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Hydrologic Instrumentation and Telemetering

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HYDROLOGIC INSTRUMENTATION AND TELEMETERING
Report for 1965-'66

The following report discusses the various phases of work carried out by the Utah State University under a cooperative agreement contract with the Soil Conservation Service for the period extending from June 1965 to June 1966.

The body of the report discusses instrumentation techniques employed for the remote telemetering of total precipitation and water-content of snow. Discussion of performance of a new type pressure pillow is also given for measuring the water-content of snow. Data taken during system evaluation is presented in the Appendix.

Pressure Pillows

Two low-volume, low-displacement type pressure pillows were constructed and evaluated during the snow season.

One pillow measures 4' x 4' x 1/2" (LWH) in size; the other pillow 2' x 2' x 1/2". (See Figure 1.) One pillow was placed on the ground, the other on a concrete platform measuring 5' x 5' x 4". The pillows were connected to separate manometers located approximately 25 feet distance by means of rubber garden hose. (See Figure 2.)

The pillows, while using the basic concepts used in the large rubber pillows, were designed out of metal and required only a few gallons of alcohol. Where a conventional 12 foot rubber pillow requires 250 gallons, the 2 foot pillow holds 2 gallons and the 4 foot pillow holds approximately 8 gallons of alcohol.

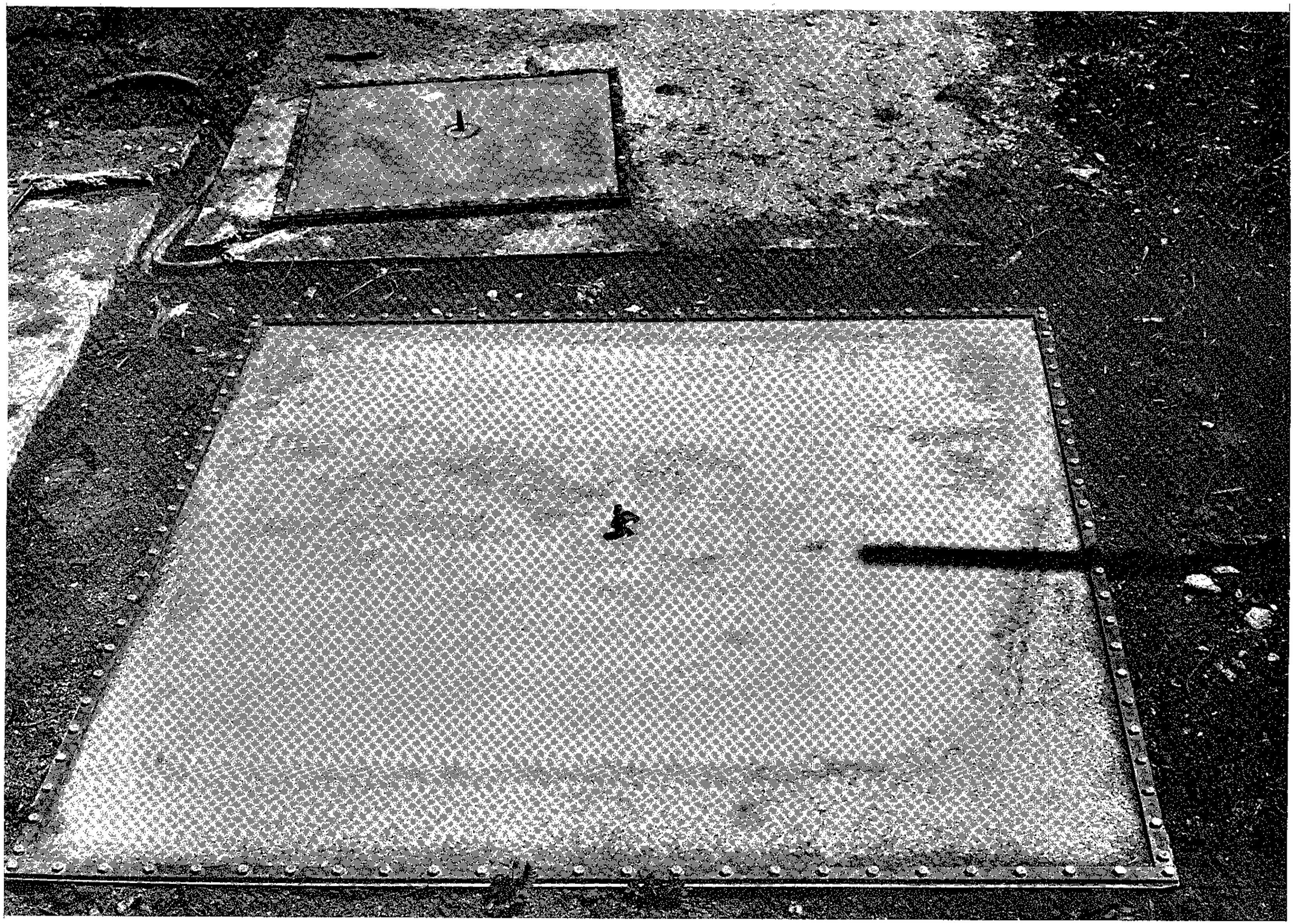


Figure 1. Two sizes of low-volume, low-displacement type pressure pillows installed at Garden City Summit snow course.

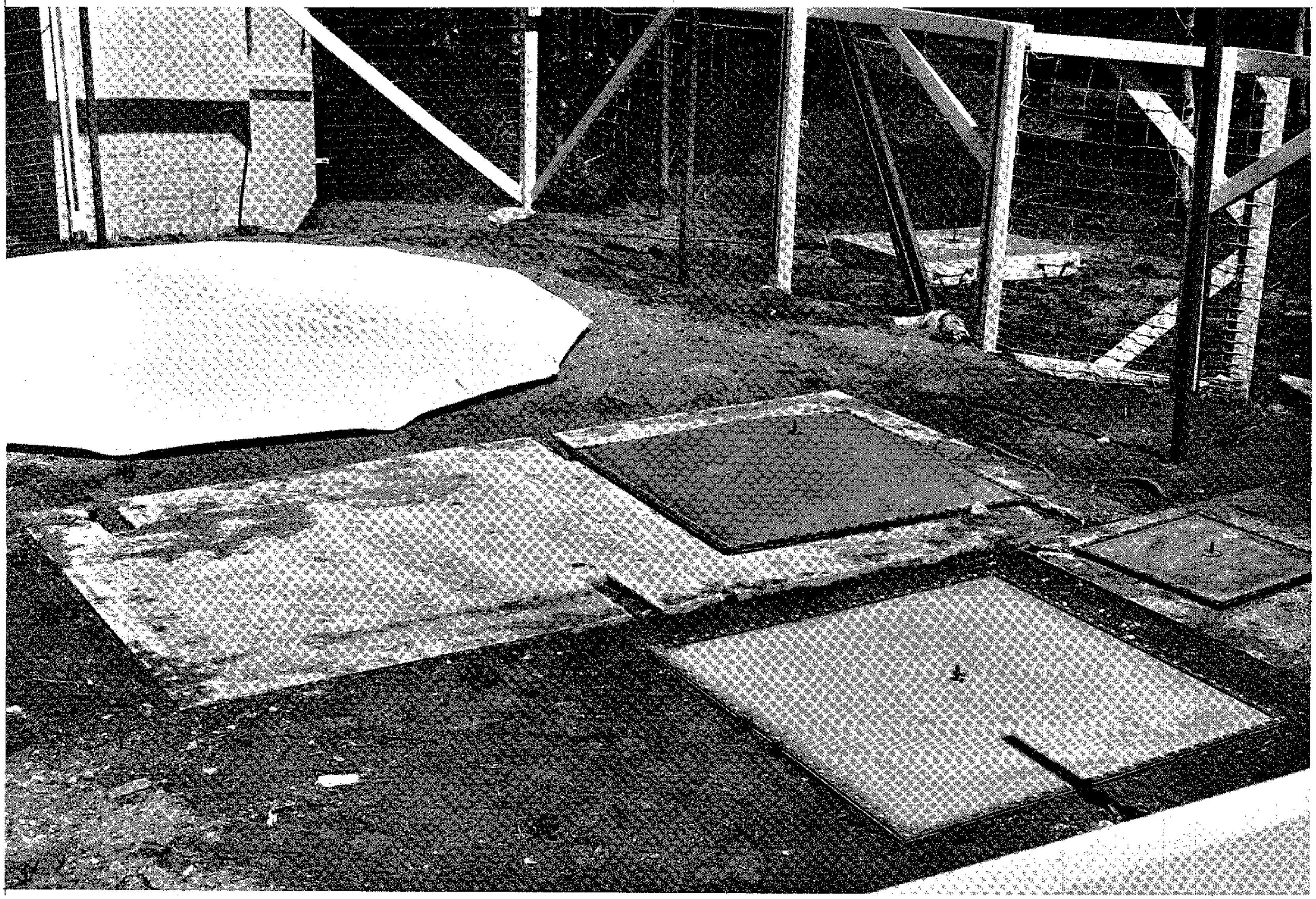


Figure 2. Picture showing various pressure pillows and their relative location. (Two pillows tested but not part of the SCS Contract are the black pillow in the center and a fiber glass pillow in upper right-hand corner.)

The concrete bases were used on two pillows to help prevent what could be called the "oil-can-effect" where the bottom of the pillow might suddenly spring up (or down) due to an accumulating load and appreciably change the internal liquid holding capacity of the pillow. This sudden change in pillow configuration would tend to displace liquid causing an increase (or decrease) in manometer pressure. The effects of this "oil can" bottom phenomena should not be underestimated at least in the earliest phases of pillow evaluation since approximately .001 inch deflection is the maximum pillow deflection necessary to cause the manometer to read full scale. Should such a deflection inadvertently occur due to an uneven support on the bottom of the pillow the resulting sudden change in the manometer level would normally readjust itself after a short period by a slight readjustment of the upper flexible diaphragm upon which the snow is resting.

This phenomena just discussed is believed to at least partially account for the perturbations in the data taken on the small pillows. These perturbations appear more noticeable than those of the 12 foot rubber pillow.

Another point to consider is that there is more averaging of non homogeneities in the larger area, which is associated with the large pillow.

Pillow data were taken both by visual manometers located in the instrument house and by remote radio interrogation and readout.

The manometer data are presented in Figure 3. These data were accumulated mainly during the snow-melt period when temperature fluctuations and snow buildup and melt patterns are most extreme. Radio

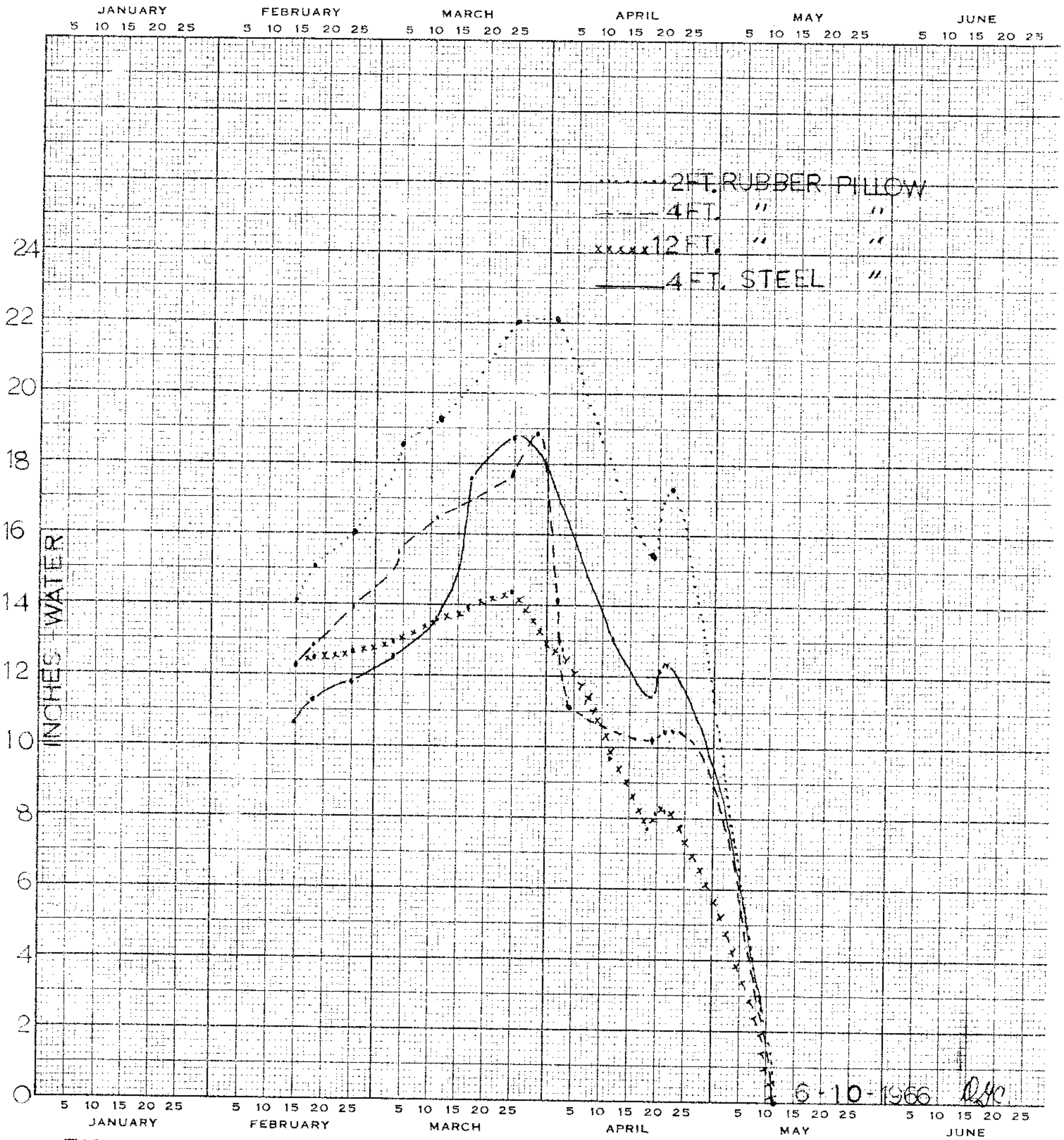


FIGURE 5, VISUAL MANOMETER READINGS — GARDEN CITY SUMMIT readout data are plotted in Figures 4 and 5. The tabulated radio readout data appear in the Appendix.

Transducers

Special transducers were designed to be compatible with the low-displacement pillow design. These transducers utilized the density ratio of mercury to water of 13.56:1 to reduce the height of the liquid column, normally needed, by that same ratio. Hence, the manometers were much smaller than they ordinarily would be had not the mercury been used. Figure 6 shows the configuration of these units.

Various sensitivities or full-scale ranges can be obtained by varying the ratio of the cross-sectional areas between the two legs of the manometer. Thus if the ratio of the leg area having the float, to the area of the other leg is 2:1, and maximum permissible float range is 1 1/2 inches, the useful manometer range is

$$\text{(differential Hg head)} \times \text{(density of Hg)} = \text{inches water equiv.}$$

or

$$3 \text{ inches Hg} \times 13.56 \frac{\text{inches water}}{\text{inches Hg}} = 40.68 \text{ inches of water}$$

Figure 6 is a picture of the mercury level manometers used in the project.

The manometers proved reliable in operation and functioned satisfactorily. One problem developed which was quite readily solved. Water condensed on the float and collected on top of the mercury vented

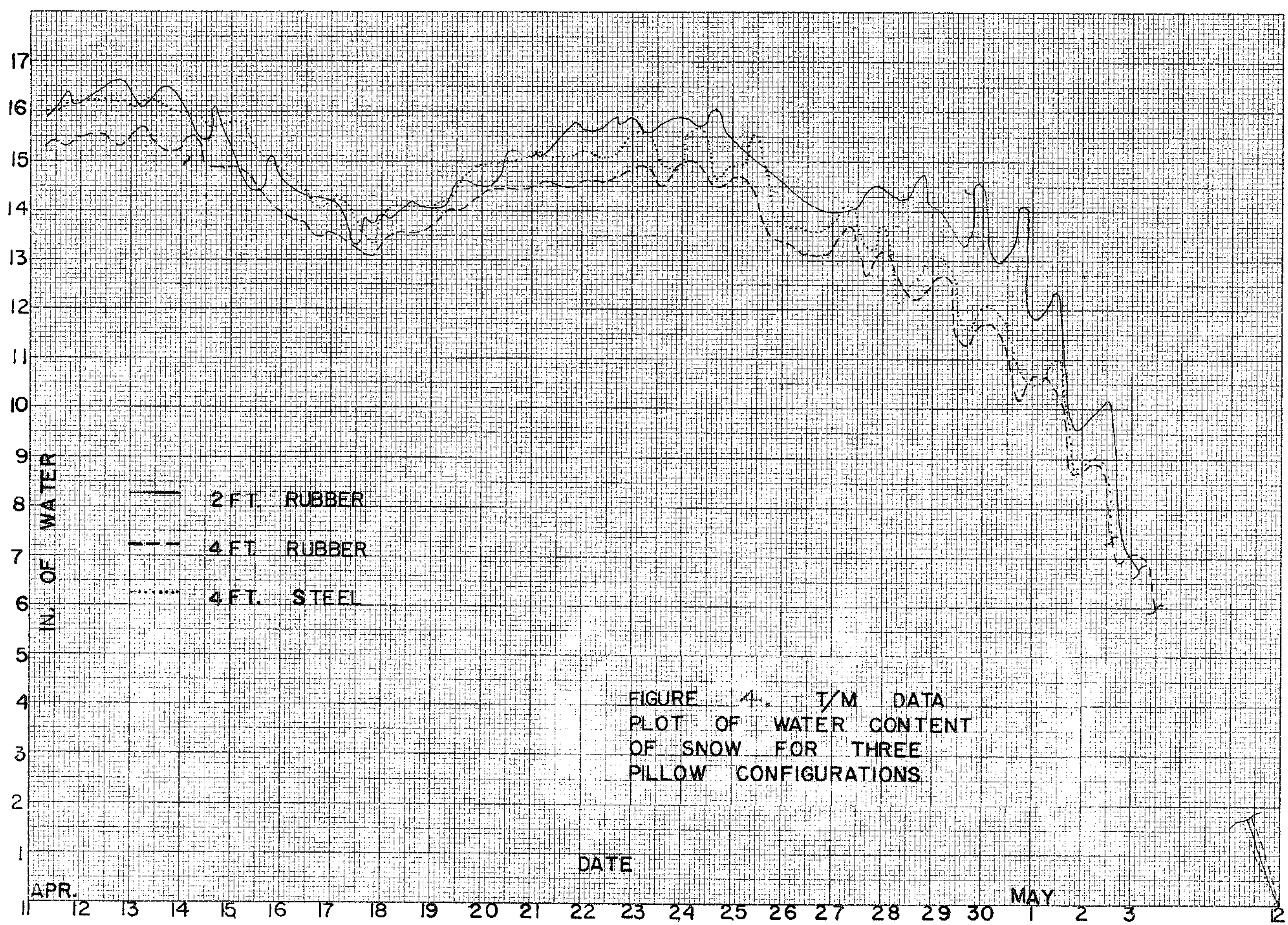


FIGURE 4. T/M DATA PLOT OF WATER CONTENT OF SNOW FOR THREE PILLOW CONFIGURATIONS

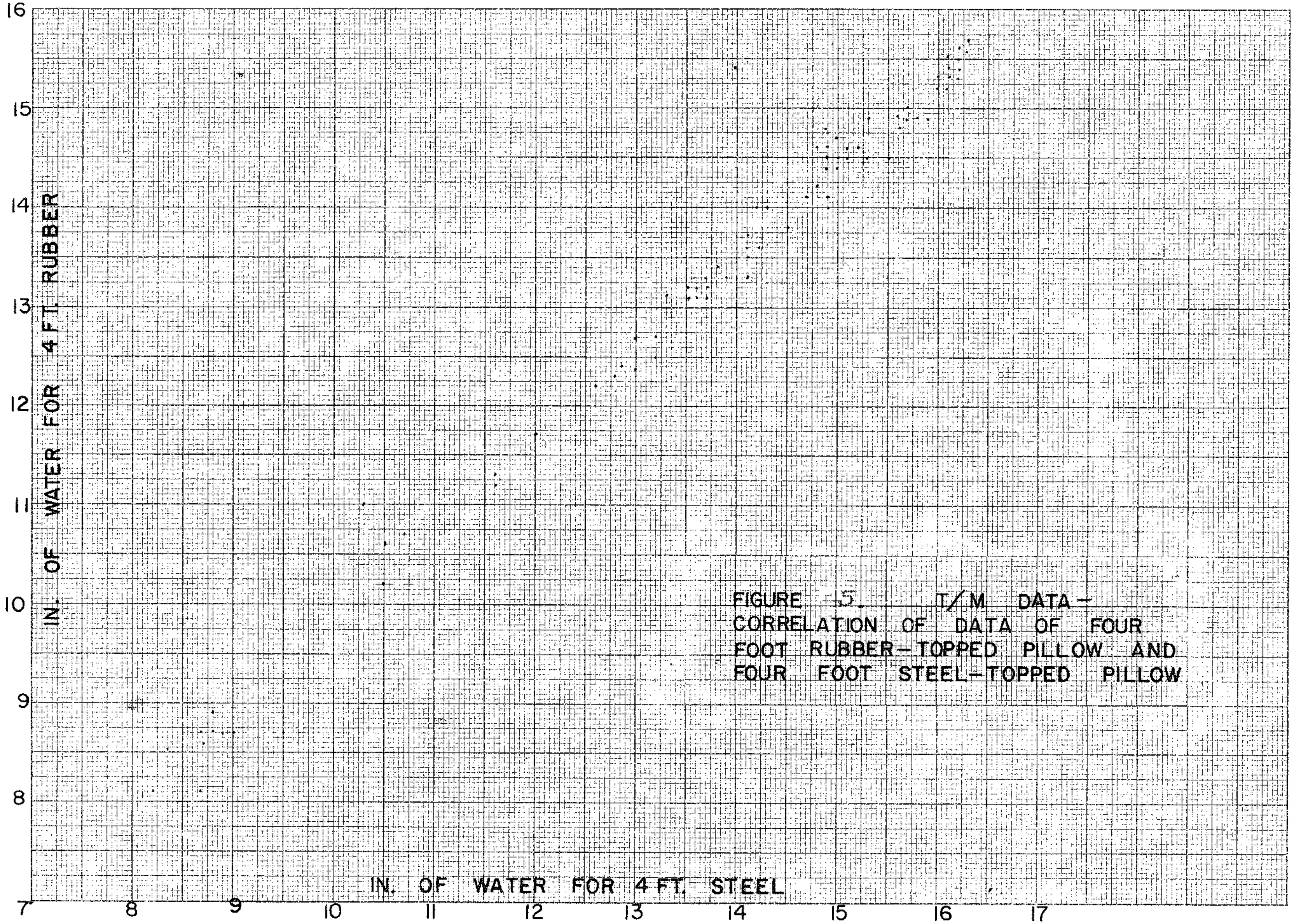


FIGURE 5. T/M DATA — CORRELATION OF DATA OF FOUR FOOT RUBBER-TOPPED PILLOW AND FOUR FOOT STEEL-TOPPED PILLOW

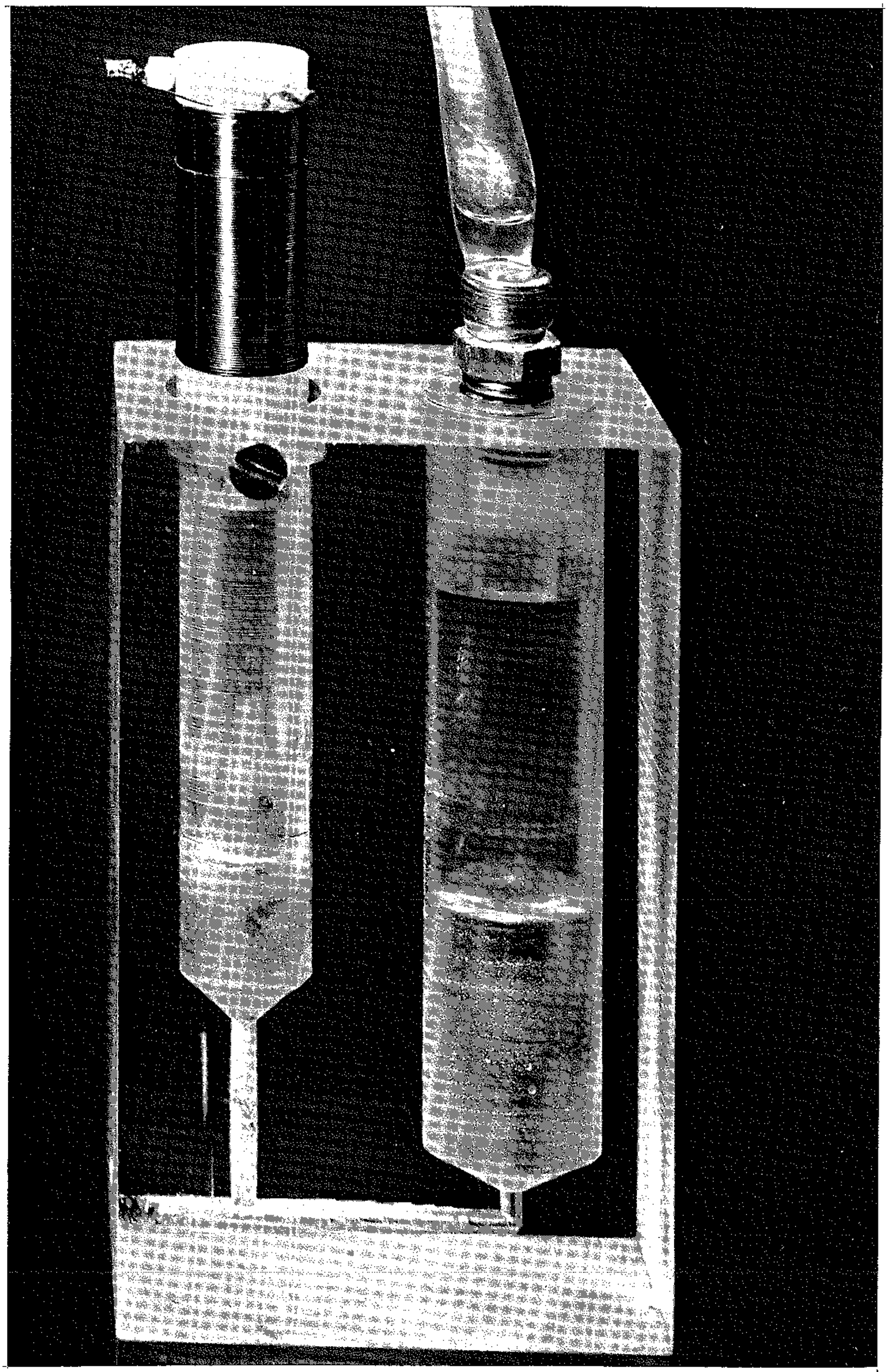


Figure 6. Mercury manometer used in transducing pillow pressure into an electrical signal.

to the atmosphere. Later this froze and the float became stuck in the ice. This was remedied by submerging the float in antifreeze. Any water subsequently condensing went into solution which would not freeze at normal winter temperatures. A calibration curve for the manometers is shown in the Appendix. (See Figure 12.)

A similar mercury float-type arrangement was designed for use in determining the liquid level in a rain can. (See Figure 7.) Several factors combined to make the unit appear less suited than the mercury transducer used on the pillow.

The primary disadvantage comes from degradation of accuracy caused by the large diameter reservoir and small orifice of the can. Intrinsic accuracy of rainfall measured by the liquid level in circular cans is inversely proportional to the ratio of the squared diameters of the reservoir to that of the orifice. Thus, a three-to-one ratio reduces intrinsic accuracies by a factor of nine. Thus, any liquid-level transducer using a Sacramento type gage suffers a considerable loss in intrinsic accuracy.

If the rain can has straight sides, the telemetering accuracy greatly improves; however, ice plugs in the can will form and this is of considerable concern during cold weather periods. The liquid-level sensor would be useless should a solid ice plug occur in the can.

As a result of these problems, a variable inductance pick-up was connected to a "buggy spring" arrangement for evaluation in lieu of the mercury float type. (See Figure 8.) Data collected on this was taken

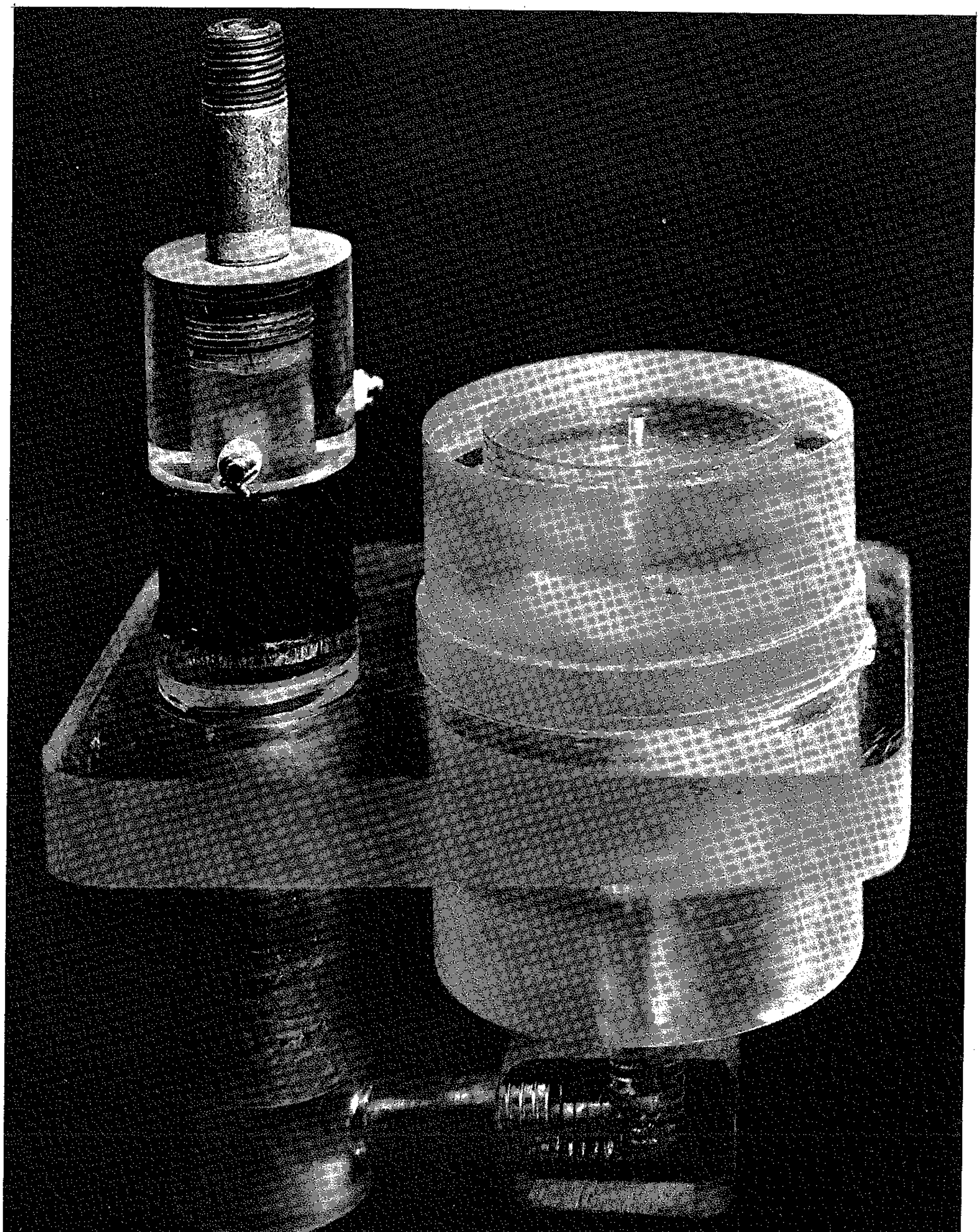


Figure 7. A mercury-type transducer unit for measuring liquid level in a precipitation can.

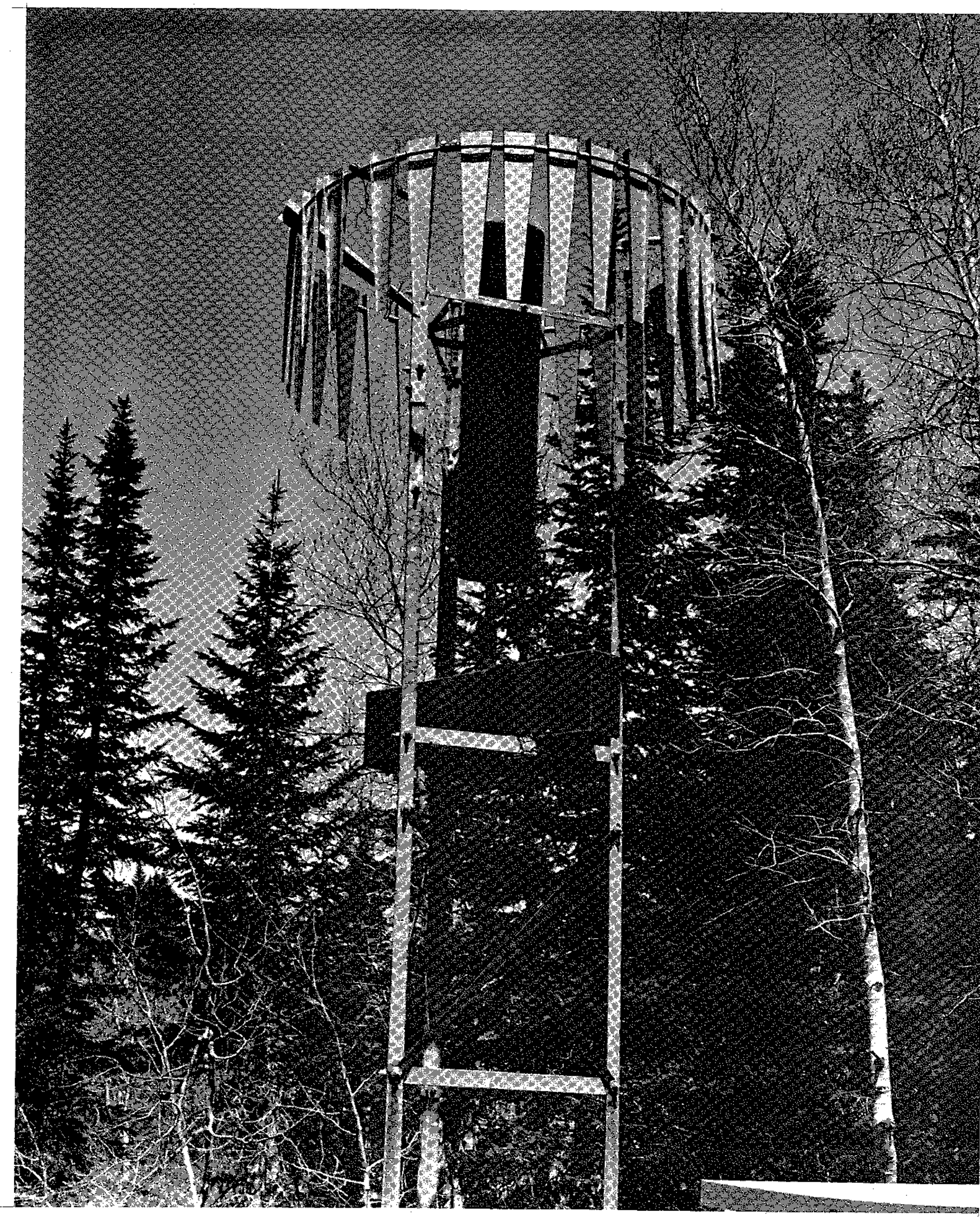


Figure 8. Pearson precipitation gage using a "buggy spring" transducer for weighing total precipitation.

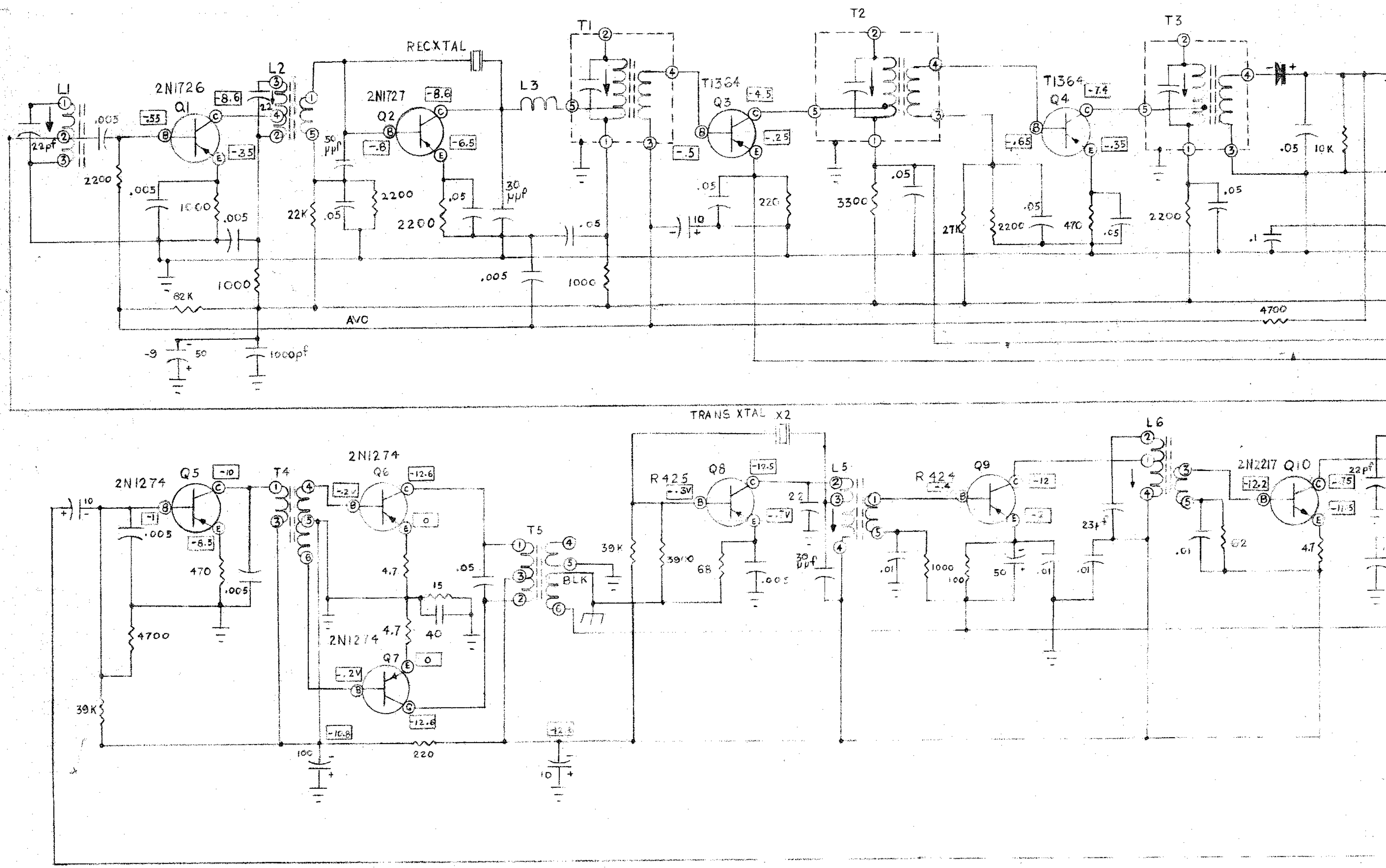
during a long no-storm period. This gave an excellent chance to check system long-time stability which held constant within ± 2 counts for periods of no precipitation.

Telemetered precipitation information was not checked quantitatively. This was due in part to the lack of significant storms during the test period. The unit was interrogated; however, each time the pillows were interrogated and the output was determined to give an extremely stable output day after day only showing deviation when precipitation did occur. As the University was not under contract to make on-site snow course measurements, the actual precipitation increments caught in the can being instrumented were not measured; hence, no quantitative comparisons are possible between the T/M readout system and the conventional spring scales method. Previous use of the "buggy spring" mechanism; however, has proven it to be highly reliable.

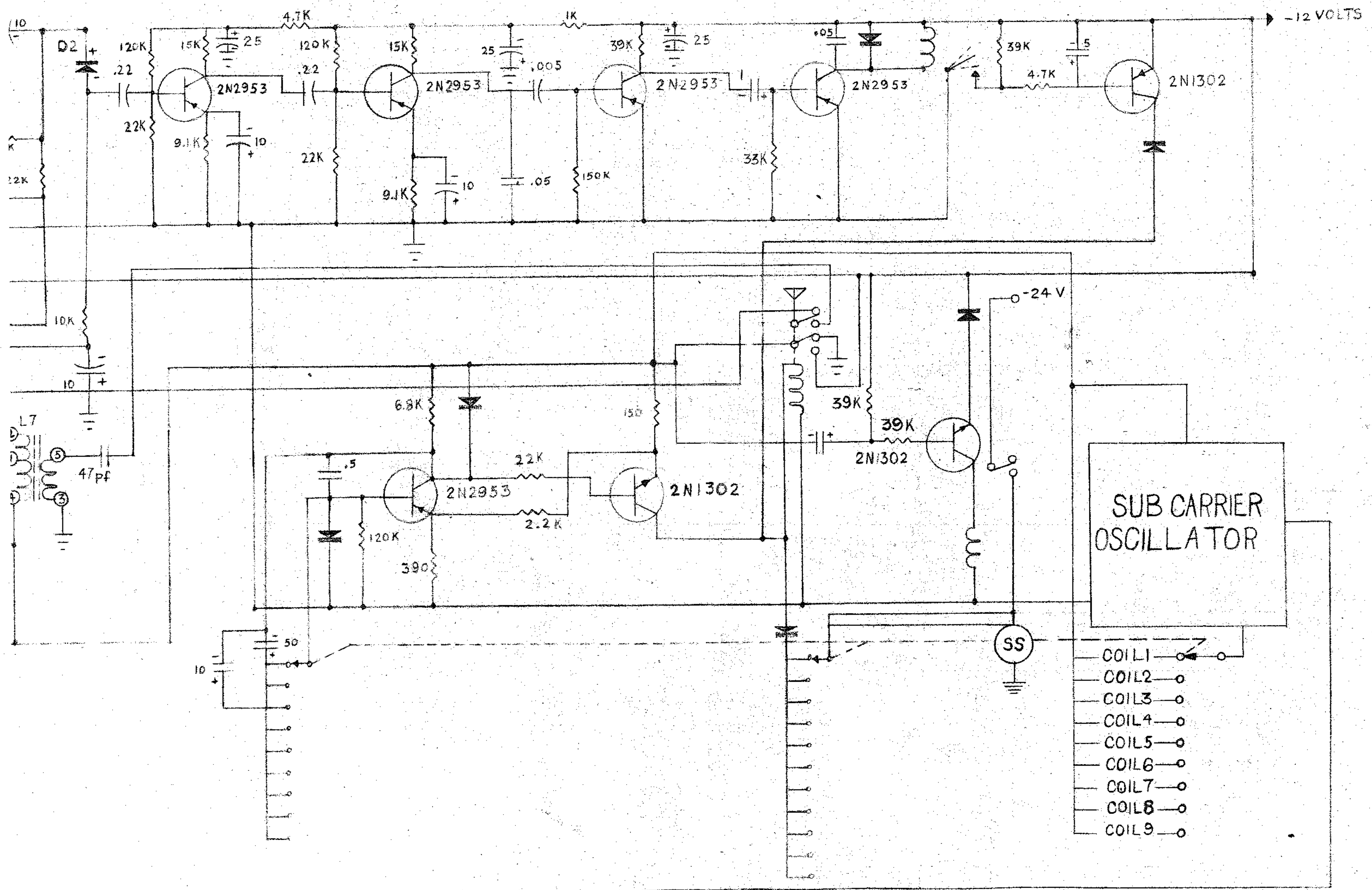
Remote Electronics

The electronic system at the remote site functioned throughout the winter without difficulty. Information from a total of five separate pillows including the 12 foot rubber, two small pillows previously mentioned, and two other pillows financed under a separate project were telemetered. In addition, total precipitation and temperature were telemetered. A total of over 700 interrogations were successfully made.

A schematic diagram of the remote electronics designed under this contract is shown in Figure 9.


RECXTAL
L1
2N1726
Q1
L2
2N1727
Q2
L3
T1
T1364
Q3
T2
T1364
Q4
T3
AVC
TRANS XTAL X2
2N1274
Q5
T4
2N1274
Q6
2N1274
Q7
T5
BLK
R425
Q8
L5
R424
Q9
L6
2N2217 Q10

RANSPONDER



NOTES:

ALL RESISTOR VALUES ARE IN Ω; K = 1000

ALL CAPACITOR VALUES ARE IN μfd EXCEPT WHERE MARKED μμf.

☐ INDICATES NEGATIVE DC VOLTAGE MEASUREMENT FROM OUTSIDE FOIL OF CIRCUIT BOARD.

FIGURE 9. GARDEN CITY SUMMIT ELECTRONICS

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Radio transmission to the Utah Water Research Laboratory from Garden City Summit is quite difficult to achieve due to the location of both the sending and receiving stations. This problem is illustrated in Figure 10.

The mountain-top translator was designed and constructed in the fall of 1965 as per the schematic diagram, Figure 11. This unit was first installed on Temple Peak, but due to the extreme non line-of-sight angle between Garden City and Temple Peak it was subsequently moved to Swan Peak. This new location proved satisfactory although the path to Garden City was still non line-of-sight.

The relay located at Swan Peak installed in mid November was capable of transmitting information to the west side of Cache Valley; however, this was about 15 miles from the Laboratory.

In order to obtain hydrologic data at the Laboratory site, another relay station was designed and installed on the Wellsville mountain range near the present Wellsville television repeater site. Due to technical problems involved when using two mountain-top repeaters simultaneously, this additional relay link was not completed and in operation until about April 10. Subsequently, information was received on demand for the last month of the snow season without difficulty. On May 3 batteries which had been carrying a fairly heavy load at Wellsville dropped below the critical value for transmitter operation and tests were concluded. As the snow was completely melted within one week after this time, the tests were not resumed.

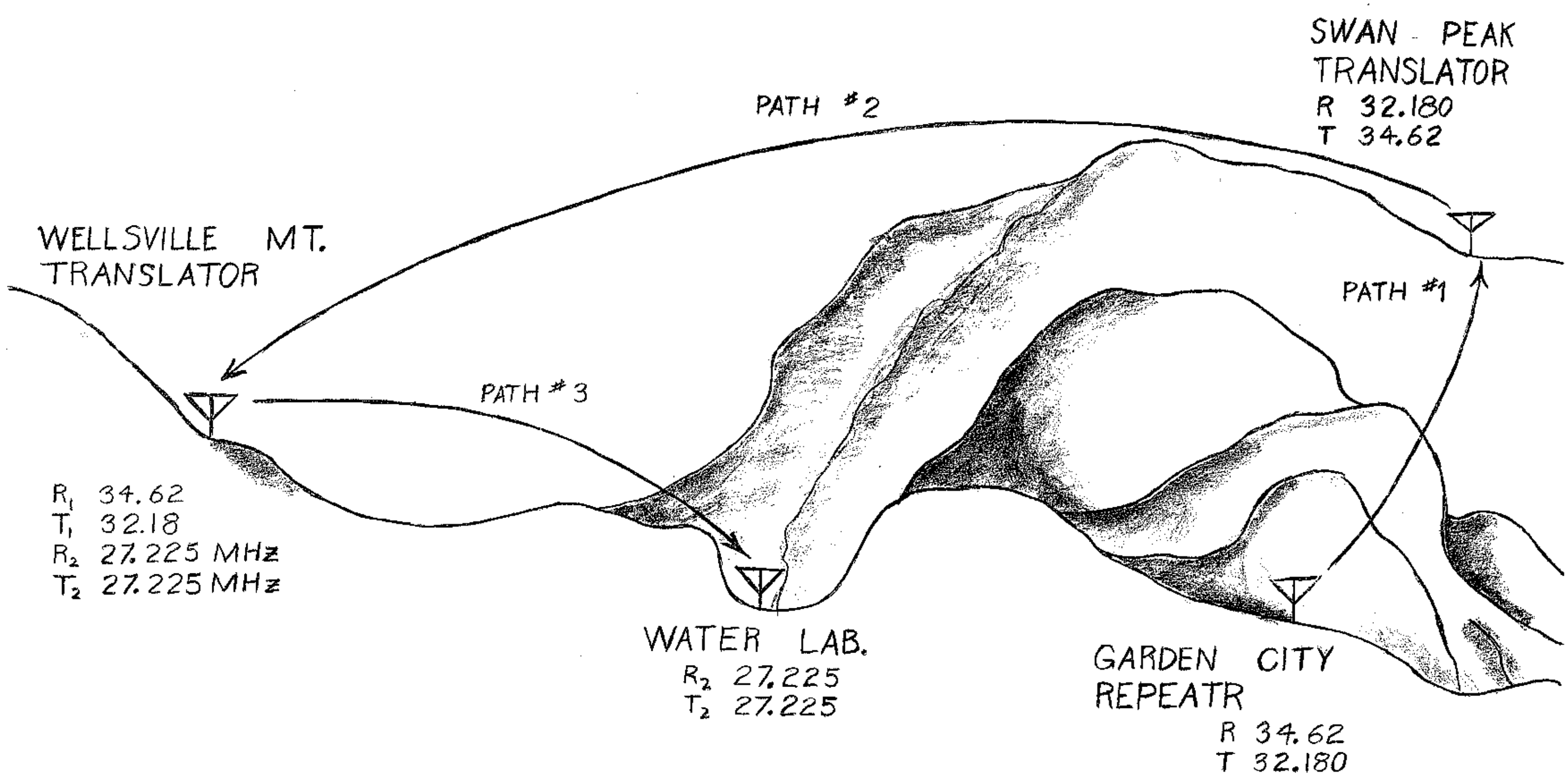
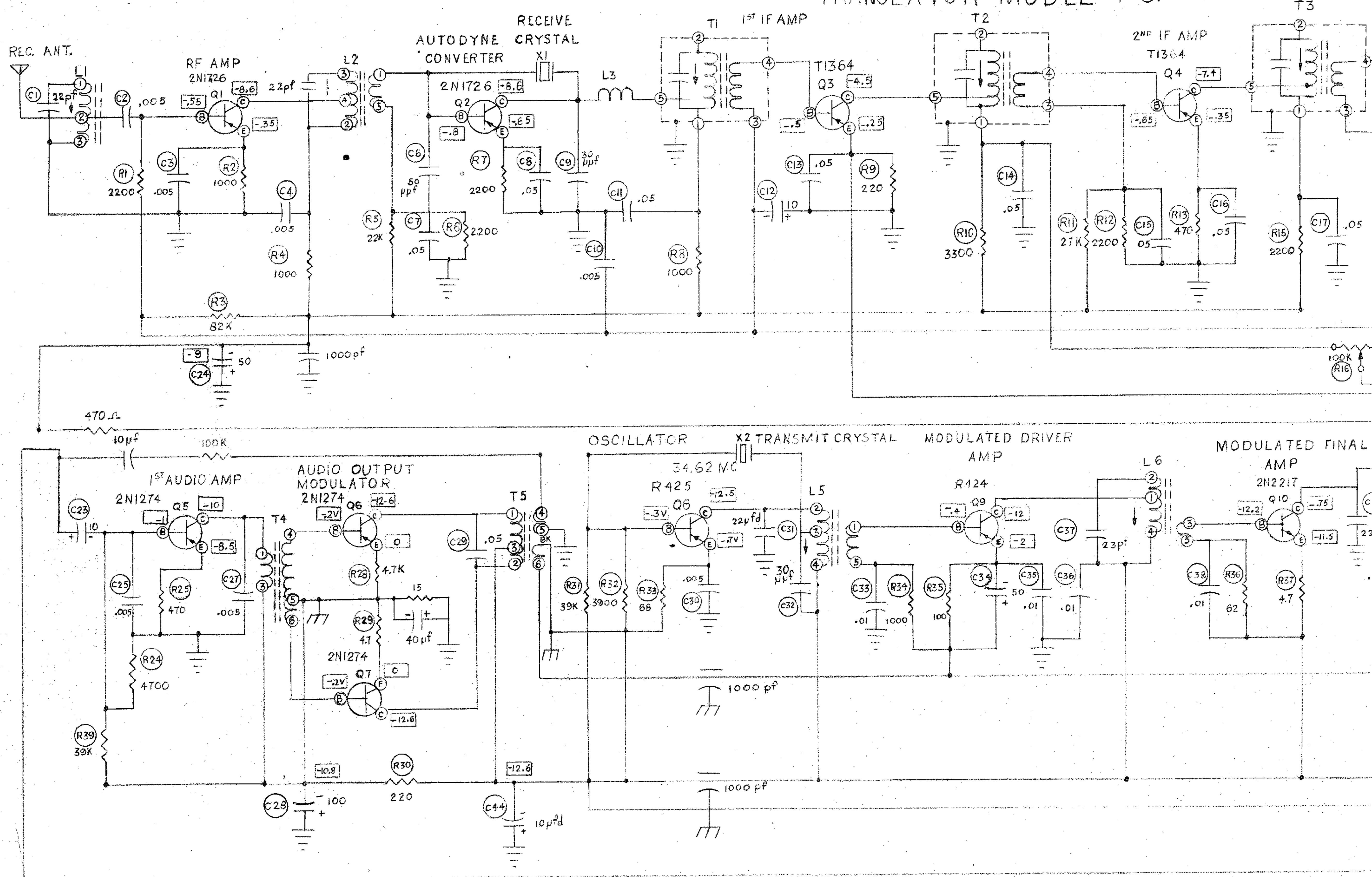
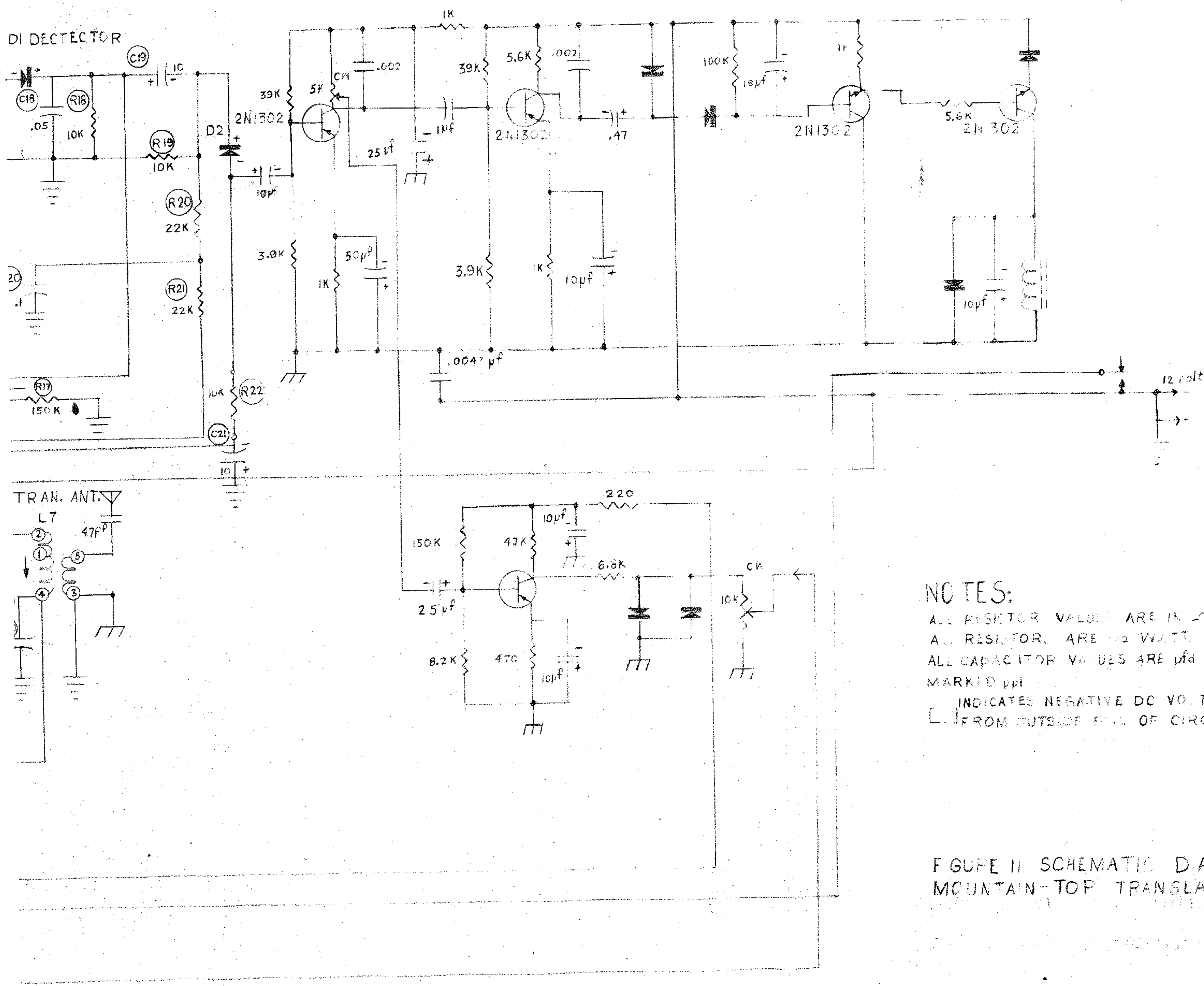


Figure 10. Diagram illustrating 3 non-line-of-site radio transmission paths used in project. R and T show radio and transmitter frequencies in MHz.

TRANSLATOR MODEL T-51





NOTES:

ALL RESISTOR VALUES ARE IN Ω; K = 1000.

ALL RESISTORS ARE ½ WATT.

ALL CAPACITOR VALUES ARE µfd EXCEPT WHERE MARKED µµf

[ ] INDICATES NEGATIVE DC VOLTAGE MEASUREMENT FROM OUTSIDE FOIL OF CIRCUIT BOARD.

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FIGURE II SCHEMATIC DIAGRAM OF SWAN PEAK MOUNTAIN-TOP TRANSLATOR

Summary

The complete telemetering-transducer system functioned exceedingly well considering that every item excepting the subcarrier oscillator and the precipitation gage transducer were of complete new design. No malfunctions occurred after the system was operational other than battery fatigue which occurred essentially at the end of the test period. Early in the test period (November) a transmitter modulation transformer went out; otherwise, there were no electrical failures.

Data from the radio readout show excellent correlation between the two four-foot pillows. Somewhat less correlation existed between the two-foot pillow and either of the four-foot pillows.

A problem as yet unresolved is: Why does the radio readout have good correlation and yet the visual manometer readings connected on the same pillows show large deviations?

Twice the manometer surprisingly overflowed showing rather dramatic changes in levels over a few days period. This occurred before the radio link was finished, so no data could be taken to make direct comparisons between the two. However, after the radio link was working abrupt changes on the manometers did not show corresponding errors on the radio readout.

At present, possible detrimental effects of entrapped air in the manometer lines is being considered in an effort to solve the dilemma.

Direct comparison of the F-recorder records to the data presented in Figure 4 is difficult as the drum of the F-recorder slipped and the record was lost for at least three periods during the time of interest.

For more complete information on the newly designed pillows and for determining a correlation coefficient between them and the larger rubber pillows, further tests will have to be made. These tests should be made in areas of deep snow, using various sized pillows of the low displacement type.

Tentative plans call for the installation of several pillows ranging in size from one foot to four feet across some connected singly, others connected in parallel. Upon suggestion of Gregory Pearson, a tentative site has been selected at Tony Grove Lake where snow depths are frequently in excess of 8 - 10 feet. The units will all be telemetered such that daily or hourly readings can be acquired readily. Other parameters that should be telemetered are temperature, humidity, and barometric pressure. Knowledge of these parameters should aid in the overall evaluation of the behavior of the snow pillows which is as yet not considered to be well understood.

APPENDIX

Data used to plot Figures 3, 4, and 5 are presented here in Tables I and II. The calibration curve used to reduce the mercury transducers data is shown in Figure 12.

As no digital calibration was made of either the 12 foot rubber pillow or the precipitation unit, these data are not reduced.

Pictures of the transponder and translator are shown in Figures 13 and 14.

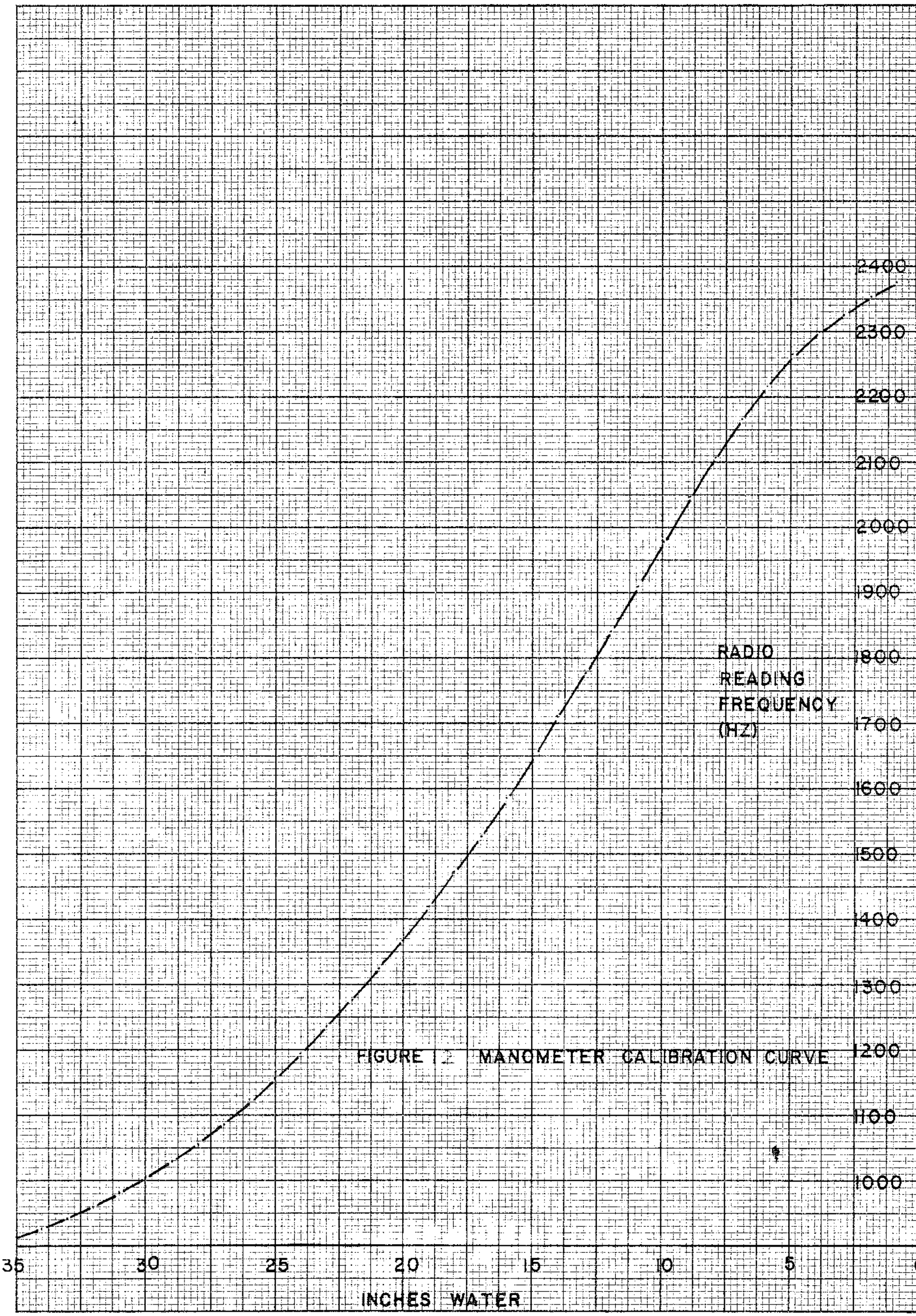

FIGURE 12 MANOMETER CALIBRATION CURVE

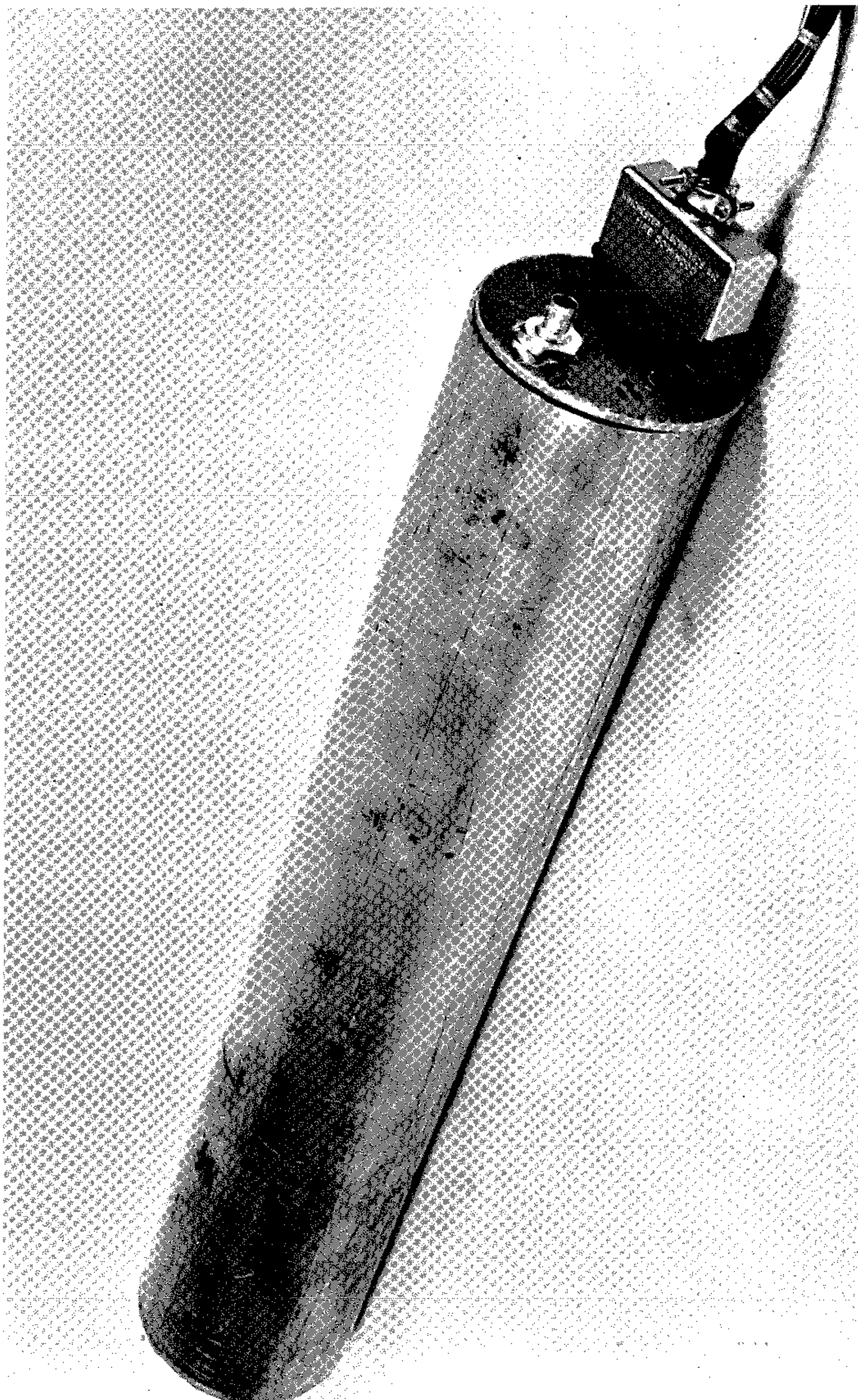

Figure 13. Picture of transponder used at Garden City Summit.

Figure 14. Picture of translator used at Swan Peak.

TABLE I

REDUCED T/M DATA USED TO PLOT FIG. 4

DATE	HOUR	4 Ft. RUBBER IN. WATER + 1.3	2Ft. RUBBER IN. WATER -6.6	4.Ft. STEEL IN. WATER + 2.3
Apr 11	0930	15.3	15.9	16.0
	1330	15.4	16.1	16.1
	1500	15.4	16.4	16.2
	1730	15.3	16.3	16.1
	1900	15.4	16.2	16.2
	2100	15.5	16.2	16.2
Apr 12	1250	15.5	16.5	16.2
	1440	15.5	16.6	16.2
	1530	15.3	16.6	16.2
	1700	15.4	16.6	16.2
	1920	15.4	16.6	16.2
	2030	15.5	16.6	16.2
	2310	15.5	16.5	16.1
Apr 13	0700	15.7	—	16.3
	0825	15.7	16.1	16.3
	0925	15.6	16.3	16.3
	1355	15.3	16.4	16.2
	1625	15.2	16.5	16.1
	1740	15.2	16.5	16.0
	2115	15.4	16.3	16.0
	2250	15.4	16.3	—
Apr 14	0700	15.5	—	—
	1130	14.9	15.3	15.8
	1600	14.9	16.1	15.7
	1755	14.9	16.0	15.7
	1915	14.9	15.8	15.8
	2225	14.9	15.5	15.8
Apr 15	0800	14.8	14.6	15.6
	1051	14.5	14.6	15.3
	1400	14.5	14.4	15.2
	1900	14.1	15.1	14.9
	2255	14.0	14.7	14.9
Apr 16	1025	13.8	14.3	14.5
	1800	13.5	14.4	14.1
	2315	13.6	14.2	14.2
Apr 17	1000	13.3	13.3	14.1

DATE	HOUR	4 Ft RUBBER IN WATER +1.3	2 Ft RUBBER IN WATER -6.6	4 Ft. STEEL IN WATER +2.3
Apr 17	1610	13.2	13.9	13.5
	1820	13.1	13.9	13.3
	2040	13.2	13.8	—
	2350	13.4	13.9	13.8
Apr 18	0620	13.6	13.9	14.1
	0851	13.6	14.0	14.1
	1035	13.6	14.0	14.1
	1315	13.6	14.2	14.1
	1820	13.6	14.1	14.1
	2245	13.7	14.0	14.1
Apr 19	0730	14.0	14.0	14.2
	0920	14.0	14.1	14.3
	1625	14.1	14.6	14.7
	1715	14.2	14.6	14.8
	2300	14.4	14.5	14.9
Apr 20	0730	14.4	14.5	14.9
	1000	14.4	14.6	14.9
	1300	14.5	15.2	15.0
	1620	14.4	15.2	15.0
	2130	14.5	15.1	15.1
	2240	14.5	—	15.1
Apr 21	0715	14.6	15.2	15.1
	1250	14.6	15.5	15.1
	1500	14.5	15.7	15.1
	2030	14.5	15.7	15.1
	2230	14.5	15.8	15.1
	2400	14.6	15.7	15.2
Apr 22	1100	14.6	15.8	15.1
	1630	14.6	15.9	15.2
	2015	14.6	15.7	15.1
	2345	14.8	15.9	15.5
Apr 23	0800	14.9	15.6	15.6
	1356	14.5	15.8	14.9
	1800	14.6	15.9	14.8
	2245	14.8	15.9	14.9
Apr 24	0830	15.0	15.7	15.7
	1515	14.5	16.1	14.7
	2020	14.6	15.7	14.9
	2245	14.6	15.6	14.9

DATE	HOUR	4 Ft. RUBBER IN. WATER +1.3	2 Ft. RUBBER IN. WATER -6.6	4 Ft STEEL IN. WATER +2.3
Apr 25	0600	14.7	15.2	15.0
	0903	14.5	15.1	15.5
	1900	13.5	15.1	14.1
	2300	13.4	14.6	13.8
Apr 26	0845	13.2	14.3	13.7
	1045	13.2	—	13.7
	1315	13.2	14.1	13.6
	1615	13.2	14.1	13.6
	1904	13.1	14.0	13.6
	2300	13.2	14.0	13.7
Apr 27	0700	13.7	14.0	14.1
	1130	13.3	14.1	13.8
	1340	13.1	14.4	13.7
	1620	12.7	14.5	13.2
	1712	12.7	14.5	13.2
	2100	13.1	14.3	13.5
	2305	13.3	14.5	13.7
Apr 28	1000	12.5	14.3	12.2
	1250	12.5	14.2	13.2
	1535	12.2	14.6	12.6
	1640	12.2	14.5	12.6
	2050	12.3	14.7	12.8
	2240	12.4	14.2	13.0
Apr 29	0730	12.7	14.0	13.0
	0935	12.1	13.7	12.8
	1600	11.3	13.6	11.6
	1815	11.2	13.3	11.6
	2320	11.7	14.6	12.0
Apr 30	0800	11.7	13.0	12.0
	1400	10.7	13.2	10.7
	1900	10.2	14.1	10.5
	2315	10.6	11.9	10.5
May 1	0730	10.7	12.0	10.7
	1230	11.0	12.4	10.3
	1620	8.7	11.1	8.7
	18.45	8.7	9.9	8.7
	2120	8.7	9.6	8.8
	2300	8.7	9.6	8.9

DATE	HOUR	4 Ft. RUBBER IN. WATER +1.3	2 Ft. RUBBER IN. WATER -6.6	4 Ft. STEEL IN. WATER +2.3
May 2	0615	8.9	9.9	9.0
	1030	8.6	10.1	8.7
	1230	8.1	10.2	8.2
	1600	7.4	8.4	6.4
	1845	6.9	7.4	6.4
	2025	7.0	7.0	6.9
	2245	7.0	7.0	7.0
May 3	0600	7.0	7.1	—
	1120	6.6	—	—

TABLE II

RAW T/M DATA AS RECEIVED AT UTAH WATER RESEARCH LABORATORY

SPRING 1966

DATE	HOUR	2 Ft RUBBER	12 Ft. RUBBER	4 Ft STEEL	4 Ft RUBBER	PRECIP.	TEMP
Apr. 11	0930	1364		1848	1825	2351	1964
	1330	1351		1843	1821	2351	1930
	1600	1343		1841	1820	2352	1920
	1730	1347		1843	1824	2352	1927
	1900	1353		1841	1819	2353	1938
	2160	1353		1841	1816	2361	—
Apr 12	1260	1338		1837	1816	2351	1920
	1440	1334		1836	1816	2350	1914
	1630	1334		1837	1816	2350	1913
	1700	1333		1836	1818	2350	1910
	1920	1332		1840	1821	2351	1924
	2030	1333		1844	1813	2351	1942
	2310	1335		1843	1811	2351	1963
Apr 13	0700	—		1830	1802	2350	2009
	0825	1351		1832	1803	2349	2000
	0925	1346		1833	1809	2350	1992
	1355	1341		1840	1823	2350	1921
	1625	1338		1844	1828	2346 ←	1894
		CLEAR				OIL ADDED	
	1740	1336		1848	1828	2346	1900
	2115	1349		1846	1818	2347	1956
	2250	1349		—	1819	2346	1957
Apr 14	0700	—		—	1814	—	—
	1130	1392		1860	1848	2346	1944
	1600	1352		1868	1849	2346	1885
	1755	1359		1866	1852	2348	1891
	1915	1368		1865	1852	2348	1908
	2225	1381		1864	1853	2346	1941
Apr 15	0800	1416 (A)		1876 (B)	1856 (C)	2346	1968
	1051	1416		1898	1877	2345	1918
	1400	1390		1901	1879	2346	1884
	1900	1403		1917	1900	2347	1893
	2255	1424		1920	1905	2347	1924
Apr 16	1025	1442		1945	1921	2346	1913

Small Rain Storm

DATE	HOUR	2 Ft. RUBBER	12 Ft RUBBER	4 Ft. STEEL	4 Ft. RUBBER	PRECIP	TEMP
Apr 16	1800	1438		1975	1941	2348	1904
	2315	1450		1962	1932	2346	1939
Apr 17	1000	1491	Cloudy	1976	1949	2345	1953
	1610	1462		2005	1961	2346	1903
	1820	1462		2011	1964	2346	1910
	2040	1467	Snow & Rain	—	1959	2348	1930
	2350	1461		1984	1944	2344	1942
Apr 18	0620	1460		1977	1935	2344	2025
	3 IN. Snow ON ground						
	0851	1457		1976	1933	2343	1967
	1035	1456		1976	1933	2343	1957
	1315	1448		1974	1932	2343	1939
	1820	1451		1973	1930	2343	1945
	2245	1459		1970	1928	2343	1980
Apr 19	0730	1455		1962	1911	2343	2007
	0830	electrical storm interferred					
	0920	1449		1959	1910	2341	2000
	1625	1428		1932	1900	2139	
	3 gal. Added To Precip. can.						
	Temp Trans. Removed						
	1750	1427		1925	1891	2139	
	2300	1432		1916	1882	2132	
Apr 20	0730	1434		1914	1881	2133	
	1000	1426		1916	1881	2130	
	1100	—		1916	1880	2129	
	1305	1402		1911	1879	2129	
	1620	1398		1908	1880	2130	
	2130	1404 ?		1905	1877	—	
	2240	—		1906	1877	2132	
Apr 21	6715	1402		1904	1874	2130	
	1250	1381		1905	1875	2129	
	1500	1375		1907	1877	2128	
	2630	1372		1904	1876	2131	
	2230	1368		1903	1876	2131	
	2400	1373		1898	1868	2129	
Apr 22	1100	1369		1904	1871	2127	
	1630	1361		1902	1871	2128	
	2015	1363		1906	1873	2130	
	2345	1363		1886	1858	2130	
Apr 23	0800	1379		1879	1853	2128	

DATE	HOUR	2 Ft. RUBBER	12 Ft RUBBER	4 Ft. STEEL	4 Ft RUBBER	PRECIP.	TEMP.
Apr 23	1350	1370		1918	1874	2126	
	1800	1364		1927	1871	2129	
	2245	1367		1917	1857	2130	
Apr 24	0830	1372		1874	1836	2127	Sunny
	1515	1358		1934	1880	2126	
	2026	1374		1919	1872	2130	
	2245	1381		1918	1871	2129	
Apr 25	0600	1397		1911	1861	2128	Sunny
	0903	1407		1926	1880	2126	WARM
	1900	1405		1977	1940	2129	
	2350	1427		1987	1945	2128	
Apr 26	0845	1440		1996	1953	2127	
	1045	—	Rain	1995	1953	2126	Rain
	1315	1447		1998	1955	2127	
	1615	1452		1996	1958	2124	
	1904	1466	Snow Cold	1998	1960	2124	Snow Cold Cloudy
	2300	1457		1989	1952	2122	
Apr 27	0700	1359 ?		1965	1927	2122	32°
	1130	1449		1985	1949	2119	Sunny Warmer
	1340	1436		1993	1963	2120	
	1620	1431	2416	2023	1973	2120	
	1712	1433	2418	2022	1973	2121	38°
	2100	1441	2416	2003	1963	2123	
	2305	1434	2415	1984	1948	2122	
Apr 28	1000	1483	2421	2020	1995	2119	
	1250	1445	2420	2020	1996	2120	1911
		Sunny		Temp-	Trans.	Put in	59.5°
	1535	1429	2445	2655	2011	2120	1929
	1640	1435	2453	2058	2018	2121	1932
	2050	1426	2453.	2040	2607	2122	1881
	2240	1447	2453	2033	2001	2122	1866
Apr. 29	0730	1458	2453	2626	1985	2121	1848
				Sunny	and	Clear	
	0935	1473	—	2043	2026	2119	1870
	1600	1477	2485	2118	2068	2121	1930
	1815	1490	2487	2116	2072	2122	1921
	2320	1428	2426	2093	2043	2122	1861
Apr 30	0800	1503	2489	2090	2047	2119	1843
	1400	1497	2510	2162	2105	2120	1939
	1900	1452	2521	2176	2132	2122	1926

DATE	HOUR	2 Ft RUBBER	12 Ft. RUBBER	4 Ft STEEL	4 Ft. RUBBER	PRECIP	TEMP
Apr 30	2315	1567	2520	2172	2113	2122	1868
May 1	0730	1564	2521	2161	2104	2121	1840
	1230	1537	2533	2180	2145	2119	1938
	1620	1631	2538	2256	2204	2126	1981
	1845	1678	2559	2252	2209	2122	1950
	2120	1690	2556	2248	2206	2123	1896
	2300	1690	2556	2243	2205	2123	1878
May 2	0615	1679	2500	2240	2199	2122	1848
	1030	1660	2562	2257	2280	2119	1915 ?
	1230	1656	2574	2278	2229	2120	1965
	1606	1768	2595	2320	2271	—	2002
	1845	1829	2598	2320	2280		1904
	2025	1853	2596	2315	2279		1922
	2245	1852	2598	2313	2279		1893
May 3	0600	1844	2598	2311	2277		1860
	1120			2318	2282	2118	1954
June 10			2617	2442	241.0	2060	2000