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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/21276343
Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB), 1973-04

ERB-866

UNCLASSIFIED

NATIONAL RESEARCH COUNCIL OF CANADA
RADIO AND ELECTRICAL ENGINEERING DIVISION

THE BELCHER ISLANDS EXPEDITION, 1971

- M. D. WATSON, V. F. CYR, AND G. W. ATTALLAH -

OTTAWA

APRIL, 1973

ABSTRACT

A chain of automatic auroral photometers was operated on the Belcher Islands during the summer of 1971. A detailed account is given of the planning, preparation and execution of the program.

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THE BELCHER ISLANDS EXPEDITION, 1971

by

M. D. Watson, V. F. Cyr, and, G. W. Attallah

1. INTRODUCTION

Since 1966 the Radio and Electrical Engineering Division has operated a program of auroral photometry at the near-conjugate locations, Great Whale Geophysical Station (Poste-de-la Baleine, Québec) and Byrd Station (Antarctica). A number of articles and reports have described this program in some detail; a list of these is given at the end of this section, and the interested reader is referred to them for further information. The following paragraphs give a brief résumé of the background to the Belcher Islands Expedition of 1971.

While Great Whale and Byrd are often referred to as being geomagnetically conjugate, the actual northern conjugate point to Byrd, as calculated from the main (internal) geomagnetic field, does not coincide with Great Whale but lies slightly to the southeast of the Belcher Islands, some sixty miles northwest of Great Whale.

The modification of the main field by the addition of a plausible magnetospheric model (Barish and Roederer 1969) results in a predicted daily motion of the northern conjugate point (assuming that the southern end of the field-line is held fixed, at Byrd) along a locus whose shape and size varies with the season and with the geomagnetic activity. Some experimental results gained from magnetometer and riometer observations (Walker 1968; Campbell 1971), while not verifying the theory in detail, do indicate that the northern conjugate does indeed move.

Since the location and movements of visible auroral forms are, to some extent at least, controlled by the geomagnetic field, it seems reasonable that this "wandering of conjugate points" should be reflected in the movements of auroras seen in the areas of Great Whale and Byrd. While this motion may be studied from all-sky camera photographs taken at a base station—subject of course to the limitations of field of view, time resolution, spectral integration, and the necessity of assuming auroral heights—the use of photometers for a similar project requires the establishment of a network or grid of stations, since there is no way of determining the position of an auroral form within the field of view of a simple photometer of the kind used in this program.

In comparing auroral records made at two or more stations, it is important that one know the correct times at which observations were made. In the case of all-sky camera photographs, which are exposed at a rate of say one per minute, a timing accuracy of a few seconds is considered acceptable, but in the photometry program envisioned, using the automatic photometers with an inter-sample period of 5.4 seconds, timing errors of more than a few tenths of a second would be prohibitive. The timing gear and its operation are described in a later section.

One stringent requirement for all conjugate auroral studies is that both northern and southern stations be in darkness simultaneously. This immediately eliminates observations during the northern winter, since Byrd experiences 24-hour daylight at that time. The practical realities of northern logistics impose a further restriction. If the helicopter is rejected as a means of transportation because of its high cost, equipment may be transported only by amphibious aircraft, or by boat, to stations on islands in Hudson Bay. Operations cannot begin until mid-July with any degree of certainty, since the winter ice does not normally disappear before then. The operating season, then, is confined to August and September.

The design of the network of auroral photometer stations has been fairly thoroughly documented in the references listed at the end of this report. The final system configuration is described in Section 2. of this report. Three sites were chosen as being suitable for installing the photometer chain. The locations were picked, first for their geographical aptness, and, second, for the maximum convenience in transportation. Together with the base station at Great Whale, they would permit a continuous sky coverage along a curved path about 160 miles in length by about 50 miles in width, with the main-field northern conjugate point falling about midway along the projected combined fields of view. However, the logistic and equipment problems described later limited the chain to the two locations shown in Fig. 1.

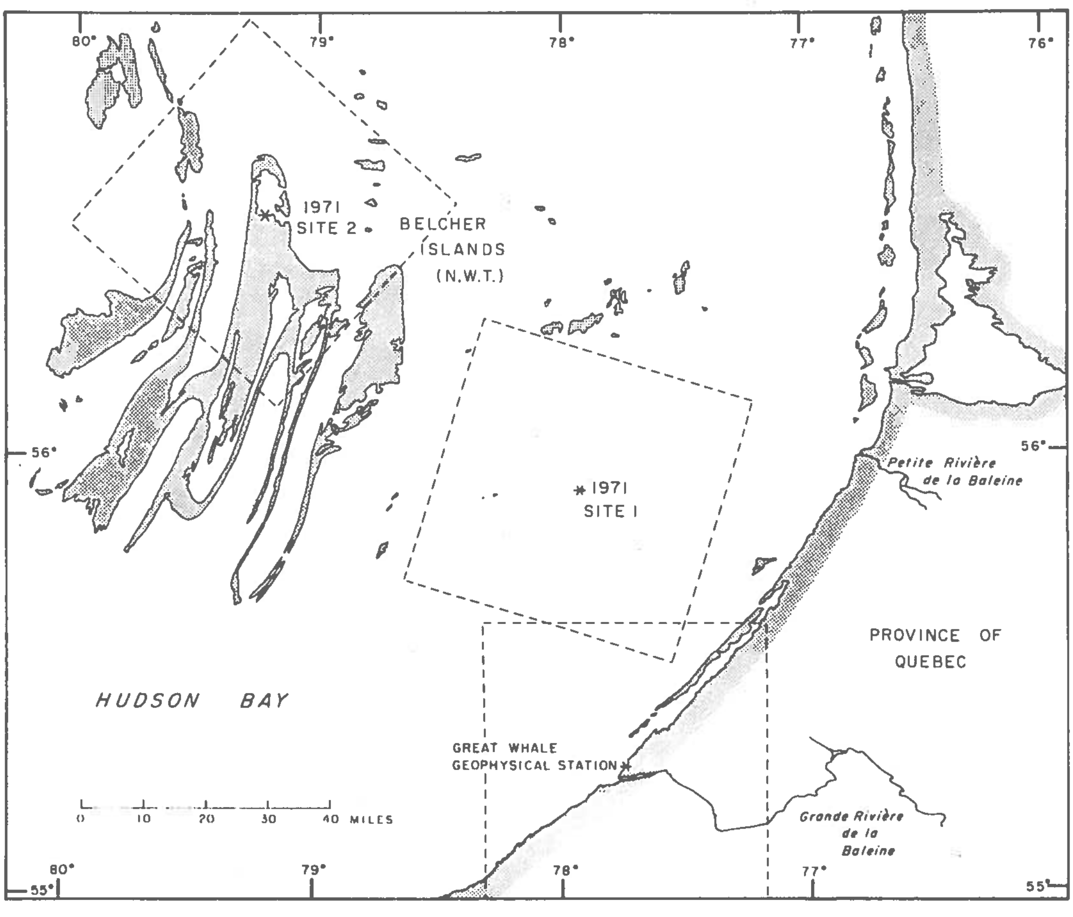


Fig. 1 Map of southeastern Hudson Bay, showing locations and fields-of-view of Great Whale Geophysical Station and the two automatic photometers.

The remainder of this report contains a description of the scientific equipment, including the photometer stations themselves and the test gear necessary for their installation. Results of the project are briefly described, as well as the geological samples collected. A description of the logistic and outfitting details is included, and, finally, detailed and informal diaries of the installation and retrieval trips.

Byrd was abandoned as a wintering station at the end of the 1971 austral winter, owing to an unexpectedly rapid and dangerous accumulation of snow. The Great Whale – Byrd conjugate auroral program thus came to an end for the foreseeable future, and it is therefore doubly unfortunate that the equipment troubles related in this report resulted in a complete lack of data from the automatic photometers. The interesting problem of conjugate-point motions remains unclarified despite the effort expended on this project.

2. SCIENTIFIC EQUIPMENT

2.1 Photometers

2.1.1 *General*

After the experience gained in operating a manned photometer station at South Camp, located at the south end of Flaherty Island, during the summer of 1967, it was apparent that stations remote from Great Whale would have to be automatic and unmanned. The expense of supporting a two-man team at each of several sites, isolated from any settlement, would be unjustifiable. Hence, the photometer system, shown in the block diagram of Fig. 2, was developed with the assistance of the Data Systems

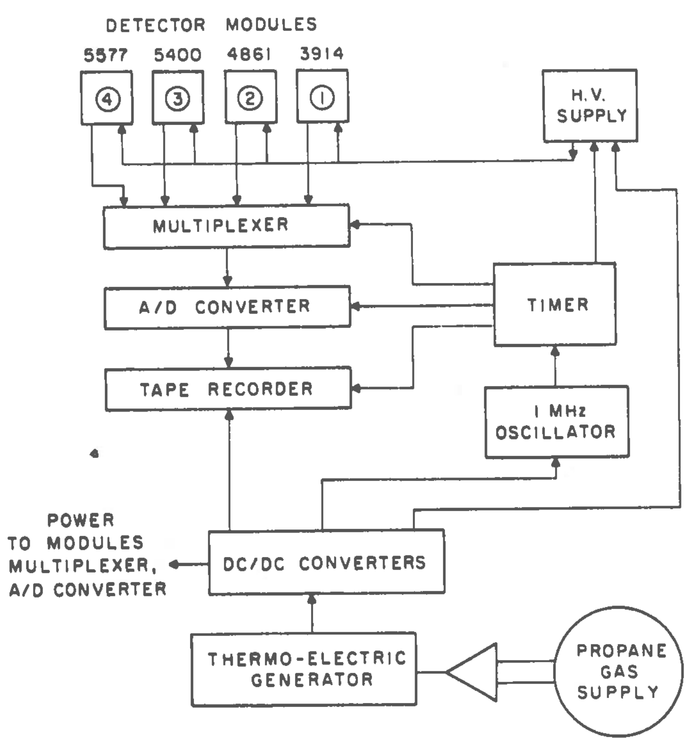
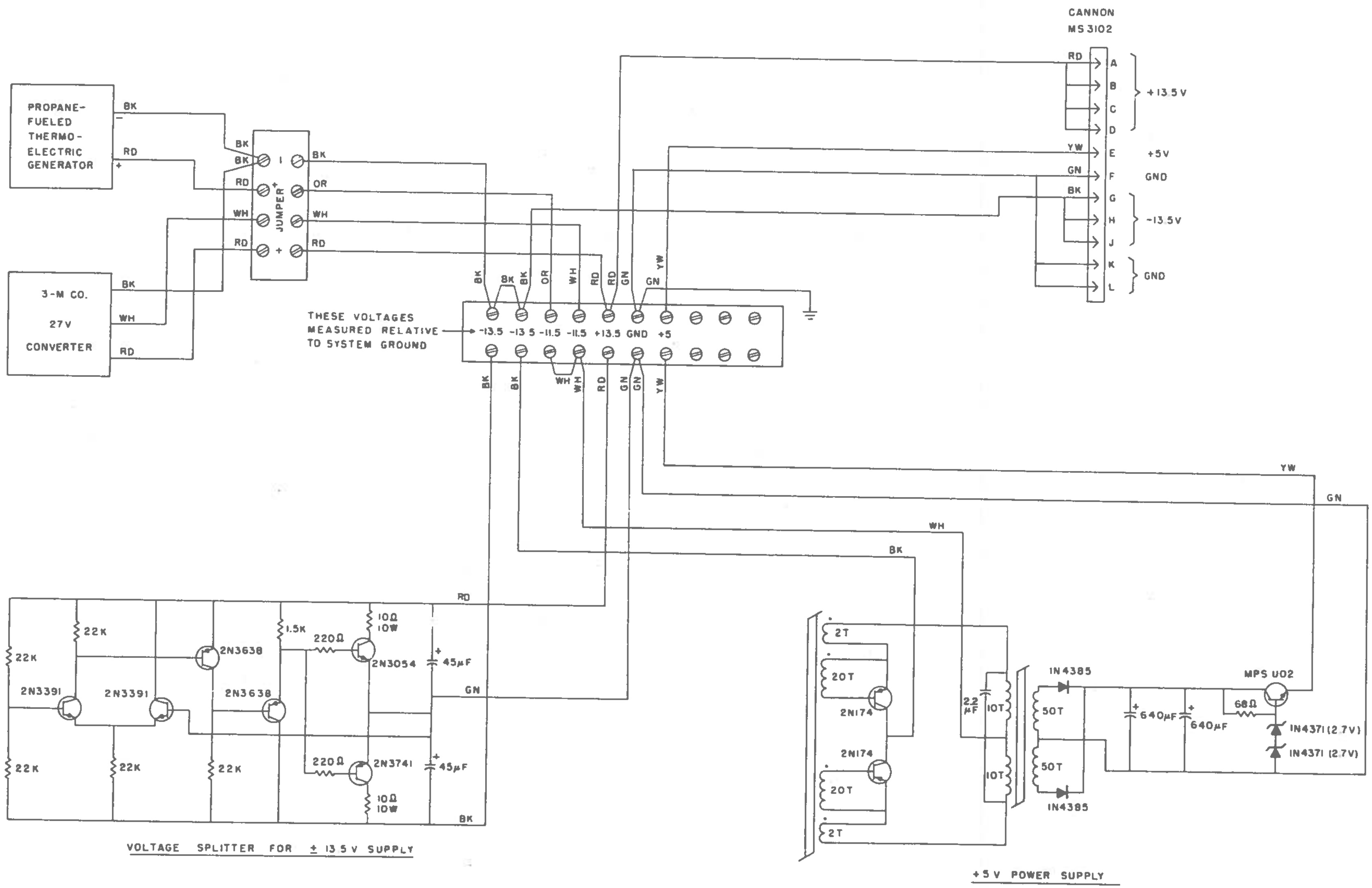


Fig. 2 Block diagram of automatic photometer system.



NOTE :

THIS DIAGRAM APPLIES TO UNITS 2&3
UNIT 1 HAS SAME CIRCUIT BUT DIFFERENT WIRING

Fig. 3 Wiring diagram of thermo-electric generator.

Section of the Radio and Electrical Engineering Division. Although five units were originally envisioned, financial limitations reduced the number actually constructed to three. Electrical power to operate each system was provided by a commercially available thermoelectric generator, burning propane gas. Three auroral wavelengths and a background monitor wavelength were measured by four photoelectric detection modules, high-voltage power being supplied by a regulated dc/dc converter unit. The analog signals from the modules were time-multiplexed, converted to digital data, and then recorded on a commercial magnetic tape recorder in a computer-compatible form. The multiplexing, analog–digital conversion, timing, and control functions were all performed by a compact unit containing a highly stable quartz crystal oscillator and associated integrated-circuit logic elements. The thermoelectric generator, propane tanks, and an insulated housing containing the rest of the system were all mounted on a rigid base to form a single structure adaptable to rough ground and able to withstand adverse weather conditions. The various sytem components are described in detail below.

2.1.2 *Power Source*

The power source of the photometer system was a solid-state thermoelectric generator or TEG (Minnesota Mining and Manufacturing Model No. 3M510) having a rated output power of 13 watts at an ambient temperature of 40°F. The TEG burned propane gas at about 8 psig, obtained from four 40-lb tanks. The propane supply was calculated to be sufficient for 80 days of operation under ambient weather conditions at Ottawa, and for 60 days in the subarctic. Each tank had its own regulator valve which fed into a manifold connected to the TEG. This arrangement was used so that any manifold leaks would be at relatively low pressure and would thus lose gas at a much slower rate than if manifolding had been done at tank pressure, followed by a common regulator valve.

The low output voltage of the TEG (about 1.9 Vdc under load, 3.9 Vdc open-circuit) was transformed into 27 Vdc by a dc/dc converter supplied as part of the generator by the 3M Company, and was also raised to +5 Vdc by an NRC-built converter. The 27 Vdc output from the 3M converter was level-shifted to be symmetrical about system ground, using an NRC-built voltage splitter, and the resulting ±13.5 Vdc was used to power operational amplifiers and other devices in the rest of the system. Figure 3 shows the wiring diagram of a typical TEG.

2.1.3 *Detector Modules*

The four photoelectric detector modules were sensitive to the wavelengths given in Table I. The experimentally measured bandwidth, sensitivity, and frequency response for each of the twelve modules are also shown in the table. Figure 4 is a schematic diagram of the optical system, and a typical module is shown in the photograph of Plate I. The circuit diagram used is shown in Figure 5. The objective lens L1 formed an image of the sky at approximately the position of the interference filter F. The filter and the two field lenses L2 and L3 acted as a field stop for the system and,

TABLE I

Detector Module Characteristics

Module No.	Unit No.	Wavelength (Å)	Bandwidth (Å)	Sensitivity (V/kr)	Freq. Resp. (Hz)
1	1	5394	109	0.187	0.398
(Background)	2	5384	105	0.282	0.379
	3	5403	111	0.182	0.361
2	1	3925	46	0.294	0.346
(N_2^+ First Negative System	2	3926	46	0.265	0.398
0,0 Band at 3914 Å)	3	3928	46	0.238	0.346
3	1	4862	88	1.656	0.379
(Hβ Line at 4861 Å)	2	4862	88	2.992	0.346
	3	4862	90	1.561	0.379
4	1	5587	105	0.177	0.379
(OI "Auroral Green" Line at 5577 Å)	2	5586	91	0.172	0.361
	3	5580	102	0.152	0.361

being square, defined a square field of view 40 degrees on each side. L2 was located at its focal length away from L1 and thus incoming light was made parallel before passing through F. The light was then focused again by L3 so that an image of L1 was formed on the cathode of the photomultiplier tube PM. The filter F was required to work at a maximum divergence of only about 4 degrees, so its passband was not seriously degraded.

2.1.4 *High-Voltage Power Supply*

The high-voltage power supply consisted of a commercial dc/dc converter (Transformer Electronics Corporation model 7009-000 or Venus Scientific model K15) with an output linearly proportional to the input, up to a maximum of 1000 V out for 12 V in, fed by a transistor regulator circuit (Fig. 6). The sensing input to the regulator was derived from the low end of the photomultiplier bleeder chain in module No. 1. In order to keep

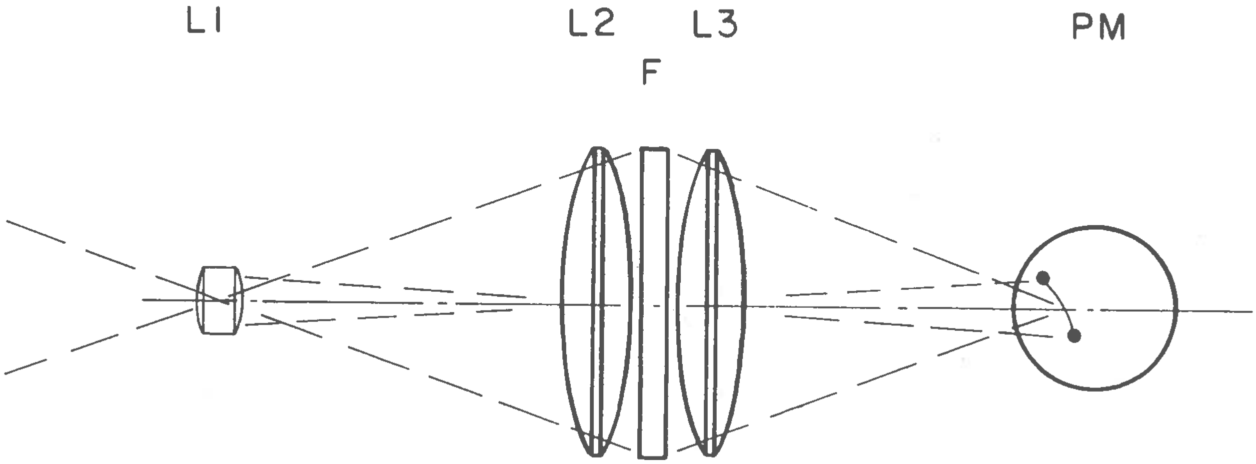
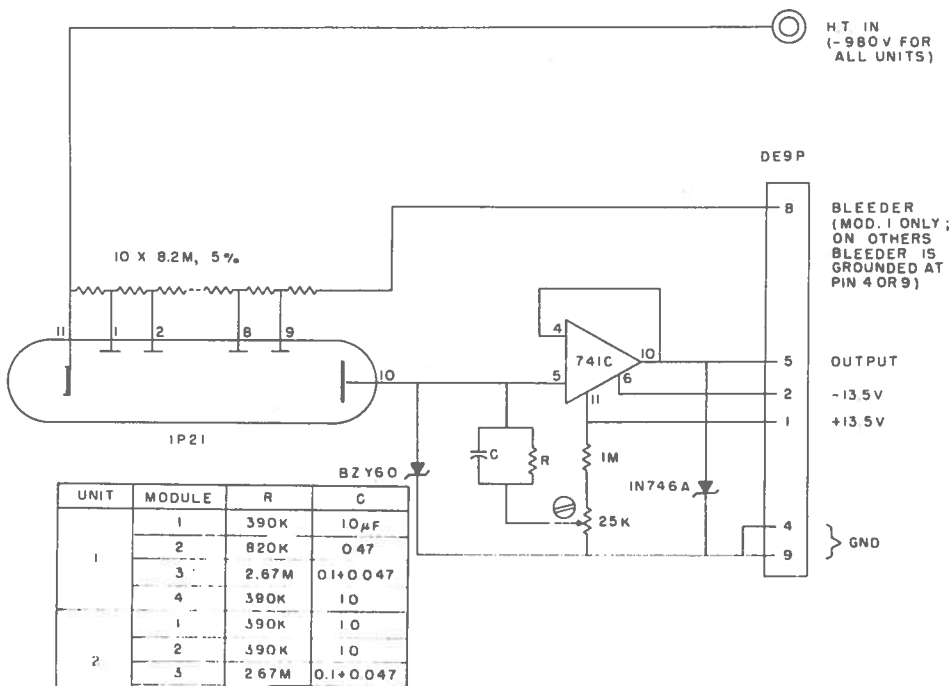


Fig. 4 Schematic diagram of photometer optical system.



UNIT	MODULE	R	C
1	1	390K	10μF
	2	820K	0.47
	3	2.67M	0.1+0.047
	4	390K	1.0
2	1	390K	1.0
	2	390K	1.0
	3	2.67M	0.1+0.047
	4	390K	1.0
3	1	270K	1.0+0.47
	2	330K	1.0+0.22
	3	2.67M	0.1+0.047
	4	270K	1.0+0.47

Fig. 5 Circuit diagram of detector modules.

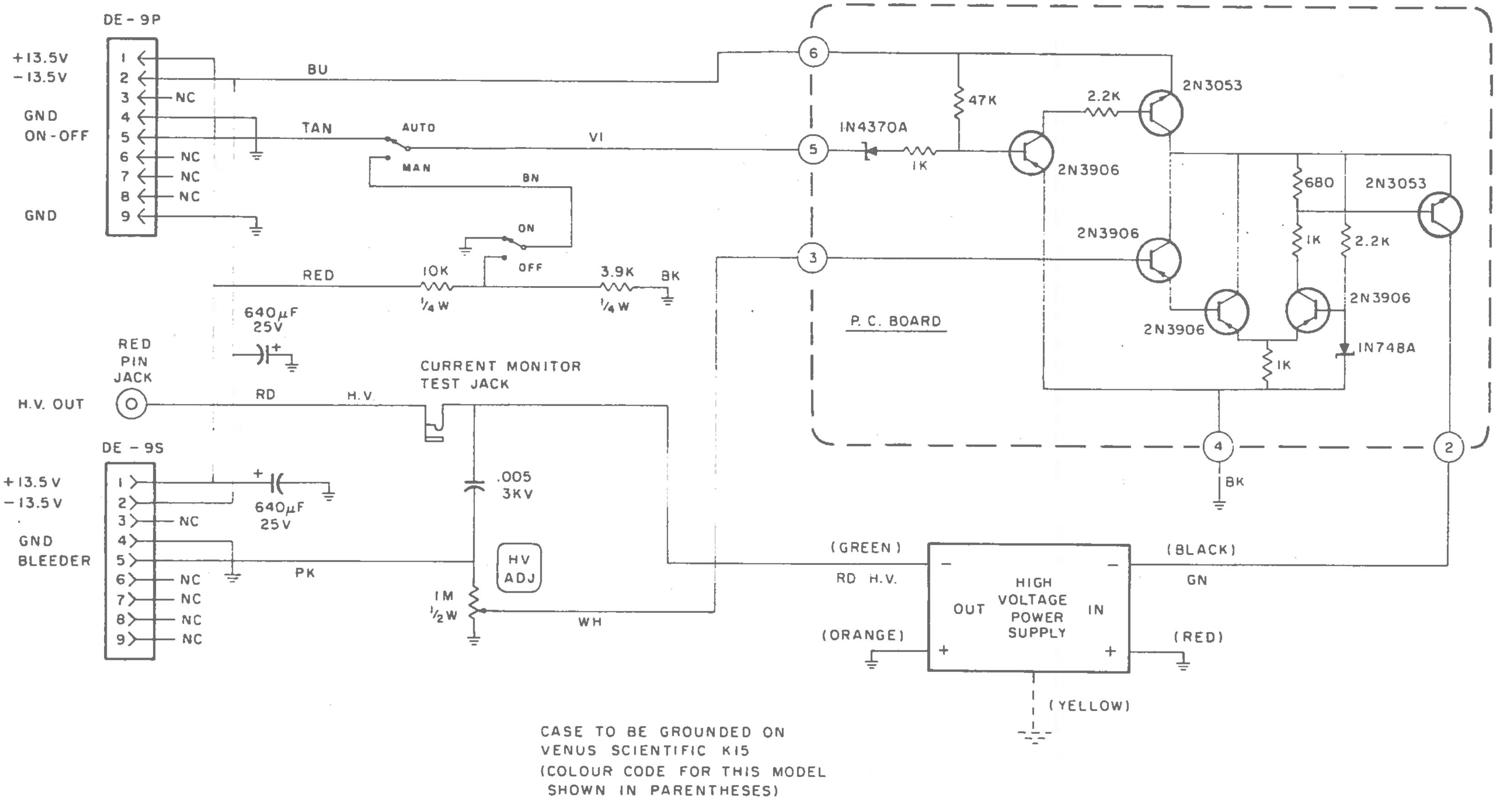


Fig 6 Circuit diagram of high-voltage power supply

the power consumption of the high-voltage supply as low as possible, the bleeder resistors were made large: 82-MΩ for each photomultiplier, for an effective load resistance of about 20 MΩ as seen by the high-voltage supply. No portable voltmeter with an input impedance high enough to keep from loading this circuit impedance was available, so the series shorting jack was included in the high-voltage line as shown in Fig. 6. A 0–100 μA meter was plugged into the jack and the total current through the (accurately-measured) bleeders was used as a measure of the high-voltage produced.

The supply was turned on and off by a logic-level applied to the control transistor by the timer unit, or alternatively by a manual toggle switch for testing. In normal service the supply was turned on at 9 p.m. (local standard time) and off at 3 a.m., corresponding to the times of civil twilight at the latitude and beginning date of the operation.

2.1.5 *Tape Recorder*

A digital magnetic tape recorder (Precision Instruments type 1387) was chosen because of its low-power characteristics: 1 W maximum standby power, and 40 W maximum power when writing. About 67,000 μF of storage capacitance and a 12-V battery (either nickel–cadmium or lead–acid) were charged through a 6.8-ohm dropping resistor from the +13.5 Vdc line, and supplied the peak current required at 12 Vdc operating voltage. The recorder was capable of writing a maximum of 200 characters per second, incrementally, on 7-track, $\frac{1}{2}$-inch tape, at a spacing of 200 characters per inch. It was housed in a heavy-gauge aluminum box which was in turn mounted on drawer slides in the main housing for ease of operation. Inter-record gaps, longitudinal redundancy check characters, and end-of-file gaps were all generated internally by the recorder electronics when commanded by logic levels at the appropriate input lines. These logic levels were supplied either automatically by the timer, or manually by two switches mounted on the recorder, as shown in the wiring diagram of Figure 7.

2.1.6 *Timer*

The timer/programmer circuitry was designed by A. Staniforth of Data Systems Section of the Division, and the prototype unit (referred to as Unit No. 1) was constructed by the technical staff of that section. Each unit consists of a stable oscillator to produce a 1-MHz signal, and low-power logic circuits to count down to lower frequencies for timing purposes. The minimum frequency generated corresponds to a period of 24 hours. As mentioned in an earlier paragraph, the high-voltage power supply was turned on for 6 hours each night starting at 9 p.m. (local standard time), and, during the ON time, measurements of auroral intensity were taken by a multiplexer and analog–digital converter with a sampling period of 5.4 sec. All logic levels to control the multiplexer, A/D converter, tape recorder and high-voltage power supply were generated by the timer/programmer.

The stable oscillator was a commercially available crystal controlled unit, enclosed in a proportionally controlled oven (Bliley Electric Co. type CC0-23MD), with a sinusoidal output at a frequency of 1 MHz within 1 part in 10^7. As with all quartz crystals, aging effects caused a continual increase of frequency; the deviation from the nominal as a function of time is shown for the three oscillators in Fig. 8. The smooth increase in each of the three

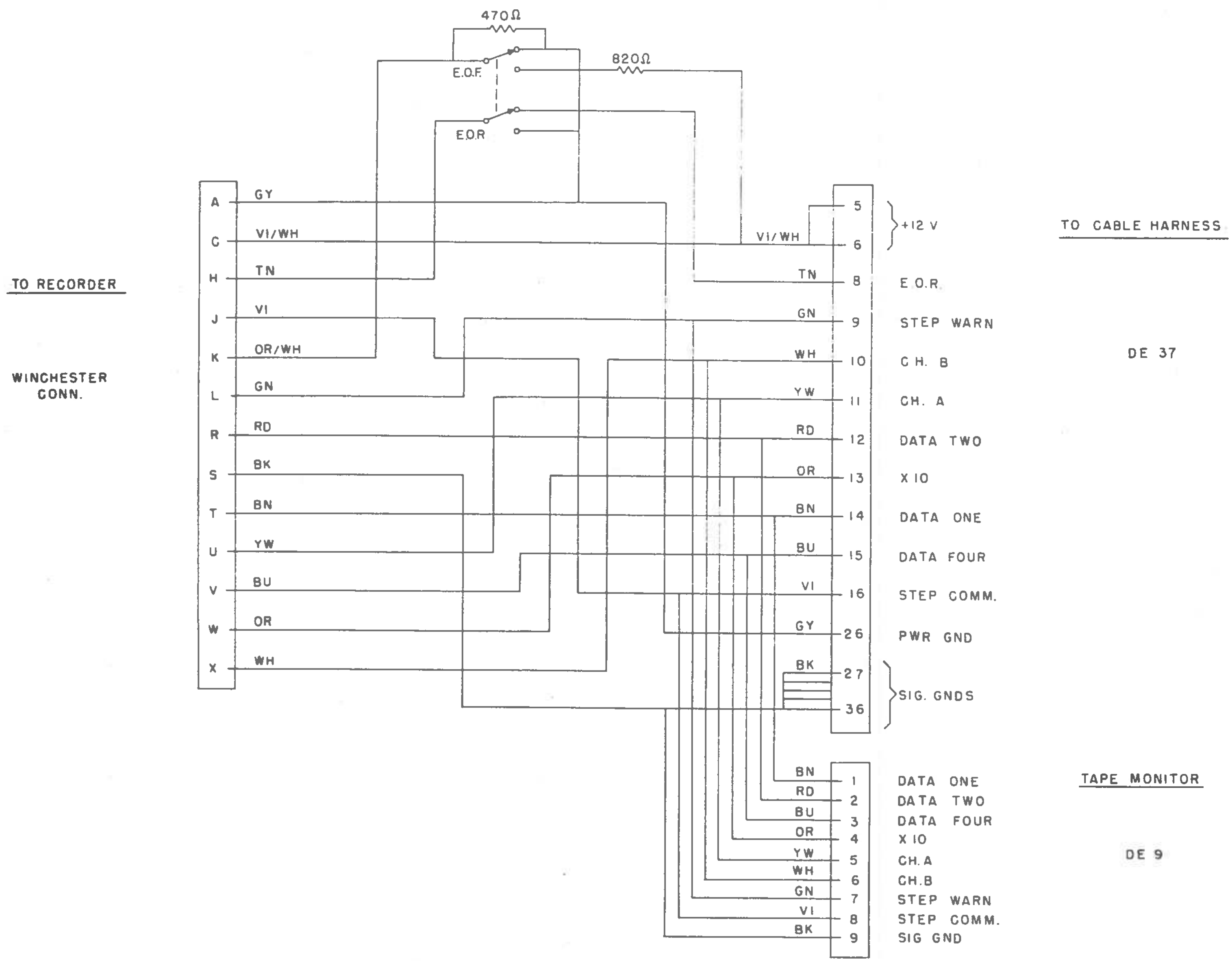


Fig. 7 Wiring diagram of tape recorder

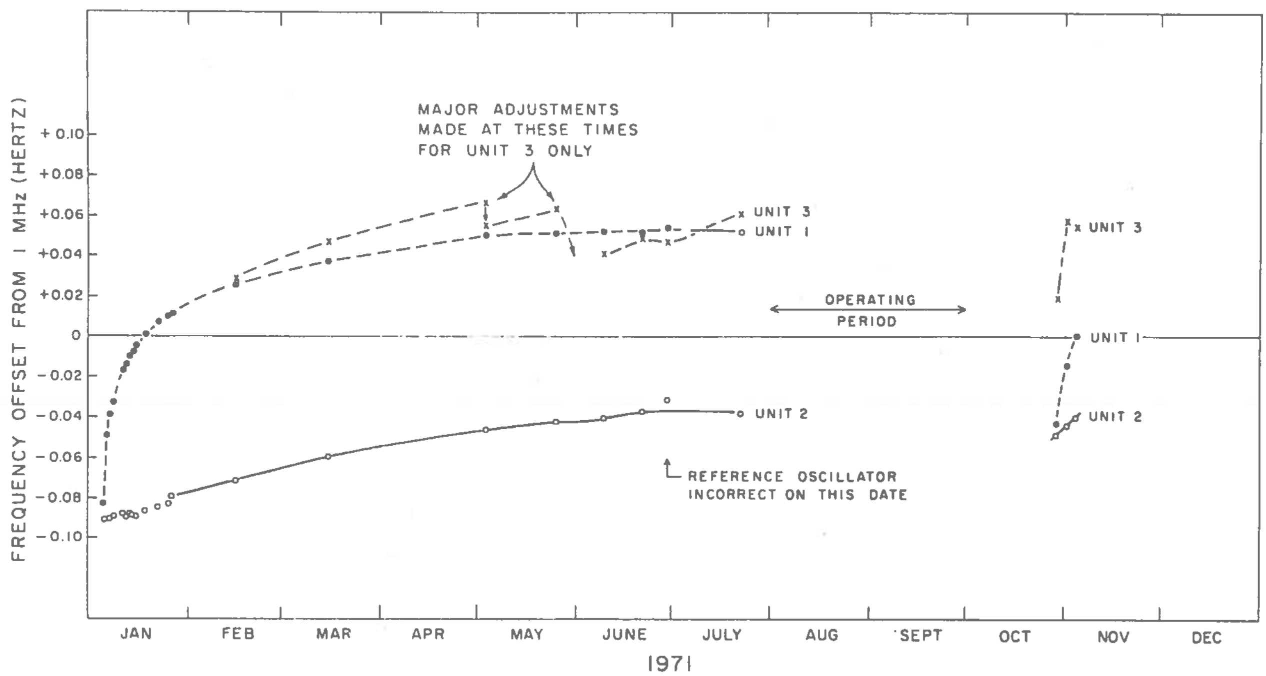


Fig. 8 Frequency versus time for three crystal oscillators.

curves up to shortly before the date of departure on the installation trip (July 22, 1971) was assumed to continue throughout the operating period of August and September 1971. All oscillators would then have offsets less than 1 part in 10^7 during this time, for an elapsed time error less than 0.3 sec. As described in Section 2.4, all three timer units ceased to operate for one reason or another before being picked up, and the sudden jumps in the curves reflect the large offsets during the stabilization period.

The oscillator unit was thermally lagged by being surrounded by about an inch of styrofoam thermal insulation, a glass Dewar flask, two more inches of styrofoam, and finally a cylindrical aluminum case for mechanical protection (Plate II). This sealed case also provided a controlled environment for the rest of the timer/programmer electronics. Electrical power connections to the timer are shown in Fig. 9.

The oscillators were never shut off after they had stabilized in the spring of 1971, since the warm-up period required more electrical power (to heat the oven) and time than could be spared during the field installation. They were transported on land and in the air while operating on battery power (each unit had its own battery pack consisting of 20 mercury

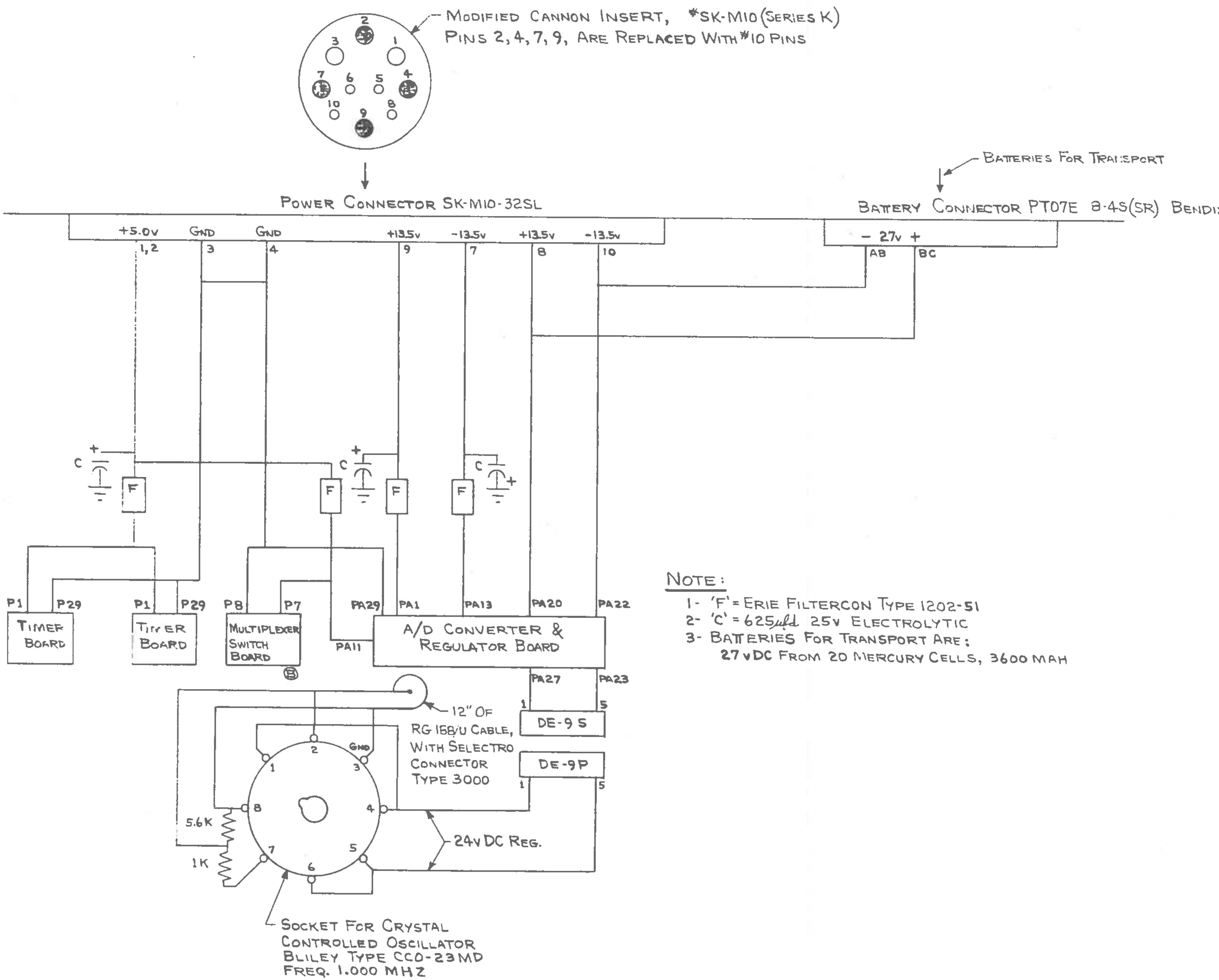


Fig. 9 Circuit diagram of power connections to timer unit.

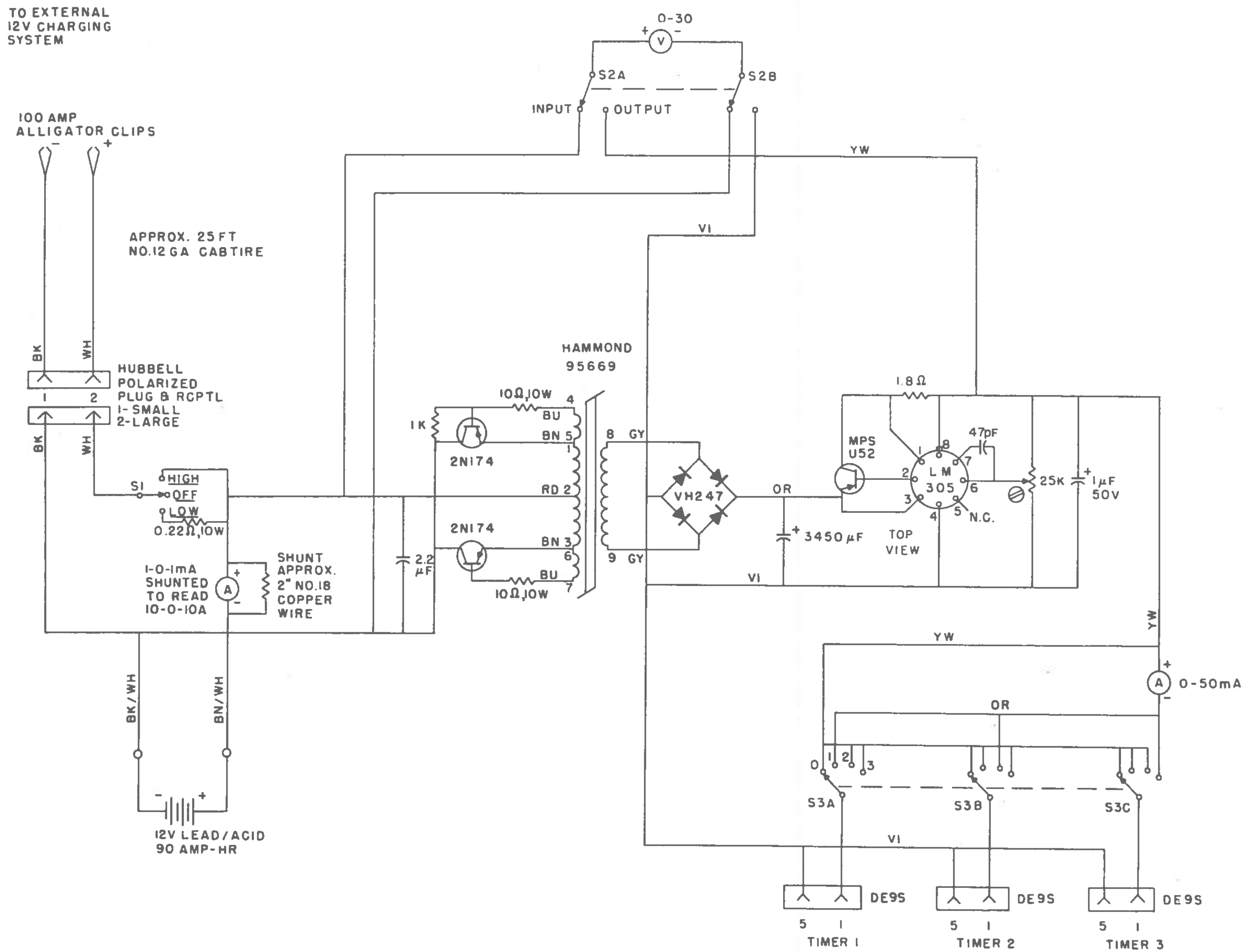


Fig. 10 Circuit diagram of 12 V/27 V DC/DC converter.

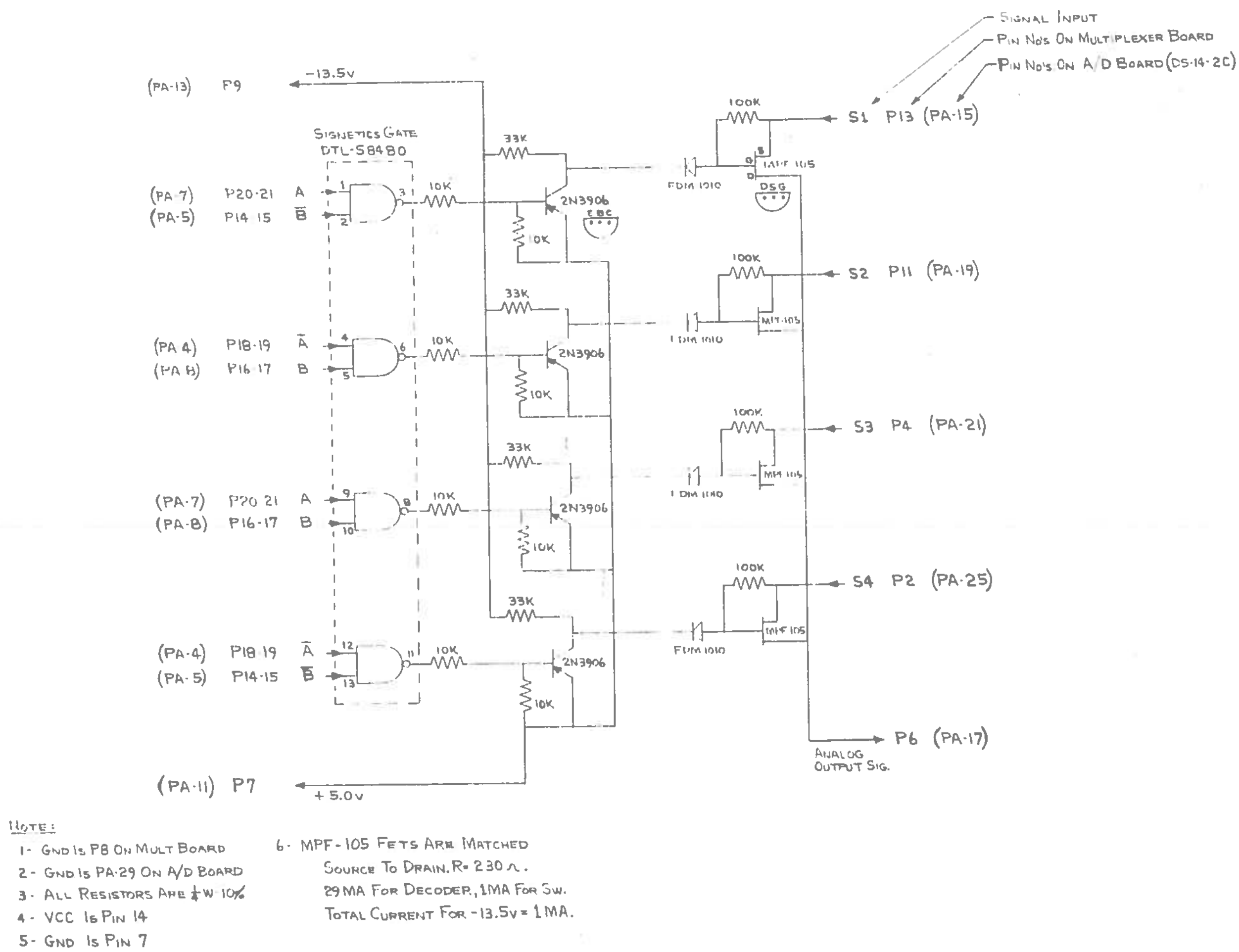


Fig. 11 Circuit diagram of multiplexer.

cells in series shown in Plate III, each supplying 1.35 V at 3600 mA-hours, for a battery operating life of about 100 hours under normal conditions). During standby periods in Montreal and Great Whale River, the oscillators were powered by a common lab-type power supply. A fail-safe relay connected the oscillators back to their individual battery packs in case of a power failure. For the trip on the boat, which would be too long for the mercury batteries, a common power supply (Fig.10) was used, powered by a lead-acid storage battery which was recharged from the boat electrical system.

The multiplexer circuit diagram is shown in Fig. 11. Analog signals from the four modules (S1 to S4) were sampled in sequence once every 5.4 sec, and connected in turn to the "analog output signal" line. The multiplexer board was hardwired to the A/D converter board which acted as a mother board.

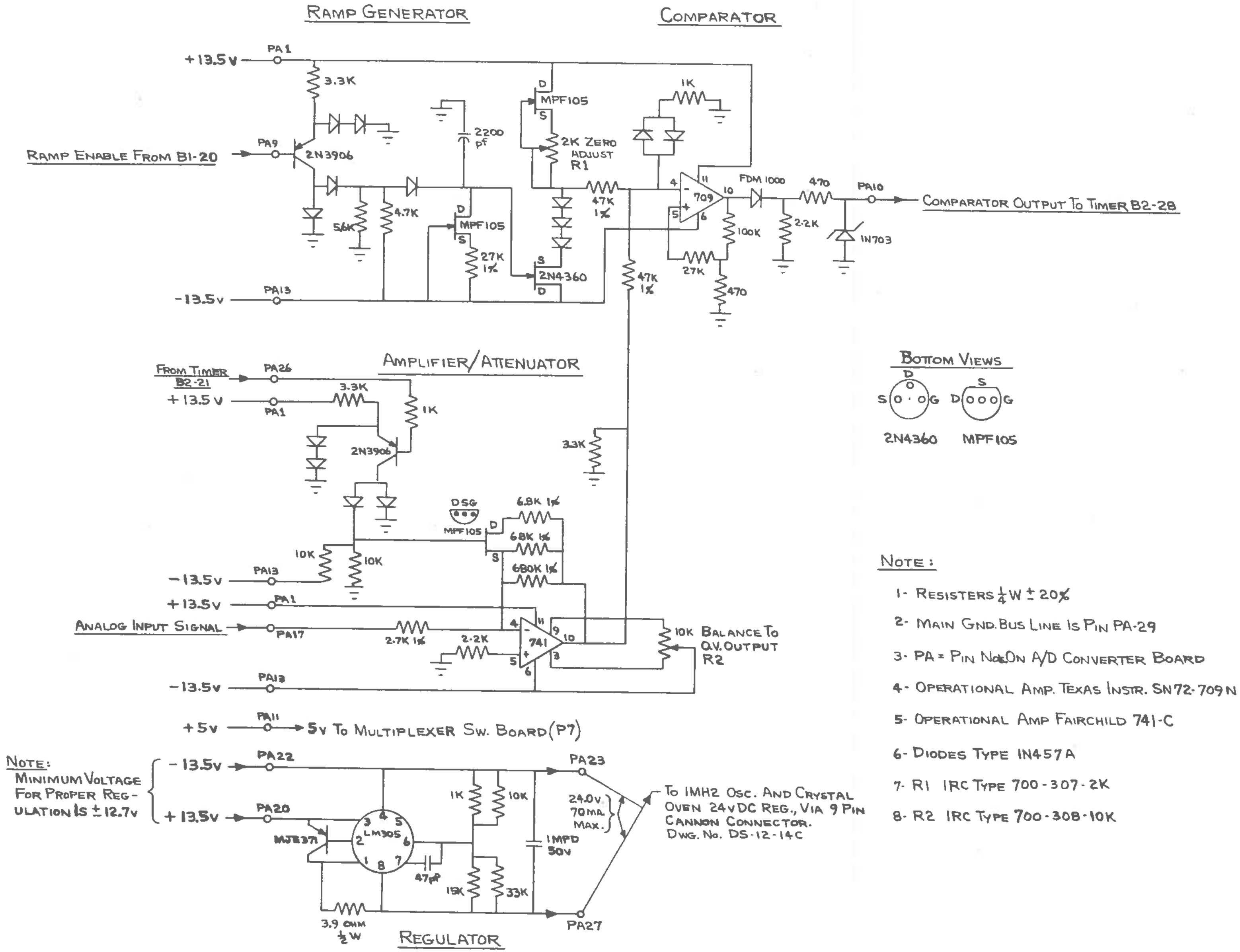


Fig. 12 Circuit diagram of A/D converter board.

TABLE II A/D CONVERSION CHARACTERISTICS

Binary Code	Unit 1				Unit 2				Unit 3			
	1	2	3	4	1	2	3	4	1	2	3	4
0001	0.014	0.014	0.014	0.014	0.015	0.015	0.015	0.015	0.013	0.013	0.013	0.013
0010	0.034	0.034	0.034	0.034	0.034	0.033	0.034	0.035	0.033	0.032	0.033	0.032
0011	0.054	0.054	0.054	0.054	0.053	0.052	0.053	0.055	0.053	0.053	0.053	0.052
0100	0.074	0.074	0.074	0.074	0.073	0.071	0.073	0.075	0.073	0.073	0.073	0.072
0101	0.093	0.093	0.093	0.093	0.091	0.089	0.092	0.094	0.094	0.093	0.094	0.093
0110	0.112	0.112	0.112	0.113	0.110	0.108	0.110	0.114	0.115	0.114	0.115	0.113
0111	0.131	0.131	0.131	0.132	0.129	0.126	0.130	0.133	0.134	0.133	0.134	0.132
1001	0.15_0	$0,15_0$	0.15_0	0.15_0	0.149	0.146	0.149	0.153	0.156	0.156	0.156	0.152
1010	0.34_0	0.34_0	0.34_0	0.34_0	0.339	0.333	0.343	0.352	0.321	0.318	0.321	0.314
1011	0.54_0	0.54_0	0.54_0	0.54_0	0.525	0.510	0.525	0.541	0.522	0.516	0.520	0.513
1100	0.73_0	0.73_0	0.73_0	0.73_0	0.706	0.693	0.708	0.728	0.721	0.717	0.721	0.713
1101	0.925	0.925	0.925	0.927	0.891	0.873	0.894	0.920	0.922	0.916	0.922	0.909
1110	1.116	1.116	1.116	1.117	1.077	1.055	1.080	1.111	1.120	1.114	1.120	1.105
1111	1.306	1.305	1.306	1.308	1.263	1.237	1.266	1.301	1.319	1.312	1.319	1.302

The circuit diagram for the A/D converter board is shown in Fig. 12 (note that this board also contained a circuit to supply regulated power for the crystal oscillator and its oven). The A/D converter output was a 4-bit code in which the most significant bit was a scale factor and the other 3 bits were the binary coded intensity. The analog input signal from the multiplexer was fed to an operational amplifier (type 741) whose gain was switched automatically between 24 and 2.4, depending on the signal level. The four-bit digital code was generated in two consecutive A/D conversions, 320 μsec apart. If, in the first pass, with the operational amplifier gain at 24, the input was found to be greater than 0.15 V, the most significant bit of the code was set to 1 and the amplifier gain was reduced to 2.4. The second conversion pass was then made, and the resultant three bits of amplitude data (coded in straight binary) were recorded along with the scale factor bit, using tracks 1, 2, 4, and 8 on the 7-track tape. If the input level was less than 0.15 V, of course, the scale bit was left at 0 and the second pass was performed with the amplifier gain still at 24. Table II lists the possible binary code values and the corresponding analog input voltages. All three units were adjusted to have approximately the same A/D conversion characteristics.

The timing sequence for the multiplexing and conversion of data from the four channels is shown schematically in Fig. 13. Note that the record electronics of the tape recorder were energized only just before the sampling began, to keep the average power consumption to a minimum.

As identification numbers for the four channels, bits were recorded on tracks A and B of each 7-track tape character, as shown in Table III. In addition, tracks A and B were used to record a time code every 108 seconds (i.e., every 20 samples, or every 80 characters). Only the A and B tracks for the first three channels were used for time coding, the fourth character reverting to the channel identification for channel 4 ("1 1"). The time code is given in Table IV. The times given in this table were the beginnings of each of the eight records that made up each night's data. These records were of unequal length, alternating between 36 and 54 minutes, or 400 samples (1600 characters) and 600 samples (2400 characters), as a result of the frequency division scheme used in the timer shown in the block diagram of Fig. 14. End-of-record commands were generated by the timer during the recording period each night (2100 to 0300 EST).

TABLE III CHANNEL IDENTIFICATION CODE

Channel No.	Track A	Track B
1	0	1
2	1	0
3	0	0
4	1	1

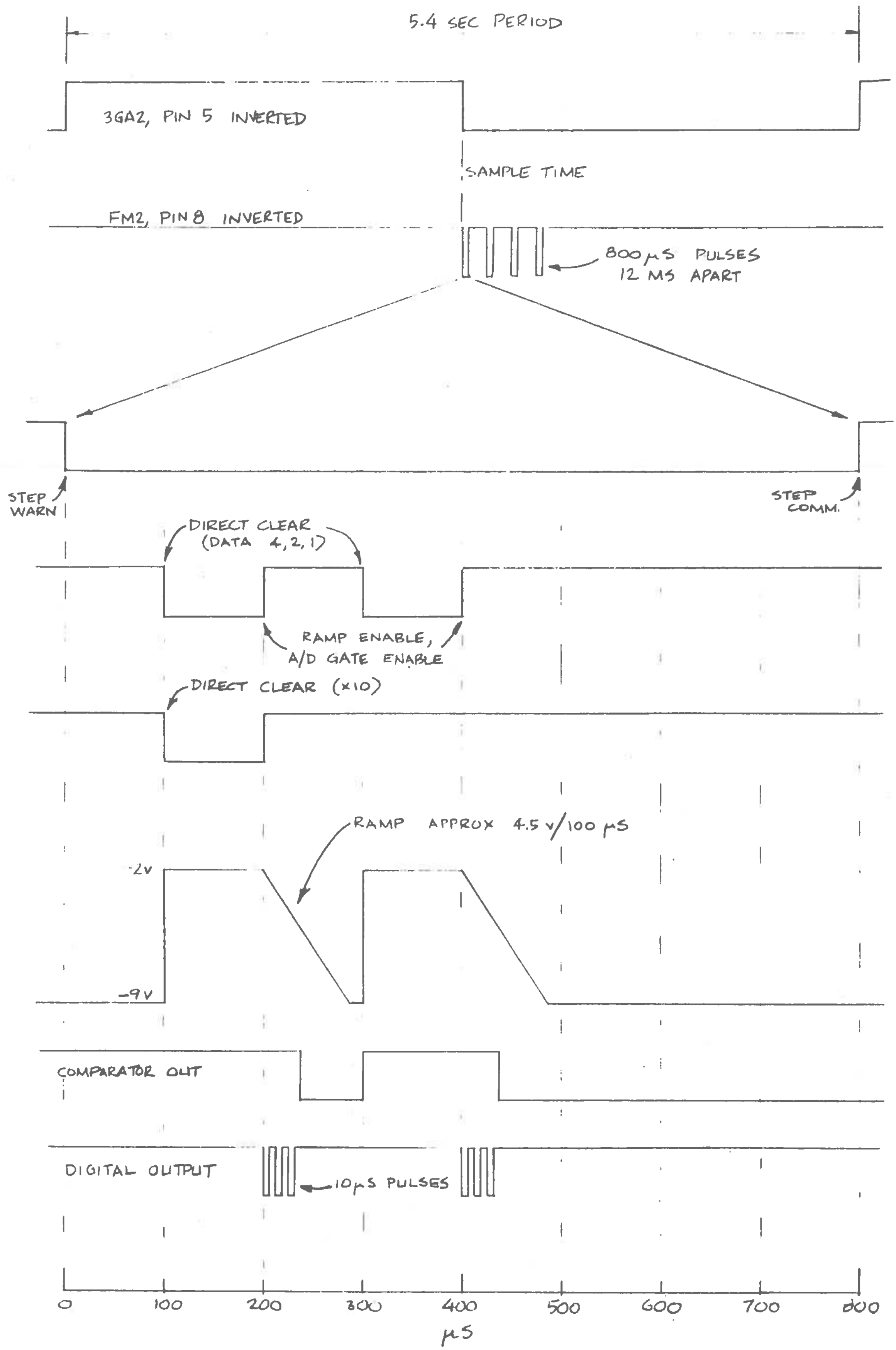


Fig. 13 Timing sequence for multiplexing and A/D conversion

TABLE IV TAPE RECORDER TIME CODE

Time (Hours)	Channel 1 A	Channel 1 B	Channel 2 A	Channel 2 B	Channel 3 A	Channel 3 B	Channel 4 A	Channel 4 B
2100	0	0	0	0	0	0	1	1
2136	0	0	0	0	1	1	1	1
2230	0	0	1	1	0	0	1	1
2306	0	0	1	1	1	1	1	1
0000	1	1	0	0	0	0	1	1
0036	1	1	0	0	1	1	1	1
0130	1	1	1	1	0	0	1	1
0206	1	1	1	1	1	1	1	1
0300	Sampling OFF							

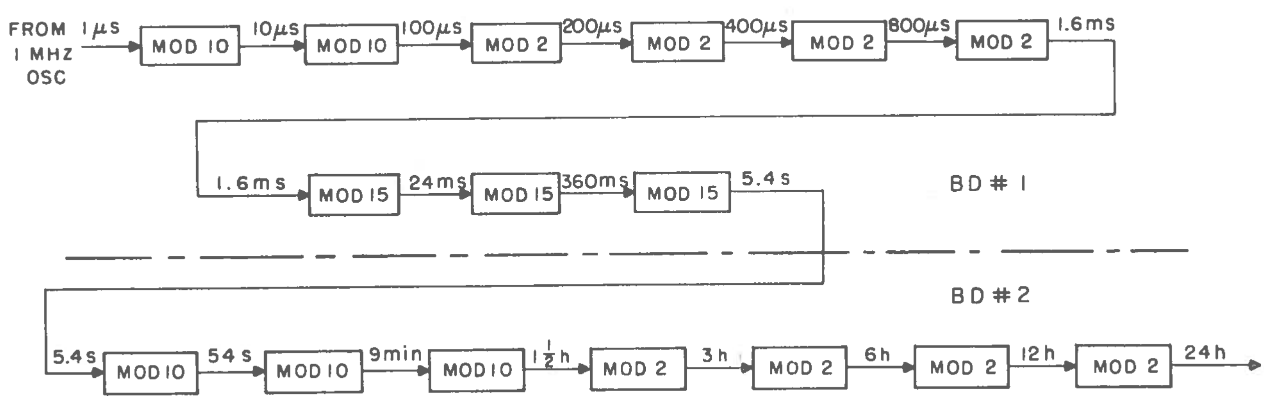


Fig. 14 Block diagram of timer showing frequency division scheme. Numbers above arrow indicate period of timing pulses at each stage.

To start the timer at a particular time of day, it was possible to disable (and reset) all the frequency division stages, and then manually to pre-set the last four stages to the desired time. The number of pre-settable stages was arbitrarily limited to conserve simplicity (and thus total power dissipation), and hence the timer could be started—correctly—only at integral multiples of $1\frac{1}{2}$ hours counting from midnight.

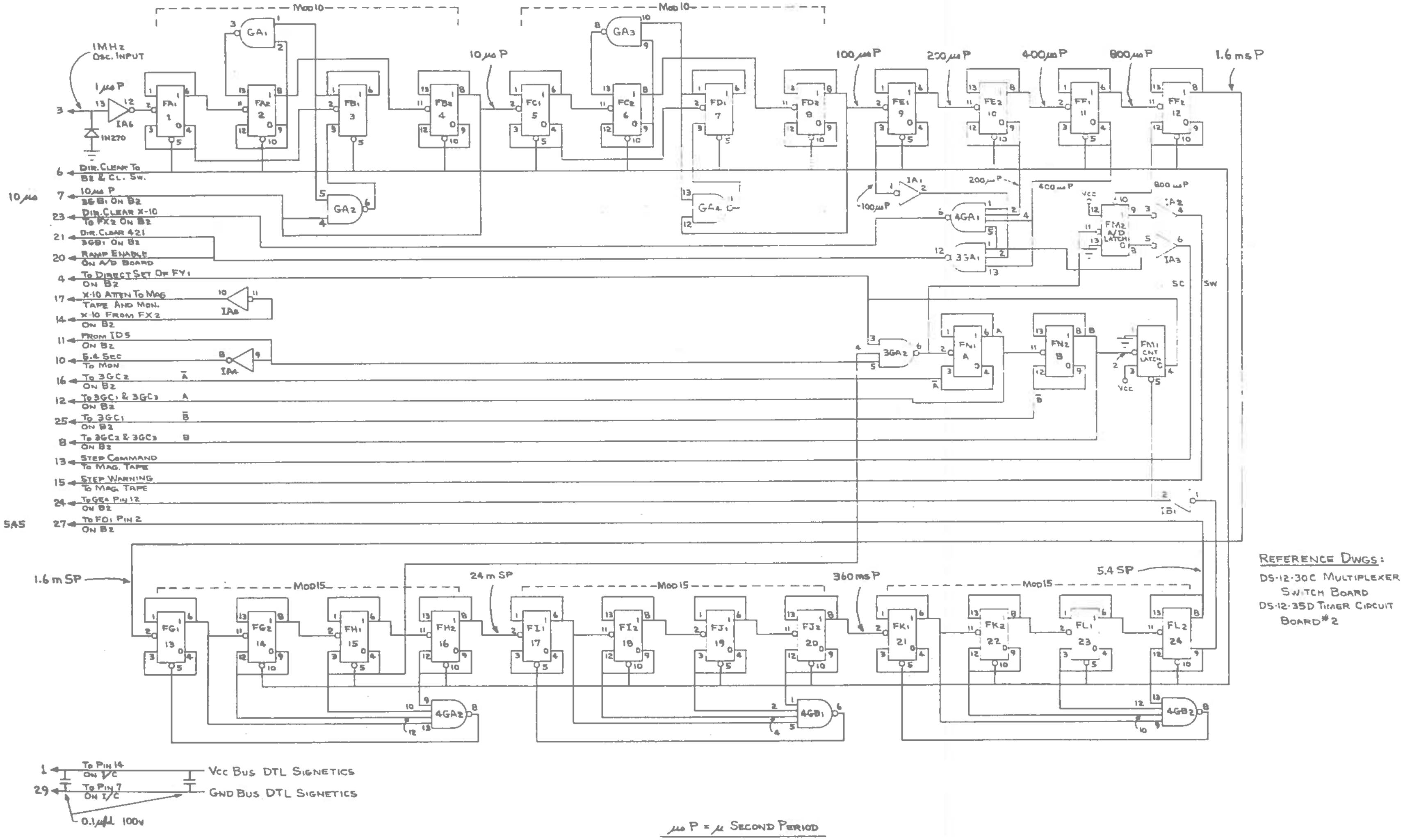


Fig. 15 Logic diagram of timer board No. 1.

Logic diagrams of the two rather complex boards which comprised the timer/controller frequency division stages are shown in Figs. 15 and 16. The inter-board wiring is shown in Fig. 17, and the cabling for the entire photometer system is shown in Fig. 18.

2.1.7 *Test Box*

A certain amount of specialized apparatus was required to monitor the operation of the photometer system after its installation. These circuits, shown in Fig. 19, were constructed inside a standard steel tool box. A switched multi-purpose voltmeter measured supply voltages in the system(± 13.5 V, +12 V, and +5 V), supply voltages in the test box circuitry (+6 V and +5 V, provided by a motorcycle type lead–acid storage battery), operating voltages for the 60-kHz WWVB receiver (see Section 2.2.3), and voltages read by a multi-scale probe. The test box also contained a custom-built strip-chart recorder for the WWBV time code, and a pair of headphones for listening to this code.

The major internal circuitry of the test box was designed to monitor and set the time as read by the timer/programmer unit, and to monitor the digital data input to the tape recorder. A display consisting of six lamps driven by six buffer units was manually switched to either *time* or *tape* input. The significance of the six lamps under each of these two configurations is shown in Table V. To set the time it was necessary to set a toggle switch on the timer/programmer unit to CLEAR and to trigger a push-button switch in the test box until the correct time was given by the four lamps labeled 24 HR, 12 HR, 6 HR, and 3 HR. The conditions of illumination for these lamps as a function of time of day is shown in Table VI.

TABLE V TEST BOX DISPLAY CODING

Input Mode	Lamp Significance					
Time	24 HR	12 HR	6 HR	3 HR	54 SEC	5.4 SEC
Tape	B	A	X10	4	2	1

The A/D converter could be field-tested by connecting a cable from the test box to the photometer system harness in place of the Channel 4 module. This channel was used for a test input point because the A/D converter electronics "remembered" the Channel 4 data during the 5.4-sec period between samples and they could therefore be easily seen on the lamp display. The timer/programmer was set to a time between 2100 and 0300 hours (i.e., when the system would be sampling) and a series of 16 analog

TABLE VI TIME-OF-DAY CODE

TIME	SAMPLING	24 HR	12 HR	6 HR	3 HR	EOR
1200	OFF	0	1	1	0	1
1330		0	1	1	1	1
1500		1	0	0	0	1
1630		1	0	0	1	1
1800		1	0	1	0	1
1930	↓	1	0	1	1	1
2100	ON	1	1	0	0	1
2136		1	1	0	0	→1
2230		1	1	0	1	→1
2306		1	1	0	1	→1
0000		1	1	1	0	→1
0036		1	1	1	0	→1
0130		1	1	1	1	→1
0206	↓	1	1	1	1	→1
0300	OFF	0	0	0	0	→1
0430		0	0	0	1	1
0600		0	0	1	0	1
0730		0	0	1	1	1
0900		0	1	0	0	1
1030		0	1	0	1	1
1200	↓	0	1	1	0	1

The 36 minute/54 minute intervals are shown during sampling period to indicate the times at which a record gap ("EOR") is generated.

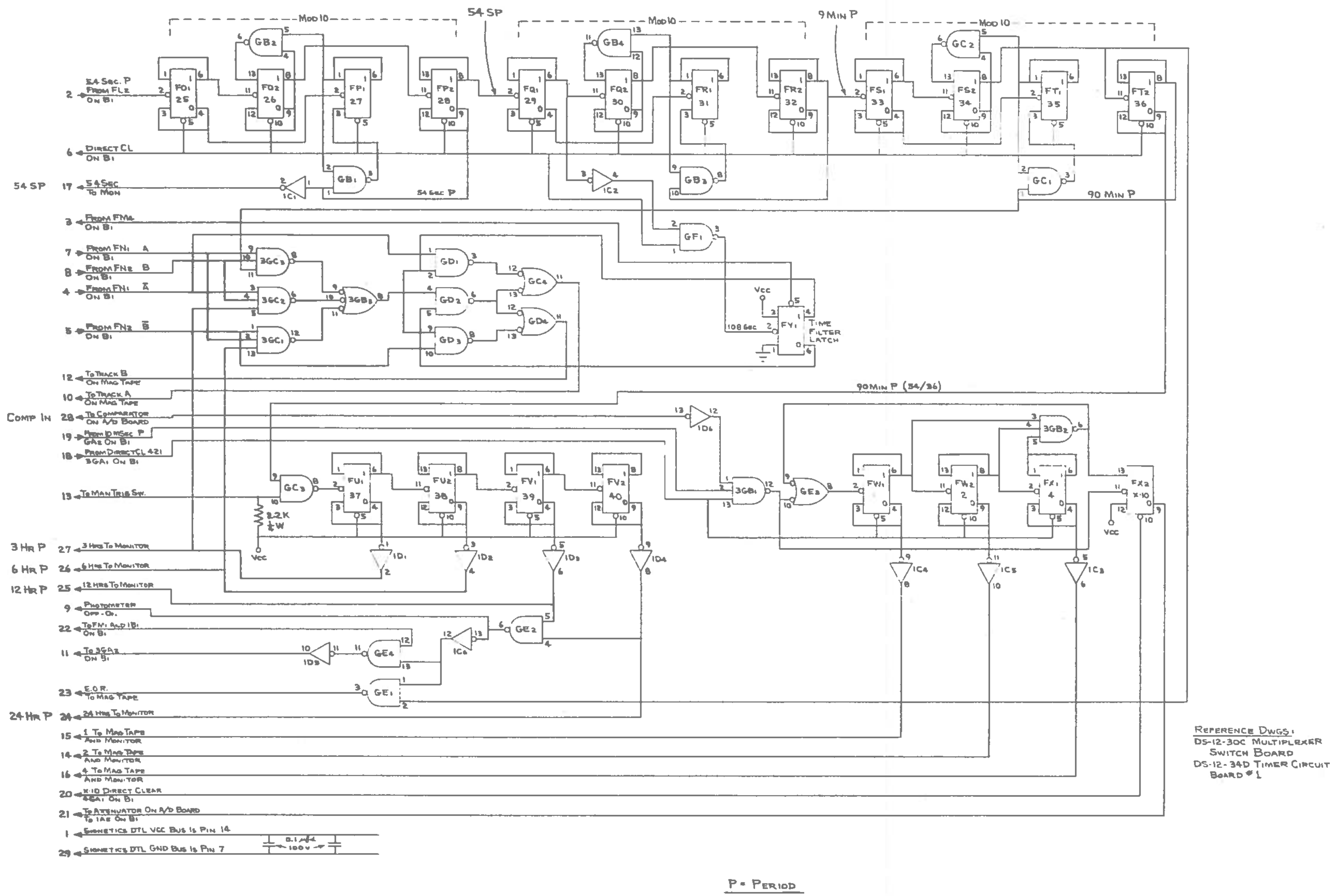


Fig. 16 Logic diagram of timer board No. 2.

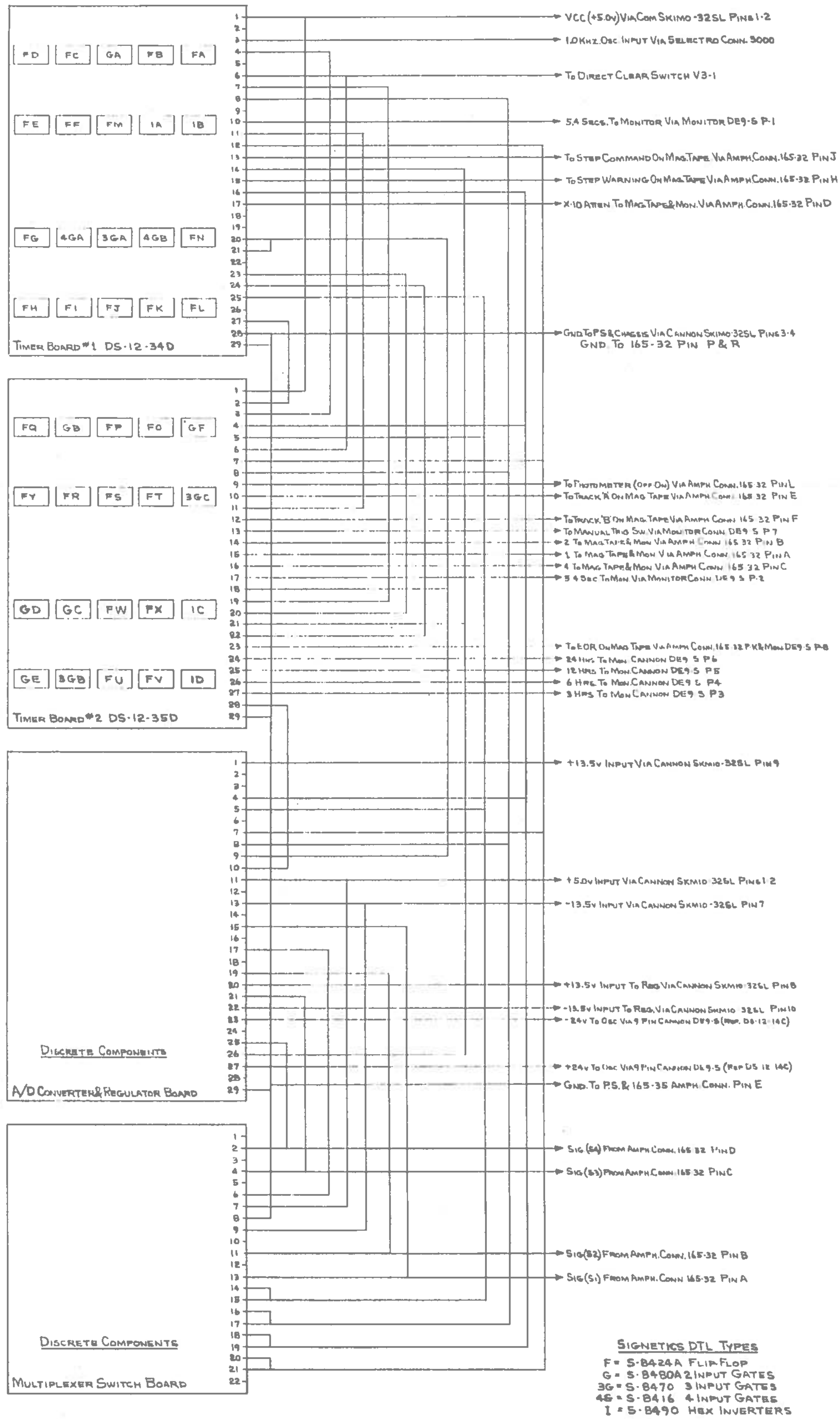


Fig. 17 Inter-board wiring diagram.

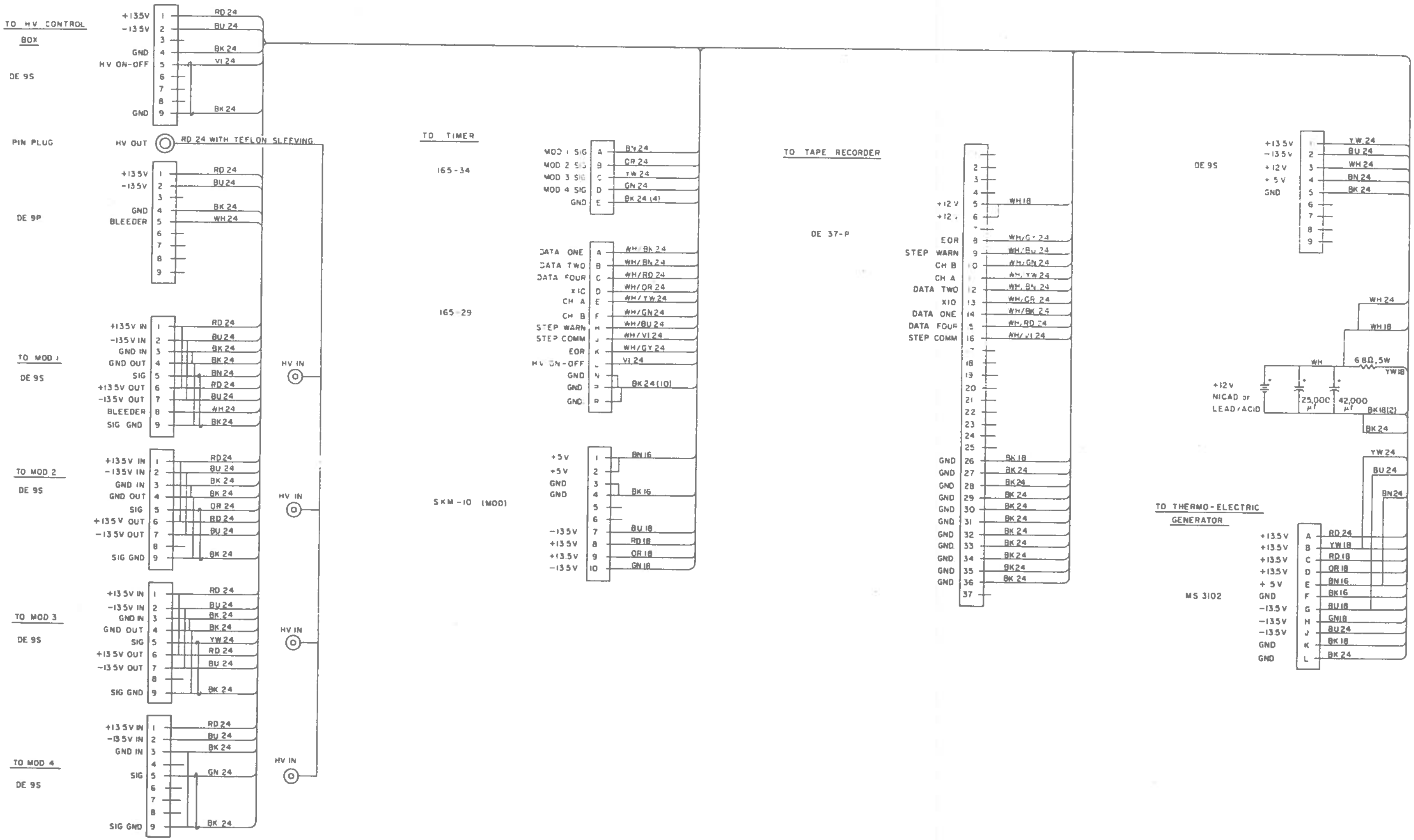


Fig. 18 Wiring diagram for photometer system cabling.

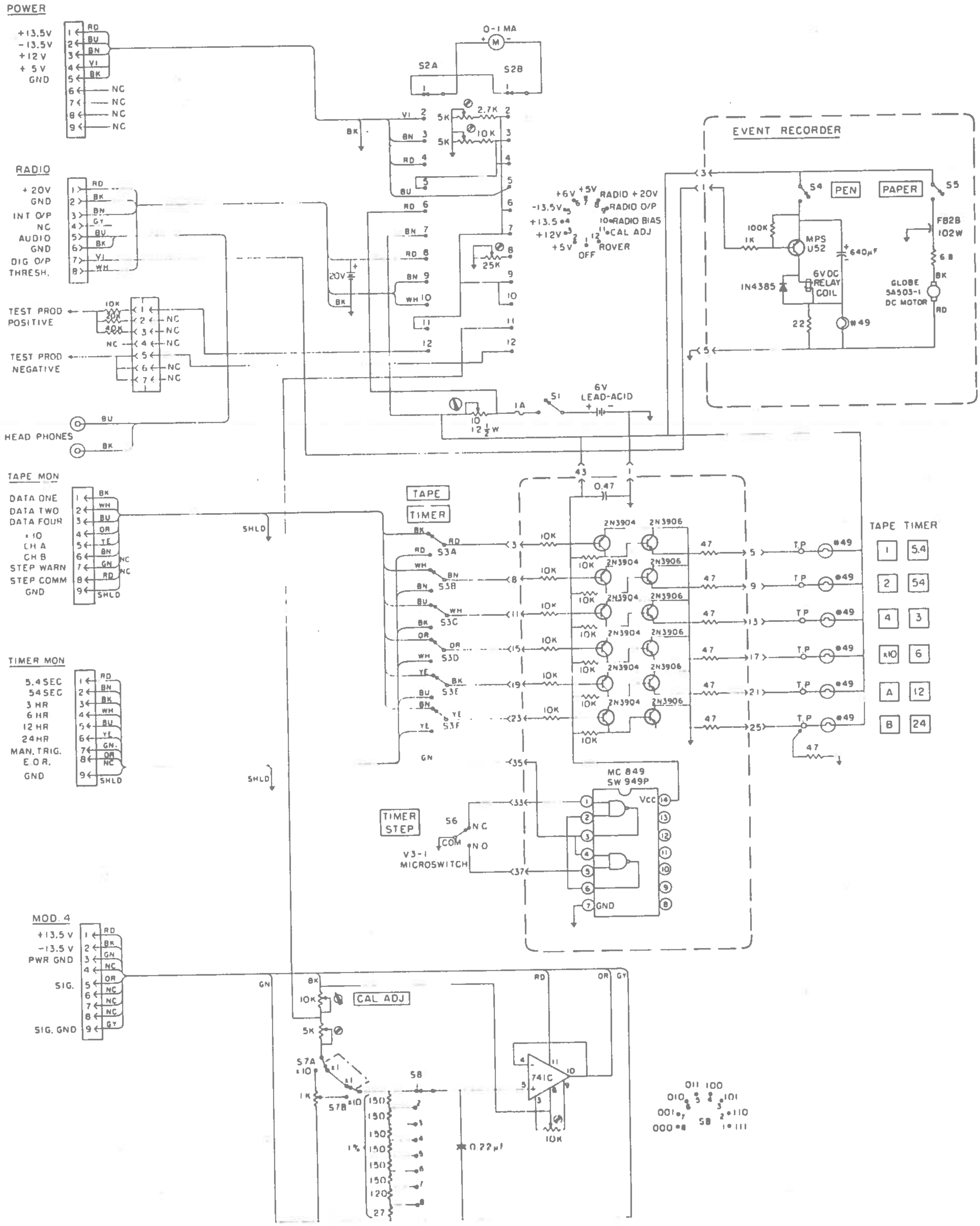


Fig. 19 Circuit diagram of test box.

voltages was applied to the A/D converter input, using a rotary switch and a toggle switch. The test voltages were chosen to lie in midrange for each of the digital steps shown in Table II, and thus each position of the switches corresponded to a definite code on the display lamps. It should be noted that this procedure did not perform an exact calibration in the field, but was simply an indication that the converter was operating at least close to its specifications.

It was mentioned in Section 2.1.4 that the high voltage applied to the photomultiplier tubes was measured by monitoring the current through a meter in series with the load. The test box contained for this purpose a 0–100 μA meter mounted upon an insulated plug, as well as a set of four black rubber stoppers for the apertures in the module housings so that the photomultipliers were in darkness during the test. These stoppers were fastened together, and to the test box, by a length of braided wire, to avoid inadvertently leaving them in place to blind the modules.

Finally, the test box lid was fitted with two plastic boxes which contained small special tools and spare parts for most of the system.

2.1.8 *Housing and Base*

The photometer system, exclusive of the TEG and propane tanks, was housed in an aluminum box insulated on all sides with a one-inch layer of urethane foam. The lid and front of the box were removable for access to the components inside, and were fitted with quick-release catches. The lid of the box was sloped to prevent water standing on the Plexiglas window, through which the four detector modules viewed the sky. One side of the housing carried a pressure relief vent screened and filtered with glass wool to exclude insects and blowing sand. Messages requesting passers-by not to disturb the equipment were placed on the outside of the housing, in Eastern Arctic Eskimo syllabics, English, and French; an NRC symbol and a decal of the Canadian flag were also affixed.

The housing and the TEG were mounted back-to-back using quick-release fasteners upon a rigid base welded from formed aluminum channel sections. Electrical power was carried from the TEG to the housing by a shielded cable fitted with waterproof connectors at each end. The four propane tanks were clamped to the corners of the base with modified hose clamps and were used as leveling feet to support and give solidity to the whole structure.

Front and rear views of the automatic photometer are shown in Plates IV and V; in addition, other photographs showing the systems are found elsewhere in this report.

2.2 **Timekeeping**

2.2.1 *General*

As explained in Section 1., *Introduction,* precise timing was of importance if meaningful correlations between Byrd and the northern stations were to be obtained.

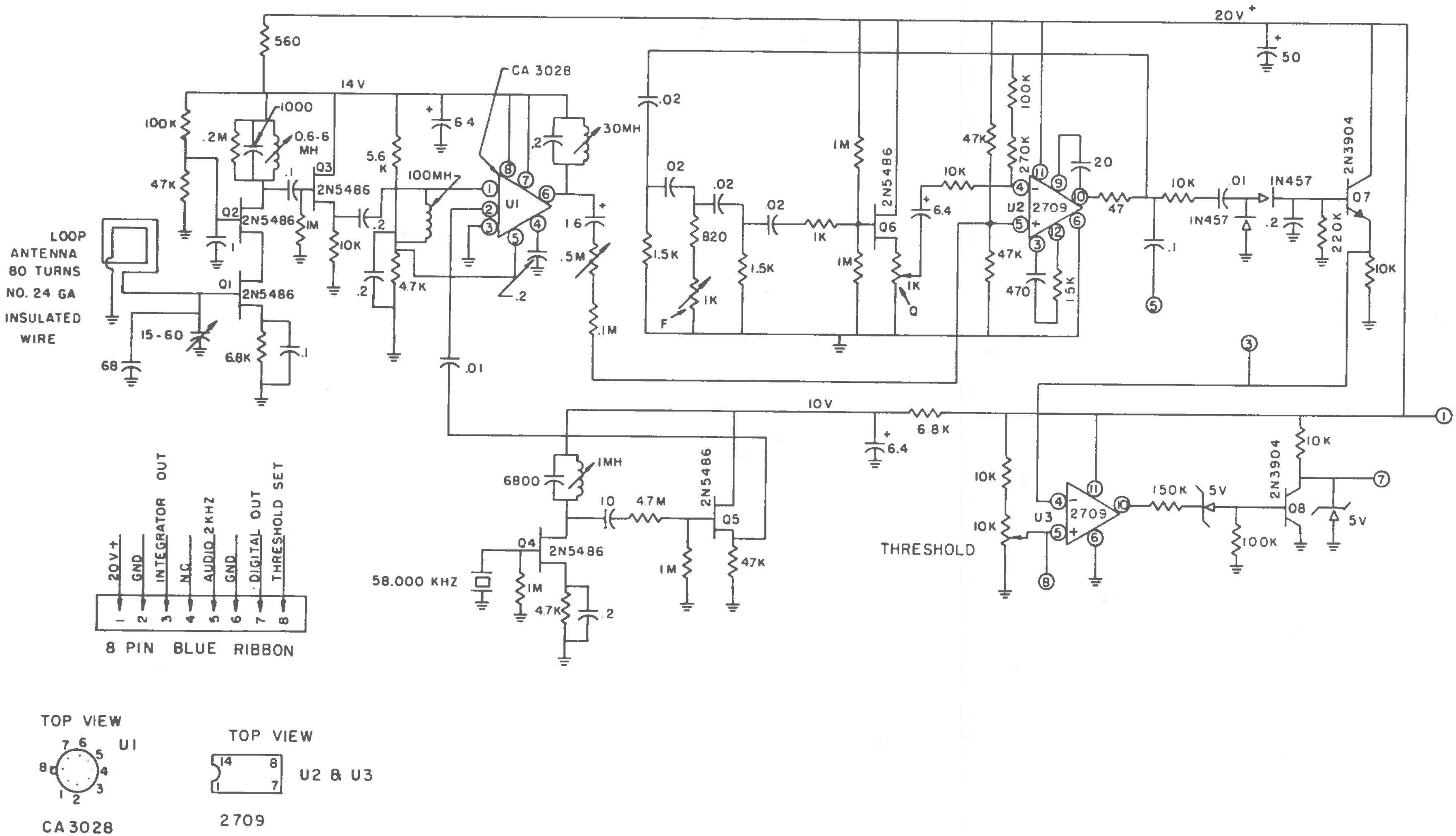


Fig. 20 Circuit diagram of 60 kHz receiver.

The crystal oscillators described in Section 2.1.6 gave promise of maintaining a very stable clock frequency during the two-month operating period, and so the problem of timing was reduced to that of starting each of the three timers at an accurately known instant.

The circuit designed by A. Staniforth of the Data Systems Section of the Division (Staniforth 1970) for automatically and precisely starting the timer from digitally detected time signals broadcast by CHU or WWV was found to be unsuable during field trials at Great Whale. The vagaries of radio reception in the area caused frequent and unpredictable lowering of the signal-to-noise ratio below the threshold level required for reliable operation. Hence it was decided to start the timers using the human ear/finger system as an interface between broadcast time signals and the timers. Although the response time is not as good as that of Staniforth's circuit, the human system will successfully operate with much lower signal-to-noise ratios.

Previous experience in the Great Whale – Belcher Islands area had shown that radio signals received there had a tendency to fade out at inopportune moments, such as just before the starting of a timer, and so a fair amount of redundancy was provided for in the timekeeping system described below.

2.2.2 *High-frequency broadcast time signals*

The most convenient sources of accurate time information were the voice and time-mark services broadcast by CHU, Ottawa, and WWV, Fort Collins, Colorado. A portable, battery operated short-wave receiver (Zenith Model "Royal 7000-1") was acquired on the recommendation of a colleague who had used one for this purpose at Resolute Bay, N.W.T.

2.2.3 *Low-frequency broadcast time signals*

It was considered extremely unlikely that all frequencies of CHU and WWV would be simultaneously unusable, but to guard against this contingency, a battery operated fixed-frequency receiver was designed and constructed to receive WWVB on 60 kHz. Its circuit diagram is shown in Fig. 20, and the finished unit in Plate 6. A shielded loop antenna was chosen over a vertical whip or horizontal wire for the following reasons: the shielded construction gives maximum immunity to natural interference sources such as distant lightning storms, which are mainly electrostatic in nature; the directivity of the loop yields some protection against man made interfering sources; and the physical configuration is small and compact. The 60-kHz signal from the loop is amplified by the FET cascode circuit Q1 and Q2, and is then coupled through the source follower Q3 to one input of the integrated circuit mixer U1. The crystal controlled local oscillator Q4 produces a 58-kHz signal which is fed, through the source follower Q5, to the other mixer input. The 2-kHz difference signal is then amplified by the tuned amplifier consisting of the integrated circuit U2 and its associated phase shift feedback network. The audio signal from the output of U2 is coupled to a high-impedance headphone through a 0.1-μF capacitor. The envelope of

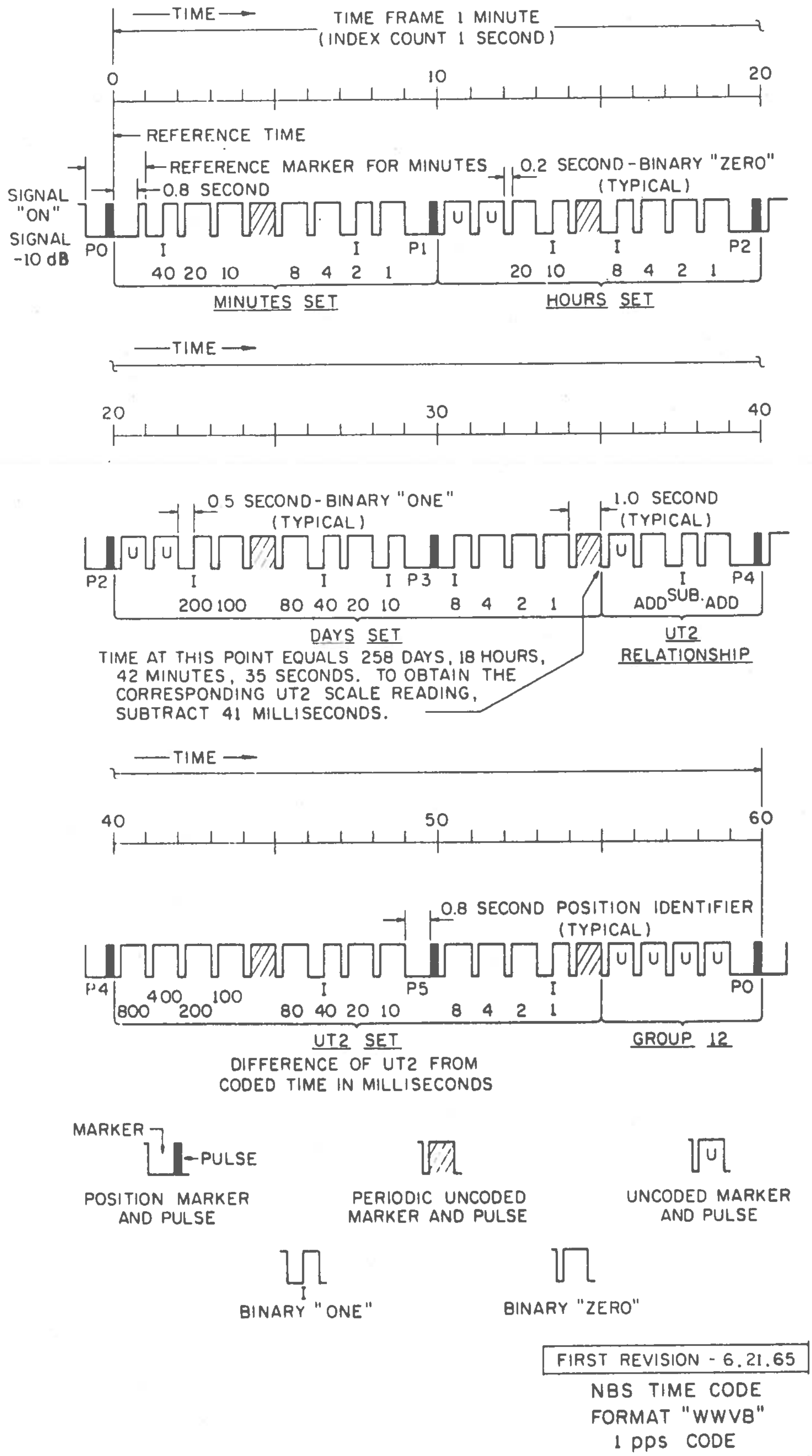


Fig. 21 Time code broadcast by WWVB.

the audio signal, which contains the time code information transmitted by WWVB, is detected by a simple diode—capacitor network, and buffered by the source follower Q7. At this point the time code pulse-train has quite severely rounded leading and trailing edges, because of low-pass filtering in the detector circuit. In addition to this, frequent noise spikes of various amplitudes are also present. Accordingly, the pulse train is fed to a threshold circuit U3 and thence to a saturating transistor Q8 followed by a zener diode clipper. The final output signal consists of a fairly "clean" train of zero-based positive-going 5-volt pulses with negligible rise and fall times. The time code embodied in the pulses is illustrated in Figure 21. A paper chart record of the pulse train could be made using the recorder built into the test box as described in Section 2.1.7 above.

2.2.4 *Chronometers*

To guard against the extremely unlikely situation of both high- and low-frequency time signals being unavailable, three different spring-driven watches were obtained.

(i) A naval deck watch was borrowed from the Department of National Defence. This timepiece, which would normally be used as a secondary or working standard aboard ship, was a fairly high-quality pocket watch mounted in a wooden box. Unfortunately, its rate was not only high (as high as seven seconds per day) but also extremely variable. No attempt was made to adjust it in any way, and it was decided eventually that it was too unreliable to be worth the trouble.

(ii) A railway conductor's pocket watch was borrowed from the father of one of the authors. There was no prohibition on adjusting this watch, and its rate was brought down to a fraction of a second per day. Its reliability appeared to be high enough to outweigh the minor inconvenience that very few contemporary trousers have watch pockets. Unfortunately, a few days before the scheduled departure date the watch stopped, and it was found that a near-microscopic pin had broken off at a strategic place in the escapement. It was not possible to repair it in time.

(iii) A pocket stop watch was taken for use as a transfer standard between radio time signals and the timer units. It was planned to start the stop watch approximately five minutes before the required starting time, in case fading occurred on the radio.

2.3 **Geological Collection**

2.3.1 *Background and references*

A number of meteor craters have been identified in various parts of the world, many of them in Canada (Millman 1971). It has been suggested (Beals 1968) that the nearly circular coastline of the south-east corner of Hudson Bay, extending from Cape Jones in the south to Bates Peninsula in the north, represents the remnant of what would be the largest, and one of the oldest, impact craters yet found. The coast forms an arc of radius about 140 miles, covering an angle of 155°, and centered just west of the North Belcher Islands. The age of some exposed rocks on the Belchers, and of the sediments which fill the circular basin, indicates that the feature is of the order of one or two billion years old. The Belcher archipelago might represent the central uplift characterizing many large impact craters.

Proof of the meteoric origin of the Hudson Bay arc would be very difficult to obtain. The feature's extreme age has resulted in severe erosion of the rim and the probable complete disappearance of material from the impacting asteroid. In addition, the existing portion of the rim indicates that the circular structure is tilted towards the west so that it is covered by thousands of feet of ancient sediments and about a hundred fathoms of salt water.

One apparently reliable proof of the impact origin of a crater is the existence of certain microscopic structures produced in quartz and some other minerals, at pressures greater than 100 kbar (Millman 1971). These are much greater than the pressures usually attributed to terrestrial volcanic processes, and the resulting deformations are therefore considered to be characteristic indications of high-energy impact.

2.3.2 *Procedure*

Dr. C.S. Beals suggested that the mineralogical examination of rocks from the Belchers would be valuable, and so it was planned to collect samples at the various sites visited during the trip. As none of the expedition members had any geological knowledge or experience, the search for rocks was deliberately limited to those of obviously crystalline nature, such as quartz or quartzite.

A prospector's pick was borrowed from the Department of Energy, Mines, and Resources, and a supply of labeled cloth bags was taken along in which to store and identify specimens.

3. RESULTS

3.1 Installations

The photometer at Site 1 was installed satisfactorily with some difficulty due to high winds, rain, and blowing sand. The A/D converter calibration was not nominal, but usable. Shortly before leaving the site it was noticed that the supply voltages were falling slowly, but rough seas made it imperative to leave immediately. When the installation was checked three days later the housing was found to be partly open but all system components in good order except that the timer had stopped. The propane pressure was increased slightly to improve the supply voltages. Timer No. 1 was replaced with timer No. 3 which was then calibrated to specifications. The station seemed in good order when left.

At Site 2, on Innetalling Island, the generator did not perform to specification. The generator from unit No. 3 was tried with no better results. The equipment was taken to Sanikiluaq Harbour and tested there where unit No. 3 was found serviceable, but not unit No. 2. (Back in Ottawa it was discovered that the propane burner orifice was slightly obstructed although nothing was visible to the unaided eye.) It was decided to abandon plans for Site 3 and to change the location of Site 2 to Sanikiluaq Harbour. The +5 V dc converter and the ±13.5 V dc splitter from unit No. 3 were found to be faulty and were replaced by their counterparts from unit No. 2. The composite photometer system was calibrated and left apparently in good order.

3.2 Operation and Resulting Data

Site 1 seemingly operated satisfactorily in most respects. A few hundred feet of tape were transported in the recorder, and the propane supply had run out by the time the site was revisited. A computer print-out of the magnetic tape data showed the final calibration (which was to specification) followed, however, by about two-months' worth of zero readings. A laboratory check of the high-voltage power supply revealed that its output voltage had inexplicably fallen to about 40% of the nominal value, resulting in a photomultiplier sensitivity of less than 1% of nominal. No explanation is available for this unexpected change in the high voltage, which resulted in the complete loss of all data.

At Site 2 (Sanikiluaq Harbour) the gas pressure and supply voltages were about half their nominal values, and the timer had ceased to function. Only about ten feet of tape had been transported in the recorder and the reel hubs were found to be loose. The computer print-out consisted of a few fragmentary records. All this would indicate that the recorder had not been started correctly, even though the tape appeared to be transported correctly during the on-site calibration process. A laboratory check on the high-voltage supply from Site 2 revealed that it too had undergone an unexplained decrease of output voltage.

To sum up, one of the three automatic photometers could not be installed because of a faulty generator, and the other two produced no data because of faults in their high-voltage supplies (and, apparently, an incorrectly loaded tape recorder at Site 2).

3.3 Geological Samples

At Site 1, five samples were collected. At Mine Lake and the nearby beach on Innetalling Island, 11 stones and 6 pieces of old drill core were picked up (Plates 7, 8, and 9).

4. LOGISTICS

4.1 Transport

In the early planning of the expedition, it was tacitly assumed that movement of personnel and equipment to the Belcher Islands would be by aircraft, the traditional northern means of transportation. A large, amphibious aircraft based at a nearby point would be necessary, a requirement satisfied only by one of the Cansos owned by Austin Airways and based at Moosonee, Ontario (and later, at Povungnituk, Quebec). At the end of the 1970 summer season, only two such machines were airworthy, one fitted with Plexiglass "bubbles" on the after part of the fuselage, and one modified to have an all-aluminum skin with a fairly large freight hatch. Since the three installations were to be made at uninhabited sites, plane-to-shore movements would require a small boat carried by the aircraft itself. A minimum of time and bother involved in boat launching and securing was desirable because of the danger of sudden unforeseen changes in weather conditions. Hence, rather than using a standard canoe lashed to the wing struts, a special, nine-foot dinghy was designed and constructed to fit inside a Canso fuselage. This craft, named "Belcher Oar-driven Airborne Transport" (BOAT for short) was taken to Mount Hope, Ontario, in November 1970, to be fitted into the two Cansos, then in winter quarters. A partially designed device intended to facilitate launching and securing, and called "Retractable Airborne Marine Platform", or RAMP, was found to be superfluous as a result of these tests.

A second, and much more important result, came out of a discussion with Austin's chief pilot, Mr. Bruce McManus, during which it became apparent that it would probably be too hazardous to service Site 1 from an aircraft, because of the complete absence of any shelter and the probable presence of shoal water around the island. At this time no definite decision was made against the use of aircraft, but the seeds of doubt were planted. The difficulty remained that there seemed to be no realistic alternative. It was thought that no boats were available and a chartered helicopter was so expensive that it was completely out of the question.

One week following the return from Mount Hope, during a visit to the offices of the Geodetic Survey of Canada, it was discovered that several small vessels available for hire were indeed to be found in the general area of the Belcher Islands. Inquiries were made through officials of the Department of Indian Affairs and Northern Development, and the Government of the Northwest Territories, and finally arrangements were made to charter M.V. *Joan Ryan*, a 40-foot longliner owned and operated by the Metiq Co-op at Sanikiluaq Harbour, Belcher Islands. This vessel turned out to be a sturdy and fairly well kept little craft (Plate X), with a hold capacity almost exactly equal to the amount of cargo taken on the expedition. The boat was powered by a 6-cylinder Perkins diesel engine, and was equipped with a good compass, an echo-sounder, and a two-way radio. The crew were all natives of Great Whale or the Belcher Islands, and knew the local waters intimately.

Shortly before the second trip of the expedition was to begin, late in September 1971, a message was received from the Belchers to the effect that the *Joan Ryan* was *hors de combat* because of a broken transmission. A flurry of telephone calls and telex messages resulted in a technician flying to Sanikiluaq Harbour on a charter flight from Churchill, then on to Great Whale. Following this arrangements were made to charter M.V. *Baie du Nord,* a Quebec government-owned 65-ton trawler which was at Great

Whale at the time. This was a considerably larger vessel than *Joan Ryan,* a fortunate circumstance in view of the rough weather encountered.

Considering the wide variety of modes of transportation that were used, it is somewhat ironic that the most frustrating delay occurred when the commercial air carrier from Montreal to Great Whale left all the propane tanks in Montreal for three days while the personnel and remaining equipment went to Great Whale. This omission was never satisfactorily explained.

4.2 Navigation

A somewhat unexpected complication in the problem of choosing suitable sites for the automatic photometers was the uncertainties in maps of the Belcher Islands and surrounding waters. This is not surprising, however, in view of the fact that the larger islands, although nearly 100 miles long and 40 miles wide, were only "discovered" in 1913 and partially explored in 1915 (Flaherty 1918). The coastlines of the main island group were well delineated by air photos made in 1952 and 1957, and a complete series of maps to a scale of 1:50,000 was integrated into the National Topographic System in 1961. However, the multitude of shoals, reefs, rocks, and islets between the main archipelago and the Quebec coast remained nearly unknown until the Aerodist survey of 1963, which permitted air photos taken over open water to be located accurately relative to the mainland through the use of airborne electronic position-finding equipment. An exact knowledge of the locations (and sometimes even of the existence) of these small islands was necessary when choosing Site 1.

It is perhaps worth mentioning that the latest edition of Hydrographic Chart No. 5003 *Hudson Bay (Southern Portion) and James Bay,* updated to May 10, 1968, showed a trio of fairly large islands at 55°45'N, 78°12'W, with the notation PD (meaning position doubtful). (This was in addition to several smaller islets and shoals found on the Aerodist survey, including the one at 55°56'N, 77°56'W, which was eventually chosen as Site 1.) The size and close spacing of these three islands made them attractive as possible sites because of the shelter they would afford to small vessels or even aircraft. However, an inspection of the original air photo films made it abundantly clear that no land actually exists at the positions shown on the chart. The islands were the result either of mistaken sighting, perhaps through fog, mist, or rain, or else were located incorrectly because of an error in the navigation of the ship which saw them. The Canadian Hydrographic Service takes the admirably cautious attitude that it is better to include non-existent hazards on a chart than to remove a possibly real one. The January 8, 1971 edition of Chart 5470 *Belcher Islands* does not show these three islands, and interestingly indicates the other islets in the area, including Site 1, as PA (position approximate).

An unpublished large scale chart of Site 1 was obtained from the Hydrographic Service; this and a 20 X 20 inch air photo of the island provided valuable aids in planning the approach and installation.

The 1:50,000 series maps of the National Topographic System were quite adequate for locating and planning Sites 2 and 3. Hydrographic Chart 5470 *Belcher Islands* and a geological map of the Belchers (Jackson 1960) were also used for reference.

4.3 Camping

After the decision had been made to charter a boat for the expedition, rather than an aircraft, it was immediately evident that the installation trip would take at least a few days. The fo'c'sle on the boat was too small to accommodate more than the crew, so it was necessary to acquire overnight camping gear for three men. Some of this equipment was borrowed from the Technical Field Support Services of the Department of Energy, Mines and Resources, some was re-used from the 1967 Belcher Island expedition, and some of the smaller items were purchased locally in Ottawa.

A number of items of camping gear were not in fact used, because of unforeseen circumstances. It was realized beforehand that this would likely be the case, but it was considered better to take equipment that might not be used, than to feel the need of some missing item.

A list of camping equipment is given in Appendix A.

4.4 Personnel Protection

The native fauna of the Canadian sub-arctic include a few species which threaten human comfort or even survival. Acting on the advice of experienced northern travellers, a small arsenal of protective devices was assembled, which consisted of:

(a) insect repellent, in aerosol cans and pocket-size sticks; anti-mosquito head nets;

(b) 6 aerosol containers of dog repellent spray;

(c) several large friction-ignition firecrackers;

(d) a 30-06 rifle with 20 rounds of ammunition.

Items (c) and (d) were included in the unlikely event that a polar bear (or rabid fox or dog) was sighted. All available information from the Canadian Wildlife Service indicated that no bears would be seen around the Belchers in summer, and conversations with a field naturalist encountered at Sanikiluaq Harbour confirmed this. In fact the insect repellent was "the only shot fired in anger", so to speak.

A fairly well-stocked first aid kit was assembled and taken along, but it is perhaps typical of such arrangements that on the only occasion on which it was needed the kit was snugly packed away in the hold of the *Joan Ryan*, riding at anchor offshore, while the accident victim was bleeding freely on dry land.

Each member of the field party was provided with a vest-type life jacket on loan from D.E.M.R.

4.5 Victualling

A menu was planned to feed three men for 10 days on the first trip, and two men for 5 days on the second. Since there would be no base camp, but the party would be effectively on the move continually, most of the food was chosen in unit sizes that would be consumed at a sitting. Cans or other waterproof containers were used whenever possible because of the wet conditions that would be encountered aboard ship. The food was assembled into packages sufficient for one day's rations for three men, and the packages were then sealed in polyethylene sheeting for moisture protection. Appendix "B" contains a detailed list of food items that were taken.

An emergency kit was made up for use in case accident or weather separated the shore party from the boat. This consisted of a knapsack containing two Sterno stoves, a supply of freeze-dried foods, and utensils and messkits. The only item of which use was made, was a roll of toilet paper. Hindsight indicates that first aid supplies should have been included in the kit.

4.6 Clothing

A number of years of pooled experience in the arctic, and more particularly at Great Whale, during both summer and winter weather, had led to a choice of clothing which was considered suitable for the Belcher expedition. It was realized beforehand that the boat trip would very likely be windier, damper, and generally more bone-chilling than previous tours of duty, and more attention was therefore paid to waterproof outer clothing than was usual. In spite of all this planning, it was found that the effects of open water and unheated quarters had been underestimated, to say nothing of the overall lowering of resistance due to seasickness, and the lack of hot food during rough weather cruising.

The philosophy of wearing many layers of clothing so that some could be removed or added in case of changing conditions, was adopted; while useful in general, the idea fell through somewhat because of the difficulty of getting at duffel bags in the sealed hold of the *Joan Ryan* when she was under way. A list of typical clothing is given in Appendix "C".

To sum up, it is recommended that full arctic kit (including the warmest parka available) be worn on any future boat trip in this area, even during high summer.

4.7 Communications

The crew of the *Joan Ryan* all understood English to some extent, but did not apparently feel competent to carry on a lengthy conversation. All discussions with the captain were transmitted by the interpreter, a teen-aged Eskimo boy who had been educated in English.

A pair of portable medium-frequency (4 MHz) transceivers was borrowed from the Department of Energy, Mines and Resources, to use as a ship-to-shore link. However, when tested before the trip, they were found unsatisfactory because of the great length of antenna required (about 100 feet), and a general lack of sensitivity. Shortly before the expedition left Ottawa, two portable Citizens' Band transceivers operating in the 27-MHz region became available through the Division, and these were used at Site 1 for communications between the *Joan Ryan* and the shore party. At Site 2 and subsequent stops, the vessel anchored close enough onshore that use could be made of the time-honoured and reliable technique of waving the arms and shouting.

The *Joan Ryan* was equipped with a radio transceiver having four crystal-controlled channels tuned to standard marine frequencies in the medium frequency band. Contacts were made with Sanikiluaq Harbour and with Great Whale at pre-arranged times.

Both settlements are connected to the continental long-distance telephone system, but contact is very seldom satisfactory because of the need to go through a noisy (and often "busy") radio link. The best routine means of communication was found to be a telex message between Ottawa and Churchill, followed by a radio-teletype message from Churchill to Great Whale. Personal messages from Great Whale to Ottawa were sent using facilities provided by radio amateurs.

5. ACKNOWLEDGMENTS

In a project which extends over a period of several years, one becomes indebted to many people in many places – probably too many to be mentioned by name. The authors wish to express their gratitude to all these benefactors who must remain anonymous, and who would probably maintain that they were simply doing their jobs.

During the year or so preceding the expedition, and while on the trips themselves, many people often went out of their way to be helpful beyond the call of duty, and we would like to mention some of these.

In Ottawa, we thank the Departments of Energy, Mines and Resources, and Defence, for the loan of equipment. In addition, we received much good advice from various persons in Indian Affairs and Northern Development, Energy, Mines and Resources, and the Canadian Wildlife Service. In Churchill, our logistics problems were eased by people in the Government of the Northwest Territories and Transair, Ltd. We are grateful to the DIAND representatives at Great Whale for permitting us to make use of their radio equipment, and to the resident NRC staff there for their help and support in all the problems and tasks that came to hand. Finally, words cannot really express our gratitude for the warm hospitality we received from Don McCoy and his people on the Belchers.

We should like to record here our appreciation of the excellent and business-like treatment we received from the crew of the *Joan Ryan* and generally from the Metiq Co-operative at Sanikiluaq Harbour.

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APPENDIX A — CAMPING EQUIPMENT

QTY	ITEM	SOURCE
2	Tents, "Mount Logan", double walled	DEMR
15	Tent pegs, magnesium	DEMR
1	Sledge hammer, $2\frac{1}{2}$ lb	DEMR
3	Campcots, metal folding	DEMR
3	Mattresses, plastic foam	DEMR
3	Sleeping bags, 4 lb filling	NRC
3	Mess kits	NRC
2	Water containers, folding	NRC
3	Flashlights, waterproof	NRC
1	Teakettle	NRC
-	Utensils, miscellaneous	NRC
2	Fire extinguishers	NRC
2	Tarpaulins, plastic, 10 ft × 12 ft	NRC

APPENDIX B — FOOD LIST

JUICES

3	20 oz cans	orange juice
6	"	apple juice
3	"	grapefruit juice
4	"	tomato juice

SOUPS

2	cans	vegetable soup
1	can	chicken rice soup
1	can	scotch broth
2	cans	"chunky" vegetable soup
1	can	pea soup

MEATS

4	cans	luncheon meat
3	cans	bacon
2	cans	corned beef
2	large cans	beef stew
3	cans	salmon
3	large cans	spaghetti and meatballs
4	20 oz cans	chicken and dumplings
4	1 lb cans	chicken
2	$1\frac{1}{2}$ lb cans	ham
4	1 lb cans	braised beef steak
2	24 oz cans	meat balls
1		salami

VEGETABLES

1	20 oz can	baked beans
8	"	potatoes
2	15 oz cans	carrots
2	"	peas
2	"	yams
2	12 oz cans	niblet corn
2	15 oz cans	tomatoes
2	15 oz cans	beets

FRUITS

3	20 oz cans	fruit cocktail
2	"	peaches
2	"	pears
16	1 oz boxes	raisins

BREADS

1	pkg	Farley's biscuits
1	"	Graham wafers
2	1 lb pkg	oatmeal cookies
2	pkgs	bread sticks
1	pkg	rye crisp
1	pkg	soda crackers
1	1 lb pkg	fruit cake
2	cans	date and nut loaf

CEREAL

1	pkg (9 servings)	instant porridge

BEVERAGES

2	10 oz jars	instant coffee
20	1 oz pkgs	instant hot chocolate
90	bags	tea
1	4 oz jar	bouillon

CONDIMENTS

1	lb	white sugar
2	lb	brown sugar
1	16 oz jar	powdered "cream"
1	8 oz pkg	chocolate chunks

HOUSEKEEPING SUPPLIES

4	rolls	toilet paper
12	pkgs	wooden matches
1	pkg	"J cloths"
24		plastic cups
6		large garbage bags
1	8 oz bottle	liquid detergent
2	bars	hand soap

APPENDIX C - CLOTHING

The following is a typical list of clothing provided for or worn by each member of the party:

undershorts

singlet or cotton T-shirt

thermal underwear ("long johns")

light wool sox

heavy wool sox

light shirt

heavy wool shirt

lined jeans or workpants

ski jacket

parka liner

rain coat (yellow nylon)

hat (sou'wester also available)

insulated rubber boots

foam-lined gloves

(hip waders also available)

waterproof duffel bag for storage

APPENDIX D - DIARY

D.1 INSTALLATION TRIP

Friday, July 23, 1971

0600 Mike Watson picked up at M-50 by NRC driver in station wagon, then to George Attallah's house to get George and three timer units on standby power in his basement.

0645 Picked up Vic Cyr.

0845 Arrived Dorval, checked in at Nordair counter. Box with timers rolled down luggage conveyer but no damage other than to Mike's nerves.

0930 Nordair advised that flight was delayed due to bad weather at Great Whale.

1430 Nordair cancelled flight. Retrieved luggage and timers, and checked in at International Motel, near airport. Omitted to bring along small screwdriver to connect timers to standby power supply, so had to buy one.

Saturday, July 24, 1971

0900 Nordair phoned delaying flight again.

1100 Ditto, flight cancelled. Montreal is not too bad a place to be marooned.

Sunday, July 25, 1971

1000 Left Montreal on Nordair, arrived Great Whale just in time for dinner.

1300 Inspected M.V. *Joan Ryan* (Plate X). Surprising how big a forty-footer looks in the Rideau, how small in the Great Whale! Boat seemed sturdy enough, paint-work and cordage in good condition. Arranged to leave next day.

Picked up equipment at Nordair office, found no propane tanks. George Legault, Nordair agent, queried Montreal; they advised propane bumped in favour of food shipment. Legault disagreed, but nothing to do but wait until next flight (Tuesday).

Monday, July 26, 1971

Worked on equipment at Great Whale Geophysical Station. Peter Burns had things in excellent shape. Mike sent telegrams to P.M. Millman at NRC and Jim Powell, Nordair cargo manager, requesting expediting of propane shipment.

Tuesday, July 27, 1971

Nordair cancelled flight again. Loaded equipment on *Joan Ryan* (except propane) and met interpreter, Charlie Takatak. Boat crew members are named Jimmy Mickeyook, (captain), Lucassie Inuktaluk (mate), Jobie Crow (deckhand). Also Moses Apakak, a passenger working his way. Vic, George and Peter Burns familiarized themselves with radio belonging to Indian Affairs: this will be our link between *Joan Ryan* and Great Whale.

Wednesday, July 28, 1971

Nordair flight finally made it. Loaded propane on boat, arranged to leave 0500 Thursday.

Thursday, July 29, 1971

0430 Peter drove us down to river. Crew still sleeping in village.

0545 Anchors aweigh.

0600 Breakfast in fo'c'sle — cold ham, bread, coffee. Four-foot headroom and seal-skin blankets made crew's quarters cosy but pungent.

0630 Crew had breakfast. Passengers sat in deck house, aft of wheelhouse. Room for 2 on bench resembling pew in Baptist church for straightness and firmness. Third man must sit on threshold of wheelhouse, which had ½-inch square door-stop nailed to it. Human anatomy not really well designed for this shape of seat. Engine exhaust and muffler located in wheelhouse making it stinking hot (literally). Later discovered muffler red hot, inside layer of ½-inch asbestos rope. Had to step outside for fresh air quite often.

0800 Heading 010 magnetic, 350 true. Right on. Rain falling; ice floes around us. Out of sight of land. Sighted a few seals and gulls.

0830 Rain and fog. Jimmy saw a white whale.

0930 Coffeetime. Vic talked to Peter on radio. Lucassie demonstrated toilet facilities, hanging suspended over wake of boat with feet braced on transom and hands gripping guardrail. We decided to wait for shore leave. Charlie and Moses asleep in fo'c'sle.

1020 Land ho! Site 1 was just where it was supposed to be. Jimmy circling island looking for suitable anchorage. Saw more seals. Rain again.

1100 Dropped the hook about 200 yards to north of island, in shoal water (*this* is a suitable anchorage?). Launched the canoe and loaded in gear for Site 1 installation. Mike, George, Vic, Lucassie and Moses formed shore party. Island very low and windswept — all rocks, from head-size down to very coarse black sand. Low, creeping vegetation above tide-line, driftwood at all levels (island probably awash during storms!), clam shells, sea urchin shells, bits of bone (gull and probably seal), and one beat-up woman's shoe (the shoe, not the woman). Set up photometer unit on a high spot. Had to use plastic tarp for shelter from wind and rain. This site had a lead-acid storage battery for the tape recorder, and battery was accidentally left aboard, so called *Joan Ryan* on Citizen's Band radio and asked Charlie to bring it ashore. Time signals loud and clear on CHU at 7.3 MHz using Zenith portable receiver.

1230 Rain stopped but wind freshened considerably, from west. Sea roughening up.

1300 Started timer unit at 1200 Standard time, on schedule. Generator voltages starting to fall alarmingly but high winds coming up made it necessary to leave.

1315 Packed up and ready to go. Because of surf canoe had to round island to eastern end and land on lee shore. Return trip to *Joan Ryan* was cross-wind, then up-wind, and very rough. Canoe was shipping water so that Lucassie, in the stern, was standing in 6 inches of water. At this time Mike began to turn slightly green. The long-liner was pitching alarmingly and waves came very close to slopping into the open hatch. The freeboard amidships was only about 2 feet under calm conditions. All equipment was quickly stowed and the crew hurried to batten down the hatch and secure the canoe crossways on deck. Even the boom was lowered and lashed down three ways. Shortly after leaving Site 1 Mike became extremely green and staked out a claim to the rail on the port side, aft. Periodically Jimmy would heave to, the boat's motion would ease off, Jobie would pump out the bilge, and Mike would feed the seagulls. The waves were running an average height of 5 or 6 feet from crest to trough.

1600 Oatmeal cookies for George and Vic. Mike wondering whether to live or die.

1900 Still rocking and rolling. Passed two small islands, indicating *Joan Ryan* on right course, and reassuring all hands that this will end sometime.

2030 Have now entered Omarolluk Sound through Ridge Passage. Waves were not as high as in the open water and we were running with the wind, which reduced pitching considerably. Sun appeared and morale improved greatly. Sighted Eskimo tent on north side of Ridge Passage.

2040 Arrived Site 2, abandoned iron mine on Innetalling Island. Unloaded propane and generator unit, started generator to warm up overnight. Jimmy took *Joan Ryan* to east side of Camp Islands for the night. Decided to sleep in hold since it was only partially filled now. Set up Coleman stove in open hatch.

2145 Supper – soup, tomato juice, chicken, tea – George and Vic ate with apparent gusto, Mike with some caution. Jimmy and Moses went hunting in canoe after dark and returned with no game, but with garbage pail of fresh water.

2230 After doing dishes, arranged cargo to make room for sleeping. Three sleeping bags on two foam mattresses, heads and feet touching crates fore and aft. During the night we changed positions (to ease circulation) by rolling over in unison. When rain began Vic crawled out and shut partially-open hatch-cover. Calm and restful night.

Friday, July 30, 1971

0800 Crossed back to Site 2, *Joan Ryan* rolling on her beam-ends in a fresh southerly breeze. Found output voltages low on generator, so increased gas pressure. While waiting for generator to respond we explored the site. Beach quite steep, covered with cobbles, terraced back to steep rounded hills 100-200 feet high. Wide flat area climbing up over ridge to mine camp on Mine Lake. Squared timbers left near beach, good condition. Mine camp site marked only by rusted scraps of metal. Picked up several rock samples, some nice crystalline quartz plus a few bits of drill core. Checked generator output again; voltage still too low. Mike tried to split one large quartz sample to fit into cloth sample bag — on second blow, prospector's pick slipped and gashed end of middle finger on his left hand. First aid kit packed away in hold of *Joan Ryan*, anchored offshore (Plate XI). Finger bound up with clean rag from toolbox. Got third generator from *Joan Ryan* to try in place of troublesome unit. It too, gave too low an output. Wondered if strong winds were causing trouble with generator, so Vic and George built a windbreak out of rusty oil drums abandoned near beach (Plate XII). No improvement. Held council of war and decided to pack everything up and head for Sanikiluaq Harbour in search of dry and warm workshop space for troubleshooting equipment. Sea running high with on-shore wind, so Jobie and Moses drifted ashore in canoe with rest of crew holding a long rope tied to bow of canoe to hold it off the rocks on the beach. Crew very happy to hear of plans to go at once to Sanikiluaq Harbour.

1145 Up anchor and away to the north with a following sea. Jobie replaced rag on Mike's finger with a couple of bandaids. Moses made coffee and Vic and George dined off oatmeal cookies and raisins. Mike subsisted on a can of gingerale.

1630 Heading approximately NW across open water between Gushie Point and Blocked Passage, the entrance to Eskimo Harbour. Running with the wind up Omarolluk Sound was relatively smooth but *Joan Ryan* now rolling somewhat. Rain and fog obscuring horizon.

1730 Running westward across southern part of Eskimo Harbour, in sight of Sanikiluaq Harbour, the settlement. All hands on deck in anticipation of homecoming. Heavy rain (naturally).

1800 Moored alongside a peterhead which was tied up at the wharf. Both boats swarming with Eskimo people but its the crew they'd come to see, not us. Mike started up the road toward the settlement and was hailed by Don McCoy, the settlement manager, who said to come up for supper. Mike relayed the message to Vic and George, who were digging some essential luggage out of the hold. Manager's house was a two-storey affair with office and storerooms on first floor and 3-bedroom apartment upstairs. Wall-to-wall carpet and *real beds*. Visions of sleeping in a warehouse rapidly faded. Dinner party consisted of Maria Holobowski (the settlement nurse), Tom Manning (naturalist on contract with Canadian Wildlife Service), Brenda Carter (an artist working with Tom), and Ernie Siebert (Coordinator of Co-ops for the Northwest Territories). Tom and Brenda had chartered the peterhead moored at the dock. Before-dinner refreshments furnished by Vic and George in support of Don's rapidly-dwindling supply. Sampled muktuk — no comment.

2030 Supper! Roast beef, gravy, potatoes, corn, salad, tea, apple pie (freshly baked by Brenda).

2330 Turned in. Vic and George in bunk beds, Mike in third bedroom.

Saturday, July 31, 1971

0800 Breakfast – juice, fried spam, toast, peanut butter, jam and coffee.

Took thermo-electric generators and one tank of propane up to garage for testing using tractor with front-end loader. Local mechanic Norm "Fergie" Ferguson was very helpful. Mike renewed acquaintance with Johnny Cookie who was at South Camp on Belchers in 1967. After testing both generators for a few hours in light rain and very little wind, found one did not have adequate output while the other was satisfactory. Mike decided to set up Site 2 at settlement and abandon plans for Site 3. Found suitably sheltered, dark site, east of settlement, about halfway down south-east side of runway. Moved equipment to site using front-end loader, left generator to warm up (Plate XIII).

Visited Co-op store, bought soapstone both raw stone and carvings. Mike discussed charter fee with Co-op board of directors, decided on charge of 5 days cruising at $125 per day, 5 days standby at $80 per day, total $1025.

Mike got his injured finger cleaned and bound up by Maria at nursing station. Population of settlement is about 240 Eskimos in 30 houses; each house had oil-fired furnace, electric lights, 50 gallon water tank, 2 sinks, "honey bucket" toilet.

When returning to site saw young Eskimo with Snowy Owl he shot near dump: Don quite upset since killing birds of prey is illegal.

1900 Started timer (1800 EST) after checking out photometer system for last time (Plate XIV). Loaded test gear and other equipment in *Joan Ryan* for departure at 0700 tomorrow. Third timer unit still operating on batteries and converter operating off boat power.

2000 Supper — T-bone steak, onions, potatoes, peas, fruit cocktail, tea. After supper went to beach to inspect catch of Eskimos returning from hunt: seals, ducks, geese, other birds, sculpins and a sea cucumber. Ernie Siebert wanted samples of seals caught — 1 lb each of liver, blubber, meat and skin — to check for mercury content. Evidently at Rankin Inlet seals were contaminated to extent of 52 ppm of mercury. Visited Richard Exner, Hudson Bay Co. manager. Also had invitation to Fergie's for coffee but too late to go. Tremendous hospitality.

Sunday, August 1, 1971

0615 Breakfast — Graham wafers and coffee. Discovered Don had no official budget allotment for entertaining guests, but had fed us from his own pocket so to speak. Donated a couple of days' worth of food parcels and a small bottle of champagne as token of thanks. Bade a fond farewell to Sanikiluaq Harbour.

0715 Under way in rain and fog. Moses stayed on Belchers.

0845 Encountered ice floes in and around Blocked Passage. Able to thread a course through ice at nearly full speed — fortunately sea was glassy calm. Weather overcast and cold. Mike had borrowed parka from Don for use at Sanikiluaq and on return cruise to Great Whale, so felt able to face prospect of seasickness with some fortitude.

1200 Leaving eastern end of Fairweather Sound heading for Site 1. Most excitement so far occurred when Lucassie and Jimmy navigated boat in tight manoeuvre around submerged reef between Rainbow Point and Johnny's Island, in western approach to Fairweather Sound. Still dead calm sea with visibility 1-2 miles in haze. Had lunch – small piece of cheese, oatmeal cookies, 1 oz raisins, 1 coke. Later coffee.

1300 Sked with Peter Burns on radio at Great Whale. Very smooth trip. Lucassie took helm from Jimmy shortly after leaving Fairweather Sound. Mike thought he was steering a course approx. 6° south of heading marked on chart, but said nothing.

1530 Lucassie pointed out island in distance. Mike's misgivings re compass heading apparently unfounded. About 1 hour to go to Site 1.

1630 Land seen at 1530 proved to be hills of Quebec coastline, indicating compass heading was in error. Jimmy took over helm and put about on a corrected course to find the island. Lucassie and Jobie on roof of wheelhouse with binoculars.

1730 Land ho! (again). Probably the right land – if the charts are right, there's nothing else out here. Charlie made coffee and we had a piece of cheese.

1800 Anchored close off-shore to SE of island in several fathoms of clear, green, very cold water. No fanfare this time as shore party hit the beach. Found main housing lid and front panel unclipped and partly open. Either we left it that way without noticing which is very unlikely, or else there was a visitor. No visible damage. Timer had stopped although generator open-circuit voltage was 3.7 V. Evidently dropping voltages noticed two days ago when leaving continued long enough to stop timer. Increased gas pressure to bring open-circuit voltage up to 3.8 V, then installed remaining timer. Calibrated system for last time. George returned to *Joan Ryan* for sked with Peter and to unpack some food from hold.

1900 Started timer (1800 EST). George had sked OK with Peter. Packed up test gear and returned aboard boat.

1910 Weighed anchor and headed south toward Great Whale. Vic prepared supper — pea soup, tomato juice, chicken and dumplings, meat balls, chocolate chunks and tea. Pretty good for a cook kneeling in the fo'c'sle with 4-foot headroom. George forgot messkits so had to eat from pots and cans, and borrow tea-mugs. Simplified dishwashing though.
Could now see Quebec coast. Making top speed of 8 knots in calm, overcast, cool weather; slight swell running on sea.

2210 Could see lights from Great Whale after darkness fell. Could also see red-hot exhaust pipe and muffler through ½-inch layer of asbestos rope; outside could see 6 inches or so of flame coming from exhaust pipe. Noticed flecks of light in wake, probably phosphorescent organisms.
Reached approach to Great Whale at low tide. Depth sounder indicated zero depth under keel. Jimmy had head out of wheelhouse window looking for bearings and Lucassie reaching over side with stick looking for bottom.

Monday, August 2, 1971

0035 Docked at Great Whale. Jimmy suggested we wait till morning to unload. Peter and Udo Schlicher waiting for us at wharf with truck. And so to bed.

0800 After breakfast, back down to river. Unloaded *Joan Ryan* and posed with crew for pictures taken by Udo (Plate XV).

D.2 RETRIEVAL TRIP

Friday, September 17, 1971

Equipment for testing and securing equipment shipped from M-50 to Great Whale. Vic Cyr and George Attallah to follow September 22.

Monday, September 20, 1971

Received telex message from Don McCoy at Sanikiluaq Harbour, to the effect that *Joan Ryan* was laid up for season with broken transmission. Message also mentioned a charter flight to Belchers on September 26. After many phone calls and telex messages Mike established that this would be a charter for National Health and Welfare out of Churchill. Arranged for Vic to go on this flight and to continue on to Great Whale on the aircraft at an additional charge.

Friday, September 24, 1971

1730 (EDT) Vic left Ottawa en route for Churchill with lashed-up test gear in suitcase.

2400 (CDT) Arrived Churchill, greeted by Roy Heppner.

Saturday, September 25, 1971

Vic confirmed time of departure of charter. Discussed *Joan Ryan* situation with Ron Milligan (Industrial Administrator for NWT) to see what chances were for Site 1 pickup trip. Apparently boat would be laid up till spring 1972 as new transmission required at cost of $1200. Borrowed Zenith portable radio from Roy Heppner to receive time signals on Belchers.

Sunday, September 26, 1971

0645 Arrived at airport for departure at 0700. Place deserted. Returned to room to get box lunch. Returned to airport to find John Hill (Transair manager) and dog trying to chase polar bear away from hangar. Apparently Vic was less than 100 feet from bear when at airport earlier. Plane had to be brought into hangar to thaw out before loading for flight.

0900 Took off for Winisk on twin-engined (turbo-prop) Otter belonging to Transair. Also aboard were two teachers and Mr. and Mrs. John Morton who were making the round trip.

1200 Arrived Winisk. Refueled by hand-pumping 180 gal of fuel. After leaving Winisk ate box lunches.

1430 Arrived Sanikiluaq Harbour. Vic said hello to Don and then proceeded to Site 1. Took panoramic photos to permit subsequent pin-pointing of locality and orientation. Generator voltages and propane pressure were low and timer not working. Dismantled equipment and transported it to aircraft with help of Fergie and truck. In discussion with Don over a glass of screech Vic enquired regarding possible charter of peterhead based at Inoucdjouak (Port Harrison) skippered by Johnny Inukpuk. Don advised against this as that boat had engine trouble. Shortly before takeoff Vic had to retrieve his suitcase from Don's house where it had been accidentally left.

1630 (CDT) Left Sanikiluaq Harbour heading for Great Whale.

1810 (EDT) Arrived Great Whale. Unloaded equipment, signed charter receipt, and plane left after refuelling enroute for Winisk and Churchill. Later in evening Vic made contact with Michel Taschereau, captain of Quebec-owned trawler *Baie du Nord*. He seemed agreeable to taking on a charter to pick up gear at Site 1 but took his orders (understandably) only from Quebec City.

Monday, September 27, 1971

Vic checked with Guy Bergeron at DIAND re Johnny Inukpuk's peterhead, but found he was at Inoucdjouak at this time. Went down to river and boarded *Baie du Nord*. Michel had suggested alternative of going to Inoucdjouak first and doing Site 1 on return trip, but he favored doing Site 1 as a separate trip. Vic decided to send a night letter to Mike in Ottawa recommending this and asking him to contact Roger Beaudoin in Quebec for authorization.

Tuesday, September 28, 1971

Mike received night letter, phoned Roger Beaudoin and arranged charter trip of *Baie du Nord* (at a price of $400 per day). Mike replied to Vic via full rate telegram sent in morning.

1700 Also sent duplicate message via amateur radio.

1900 Vic received message via amateur radio, then checked M.O.T. office at Great Whale and found telegram waiting!

Wednesday, September 29, 1971

Michel received authorization to undertake charter trip. Could not unload cargo of steel pipe because supply ship was in port and barges continually using dock.

Thursday, September 30, 1971

Baie du Nord unloaded. Some lumber kept in hold as ballast. Set departure time of 0600, October 1. Vic had to hire freight canoe and motor since tender on *Baie du Nord* too small for the job. Hired Alex Kopi (teacher at trade school) to bring boat and two motors, at cost of $10.

Friday, October 1, 1971

0615 Cast off and took on fresh water in middle of river.

0630 Sailed on high tide. Rubbed sand bottom a few times in mouth of river as *Baie du Nord* was drawing 8½ feet of water. Breakfast for crew, and for Alex and lady friend, but not for Vic. Cruised up Manitounuk Sound along Quebec coast, then through Schooner Opening between Merry and Castle Islands heading NW for Site 1, directly into strong winds and swell. Vic took up position on after deck for strategic reasons, was joined shortly by Alex and lady friend, and by Jacques Richard (the cook). The latter three began to feed the gulls so Vic, having nothing to contribute, went back in the wheelhouse.
Spotted island to port on radar so changed course to suit.

1130 Anchored well offshore in 5 fathoms. Launched and boarded canoe with some difficulty in heavy swell. After starting motor with more difficulty, finally got ashore and pulled canoe well up on beach. Propane supply was exhausted and equipment not operating. Vic and Alex took site photographs (Plate XVI), dismantled station and loaded canoe. Vic fended boat off shore till Alex got motor started again. More trouble boarding *Baie du Nord* due to heavy swell.

1230 Weighed anchor and ran downwind for Schooner Opening once more. Return trip much smoother encouraging Vic to visit the galley forward for bacon-and-tomato sandwiches.

1630 Anchored in lee of Manitounuk Islands to wait for high tide at Great Whale. Cook dished up fried steak, potatoes and salad.

1730 Up anchor and into Great Whale, rubbing bottom a few times again.

1900 Docked, unloaded equipment and headed for barracks.

Monday, October 4, 1971

Did some packing. Vic contacted Mike in Ottawa via amateur radio.

Tuesday, October 5, 1971

Brought packing crates to Nordair office. Supper — baked Arctic char — at Udo's house; made the trip worthwhile.

Plate I. View of detector module used in automatic photometer system.

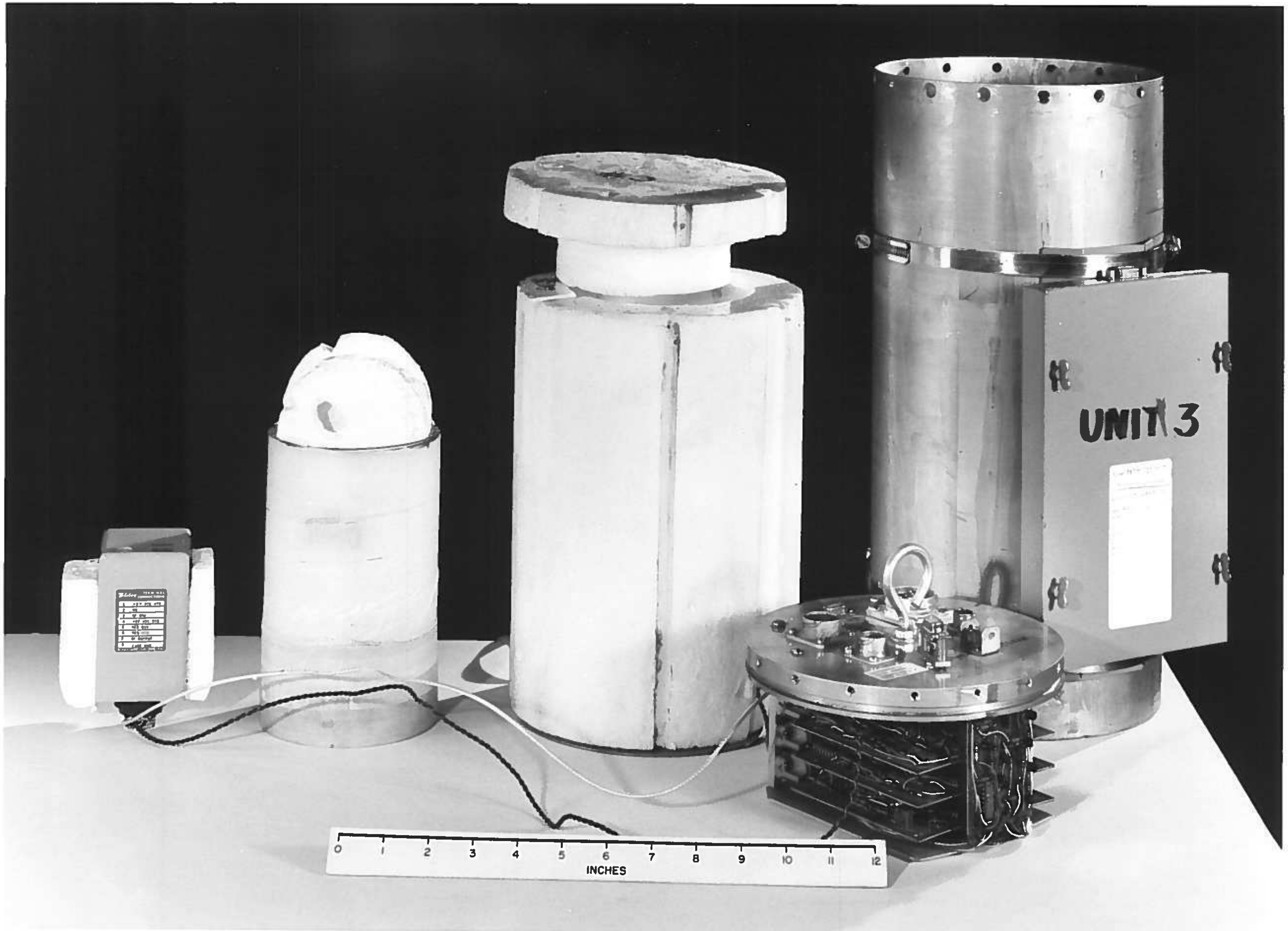

Plate II. Disassembled view of timer unit showing oscillator and thermal lagging.

Plate III. View of timer unit with battery box, ready for air shipment.

Plate IV. Front view of automatic photometer station.

Plate V. Rear view of automatic photometer station.

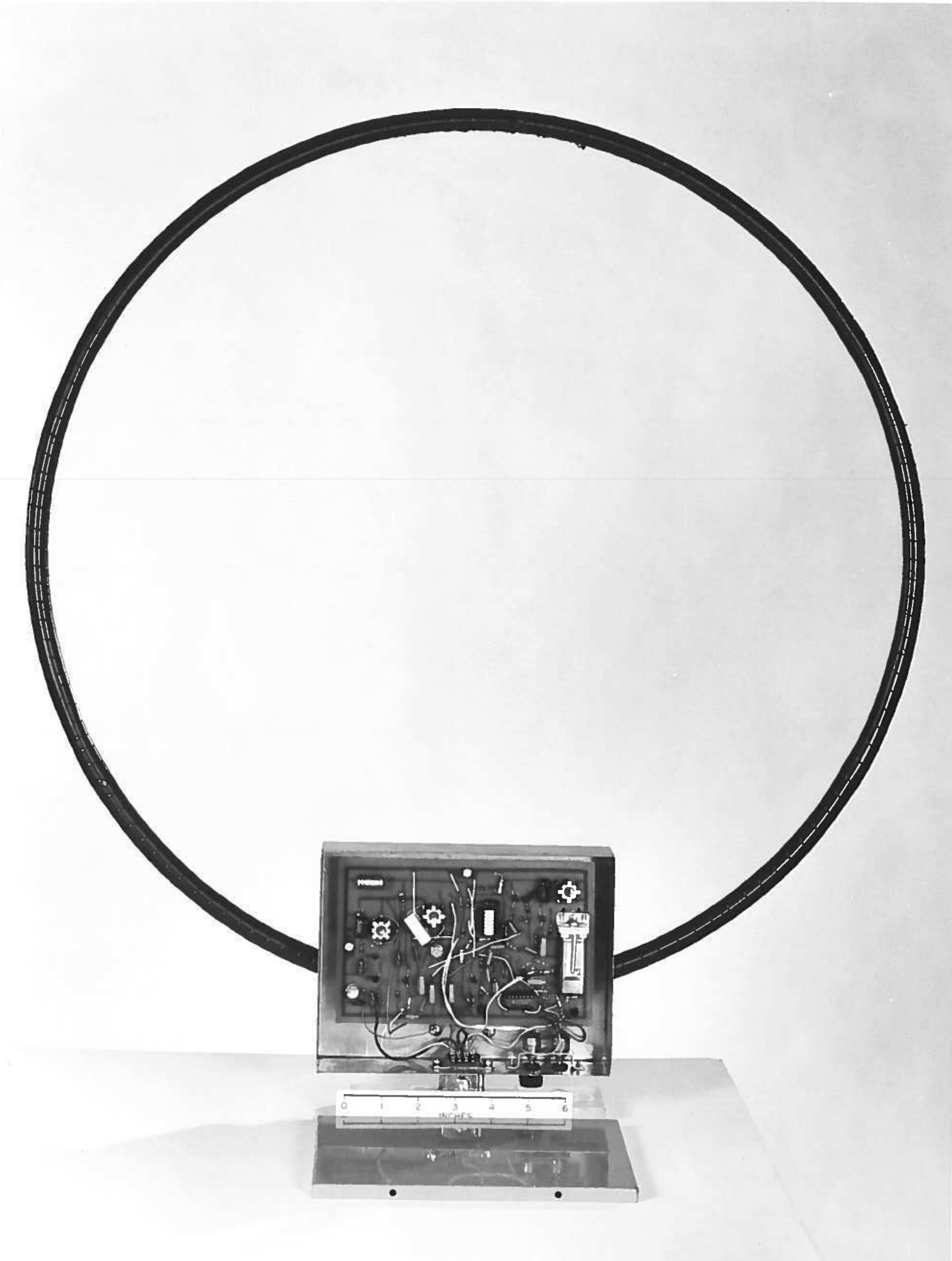

Plate VI. View of 60 kHz receiver

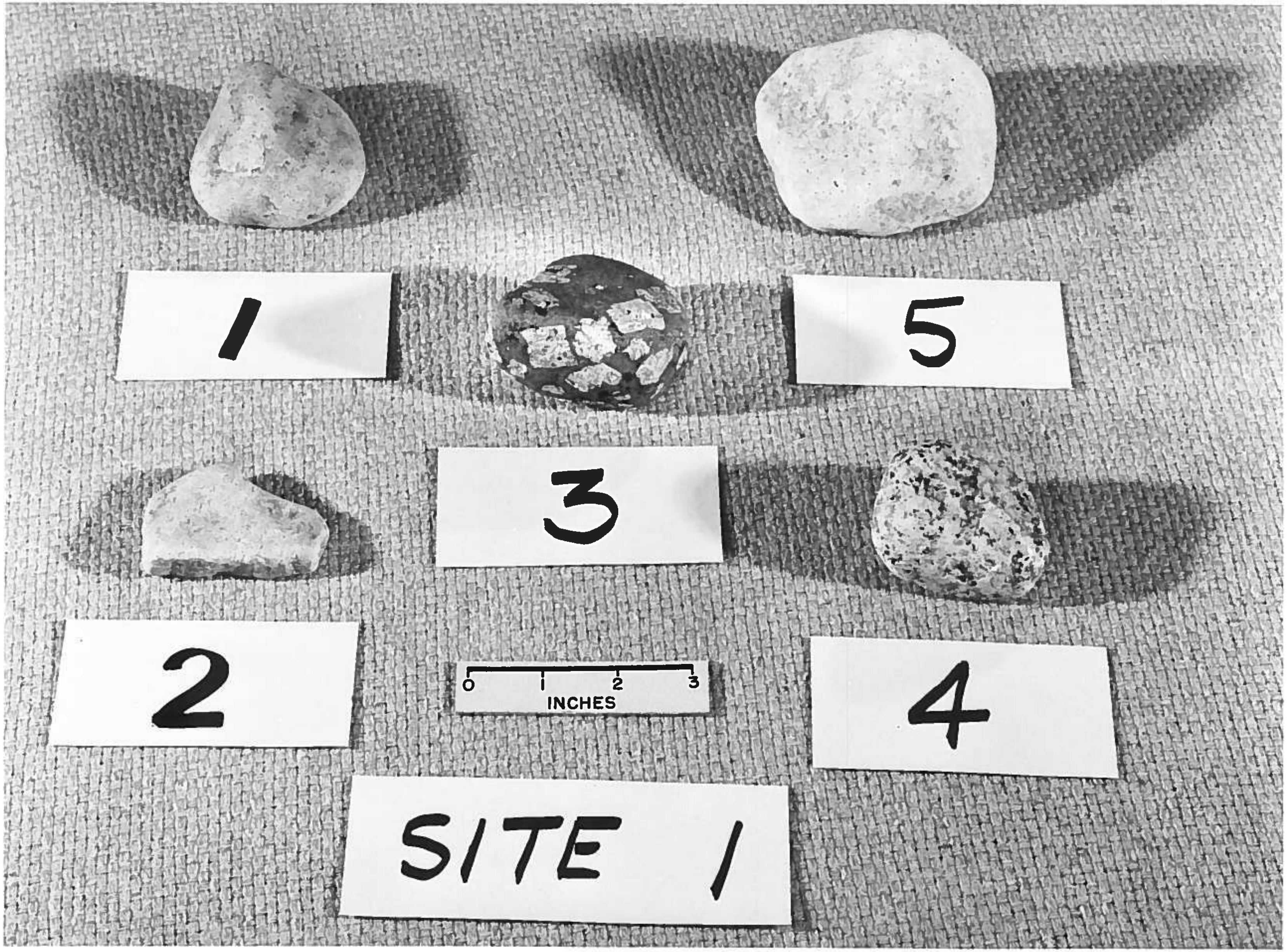

Plate VII. Geological specimens from Site 1, 55°56'N, 77°56'W.

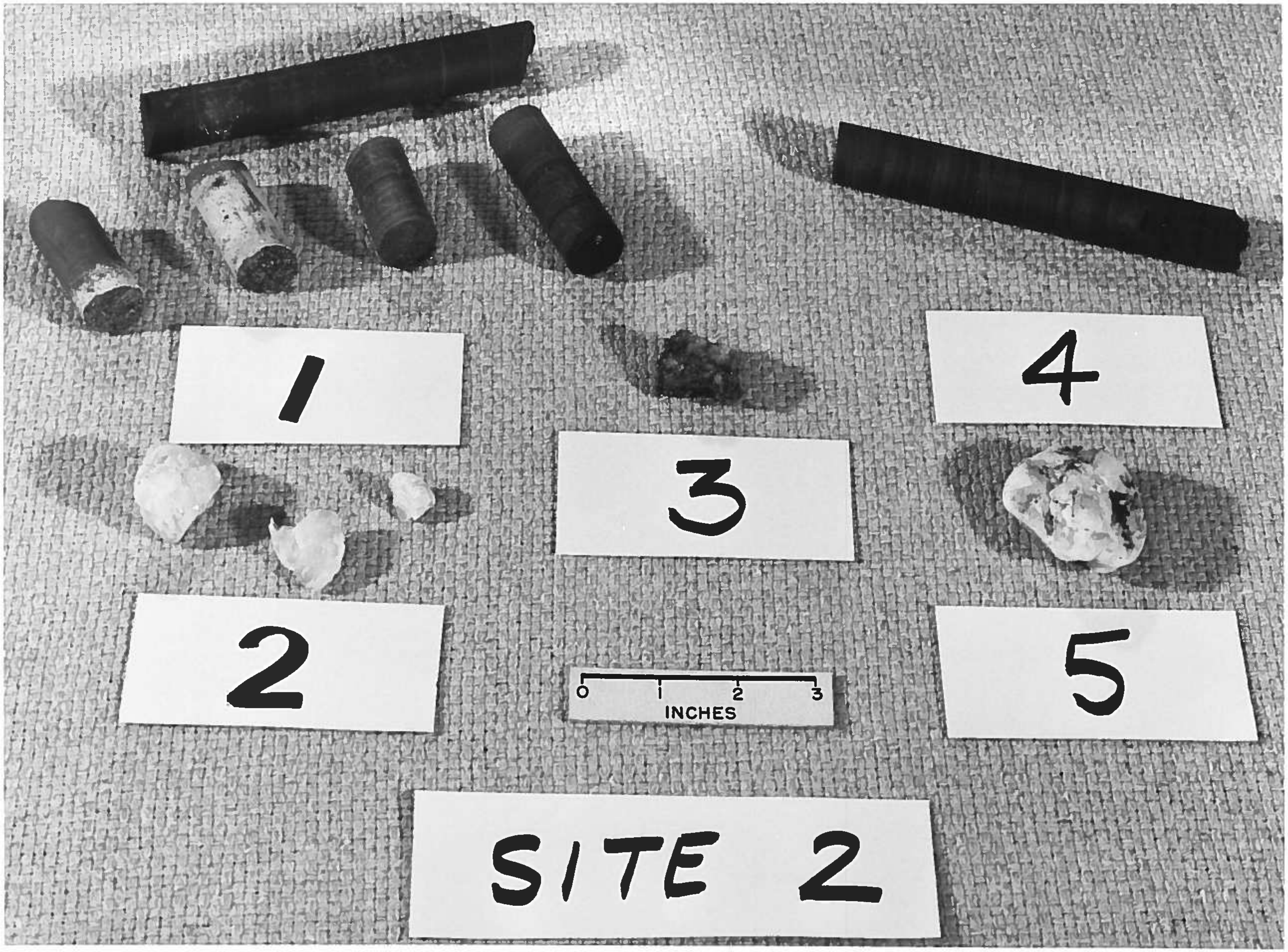

Plate VIII. Geological specimens from Mine Lake site on Innetalling Island.

Plate IX. Geological specimens from Mine Lake site on Innetalling Island (cont'd).

Plate X. M. V. Joan Ryan at Great Whale River.

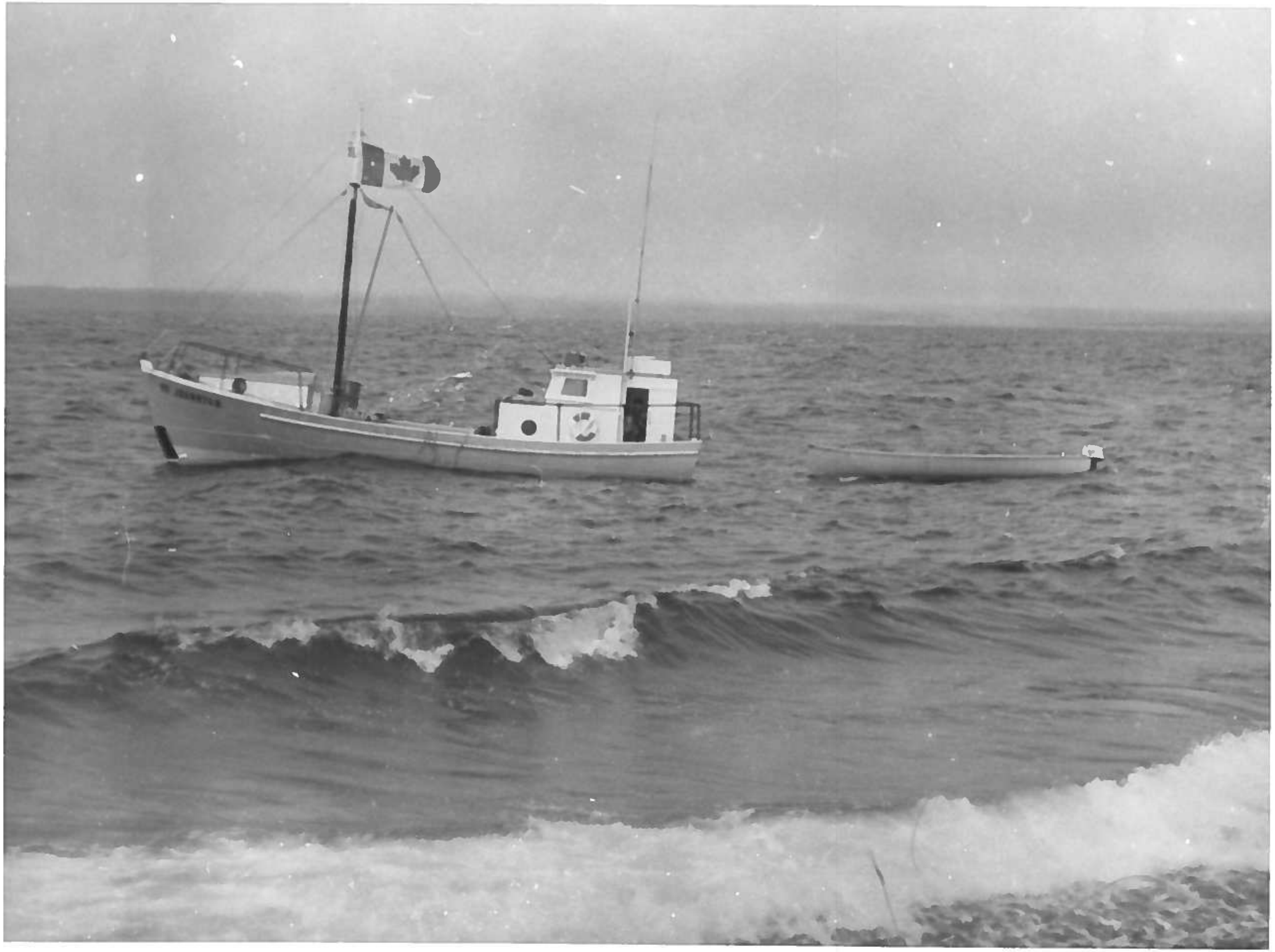

Plate XI. M. V. Joan Ryan anchored offshore at Mine Lake site.

Plate XII. Mine Lake installation with windbreak.

Plate XIII. Vic Cyr and Mike Watson adjusting photometer at Sanikiluaq Harbour.

Plate XIV. George Attallah putting finishing touches to photometer set up at Sanikiluaq prior to leaving it.

Plate XV. M. V. Joan Ryan, with crew and passengers alongside wharf at Great Whale. From left: Jobie Crow, Mike Watson, Vic Cyr, Charlie Takatak, George A+talah, Lucassie Inuktaltuk and Jimmy Mickeyook.

Plate XVI. Vic Cyr and the Site 1 photometer.