount. Once any of these brushes were bent the entire system was out of synchronism. All the brushes were replaced with ones that were rhodium plated and had a small loop on the contact end. The sleeve bearings were replaced with ones made of oilite and impregnated with low temperature instrument oil.

Code-Generator Drum – The code-generator drum presented the same problems as the channel-sequence-selector drum, necessitating identical repairs.

Transmitter

The operating frequency of the Grasshoppers (NEL Nos. 1 and 2) furnished Task Force 43 was 5072.5 kc. This 15-watt (input to the final) transmitter performed satisfactorily. The frequency assigned the stations made at NAFI was 4223 kc.

The styrene insulators on the antenna were crazed, thus made vulnerable to electrical breakdown. These were replaced with insulators made of Teflon having good radio frequency properties and excellent weathering characteristics.

Power Supply

The lead acid batteries were replaced with a Sonotone (60M320) nickel-cadmium 11-cell 14-volt battery (Fig. 11). This nominal 14-volt battery resulted in more efficient operation of the station. This battery has a 60-ampere-hour rating and will extend the operation of the station (3-minute transmissions every 6 hours) from a period of 15 days (approximately 60 transmissions) to about 60 days (approximately 240 transmissions) at low temperatures. This battery has excellent low temperature properties as well as sealed caps to prevent electrolyte leakage in transit. The lead acid battery weighed approximately 31 pounds and the new battery assembly weighed 72 pounds.

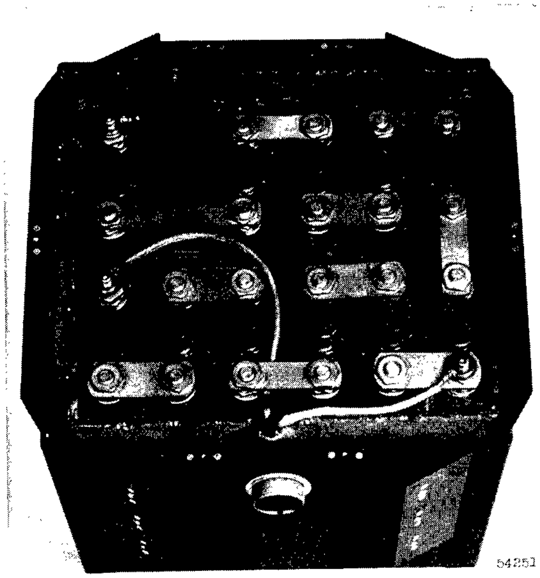


Fig. 11 - Battery assembly

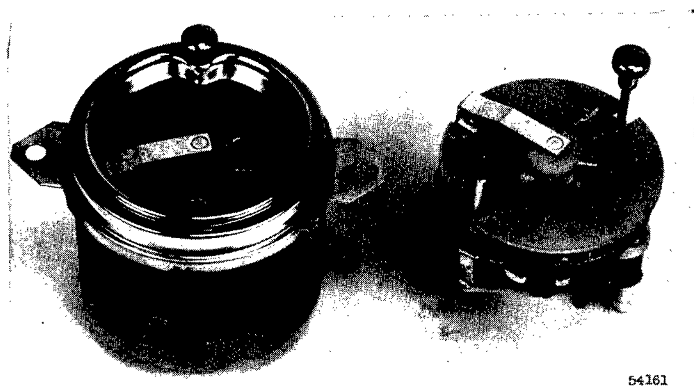


Fig. 12 - Clock assembly

Clock

To replace the Borg clock used in the original Grasshopper, a Jaeger 6-volt direct-current magnetic-movement clock with shock jewels (Model PL554) was selected (Fig. 12). This 6-volt movement had a 180-ohm coil and an average current consumption of 1000 microamperes. A printed-circuit face with a 6-hour schedule having the minute contact 13.2 degrees wide to match with a 17-word-per-minute system was added. A 3-hour schedule was made available by bridging the 3 and 9 o'clock contacts to a common ring with solder. The hands on the clock were replaced with wipers whose lengths were 3/8 inch for the hour wiper and 5/8 inch for the minute wiper. The printed circuit and wipers were silver plated. The clock movement was cleaned and oiled with low temperature instrument oil and a light coat of DC 5 compound was wiped on the printed circuit to control condensation freezing. Test at -20 °F showed the error in rate did not exceed ±1 minute per day. This clock performed satisfactorily after being subjected to shock in excess of 50 g. The time-setting knob had to be pulled out to start the clock.

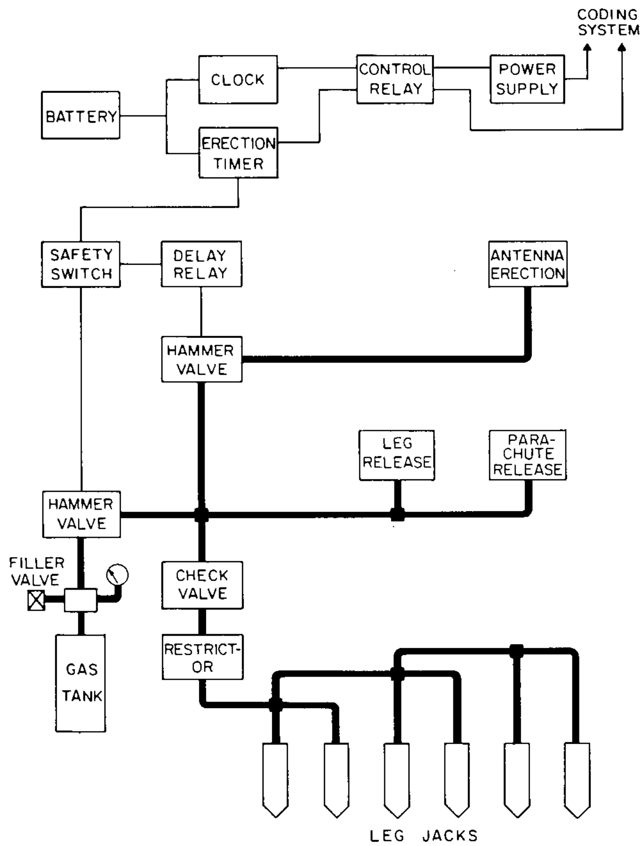


Fig. 13 - Pneumatic system block diagram

Pneumatic System

A plumbing schematic of the system is shown in Fig. 13. When the Grasshopper (NEL No. 1) was tested for erection at -50°F in the temperature chamber, it would not upright itself because the gas leaks past the O-rings in the leg jacks were excessive. A further complication from the leaks was insufficient pressure remaining to erect the antenna. Through a series of progressive investigations the following modifications were made to the system:

1. The restrictor in the leg jack system was increased from 0.014 to 0.024 inch to allow the jack cylinders to fill faster.

2. At ambient temperature a new relay was installed to reduce the elapsed time (45 to 20 seconds) that occurs from the time the station starts erecting and the hammer valve releases pressure to erect the antenna. Where minor leaks are unavoidable, pressure is retained in this way for erecting and locking the antenna.

3. It was found that after the cylinder jacks were assembled and the legs were actuated several times the amount of moisture in the air behind each piston depended on the climatic conditions of the day on which this took place. When low temperature laboratory tests were conducted on the cylinders at NRL, the moistened air pulled into the area back of the pistons would condense on the inside walls of the cylinders and freeze. This was representative of what would happen if the cylinders were assembled in the temperate

zone, then exposed to low temperatures at the Antarctic. This ice formation would damage the O-rings, thereby causing them to leak, and in some cases would not allow the pistons to go out far enough to lock the legs in their extended positions. An air dehydrator system was designed and built into the connecting rods of these leg jacks. The air would be dried as it passed through dried silica gel (in the hollow connecting rods) on its way into the cylinders. Cotton was placed on each side of the silica gel to collect dust and prevent air from getting to the silica gel when the pistons were stationary. One filling of the rods with dried silica gel is sufficient to dry the air for a number of operations.

4. The leaks past the piston O-rings were stopped by placing two O-rings in parallel. The material specified for the O-rings was Mil-R-5516 so a compatible low temperature lubricant, GLT-700-(60) made by Lehigh Chemical Products or DC 11 compound made by Dow-Corning, could be used on all O-rings.

5. The leg jack support pins were made of stainless steel in preference to the aluminum originally used. This was to prevent the pins from bending at erection with the added battery load.

6. A longer pipe with a modified argon valve was installed on the top of the gas storage tank for ease of filling and safety. The valve was modified for installation of a 0 to 3000 lb gage and equipped with a built-in safety plug. The gas storage tank was filled from the supply tank with a special tube and the modified valve.

Structure

The structure was well designed, resulting in very few repairs necessary for this Grasshopper. Weather sealing to keep out blowing snow along with other modifications listed below were found necessary:

1. Silicon rubber boots were made and installed on all leg openings into the instrument compartment.

2. All panels were made thicker (0.091-inch aluminum) so extruded ribbons or hand-rolled strings of Duxseal could be used as gaskets.

3. New panels were made without openings except in front of power supply and gas filler valve. These openings were provided with covers of the same size and shape as those on the original panels.

4. Openings were made in the top deck and sun shield for windspeed transducers.

5. Two handles on each side were provided for ease of handling.

6. An assembling and shipping stand was provided with each station.

7. The plastic shock-absorber ball in the nose was replaced with foam plastic. This fitted closely between the nose and battery box and crushed when the Grasshopper's nose encountered the earth during air delivery.

8. The electrical junction for the weather transducer was replaced and relocated in a more accessible position.

9. The new pressure transducers were relocated and the plug-in apparatus previously used was removed.

Parachute

To accommodate the new battery weight (72 lbs) a 35-ft extended-skirt-type parachute with 3-foot extensions was used. This parachute was packaged in the same space in the tail cone as the previous chute. The new parachute and tail cone assembly weighed 25 pounds. The assembled Grasshopper with the new battery and parachute chute weighed 220 pounds.

MODIFICATIONS (1959)

When an evaluation was made to determine the modifications and repairs necessary to make the Grasshopper operate successfully in the Antarctic, it was found that when the Grasshoppers were manufactured, all the units were not given sufficient "shakedown" or "debugging" before delivery, resulting in a number of unnecessary failures in the field; trained personnel were not detailed to the stations to place them in operation, service them, or monitor them; shipping damage was greater than had been expected and exceeded the shocks experienced in air delivery of the station; and air delivery was a disadvantage in the Antarctic.

The following repairs were found to be necessary on most of the Grasshoppers: (a) repaired anemometer shaft broken at weld, mostly from defective weld, (b) replaced sapphire jewel, in anemometer movement with brass jewel (broken in shipment), (c) replace solid wire from transmitter to antenna with a stranded wire because the solid wire was broken in shipment, (d) replaced transmitter base plate, (the original base plate was broken in shipment), (e) placed 12-ohm resistor in series with code motor to make it run at 17 rpm since the original motor ran at 24 rpm, (f) pinned all gears in code system (set screws were loose allowing gears to slip), (g) aligned brushes and synchronized code system, (h) corrected the wind direction transducer to correspond to the station heading as indicated by a painted stripe and arrow because it was out 180 degrees, (i) renewed clock-face printed circuit so contact would be made for 2 minutes and 15 seconds to correspond with a 17 rpm motor, and (j) provided space in battery box for battery to vent, because the battery box cover fitted so tight that the battery vent holes were "stopped-off." Water drain holes were also provided around nose cone.

The following modifications were made:

1. The air delivery capability was removed by elimination of the tail cone, parachute, fins, leg locks, blocking the leg-jack plumbing system, and adding six leg clamps (Figs. 14 and 15).

2. The antenna could be erected either manually or pneumatically.

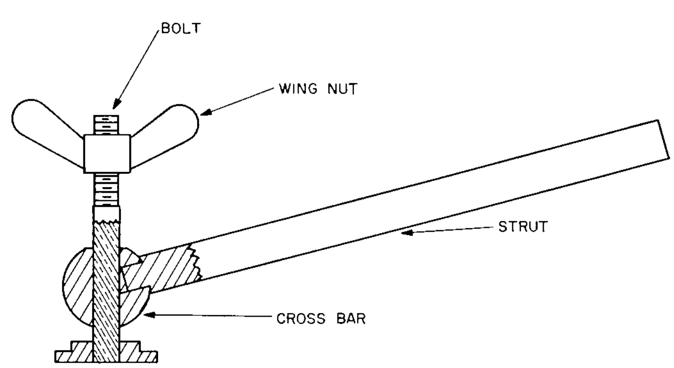


Fig. 14 - Sketch of leg clamps

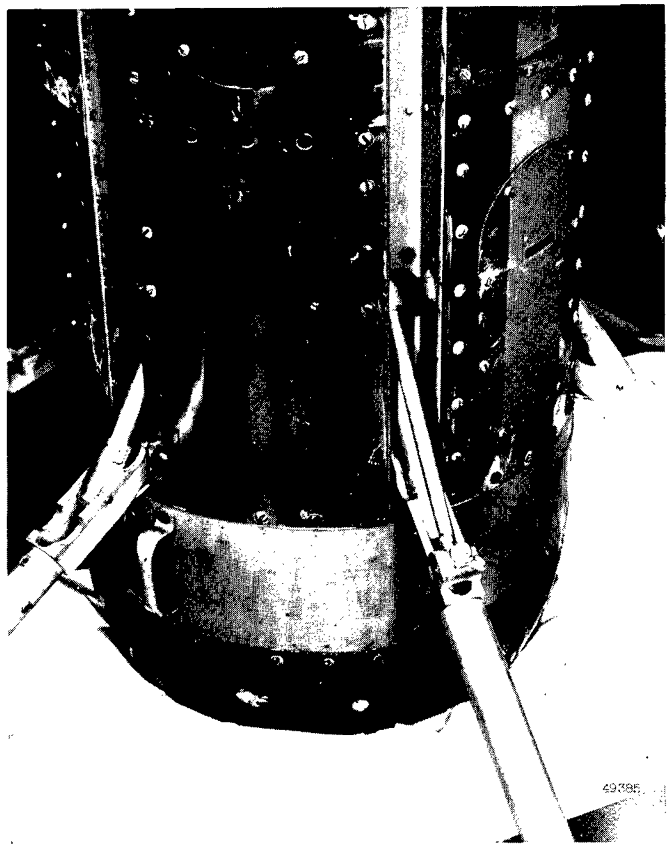


Fig. 15 - Leg clamps installed

3. A new bracket was designed for pressure transducers having a 6-volt dc relay mounted on it. This relay was wired parallel with the keying relay, which made the armature operate in unison with the keying relay, thereby vibrating the pressure transducers slightly. This vibration reduced the frictional error and made the pressure repeatable within ±1 mb.

4. The frequency of the transmitter was changed to 2720 kc.

5. Spare batteries and connecting cable were supplied to connect external batteries to the terminal block of the power supply.

6. A three-position switch was substituted for the two-position switch on the calibration test set to allow the bulbs to light in the "run" position.

7. A new master wiring diagram was made to reflect current circuit modifications.

8. New calibrations were made and a chart giving information versus letters was supplied with each transducer.

9. New daily log sheets for accumulating the data systematically were furnished.

MODIFICATIONS (1960)

A special thermoshield was designed for the temperature transducer of the modified Grasshopper. A bimetal element with a 3-degree rotation for a temperature change of 1°F was selected to drive a rugged low-torque minitorque potentiometer (Fig. 16). These units were assembled on a thermoinsulated plate which was supported in a well-ventilated tubular housing. A second ventilated tubular-radiation shield was installed outside the first unit giving a double-shield effect. Two cover plates were provided, separated with spacers to give ventilation and act as thermal insulators. This unit was mounted on a supporting pedestal which carries the electrical plug-in feature. A complete unit is shown in Fig. 17. The plug-in feature made the unit convenient to install on the top deck of the Grasshopper as shown in Fig. 18. When the temperature transducer and thermoshield were tested continuously on the Grasshopper for four days under varying conditions such as cloudy nights, clear nights, bright sunshine, overcast, rain, and winds up to 20 knots, the telemetered data showed a maximum deviation of ±1-1/2°F from the weather bureau's observed values. Four of the above temperature transducers and thermoshields were supplied to Deepfreeze with calibration charts and installation instructions.

Instructions, crystals, and parts necessary to convert the transmitters to 4223 kc were supplied Deepfreeze in the modification kits. Necessary instructions, connectors, and cables to make external battery connections on the top deck were also supplied. Calibration graphs, with letters but without information, were supplied so the information could be transferred from the six charts on each station at Deepfreeze to one graph.

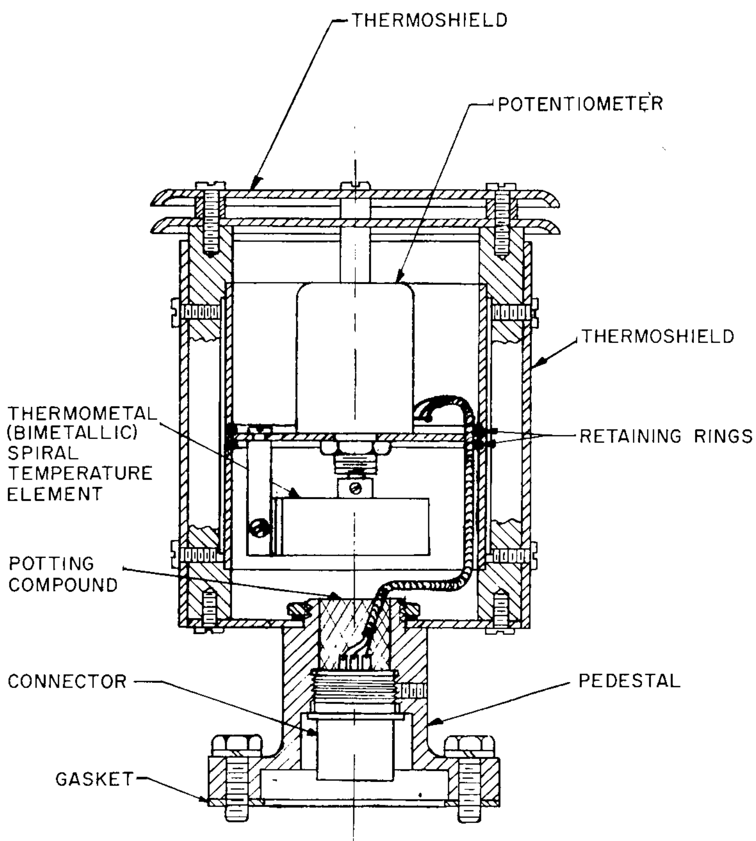


Fig. 16 - Thermoshield and temperature transducer

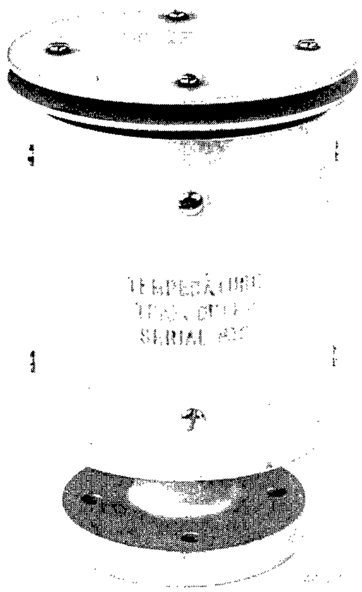


Fig. 17 - Thermoshield and temperature transducer

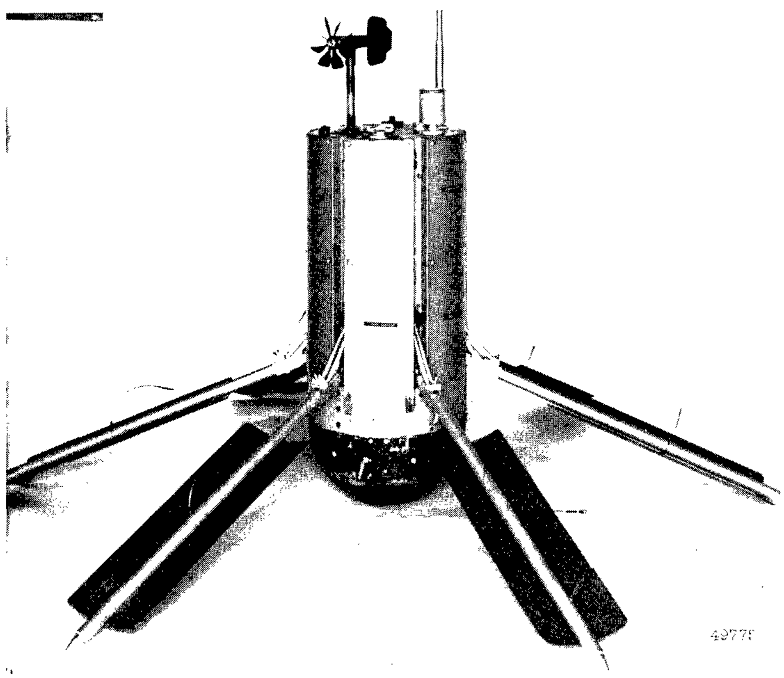


Fig. 18 - Grasshopper showing thermoshield and temperature transducer installed

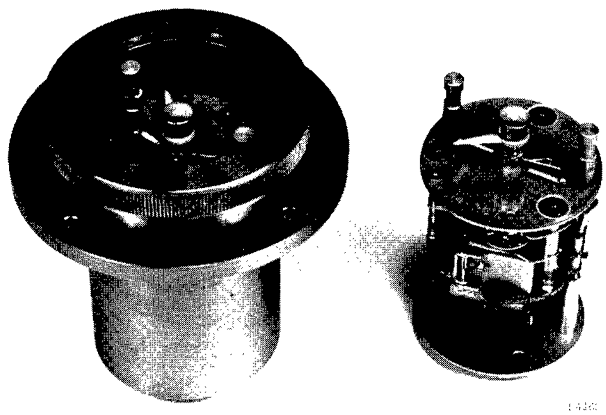


Fig. 19 - Borg clock

MODIFICATIONS (1961)

In making the plans to rework a Grasshopper for use on Scott Island, the one thing that presented a problem was the type clock to use on this station. The clocks that had been used previously were no longer available. The most convenient clock to use was the modified Borg clock (Fig. 19). This clock used the hour hand to do its programming by closing alternate circuits. The hour-hand wiper system was used on this clock, so that the wiper would present the least possible load on the clock movement and the length of time the wiper stayed on contact did not become critical. However, a study revealed that this type clock programmer could not be used with the clock bypass arrangement previously used in the Grasshopper code mechanism, and to use this clock, a converter circuit was needed. It was decided the Grasshopper (NAFI No. 1) would be modified similarly to the 1960 units as well as to add the Borg clock and rework the code mechanism completely.

The Borg clock was installed on the top deck for convenience (Fig. 20); then an interim design was made for the clock converter (Fig. 21). A ten-step, three-bank stepping switch (step on break) coupled with two other double-pole relays were used in the converter circuit. These were housed in a sealed box and located on the middle deck with cables connecting it to the system.

The code mechanism was overhauled, which included installing all new brushes, rewiring the unit, relocating the switches, and making the covers larger (Figs. 22 and 23). Drain holes were made in the nose cone to get rid of excess water around the battery. The external panels were sealed and only six screws were required to secure them.

One clock-converter kit with spare parts was made up to modify another Grasshopper in the Antarctic.

A new wiring diagram and parts list showing the new clock were made for the Grasshopper.

The completed station as shown in Fig. 24 was tested, calibrated, and shipped on Oct. 2, 1961.

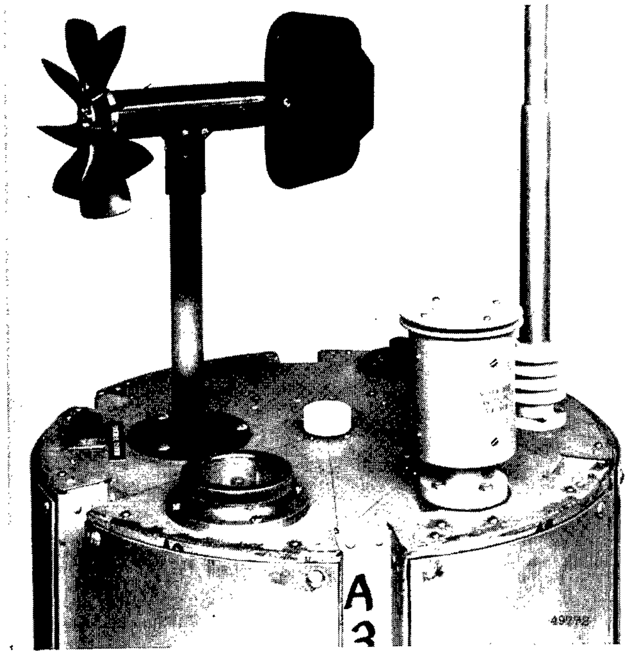


Fig. 20 - Borg clock on top deck

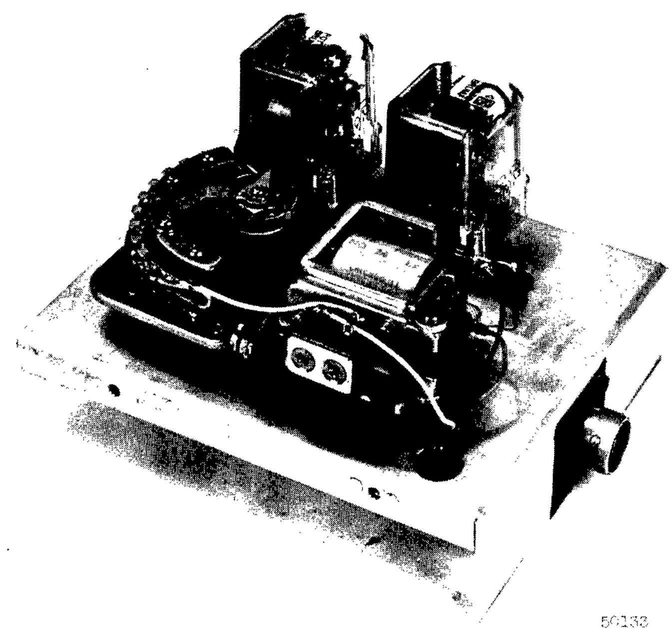


Fig. 21 - Clock converter

UNCLASSIFIED

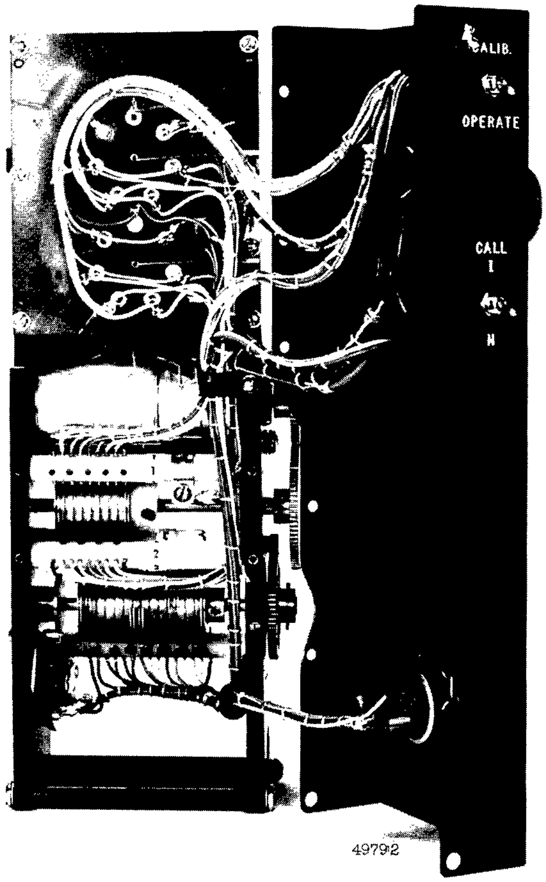


Fig. 22 - Code mechanism

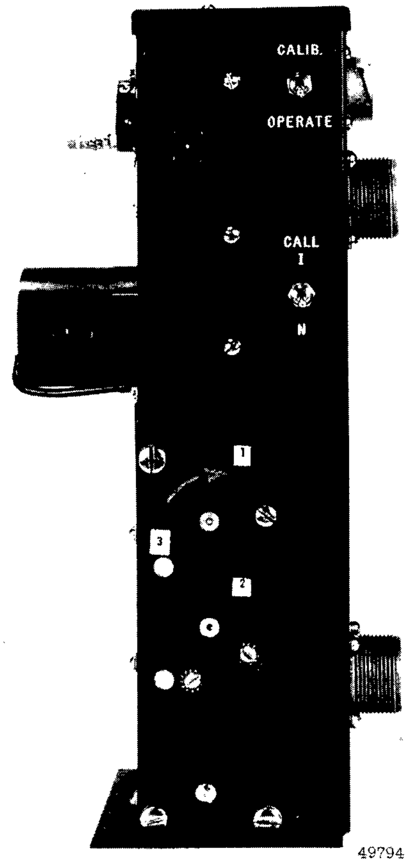


Fig. 23 - Code mechanism assembly

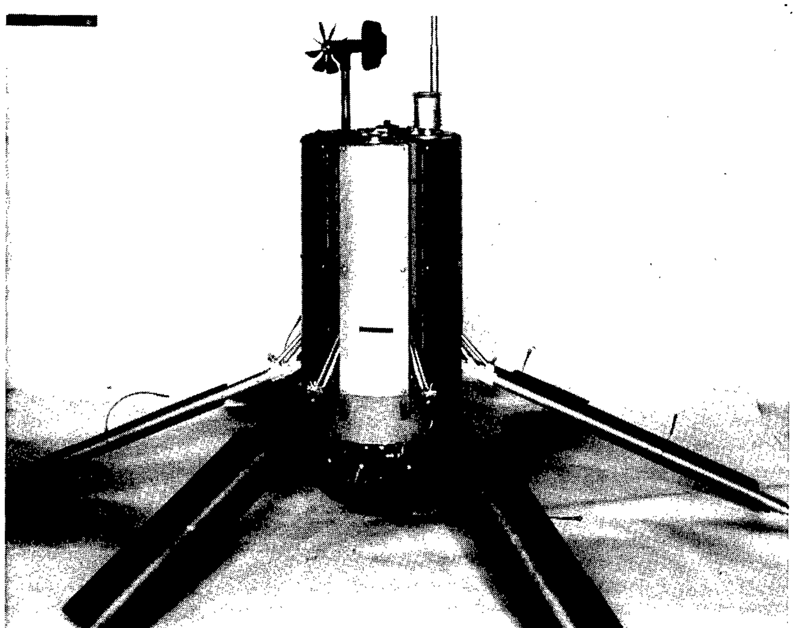


Fig. 24 - Modified Grasshopper (NAFI No. 1)

CALIBRATION OF GRASSHOPPERS

Each Grasshopper must be calibrated individually and a complete set of calibration charts must be supplied with every station. The accuracy of the transmitted data on the NRL-modified stations is shown in Table 2 and to retain this accuracy, the stations must be recalibrated on a regular annual schedule. Since the transmitted weather data is expected to be accurate within ±1-1/2 mb, the calibration must be done very precisely. The standards used for calibrating must be checked and compared periodically with the primary standards for each variable.

Table 2
Accuracy of Data Transmitted

Transducer	Channel	Transducer Range	System Accuracy (-20° to 80°F)
Wind Direction	B	0 - 360°	±2
Wind Speed	V	3 - 80 knots	±2 knots
Air Temperature	T	-70° to 130°F	±1-1/2°F
Barometric Pressure, High Range	U	820 to 1040 mb	±1-1/2 mb
Barometric Pressure, Low Range	S	690 to 900 mb	±1-1/2 mb

To interchange one transducer for another in the field, the calibration is supplied in resistance versus response for that transducer and this information is used to plot a new line on the existing chart.

Attempts are being made to standardize the transducers so they can be made interchangeable with a single calibration chart for use with a large network of stations. This feature is desirable; however it becomes very expensive and until all the designs are confirmed the interchangeability could inhibit the development program.

The initial Grasshoppers used a complicated procedure to convert the transmitted data into weather information. The first letter of the three-letter code group identified the channel and the last two letters were the weather information. The last two letters were converted to a corresponding resistance value from a chart giving code letter versus resistance. Any necessary temperature correction was then applied from another chart. The corrected resistance value was then used with a chart corresponding to the proper channel and converted to meteorological information.

In 1955, NRL introduced a simplified arrangement for interpreting the transmitted code with the use of six tabulated charts, one of which is shown in Fig. 25. The three-letter group was received and, as before, the first letter identified the channel and the last two letters the weather information; however, by means of these new charts, the last two letters are converted directly into weather information.

These simplified charts were prepared by having the transducers and instrument package exposed to preselected temperatures and connected to transmit directly in code letter versus weather data. These data were plotted on graphs and a calculated correction used. The method was convenient because there was less chance of error with no data to transfer, and corrections were included in the charts.

B A R O M E T R I C   P R E S S U R E

CODE LETTERS VS PRESSURE IN MILLIBARS FOR AUTOMATIC WEATHER STATION

Serial No. 2 Transducer No. 823 Sept. 23 1955

UIN		UWG	867.6	UBV	923.4	UMA	979.1	USS	1034.9
ID		WU	868.6	BK	924.4	MT	980.2	SH	1035.9
IS		WM	870.0	BB	925.8	MW	981.6	SI	1037.4
IH		WN	871.5	BG	927.3	MV	983.0	SA	1038.8
II		WD	872.9	BU	928.7	MK	984.5	ST	1040.2
IA		WS	874.3	BM	930.1	MB	985.9	SW	1041.7
IT	820.0	WH	875.8	BN	931.5	MG	987.3	SV	1043.1
IW	821.4	WI	877.2	BD	933.0	MU	988.7	SK	1044.5
IV	822.9	WA	878.6	BS	934.4	MM	990.2	SB	1045.9
IK	824.3	WT	880.0	BH	935.8	MN	991.6	SG	1047.4
IB	825.7	WW	881.5	BI	937.3	MD	993.0	SU	1048.8
IG	827.2	WV	882.9	BA	938.7	MS	994.5	SM	1050.2
IU	828.6	WK	884.4	BT	940.1	MH	995.9	SN	1051.7
IM	829.6	WB	885.4	BW	941.2	MI	997.0	SD	1052.6
UAM	830.4	UVB	886.2	UGW	942.0	UNI	997.8	UHD	
AN	831.4	VG	887.2	GV	943.0	NA	998.8	HS	
AD	832.8	VU	888.6	GK	944.4	NT	1000.2	HH	
AS	834.3	VM	890.1	GB	945.8	NW	1001.6	HI	
AH	835.7	VN	891.5	GG	947.3	NV	1003.0	HA	
AI	837.2	VD	892.9	GU	948.7	NK	1004.5	HT	
AA	838.6	VS	894.4	GM	950.1	NB	1005.9	HW	
AT	840.0	VH	895.8	GN	951.6	NG	1007.3	HV	
AW	841.5	VI	897.2	GD	953.0	NU	1008.8	HK	
AV	842.9	VA	898.7	GS	954.4	NM	1010.2	HB	
AK	844.3	VT	900.1	GH	955.9	NN	1011.6	HG	
AB	845.7	VW	901.5	GI	957.3	ND	1013.0	HU	
AG	847.2	VV	902.9	GA	958.7	NS	1014.5	HM	
AU	848.2	VK	904.0	GT	959.7	NH	1015.6	HN	
UTU	849.0	UKK	904.8	UUT	960.5	UDH	1016.4		
TM	850.0	KB	905.8	UW	961.6	DI	1017.3		
TN	851.5	KG	907.2	UV	963.0	DA	1018.8		
TD	852.9	KU	908.7	UK	964.4	DT	1020.2		
TS	854.3	KM	910.1	UB	965.9	DW	1021.6		
TH	855.8	KN	911.5	UG	967.3	DV	1023.0		
TI	857.2	KD	913.0	UU	968.7	DK	1024.5		
TA	858.6	KS	914.4	UM	970.2	DB	1025.9		
TT	860.0	KH	915.8	UN	971.6	DG	1027.4		
TW	861.5	KI	917.2	UD	973.0	DU	1028.8		
TV	862.9	KA	918.7	US	974.4	DM	1030.2		
TK	864.3	KT	920.1	UH	975.9	DN	1031.6		
TB	865.8	KW	921.5	UI	977.3	DD	1033.0		
TG	866.8	KV	922.6	UA	978.3	DS	1034.1		

TEMPERATURE CORRECTION
- Between -40°F and 0°F Use values given
- Between 0°F and +40°F Add 1 mb to all pressure values
- Between +40°F and +80°F Add 2 mb to all pressure values

Fig. 25 - Sample of calibration charts

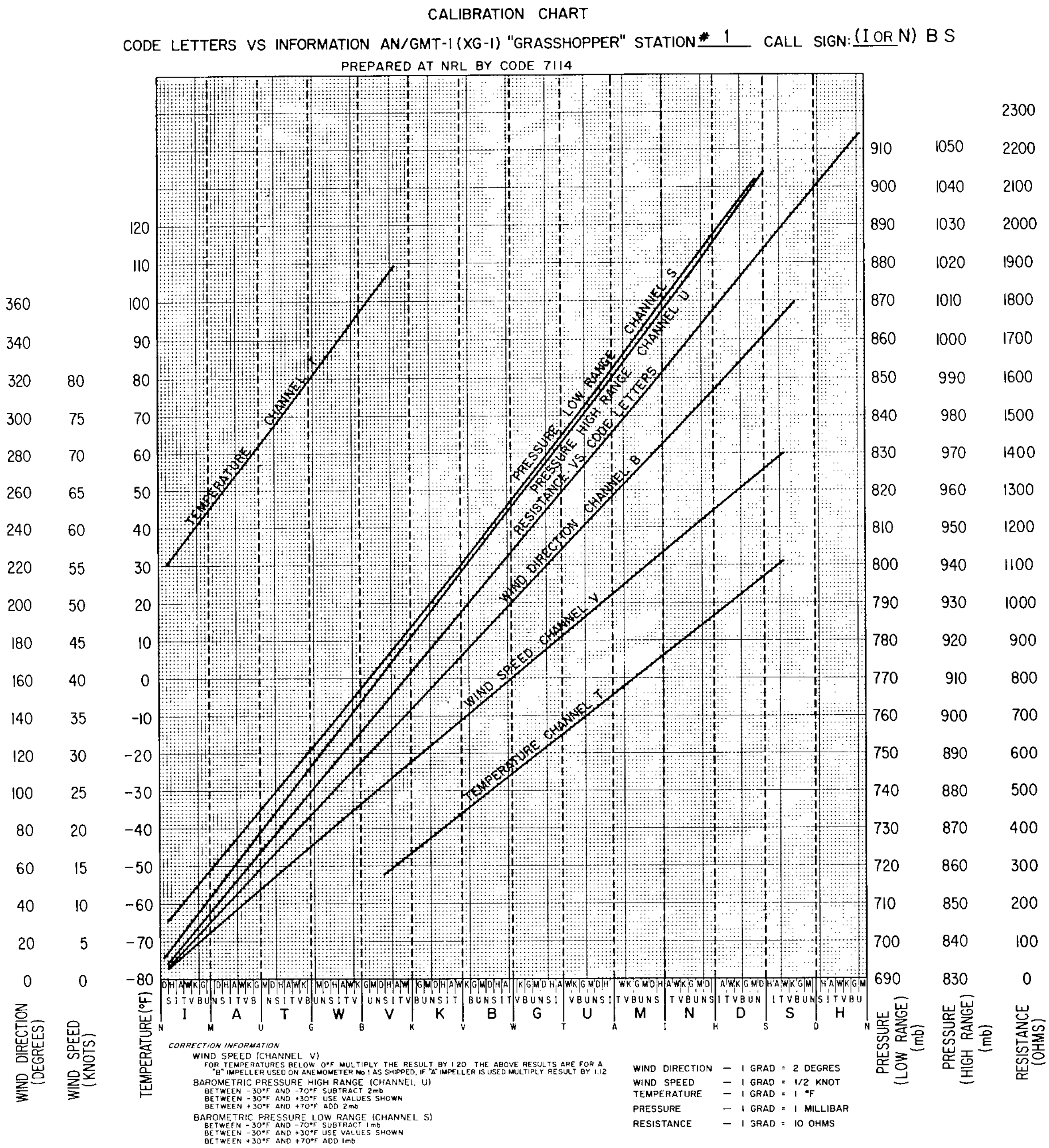


Fig. 26 - Calibration chart using graph

In 1960, these six charts were combined into one graphical arrangement (Fig. 26). This reduced the number of charts for each station from six to one.

The first Grasshoppers sent to Deepfreeze were calibrated from room temperature down to -20°F. Lower temperatures were not used because of limitations of the testing equipment available.

In 1959 it was agreed that an operating temperature range of -30° to +40°F for the modified Grasshopper was necessary during the summer season at Deepfreeze.

Emphasis was placed on this range for the following reasons:

1. The primary use for the modified station in the Antarctic was during the summer season, which seldom has temperatures beyond this range.

2. The unnecessary time and money spent making the station meet every aspect of the original specification (-70°F to +110°F) would not improve the usefulness of the station.

3. The low temperature test equipment necessary for testing and calibrating below -30°F was not available at NRL.

The clocks that program the stations are regulated to within ±10 seconds a day, and a chart is supplied with each clock showing its rate at a given temperature.

TESTING OF GRASSHOPPER

When NRL received the Grasshoppers in 1955, the structure and parachute delivery system had already undergone an extensive test program (1,2). Since then each new or modified stage has been given actual or simulated service tests to insure that the obvious is not overlooked and the not-so-obvious is taken into account.

The gas storage tank was filled with nitrogen to 1075 psi at room temperature, but when checked at -50°F the tank pressure had decreased 175 to 200 psi. In testing the righting system in an environmental chamber at -50°F, 475 psi was used to erect the system in 20 seconds, leaving about 400 psi to erect the antenna in an additional 25 seconds. Normally 200 to 300 psi is adequate to erect the antenna.

To aid in calibrating and testing the Grasshopper, a calibration set and a test set are provided. The calibration set has lights to indicate the code letters selected for transmission and has to be connected directly to code system. The test set has a special connector provided and when connected shows the station's voltages and currents. The test set is useful in tuning the transmitter as well as checking battery voltage, bridge voltage and current, and transmitter voltage and current.

Temperature testing and calibrating is done in a 4 × 6 ft temperature chamber that uses dry ice as a refrigerant and was modified by NRL for this project. This chamber has a range of -30°F to +130°F.

For testing anemometers, NRL built a small wind tunnel capable of operating from -30°F to +80°F. This tunnel has a variable speed from 0 to 25 knots and one additional speed of 50 knots. The final test of an anemometer is conducted in the wind tunnel at National Bureau of Standards.

The testing of the pressure units while connected to the station's instrumentation is done in the temperature chamber. The pressure is piped into the chamber from a controlled external system which has been calibrated to within 0.1 mb. The resulting pressure reading is indicated on the calibration set.

For the shakedown test, the Grasshopper was run in the laboratory on an accelerated basis of one transmission per hour for at least 100 transmissions (25 days in service). The collected data was compiled and plotted showing deviations from Weather Bureau reports and NRL standards.

After this period of operation in the laboratory, the Grasshopper was tested under environmental conditions on the lawn at NRL. The transmitter was tuned and again the station was tested for at least 100 transmissions and the collected data plotted showing deviation. The transmitter signal strength was also observed during this test.

DATA COLLECTION

Data collection was improved during the development stage when a crystal calibrated radio receiver was used to monitor the stations. The McElroy code tape recorder proved useful in that it gave a visual record of the code formation. This tape recorder can also be used to automatically monitor the stations continuously while they undergo test and field operation. Log sheets (Fig. 27) for recording the transmitted code and the converted weather data provides a systematic method to keep a running record of each station.

AUTOMATIC WEATHER STATION

Daily Log Sheet

FROM DATE HOUR ______________ TO DATE HOUR ______________

LOCATION OF WEATHER STATION ______________

SERIAL NUMBER OF WEATHER STATION ______________

TIME OF TRANSMISSION ______________

	Call Letters	Wind Dir. Degrees	Wind Speed Knots	Temperature °F	Pressure Millibars	Pressure Millibars
Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Weather Observations						

TIME OF TRANSMISSION ______________

	Call Letters	Wind Dir. Degrees	Wind Speed Knots	Temperature °F	Pressure Millibars	Pressure Millibars
Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Weather Observations						

TIME OF TRANSMISSION ______________

Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Weather Observations						

TIME OF TRANSMISSION ______________

Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Code	N __ __	B __ __	V __ __	T __ __	U __ __	S __ __
Weather Observations						

Fig. 27 - Sample of daily data log sheet

TRAINING OF PERSONNEL

The success of the Grasshopper has been hampered by lack of trained manpower to monitor, keep logs, and service the stations during Operation Deepfreeze.

The present models are experimental to the extent that they are being evaluated and are undergoing modifications regularly to meet the needs of Operation Deepfreeze. Under these conditions it is essential that all personnel associated with operating the stations be trained annually.

For success it is evident that men with the proper background have to be selected for training, because the bulk of the equipment is a complicated electromechanical device. Electronic technicians have fulfilled this requirement very successfully when the period of training is long enough, and they are given the stations as a prime responsibility.

The success of the 1960, 1961, and 1962 seasons is mainly attributed to the technical competence and personal interest of the men who were given instructions at NRL before leaving for Antarctica.

1955

To accompany the Grasshopper (NEL No. 1) to Deepfreeze for the season 1956, one aerographer received training for less than one day. It was difficult for him to understand the operation of the station with his limited knowledge of electronics; therefore very little was accomplished in such a short time.

1956

The U.S. Naval Avionics Facility trained several aerographers in their plant for a period of one week on the operation of the Grasshopper. These men accompanied eight Grasshoppers to Operation Deepfreeze in 1956.

1959

When it was decided to reactivate the Grasshoppers for the 1960 season, plans were made to have two electronic technicians detailed to the stations and trained at NRL on complete operation of the weather stations. The two electronic technicians were James F. Ronner and Martice E. Wise, NRL. In addition to instructions in the operation of the modified Grasshopper, they were to assist in getting two Grasshoppers (NAFI Nos. 3 and 6) ready for service at Deepfreeze. They were also prepared to make modifications, with NRL-furnished kits, on the Grasshoppers (NAFI Nos. 5 and 8) at Deepfreeze. Mr. Leroy Allison of the National Bureau of Standards, who was working with similar equipment at NBS, was also included in the training program.

1960

Plans were made early in 1960 for NRL to train electronic technicians on the modified Grasshopper. Two electronic technicians, Charles A. Lauter and Paul R. Wick, were sent to NRL in 1960 for training. In addition to instructions, they were to rework the Grasshopper (NAFI No. 1) as well as install the new temperature transducer thermoshield. The extra time allowed for training this year was very beneficial. With the technical ability and personal interest of these two men, the training went so smoothly that there was sufficient time left in the four-week period to set up a Grasshopper on the lawn at NRL and monitor all telemetered data for one week. This data was compared with bonofide standards to check the accuracy of the telemetered data. In all cases the accuracy was within the specified tolerance of the transducers.

1961

Three electronic technicians, Anthony N. Fabiano, Lonnie L. Arnold, and Ronald W. Dana, were detailed to NRL for instruction on the modified Grasshopper. In addition to this instruction, they assisted in preparing a Grasshopper (NAFI No. 1) for service on Scott Island.

FIELD OPERATIONS WITH GRASSHOPPERS

Deepfreeze Season - 1956

The Grasshopper (NEL No. 1) reworked at NRL was air delivered at the South Pole by Deepfreeze and was not heard from thereafter. This was a disappointment but not entirely unexpected because adequately trained personnel did not accompany the Grasshopper to place it in operation.

Naval Avionics Facility, Indianapolis - 1956

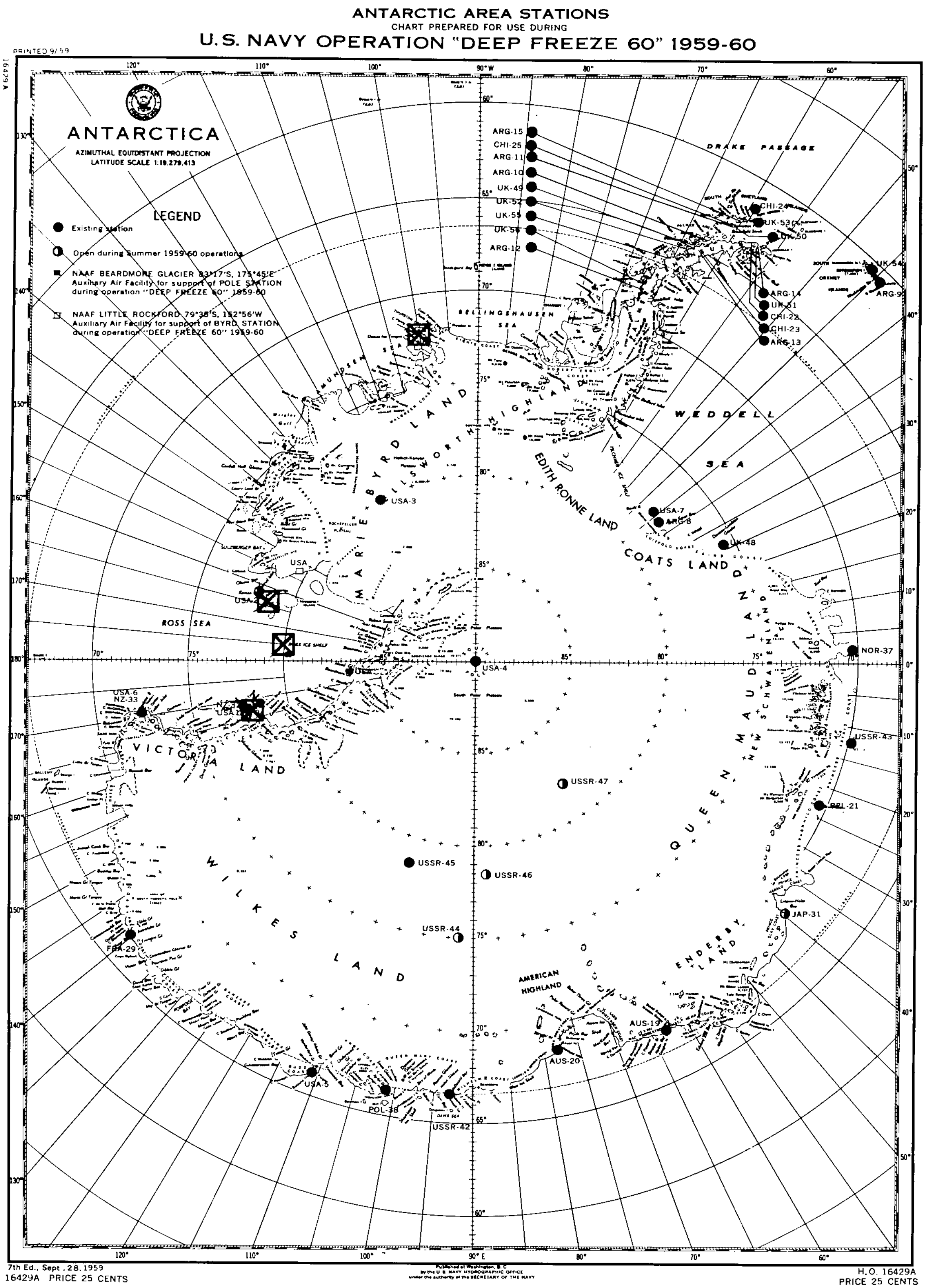
The Grasshopper (NEL No. 2) reworked at NRL for use as manufacturing model was subjected to air delivery tests by NAFI in Indianapolis, Indiana, and these tests were considered successful. The Grasshopper was manually ejected through a large door in the side of a cargo plane at about 500 feet. Several of these drop tests were witnessed by personnel from NRL. On one air delivery test the safety switch was not closed before delivery, resulting in a successful delivery but the station failed to erect itself automatically. On another test the gas pressure remaining, after station erection, was sufficient to make the threads in the Teflon antenna base yield, thereby ejecting the antenna instead of erecting it (this was corrected by adding a metal insert in the antenna base and there were no recurrences). Outside of these minor problems the station and its instrumentation performed satisfactorily even after a number of air delivery tests.

Deepfreeze Season - 1957

The season's operation was not considered successful as the Grasshoppers did not render service on an operational basis as desired. Eight Grasshoppers were delivered to Task Force 43 by NAFI; some were dropped by aircraft at the operating site and the others were manually delivered. One of the dropped stations was lost and no transmissions were received from it. Another station did not operate after delivery, and an investigation showed that the battery was not connected properly. On another occasion when a station failed to be received, an investigation revealed that so far as could be determined in the field, the system was operating but not transmitting. A shortage of monitoring personnel as well as receivers resulted in a failure to accumulate data systematically from the stations that did operate. This was especially acute when the rate on the clocks (that program the station) was not exact; therefore when the stations were not received on the exact preset schedule, time could not be allotted to investigate the pattern of the clock rate and follow it daily.

Deepfreeze Season - 1960

Deepfreeze 1960 was an encouraging season for the Grasshopper weather stations. Equipment reliability was excellent and reception was good on all sites (Fig. 28). Trained personnel were on hand to monitor the stations, accumulate data, service the Grasshoppers, and keep logs on all activities. Two Grasshoppers (NAFI Nos. 5 and 8) were used. Modification kits prepared by NRL arrived in time to modify these stations. Two other



☒ "GRASSHOPPER" OPERATIONS SITES-SEASON 1960

Fig. 28 - Map of Antarctica showing Grasshopper operation sites (Season 1960)

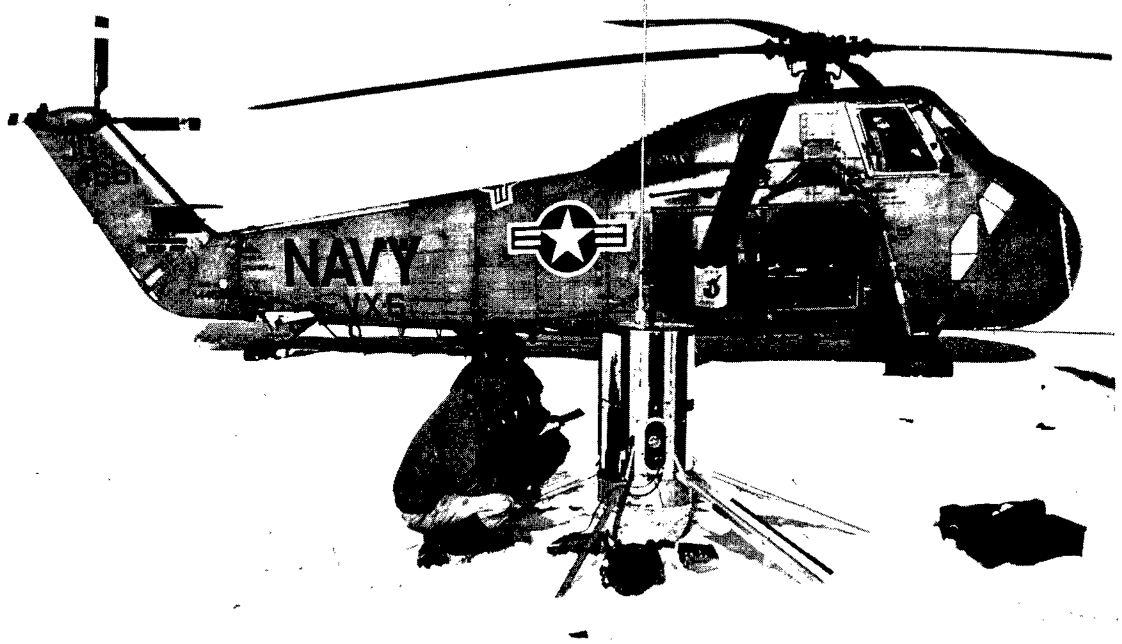


Fig. 29 - Placing Grasshopper in service on Ross Ice Shelf at Antarctica (Season 1960)

Grasshoppers (NAFI Nos. 3 and 6), which were modified at NRL, did not arrive until late in the season. A Grasshopper being placed in service on the Ross Ice Shelf is shown in Fig. 29.

The telemetered data collected at McMurdo Station, on these two Grasshoppers, when operated in temperatures between -21°F and +35°F and compared with standard aerological equipment there (no better standards were available), showed all errors to be within the specified tolerance of standard equipment. The maximum deviation in telemetered weather information from these standards are ±2 knots for wind speed (channel V) ±1-1/2 mb for barometric pressure high range (channel U), and up to 17°F high for temperature (channel T) with the sun shining. A standard was not available for wind direction (channel B) and no pressures low enough for barometric pressure low range (channel S) was experienced.

In the majority of the cases the accuracy of the data was within the limits of those quoted on the transducer's performance. The vibrator on the pressure transducer was satisfactory. The high air-temperature reading that occurred when the sun was shining (resulting from sealing the station's interior from fine snow) was not expected in the Antarctic. As a result of these findings an engineering study revealed that a properly designed radiation shield for the temperature transducer mounted on the top deck of the Grasshopper would eliminate this problem.

The 2720-kc frequency was found to give very poor reception. Other frequencies were tried, 4223 kc, 5305 kc, and 6875 kc, and it was found that either 4223 kc or 5305 kc gave the best results. Therefore 4223 kc was used since crystals were available for this frequency from the original NAFI stations. The painted stripe for wind direction reference from the air was expanded farther by walking out paths in the snow and by using red fluorescent flags as shown in Fig. 30. It should be pointed out that due to the geometry of the Grasshopper, the station was not snowed in as was other equipment when subjected

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Fig. 30 - Grasshopper in service on Ross Ice Shelf at Antarctica (Season 1960)

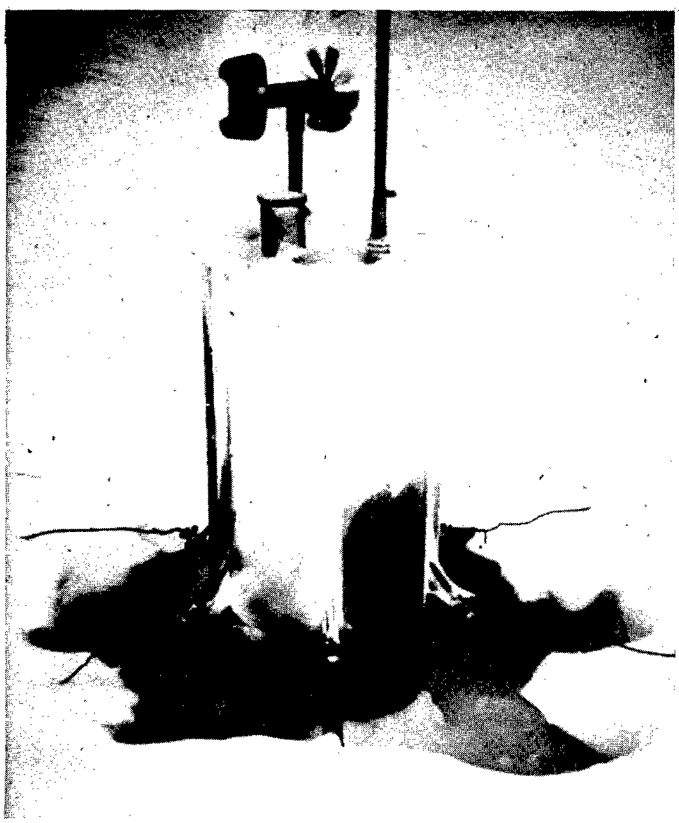

Fig. 31 - Grasshopper after 7 months of exposure at Beardmore station during winter season showing resistance to snowing-in

to the same exposure of drifting snow (Fig. 31). This is considered to be one of the most valuable and remarkable features of the Grasshopper structure.

Deepfreeze Season - 1961

The 1961 season was considered another successful season for the modified Grasshopper weather station. Trained personnel arrived at Deepfreeze early in the season and had an opportunity to be acquainted with the operation before the personnel of the 1960 season departed. Modification kits, prepared by NRL, arrived in time to be installed on all three stations (NAFI Nos. 5, 6, and 8). The temperature transducer with its thermoshield provided air temperature accuracies that were not previously available. The telemetered data showed a maximum deviation from standard aerological reading at McMurdo of less than ±2 °F under all conditions. On one occasion the thermoshield filled with snow and caused some concern; however, the bimetal spiral was inverted, pointed downward with respect to the potentiometer, resulting in no recurrences. The connector on top deck for connecting the external battery was reported as being very convenient. The composite calibration chart (Fig. 25) proved to be very helpful and time saving.

Operation of the Grasshoppers at Deepfreeze from the viewpoint of a technician were described by Wise (4).

Deepfreeze Season - 1962

Modified station NAFI No. 1 arrived at McMurdo Station in time to be placed on Scott Island on Nov. 13, 1961 (Figs. 32 and 33). This station was heard only several times. When an investigation was made on Dec. 26, 1961, the antenna was found collapsed. The antenna was extended and the station appeared to work. However, the station was heard only several times again. This station was returned to McMurdo Station on Feb. 10, 1962, and the antenna was found shorted from salt water which entered the antenna while it was collapsed, thereby causing the failure of the station. This station was installed at Beardmore (since the manned weather station there was vacated during the winter) with sufficient batteries for the winter season (Fig. 31). It operated intermittently over the five-month period and was heard for 300 miles. The intermittent reception was linked with lubricant freezing since it was heard whenever the temperature would rise above -40° F. The temperature transducer became inoperative and was believed to have filled with snow. This was a severe test of the station and the experiment was considered encouraging.

Stations NAFI Nos. 5 and 8 were used mostly this season with No. 5 operating 37 days on three locations. Station No. 6 was inoperative most of the season because of a wait for NRL to overhaul and return the code mechanism and anemometer. Station No. 8 was returned to NRL for overhaul at the end of the season. Station No. 5 withstood a violent storm at the Arcas rocket tracking site, where wind speeds of over 78 knots were recorded The station moved about 50 feet during the storm and the only damage was the loss of four leg chaps.

To prevent the antennas from giving further trouble by collapsing, a hose clamp was used at the base of each section. The new Borg clock, as a whole, did well but did not keep accurate time at the extreme temperatures.

The operation for the 1962 season was considered successful.

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Fig. 32 - Placing Grasshopper in service on Scott Island (Season 1962)

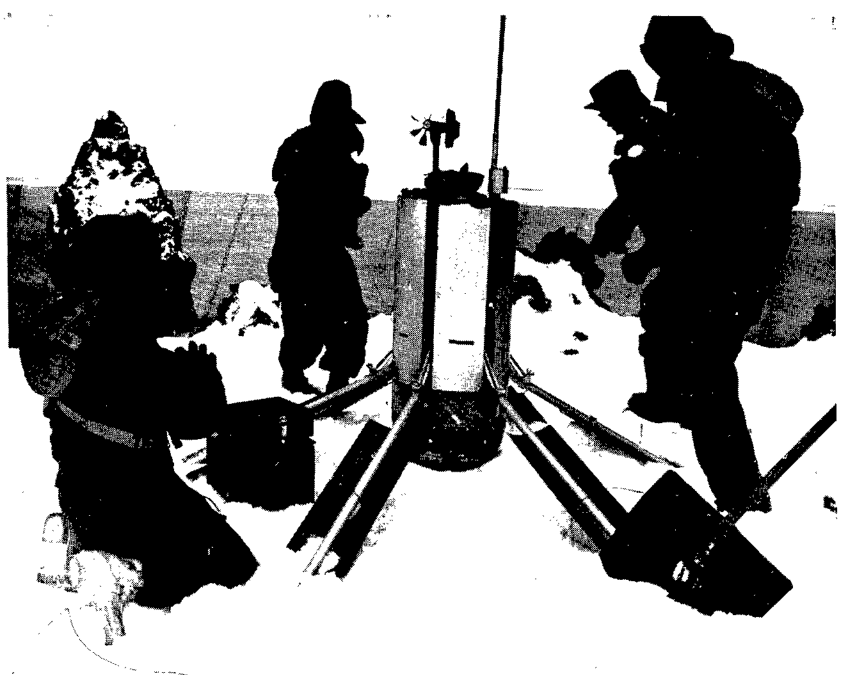

Fig. 33 - Placing Grasshopper in service on Scott Island (Season 1962)

RECOMMENDATIONS

It has been observed that there is a need for two types of land automatic weather stations, parachute type and manually erected type. When it became apparent that air delivery was not useful in the antarctic, NRL concentrated its efforts on converting the parachute type to manually erected models with the least number of modifications. It was expected that the development would continue throughout the evaluation period and modifications as indicated by the field trials would have to be provided. The following recommendations are offered as a guide to exploit the Navy's capability of improving and maintaining these automatic weather stations.

1. The Grasshopper parachute-type automatic weather station design should be improved by incorporating the parachute delivery system design now used on a similar vehicle in another NRL project, and making the instrumentation current with the manually erected station.

2. In addition to what has been accomplished, the following measures should be taken to improve the manually erected automatic weather station:

   a. The station should be assigned a nomenclature, and it has been suggested that Navy Environmental Telemeter (NET) would be appropriate.

   b. The station should be made as light in weight as possible.

   c. The present leg erection should be done away with and a simple manually operated leg system designed.

   d. The code mechanism system should be completely redesigned to do away with clock converter, eliminate the errors in the code selector at the changeover points, and make other features current.

   e. A manually extended antenna should be used that will not collapse during high winds.

3. Drawings should be made to show the latest developments.

4. Specifications should be drawn up for purchasing automatic weather stations.

5. An instruction book should be written to describe the current equipment and replace outdated instruction manual (5).

6. A training program should be set up to relieve NRL of this phase of the operation.

7. Additional stations should be procured reflecting the current designs to continue the field evaluation.

8. The automatic weather station should be returned to a normal Navy facility for overhaul and calibration on a scheduled basis.

CONCLUSION

Development of the expendable, parachute deliverable, land-type automatic weather station Grasshopper (AN/GMT-1(XG-1)) was essentially completed in 1956. This design has been refined and modified into a station that functions reliably. These refinements and modifications based on experience in the antarctic have served as the basis for the development of a manually delivered and erected land-type automatic weather station.

This station is very similar to the Grasshopper except that it weighs less, is manually erected, and can be recovered for use again in a different locality. Models of this station contain all proven instrumentation and are now being field tested in the antarctic. This station has proven to be a valuable tool in forecasting weather conditions. This station has demonstrated that it is feasible to take an automatic weather station out of the laboratory and place it in the hands of the operating command and get usable results.

To meet the requirement for a parachute deliverable station, the next step should now be the manufacturing and field testing of a small number of prototype models incorporating these advanced designs.

It is foreseen that a network of these stations may provide the Navy with increased weather data coverage.

ACKNOWLEDGMENT

The author wishes to thank his coworker, Richard B. Bridge, and his supervisor, Walter A. Von Wald, Jr., for their cooperation and assistance in this development.

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APPENDIX A

REVISED LIST OF NRL DRAWINGS FOR THE AUTOMATIC WEATHER STATION (GRASSHOPPER) - 1956

The Navy Electronics Laboratory furnished NRL with Van Dyke transparent copies of the original Grasshopper drawings. These copies were revised and necessary sheets added to reflect the repairs, modifications, and design changes. NRL numbers were assigned the revised drawings (D-2573) and the wind speed transducer drawings (F-2575). The index of these drawings follows:

NRL Drawing Number	NEL Drawing Number	Number of Sheets	Titles
E2573-1 thru E2573-2	RAA 10 E 4230	2	Assembly
E2573-3 thru E2573-5	RAA 10 E 7100	3	Wiring Diagram
E2573-6 thru E2573-21	RAA 10 E 44	16	Structure
E2573-22	RAA 10 E 4215	1	Fin
D2573-23 thru D2573-31	RAA 10 D 46	9	Righting Mechanism
D2573-32 thru D2573-35	RAA 10 D 447	4	Timer
D2573-36 thru D2573-38	RAA 10 D 455	3	Battery Box
D2573-39 thru D2573-41	RAA 10 D 4109	3	Bridge Amplifier
D2573-42 thru D2573-44	RAA 10 D 4114	3	Transmitter
D2573-45 thru D2573-53	RAA 10 D 4126	9	Coding Mechanism
D2573-54	RAA 10 D 4172	1	Erection Delay Mechanism
D2573-55 thru D2573-57	RAA 10 D 4248	3	Post Release
D2573-58	RAA 10 D 4277	1	Thermometer
D2573-59	RAA 10 D 4402	1	Ground Release
D2573-60	RAA 10 C 781		Terminal
	RAA 29 A 779	1	Layout
D2573-61	RAA 10 D 7149	1	Cable Assembly
D2573-62	RAA 10 D 7151	1	Power Supply Terminal Layout
D2573-63	RAA 10 D 7152	1	Transducer Terminal Layout
D2573-64	RAA 10 D 7154	1	Hammer Valve
D2573-65	RAA 10 D 7157	1	Tail Cone
D2573-66	RAA 24 D 7147	1	Cutoff Switch
D2573-67	RAA 29 D 7135	1	Relay Assembly
D2573-68 thru D2573-70	RAA 62 D 4168	3	Power Supply Case
D2573-71 thru D2573-73	RAA 66 D 413	3	Antenna
D2573-74 thru D2573-76	- - -	3	Frame for Assembly
D2573-77 thru D2573-78	RAA 10 D 7141	2	Test Meter
D2573-79 thru D2573-81	- - -	3	Calibrating Apparatus
F2575-1 thru F2575-8	- - -	8	Anemometer