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USU remote total precipitation telemetry station

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USU REMOTE TOTAL PRECIPITATION

TELEMETRY STATION

by

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Table of Contents

List of Figures ii

List of Tables ii

Abstract iii

Introduction 1

Remote Precipitation Station 3

Precipitation Catchment Devices 13

Weighing Transducer. 15

Electrical Equipment 17

Summary 19

References 21

List of Figures

Figure		Page
1	Remote Total-Precipitation Telemetering System . .	2
2	Wasatch Weather Modification Telemetering Stations	5
3	Total Precipitation Telemetry Station	6
4	Raingage Assembly - 36" Capacity	7
5A	Raingage Assembly for 70" Precipitation Can . . .	8
5B	Raingage Assembly - 70" Capacity	9
5C	Raingage Stand Baffle Assembly	10
6	Weighing Transducer	16
7	Radio Telemetering Transponder	18
8	Five Element Yagi Antenna and Mast	20

List of Tables

Table		Page
1	Utah Raingage Stand	11

Abstract

A total precipitation catchment and telemetering device is described for use in mountainous regions. The precipitation transducer uses a weighing-type mechanism which has a variable inductor sensor.

The catchment system floats on springs and has negligible static friction. The radio transponder is powered by dry batteries. It responds upon coded interrogation, sending hydrologic or meteorological data through a mountaintop translator to a base station.

USU REMOTE TOTAL PRECIPITATION TELEMETRY STATION

Introduction

The purpose of this report is to report salient features of the remote telemetry station used by Utah State University on the Wasatch Weather Modification Project (see Figure 1).

The installation of a remote telemetering system was part of a program that has as its overall objective the assessment of the relative effectiveness and the practicality of selected procedures for increasing the water supply from precipitation over the Wasatch Mountains by cloud seeding. The fulfillment of this objective requires the acquisition of data concerning the natural precipitation processes in the experimental area. The evaluation of cloud seeding activities is then possible through comparisons between natural and seeded precipitations.

A telemetering (T/M) system has been constructed that will facilitate the determination of precipitation patterns in mountainous regions. This system consists of numerous remote precipitation radio T/M stations, the Mt. Logan translator, and the terminal readout station. The remote system is capable of monitoring precipitation in high mountainous regions during winter months when obtaining data from a conventional type station during generally adverse conditions would be impractical.

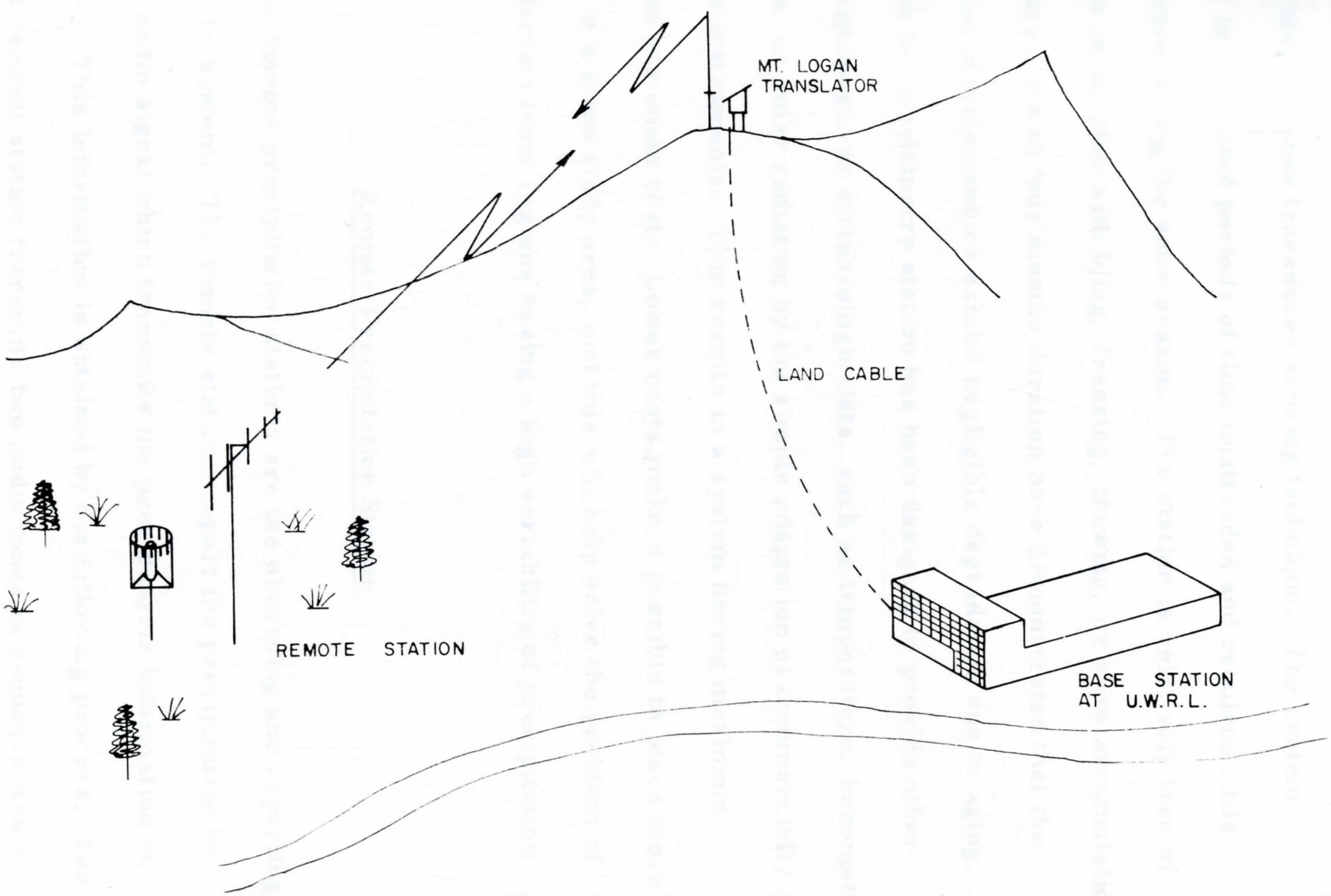

Figure 1 Remote Total-Precipitation Telemetering System. Subsystem Discussed In Report Is Remote Station Only

The basic remote telemetry station is simple in design, and incorporates a unique transducer sensing technique. The system operates for extended periods of time unattended and requires little maintenance during the snow season. The station is relatively free of problems associated with icing, freezing, thawing, or snow accumulation. Laboratory tests of four months duration have demonstrated that the transducer and electronics exhibit negligible degradation due to aging.

The basic telemetry station has been designed to provide other needed hydrologic or meteorologic data, such as temperature, barometric pressure, or solar radiation by the simple adaptation of commercially available instruments. This results in a system having maximum utility and minimum cost. Lower costs make it possible to place more stations in a given study area, and this will help solve the problem of data collection from regions having a high variability of precipitation patterns.

Remote Precipitation Station

The remote precipitation stations are the observing and reporting posts of the system. The remote stations report the precipitation by way of a radio signal which transmits the precipitation information on command. This information is obtained by the following process: The terminal readout station transmits two audio tones in sequence which correspond to a chosen remote station address. These signals are transmitted through a telephone cable to the Mt. Logan translator which, in turn, radio relays the message to the remote stations. A particular station, having received its correct address, as determined by the vibration of two resonant reeds, turns on a radio transmitter. An audio tone is subsequently transmitted with a frequency proportional to the weight of the precipitation that has been accumulated up to the time of interrogation. The remote station transmits the information to the Mt. Logan translator which relays the signal by way of a telephone ground cable to the terminal readout station. There are 33 remote stations in operation (May 1, 1968) which monitor the amount of precipitation in the regions of interest. The locations of these stations are shown in Figure 2.

A typical remote station is illustrated by the sketch in Figure 3. The station consists of a precipitation can stand, Figure 4, which is principally made from a 2 1/2-inch galvanized pipe with a standard Alter shield. The Alter shield, used to enhance the snow catch, consists of 30 baffles placed on a 42-inch diameter 3/8-inch steel rod.

The single-pipe stand, as detailed in Figure 4, is used at low elevation stations where the snowfall is not as great as it is in the high mountain regions. For the higher elevations and larger snow accumulations, a three-legged stand, patterned after the Soil Conservation Service stands, is used. This type of stand, illustrated in Figures 5A, 5B, and 5C, uses 1 1/2-inch pipe for each of the three legs. The Soil Conservation Service is providing the towers at many locations where the three-legged stand is in use. A complete parts list for this stand is given in Table 1.

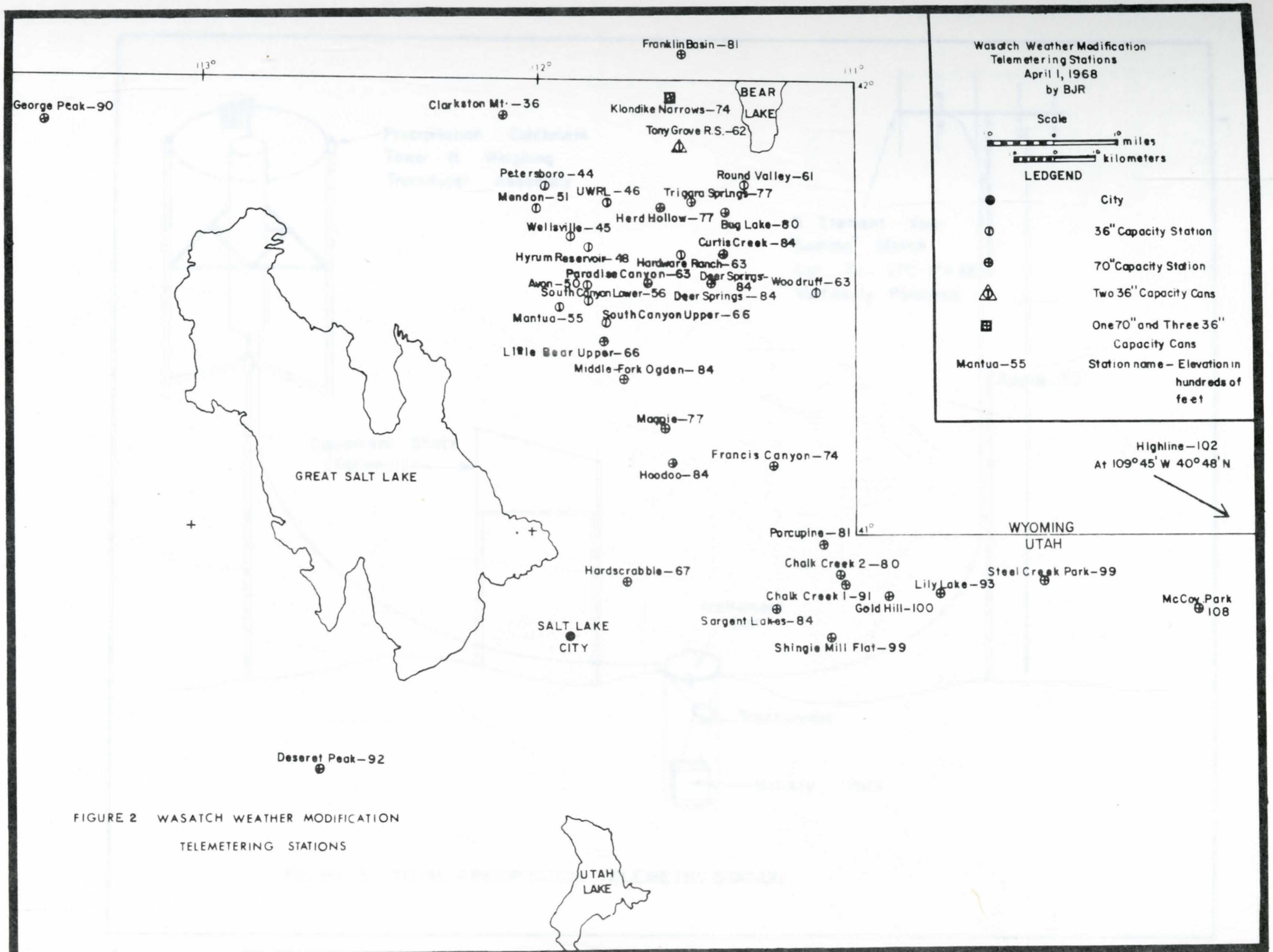

FIGURE 2 WASATCH WEATHER MODIFICATION TELEMETERING STATIONS

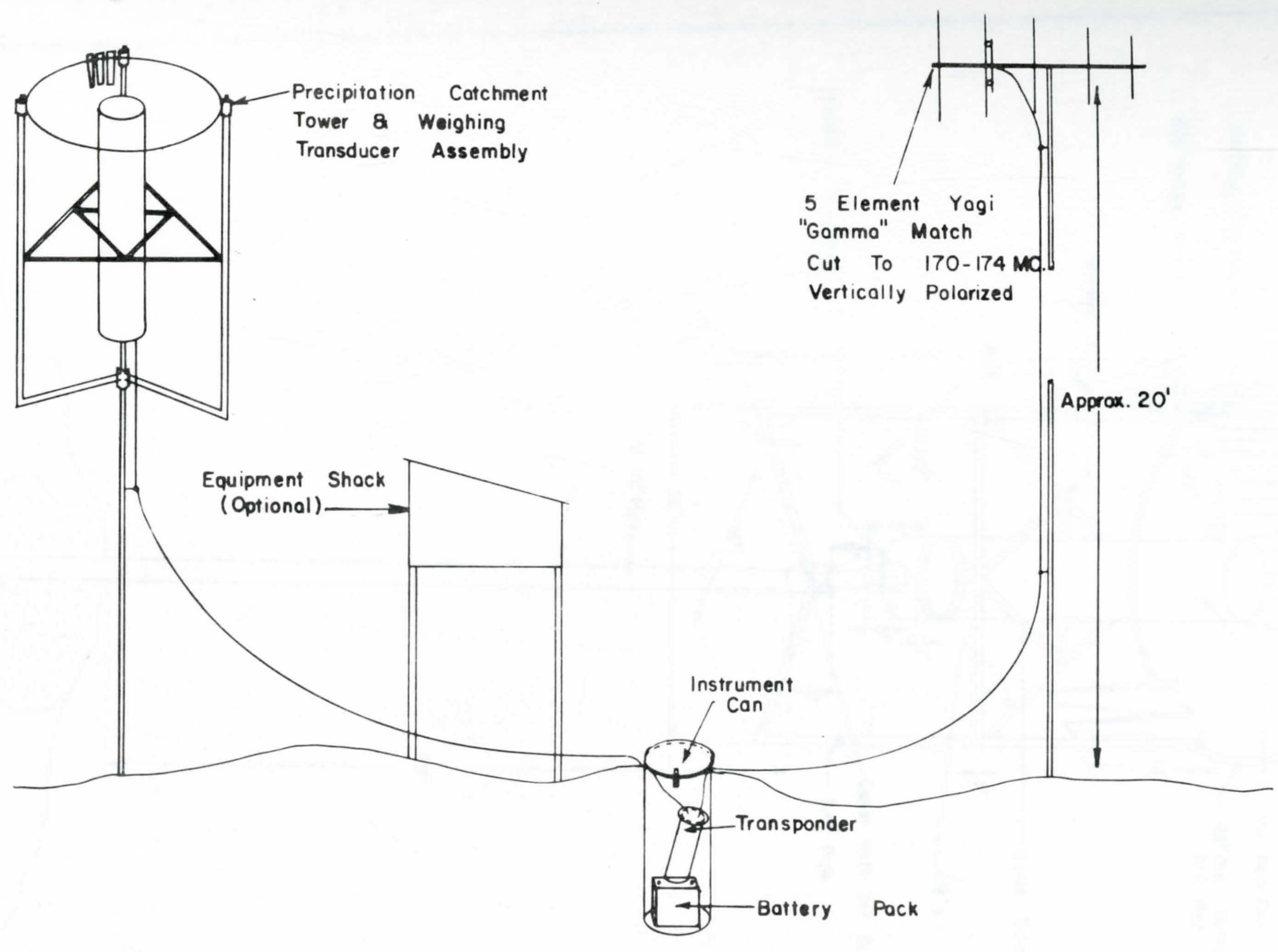

FIGURE 3 TOTAL PRECIPITATION TELEMETRY STATION

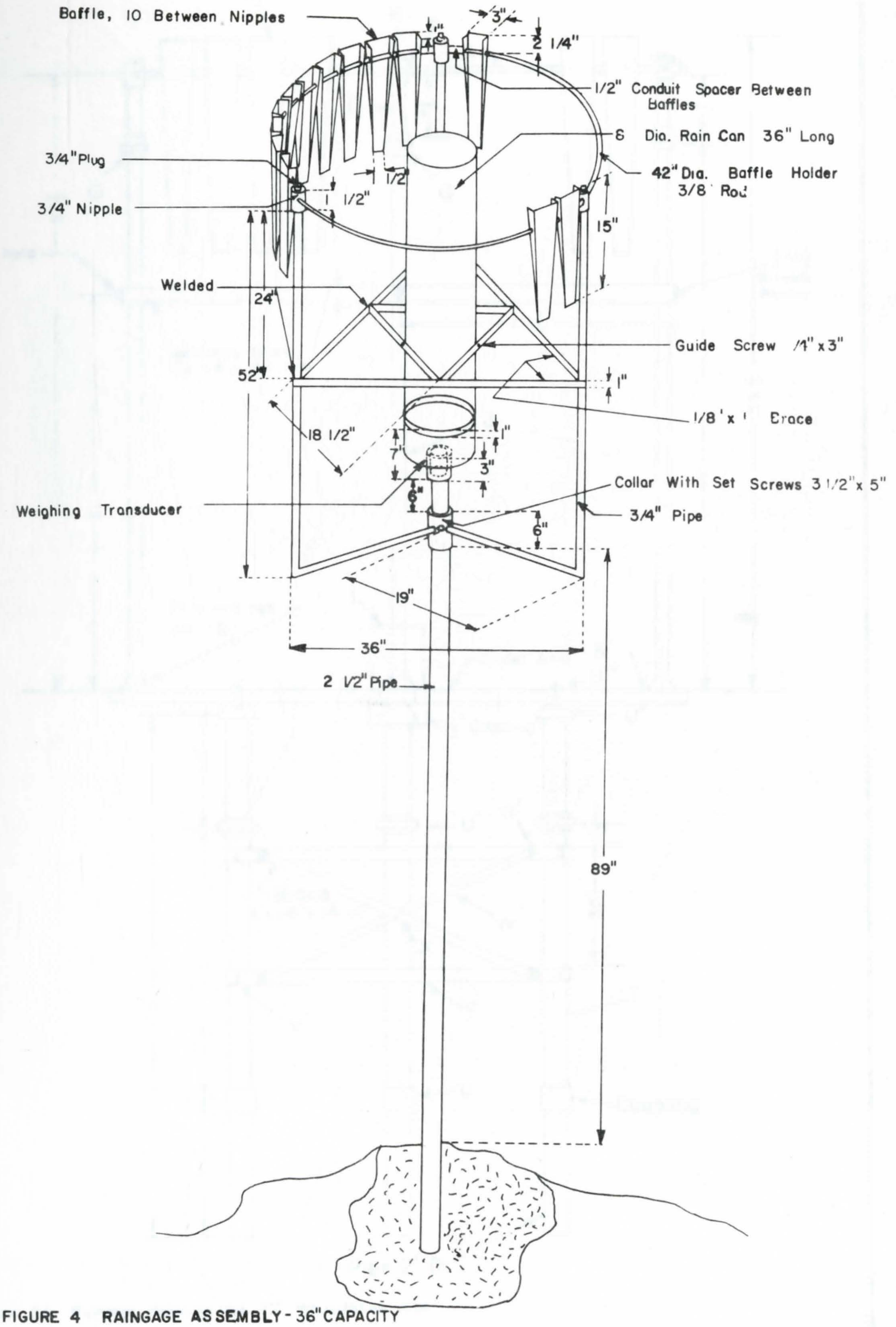

FIGURE 4 RAINGAGE ASSEMBLY - 36" CAPACITY

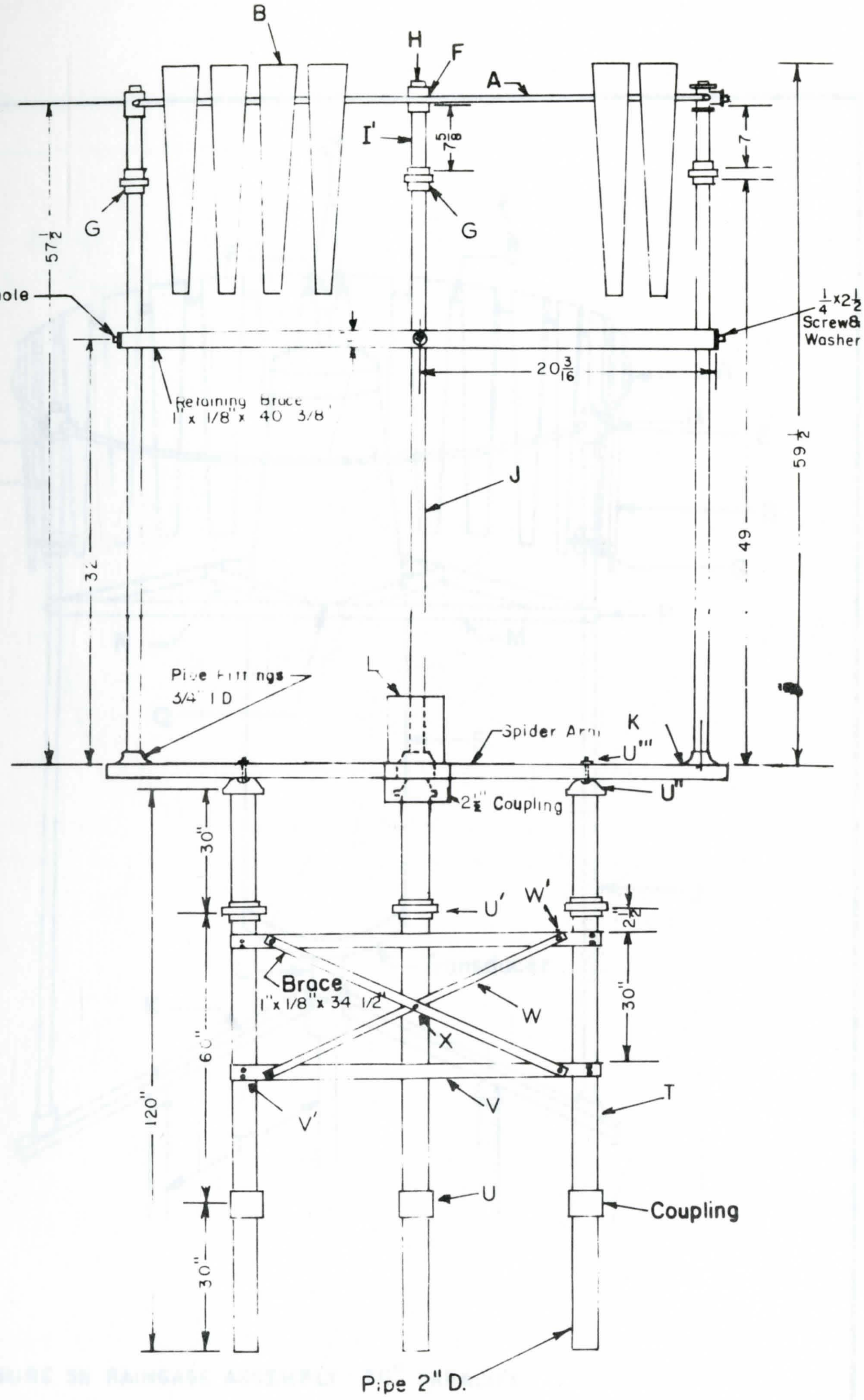

Figure 5A Raingage Assembly For 70" Precipitation Can

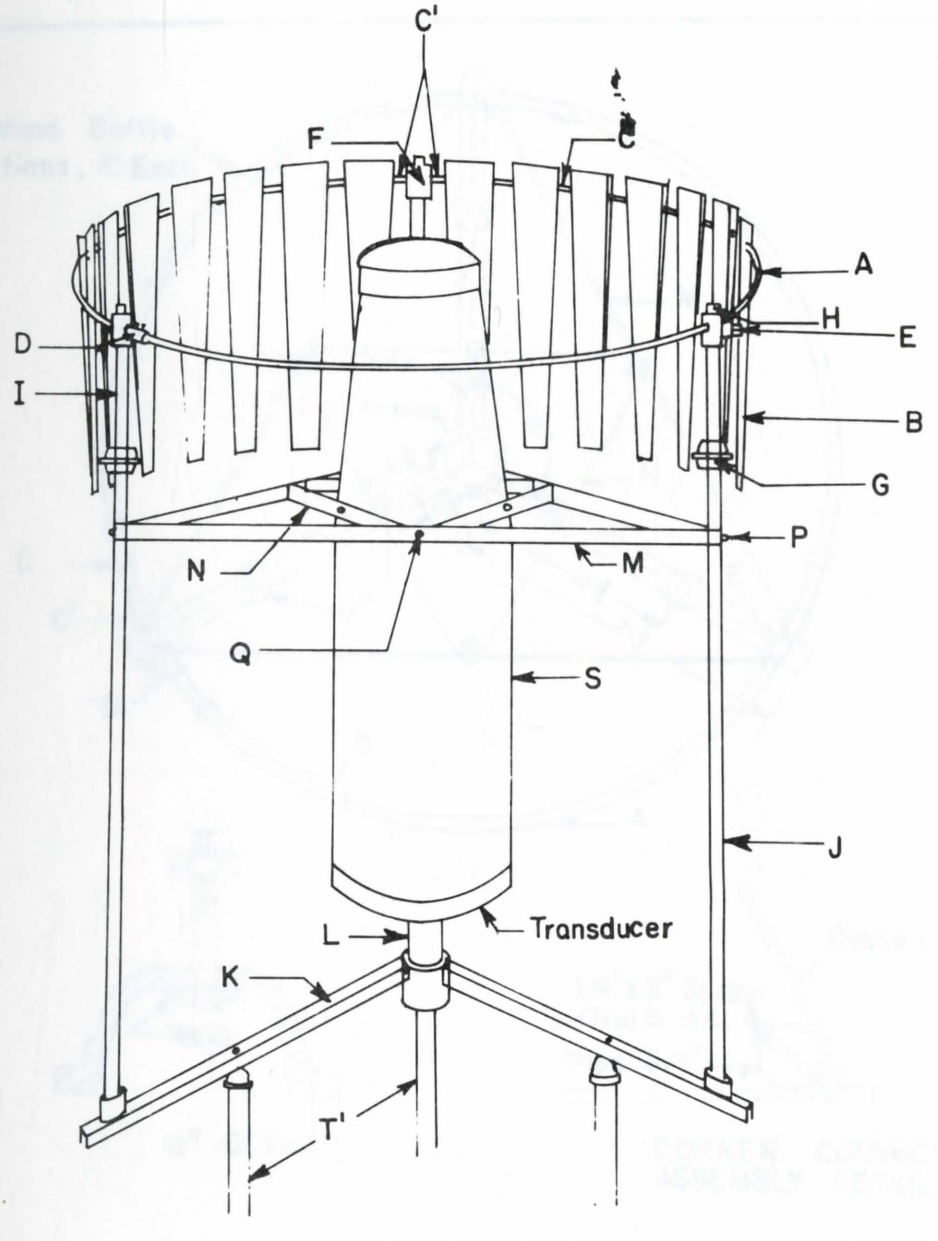

FIGURE 5B RAINGAGE ASSEMBLY - 70" CAPACITY

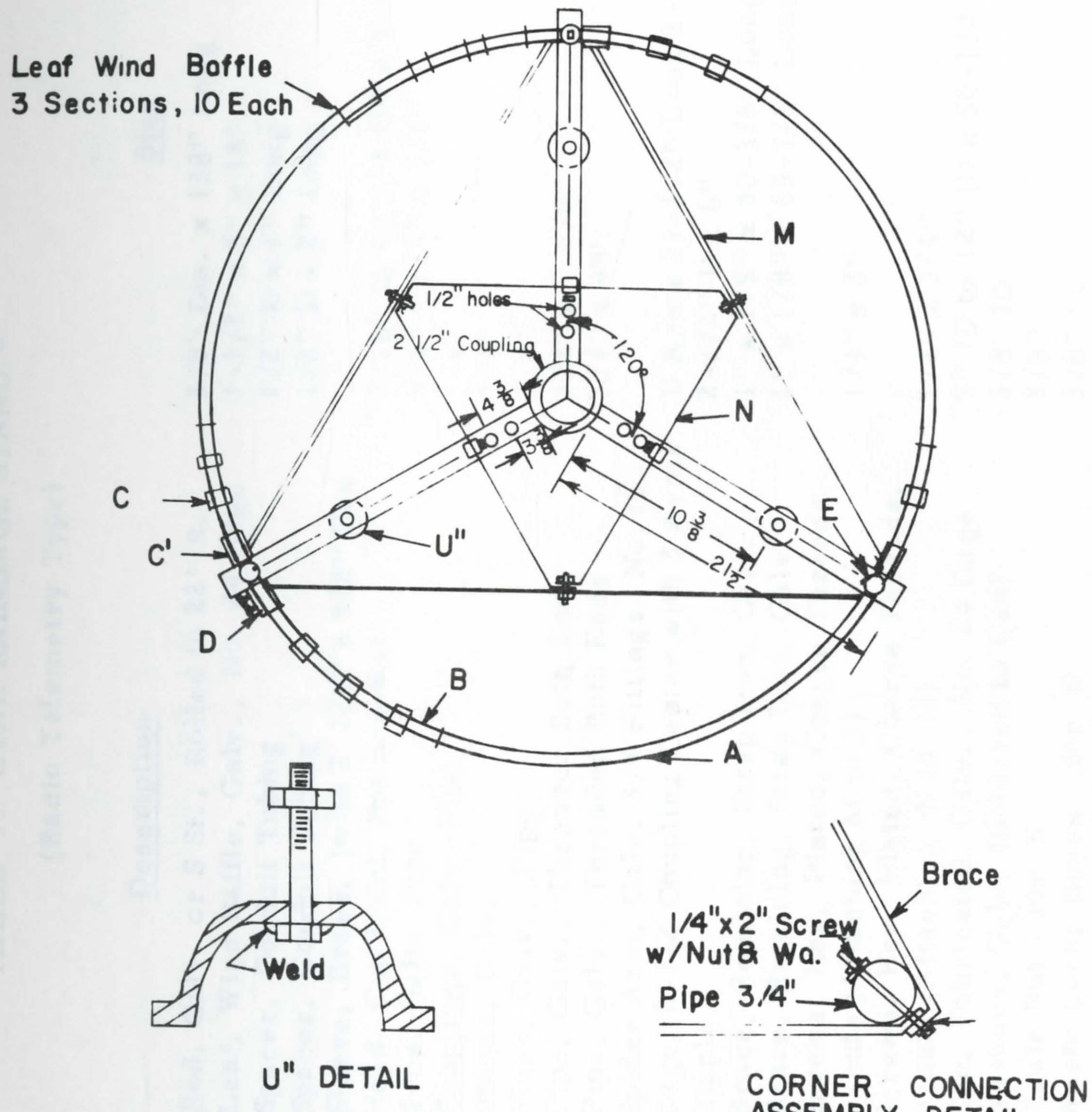

FIGURE 5C RAINGAGE STAND BAFFLE ASSEMBLY

TABLE 1. UTAH RAINGAGE STAND.*

(Radio Telemetry Type)

Member	Pieces Required	Description	Size
A	1	Rod, Galv. or S St., Rolled to 22" R.	3/8" Dia. x 138" Long
B	30	Leaf, Wind Baffle, Galv., No. 24 Gage	1-1/2" x 5" x 18"
C	27	Spacer, Conduit Tubing	1/2" D x 1" Long
C'	5	Spacer, Conduit Tubing	1/2" D x 2" Long
D	1	Sleeve, Brass, (with 2 1/4" x 3/8" Hex Head, Cup Point, Set Screws)	7/16" ID by 3/4 OD x 2-1/4" Long
E	1	Tees, Galv. Pipe	3/4" x 3/4" x 3/4"
F	2	Couplings, Galv. Pipe	3/4"
G	3	Unions, Galv.	3/4"
H	4	Plugs, Galv., Pipe	3/4"
I	2	Pipe, Galv., Threaded Both Ends	3/4" x 7-5/8"
J	3	Pipe, Galv., Threaded Both Ends	3/4" x 49"
K	1	Spider Arm, Galv. 3/4 Fittings, No. 10 Gage, 2-1/2 Coupling Center with 3 Arms	U Arms 21-1/2" Long 1-1/2"x 1-1/2"
L	1	Nipple	2-1/2" D x 6"
M	3	Brace, Retaining, Strap Iron, Galv.	1" x 1/8" x 40-3/8" Long
N	1	Brace, Retaining, Strap Iron, Galv.	1" x 1/8" x 65-7/8" Long
P	3	Screws, Hex, Plated, Coarse Threads, w/nuts (Attaching M to J)	1/4" x 2"
Q	3	Screws, Hex, Plated, Coarse Threads, w/nuts (Attaching N to M)	1/4" x 3/4"
S	1	Can, Fabricated, Galv., No. 24 Gage	8" ID to 12" ID x 50-1/2 Long
	2	Washers, Galv. (Soldered to Can)	3/8" ID
	1	Waste Nut - for S	3/8"
	1	Waste Cock, Brass - for S (Threaded Both Ends)	3/8"

TABLE 1. CONTINUED

Member	Pieces Required	Description	Size
T	3	Pipe, Galv. Threaded Both Ends	2" D x 60"
T'	6	Pipe, Galv. Threaded Both Ends	2" D x 30"
U	3	Coupling, Galv.	2" D
U'	3	Unions, Galv.	2" D
U"	3	Caps, Galv. with 5/16" x 2-1/2 Screw, Hex, Plated, Coarse Threads, w/nuts	2" D
U'''	3	Screw, Hex, Plated, Coarse Threads, w/nuts	5/16" x 2-1/2"
V	6	Brace, Support, Angle Iron, Galv.	1-1/2" x 1-1/2" x 22-5/8"
V'	12	Screws, Hex, Plated, Coarse Thread, w/nuts and washers	5/16" D x 2-1/2"
V"	24	Washers, Plated	5/16"
W	6	Brace, Support, Strap Iron, Galv.	1" x 1/8" x 34-1/2"
W'	18	Screws, Hex, Plated, Coarse Thread, w/nuts and washers	1/4" D x 3/4"
W"	36	Washers, Plated	1/4"
X	3	Screws, Hex, Plated, Coarse Thread, w/nuts, Balance	1/4" D x 1-1/2"
X'	6	Washers, Plated	1/4" D

* Parts list and design courtesy of Soil Conservation Service--Utah.

The can is placed upon a weighing transducer which changes an audio frequency as the precipitation accumulates in the can; the heavier the can the lower the audio frequency. An electrical cable passes from the transducer down through the pipe leg. The cable then runs from the tower to the instrument container, entering through a watertight fitting. The instrument container houses the main electrical equipment of the station and the batteries which supply the station power. A cable also runs from the metal instrument container through another watertight fitting to a Yagi-type antenna.

An optional instrument housing, as illustrated in Figure 2, may be constructed if additional instruments are needed for measurement of other physical parameters.

Precipitation Catchment Devices

The precipitation catchment devices (rain cans) are cylindrical metal containers. Cans presently used are of two basic configurations. The opening in either configuration is 8 inches in diameter. One is 36 inches long having straight sides, and is used at lower elevations where precipitation is not expected to exceed the capacity of the can. The other precipitation can, for higher elevations and less accessible regions, has a 12-inch diameter reservoir, giving a total capacity of 70 inches. This capacity is adequate for a year's accumulation of precipitation at nearly all of the sites located in Utah. Some consideration is being given to the use of a smaller can which will give a correspondingly higher threshold sensitivity. This would be desirable when reading out information at short time-base intervals. Obviously, if the readout resolution were 0.1 percent of the full-scale value, for example, then smaller precipitation increments could be detected using the smaller cans. Use of the small can may require occasional emptying since it has insufficient capacity for an entire season's catch. It is desirable to keep the snow catch in at least a semi-liquid state so that the snow does not accumulate and overflow. To accomplish this, the can is precharged with an antifreeze and water mixture. A small quantity of motor oil, which floats on the top of the liquid mixture, is added to prevent loss of water through evaporation.

The cans are painted black so that solar radiation absorption can be enhanced thereby thawing the ice and snow accumulation periodically.

The accuracy of the can in obtaining representative samples of precipitation has often been questioned, but will not be discussed here. A report of the Utah Water Research Laboratory in 1967 (Israelsen, 1967) presents these factors in detail. The accuracy of the weighing mechanism and of the T/M system is described in "Telemetering Performance During Initial Operational Periods" (Chadwick, 1968).

The cans being used are patterned after those used by the Soil Conservation Service in Utah. Initially, the cans were made of fiber glass with a black pigment that made paint unnecessary. These cans were found to be unacceptable as most of them developed leaks through fine hairline cracks. The fiber glass cans are being replaced with galvanized metal cans painted black.

Weighing Transducer

The weighing transducer is situated on the precipitation stand as illustrated in Figure 6. This component is located directly underneath the precipitation catchment can, and its function is to weigh the can's contents. The positional sensing element of the transducer consists of a metal plunger which can be lowered into an inductive coil without friction. As weight increases by the accumulation of precipitation, the springs are compressed and the plunger lowers into the coil of wire, causing the inductance of the coil to increase. An increase in inductance changes the frequency of oscillation of the subcarrier oscillator. The frequency has a known relationship to the amount of precipitation in the can.

Variations in the deflection of the springs due to differences in temperature are largely overcome by using springs made of Ni Span C material. This material has the lowest temperature coefficient of any known spring alloy.

The weighing transducer and can which monitor the amount of precipitation, being free of friction, provides for an extremely sensitive system. As a consequence, wind may have a tendency to cause some

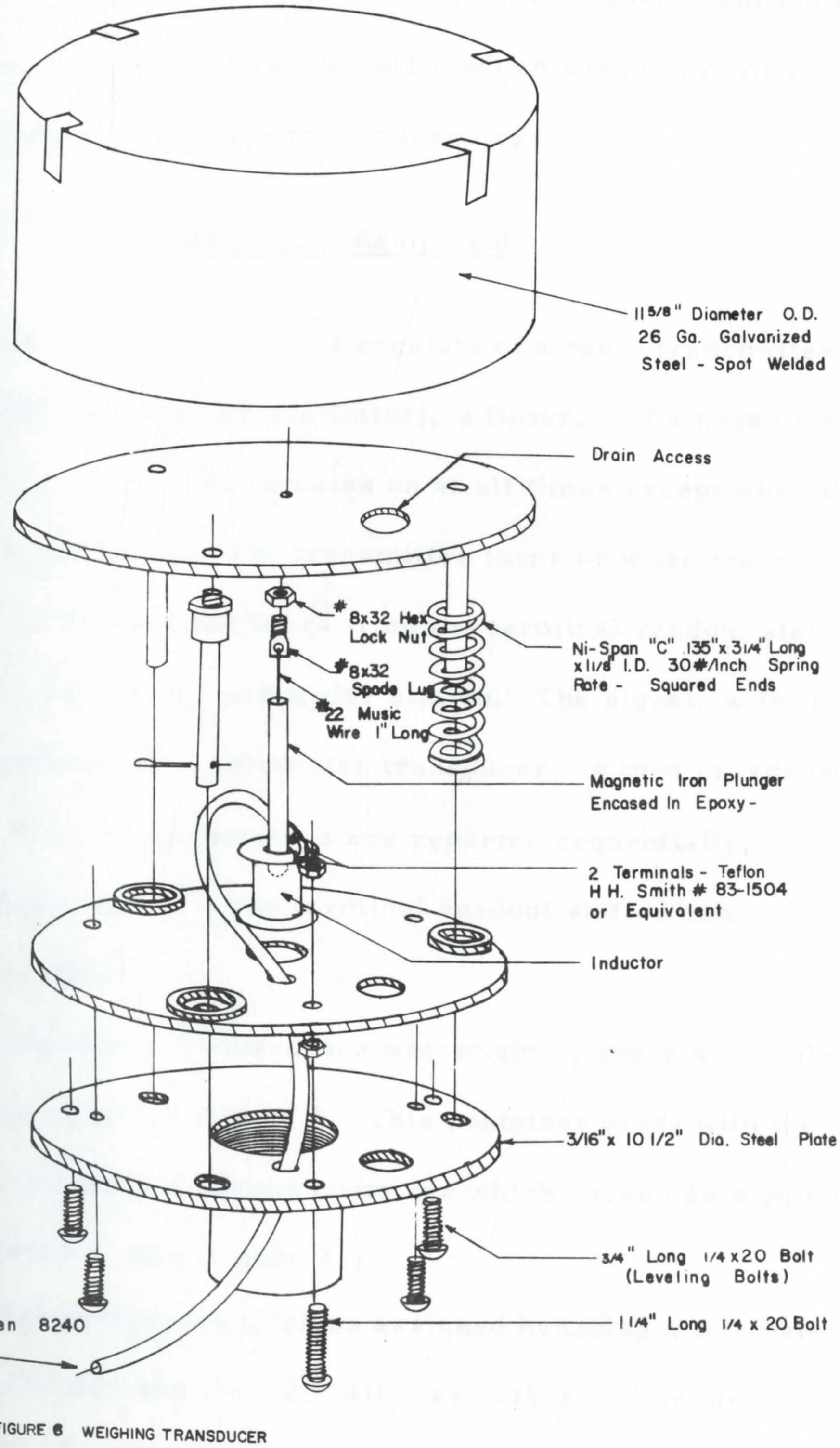

FIGURE 6 WEIGHING TRANSDUCER

fluctuation in the data. To reduce this dynamic response caused by wind, a viscous damper may be installed which would minimize the oscillation evident in the system on windy days.

Electrical Equipment

The transponder electronics consists of a radio transmitter and receiver, a SCO (subcarrier oscillator), a timer, and a parameter commutator. The receiver remains on at all times except when the transmitter is operating. The transmitter turns on when the receiver is signaled with two distinct tones from the terminal readout station at a frequency coded for that particular station. The signal, with its frequency modulated by a parameter transducer, is then broadcast for 15 seconds. After all parameters are reported sequentially, a timer turns the transmitter off. The terminal readout station can re-interrogate as desired.

The transponder is housed in a watertight cylinder and sealed with an "O" ring as shown in Figure 7. This container along with the batteries are housed in a second container which serves as a suitable waterproof shelter. (See Figure 3.)

The entire system operates on assigned hydrologic telemetering frequencies, 170.225 and 170.325 MH_z, as authorized by the Federal Communications Commission. In this frequency band, 170 to 174 MH_z, radio propagation is essentially line-of-sight. Some forward scatter is possible over mountain ridges in forward propagation, however.

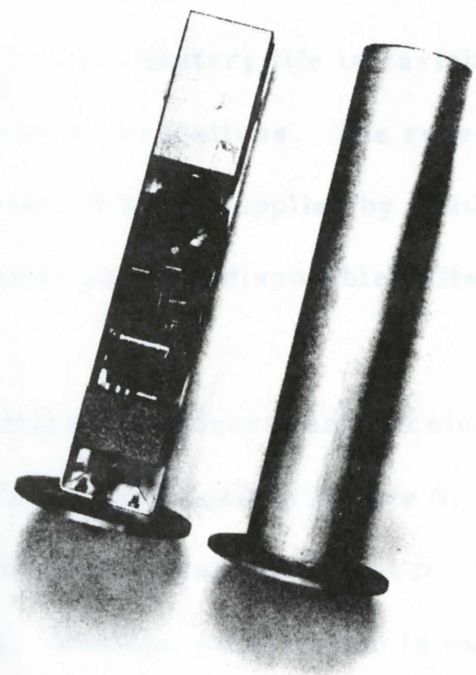

FIGURE 7. RADIO TELEMETERING TRANSPONDER--CAPABLE OF ACCEPTING UP TO NINE TRANSDUCER INPUTS.

Radio paths also can be established by the "bouncing" of radio waves off of hill sides and other pronounced objects.

Power is supplied to the remote station by three or six, six-volt batteries. Six ignition-type batteries have been placed in the stations at higher elevations in the less accessible areas. This has been done to increase station reliability. Three batteries have been placed in the more accessible stations since these batteries may easily be replaced if they run low on power. Battery life is variable; being a function of the number of station interrogations. The receiver standby power is 4 ma. at 12 - 18 volts which is supplied by readily available disposable or rechargeable batteries. Six disposable batteries will last at least one year.

The remote station broadcasts and receives using a single 5-element Yagi antenna, as shown in Figure 8. The antenna is usually 20 feet in height and is placed about 10 feet to 15 feet from the instrument housing. Vertical polarization is used to be compatible with the vertical omni-direction antenna installed at the mountaintop translator.

Summary

The remote T/M station incorporates design simplicity which has made possible the construction of many stations at a nominal cost.

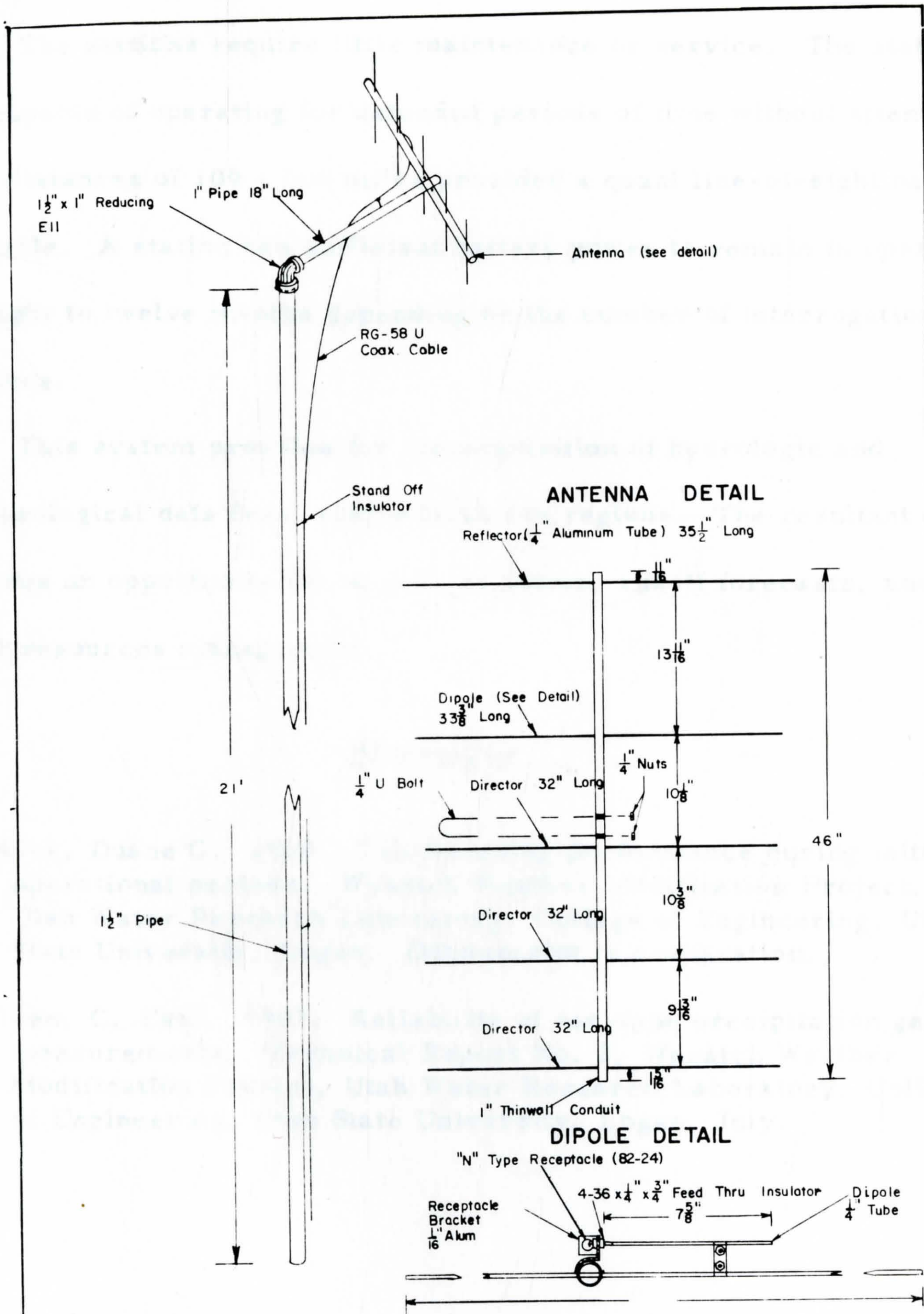

FIGURE 8 FIVE ELEMENT YAGI ANTENNA AND MAST

The stations require little maintenance or service. The stations are capable of operating for extended periods of time without attention over distances of 100 - 200 miles provided a quasi line-of-sight path is available. A station has sufficient battery power to remain in operation for eight to twelve months depending on the number of interrogations it receives.

This system provides for the acquisition of hydrologic and meteorological data from vast uninhabited regions. The resultant data provides an opportunity for storm evaluation, runoff forecasts, and water resources management.

References

Chadwick, Duane G. 1968. Telemetering performance during initial operational periods. Wasatch Weather Modification Project. Utah Water Research Laboratory, College of Engineering, Utah State University, Logan. (Manuscript in preparation.)

Israelsen, C. Earl. 1967. Reliability of can-type precipitation gage measurements. Technical Report No. 2, Wasatch Weather Modification Project, Utah Water Research Laboratory, College of Engineering, Utah State University, Logan, July.