A manual for the installation, operation and calibration of a telemetry system

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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/21276291
Report (National Research Council of Canada. Radio and Electrical Engineering Division : ERB), 1972-02

National Research Council Canada
Conseil national de recherches Canada

A MANUAL FOR THE INSTALLATION, OPERATION AND CALIBRATION OF A TELEMETRY SYSTEM

- W. T. FOSTER AND F. E. VACHON -

ERB - 846

FEBRUARY 1972

RADIO AND ELECTRICAL ENGINEERING DIVISION

DIVISION DE RADIOTECHNIQUE ET DE GENIE ELECTRIQUE

ERB-846

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RADIO AND ELECTRICAL ENGINEERING DIVISION

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OTTAWA

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– W.T. Foster and F.E. Vachon –

This manual was written to help the inexperienced (novice operator and user) to install and operate the equipment, for the first time. However, it is advisable to have someone who has installed it before, to supervise the first installation made by a beginner.

The telemetry equipment is divided into three main sections: the transmitting section, the receiving section, a visual meter display section.

The transmitting section will be described in Part I. The receiving section will be described in Part II. The visual meter display in Part III.

PART I The Transmitting Section

The transmitting section is comprised of: a modulation unit, with its power supply, and electronic circuitry to form a modulator; a 260 MHz crystal controlled transmitter which is battery powered; a dipole antenna cut for 260 MHz; digital rpm transducers; and a monitor interface unit.

A. Installation of the Equipment in a Model Ship

(1) Install the modulator unit at or near the stern of the model ship, which is under test. Secure unit firmly to the wooden decking, as some testing may be under wave conditions which

will subject the model to a rough sea.

(2) Install the 260 MHz transmitter unit close to the modulator unit.

(3) Install the dipole antenna at the stern position of the model in order to give some separation between the antenna for the Remote Control System, and the antenna for the Telemetry Equipment.

(4) Install a digital rev./per/min. transducer, one for each propulsion motor, if there is more than one. The installation should be between the motor and the propeller and close to the main drive shaft. If a gear box is used after the motor, the coupling should be made to the output shaft of the gear box. A timing pulley, matching the specifications of the pulley on the transducer assembly, should be installed on the output shaft and coupled to the transducer assembly with a rubber timing belt.

(5) Install the monitor interface unit, about midship, between the relay unit of the remote control system and the modulator unit of the telemetry equipment.

(6) Interconnecting Cables

(a) If the equipment is to be run from a 120 volt 60 cycle source, a cable with a 3 prong male AC connector, on one end, and a 4 socket Amphenol screw-lock connector on the other end, connects the AC source to the 4 pin Amphenol connector on the lower left side of the modulator unit.

(b) If a 24 volt battery source is used, a cable with two alligator type battery clamps plainly labelled (Positive +) and (Negative -) on one end, and a 2 socket Amphenol screw-lock connector on the other end, connects the DC source to the 2 pin Amphenol connector, on the lower left side of the modulator unit.

(c) A cable with a 5 socket Amphenol connector on one end, and a 5 pin Amphenol connector on the other end, connects the rpm transducer assembly to an Amphenol connector, located on the upper part of the second section, hinged door on the left side of the modulator unit. There are three 5 socket connectors here, labelled RPM A, B, C, one for each of the three rpm transducer assemblies.

(d) A cable with a 5 pin Amphenol connector, on one end and a 5 socket Amphenol connector on the other end connects a 5 socket Amphenol connector on the lower right side of the modulator unit, to a 5 pin Amphenol connector on the front edge of the monitor interface unit. This supplies the voltage to the telemetry part of the unit's circuitry.

(e) A RG 58 coaxial cable with male BNC connectors at each end, connects the modulation output connector, on the top panel of the unit, to the pulse code modulation input connector on the front panel of the 260 MHz transmitter.

(f) A RG 58 coaxial cable with male BNC connectors at each end connects the modulated RF output connector on the front panel of the transmitter to the BNC connector of the transmitting dipole antenna.

(g) A cable with a 12 pin Amphenol connector, on both ends, connects the Amphenol connector on the front edge of the monitor interface unit to the Amphenol 12 socket connector, labelled monitor "on/off" commands, located on the upper part of the second section hinged door, on the left side of the modulator unit.

Refer to the diagram - BLOCK DIAGRAM OF CONNECTIONS OF MONITOR INTERFACE UNIT BETWEEN REMOTE CONTROL UNIT AND TELEMETRY EQUIPMENT. (AF-12-134D)

(h) On the first section hinged door on the left side of the modulator unit, eleven 5 socket Amphenol connectors are installed. These are inputs to the analog channels of the telemetry equipment. These inputs have been assigned to monitor the appropriate transducers for the following: Torque, Rate Gyro, Thrust, Rudder Position Potentiometer, Pitch, Roll, Yaw, Heave, Surge and Sway. Where it is required, a reference voltage is wired to these connectors. High side to pin A, low side to pin B and the moveable arm of the transducer potentiometer to pin C, which is wired into the assigned analog channel.

Cables would have to be connected to these input connectors and to the aforementioned transducers.

The eleventh connector, the only one in the second column of this hinged door, is assigned to the test "Staircase" waveform. This waveform is brought out on an Amphenol connector, at the mid point of the second section hinged door, and a cable from it could be put into any of the above connector inputs, in order to check out that particular channel.

(i) A cable with a 12 socket Amphenol connector on both ends connects the connector on the back edge of the monitor interface unit to a connector on one end of the relay unit of the remote control system. This carries the status of the remote control "on/off" commands.

(j) A cable with a 5 socket Amphenol connector on one end, and a 5 pin Amphenol connector on the other end, connects a connector on the left end of the monitor interface unit to a connector on one end of the relay unit. This supplies 3.6 volts, from the relay unit, to the monitor interface unit. This voltage lights the "Vactec" units.

B. <u>Operation of the Transmitting End</u> (Refer to Plate 7)

(1) Open the lower front hinged door, which covers the switch, fuse and meter panel. Having plugged in the input power cable to the AC line, the first meter on the left, #8 of the power supply circuit diagram, a normal 0-1 MA movement with a 1N2071 rectifier and a 120K resistor in series, connected across the line, will give a reading on the positive cycles, and will register 120 volts, at approximately half scale of the meter. This is indicated by a black dot on the scale. The line voltage is stepped down, rectified and filtered by the usual methods, before it is switched to the chopper circuit. The normal use of this part of the equipment (chopper) is with a battery source. Two twelve volt 32 ampere-hour batteries in series should be connected to the unit. The first meter in this case will not read.

(2) The first toggle switch along the panel selects the AC line with its conversion to DC, or the direct output from a battery source. The "Up" position is for the 120 V 60 cycle line source and the "Down" position is for the 24 volt battery source.

(3) The next switch along the panel turns the power "on" to the chopper circuitry; "Up" is "on" and "Down" is "off". The second meter along the panel (#1 on the power supply circuit diagram) will read the DC volts out of the battery source, after the protective diode, when on battery, or the DC output of the AC line rectified source, when on line. If the chopper doesn't start (rest of the meters all at zero, and no familiar chopper noise is heard) press the push button, next along the panel, to trigger the chopper.

(4) With the chopper operating, the rest of the meters along the panel will indicate the required voltages for the circuitry in this unit. Each meter scale is marked with a black line which will indicate normal voltage conditions.

Meter #2 Reads + 3.6 Volts for all the logic circuits

Meter #3 Reads + 7 Volts for the "FET" Switch Drivers

Meter #4 Reads + 12 Volts for the Ladder Switches
Meter #5 Reads 5.12 Volts for the Ladder Reference Volts
Meter #6 Reads -12 Volts for the "FET" Switches
Meter #7 Reads -6 Volts for the Comparator Component.

In the chopper D.C. Power Supply is a reference cell. It is in the regulator circuit of the reference supply. It is a 1.35 Mallory Battery #RM12R. It should be checked for voltage and also for any corrosion about the battery or its holder contacts.

(5) On the right side of the modulator unit, behind a hinged door, are several facilities for the operation of the equipment. (Refer to Plate 13)

(a) First there is a patch panel board, with pins inserted in the sockets. These pins select the required waveforms for super-commutation, of 10 normal analog inputs. (See diagram on the back of the door for where to place the pins.)

Input #9 can be sampled at 4 times normal or 800 samples per second.

Input 10, 11, 12 and 13 can be sampled at 2 times normal or 400 samples per second.

Inputs 9, 10, 11, 12, 13, 30, 31, 32, 33, and 34 can be sampled normally at 200 samples per second.

(b) There are 6 BNC connectors above the patch panel. These are monitor points for the different waveforms in the circuitry of this unit. (See instructions PART 1, Section E, "Procedure for Checking The Transmitter End Waveforms".)

(c) Above the BNC connectors, are located a clock face dial potentiometer and a multi-pole two position switch (SW3). These two components are used as test facilities. The potentiometer is connected across the reference voltage of the system and will feed an analog voltage into analog channel #1.

In order to monitor this test, a column of lamps is used, and is located behind a plastic window at the top left side of the front panel.

The switch labelled (SW3) must be placed in the "down" position. This will cause the lamps to be powered ready to be turned on, by lamp drivers, according to the digital representation of the analog value of the setting of the clock face dial potentiometer. At the same time, the switch will stop the shifting of the shift register. Only analog input #1 will be loaded into the shift register. Changing the clock face dial potentiometer will change the arrangement of the lamps, "on" or "off". The top ten lamps indicate the 10 bits for which the analog voltage is converted to digital form. Reading from the top lamp means 1/2 the value of the Reference Volts, next would be 1/4 value, then 1/8 value, 1/16, 1/32, 1/64, 1/128, 1/256, 1/512, 1/1024. The 11th lamp is not used but will be "on". The 12th, 13th, and 14th lamps signify the minor frame number, which in this case is FO and the three lamps will be "off".

The 15th lamp is not used but will be "on". The 16th lamp is a spare which is not connected and will be "off". To check out each bit, gradually increase the clock face dial. Observe the lamps going on and off, as the dial is increased. All the first 10 lamps will be "on" when the dial of the potentiometer is at its most clockwise position.

(d) Inside the unit, located on page 2 of the logic section (numbering from the back as 1, 2, on the hinged door, 3 & 4 are fixed pages, 5 & 6 on the front hinged door) is a group of monitoring lamps. These monitor the minor frame sequence. The speed of the normal sequence is too fast to observe, so switch #1 at the top of page 2 is placed in the up position. This changes the shift rate to 444 C/S which is quite slow, and the lamps will come on, one at a time, showing the sequence of the minor frames. Only the bottom eight lamps of the column are used. The bottom lamp is for F0 and upwards is F1, F2, F3, F4, F5, F6, and F7. Switch #1 is left in the centre position for normal operation. Further along the top of page 2 is another switch, SW2, labelled automatic/manual. In the automatic position the clock timing does the shifting. In the manual position the adjacent push button is used to pulse the equipment. It will take quite a number of pulses to operate the necessary shifting.

(e) Located along the top of page 6 are 6 potentiometers for adjustment of the load of the LS 600 light sensors, and 3 potentiometers to adjust the light brightness in the circuitry of the rpm transducers. These have been adjusted and should not need any further attention. These are labelled A, A1, A2, for rpm transducer A; B, B1, B2, for rpm transducer circuit B; and C, C1, C2, for rpm transducer circuit C. Lamp brightness adjustments are A, B, C. (Refer to diagrams - RPM Pickoffs, Counter and Buffer Register.) Adjust for brightness with Pot A. Adjust A1, A2 for symmetry of square wave at the monitor points on pin 6 position 1 and pin 6 position 2, page 6.

C. <u>Assignment of the Analog Channels</u> (Refer to Plate 11)

The eleven Amphenol, 5 socket connectors, on the hinged door at the left side of the unit, have been assigned to certain functions, and would require a cable connection from the appropriate transducer.

(1) The top connector of the first column is labelled Torque. It has a fixed connection to

channel #9 which is a normal channel and is sampled at 200 times per second. It is not connected to the reference voltage. It does have a connection to signal ground on socket B. Socket C, which would receive the output of the Torque transducer amplifier, is wired into channel #9 input, page 4.

(2) The second connector down is labelled Rate Gyro. It is connected to the reference voltage, on socket A, to supply the transducer potentiometer with + 5.12 volts. Signal ground or low side of the reference volts is on socket B. Output of the moving arm of the potentiometer of the Rate Gyro is received on socket C, which is wired into sub-commutated channel #20, page 3, and sampled at 25 times per second.

(3) The third connector down is labelled Thrust. It is not connected to the reference voltage. It does have a connection from socket B to signal ground. Socket C which would receive the output of the Thrust transducer amplifier is wired into channel #10, page 4. This is a normal channel and sampled at 200 times per second.

(4) The fourth connector down is labelled Rudder Position Pot. This is connected to the reference voltage, to supply voltage to the potentiometer located on the top of the Remote Control Rudder Servo Unit, and attached to the main rudder shaft. The 5.12 volts is on socket A and the low side or signal ground is on socket B. Socket C would carry the output from the moving arm of the potentiometer on the rudder and is wired into sub-commutated channel #4, page 4. It is sampled 25 times per second.

(5) The fifth connector down is labelled Pitch. It is connected to the reference voltage to supply voltage to the pitch indicator potentiometer, on the stable platform. 5.12 volts is on socket A, and the low side of the reference or signal ground is on socket B. The output of the moving arm of the pitch indicator potentiometer is received on socket C, which is wired into sub-commutated channel #14 page 3. It is sampled 25 times per second.

(6) The sixth connector down is labelled Roll. It is connected to the reference voltage, to supply voltage to the roll indicator potentiometer, on the stable platform. 5.12 volts is on

socket A and the low side of the reference or signal ground is on socket B. Socket C which would receive the output of the movable arm of the roll indicator potentiometer is wired into sub-commutated channel #15 page 3. It is sampled 25 times per second.

(7) The seventh connector down is labelled Yaw. It is connected to the reference volts to supply voltage to the yaw indicator potentiometer on the stable platform. 5.12 volts is on socket A and the low side of the reference or signal ground is on socket B. Socket C, which would receive the output of the movable arm of the yaw indicator potentiometer, is wired into sub-commutated channel #16 page 3. It is sampled 25 times per second.

(8) The eighth connector down is labelled Heave. It is not connected to the reference voltage. It does have a connection to signal ground on socket B. Socket C would receive the output of the amplifier connected to the Heave accelerometer of the stable platform, and is wired into sub-commutated channel #17 page 3. It is sampled 25 times per second.

(9) The ninth connector down is labelled Surge. It is not connected to the reference volts. It does have a connection to signal ground on socket B. Socket C would carry the output of the amplifier connected to the Surge accelerometer of the stable platform, and is wired into sub-commutated channel #18 page 3. It is sampled 25 times per second.

(10) The bottom connector of this column is labelled Sway. It is not connected to the reference voltage. It does have a connection to Signal ground on socket B. Socket C would carry the output of the amplifier connected to the Sway accelerometer of the stable platform, and is wired into sub-commutated channel #19 page 3. It is sampled 25 times per second.

(11) The connector in the second column is assigned to the "stair case" test signal. Socket C, which would receive the signal, is wired into sub-commutated channel #2 page 4. It is sampled 25 times per second.

(12) The clock face dial potentiometer behind the upper right side panel door, which is connected across the reference voltage, has its

movable arm connected to sub-commutated channel #1 page 4, and is sampled 25 times per second.

(13) The 3.6 volts (Vcc) which powers all the logic circuitry is also monitored. It is wired into sub-commutated channel #3 page 4. It is sampled 25 times per second.

(14) There are four digital channels in the telemetry unit. The input connectors to these channels are located on the second section of the hinged door, on the left side of the unit. A connection is required to each rpm pick-off assembly.

(a) The connectors labelled RPM A, B, C, are 5 socket connectors. Each connector has sockets A and B used to provide 3.6 volts for the light source in the digital pick-off assembly. Sockets D and E carry outputs of the T.I. LS600 light sensors, which are in the pick-off assembly, to the inputs of the circuitry which handles the output of the light sensors. Socket C is a common signal return or signal ground. (See diagram RPM Pick off, Counters and Buffer Registers.)

(b) The fourth connector is a 12 socket Amphenol connector. It is used to connect the monitor interface unit of the Remote Control Equipment to the telemetry unit. The connector is wired to input gates (see diagram sub-commutated digital multiplexer) for digital channel #4. It monitors the "on/off" status of the Remote Control Equipment.

(15) (a) There are 34 analog channels in the unit, of which the foregoing assignment uses 13. The remainder can be used by patching into the appropriate inputs

5- 8 inclusive,
11-13 inclusive,
21-34 inclusive.

(b) Inputs to the connectors for analog inputs should be positive and from 0 to 5.12 volts, which is the reference volts. The digital inputs are 0 volts or 3.6 volts.

D. The Transmitter

Some Notes on the 260 MHz Telemetry Transmitter

(1) The previous transmitter had a crystal (130 MHz overtone) in the base circuit of a Hartley type oscillator. Feedback was from a tap on the collector tank circuit to the emitter. Frequency doubling occurred via the non-linear (voltage-dependent) capacity from collector to base and from collector to emitter. The tank circuit output was fed into another voltage dependent tuned circuit which was purposely "detuned" through the action of a "varicap" on which the binary modulation was impressed. The problem with this transmitter was the sensitivity to battery voltage. Any small change in battery voltage caused a mistuning and other undesirable effects, such as the oscillator stopping or the modulation being "reversed". Antenna loading was also critical.

(2) The following is a description of a more standard type of circuit. The function of oscillation, doubling, and modulation are separated physically. This was to provide the necessary isolation between the 3 stages.

The oscillator is identical to the one described above. The tank circuit is tuned to the crystal frequency. Monitoring of the collector current was provided so that the initial (or subsequent) tuning can be done easily in the laboratory as well as in the field. The doubler stage consists of another transistor whose base is coupled to the 130 MHz crystal oscillator by a few turns (loosely coupled) to the collector tank circuit of the oscillator. These turns are tuned to 130 MHz in a parallel tuned circuit. The collector of this doubler is tuned to 260 MHz. Although the efficiency of this type of doubler may be low, the primary object, --isolating the crystal oscillator-- , has been accomplished in this way. The next step was to modulate the 260 MHz. This was done by a FET transistor on which there are two gates, besides the source and drain. One gate, gate #1, is fed with the RF carrier (260 MHz) and the other gate, gate #2, is fed with the binary modulation voltage. This FET (3N140) has sufficient gain to allow feeding the antenna directly for our purposes. The modulation voltage is interfaced to gate #2 by another transistor. The level changing required was minimal. One other aspect of the transmitter requires explanation. This is the output tuning and matching of the signal to the antenna. A parallel tank circuit in the output accomplishes the tuning and this is followed by a small (few pFs) capacitor which "transforms" the impedances. The antenna impedance is low (35 ohms or so) and a slight mismatch 35 ohms to 50 ohms cable occurs. Any reactance is "tuned" by means of the output capacitor.

A schematic of the complete transmitter is shown in diagram labelled "Shipboard Telemetry Equipment Transmitter 260 MHz with 3N141 Switch". (AF-12-132D) (Plates 6 and 9)

(3) Tuning Procedure

Referring to the schematic diagram above, the tuning procedure is as follows:

(a) Adjust the oscillator tank circuit to resonance by C_1. Note the rise in collector current as resonance is approached. Tune C_1 till a maximum is reached. This is about 12 mA for a collector supply voltage of 10 volts.

(b) Tune C_2 for resonance. This is done by observing the collector current of the doubler stage. A rise in collector current indicates a tuned condition.

(c) Tune C_3 for maximum collector current. Again, use the meter in the collector circuit for indication of tuning.

(d) Attach an antenna to the output connector. Using an RF detector (described elsewhere) coupled close to the antenna, tune the collector tank circuit of the final stage for a maximum reading on the detector meter.

Go back to trim up - do steps a, b, and c over again to maximize the detector reading.

(4) Modulation Test

There are two bias potentiometers which control V_{g1} and V_{g2}. These are initially set up in the lab. V_{G1} = -0.5 volts and V_{G2} = +4 volts (all voltages are with respect to the source). The modulation is applied to the connector marked "MOD" and the levels here are + 0.2 volts for a '1' and + 2.7 volts for a '0'. When the MOD input is open circuited, carrier is outputted.

Using the video detector, (described elsewhere), check for modulation by putting a square wave or the actual PCM signal from the telemetry unit into the MOD connector and observe on a good D.C. oscilloscope. Note the rise and fall times. This should be about one microsecond or less.

<u>Typical Meter Readings</u> (10 volts)

	I_1	I_2	I_3
	Oscillator	Doubler	Modulator
	11 MA	20 MA	7 MA
Volts	9		

RF OUT 14 mW Not Modulated

on FXR Power Meter

B831A

MOD SWITCH

Source to Gnd 1.7 volts

V_{g1} - .2 V to source

V_{g2} + 2.6 volts to source

FET Transistor 3N141

(5) <u>Some Physical Features of the Transmitter</u>

(a) The transmitter is powered by two Mallory 5.4 volt batteries in series (TR 134R).

(b) Monitor Meter -

A 0-1.0 milliampere meter is used to read the collector current in each of the oscillator, doubler and modulation circuits. The meter has a shunt resistor of 8.2 ohm to read 20 mils full scale, and a 10 K resistor in series when used as a voltmeter (Push Button) to read 10 volts full scale.

With the rotary switch in position 1, the meter will read the oscillator circuit collector current; in position 2, the meter will read the doubler collector current; in position 3, the meter will read the modulator current.

(c) Toggle switch turns the battery power "on/off".

(d) Pulse code modulation input BNC connector carries the modulation to the modulator switch.

(e) RF output BNC connector carries RF to the antenna.

(f) In order to tune the various stages, lift the hole plugs, left side of the case, and insert a tuning wand to vary the air-type capacitors. Observe the appropriate meter reading, and adjust the capacitor to peak the current reading.

(g) The RF carrier is "on" when the modulation level is at 0 volts and "off" when it is 2.3 volts.

(h) A wavemeter, provided with the transmitter, can be held against the dipole to monitor the output of the transmitting antenna. It is tunable and reads on a meter scale. The 260 MHz point is marked and labelled.

(i) A detector unit, supplied with the equipment can be held against the antenna and its output can be fed into an oscilloscope and the modulation can be observed.

(j) Wavemeter to cover 200-280 MHz

Useful for checking both the remote control and telemetry transmitters.

(Plate 14)

Construction details

Take about 6" of copper strap 1/32 inch thick and 1/4 inch wide and bend into a U-shape with the ends 1" apart. Then solder an air capacitor, 2-15 pF directly across the ends. This should be very rigidly soldered. Note that the variable side of this capacitor should be on the "cold" side of the circuit. Put a small diode as close as possible to the "hot" side of the coil and connect the other end to the 0.001 capacitor. Again, use short leads. The 0.001 should be a ceramic disc type. A 0.33 uH (wee-ductor) RF choke blocks the RF from the D.C. circuit.

Mount all the parts on a copper plate 2" x 6" x 1/16" thick. 1K resistor is added to "match" the meter (0-25 uA) to the detector.

Attach a good dial and a pointer to the variable capacitor and calibrate using a good RF generator.

(k) Detector to cover 200-280 MHz

This detector is used for initially checking the modulation envelope from the telemetry transmitter and the remote-control transmitter. (Plate 14)

Construction Details

Take a 6" long x 1/4" wide x 1/32" thick copper strap and bend it into a U-shaped piece and solder an air-capacitor across the ends. A small diode, 33 uF capacitor, and a 1K load resistor are required. The circuits are as shown in Figure #1.

E. Procedure for Checking the Transmitting End Waveforms

It is advisable to use a Tektronix Oscilloscope type number 543 with a type "CA PLUG IN UNIT" to check the following waveforms. Refer to Fig. 2 "WAVE FORMS FOR TRANSMITTING END TO TELEMETRY" and photographs of waveforms.

Locate the group of 6 BNC connectors, behind the hinged door, upper right side of transmitting end unit of the telemetry equipment. These BNC connectors monitor waveforms U, Shift Pulse, a, A, FO, and Modulation. These waveform photographs were taken of equipment in serviceable condition. So we will assume FO is correct.

(1) Set the oscilloscope for external trigger + and AC FAST.

(2) Connect a cable from the BNC connector labelled FO, to the trigger input of the oscilloscope and also to channel A on the "plug in" unit of the oscilloscope.

(3) Set mode switch to A.

(4) Set volts/cm to 2 volts.

(5) Set sweep time/cm to 5 milliseconds.

(6) Adjust the triggering level so the sweep will trigger on the leading edge of FO.

(7) Observe the resulting waveform. It should look like the waveform labelled FO Fig. 2, "Waveforms for Transmitting End of Telemetry Equipment". Check the triggering time and measure the time intervals.

(8) Leave the controls for the external trigger and the triggering level at the same setting for the rest of the procedure.

(9) Disconnect the cable attached to channel A of the oscilloscope from the BNC connector labelled FO and connect it to the BNC connector labelled SHIFT.

(10) Set Sweep Time/cm to 10 microseconds.

(11) Set Volts/cm to 2 volts.

(12) Compare with waveforms of Fig. 2 labelled shift. Observe start of shift, length of the pulse (5 microseconds) interpulse period, (20 microseconds) and 1.4 volts.

(13) Remove the BNC connector from the Shift monitor point and connect it to the BNC connector labelled "a".

(14) Set the Sweep Time/cm to 50 microseconds.

(15) Compare to waveforms of Fig. 2, labelled "a". Observe the start of "a", length of pulse, (20 microseconds) interpulse period (320 microseconds).

(16) Set Sweep Time/cm to 5 microseconds.

(17) Observe the length of the pulse in expanded form.

(18) Remove the BNC connector from monitor point "a" and connect it to the monitor point "A".

(19) Set the Sweep Time/cm to 50 microseconds.

(20) Compare to waveform of Fig. 2 labelled "A", notice the start of the waveform and its length, 320 microseconds with a 1.7 volt height.

(21) Switch Sweep Time/cm to 1 millisecond.

(22) Observe the inter pulse period, (5.120 usec.).

(23) Remove the BNC connector from "A" and connect it to monitor point U.

(24) Set Sweep Time/cm to 1 millisecond.

(25) Compare to waveforms of Fig. 2 labelled U. Notice time from t_{16} to t_{48}. This is when the frame sync pattern is shifted out of the register.

(26) Remove the BNC connector from monitor point U and connect it to the BNC connector labelled "Mod" for modulation.

(27) Take another cable and connect it to channel "B" on the oscilloscope plug in unit, and to monitor point U.

(28) Set Sweep Time/cm to 200 microseconds and mode switch to alternate.

(29) Observe the two waveforms and compare them to Fig. 2 waveforms, labelled "Mod". Observe the two frame sync patterns are shifted out during waveform U. Check the frame sync pattern. It should be 1111 000 100 110 100 (8 ones & 8 zeros) followed by 1111 000 100 110 100.

(30) Observe channel #1 which follows immediately after the end of waveform U. This is a digital representation of the analog value, set into channel #1 by the setting of the clock face dial potentiometer. The potentiometer is set at 9.14 turns of the dial and has an analog voltage of 4.670 volts. A column of lamps monitoring the digital conversion would show 1110100110 for its 10 bits of conversion.

(31) The value of the digital bit stream would be

$$\text{"E Ref"} \ \frac{5.12 \text{ Volts} \times [512(1)+256(1)+128(1)+32(1)+4(1)+2(1)]}{1024}$$

$$= 4.670 \text{ volts}$$

The 11th lamp shows a "1". It will always show as a "1", due to the input circuitry of the gate being at zero volts, which shows as a "1" in the shifted output bit stream.

The next three lamps show three zeros. These are used to show the minor frame number, which is in this case, FO. The 15th bit is a "1" for same reason as 11th bit. The last or 16th bit is called Parity Bit. It is dependent on the preceding number of bits. If the preceding bits come to an even number of 1's, a parity bit of "1" is added to the bit stream so that the total number of "1's" will be odd. This is called odd parity.

Immediately following channel 1 is channel 9.

F. R.P.M. Measurement

1. Figure 3 shows the prefocused lamp and the two photo transistors used in conjunction with a slotted wheel (shown in drawing BD-15-3B) to measure the RPM of the propeller. The 150 tooth wheel is driven at the same speed as the propeller by a toothed belt. Circuitry is provided in the logic unit to slice and square up the sine wave coming from each photo transistor. Five μsec. pulses are produced at each transition in both square waves and gated into a 10-bit counter for a time interval of 40 MS. 320 μsec. later the content of the counter is parallel transferred into a buffer register. Another 320 μsec. later

the counter is cleared by a 320 μsec. pulse. At the end of this clearing pulse, the 40 MSec. gate is again enabled to generate another RPM measurement.

The sine waves produced by the two photo transistors must have a 90 degree phase difference so that the 5 μsec. pulses derived from one sine wave are positioned, timewise, at the mid-point between the 5 μsec. pulses derived from the other sine wave. This means that the distance between the photo transistors measured along the circumference of the wheel must be an odd number of 1/4 tooth intervals (1 tooth interval = the circumference of the wheel divided by 150 or about 0.062 inch). In practice this phasing adjustment is done quite simply by observing the 2 square waves on a dual-beam oscilloscope and rotating the photo transistor holder until the proper 90° phasing is obtained.

One lamp is sufficient to illuminate both photo transistors and no masks are required because each tooth is wide enough (about 0.032 inch) to cover up the lens on one transistor.

The direction of rotation of the propeller shaft is obtained by observing the phase relation of the 2 square waves. The phase difference is always 90° but the leading square wave becomes the lagging one if the direction of rotation is changed. In practice one of the square waves is used to condition a JK flip-flop while the negative edges of the other square wave are used to trigger the same flip-flop. Thus the direction of rotation is loaded into this flip-flop.

The symmetry of the square waves can be adjusted by a potentiometer in series with the lamp and also by two other potentiometers in series with the two photo transistor load resistors.

Three RPM pick-offs can be handled by the circuitry in the logic unit. There are three 10-bit counters and three buffer registers. The three counters count simultaneously and are all transferred to their buffer registers by one transfer pulse. One TIP 14 transistor is used to regulate the lamp voltage on the 3 RPM pick-offs.

2. The measurement of RPM is thus arrived at in the following manner. Each tooth produces two five μsec. pulses for each photo transistor it goes past. This gives 4 pulses per tooth.

$$\text{The RPM} = \frac{\text{No. of teeth per minute}}{150}$$

$$= \frac{\text{No. of pulses per minute}}{4 \times 150}$$

$$= \frac{\text{No. of pulses per 40 MS} \times 1500}{4 \times 150}$$

$$= \text{No. of pulses per 40 MS} \times 2.5$$

Each pulse produced is worth 2.5 RPM. The 10-bit counter could count up to 2,557.5 RPM, (1023 x 2.5). There is also provision made to delete one half of the 5 μsec. pulses. This would make each remaining pulse worth 5 RPM and the 10-bit counter could then count up to 5,115 RPM, (1023 x 5).

G. Chopper Power Supply

The lower portion of the logic unit contains a chopper power supply. The chopper, shown in circuit diagram (AF 12-148D) operates from 24 volts DC (fused for 1.5 amps) which can be supplied from lead acid batteries or from an internal transformer and rectifier supply connected to a 115 volt 60 cycle source such as a gas-electric generator. A switch is provided to select battery or 60 cycle operation. A 1N3210 rectifier is connected in series with the positive battery lead to prevent damage to the two chopper transistors if the batteries are accidentally connected in reverse. A push button is provided to start the chopper in case it does not self-start. The push button merely applies a short voltage spike, via a capacitor, to the base of one of the transistors.

The toroidal transformer, with orthonol core #50038 (with 2 mil tape), has three secondary windings to provide + 3.6 volts, + 12 volts and - 12 volts after full-wave rectification. The + 12 and - 12 volt supplies are further reduced by dropping resistors and zener diode regulated to provide + 7 and - 6 volts. The + 12 volt supply is also used as the input to a + 5.12 volt regulator for the reference supply. This reference voltage regulator utilizes a 2N3704 series transistor driven by an MC1430 operational amplifier. A 1.35 volt mercury cell is used as a reference for the MC1430 and a potentiometer is provided to adjust the regulated output to + 5.120 volts.

Eight voltmeters, labelled V_1 to V_8 are provided on the front panel of the logic unit to monitor the following 8 voltages:

V_1 monitors the 24 V input to the chopper

V_2 monitors the + 3.6 V for the integrated circuits

V_3 monitors the + 7V

V_4 monitors the + 12 V

V_5 monitors the + 5.120 V regulated reference

V_6 monitors the - 12V

V_7 monitors the -6 V

V_8 monitors the 115 V - 60 cycle source (if used).

A 1N600A (4.7V, 10 watt zener diode) is connected across the + 3.6 volt supply to prevent damage to the integrated circuits in case an excessive voltage is applied to the input of the chopper.

H. Staircase Generator

A nine level staircase generator, located at the bottom of page 2 and shown in circuit diagram AF12-152D is provided to simulate data in order to check the various analog channels of the telemetry. Three types of staircase waveforms could be obtained. These are shown in the bottom three waveforms on the circuit diagram. Pin 14 of integrated circuit No. 69 (or $\bar{h}$) can be jumpered to ground to obtain the bottom waveform, or pin 13 of the same IC (or h) can be jumpered to ground to obtain the second waveform from the bottom. These two bottom waveforms have not proven to be very useful because their fast transitions make them quite unlike the actual data. The third waveform from the bottom, labelled "normal output", is preferred because of its closer resemblance to the actual data. It is obtained by leaving the circuitry as shown in the diagram.

The staircase output is brought out to a connector on the left side of the logic unit and can be patched into any one of the eleven adjacent connectors which are inputs to 11 of the analog channels. Normally it is left patched into the channel 2 connector. Furthermore, inside the unit, on page 4, this channel 2 connector can be disconnected from channel 2 and plugged into any one of the other analog channels for checking each channel separately. As will be described later, the staircase waveform can be transmitted on channel 2 and made to appear simultaneously at all 10 analog outputs at the receiving end. Thus when a multi-channel paper chart recorder (up to 10 channels) is used, all the channels can be easily adjusted for range (or gain) and zero setting.

The staircase generator consists of a counter and a resistance ladder containing four weighted resistors of values 1.35 K, 2.7K, 5.4K and 5.4K. Flip-flops D, E, F and G drive the input ends of the resistors to ground potential or to +5.12 volts by means of the ladder drivers. The outputs of the flip-flops are complemented or not complemented by integrated circuits 63, 64 and 65 depending on the setting of flip-flop H. Waveform F_o drives a divide by 4 counter (flip-flops B and C) which in turn drives the divide by 10 counter (ladder flip-flops D, E, F and G) which in turn drives the complementing flip-flop H. The 1.35 K, 2.7K, 5.4K and 5.4K resistors will contribute to the ladder output respectively 1/2, 1/4, 1/8 and 1/8 of the 5.12 volt reference. If a resistor input is at ground potential it does not contribute to the output, but if it is at + 5.12 volts it does contribute.

Recording No. 1 shows the original staircase plus its received version on channel 2 at 25 samples per second and on channel 9 at 200 samples per second.

PART 11 <u>The Receiving Section</u>

(1) The receiving section is comprised of a 260.4 MHz receiver, with a 10.7 MHz intermediate frequency, 270.7 MHz local oscillator, crystal detector and an automatic slicer in its output. The receiver is externally battery powered, with + 12 volt and - 12 volt batteries.

(2) A dipole antenna cut for 260.4 MHz.

(3) A demultiplexing unit with its time recovery,

demultiplexing, shift register, buffer and hold registers, digital readout, D/A conversion and analog switching circuits.

A. Installation of the Equipment in the Tower

(1) The equipment should be installed on a table, located on the tower platform, and adjacent to the remote control console. The operator of the remote control equipment should be able to see the monitoring panel of the telemetry equipment, in order to monitor the "Status of the Remote Control System".

(2) Mount the receiving dipole antenna with its wire mesh reflector, on the tower close to the platform, which holds the tower equipment.

(3) The 260.4 MHz receiver could be mounted on a shelf below the demultiplexing unit.

(4) Mount the demultiplexing unit, as mentioned, beside the remote control console.

(5) Interconnecting Cables

(a) A RG 58 coaxial cable, with male BNC connectors at both ends, connects the dipole antenna, to the input BNC connector on the 260.4 MHz receiver.

(b) A RG 58 coaxial cable, with male BNC connectors at both ends, connects the sliced output of the reciver, to the BNC connector on the left side panel of the demultiplexer unit.

(c) A cable with a male 3 prong AC connector, on one end, and a female 3 socket AC connector on the other end connects the tower AC hydro 115 volt 60 cycle power line connector, to the demultiplexing unit, at the connector on the lower left side panel.

B. Operation of the Receiving End (Refer to Plate 1)

(1) Open the lower hinged door which covers the switch, fuse and meter panel.

The meter on the left reads the AC line volts, which would be about 115 volts. The D.P.D.T. toggle switch, with the fuse holder above it, next along the panel, is the AC power "on/off" switch to the D.C. power supplies. One supply is located in the base of the unit, and the other a 28 volt power supply is located behind the monitor lamps, of the upper right front panel. The second pole of the switch controls a Mallory cell (1.34 volts) in the reference voltage regulation circuit. The next seven meters along the panel monitor the various D.C. voltages required for the circuitry in the unit. The meters read:

Reference voltage, which would read 5.12 volts.

Logic Voltage, which would read 3.6 volts.

Ladder Switch Voltage, which would read + 12 volts.

Operational Amplifier Voltage, which would read + 12 volts.

"Fet" switch voltage, which would read - 12 volts.

Operational Amplifier Recorder Driver, + 12 volts (sixth meter) - 12 volts (seventh meter).

The next fuse along the panel is for the 28 volts DC power supply which operates the lamps of the monitor assemblies.

The toggle "on/off" switch next along the panel controls the 28 volt DC to the lamps of the top three rows of the monitor assemblies.

(2) The sloping panel has two hinged doors--

Lift the one on the right side. Under it is a patch panel board, with many sockets. Some of these sockets have the waveforms which switch the six digital registers and the ten analog switch circuits. The sockets show:

First Row-Sub commutating waveforms for Ch 1-Ch 8

Second Row-Normal commutating waveforms for Ch 9-Ch 13

Third Row-Sub Commutating waveforms for Ch 14 - Ch 21

Fourth Row-Normal commutating waveforms for Ch 30-Ch 34

Fifth Row-Super Commutating waveforms for channels (9 and 30) (10 and 31) (11 and 32) (12 and 33) (13 and 34) (9 and 30 and 13 and 34)

Sixth Row-Waveforms for digital Ch 1 - Ch 8 but only Ch 1 to Ch 4 are utilized at the sending end equipment.

Seventh Row-is the connections to the output gates which switch the six digital registers with their display circuits and the ten analog switching circuits, labelled ABCDEFGHJKLM.

(A) One digital register and one analog circuit

(B) One digital register and one analog circuit

(C) One digital register and one analog circuit

(D) One digital register and one analog circuit

(E) One digital register and one analog circuit

(F) One digital register and one analog circuit

(G) One analog circuit

(H) One analog circuit

(J) One analog circuit

(K) One analog circuit

(L) Spare socket not connected

(M) Spare socket not connected.

(3) The operation of the patch panel is as follows: Select, say, sub commutated channel socket number 1 and patch it into socket in bottom row, say output gate socket A. The waveform out of socket 1 will switch the first digital register with its column of monitor lamps, on page 3 of logic circuitry, located behind the hinged panel at upper left of unit, and also will switch analog circuit A, on page 6 of the logic circuitry. The information displayed on the digital register lamps will be a digital representation of the analog value placed into analog channel #1 at the transmitting end. At the same time, the output of the analog switch circuit A will be at an analog value which will be the same, or with very little error, as that of the analog input to channel #1 at the transmitting end. If sub commutated channel socket number 1 was patched

into say output Gate B, the waveform of Ch 1 will switch the second digital register and its column of monitor lamps, page 3, of logic circuitry, and the register will display the digital representation of the analog value which is fed into analog Ch 1 at the transmitting end. At the same time the output of analog switch circuit B will have the same analog value as that which was fed into Ch 1 at the transmitting end. If you selected sub-commutated channel socket number 2 and patched it into A or B, as above, the result would be the same except that the analog input to channel 2 (instead of channel 1) at the transmitting end, would be displayed on the digital monitor lamps and appear at the analog output of the analog switching circuit. Likewise, if any channel of the above section B2 is patched into the first six output gates, a digital representation and an analog value will be displayed for the inputs associated with the number of the channel chosen above. Channel 1 input at transmitting end with channel 1 socket waveform will display channel 1.

Channel 9 waveform will display input 9 of transmitting end.

If any one of the first four digital channel sockets is patched into output gate A on the bottom row, it would display the corresponding digital input of the transmitting end, on the digital monitor lamps, and an analog value of that digital input would appear at the output of the analog switch circuit A. The first four digital channels have inputs at the transmitting end only, so digital sockets 5, 6, 7 and 8 at the receiving end are not used. Output gates G, H, J, K drive only an analog switching circuit and so will produce only an analog value and no digital representation of the analog value. The digital inputs at the transmitting end are namely: RPM A assigned to digital input 1; RPM B assigned to digital input 2; RPM C assigned to digital input 3. Status conditions of the Remote Control are assigned to digital input #4. When any of these inputs require monitoring, patch cords between the appropriate sockets, of Digital 1, 2, 3, 4, would have to go to output gate sockets A to F, except digital 4. It has to go to socket "F", as the digital register and the lamp display operated by the use of socket F is the only register to which the monitor lamp assemblies, upper right front panel, are wired.

The super-commutation sockets as labelled (9 and 30) (10 and 31) (11 and 32) (12 and 33) (13 and 34) on the sloping panel are wired "OR"'s. If we select (9 and 30) and patch it into output gate A, the digital monitor would display a digital representation of the analog value, and the output of the analog switch circuit A would be that of the analog input value feed into input #9 at the transmitting end. This would require a pin change in the patch panel of the transmitting end, behind right side panel door. The pin in the horizontal row in line with gating waveform 30 would have to be moved over and placed in the socket under the vertical column 9 of the gates for the channels.

The above operation causes channel #9 to be sampled at 2 times normal (200 samples per second) which would be 400 samples per second. Likewise, if we patch (10 & 31) at the receiving end into output gate B we would need to move (on the patch panel at the transmitting end) the pin in the horizontal row, in line with gating waveform 31, over and plug it into the vertical column under channel #10. This would cause channel #10 input to be sampled at 2 times normal or 400 samples per second. Similarly, patching (11 & 32) at the receiving end into output gate C would require the pin, at the transmitting end, in the horizontal row 32 to be moved and plugged into the socket under the vertical column for channel #11. This would cause channel #11 input to be sampled 2 times normal or 400 samples per second. Selecting (12 & 33) and patching it into output gate D, would require, as above, moving the pin in horizontal row 33 over and inserting it under the vertical column for channel #12. Channel #12 is then sampled at 400 samples per second. Selecting (13 & 34) and patching it into output gate E would require moving the pin in horizontal row 34 over and inserting it in vertical column under channel #13. Channel 13 is then sampled at 400 samples per second.

The above mentioned pin positions at the transmitting end patch panel are the (red) coloured dots on the diagram attached to the hinged door covering the patch panel. If the gating waveform from the socket labelled 9 & 30 & 13 & 34 on the sloping panel at the receiving end is patched into output gate A, 3 pins would have to be moved at the transmitting end patch panel. The pins in horizontal rows 13, 30, and 34 would all have to be moved to the left to the vertical column labelled channel #9. This would cause channel #9 to be sampled at four times normal or 800 samples per second. The above mentioned pin positions at the transmitting end patch panel are the green coloured dots on the diagram, mounted on the hinged door.

For normal operation the pins are left in the positions shown by the black dots on the diagram on the door. During super commutation it is obvious that where you combine waveforms to sample, say, channel 9 four times the other channels which would be sampled normally would not be sampled now.

(4) The second hinged door on the sloping panel covers a 0 - 100 microampere meter, with a 10 turn 300 K potentiometer at the left of the meter. This potentiometer is in series with a

15K resistor to the positive terminal of the meter. The other terminal of the meter is to signal ground. The movable arm of the potentiometer is brought out to a lead, which can be plugged into the various sockets on the right side of the meter. The sockets are the voltage outputs of the switched analog circuits and labelled A B C D E F G H J K L M. L and M are spares for future expansion.

The sockets labelled ladder and Zeltex are connected to the points (see diagram on door) which would monitor the output voltage of the D/A ladder and the output of the Zeltex differential operational amplifier, model 132. The operation to use the facility requires a little explanation.

In the logic circuit unit behind the upper left hinged door is switch #2 located on page 1, labelled Normal (up) and Test (down), and on page 3 is switch #3, labelled Normal (up) and Hold (down). Refer to the circuit diagram, "Trouble shooting check points". When SW#2 is in the "Test Position" and any channel waveform on the patch panel is connected into output gate A, the digital representation of the analog value, which is fed into that channel (transmitting end) will be loaded into the left column digital hold register and displayed on its monitor lamps. Only this digital representation will be loaded into the Digital-to-Analog buffer register, due to the connection wired to pin 7 position 31 page 4, of logic circuitry, which is associated with output gate A (only). So whatever channel waveform is used, be it channel 1 or channel 2, etc., it must be plugged into output gate A. The information loaded into the registers will be the input associated with that particular channel number at the transmitting end. If we had selected channel #1 into output gate A, the information loaded would be that of the input of channel #1. The rest of the channel inputs would not be loaded. The digital contents of the D/A buffer register will be converted to an analog value and fed into the Zeltex Operational Amplifier. It is at this point that the ladder output can be checked by plugging the lead from the meter into the socket labelled "ladder". Then the Zeltex amplifier can be checked by plugging the meter lead into socket labelled Zeltex. Since there is only one of the channels being loaded into the D/A register, converted and placed on the output "bus" of the "op amp" (Zeltex), and the other output gates B, C, D, etc., may have a switching waveform patched to their sockets, this value placed on the output "bus" would appear at the output of each switched analog circuit.

The loading of the above mentioned D/A buffer register and its similarly loaded digital hold register is being updated each time channel 1 waveform appears to output gate A, which is about 25 times a second or every 40.960 milliseconds.

Recapitulating, we see that the meter lead can be plugged into A, B, C, D, E, F, G, H, J, K at any time to check the 10 analog outputs. However, if the ladder or the Zeltex are to be checked we must first put SW2 in the test or down position. This allows the D/A buffer register (the input to the ladder) to be loaded with only the channel that is patched into the gate of analog output A. In this position of SW2, all the sockets to the right of the meter will read the same (the same as A). Putting SW2 in the test position merely makes the D/A buffer get loaded with the same thing as digital hold register A.

SW#3 is intended to stop the updating of all six digital hold registers. If SW3 is put in down or hold position, at any time, the registers will simply maintain their previous contents.

If SW2 is put down first and then SW3 is also put down the D/A buffer will of course also stop being updated and will just hold its previous contents wich will be the same as digital hold register A.

If SW3 is put down first and then SW2 is put down, the action here is indeterminate and should be avoided.

The Zeltex op amp is located on page 6 of the logic unit and has a 5K potentiometer in parallel with 2.7K between its offset input and + 15 volts. Any error between the output "bus" of the ladder and the output "bus" of the Zeltex unit can be "offset" by adjusting the potentiometer (p3).

(5) Some features in the logic section (Refer to Plate 4)
Located behind the upper left hinged door of the front panel is the logic section.

(a) On page 1 at the bottom left corner is located SW1. This toggle switch just inserts an inverter into the input digital stream, which comes from the receiver. This makes an adjustment, if necessary, in the polarity of the input signal stream. If the input is high for a "1" and low for a "0", by changing the switch the input to this unit would be low for a "1" and high for a "0".

(b) At the bottom right corner of page 1 is a slug tuned transformer. This is part of the bit timing recovery circuit. It is tuned to ring at 50 KHz when it is triggered by the transitions in the input bit stream. It should not need any further tuning.

(c) At the top of page 3 of this unit is a panel with sockets mounted on it. These sockets are wired in parallel with those of the sloping panel (previously described).
BNC monitor test point labelled channel Sync (upper left side panel waveform monitor group)

is plugged into channel 1 socket but it could be moved around to obtain an oscilloscope sync pulse for the other channels.

(d) Located on this panel is switch #4 (SW4). It controls the voltage to the digital register display lamps. It is used mostly for circuit checking when the equipment is being serviced. It is usually left in off position (up) to decrease the loading of the power supply.

(6) Features in the Power Supply Unit

(a) A Boxer fan is installed on the lower right side panel of the unit. This cools the power supply and logic circuit area. It is connected to the main off/on switch of this demultiplexing unit.

(b) The Mallory mercury cell (1.35 volts RM 12R) used as a reference cell in the regulator circuit of the 5.12 volt reference supply should be carefully maintained. Watch for any signs of corrosion about the ends of the cell in contact with the cell holder. Replace if found necessary.

(c) In regard to the regulator circuit of the reference supply there is a small 5K potentiometer which may be adjusted if the reference reading is not 5.120 volts as read on a good digital voltmeter.

(7) Analog Output Terminals

Each of the ten switched analog circuit outputs is brought out at two places. There is a ten terminal barrier strip, located behind the hinged door on the left side of the unit. These are labelled A B C, etc., for analog outputs A, B, etc. On the back panel of the unit are two "Cannon" connectors, each having 10 sockets. Each analog output is brought to a connector terminal, along with a signal ground return, one for each output terminal, which is picked up at the main signal ground tie point. The top connector handles circuits A to E and the bottom connector handles circuits F to K.

C. Monitor Indicators at the Receiving End of the Telemetry Equipment "Status of On/Off Commands"
"Telemetry Sync"
(Refer to Plate 1)

(1) Located on the upper right panel of the receiving end of the telemetry equipment is a group of sixteen indicator assemblies. This group is divided into four rows, with four indicators to a row. The screen covering the lamps of each indicator is divided horizontally to give two horizontal sections. The lamps behind

the top section will cause that section of the screen to glow with a green colour. The lamps behind the lower section will cause that section to glow with a red colour. The colour of the lamps is due to coloured plastic caps over each of the four lamps in the indicator assembly. The lamps are G.E. #327, 28 volts at 40 mils. each, Flange type T 1 3/4. The 28 volt source power supply for the lamps is located behind the panel, and is serviceable from the rear panel of the unit. Top three rows of these indicator assemblies can be turned "on/off" by a switch, located at the extreme right side of main meter and switch panel. The bottom row is not switched, because that row monitors the operational condition of the telemetry equipment.

(2) Each section of the indicator assembly lamps is driven on or off by two 2N 3904 transistors. When the first transistor is turned "on" its output turns the other transistor "off", and when first transistor is turned "off" its output turns the other transistor "on". An "on" transistor returns one terminal of the lamp to the low side of the 28 volt power supply and

lights the lamp. The input of the first transistor driver for each of the eleven indicator assemblies is connected to the number nine pin output of eleven Motorola 790 flip-flops, which make up a digital hold register. The hold register is located in the upper left section on page 4, column six, of the receiving end of the telemetry equipment. Low volts at the output of the flip-flops turns on the lower two lamps of the assembly. A high output would turn on the upper two lamps of the assembly.

(3) The eleven indicator assemblies above are the two upper rows and three assemblies of the third row. The last of these eleven assemblies and the last assembly in the third row are spares at the present time. The first three assemblies of the bottom row are used to monitor the timing of the telemetry equipment.

The first on the left is connected to the buffer inverter of the frame counter, position 6, pin 1, page 2. This monitors the Major Frame Counter by driving the upper and lower section lamps on and off, approximately 25 times a second.

The second indicator assembly is connected to a

Motorola 790 flip-flop position 5 pin 13, page 2, which in turn is connected to the clear pulse of the frame counter. This monitors the Major Frame Sync by driving the upper and lower section lamps on and off approximately 12 times a second.

The third indicator assembly is connected to a three bit counter made up of Motorola 790 flip-flops, pin 8 location 4, page 2. The counter is triggered from pin 10 location 37, page 2, which is the clear pulse of the bit and word counters. This monitors the Minor Frame Sync by driving the upper and lower section lamps on and off approximately 25 times a second.

The fourth indicator assembly is a spare at this time. The bottom row of indicator assemblies does not have the colour caps on the lamps and will just show a white screen colour. The first two rows and first two units of the third row of indicator assemblies have been assigned to monitor different devices and the function of the device of a Remote Control System used to manoeuvre model ships in a test basin (ERB 837). The devices and functions are:

Motor A	Times 2	Times 1
Motor A	Go	Stop

Motor A	Power On	Power Off
Motor B	Times 2	Times 1
Motor B	Go	Stop
Motor B	Power On	Power Off
Motor C	Times 2	Times 1
Motor C	Go	Stop
Motor C	Power On	Power Off
Rudder	Power On	Power Off

(4) In order to dump the contents of the shift register into the appropriate hold register which operates these indicator assemblies, a patch cord is required from digital channel socket #4 to output gate F. These sockets are located under the right side hinged door of the sloping panel. The contents of the shift register were received, via an R.F. link, from the transmitting end of the telemetry equipment.

(5) The input to the transmitting end unit is an Amphenol 12 socket connector, located on the upper part of the second section of the hinged door, on the left side of the unit. A zero volt input on any of the sockets of this connector at this point of the circuit would turn on the lamps of the lower section of the indicator assemblies.

(6) <u>Monitor Interface Unit</u> (Refer to Plate 10)

(a) This unit is used to route the status information of the remote control devices to the telemetry equipment. The Remote Control equipment, at the same time, is isolated from the telemetry equipment.

(b) The status information of the Remote Control equipment is at 0 volts, 3.6 volts, or 24 volts. This is obtained from a unit of the Remote Control system called "Relay Unit". These relays are operated by coded push buttons at the Control Console. The appropriate connections are brought out to an Amphenol connector on the relay unit, and brought by a cable to the Amphenol connector on the Monitor Interface Unit (see Block Diagram of "Connections of Monitor Interface Unit Between Remote Control and Telemetry Unit AF-12-134D). The connector is located on the rear of the interface chassis unit.

(c) The monitor interface unit has eleven rotary switches located under the hinged lid. Each switch has seven positions available. At this time only number 1 position on each switch is used. The other positions are for any future points, which may require monitoring. The movable arm of each switch is connected through an 8.2 K resistor to the base of a 2N3904 transistor (a separate transistor for each switch). The voltage level of 0, 3.6 volts, or 24 volts mentioned above, turns "on" or "off" the transistor. The "on" or "off" condition of the transistor in turn operates a lamp in a Vactec VT6005 Unit. The lamp of the Vactec unit is supplied by 3.6 volts from the remote control source. This voltage into the interface unit came from the relay unit by a cable, using a 5 terminal Amphenol connector, to a connector located on the left side of the chassis. This is the point at which the isolation between the two systems is maintained. The lamp "on" in the Vactec unit causes a resistance change, in the unit's output circuit, to go from 100 meg. (lamp off condition) to 90 ohms.

This in turn changes the bias on another 2N3904 transistor causing it to turn "on" and its output is 0 volts. This output is connected to one terminal of an Amphenol connector, front of chassis, which is then brought through a cable to the input 12 socket Amphenol connector on the second section of the hinged door on the left side of the telemetry unit. There are eleven identical circuits of the above description, one for each switch. The voltage to operate the transistor in the output circuit of the Vactec unit is obtained from the transmitting end of the telemetry equipment. This is brought to the monitor interface unit by a 5 terminal Amphenol connector, located on the front edge of the chassis, and a cable from a 5 terminal Amphenol connector, located on the right side panel of the telemetry unit.

A 3.6 volt input to the selector switches will end up lighting the lamps of the lower section of the indicator assemblies, on the receiving end of the telemetry.

Likewise 0 volts at the input to the switches will end up lighting the lamps of the upper section on the indicator assemblies.

The 3.6 volts received from the remote control relay unit is switched on/off, at the relay unit.

D. Procedure for Checking the Receiving End Waveforms

It is advisable to use a Tektronix Oscilloscope type number 543 with a type CA PLUG IN UNIT to check the following waveforms. Refer to Fig. 4 "WAVEFORMS FOR RECEIVING END OF THE TELEMETRY". Locate the group of 8 BNC connectors behind the hinged door on the left side of the telemetry receiving equipment. These connectors are wired to monitor waveforms, FO, Frame Sync, Correlator, B, Zeltex Output, Bit Timing, Receiver, and Channel Sync, as seen on Fig. 4 "Waveforms for Receiving End of the Telemetry" and waveform photographs. These photographs were taken of equipment in a serviceable condition.

(1) Set the oscilloscope for external trigger +, and AC FAST.

(2) Connect a cable from the BNC connector labelled FO, to trigger input of the oscilloscope and also to channel A of the "plug in" unit of the oscilloscope.

(3) Set mode switch to A.

(4) Set Volts/cm switch to 2 volts.

(5) Set sweep time/cm to 5 milliseconds.

(6) Adjust triggering level so that the sweep will trigger on the leading edge of FO.

(7) Observe resulting waveform. It should look like waveform FO on Fig. 4 "Receiving end waveforms". Check the triggering point and measure the time intervals.

(8) Leave external trigger and triggering level the same for the rest of the procedure.

(9) Disconnect the cable attached to channel A of the oscilloscope from the BNC connector labelled FO and connect it to the BNC connector labelled Frame Sync.

(10) Set sweep time/cm to 1 millisecond.

(11) Observe resulting waveform. Compare with Frame Sync waveform on Fig. 4.

(12) Set sweep time/cm to 2 microseconds and observe waveform. Compare to the waveform on Fig. 4 labelled Frame Sync expanded.

(13) Remove the BNC connector from the Frame Sync monitor point and connect it to the BNC connector labelled Correlator Output.

(14) Set volts/cm to 5 volts.

(15) Set sweep time/cm to 1 millisecond.

(16) Observe and compare waveform to that labelled Correlator Output of Fig. 4.

(17) Set sweep time/cm to 5 microseconds.

(18) Observe and compare to waveform of Fig. 4 labelled Correlator Output expanded.

(19) Remove the BNC connector from the Correlator Output monitor point and connect it to the BNC connector labelled "B".

(20) Set sweep time/cm to 1 millisecond.

(21) Set volts/cm to 2 volts.

(22) Observe and compare to waveform Fig. 4 labelled "B".

(23) Remove the BNC connector from "B" monitor point and connect it to Channel Sync.

(24) Set sweep time/cm to 5 milliseconds.

(25) Observe and compare to waveform Fig. 4 labelled Channel Sync.

(26) Set sweep time/cm to 0.1 milliseconds.

(27) Observe and compare to waveform Fig. 4 labelled Channel Sync expanded.

(28) Remove the BNC connector from Channel Sync monitor point and connect it to the BNC connector labelled Bit Timing.

(29) Set sweep time/cm to 10 microseconds.

(30) Set volt/cm to 2 volts.

(31) Observe and compare to waveform Fig. 4 labelled "Bit Timing".

(32) Remove the BNC connector from the Bit Timing monitor point and connect it to the BNC connector labelled Receiver (Rec.).

(33) Set the clock face dial potentiometer, located behind the hinged panel on the left side of the transmitting unit of the telemetry equipment, to read 9.14 which when observed on the left column of indicator lights, located on page three, behind hinged door, upper left of receiving end telemetry unit, will read 111 01 00110 11. The first 10 lights show a digital representation of the analog value of the setting of the above potentiometer. The last two lights are a sign and a parity bit. The indicator lights require a patch cable to be connected between sub commutated channel 1 and output gate A, located behind hinged sloping panel of receiving end unit. Output of the clock face dial potentiometer is wired into the input of channel 1 at the transmitting end equipment.

(34) Set the sweep time/cm to 50 microseconds.

(35) Set volt/cm to 5 volts.

(36) Observe and compare to waveform Fig. 4 labelled Receiver Output, of channel 1. Notice a small delay at first bit of 10 microseconds, and also the first bit is 15 microseconds wide if it is a "1". This is due to timing at the transmitting end. The first ten bits of the waveform, as mentioned above in regard to the indicator lights, are the digital representation of the analog value of the setting of the clock face dial potentiometer at the transmitting end. The next bit is a "1" which is not used and will always show as a "1" because the input to that gate in the multiplexer, at the transmitting end, is not connected and will show at the receiving end as a light on or in the transmitted bit stream as a "1". The next three bits are "0". These three bits are assigned to indicate minor frame number, and in this case the minor frame number is F0.
The 15th bit is a "1" and referred to as a sign bit. It will show as a "1" because, again, the input to that gate in the multiplexer, at the transmitting end, is not connected. The 0 volts, at that point in the circuitry,

will show at the receiving end as a light "on" or in the transmitted bit stream as a "1". The 16th bit is referred to as a parity bit. This bit is dependent on the preceding 15 bits. If there is an even number of "1"'s preceding the sixteenth bit a parity bit is "put in" so that there will be an odd number of "1"'s in the transmitted bit stream. The next 10 bits along the waveform are allotted to the digital representation of the analog value connected into channel 9.

(37) Remove the BNC connector from the Receiver monitor point and connect it to the Zeltex Output monitor point.

(38) Set sweep time/cm to 0.1 milliseconds.

(39) Set volts/cm to 2 volts.

(40) Observe and compare to waveform Fig. 4 labelled Zeltex Output.

Notice the first 320 microseconds of time. It has the analog value, which is represented by the first ten bits of the frame sync pattern. The first 10 bits are 1111000100. Converting this to analog volts would be

$$\text{'E Ref' } 5.12 \text{ volts} \times \frac{[512(1)+256(1)+128(1)+64(1)+4(1)]}{1024}$$

$$= 5.12 \times \frac{964}{1024} = 4.82 \text{ volts}$$

The second 320 microseconds of time has the analog value of the digital representation of the value set into channel 1 by the clock face dial potentiometer. The dial was set as previously mentioned, at 9.14 turns and gave a digital bit stream of 1110100110. This converted into the analog voltage would be

$$\frac{5.12 \times [512(1)+256(1)+128(1)+64(0)+32(1)+16(0)+8(0)+4(1)+2(1)+1(0)]}{1024}$$

$$= \frac{5.12 \times 934}{1024} = 4.670 \text{ volts}$$

The third 320 microseconds of time has the analog voltage that would appear if an input was fed into channel 9 at the transmitting end. The photograph of the Zeltex output shows a case where a staircase generator was fed into channel 9. The multi levels show the various voltages of the staircase generator fed into the channel.

PART III. Visual Meter Display

(1) This rack of meters is to provide an instant visual display of the analog outputs for the ten circuits. (Refer to Plate 3)

(2) Connections from the demultiplexer unit to the meter rack is by two cables, each with a 10 pin male connector on one end, and a 10 socket female connector on the other end.
The connectors are located on the left side of the meter rack. The first connector from the front of the rack handles meters labelled A to E. (Top row and two of second row) The second connector handles meters labelled F to K (the remaining meters).

(3) The connectors on the rack have their pins connected to a Jones barrier strip, located behind the meters, to serve as a junction for the meter and recorder connections (banana sockets). The input to the (+) plus side of each meter is through a 5.6 K resistor in series with a variable 50 K potentiometer. This permits calibrating the meters, which are 0 - 100 micro-amperes, to read full scale

at 5.12 volts (reference voltage). The meters indicate what percentage of the reference voltage the monitored analog values are. The adjustment of the 50K potentiometers is through the small openings on the front panel, labelled "Meter Calibration Adjustment", and each meter, potentiometer and analog circuit is indicated by letters A B C .....K (omitting I). The group of banana type sockets on the front panel are also connected to the Jones barrier junction strip. This provides a place to connect external recording equipment. The "output" of the sockets would be the same as what appears on the meter display. Each vertical column of sockets (one column for each analog output) has four sockets, white, black, red, and yellow. The white output socket is connected to the high side of the analog output, and the black socket to the low side of analog output. The red socket is connected to the low side (black socket). The yellow socket is not connected for this installation. If a TI oscilloriter recorder was attached to these outputs (see diagram Meters-Visual Readout AF-12-129D) the connections to the white and black sockets could be interchanged to cause the pens on the recorder to read to the right for a positive voltage or to the left for a positive voltage. The connector on the recorder is such that the recorder cable shield is not connected to the meter rack.

PART IV. Description of Test Results

A. (1) Tables I to VI and Graphs

The following is a description of tables I to VI and of graphs 1 to 12. The measurements were all made with a Dymec Integrating Digital Voltmeter, model DY-2401A with a reading accuracy of ± 0.0001 volts. Some of the telemetered quantities were transmitted at 25 samples per second and some at 200 samples per second. Figure 7 indicates the labelling of the various measured points at the receiving end. These measurements were taken in the laboratory with the transmitting and receiving equipment connected together by a co-axial cable instead of by the usual radio link.

Table I shows results ot a test made on the telemetry link to see how long the system will work when the transmitting end is powered by two 12 volt-32 ampere-hour lead acid batteries type 9LU-Prestolite. For this test the protective diode in series with the batteries was shorted out. The receiving equipment was connected directly to the 117 volt 60 cycle line. The measurements taken at the transmitting end were: 24 volt battery voltage, reference supply and a standard voltage source consisting of 2 mercury cells in series. This standard voltage was telemetered on channel 17 at 25 samples per second and also measured at the receiving end. The reference supply at the receiving end was also measured. All these voltages, except the standard at the transmitting end are plotted in graphs No. 1 to 10. Graph No. 11 is merely a condensation of graphs 1 to 10. The only points plotted in graph 11 are those obtained after the equipment had been on for a few hours.

As can be seen from table I or from the graphs, the transmitting equipment works satisfactorily from 20 volts DC to 26 volts DC. Removing the short from across the protective diodes makes these figures 21 volts to 27 volts. The two 12 volt batteries can, therefore, satisfactorily power the transmitting equipment for 29 hours of normal operation. If instead of using batteries the transmitting equipment is powered from a 60 cycle source, satisfactory operation will result from 96 to 130 volts

Table II shows the accuracy of the D/A network of resistors and switches. For this test, switch 2 was put in the test position so that the D/A input buffer register was only being loaded with channel one, the clock faced potentiometer. The potentiometer was only used as a means of loading a certain binary number in the D/A buffer. This binary number was observed on the digital register monitor lamps associated with analog output E_A. A comparison is made between actual D/A output E_{ZI} and the theoretical values calculated by assuming a value of 5.120 volts for the reference supply at the receiving end. As can be seen the error varies from + 2.8 MV to - 3.2 MV.

Table III shows the effect of increasing the sampling rate on the analog output E_B. On channel 1, or at 25 samples per second the maximum error is -7.9 MV while at 200 samples per second on channel 10 the maximum error is -2.8 MV. There is thus an improvement of about 5 MV by increasing the sampling rate.

Table IV shows a binary number, going into the D/A network, and its corresponding theoretical value based on a reference supply of 5.120 volts. The resulting D/A output and the 10 analog outputs E_A to E_K at 25 and 200 samples per second are also shown. Switch 2 was in test position so that the D/A buffer was only loaded with channel 1 for 25 samples per second or with channel 10 for 200 samples per second.

Table V shows the effect of sampling rate on analog outputs E_A and E_B appearing in Table IV. This is done in order to have a comparison between E_A and E_B. Output E_A employs an MC 1533 for output buffering while outputs

E_B to E_K employ MC 1433's for output buffering. The MC 1533 has a higher input impedance, so output E_A should not be affected as much as E_B by sampling rate. E_A improves by about 3.5 MV by increasing the sampling rate while E_B improves by about 5.0 MV.

Table VI shows the drift with time in the two reference supplies and in the analog output E_A as received on channel 17. Graph No. 12 is a plot of Table VI.

The maximum drift in the reference supply at the transmitting end is 5.1197-5.1162 volts or 3.5 MV.

The maximum drift in the reference supply at the receiving end is 5.1216-5.1196 volts or 2.0 MV.

The maximum drift of output E_A is 2.6970-2.6900 volts or 7.0 MV. However, the input to channel 17 dropped by 1.2 MV during this time so that the real drift in E_A is only 7.0 - 1.2 or 5.8 MV.

TABLE I

Transmitting Equipment on Two 12V Batteries (9LU-32 AH-Prestolite)
Receiving Equipment on 115V-60 Cycles

DATE AND TIME	OPERATING TIME ON BATTERIES	BATTERY VOLTS (NO SERIES DIODE)	TX. END REFERENCE SUPPLY	CHANNEL 17 INPUT 2 MERCURY CELLS	CHANNEL 17 OUTPUT E_A 25 SPS	REC. END REFERENCE SUPPLY
MAR 13						
2:19PM	0:00	25.8	5.1120	2.6915	2.6902	
2:23	0:04	25.1	5.1143	2.6926	2.6896	
2:25	0:06	25.1	5.1147	2.6928	2.6895	
2:31	0:12	25.17	5.1147	2.6932	2.6895	
2:37	0:18	25.19	5.1143	2.6934	2.6896	
2:44	0:25	25.2	5.1142	2.6935	2.6895	
3:05	0:46	25.18	5.1134	2.6938	2.6896	5.1188
3:28	1:09	25.15	5.1139	2.6939	2.6895	
3:45	1:26	25.12	5.1134	2.6941	2.6896	
4:20	2:01	25.07	5.1129	2.6941	2.6897	
4:25	2:06					
MAR 16						
9:03AM	2:06	24.83	5.1050	2.6955	2.6970	5.1202
9:15	2:18	24.86	5.1072	2.6948	2.6956	5.1194
9:40	2:43	24.84	5.1079	2.6947	2.6947	
10:10	3:13	24.81	5.1076	2.6946	2.6946	5.1189
10:55	3:58	24.76	5.1070	2.6945	2.6944	5.1193
11:15	4:18	24.73	5.1068	2.6944	2.6946	5.1193
11:26	4:29	24.71	5.1070	2.6944	2.6947	5.1193
12:00	5:03	24.66	5.1069	2.6943	2.6947	5.1193
1:15PM	5:03					
1:50	5:38	24.61	5.1055	2.6906	2.6898	5.1187
2:33	6:21	24.55	5.1062	2.6919	2.6897	5.1186
3:10	6:58	24.49	5.1060	2.6923	2.6915	5.1194
3:43	7:31	24.44	5.1059	2.6924	2.6911	5.1186
4:32	8:20	24.36	5.1059	2.6924	2.6928	5.1185
MAR 17						
9:04AM	8:20					
9:10	8:26	24.27	5.1017	2.6947	2.6974	5.1203
9:33	8:49	24.28	5.1048	2.6935	2.6947	5.1188
9:55	9:11	24.24	5.1056	2.6935	2.6954	5.1188
10:25	9:41	24.20	5.1057	2.6934	2.6950	5.1187
11:00	10:16	24.14	5.1066	2.6933	2.6948	5.1186
12:00	11:16	24.05	5.1062	2.6933	2.6950	5.1181

TABLE I (Continued)

DATE AND TIME	OPERATING TIME ON BATTERIES	BATTERY VOLTS (NO SERIES DIODE)	TX. END REFERENCE SUPPLY	CHANNEL 17 INPUT 2 MERCURY CELLS	CHANNEL 17 OUTPUT EA	REC. END REFERENCE SUPPLY
MAR 17						
1:15PM	11:16					
1:20	11:21	24.03	5.1045	2.6935	2.6953	5.1190
1:50	11:51	23.98	5.1053	2.6932	2.6944	5.1186
2:35	12.36	23.90	5.1056	2.6930	2.6945	5.1187
3:05	13:06	23.86	5.1051	2.6930	2.6945	5.1191
4:25	14:26	23.73	5.1056	2.6929	2.6945	5.1192
MAR 18						
8:55AM	14:26					
9:04	14:35	23.69	5.1026	2.6936	2.6964	5.1208
9:10	14:41	23.68	5.1036	2.6935	2.6958	5.1205
9:22	14:53	23.66	5.1042	2.6933	2.6956	5.1202
9:38	15:09	23.64	5.1045	2.6933	2.6954	5.1199
10:09	15:40	23.58	5.1049	2.6932	2.6949	5.1198
10:30	16:01	23.55	5.1050	2.6932	2.6949	5.1197
10:49	16:20	23.51	5.1052	2.6931	2.6949	5.1197
11:20	16:51	23.45	5.1052	2.6931	2.6950	5.1196
11:55	17:26	23.39	5.1054	2.6931	2.6949	5.1196
12:55PM	17:26	23.33	5.1012	2.6943	2.6975	5.1213
1:12	17:43	23.37	5.1046	2.6934	2.6961	5.1203
2:00	18:31	23.27	5.1058	2.6931	2.6944	5.1194
2:27	18:58	23.22	5.1058	2.6930	2.6942	5.1194
3:03	19:34	23.15	5.1058	2.6930	2.6947	5.1194
4:05	20:36	23.05	5.1059	2.6929	2.6940	5.1194
MAR 19						
8:42AM	20:36	22.98	5.0992	2.6943	2.6980	5.1220
9:10	21:04	22.96	5.1039	2.6932	2.6957	5.1203
9:45	21:39	22.89			2.6949	5.1199
10:35	22:29	22.78	5.1044	2.6929	2.6950	5.1198
12:00	23:54	22.59	5.1052	2.6929	2.6948	5.1192
12:55PM	23.54	22.57	5.1017	2.6937	2.6972	5.1210
2:17	25:16	22.38	5.1054	2.6929	2.6947	5.1194
2:55	25:54	22.26				
3:30	26:29	22.14	5.1048	2.6928	2.6954	5.1202
3:50	26:49	22.06	5.1052	2.6927	2.6946	5.1192
4:17	27:16	21.96	5.1053	2.6927	2.6947	5.1192

TABLE I (Concluded)

DATE AND TIME	OPERATING TIME ON BATTERIES	BATTERY VOLTS (NO SERIES DIODE)	TX. END REFERENCE SUPPLY	CHANNEL 17		REC.END REFERENCE SUPPLY
				INPUT 2 MERCURY CELLS	OUTPUT E_A 25 SPS	
MAR.20						
8:38AM	27:16					
8:41	27:19	21.96	5.1000	2.6943	2.6976	5.1215
9:00	27:38	21.85	5.1042	2.6931	2.6957	5.1200
9:45	28:23	21.55	5.1048	2.6929	2.6949	5.1192
9:55	28:33	21.49				
10:37	29:15	21.01	5.1050	2.6929	2.6947	5.1192
10:50	29:28	20.74	5.1045	2.6928	2.6948	5.1192
10:58	29:36	20.20	5.1024	2.6929	2.6951	
11:00	29:38	20.07				
11:02	29:40	19.97	Staircase output not O.K.			
11:04	29:42	19.78				
11:08	29:46	19.40	5.08±.01		2.708	
11:10	29:48	19.20				
11:14	29:52	18.90	5.06±.01		2.715	
11:16	29:54	18.75				
11:19	29:57	18.50				
11:21	29:59	18.30				
11:24	30:02	18.00				
11:26	30:04	17.8	Output meters all wavering			

TABLE II

CHECK OF D/A ACCURACY AT RECEIVING END AS PER FIG. 10 REFERENCE SUPPLY=5.120 VOLTS (THEORETICAL)			
D/A INPUT CODE FROM D/A BUFFER SW 2 ON TEST	D/A OUTPUT (E_{ZI})		
	ACTUAL VOLTS	THEOR-ETICAL VOLTS	ERROR MV
0 0 0 0 0 0 0 0 0 0	+0.0010±.0002	0.000	+1.0
0 0 0 1 0 0 0 0 0 0	0.3208±.0003	0.320	+0.8
0 0 0 1 0 0 0 1 1 1	0.3552±.0002	0.355	+0.2
0 0 0 1 0 0 1 0 0 0	0.3607±.0002	0.360	+0.7
0 0 0 1 0 0 1 1 1 1	0.3953	0.395	+0.3
0 0 0 1 0 1 0 0 0 0	0.4007±.0003	0.400	+0.7
0 0 0 1 0 1 1 1 1 1	0.4751	0.475	+0.1
0 0 0 1 1 0 0 0 0 0	0.4808	0.480	+0.8
0 0 0 1 1 1 1 1 1 1	0.6352	0.635	+0.2
0 0 1 0 0 0 0 0 0 0	0.6406±.0002	0.640	+0.6
0 0 1 0 0 0 0 1 1 1	0.6751	0.675	+0.1
0 0 1 0 0 0 1 0 0 0	0.6807±.0003	0.680	+0.7
0 0 1 0 0 0 1 1 1 1	0.7151	0.715	+0.1
0 0 1 0 0 1 0 0 0 0	0.7205	0.720	+0.5
0 0 1 0 0 1 1 1 1 1	0.7951	0.795	+0.1
0 0 1 0 1 0 0 0 0 0	0.8004	0.800	+0.4
0 0 1 0 1 1 1 1 1 1	0.9552	0.955	+0.2
0 0 1 1 0 0 0 0 0 0	0.9605	0.960	+0.5
0 0 1 1 0 0 0 1 1 1	0.9951	0.995	+0.1
0 0 1 1 0 0 1 0 0 0	1.0003	1.000	+0.3
0 0 1 1 0 0 1 1 1 1	1.0351	1.035	+0.1
0 0 1 1 0 1 0 0 0 0	1.0406	1.040	+0.6
0 0 1 1 0 1 1 1 1 1	1.1150±.0003	1.115	0.0
0 0 1 1 1 0 0 0 0 0	1.1205	1.120	+0.5
0 0 1 1 1 1 1 1 1 1	1.2756	1.275	+0.6
0 1 0 0 0 0 0 0 0 0	1.2794	1.280	-0.6
0 1 0 0 0 0 0 1 1 1	1.3141	1.315	-0.9
0 1 0 0 0 0 1 0 0 0	1.3195	1.320	-0.5
0 1 0 0 0 0 1 1 1 1	1.3543	1.355	-0.7
0 1 0 0 0 1 0 0 0 0	1.3595	1.360	-0.5
0 1 0 0 0 1 1 1 1 1	1.4345	1.435	-0.5
0 1 0 0 1 0 0 0 0 0	1.4396	1.440	-0.4
0 1 0 0 1 1 1 1 1 1	1.5945	1.595	-0.5

TABLE II (Continued)

CHECK OF D/A ACCURACY AT RECEIVING END AS PER FIG. 10 REFERENCE SUPPLY=5.120 VOLTS (THEORETICAL)			
D/A INPUT CODE FROM D/A BUFFER SW 2 ON TEST	D/A OUTPUT (E_{ZI})		
	ACTUAL VOLTS	THEOR-ETICAL VOLTS	ERROR MV
0 1 0 1 0 0 0 0 0 0	1.5996	1.600	-0.4
0 1 0 1 0 0 0 1 1 1	1.6345	1.635	-0.5
0 1 0 1 0 0 1 0 0 0	1.6398	1.640	-0.2
0 1 0 1 0 0 1 1 1 1	1.6746	1.675	-0.4
0 1 0 1 0 1 0 0 0 0	1.6798	1.680	-0.2
0 1 0 1 0 1 1 1 1 1	1.7549	1.755	-0.1
0 1 0 1 1 0 0 0 0 0	1.7598	1.760	-0.2
0 1 0 1 1 1 1 1 1 1	1.9150	1.915	0.0
0 1 1 0 0 0 0 0 0 0	1.9197	1.920	-0.3
0 1 1 0 0 0 0 1 1 1	1.9546	1.955	-0.4
0 1 1 0 0 0 1 0 0 0	1.9597	1.960	-0.3
0 1 1 0 0 0 1 1 1 1	1.9947	1.995	-0.3
0 1 1 0 0 1 0 0 0 0	1.9998	2.000	-0.2
0 1 1 0 0 1 1 1 1 1	2.0749	2.075	-0.1
0 1 1 0 1 0 0 0 0 0	2.0799	2.080	-0.1
0 1 1 0 1 1 1 1 1 1	2.2355	2.235	+0.5
0 1 1 1 0 0 0 0 0 0	2.2401	2.240	+0.1
0 1 1 1 0 0 0 1 1 1	2.2751	2.275	+0.1
0 1 1 1 0 0 1 0 0 0	2.2802	2.280	+0.2
0 1 1 1 0 0 1 1 1 1	2.3153	2.315	+0.3
0 1 1 1 0 1 0 0 0 0	2.3203	2.320	+0.3
0 1 1 1 0 1 1 1 1 1	2.3956	2.395	+0.6
0 1 1 1 1 0 0 0 0 0	2.4004	2.400	+0.4
0 1 1 1 1 1 1 1 1 1	2.5562	2.555	+1.2
1 0 0 0 0 0 0 0 0 0	2.5625	2.560	+2.5
1 0 0 0 0 0 0 1 1 1	2.5976	2.595	+2.6
1 0 0 0 0 0 1 0 0 0	2.6026	2.600	+2.6
1 0 0 0 0 0 1 1 1 1	2.6378	2.635	+2.8
1 0 0 0 0 1 0 0 0 0	2.6427	2.640	+2.7
1 0 0 0 0 1 1 1 1 1	2.7178	2.715	+2.8
1 0 0 0 1 0 0 0 0 0	2.7225	2.720	+2.5
1 0 0 0 1 1 1 1 1 1	2.8775	2.875	+2.5

TABLE II (Continued)

CHECK OF D/A ACCURACY AT RECEIVING END AS PER FIG. 10 REFERENCE SUPPLY=5.120 VOLTS (THEORETICAL)			
D/A INPUT CODE FROM D/A BUFFER SW 2 ON TEST	D/A OUTPUT (E_{ZI})		
	ACTUAL VOLTS	THEOR-ETICAL VOLTS	ERROR MV
1 0 0 1 0 0 0 0 0 0	2.8821	2.880	+2.1
1 0 0 1 0 0 0 1 1 1	2.9172	2.915	+2.2
1 0 0 1 0 0 1 0 0 0	2.9222	2.920	+2.2
1 0 0 1 0 0 1 1 1 1	2.9573	2.955	+2.3
1 0 0 1 0 1 0 0 0 0	2.9621	2.960	+2.1
1 0 0 1 0 1 1 1 1 1	3.0372	3.035	+2.2
1 0 0 1 1 0 0 0 0 0	3.0420	3.040	+2.0
1 0 0 1 1 1 1 1 1 1	3.1973	3.195	+2.3
1 0 1 0 0 0 0 0 0 0	3.2010	3.200	+1.0
1 0 1 0 0 0 0 1 1 1	3.2361	3.235	+1.1
1 0 1 0 0 0 1 0 0 0	3.2412	3.240	+1.2
1 0 1 0 0 0 1 1 1 1	3.2760	3.275	+1.0
1 0 1 0 0 1 0 0 0 0	3.2811	3.280	+1.1
1 0 1 0 0 1 1 1 1 1	3.3563	3.355	+1.3
1 0 1 0 1 0 0 0 0 0	3.3609	3.360	+0.9
1 0 1 0 1 1 1 1 1 1	3.5159	3.515	+0.9
1 0 1 1 0 0 0 0 0 0	3.5205	3.520	+0.5
1 0 1 1 0 0 0 1 1 1	3.5556	3.555	+0.6
1 0 1 1 0 0 1 0 0 0	3.5606	3.560	+0.6
1 0 1 1 0 0 1 1 1 1	3.5957	3.595	+0.7
1 0 1 1 0 1 0 0 0 0	3.6004	3.600	+0.4
1 0 1 1 0 1 1 1 1 1	3.6758	3.675	+0.8
1 0 1 1 1 0 0 0 0 0	3.6804	3.680	+0.4
1 0 1 1 1 1 1 1 1 1	3.8357	3.835	+0.7
1 1 0 0 0 0 0 0 0 0	3.8389	3.840	-1.1
1 1 0 0 0 0 0 1 1 1	3.8742	3.875	-0.8
1 1 0 0 0 0 1 0 0 0	3.8791	3.880	-0.9
1 1 0 0 0 0 1 1 1 1	3.9142	3.915	-0.8
1 1 0 0 0 1 0 0 0 0	3.9191	3.920	-0.9
1 1 0 0 0 1 1 1 1 1	3.9944	3.995	-0.6
1 1 0 0 1 0 0 0 0 0	3.9990	4.000	-1.0
1 1 0 0 1 1 1 1 1 1	4.1543	4.155	-0.7

TABLE II (Concluded)

CHECK OF D/A ACCURACY AT RECEIVING END AS PER FIG. 10 REFERENCE SUPPLY=5.120 VOLTS (THEORETICAL)			
D/A INPUT CODE FROM D/A BUFFER SW 2 ON TEST	D/A OUTPUT (E_{ZI})		
	ACTUAL VOLTS	THEOR-ETICAL VOLTS	ERROR MV
1 1 0 1 0 0 0 0 0 0	4.1586	4.160	-1.4
1 1 0 1 0 0 0 1 1 1	4.1937	4.195	-1.3
1 1 0 1 0 0 1 0 0 0	4.1986	4.200	-1.4
1 1 0 1 0 0 1 1 1 1	4.2338	4.235	-1.2
1 1 0 1 0 1 0 0 0 0	4.2385	4.240	-1.5
1 1 0 1 0 1 1 1 1 1	4.3138	4.315	-1.2
1 1 0 1 1 0 0 0 0 0	4.3184	4.320	-1.6
1 1 0 1 1 1 1 1 1 1	4.4739	4.475	-1.1
1 1 1 0 0 0 0 0 0 0	4.4773	4.480	-2.7
1 1 1 0 0 0 0 1 1 1	4.5125	4.515	-2.5
1 1 1 0 0 0 1 0 0 0	4.5175	4.520	-2.5
1 1 1 0 0 0 1 1 1 1	4.5526	4.555	-2.4
1 1 1 0 0 1 0 0 0 0	4.5574	4.560	-2.6
1 1 1 0 0 1 1 1 1 1	4.6326	4.635	-2.4
1 1 1 0 1 0 0 0 0 0	4.6373	4.640	-2.7
1 1 1 0 1 1 1 1 1 1	4.7927	4.795	-2.3
1 1 1 1 0 0 0 0 0 0	4.7968	4.800	-3.2
1 1 1 1 0 0 0 1 1 1	4.8320	4.835	-3.0
1 1 1 1 0 0 1 0 0 0	4.8369	4.840	-3.1
1 1 1 1 0 0 1 1 1 1	4.8721	4.875	-2.9
1 1 1 1 0 1 0 0 0 0	4.8769	4.880	-3.1
1 1 1 1 0 1 1 1 1 1	4.9523	4.955	-2.7
1 1 1 1 1 0 0 0 0 0	4.9568	4.960	-3.2
1 1 1 1 1 1 1 1 1 1	5.1126	5.115	-2.4
ACTUAL REFERENCE SUPPLY=5.1198 VOLTS			

TABLE III

EFFECT OF SAMPLING RATE ON E_B (SEE FIG. 10)

D/A INPUT CODE	THEORETICAL OUTPUT VOLTS	ANALOG OUTPUT E_B (MC 1433) ACTUAL OUTPUT CHANNEL 1--25 SPS VOLTS	CHANNEL 1--25 SPS ERROR (MV)	CHANNEL 10--200 SPS VOLTS	CHANNEL 10--200 SPS ERROR (MV)
0 0 0 0 0 0 0 0 0 0	0.000	-0.0070	-7.0	-0.0020	-2.0
0 0 0 1 0 0 0 0 0 0	0.320	+0.3131	-6.9	+0.3180	-2.0
0 0 1 0 0 0 0 0 0 0	0.640	0.6330	-7.0	0.6380	-2.0
0 0 1 1 0 0 0 0 0 0	0.960	0.9532	-6.8	0.9580	-2.0
0 1 0 0 0 0 0 0 0 0	1.280	1.2721	-7.9	1.2772	-2.8
0 1 0 1 0 0 0 0 0 0	1.600	1.5927	-7.3	1.5975	-2.5
0 1 1 0 0 0 0 0 0 0	1.920	1.9127	-7.3	1.9177	-2.3
0 1 1 1 0 0 0 0 0 0	2.240	2.2334	-6.6	2.2384	-1.6
1 0 0 0 0 0 0 0 0 0	2.560	2.5566	-3.4	2.5616	+1.6
1 0 0 1 0 0 0 0 0 0	2.880	2.8762	-3.8	2.8810	+1.0
1 0 1 0 0 0 0 0 0 0	3.200	3.1952	-4.8	3.2003	+0.3
1 0 1 1 0 0 0 0 0 0	3.520	3.5149	-5.1	3.5200	0.0
1 1 0 0 0 0 0 0 0 0	3.840	3.8338	-6.2	3.8388	-1.2
1 1 0 1 0 0 0 0 0 0	4.160	4.1537	-6.3	4.1586	-1.4
1 1 1 0 0 0 0 0 0 0	4.480	4.4725	-7.5	4.4777	-2.3
1 1 1 1 0 0 0 0 0 0	4.800	4.7924	-7.6	4.7974	-2.6
1 1 1 1 1 1 1 1 1 1	5.115	5.1076	-7.4	5.1130	-2.0

TABLE IV

Measurements taken of 10 analog outputs and E_{ZI} and E_{ZO} for comparison with the theoretical values

D/A INPUT CODE	THEOR-ETICAL OUTPUT VOLTS	D/A OUTPUT (E_{ZI}) VOLTS	ZELTEX OUTPUT (E_{ZO}) VOLTS	10 ACTUAL ANALOG OUTPUTS									
				MC1533	MC 1433								
				E_A VOLTS	E_B VOLTS	E_C VOLTS	E_D VOLTS	E_E VOLTS	E_F VOLTS	E_G VOLTS	E_H VOLTS	E_J VOLTS	E_K VOLTS
0000000000	0.000	+.0013	-.0002	-.0034	-.0062	-.0063	-.0075	-.0045	-.0020	-.0076	-.0056	+.0028	+.0029
0010100000	0.800	0.8005	0.7997	0.7965	0.7935	0.7935	0.7923	0.7952	0.7979	0.7923	0.7942	0.8025	0.8027
0101000000	1.600	1.5994	1.5992	1.5960	1.5931	1.5930	1.5918	1.5947	1.5975	1.5917	1.5937	1.6020	1.6020
0111100000	2.400	2.4004	2.4006	2.3974	2.3945	2.3944	2.3931	2.3962	2.3989	2.3932	2.3952	2.4036	2.4035
1010000000	3.200	3.2011	3.2019	3.1987	3.1956	3.1956	3.1943	3.1973	3.2000	3.1943	3.1963	3.2047	3.2048
1100100000	4.000	3.9992	4.0005	3.9972	3.9941	3.9941	3.9928	3.9959	3.9986	3.9928	3.9949	4.0031	4.0032
1111000000	4.800	4.7972	4.7992	4.7958	4.7925	4.7927	4.7913	4.7944	4.7971	4.7914	4.7934	4.8015	4.8017
REFERENCE VOLTAGE = 5.1187 ± .0003													
All the above readings are at 25 SPS on channel 1 with switch 2 in test position.													
All the readings below are at 200 SPS on channel 10 with switch 2 in test position.													
0000000000	0.000	+.0013	-.0002	-.0002	-.0017	-.0015	-.0011	-.0007	+.0004	-.0025	-.0006	+.0047	+.0066
0010100000	0.800	0.8009	0.8000	0.7999	0.7985	0.7986	0.7989	0.7994	0.8004	0.7976	0.7995	0.8048	0.8066
0101000000	1.600	1.6000	1.5996	1.5996	1.5981	1.5982	1.5985	1.5990	1.6001	1.5972	1.5992	1.6044	1.6062
0111100000	2.400	2.4007	2.4010	2.4009	2.3994	2.3995	2.3999	2.4003	2.4015	2.3986	2.4005	2.4057	2.4076
1010000000	3.200	3.2017	3.2026	3.2024	3.2009	3.2011	3.2015	3.2019	3.2030	3.2001	3.2020	3.2073	3.2090
1100100000	4.000	3.9999	4.0012	4.0011	3.9996	3.9996	4.0000	4.0005	4.0016	3.9987	4.0007	4.0057	4.0076
1111000000	4.800	4.7978	4.7997	4.7995	4.7981	4.7982	4.7986	4.7990	4.8001	4.7973	4.7992	4.8043	4.8060
REFERENCE VOLTAGE = 5.1193 ± .0002													

TABLE V

EFFECT OF SAMPLING RATE ON E_A AND E_B (FROM TABLE IV)

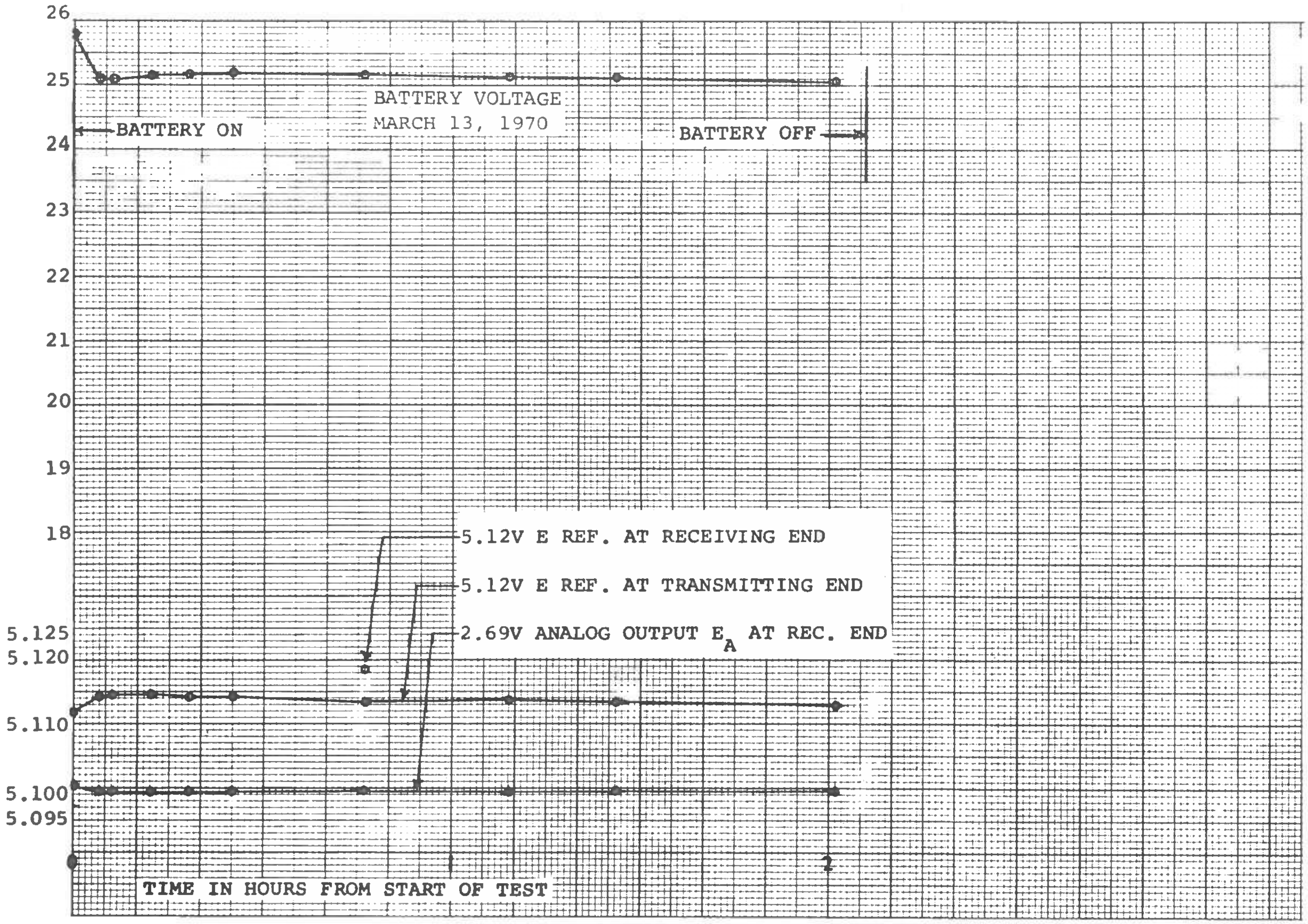
D/A INPUT CODE	THEORETICAL OUTPUT VOLTS	ACTUAL ANALOG OUTPUT E_A (MC 1533)				ACTUAL ANALOG OUTPUT E_B (MC 1433)			
		CHANNEL 1 25 SPS		CHANNEL 10 200 SPS		CHANNEL 1 25 SPS		CHANNEL 10 200 SPS	
		OUTPUT VOLTS	ERROR MV	OUTPUT VOLTS	ERROR MV	OUTPUT VOLTS	ERROR MV	OUTPUT VOLTS	ERROR MV
0000000000	0.000	-0.0034	-3.4	-0.0002	-0.2	-0.0062	-6.2	-0.0017	-1.7
0010100000	0.800	+0.7965	-3.5	+0.7999	-0.1	+0.7935	-6.5	+0.7985	-1.5
0101000000	1.600	1.5960	-4.0	1.5996	-0.4	1.5931	-6.9	1.5981	-1.9
0111100000	2.400	2.3974	-2.6	2.4009	+0.9	2.3945	-5.5	2.3994	-0.6
1010000000	3.200	3.1987	-1.3	3.2024	+2.4	3.1956	-4.4	3.2009	+0.9
1100100000	4.000	3.9972	-2.8	4.0011	+1.1	3.9941	-5.9	3.9996	-0.4
1111000000	4.800	4.7958	-4.2	4.7995	-0.5	4.7925	-7.5	4.7981	-1.9

TABLE VI

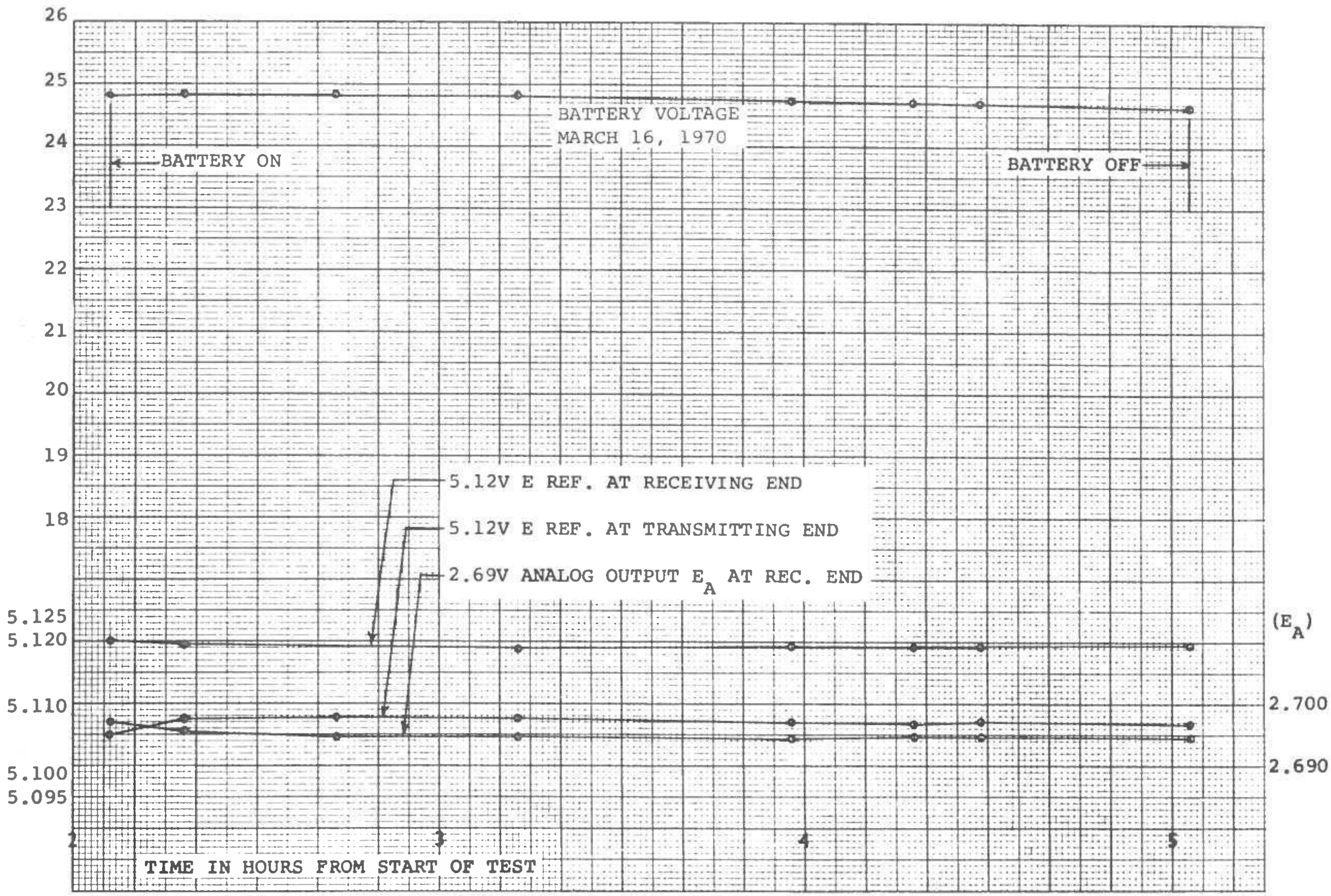
DRIFT OF REFERENCE SUPPLIES AND RECEIVED ANALOG SIGNAL E_A WITH TIME

TRANSMITTING END			RECEIVING END	
TIME	REF. (VOLTS)	INPUT CHAN. 17	REF. (VOLTS)	OUTPUT E_A (VOLTS)
10:47	5.1162	2.6963	5.1216	2.6970
10:53	5.1183	2.6959	5.1211	2.6925
11:00	5.1194	2.6956	5.1208	2.6916
11:00				2.6923
11:10	5.1196	2.6955	5.1204	2.6912
11:10	5.1197		5.1205	2.6906
11:20	5.1196	2.6954	5.1203	2.6907
11:20	5.1197	2.6955	5.1204	2.6911
11:30	5.1196	2.6954	5.1201	2.6908
11:30	5.1195	2.6953	5.1202	2.6911
11:40	5.1194	2.6954	5.1202	2.6906
11:40	5.1193	2.6953	5.1201	2.6911
11:50	5.1192	2.6954	5.1200	2.6901
11:50	5.1193	2.6953	5.1201	2.6910
12:00	5.1187	2.6953	5.1200	2.6906
12:00	5.1188	2.6953	5.1201	2.6913
12:10	5.1185	2.6953	5.1200	2.6904
12:10	5.1184	2.6952	5.1199	2.6910
12:20	5.1181	2.6952	5.1200	2.6906
12:20	5.1182	2.6953	5.1200	2.6911
12:30	5.1179	2.6953	5.1198	2.6904
12:30	5.1180	2.6952	5.1199	2.6910
12:40	5.1180	2.6953	5.1199	2.6908
12:40	5.1180	2.6952		2.6903
12:50	5.1178	2.6952	5.1199	2.6905
12:50	5.1179	2.6952	5.1198	2.6910
1:00	5.1178	2.6952	5.1197	2.6909
1:00	5.1180	2.6953	5.1198	2.6906
1:10	5.1179	2.6951	5.1196	2.6900
1:10	5.1179	2.6952	5.1197	2.6908
1:20	5.1179	2.6952	5.1197	2.6907
1:20	5.1178	2.6951	5.1198	2.6912
1:30	5.1178	2.6952	5.1197	2.6904

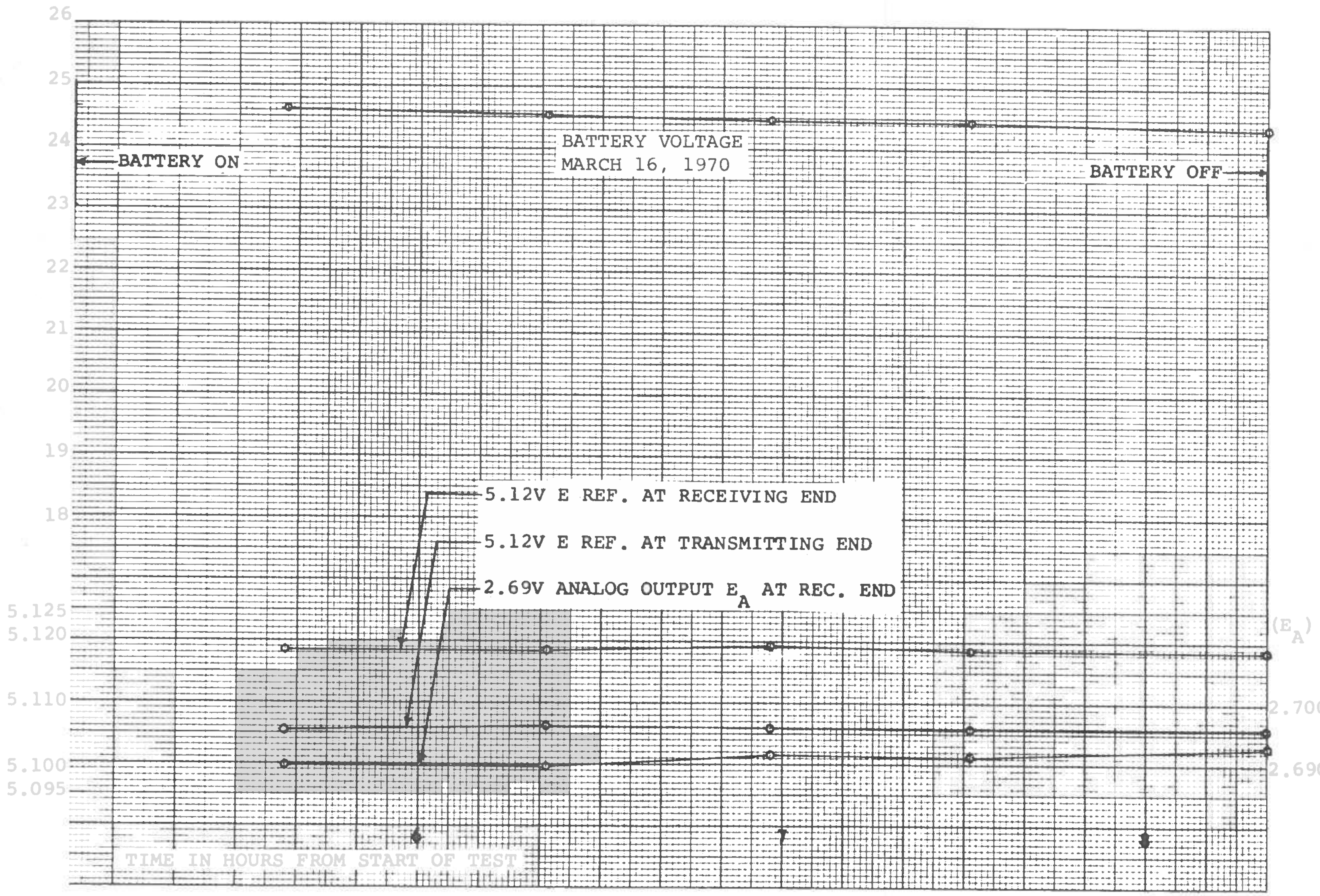
GRAPHS



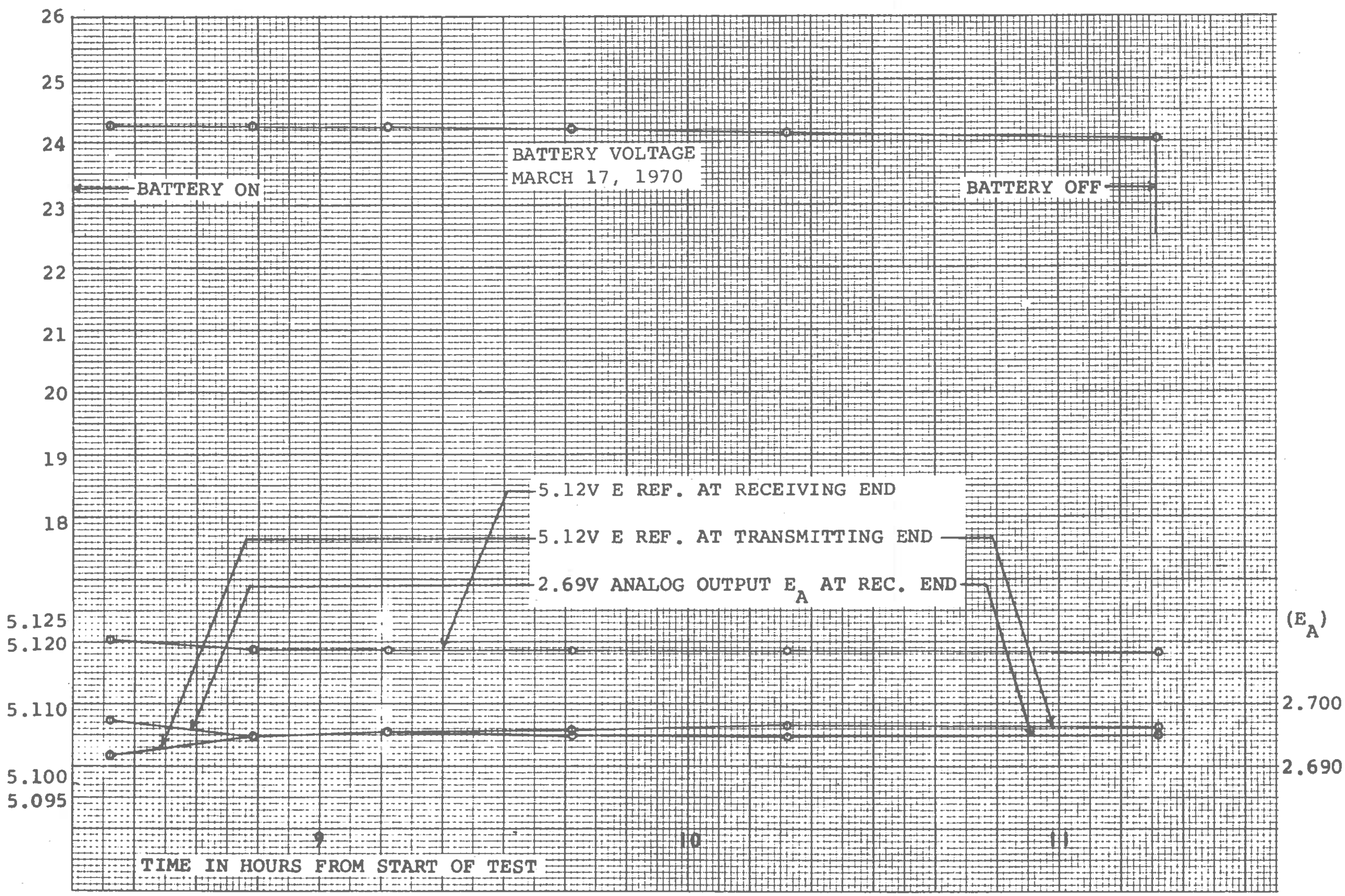
Graph 1 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere–Hrs, Prestolite)



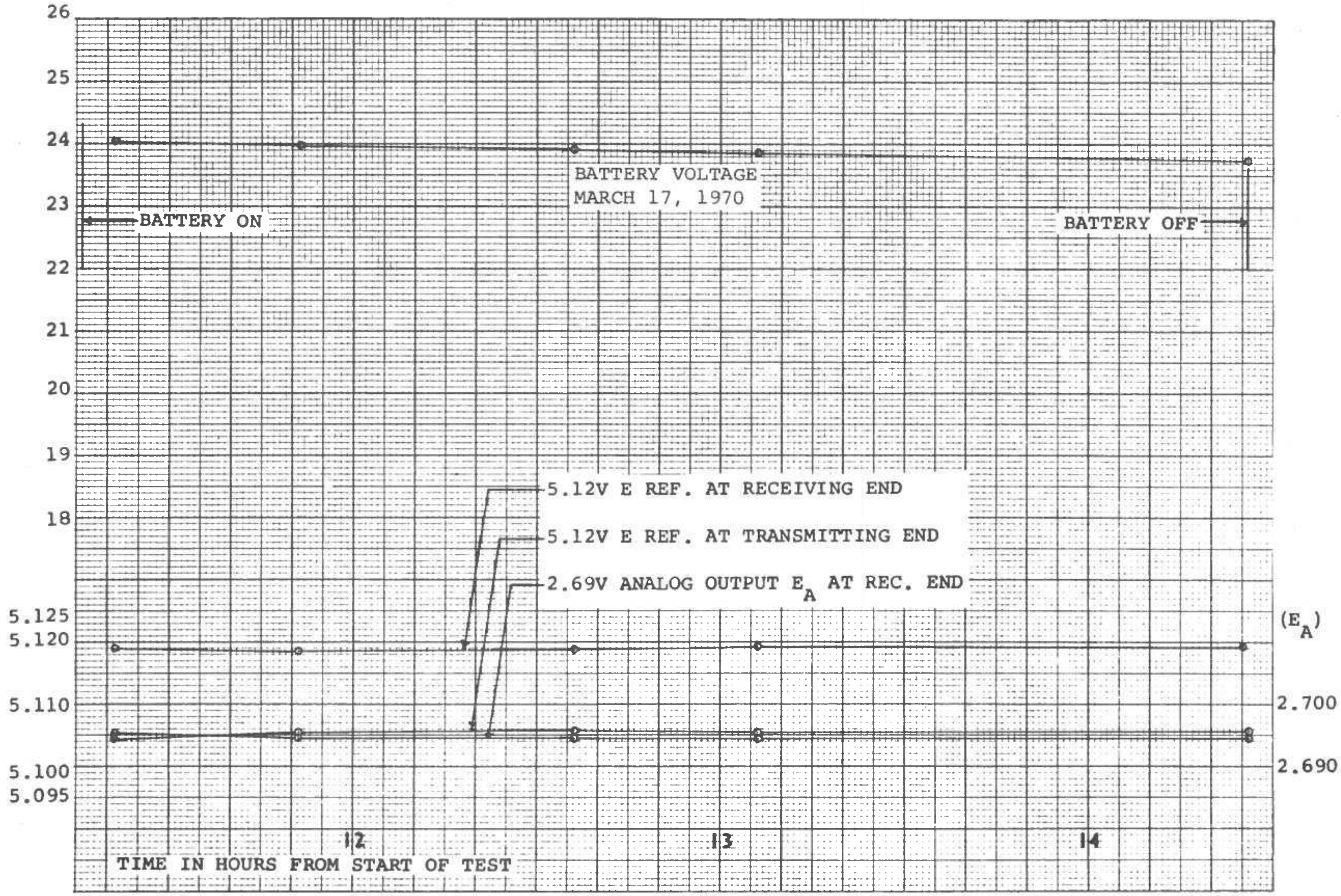
Graph 2 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere--Hrs, Prestolite)



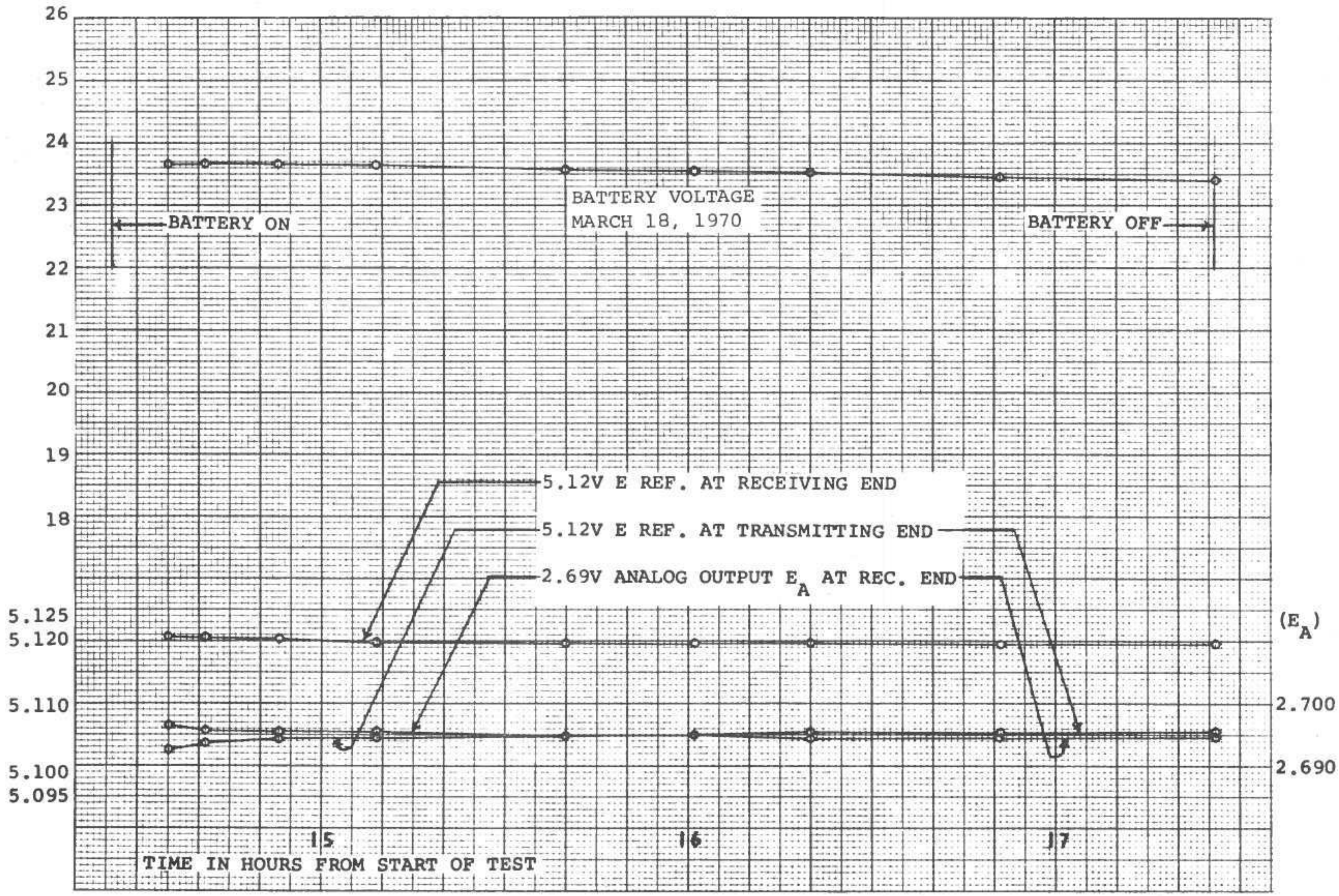
Graph 3 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere--Hrs, Prestolite)



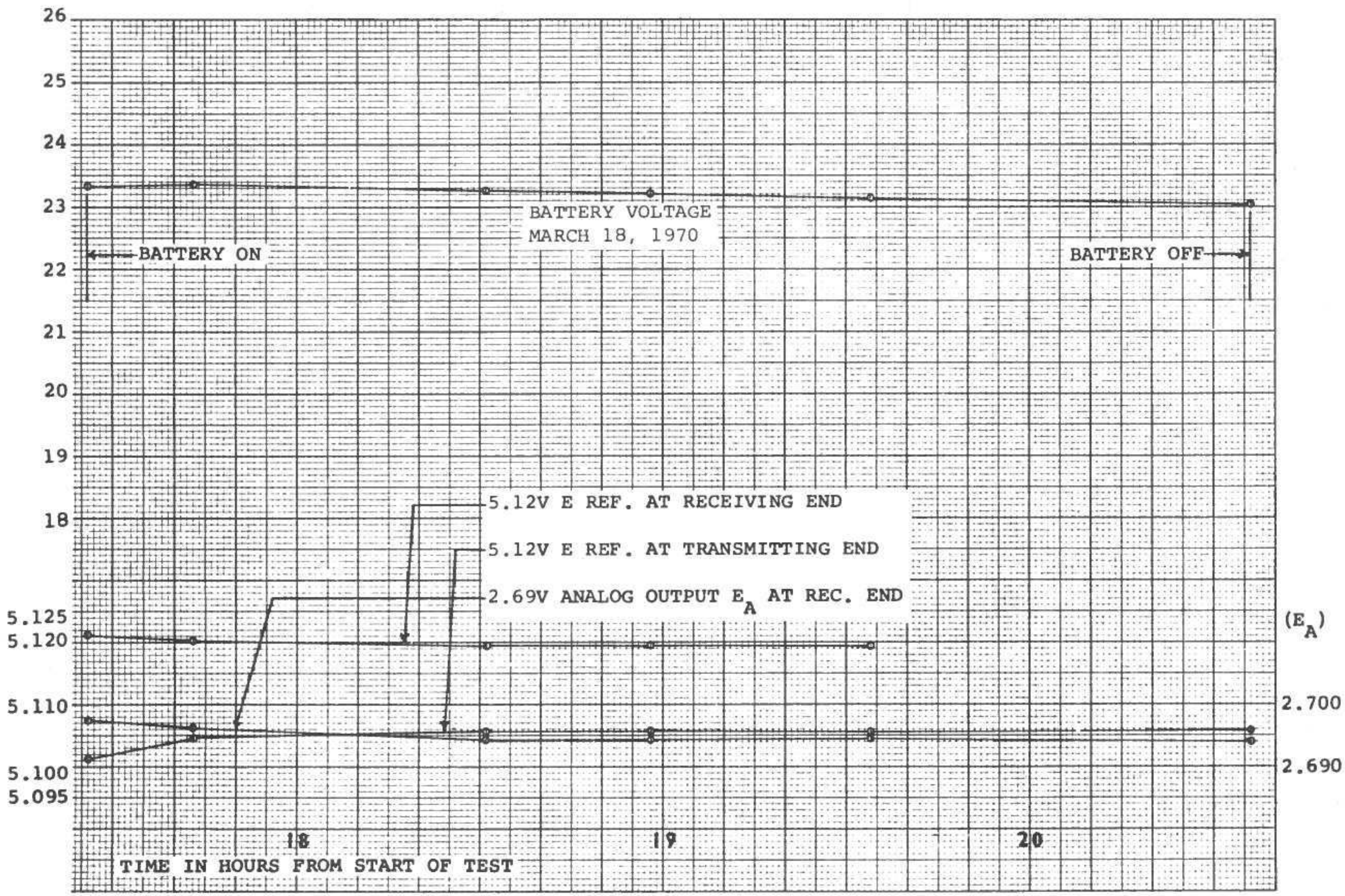
Graph 4 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere--Hrs, Prestolite)



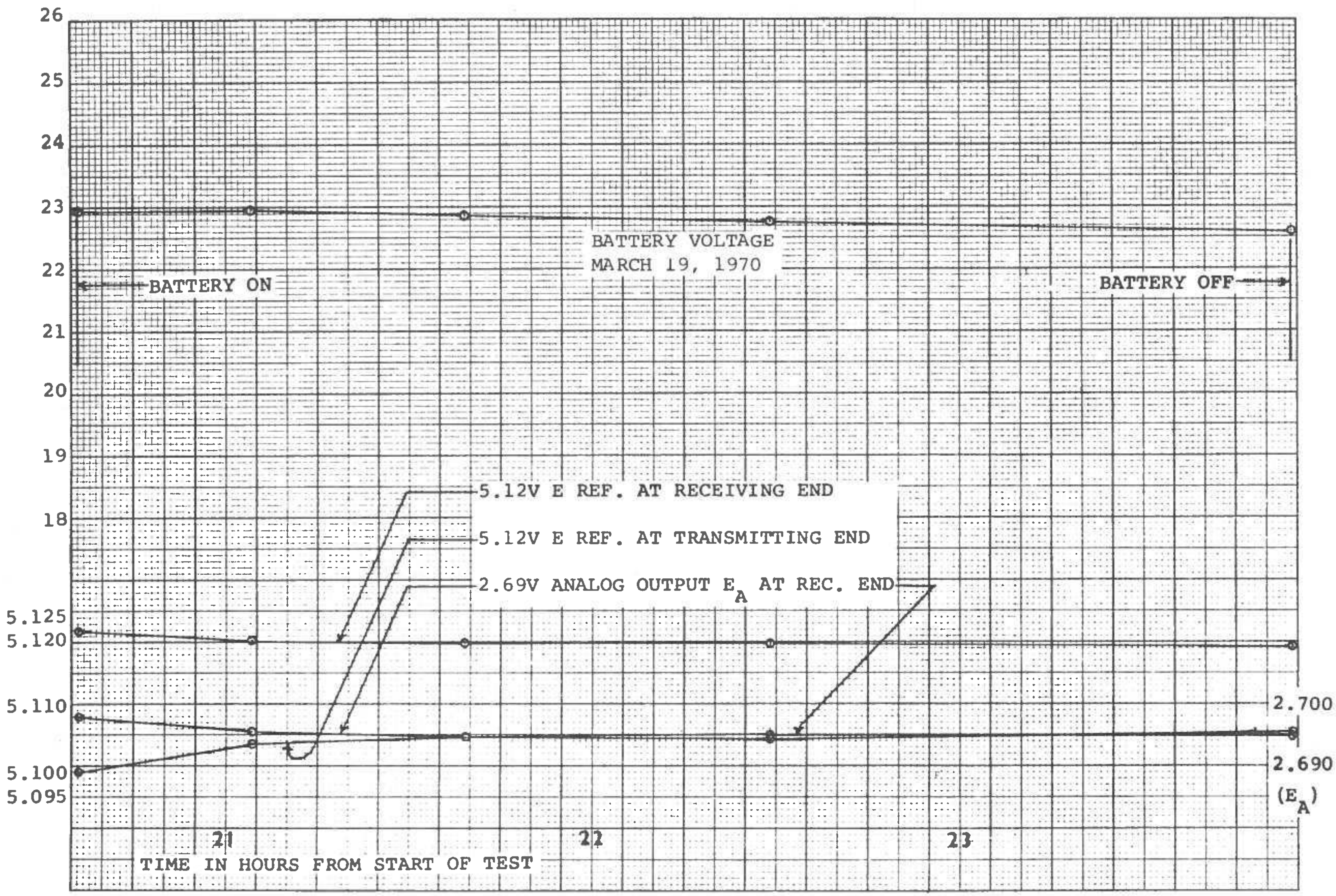
Graph 5 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere--Hrs, Prestolite)



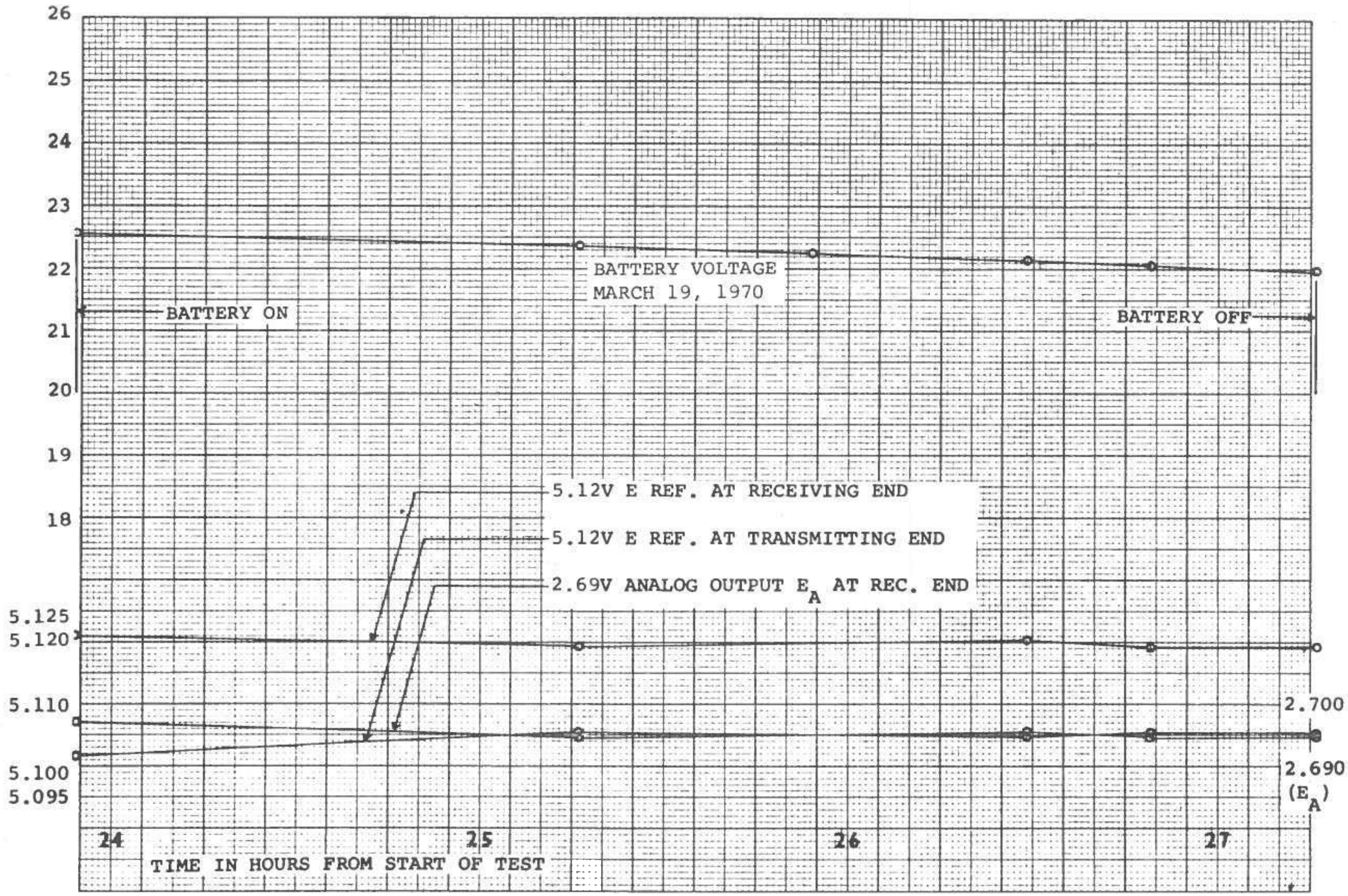
Graph 6 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere–Hrs, Prestolite)



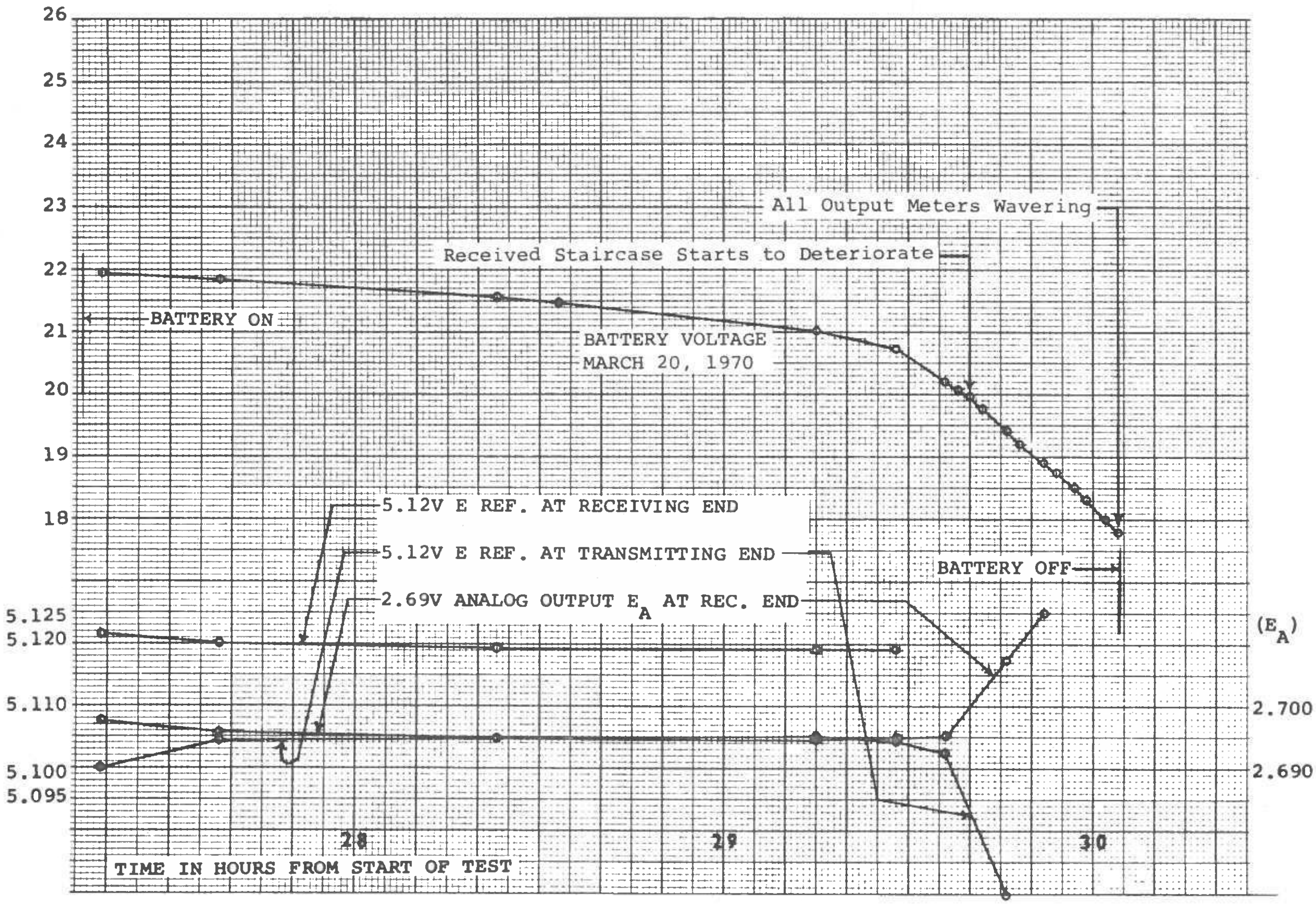
Graph 7 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere--Hrs, Prestolite)



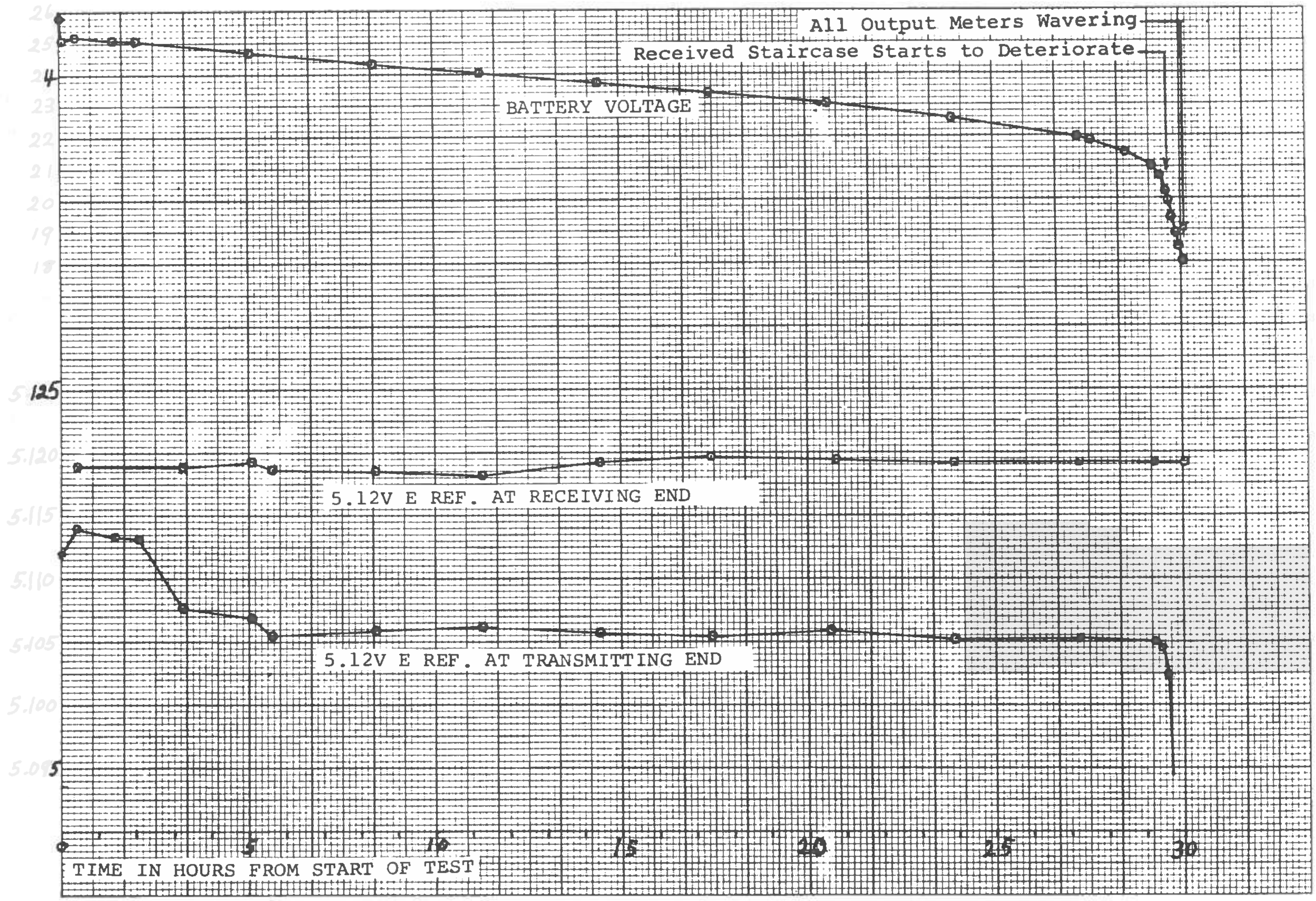
Graph 8 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere--Hrs, Prestolite)



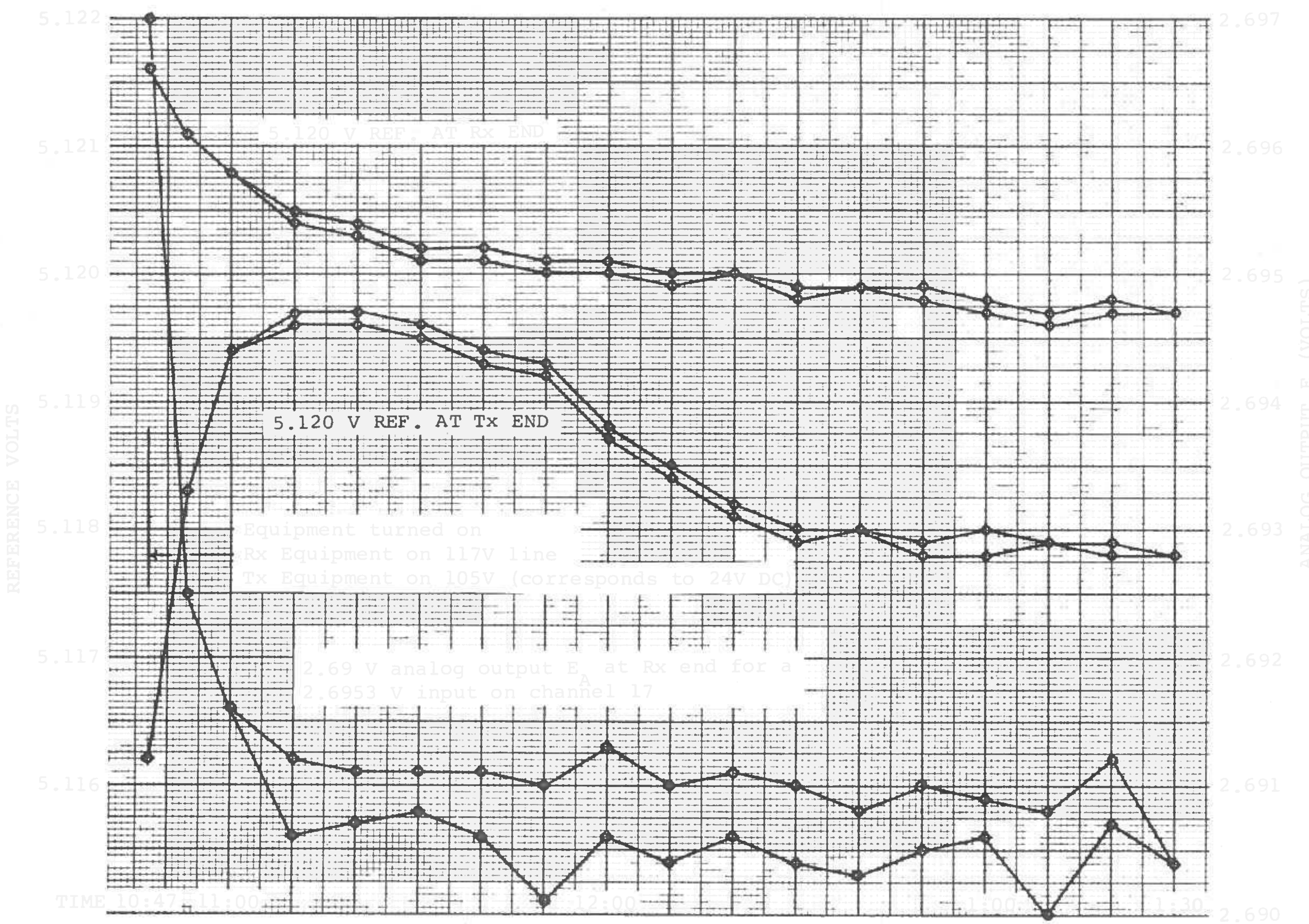
Graph 9 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere–Hrs, Prestolite)



Graph 10 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere–Hrs, Prestolite)



Graph 11 Test of TX Equipment on Two 12V Batteries (9 LU, 32 Ampere–Hrs, Prestolite)



Graph 12 Drift of Reference Supplies and of Received Signal E_A

All the following recordings were made on a Texas Instrument Oscilloriter, Model No. P2CBH-HA2-HA2

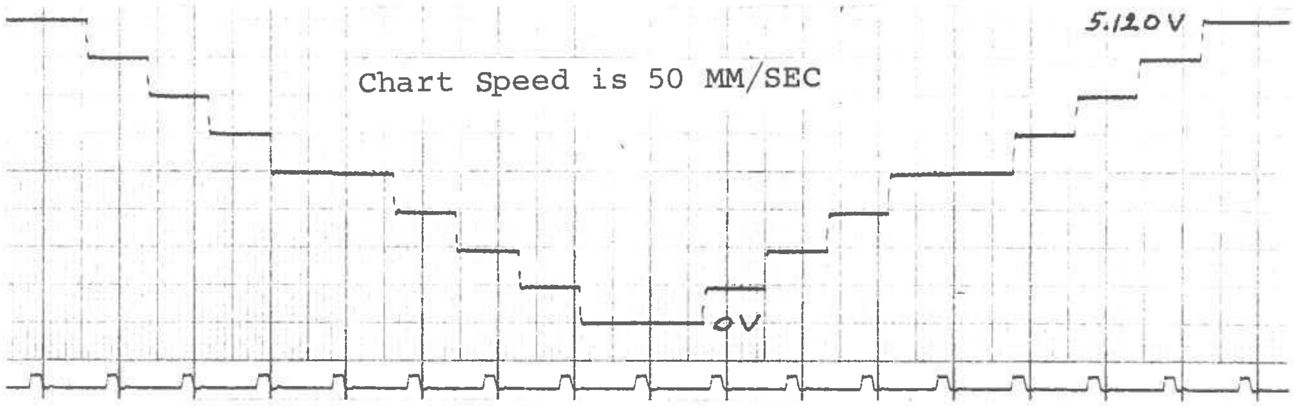
Recordings

All the recordings were made on a Texas Instrument oscilloriter model no. P2CBH-HA2-HA2. The recordings shown are:

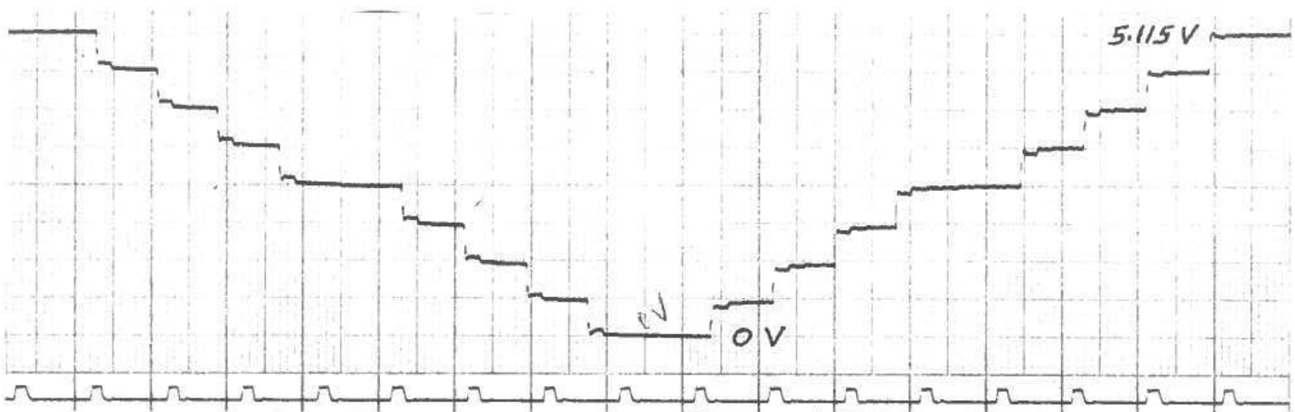
(1) The analog staircase test signal at the transmitting end before multiplexing into the A/D. On the same page the staircase is shown as received on channel 2 at 25 SPS and on channel 9 at 200 SPS for comparison (recording #1).

(2) The staircase as received on all 34 channels (only one at a time) (recording #2-10).

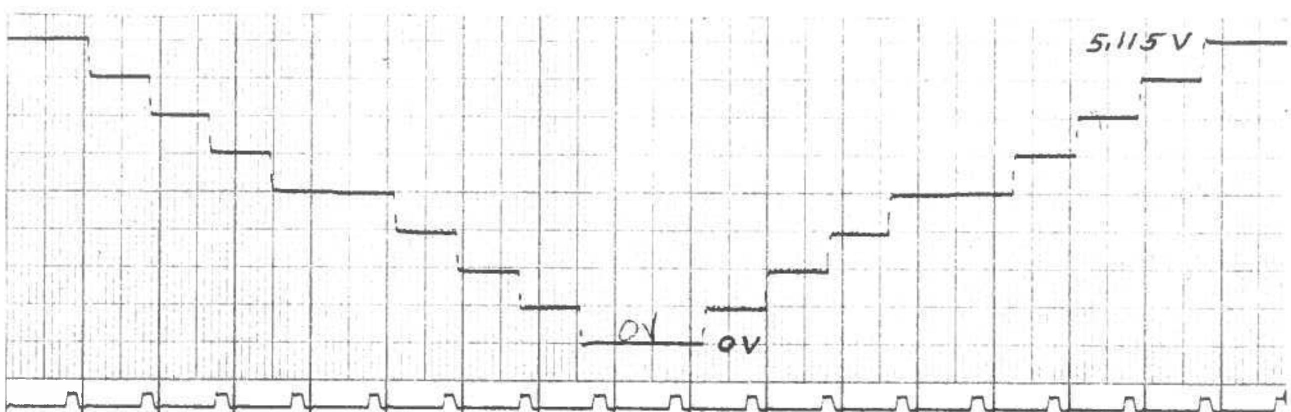
(3) The transient response of output amplifier A as received on channel 17 at 25 SPS. This is actually the response of the complete system but the charging of the holding capacitor on the input ot the amplifier causes by far the most delay. For this recording the input to channel 17 was quickly changed from zero volts to 2.693 volts (recording #10).



Input Signal (Staircase) at Transmitting End

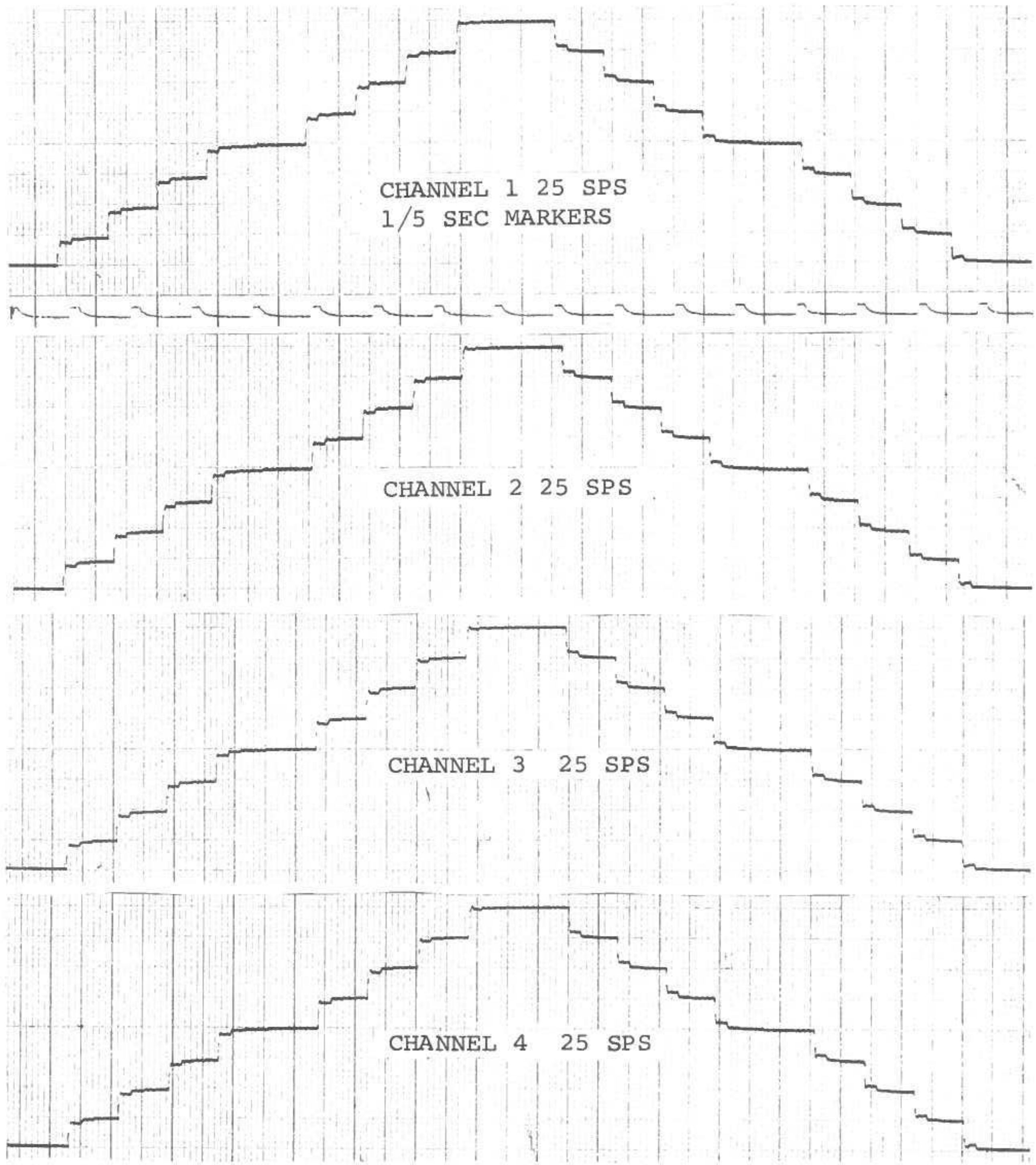


Output Signal (Staircase) after D/A Conversion as Received on Channel 2 (25SPS)

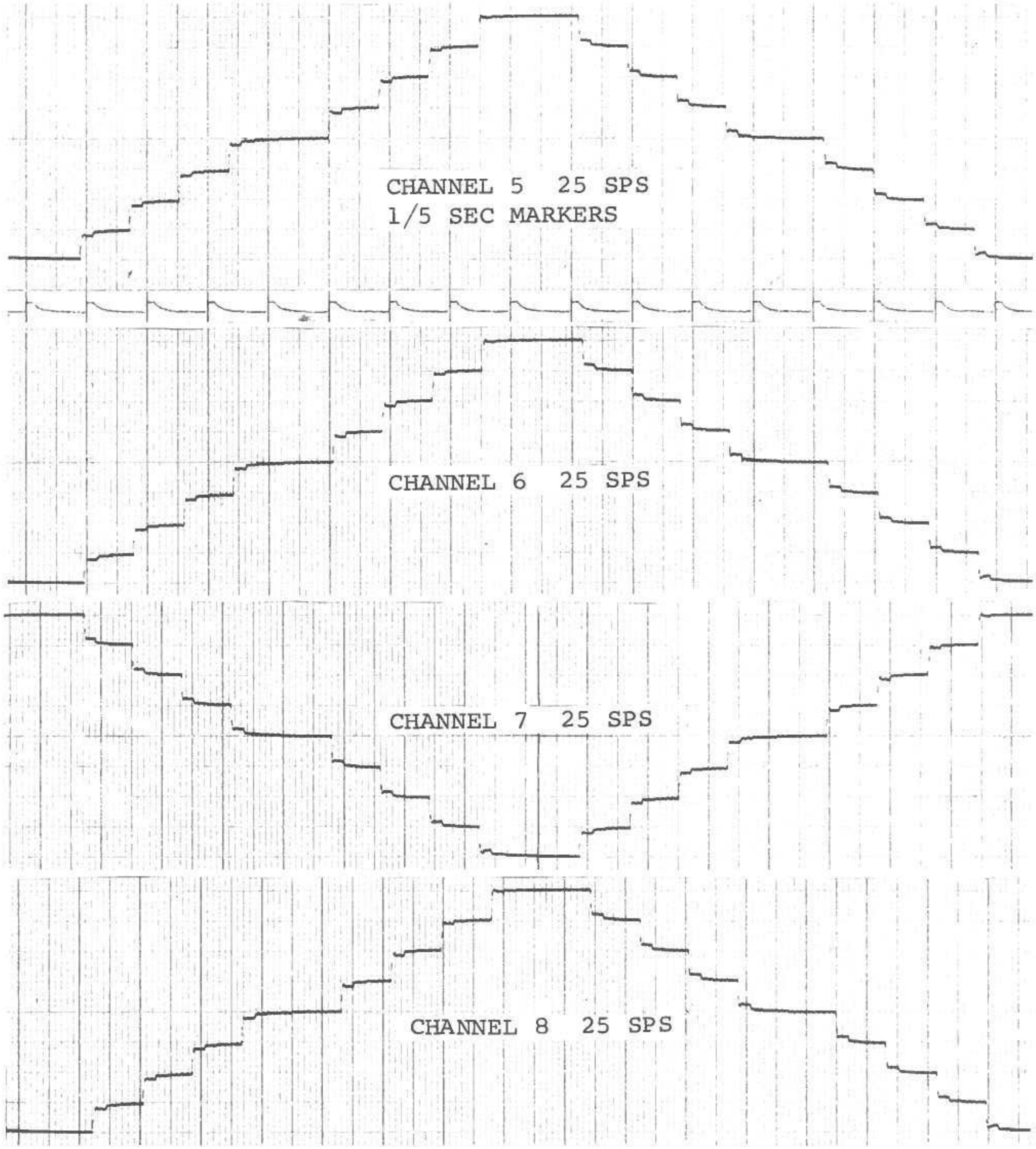


Output Signal (Staircase) after D/A Conversion as received on Channel 9 (200SPS)

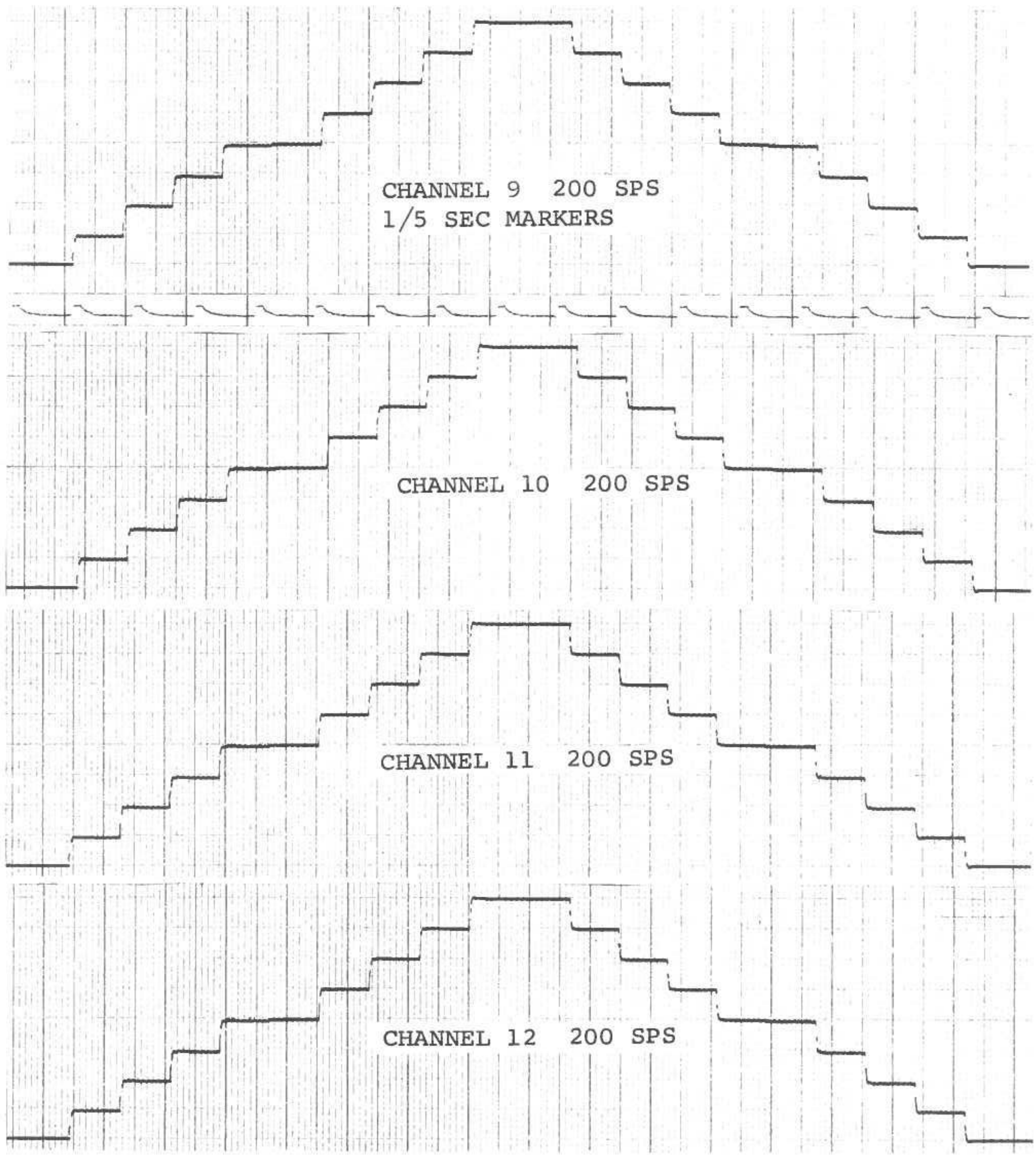
Recording 1 Input and Output Signals (Staircase) at 25 and 200 SPS)



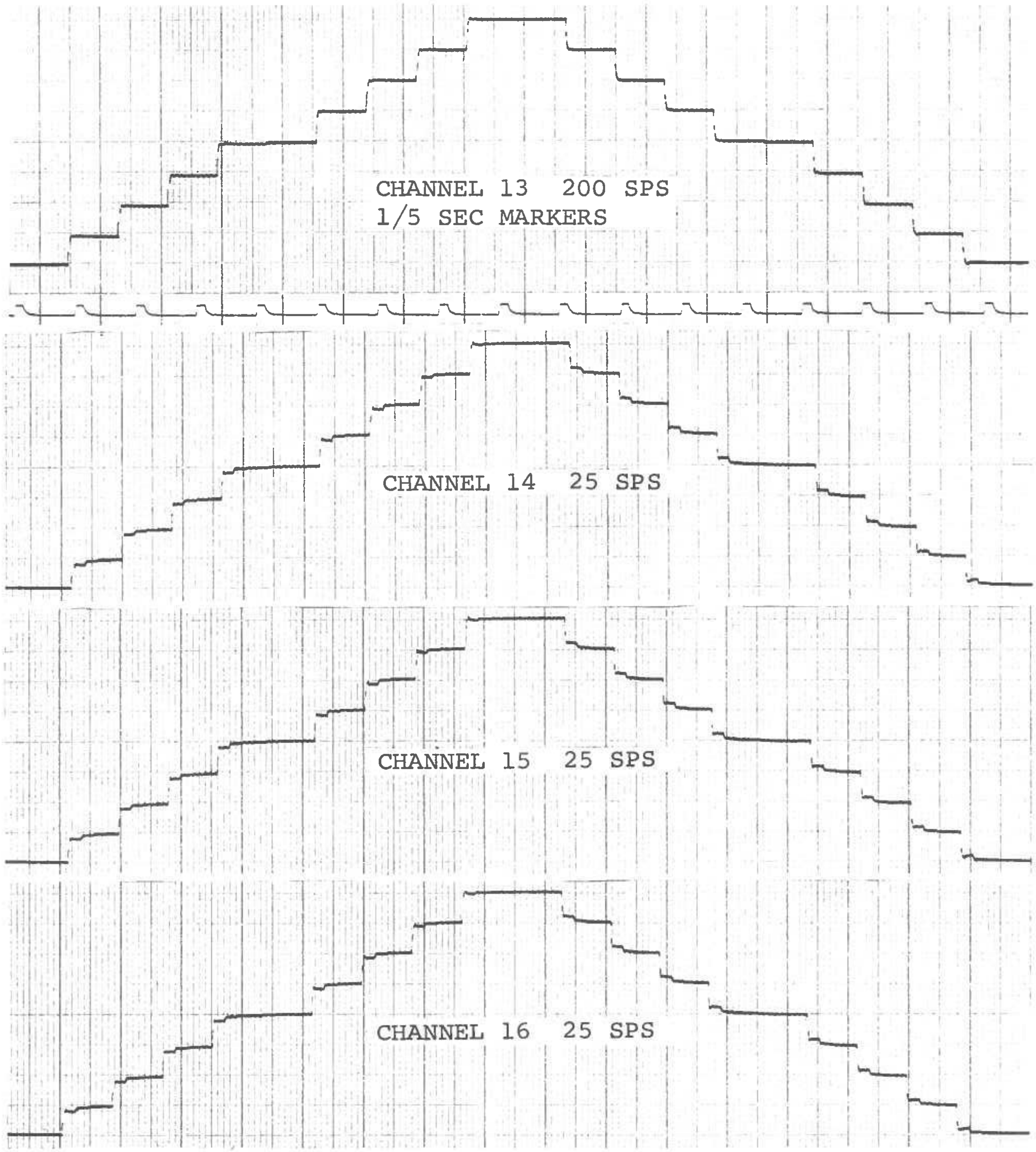
Recording 2 Output Signal (Staircase) at Receiving End



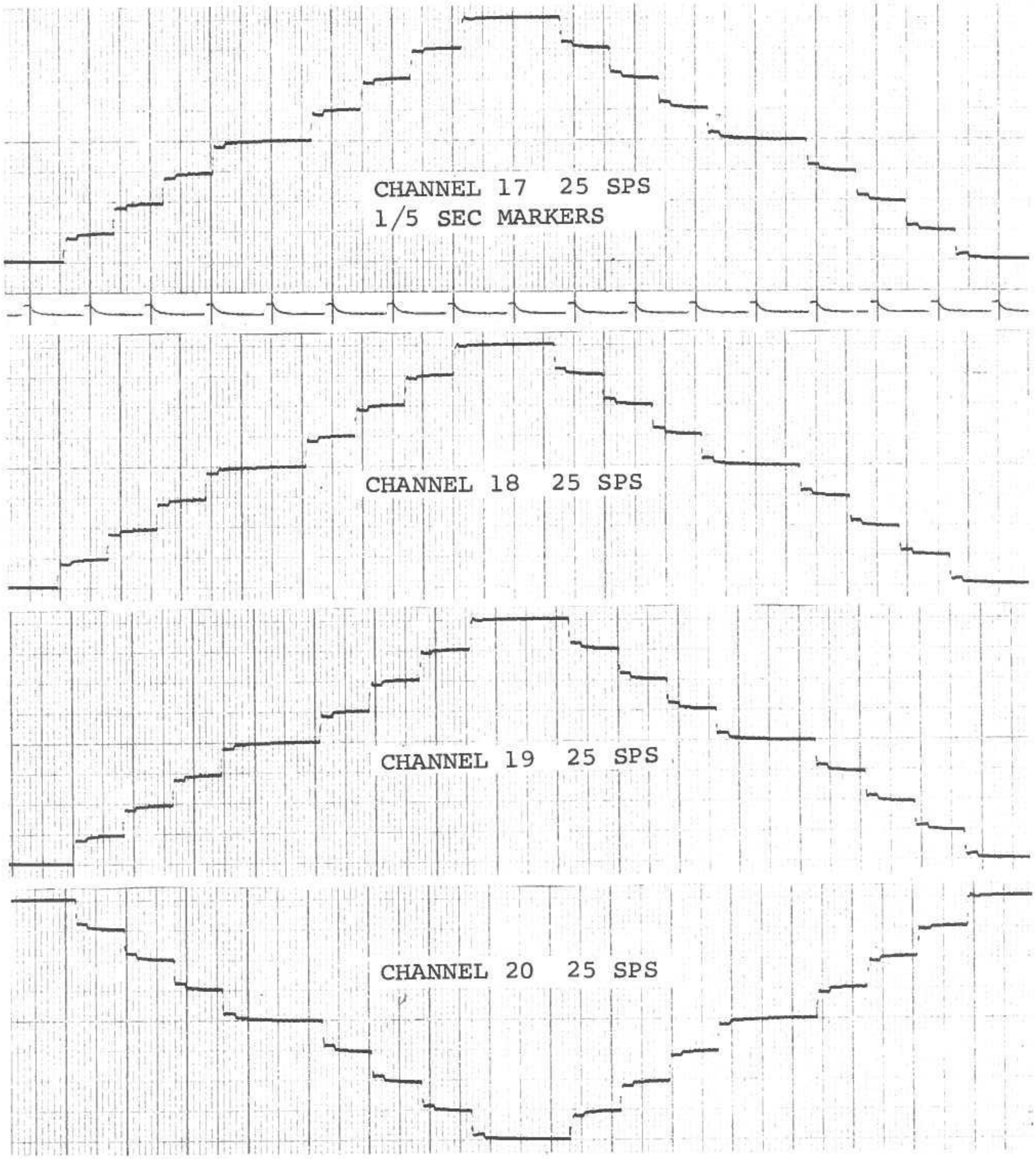
Recording 3 Output Signal (Staircase) at Receiving End



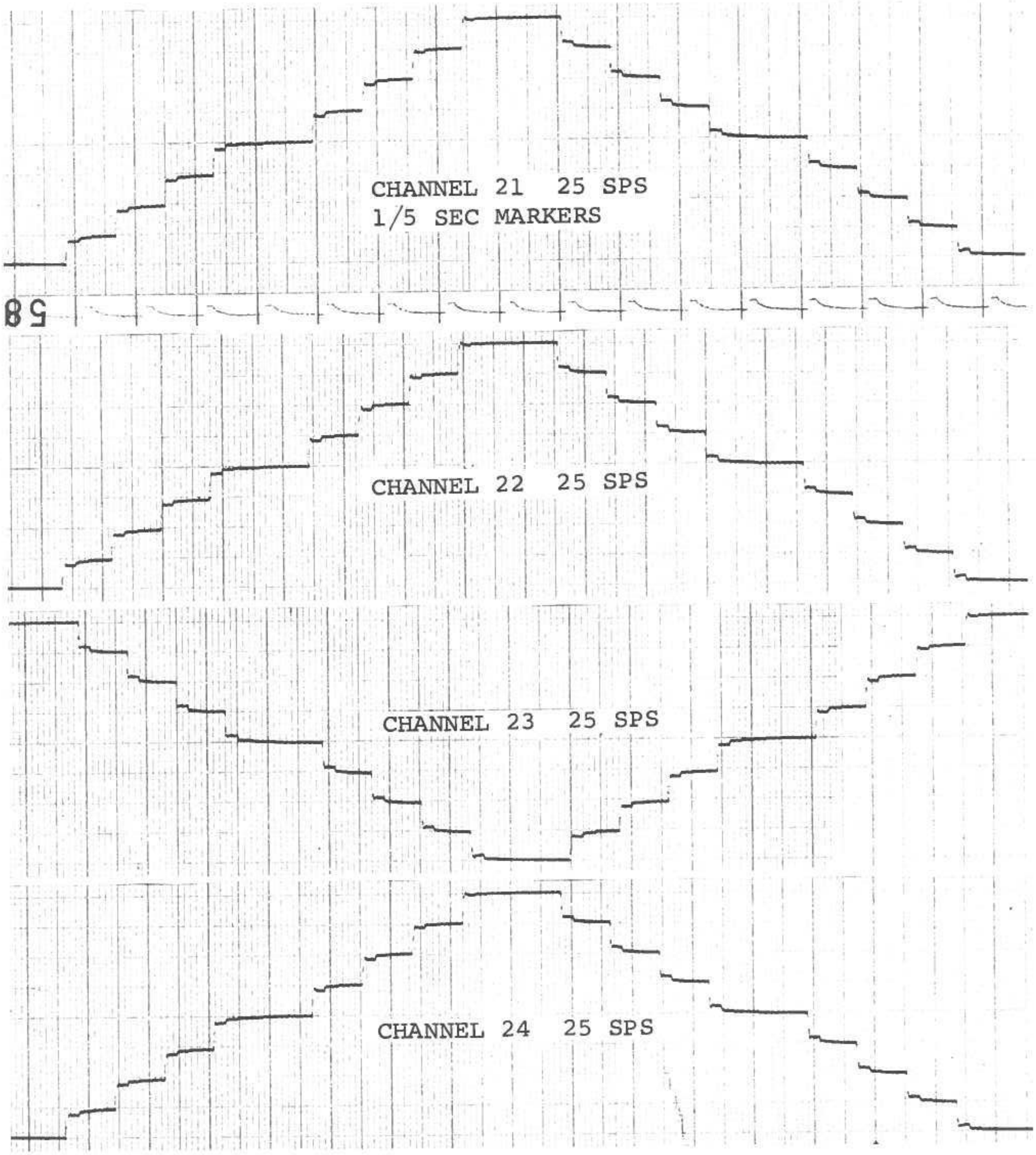
Recording 4 Output Signal (Staircase) at Receiving End



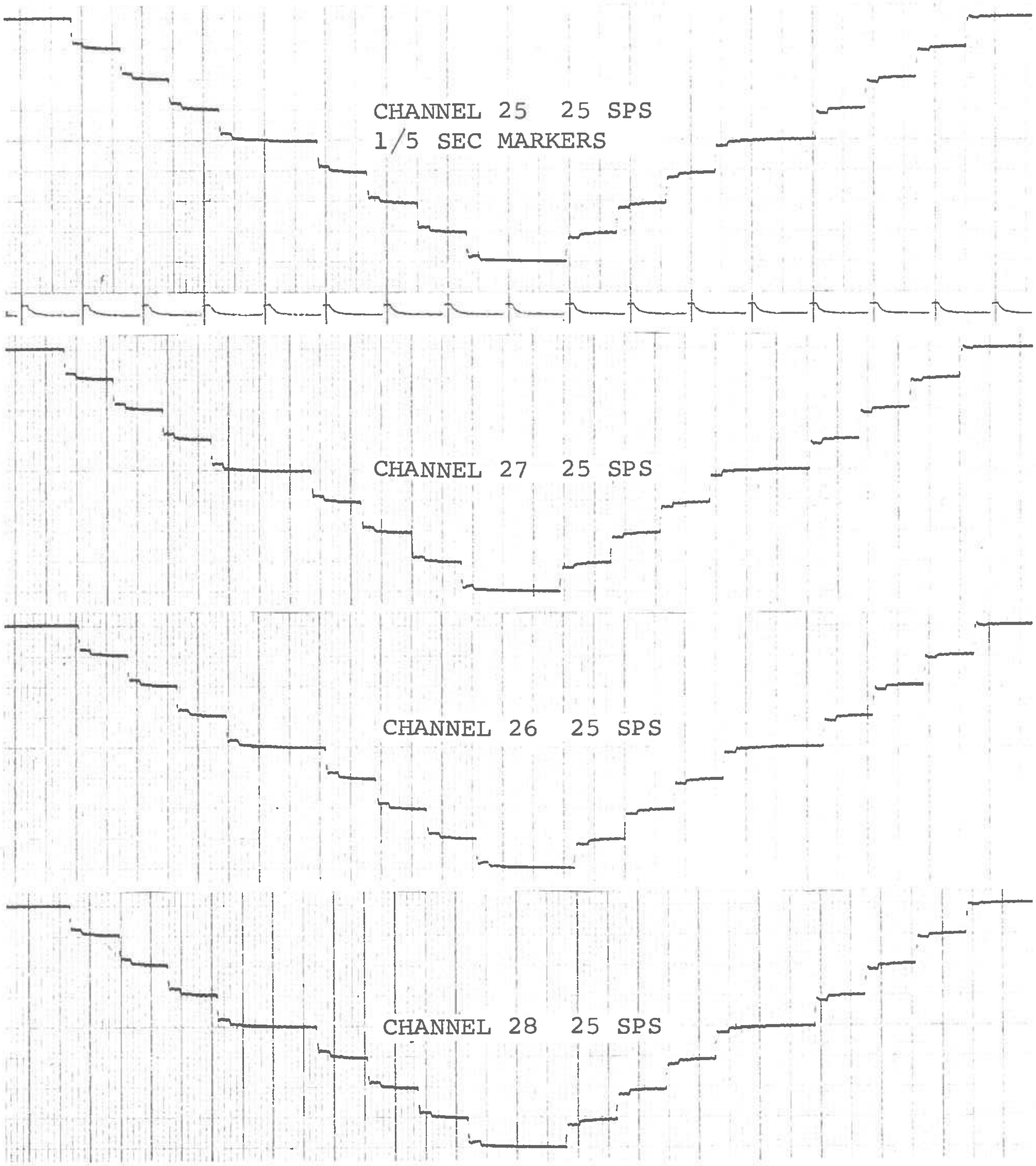
Recording 5 Output Signal (Staircase) at Receiving End



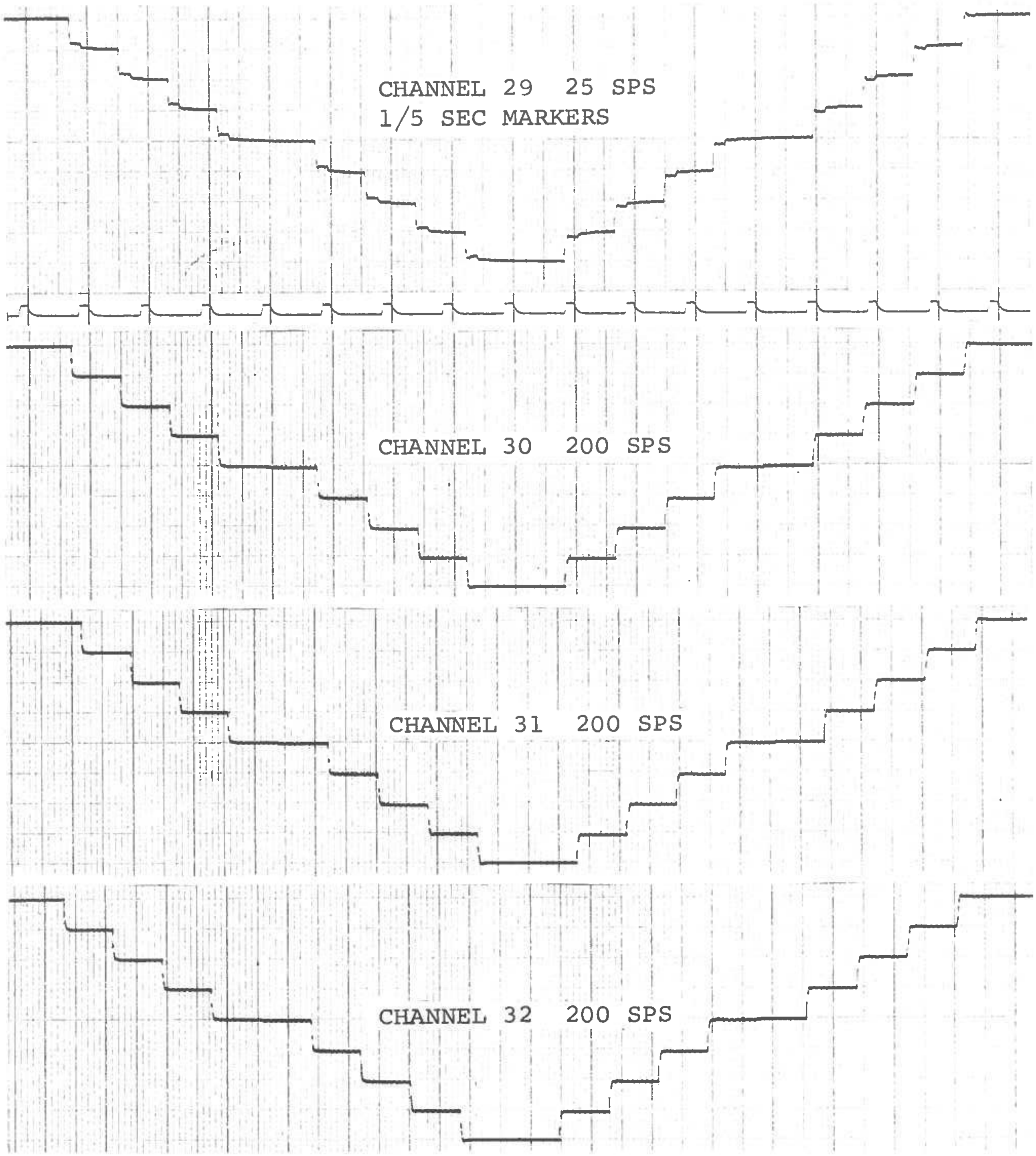
Recording 6 Output Signal (Staircase) at Receiving End



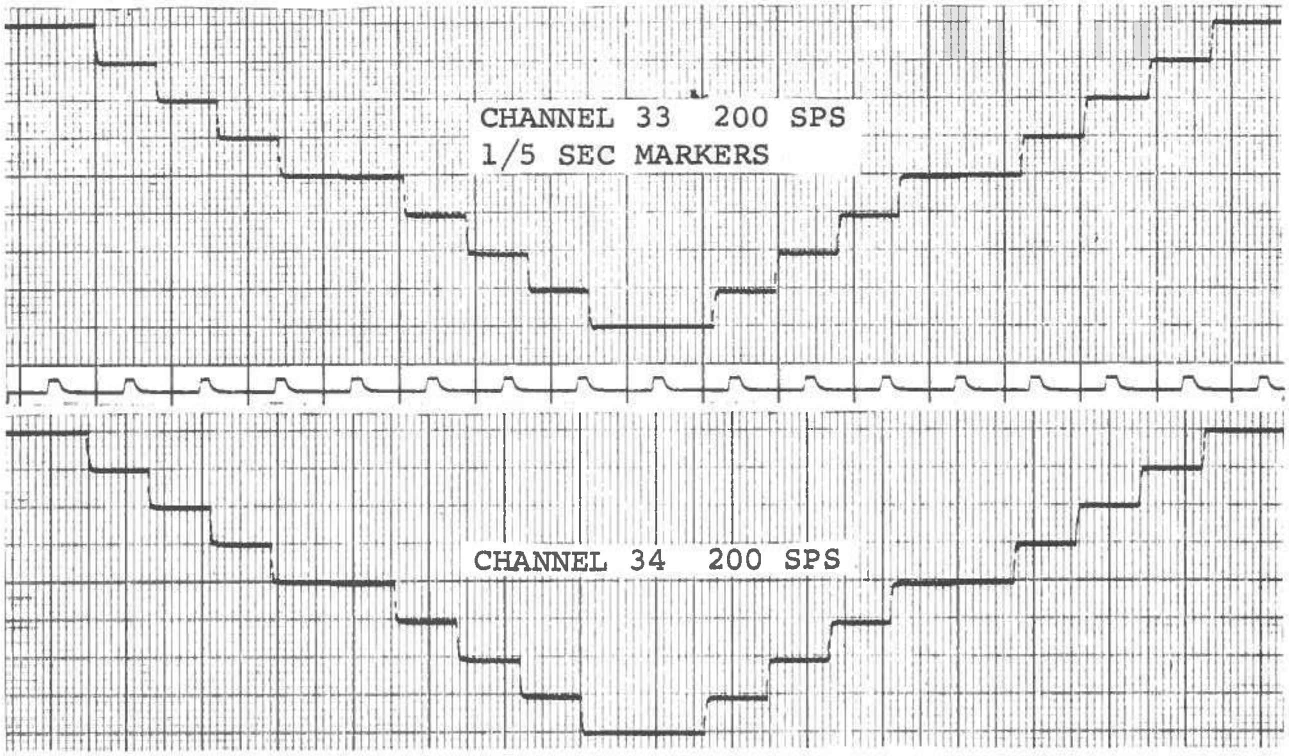
Recording 7 Output Signal (Staircase) at Receiving End



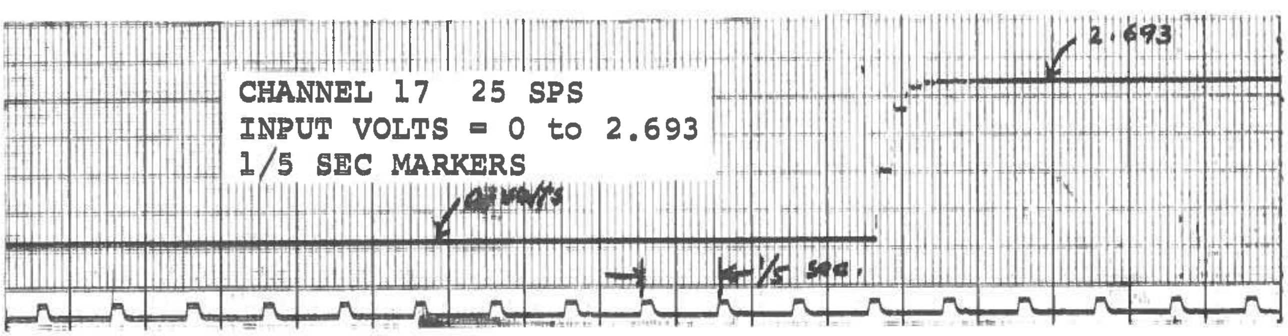
Recording 8 Output Signal (Staircase) at Receiving End



Recording 9 Output Signal (Staircase) at Receiving End



Recording 10 Output Signal (Staircase) at Receiving End



Recording 11 Transient Response of Output Amplifier A

APPENDIX A

LIST OF FIGURES

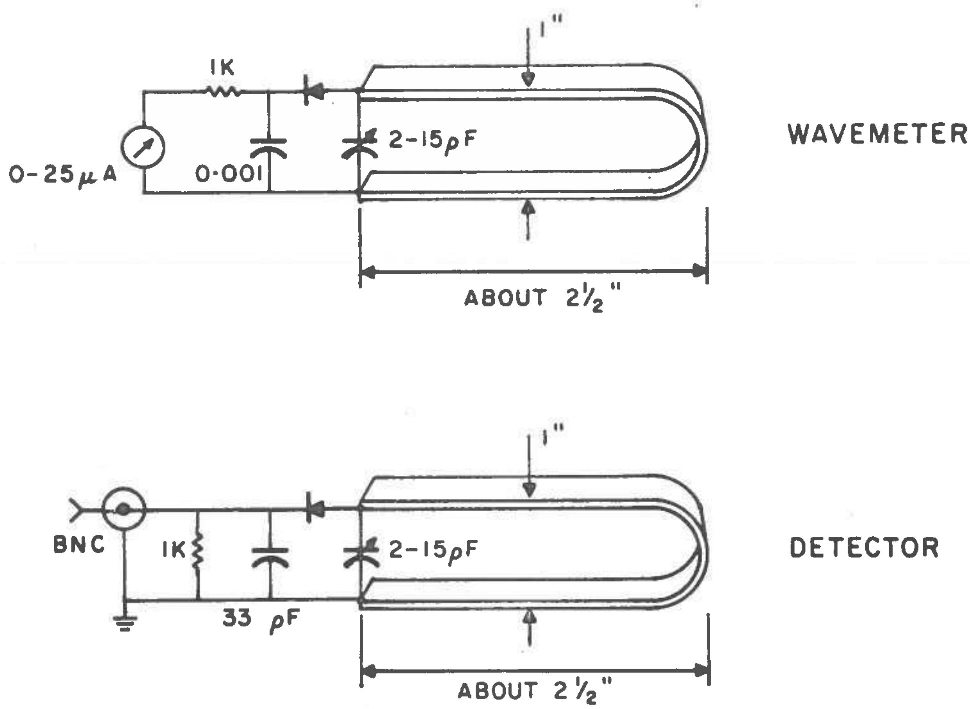


Fig. 1   Wavemeter and detector

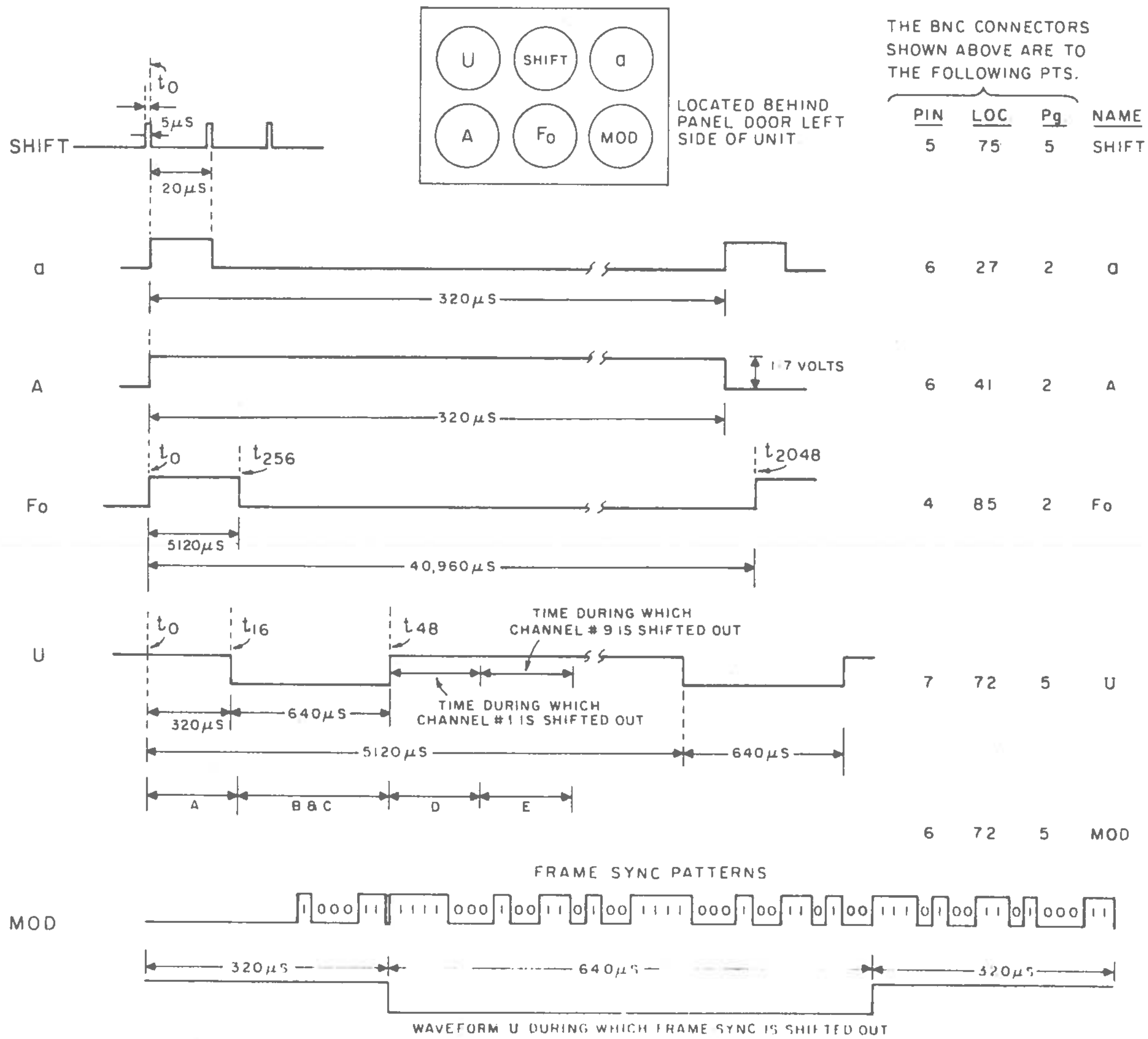


Fig. 2 Waveforms for transmitting end of telemetry

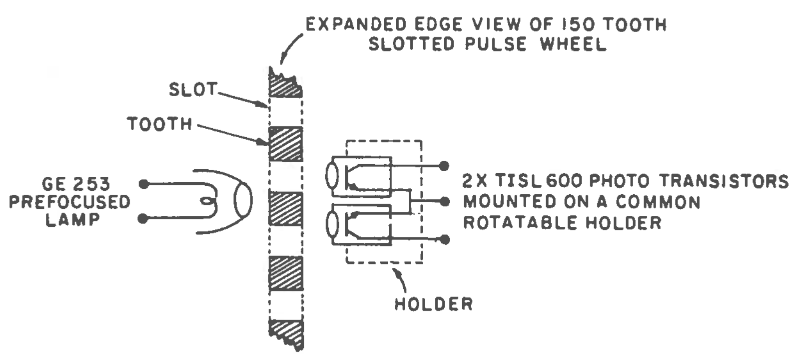


Fig. 3 Pickup for r.p.m. measurement

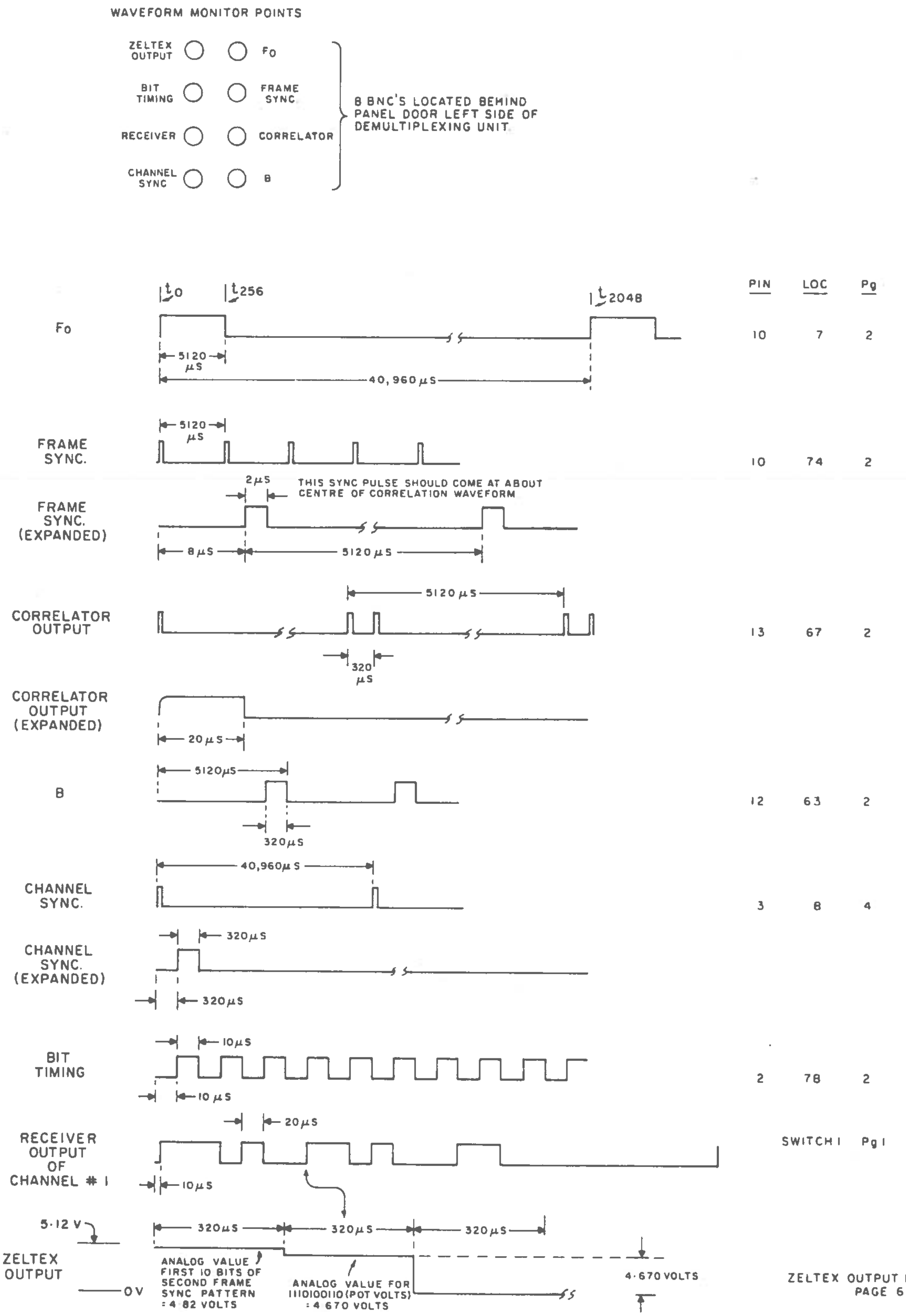


Fig. 4 Waveforms for receiving end of telemetry

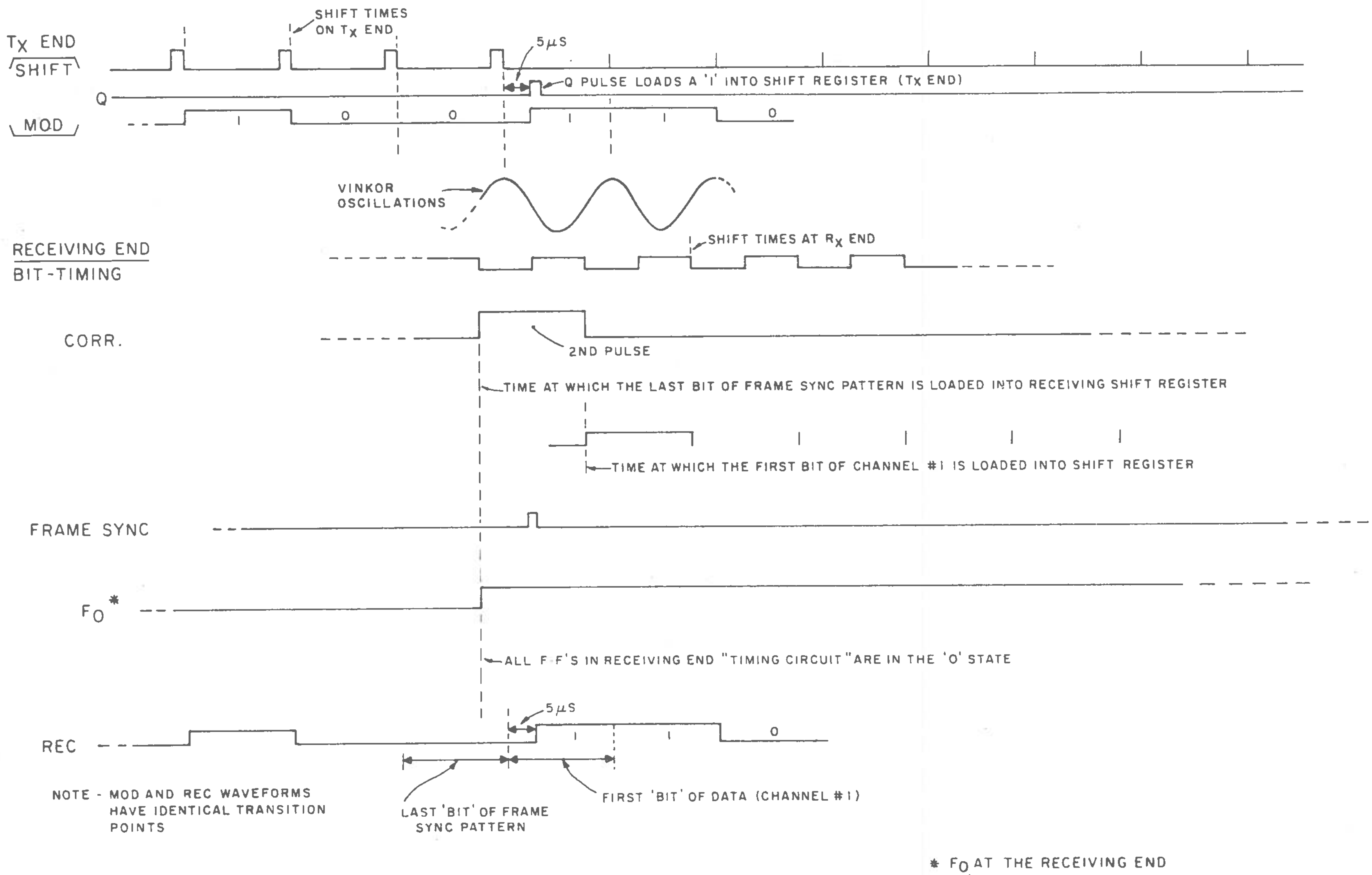


Fig. 5 Details of timing in the vicinity of F_O

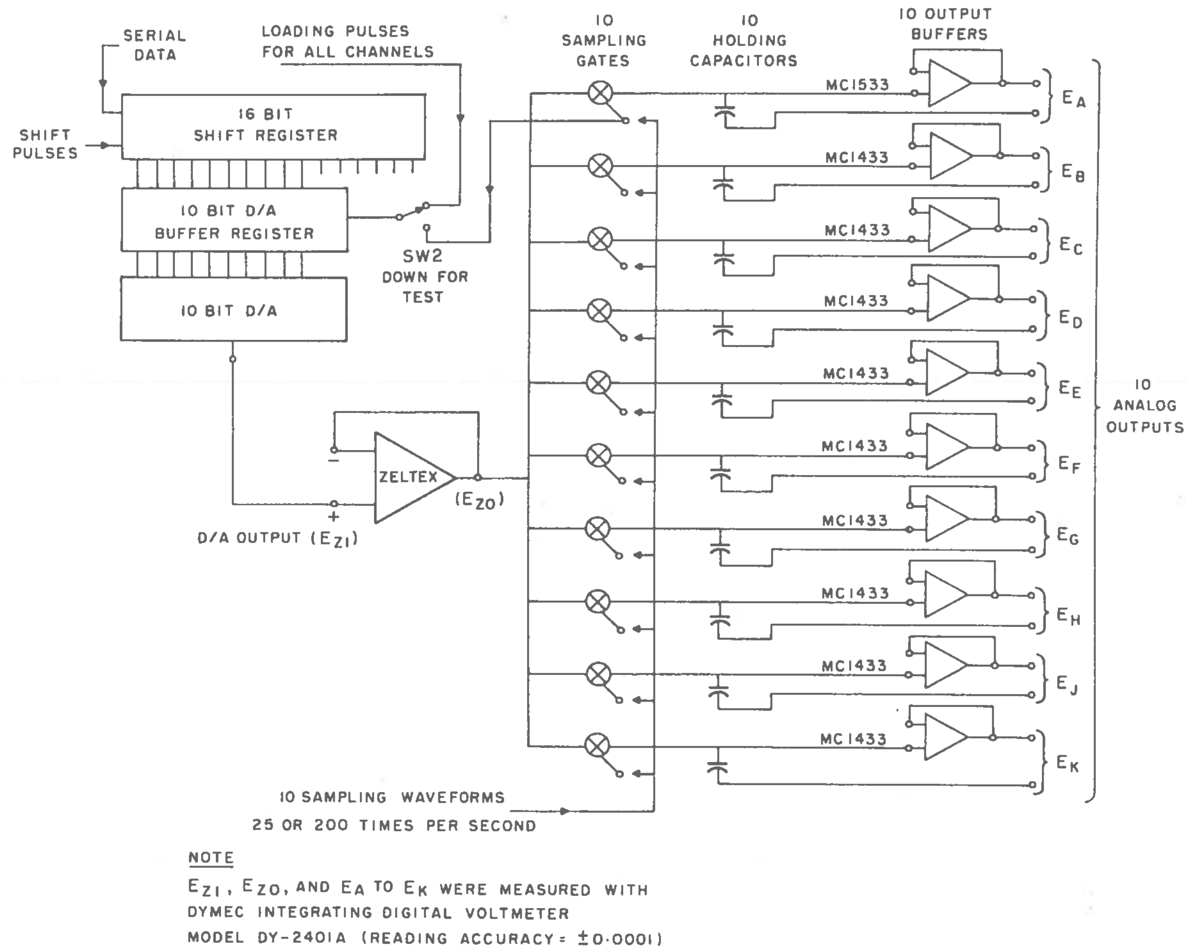


Fig. 6   Check points for D/A zeltex and 10 analog outputs

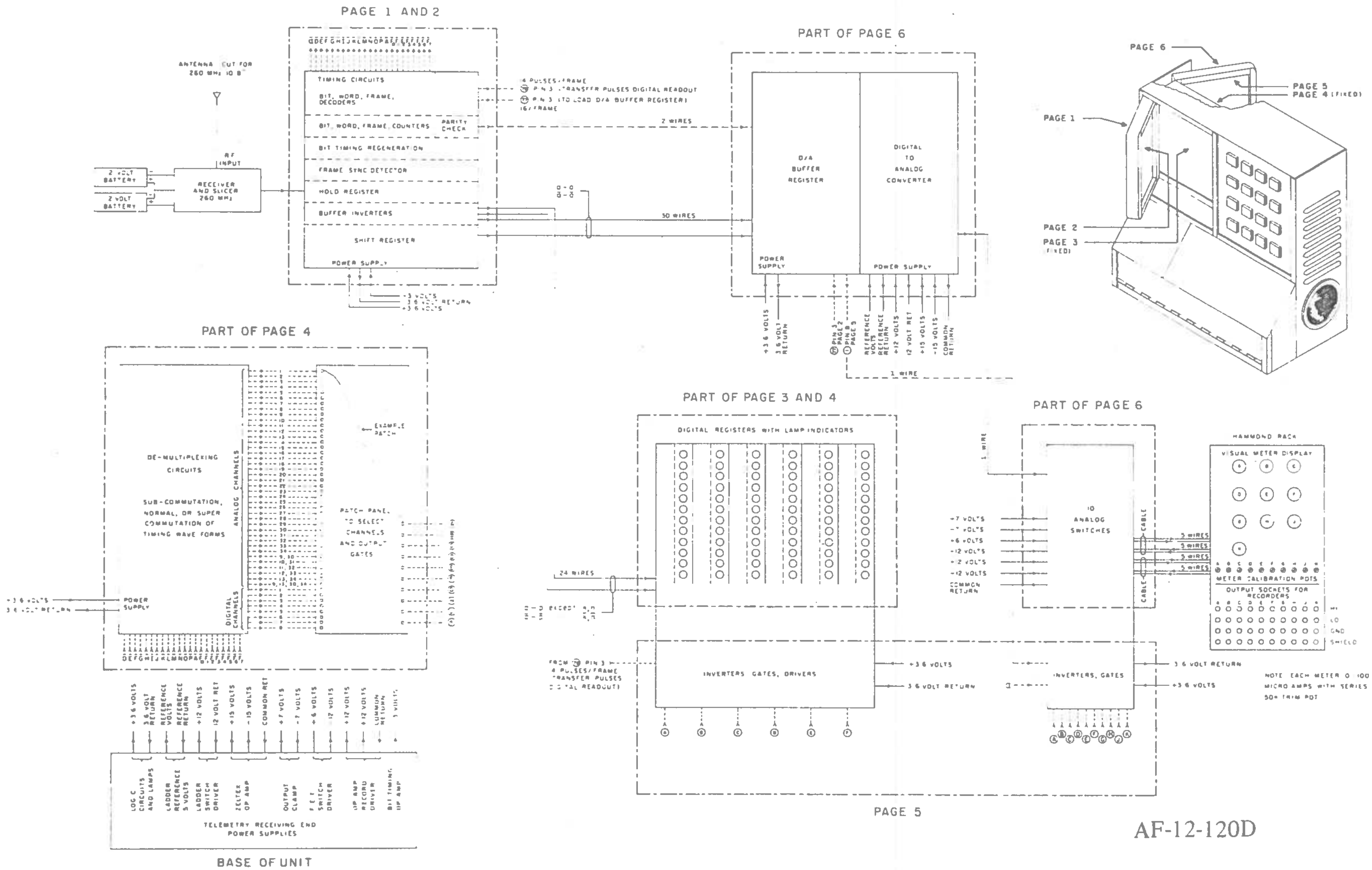
APPENDIX B

List of Diagrams

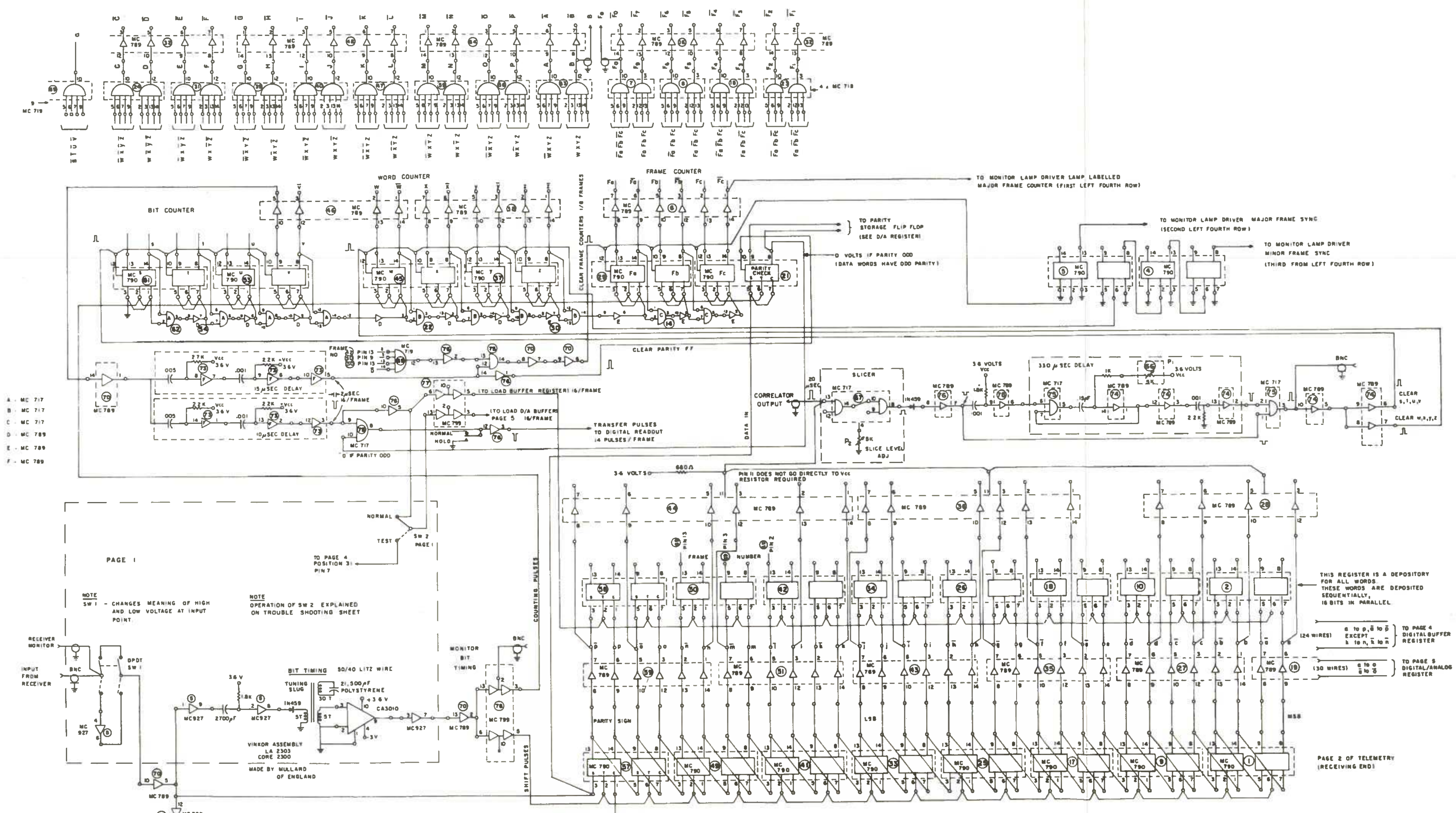
Receiving End

List of Diagrams – Cont'd

Transmitting End


PAGE 1 AND 2
TIMING CIRCUITS
BIT, WORD, FRAME, DECODERS
BIT, WORD, FRAME, COUNTERS
PARITY CHECK
BIT TIMING REGENERATION
FRAME SYNC DETECTOR
HOLD REGISTER
BUFFER INVERTERS
SHIFT REGISTER
POWER SUPPLY
RECEIVER AND SLICER 260 MHz
2 VOLT BATTERY
2 VOLT BATTERY
RF INPUT
2 WIRES
30 WIRES
PART OF PAGE 6
D/A BUFFER REGISTER
DIGITAL TO ANALOG CONVERTER
POWER SUPPLY
POWER SUPPLY
1 WIRE
PAGE 6
PAGE 5
PAGE 4 (FIXED)
PAGE 1
PAGE 2
PAGE 3
PART OF PAGE 4
DE-MULTIPLEXING CIRCUITS
SUB-COMMUTATION, NORMAL, OR SUPER COMMUTATION OF TIMING WAVE FORMS
ANALOG CHANNELS
DIGITAL CHANNELS
PATCH PANEL TO SELECT CHANNELS AND OUTPUT GATES
EXAMPLE PATCH
POWER SUPPLY
PART OF PAGE 3 AND 4
DIGITAL REGISTERS WITH LAMP INDICATORS
24 WIRES
INVERTERS, GATES, DRIVERS
+3.6 VOLTS
3.6 VOLT RETURN
PART OF PAGE 6
10 ANALOG SWITCHES
CABLE
CABLE
5 WIRES
5 WIRES
5 WIRES
5 WIRES
INVERTERS, GATES
HAMMOND RACK
VISUAL METER DISPLAY
METER CALIBRATION POTS
OUTPUT SOCKETS FOR RECORDERS
3.6 VOLT RETURN
+3.6 VOLTS
NOTE: EACH METER 0-100 MICRO AMPS WITH SERIES 50K TRIM POT
PAGE 5
TELEMETRY RECEIVING END POWER SUPPLIES
BASE OF UNIT

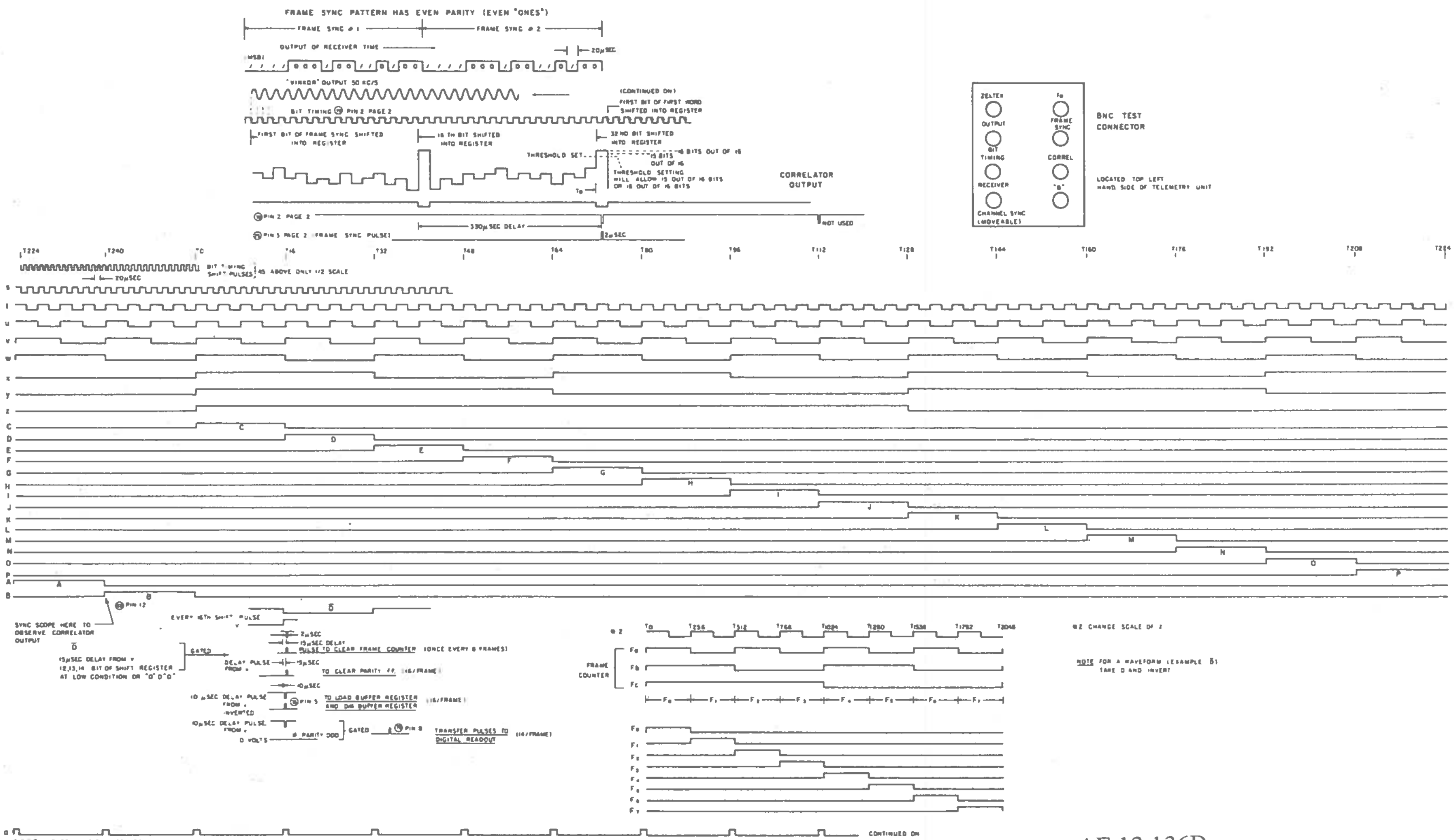
AF-12-120D



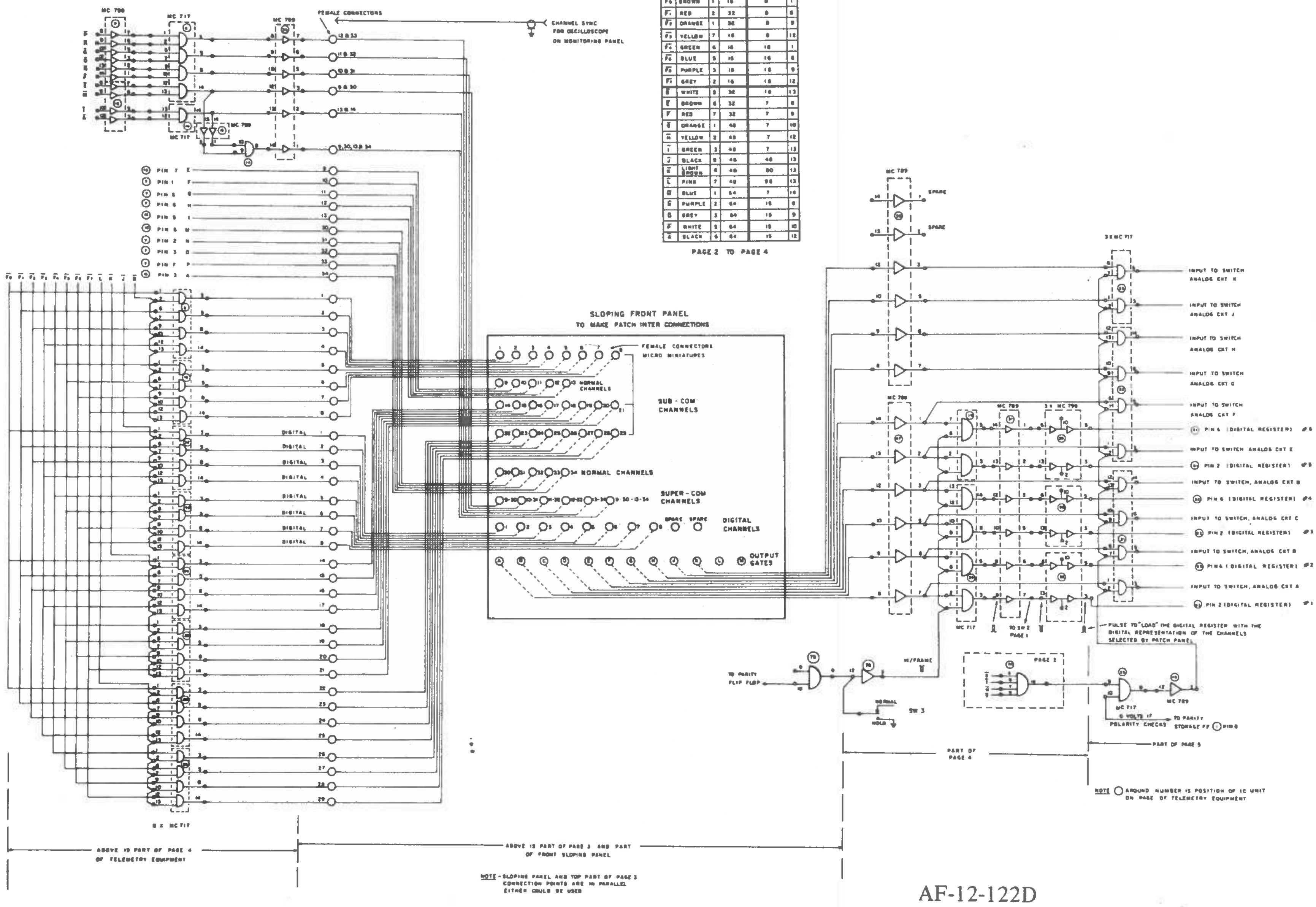
NOTE ○ AROUND A NUMBER SHOWS POSITION OF IC UNIT ON PAGE OF TELEMETRY EQUIPMENT

PIN 11 OF EACH UNIT TO 3.6 VOLTS
PIN 4 OF EACH UNIT TO RETURN OF 3.6 VOLTS

EXCEPT 927 – PIN 10 TO 3.6 VOLTS
PIN 5 TO RETURN OF 3.6 VOLTS


FRAME SYNC PATTERN HAS EVEN PARITY (EVEN "ONES")
FRAME SYNC # 1
FRAME SYNC # 2
OUTPUT OF RECEIVER TIME
20μSEC
"VIRDOR" OUTPUT 50 KC/S
(CONTINUED ON)
FIRST BIT OF FIRST WORD SHIFTED INTO REGISTER
FIRST BIT OF FRAME SYNC SHIFTED INTO REGISTER
16 TH BIT SHIFTED INTO REGISTER
32 ND BIT SHIFTED INTO REGISTER
THRESHOLD SET
16 BITS OUT OF 16
15 BITS OUT OF 16
THRESHOLD SETTING WILL ALLOW 15 OUT OF 16 BITS OR 16 OUT OF 16 BITS
CORRELATOR OUTPUT
330μ SEC DELAY
2μ SEC
NOT USED
BNC TEST CONNECTOR
ZELTEX OUTPUT
BIT TIMING
RECEIVER
CHANNEL SYNC (MOVEABLE)
F0 FRAME SYNC
CORREL
"B"
LOCATED TOP LEFT HAND SIDE OF TELEMETRY UNIT
AS ABOVE ONLY 1/2 SCALE
SYNC SCOPE HERE TO OBSERVE CORRELATOR OUTPUT
EVERY 16TH SHIFT PULSE
GATED
DELAY PULSE
PULSE TO CLEAR FRAME COUNTER (ONCE EVERY 8 FRAMES)
TO CLEAR PARITY FF. (16/FRAME)
TO LOAD BUFFER REGISTER AND D/A BUFFER REGISTER (16/FRAME)
PARITY ODD
TRANSFER PULSES TO DIGITAL READOUT (16/FRAME)
FRAME COUNTER
CHANGE SCALE OF Z
NOTE FOR A WAVEFORM (EXAMPLE B) TAKE B AND INVERT
CONTINUED ON

AF-12-136D

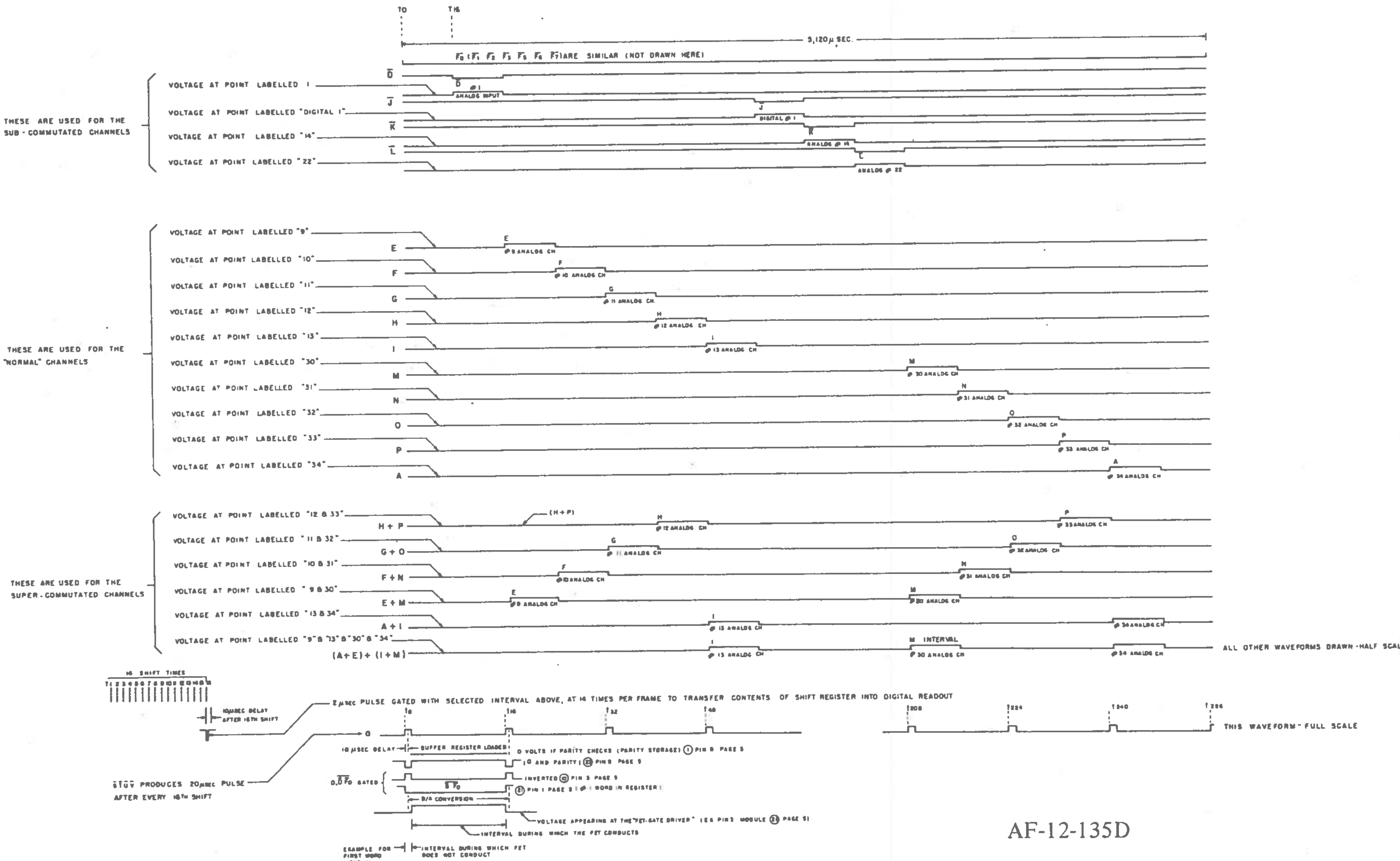


INTER PAGE CONNECTIONS

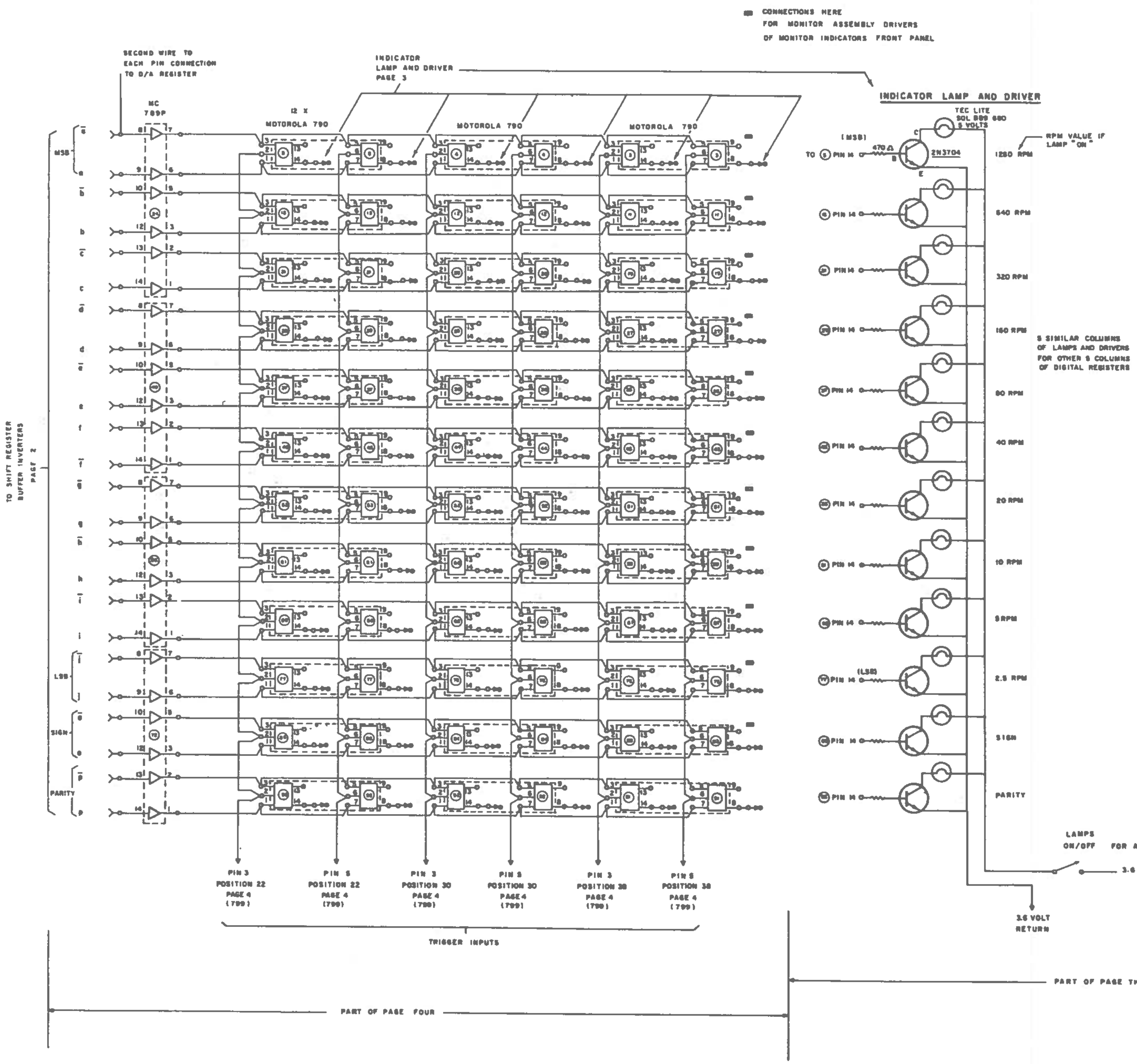
	COLOUR	PIN	POSITION	POSITION	PIN
$\bar{F}_0$	BROWN	1	16	8	1
$\bar{F}_1$	RED	2	32	8	6
$\bar{F}_2$	ORANGE	1	32	8	9
$\bar{F}_3$	YELLOW	7	16	8	12
$\bar{F}_4$	GREEN	6	16	16	1
$\bar{F}_5$	BLUE	5	16	16	6
$\bar{F}_6$	PURPLE	3	16	16	9
$\bar{F}_7$	GREY	2	16	16	12
$\bar{B}$	WHITE	5	32	16	13
E	BROWN	6	32	7	8
F	RED	7	32	7	9
$\bar{G}$	ORANGE	1	48	7	10
$\bar{H}$	YELLOW	2	48	7	12
$\bar{I}$	GREEN	3	48	7	13
$\bar{J}$	BLACK	5	48	48	13
$\bar{K}$	LIGHT BROWN	6	48	80	13
$\bar{L}$	PINK	7	48	96	13
B	BLUE	1	64	7	14
$\bar{E}$	PURPLE	2	64	15	6
G	GREY	3	64	15	9
F	WHITE	5	64	15	10
$\bar{A}$	BLACK	6	64	15	12

PAGE 2 TO PAGE 4

WAVEFORMS IN "DEMULTIPLEXING CIRCUITRY"



AF-12-135D

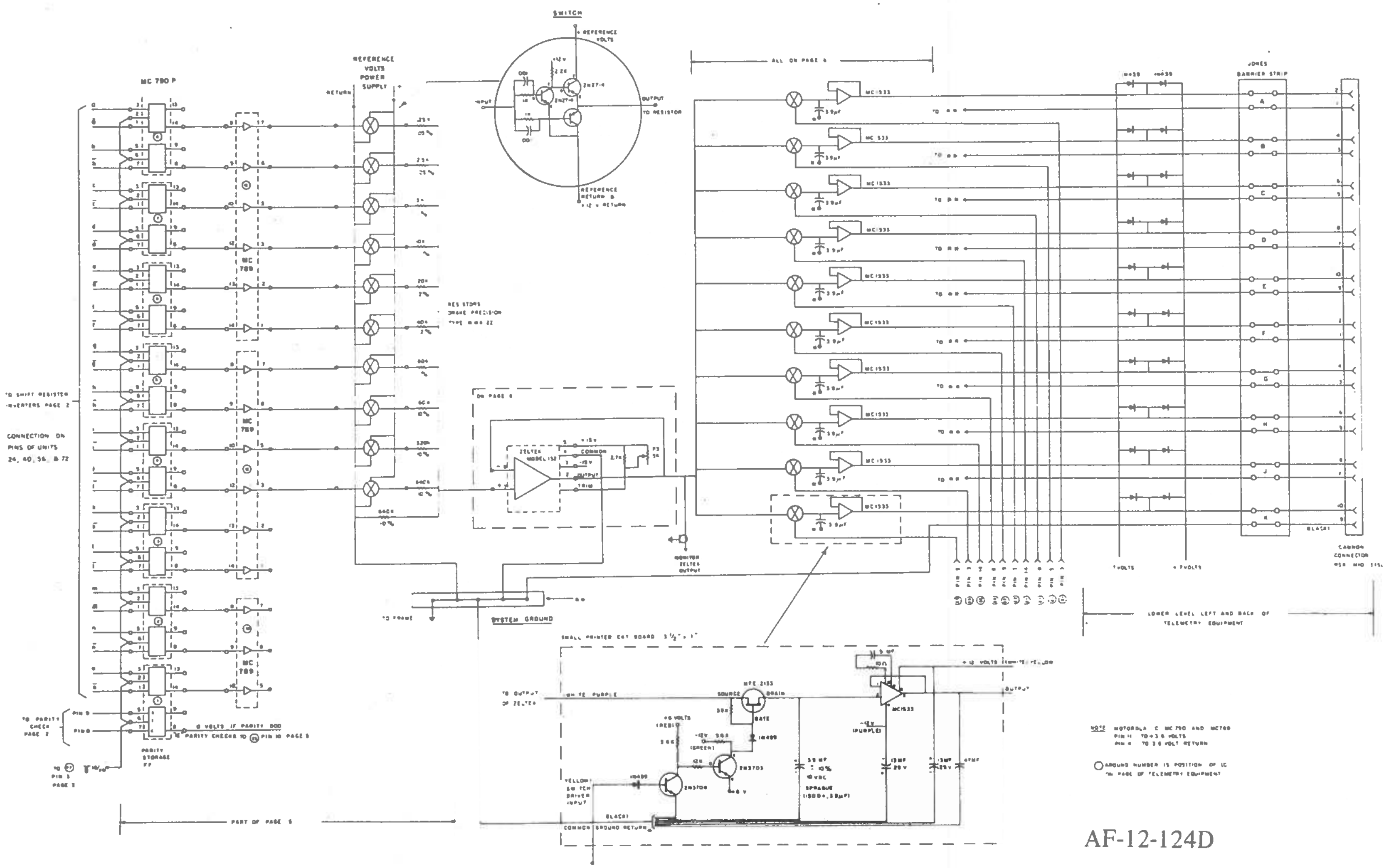


PAGE INTERCONNECTIONS

PAGE 2				PAGE 4				PAGE 5			
PIN NUMBER	LOCATION NUMBER	WIRE COLOUR		TO PIN NUMBER	LOCATION NUMBER	WIRE COLOUR		TO PIN NUMBER	LOCATION NUMBER	WIRE COLOUR	
7	19	RED	$\bar{a}$	8	24	RED	$\bar{a}$	1	8	RED	$\bar{a}$
12	28	BROWN	a	9	24	BROWN	a	3	8	BROWN	a
2	27	YELLOW	$\bar{b}$	10	24	YELLOW	$\bar{b}$	7	8	YELLOW	$\bar{b}$
1	27	ORANGE	b	12	24	ORANGE	b	5	8	ORANGE	b
5	27	BLUE	$\bar{c}$	13	24	BLUE	$\bar{c}$	1	7	BLUE	$\bar{c}$
3	27	GREEN	c	14	24	GREEN	c	3	7	GREEN	c
7	27	GREY	$\bar{d}$	8	40	GREY	$\bar{d}$	7	7	GREY	$\bar{d}$
6	27	PURPLE	d	9	40	PURPLE	d	5	7	PURPLE	d
2	35	BLACK	$\bar{e}$	10	40	BLACK	$\bar{e}$	1	6	BLACK	$\bar{e}$
1	35	WHITE	e	12	40	WHITE	e	3	6	WHITE	e
5	35	RED	$\bar{f}$	13	40	RED	$\bar{f}$	7	6	RED	$\bar{f}$
3	35	BROWN	f	14	40	BROWN	f	5	6	BROWN	f
7	35	YELLOW	$\bar{g}$	8	56	YELLOW	$\bar{g}$	1	5	YELLOW	$\bar{g}$
6	35	ORANGE	g	9	56	ORANGE	g	3	5	ORANGE	g
2	43	BLUE	$\bar{h}$	10	56	BLUE	$\bar{h}$	7	5	BLUE	$\bar{h}$
1	43	GREEN	h	12	56	GREEN	h	5	5	GREEN	h
5	43	GREY	$\bar{i}$	13	56	GREY	$\bar{i}$	1	4	GREY	$\bar{i}$
3	43	PURPLE	i	14	56	PURPLE	i	3	4	PURPLE	i
7	43	BLACK	$\bar{j}$	8	72	BLACK	$\bar{j}$	7	4	BLACK	$\bar{j}$
6	43	WHITE	j	9	72	WHITE	j	5	4	WHITE	j
5	59	BLACK	$\bar{o}$	10	72	BLACK	$\bar{o}$	1	1	BLACK	$\bar{o}$
3	59	WHITE	o	12	72	WHITE	o	3	1	WHITE	o
7	59	RED	$\bar{p}$	13	72	RED	$\bar{p}$				
6	59	BROWN	p	14	72	BROWN	p				
2	81	RED	$\bar{k}$					1	3	RED	$\bar{k}$
1	81	BROWN	k					3	3	BROWN	k
5	81	YELLOW	$\bar{l}$					7	3	YELLOW	$\bar{l}$
3	81	ORANGE	l					5	3	ORANGE	l
7	81	BLUE	$\bar{m}$					1	2	BLUE	$\bar{m}$
6	81	GREEN	m					3	2	GREEN	m
2	89	GREY	$\bar{n}$					7	2	GREY	$\bar{n}$
1	89	PURPLE	n					5	2	PURPLE	n
				7	47	BROWN		1	21	BROWN	
				6	47	RED		5	21	RED	
				5	47	ORANGE		10	21	ORANGE	
				3	47	YELLOW		12	21	YELLOW	
				2	47	GREEN		1	22	GREEN	
				1	47	BLUE		6	22	BLUE	
				7	55	PURPLE		10	22	PURPLE	
				6	55	GREY		12	22	GREY	
				5	56	WHITE		1	23	WHITE	
				3	56	BLACK		6	23	BLACK	

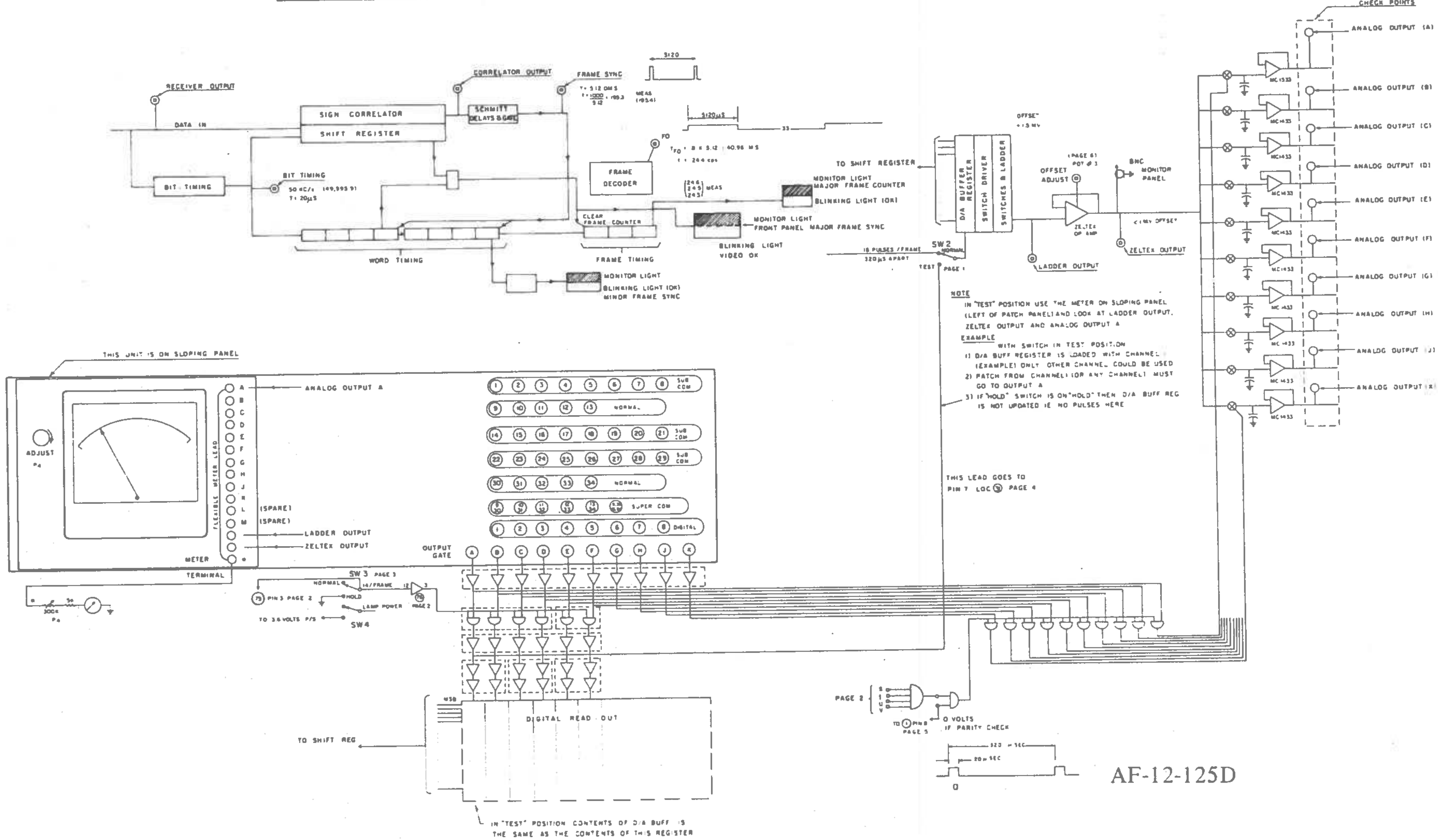
NOTE ◯ AROUND NUMBER SHOWS POSITION ON PAGE 4 OF TELEMETRY UNIT

AF-12-123D


SWITCH
REFERENCE VOLTS POWER SUPPLY
MC 790 P
SYSTEM GROUND
PART OF PAGE 5
ALL ON PAGE 6

AF-12-124D

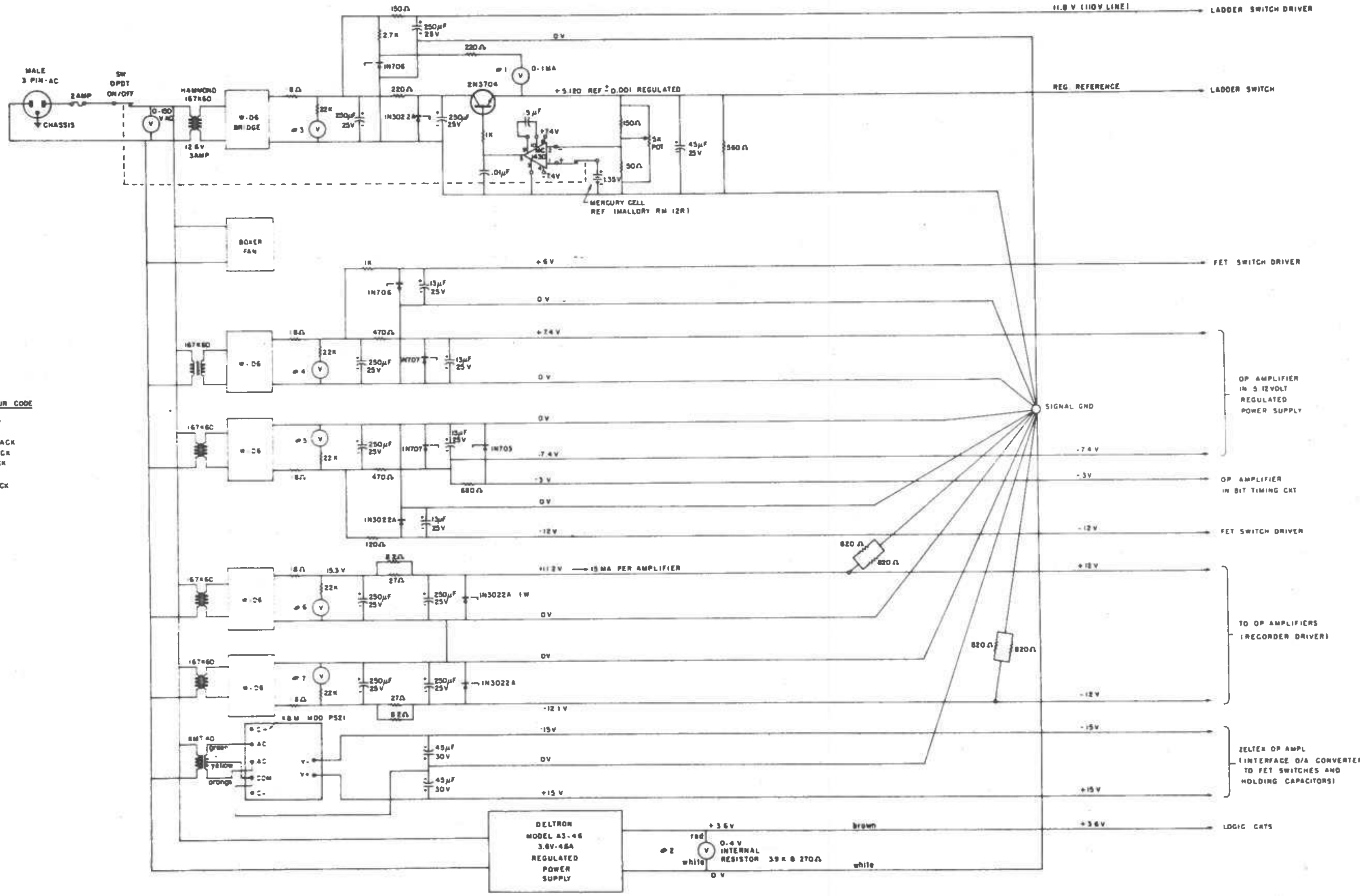
TROUBLE SHOOTING CHECK POINTS



AF-12-125D

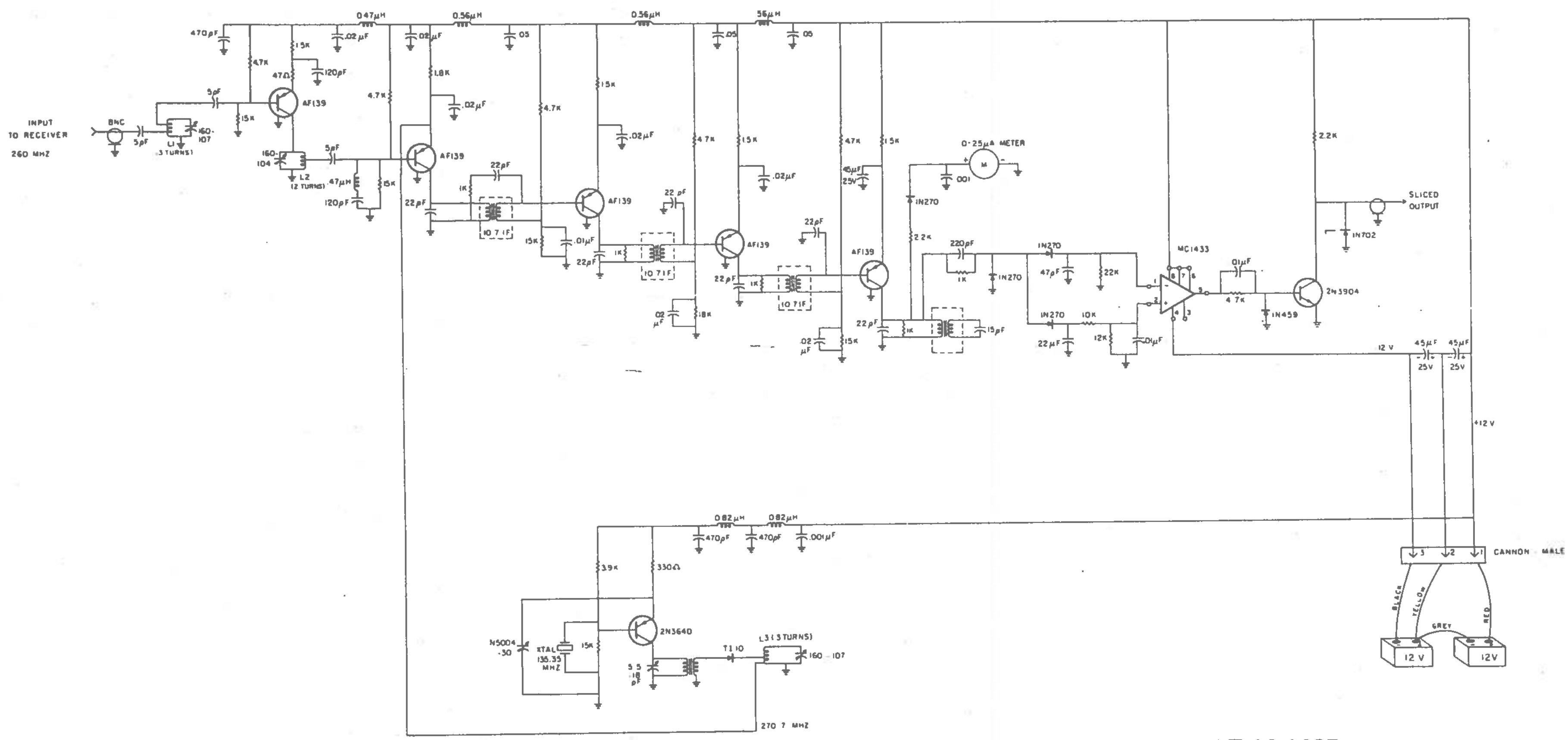
METER LEAD COLOUR CODE

- #1 BROWN & GREY
- #2 RED & WHITE
- #3 ORANGE & BLACK
- #4 YELLOW & BLACK
- #5 GREEN & BLACK
- #6 BLUE & BLACK
- #7 PURPLE & BLACK



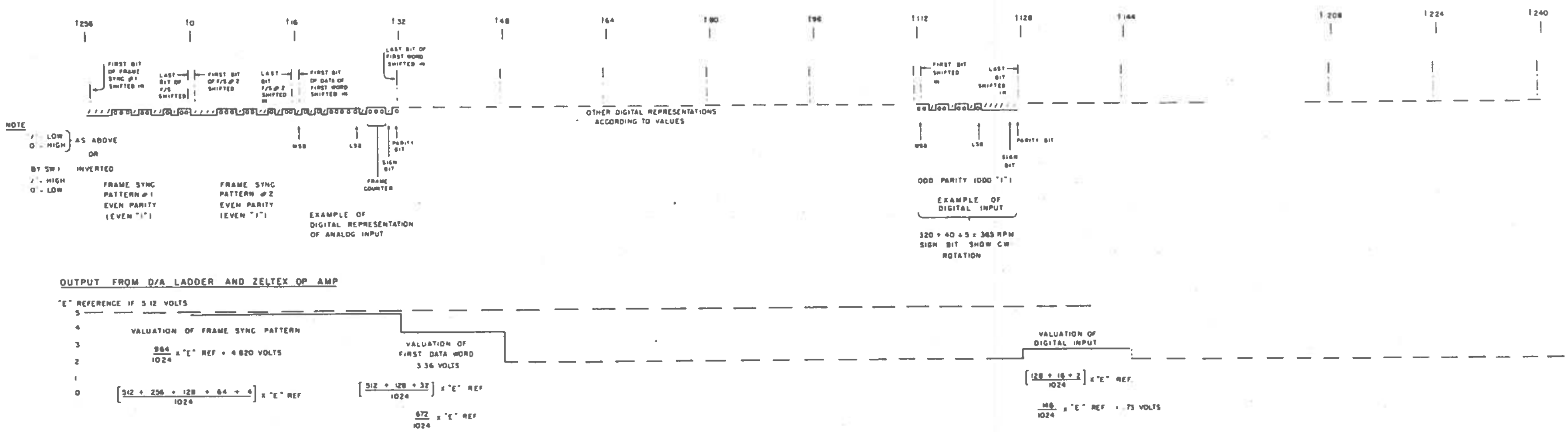
LOWER LEVEL OF TELEMETRY UNIT

AF-12-127D



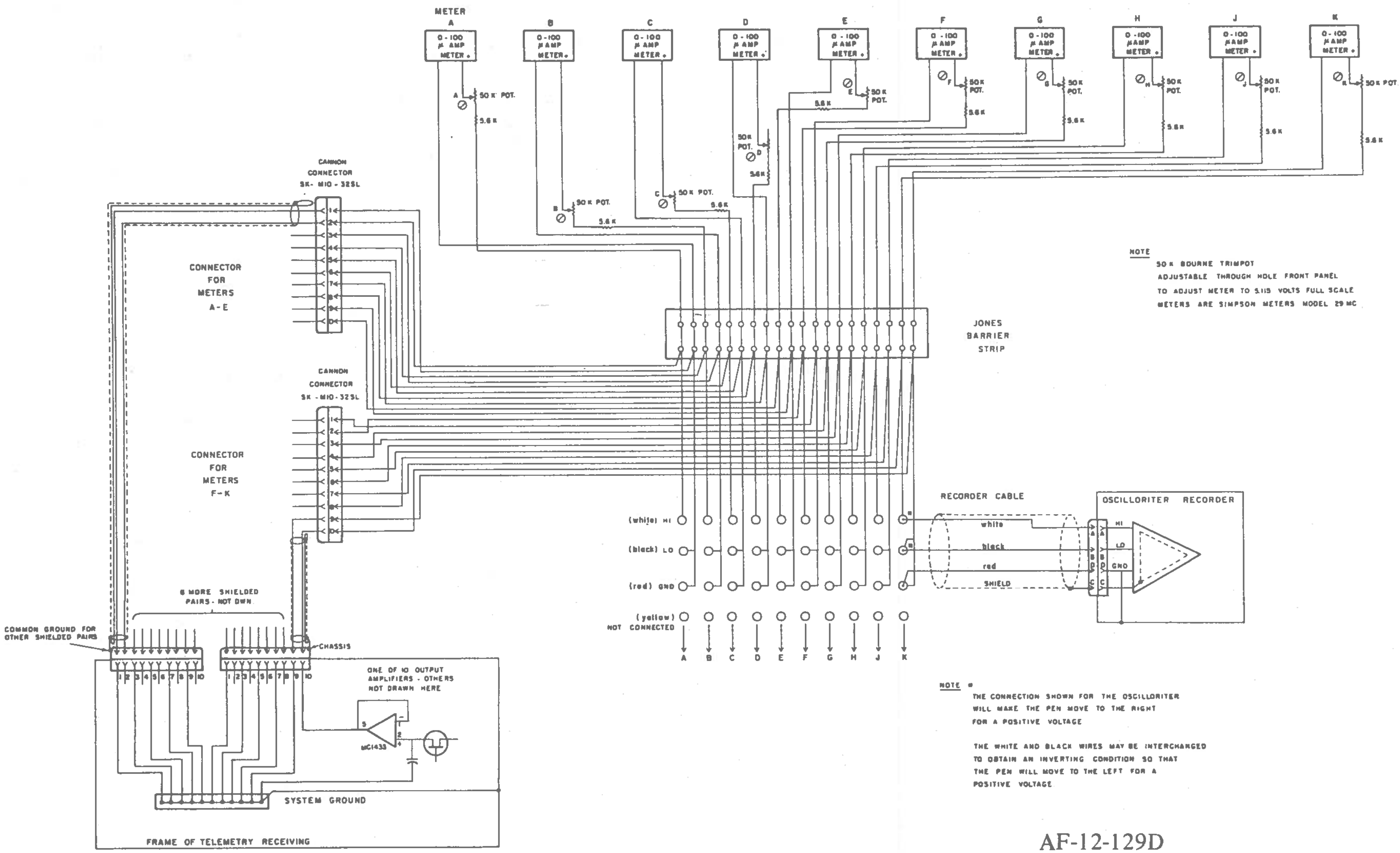
INPUT
TO RECEIVER
260 MHZ
BNC
5pF
L1
(3 TURNS)
160-107
160-104
L2
(2 TURNS)
.47μH
120pF
15K
470pF
4.7K
47Ω
AF139
.02μF
0.47μH
0.56μH
56μH
1.8K
22pF
1K
10.7 IF
.01μF
18K
.05
45μF
25V
0-25μA METER
M
.001
1N270
220pF
47pF
22K
10K
12K
MC1433
.01μF
1N459
2N3904
2.2K
SLICED
OUTPUT
1N702
12 V
+12 V
CANNON MALE
BLACK
YELLOW
GREY
RED
12 V
12V
0.82μH
.001μF
3.9K
330Ω
2N3640
N5004
-30
XTAL
135.35
MHZ
5.5
-18
pF
T1 10
L3 (3 TURNS)
160-107
270.7 MHZ

AF-12-128D

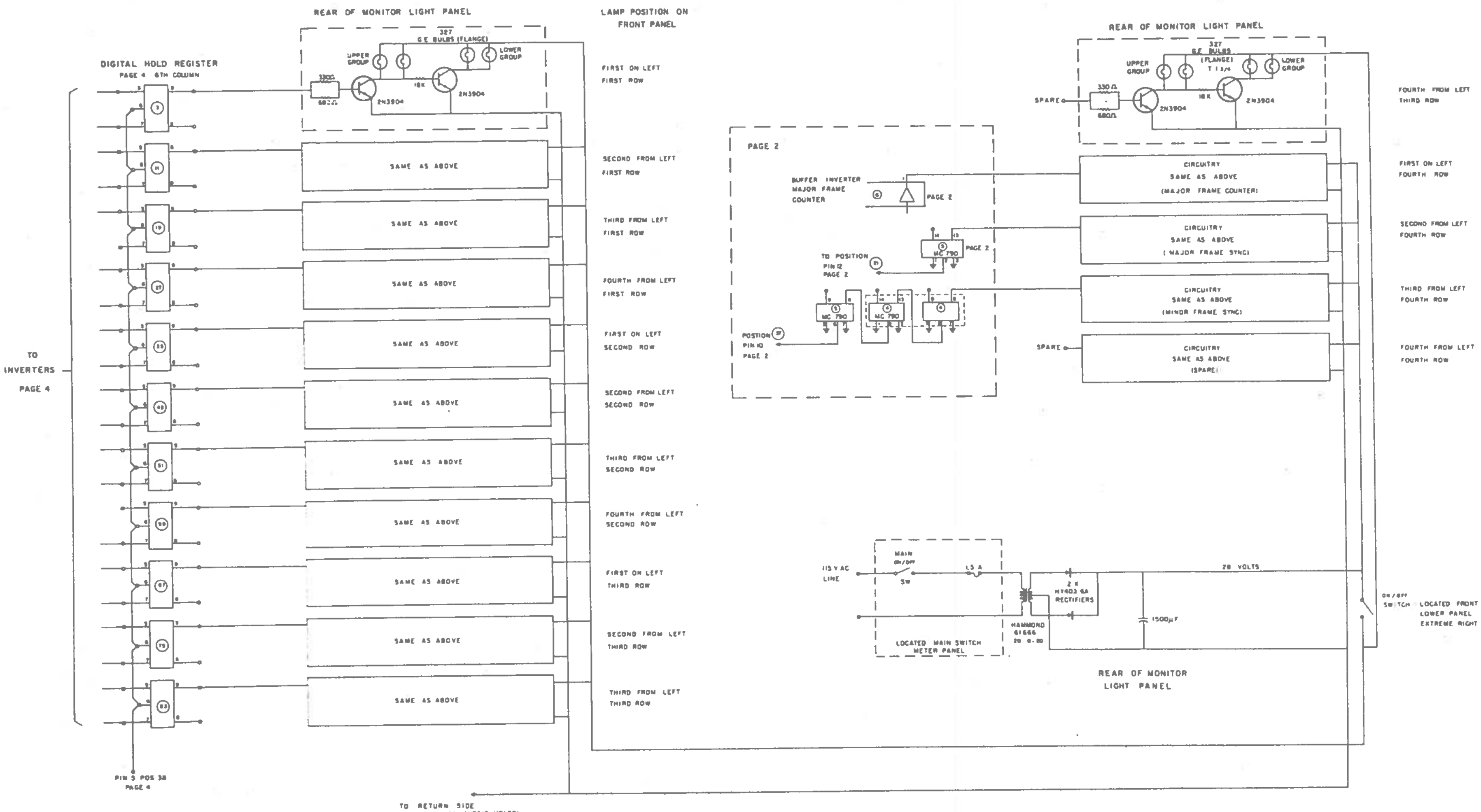


t256
t0
t16
t32
t48
t64
t80
t96
t112
t128
t144
t208
t224
t240
FIRST BIT OF FRAME SYNC #1 SHIFTED IN
LAST BIT OF F/S SHIFTED
FIRST BIT OF F/S #2 SHIFTED
LAST BIT F/S #2 SHIFTED IN
FIRST BIT OF DATA OF FIRST WORD SHIFTED IN
LAST BIT OF FIRST WORD SHIFTED IN
OTHER DIGITAL REPRESENTATIONS ACCORDING TO VALUES
NOTE
/ - LOW
0 - HIGH
AS ABOVE
OR
BY SW 1 INVERTED
/ - HIGH
0 - LOW
FRAME SYNC PATTERN #1 EVEN PARITY (EVEN "1")
FRAME SYNC PATTERN #2 EVEN PARITY (EVEN "1")
MSB
LSB
PARITY BIT
SIGN BIT
FRAME COUNTER
EXAMPLE OF DIGITAL REPRESENTATION OF ANALOG INPUT
FIRST BIT SHIFTED IN
LAST BIT SHIFTED IN
ODD PARITY (ODD "1")
EXAMPLE OF DIGITAL INPUT
320 + 40 + 5 = 365 RPM SIGN BIT SHOW CW ROTATION
OUTPUT FROM D/A LADDER AND ZELTEX OP AMP
"E" REFERENCE IF 5.12 VOLTS
5
4
3
2
1
0
VALUATION OF FRAME SYNC PATTERN
984/1024 x "E" REF = 4.920 VOLTS
[(512 + 256 + 128 + 64 + 4)/1024] x "E" REF
VALUATION OF FIRST DATA WORD 3.36 VOLTS
[(512 + 128 + 32)/1024] x "E" REF
672/1024 x "E" REF
VALUATION OF DIGITAL INPUT
[(128 + 16 + 2)/1024] x "E" REF
146/1024 x "E" REF = .73 VOLTS

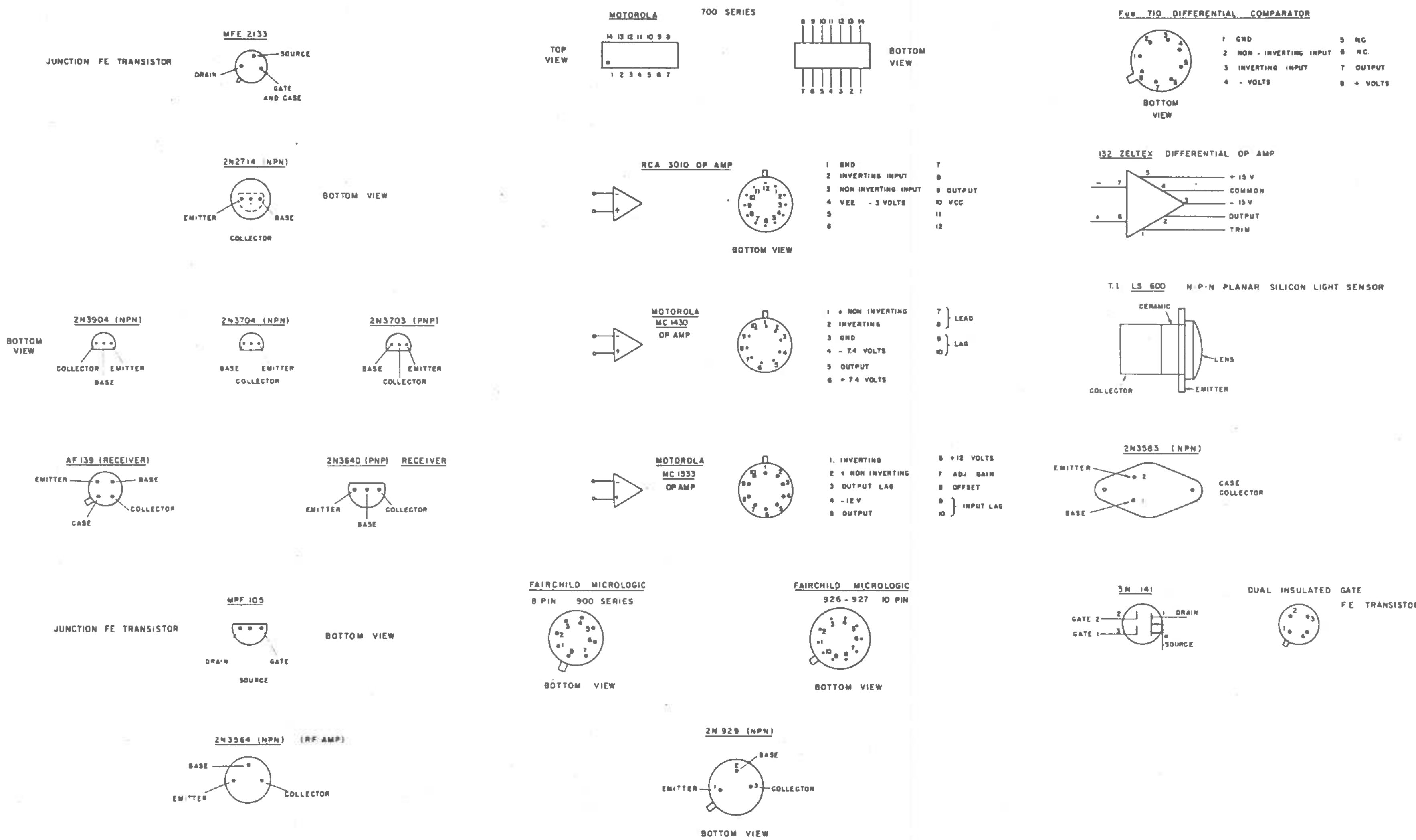
AF-12-137D


METER A
B
C
D
E
F
G
H
J
K
0-100 µ AMP METER +
50 K POT.
5.6 K
CANNON CONNECTOR SK-MIO-32SL
CONNECTOR FOR METERS A-E
CONNECTOR FOR METERS F-K
JONES BARRIER STRIP
NOTE
50 K BOURNE TRIMPOT
ADJUSTABLE THROUGH HOLE FRONT PANEL
TO ADJUST METER TO 5.115 VOLTS FULL SCALE
METERS ARE SIMPSON METERS MODEL 29 MC
RECORDER CABLE
OSCILLORITER RECORDER
white
black
red
SHIELD
HI
LO
GND
(white) HI
(black) LO
(red) GND
(yellow) NOT CONNECTED
6 MORE SHIELDED PAIRS - NOT DWN
COMMON GROUND FOR OTHER SHIELDED PAIRS
CHASSIS
ONE OF 10 OUTPUT AMPLIFIERS - OTHERS NOT DRAWN HERE
MC1433
SYSTEM GROUND
FRAME OF TELEMETRY RECEIVING
NOTE *
THE CONNECTION SHOWN FOR THE OSCILLORITER
WILL MAKE THE PEN MOVE TO THE RIGHT
FOR A POSITIVE VOLTAGE
THE WHITE AND BLACK WIRES MAY BE INTERCHANGED
TO OBTAIN AN INVERTING CONDITION SO THAT
THE PEN WILL MOVE TO THE LEFT FOR A
POSITIVE VOLTAGE

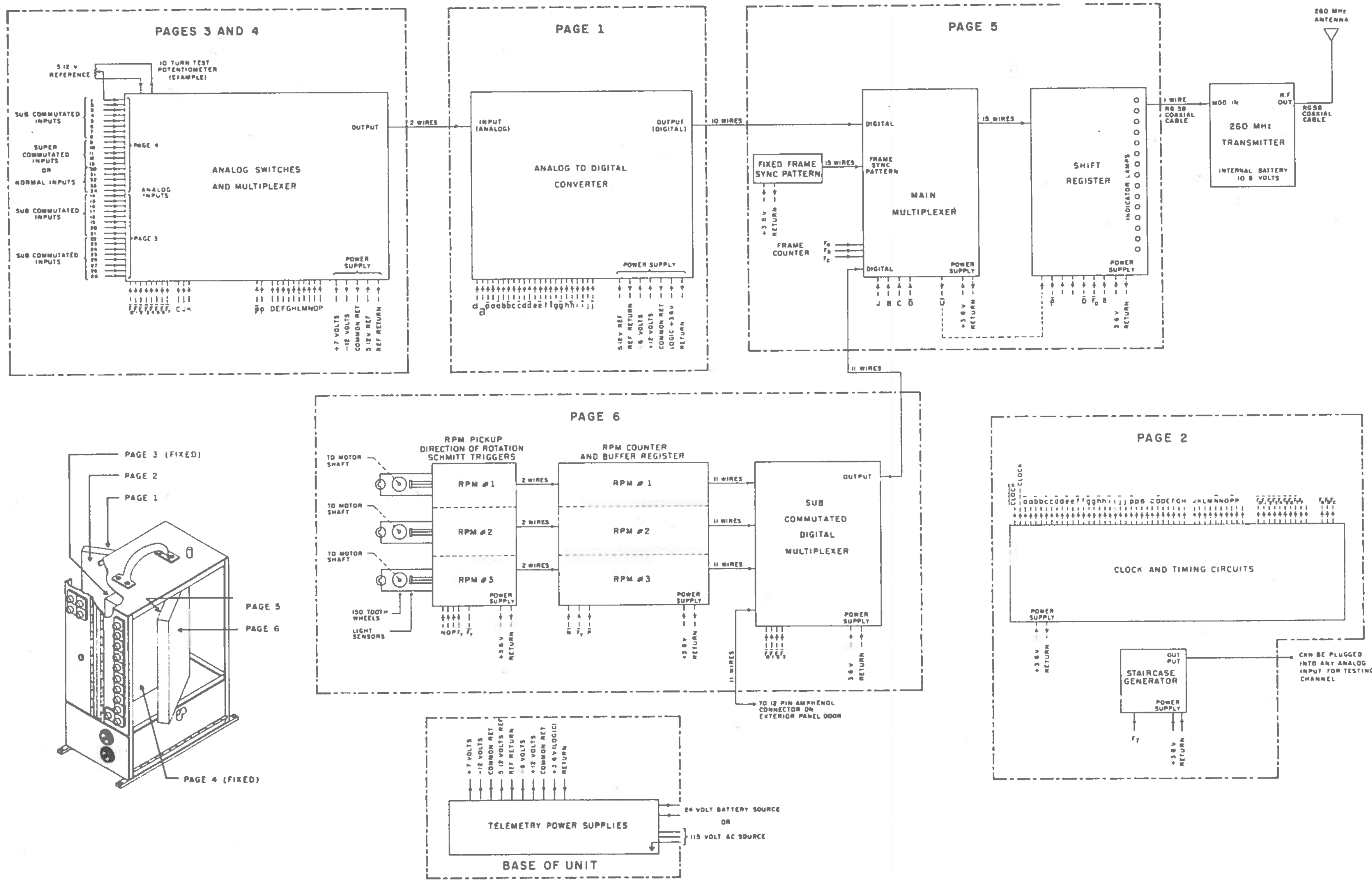
AF-12-129D


REAR OF MONITOR LIGHT PANEL
LAMP POSITION ON FRONT PANEL
DIGITAL HOLD REGISTER
PAGE 4 6TH COLUMN
327
G.E. BULBS (FLANGE)
UPPER GROUP
LOWER GROUP
330Ω
680Ω
18K
2N3904
SAME AS ABOVE
FIRST ON LEFT FIRST ROW
SECOND FROM LEFT FIRST ROW
THIRD FROM LEFT FIRST ROW
FOURTH FROM LEFT FIRST ROW
FIRST ON LEFT SECOND ROW
SECOND FROM LEFT SECOND ROW
THIRD FROM LEFT SECOND ROW
FOURTH FROM LEFT SECOND ROW
FIRST ON LEFT THIRD ROW
SECOND FROM LEFT THIRD ROW
THIRD FROM LEFT THIRD ROW
TO INVERTERS PAGE 4
PIN 5 POS 38 PAGE 4
TO RETURN SIDE OF 38 VOLTS (LOGIC VOLTS)
PAGE 2
BUFFER INVERTER MAJOR FRAME COUNTER
TO POSITION PIN 12 PAGE 2
POSTION PIN 10 PAGE 2
MC 790
SPARE
CIRCUITRY SAME AS ABOVE (MAJOR FRAME COUNTER)
CIRCUITRY SAME AS ABOVE (MAJOR FRAME SYNC)
CIRCUITRY SAME AS ABOVE (MINOR FRAME SYNC)
CIRCUITRY SAME AS ABOVE (SPARE)
FOURTH FROM LEFT THIRD ROW
FIRST ON LEFT FOURTH ROW
SECOND FROM LEFT FOURTH ROW
THIRD FROM LEFT FOURTH ROW
FOURTH FROM LEFT FOURTH ROW
115 V AC LINE
MAIN ON/OFF SW
1.5 A
LOCATED MAIN SWITCH METER PANEL
HAMMOND 61666
2 X HY403 6A RECTIFIERS
1500μF
28 VOLTS
ON/OFF SWITCH LOCATED FRONT LOWER PANEL EXTREME RIGHT
REAR OF MONITOR LIGHT PANEL

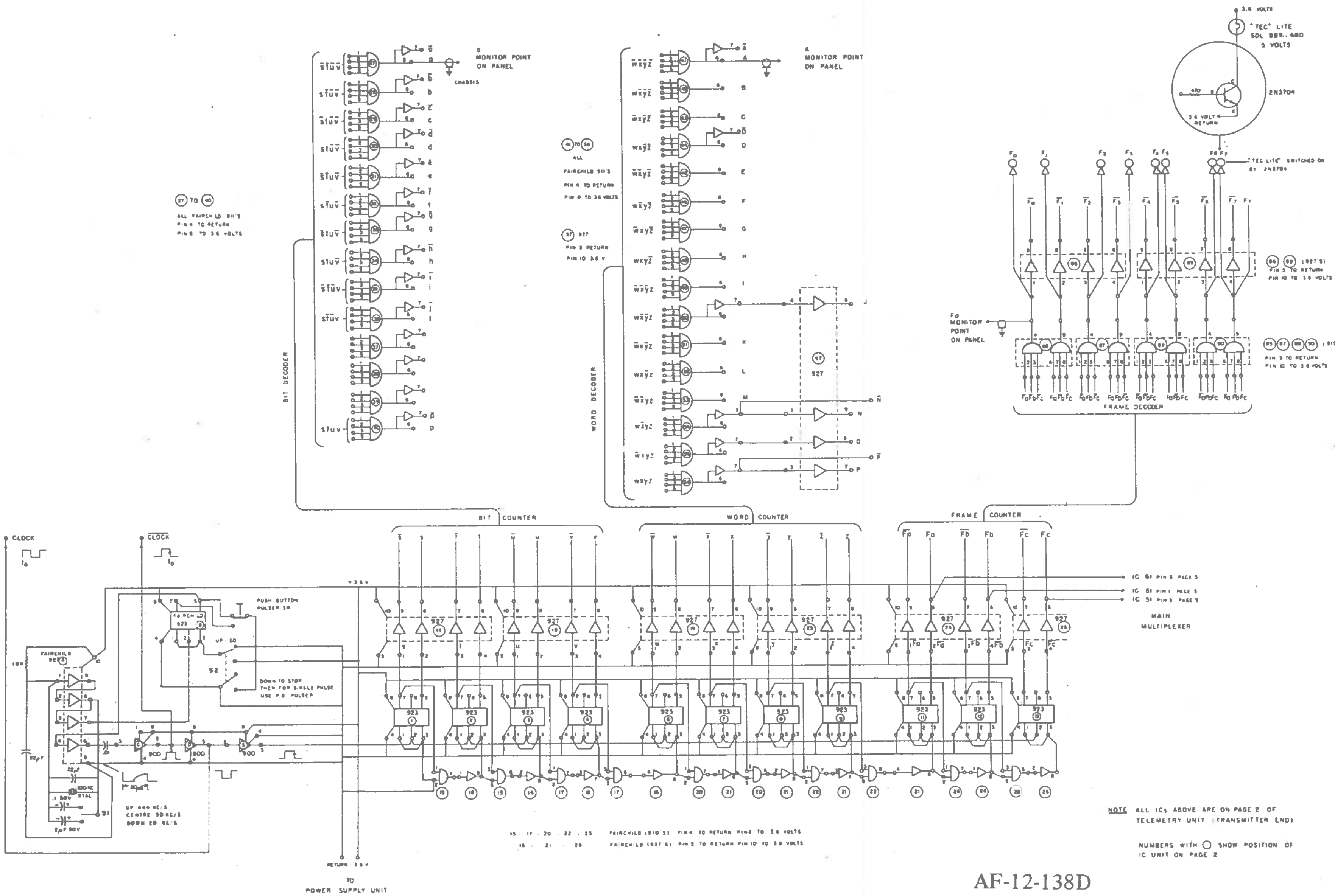
AF-12-118D


JUNCTION FE TRANSISTOR
MFE 2133
SOURCE
DRAIN
GATE AND CASE
MOTOROLA 700 SERIES
TOP VIEW
BOTTOM VIEW
Fuo 710 DIFFERENTIAL COMPARATOR
1 GND
2 NON - INVERTING INPUT
3 INVERTING INPUT
4 - VOLTS
5 NC
6 NC
7 OUTPUT
8 + VOLTS
BOTTOM VIEW
2N2714 (NPN)
EMITTER
BASE
COLLECTOR
BOTTOM VIEW
RCA 3010 OP AMP
1 GND
2 INVERTING INPUT
3 NON INVERTING INPUT
4 VEE - 3 VOLTS
5
6
7
8
9 OUTPUT
10 VCC
11
12
BOTTOM VIEW
132 ZELTEX DIFFERENTIAL OP AMP
+ 15 V
COMMON
- 15 V
OUTPUT
TRIM
T.I LS 600 N-P-N PLANAR SILICON LIGHT SENSOR
CERAMIC
LENS
COLLECTOR
EMITTER
BOTTOM VIEW
2N3904 (NPN)
COLLECTOR EMITTER
BASE
2N3704 (NPN)
BASE EMITTER
COLLECTOR
2N3703 (PNP)
BASE EMITTER
COLLECTOR
MOTOROLA MC 1430 OP AMP
1 + NON INVERTING
2 INVERTING
3 GND
4 - 7.4 VOLTS
5 OUTPUT
6 + 7.4 VOLTS
7, 8 LEAD
9, 10 LAG
AF 139 (RECEIVER)
EMITTER
BASE
CASE
COLLECTOR
2N3640 (PNP) RECEIVER
EMITTER
COLLECTOR
BASE
MOTOROLA MC 1533 OP AMP
1. INVERTING
2 + NON INVERTING
3 OUTPUT LAG
4 -12 V
5 OUTPUT
6 +12 VOLTS
7 ADJ GAIN
8 OFFSET
9, 10 INPUT LAG
2N3583 (NPN)
EMITTER
BASE
CASE COLLECTOR
JUNCTION FE TRANSISTOR
MPF 105
BOTTOM VIEW
DRAIN
GATE
SOURCE
FAIRCHILD MICROLOGIC
8 PIN 900 SERIES
BOTTOM VIEW
FAIRCHILD MICROLOGIC
926 - 927 10 PIN
BOTTOM VIEW
3N 141
GATE 2
GATE 1
DRAIN
SOURCE
DUAL INSULATED GATE FE TRANSISTOR
2N3564 (NPN) (RF AMP)
BASE
EMITTER
COLLECTOR
2N 929 (NPN)
BASE
EMITTER
COLLECTOR
BOTTOM VIEW

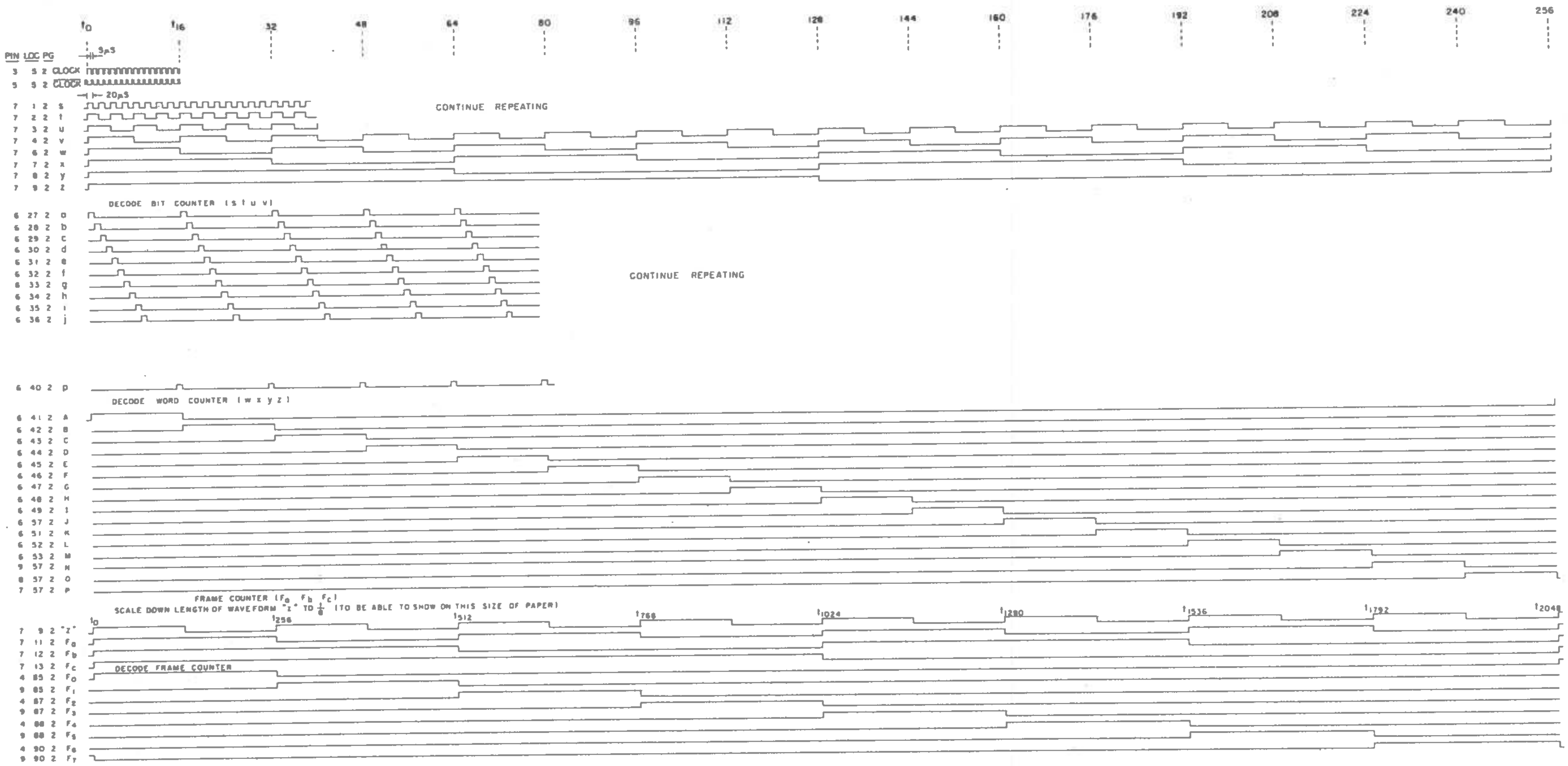
AF-12-126D


PAGES 3 AND 4
ANALOG SWITCHES AND MULTIPLEXER
OUTPUT
SUB COMMUTATED INPUTS
SUPER COMMUTATED INPUTS OR NORMAL INPUTS
SUB COMMUTATED INPUTS
SUB COMMUTATED INPUTS
PAGE 4
PAGE 3
ANALOG INPUTS
POWER SUPPLY
2 WIRES
PAGE 1
INPUT (ANALOG)
OUTPUT (DIGITAL)
ANALOG TO DIGITAL CONVERTER
POWER SUPPLY
10 WIRES
PAGE 5
FIXED FRAME SYNC PATTERN
15 WIRES
DIGITAL
FRAME SYNC PATTERN
MAIN MULTIPLEXER
FRAME COUNTER
DIGITAL
POWER SUPPLY
13 WIRES
SHIFT REGISTER
INDICATOR LAMPS
POWER SUPPLY
1 WIRE
RG 58 COAXIAL CABLE
MOD IN
RF OUT
260 MHz TRANSMITTER
INTERNAL BATTERY 10.8 VOLTS
RG58 COAXIAL CABLE
260 MHz ANTENNA
11 WIRES
PAGE 6
RPM PICKUP DIRECTION OF ROTATION SCHMITT TRIGGERS
RPM COUNTER AND BUFFER REGISTER
TO MOTOR SHAFT
TO MOTOR SHAFT
TO MOTOR SHAFT
RPM #1
RPM #2
RPM #3
2 WIRES
11 WIRES
SUB COMMUTATED DIGITAL MULTIPLEXER
OUTPUT
POWER SUPPLY
150 TOOTH WHEELS
LIGHT SENSORS
TO 12 PIN AMPHENOL CONNECTOR ON EXTERIOR PANEL DOOR
PAGE 2
CLOCK AND TIMING CIRCUITS
POWER SUPPLY
STAIRCASE GENERATOR
OUTPUT
CAN BE PLUGGED INTO ANY ANALOG INPUT FOR TESTING CHANNEL
PAGE 3 (FIXED)
PAGE 2
PAGE 1
PAGE 5
PAGE 6
PAGE 4 (FIXED)
TELEMETRY POWER SUPPLIES
BASE OF UNIT
24 VOLT BATTERY SOURCE
OR
115 VOLT AC SOURCE

AF-12-143D


BIT DECODER
WORD DECODER
FRAME DECODER
BIT COUNTER
WORD COUNTER
FRAME COUNTER
MONITOR POINT ON PANEL
CHASSIS
CLOCK
PUSH BUTTON PULSER
DOWN TO STOP THEN FOR SINGLE PULSE USE P.B. PULSER
MAIN MULTIPLEXER
RETURN 3.6 V
TO POWER SUPPLY UNIT
2N3704
"TEC" LITE SDL 889-680 5 VOLTS
NOTE ALL ICs ABOVE ARE ON PAGE 2 OF TELEMETRY UNIT (TRANSMITTER END)
NUMBERS WITH ◯ SHOW POSITION OF IC UNIT ON PAGE 2

AF-12-138D



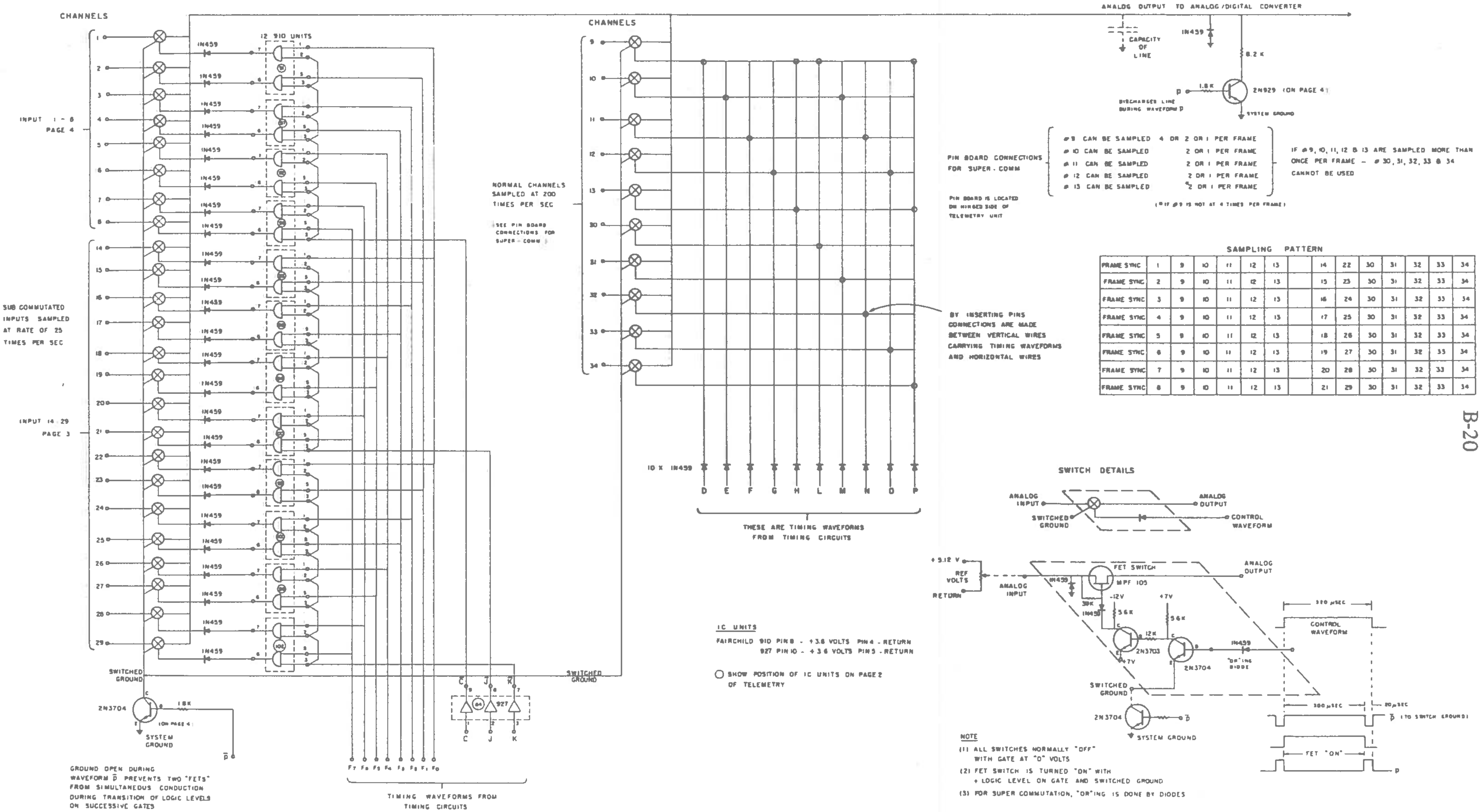
NOTE SEE DIAGRAM OF TIMING CIRCUITS
WAVEFORM OF COUNTERS SHOW OUTPUT AT PIN 7 (L H S) OF FLIP FLOP UNIT NUMBER (1)

EXAMPLE s
IF COMPLEMENT OF s WHICH IS $\bar{s}$ IS REQUIRED, s IS TAKEN THROUGH
A BUFFER INVERTER AND $\bar{s}$ IS OBTAINED

OR IF COMPLEMENT OF A DECODED WAVEFORM IS REQUIRED AN INVERTED OUTPUT
IS OBTAINED FROM ANOTHER OUTPUT PIN ON THE IC GATE

EXAMPLE a PIN 6 POSITION 27
$\bar{a}$ PIN 7 POSITION 27

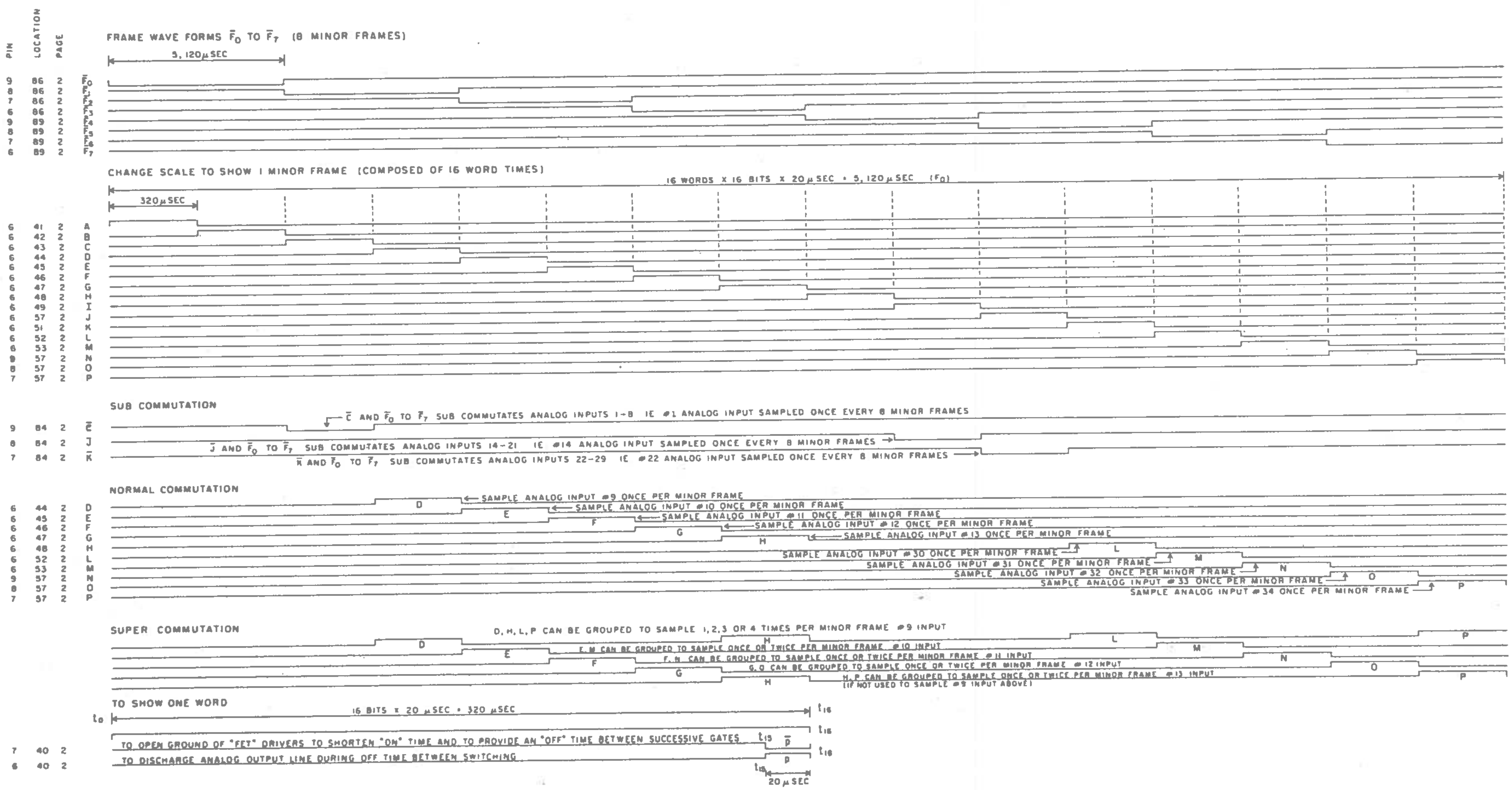
AF-12-140D



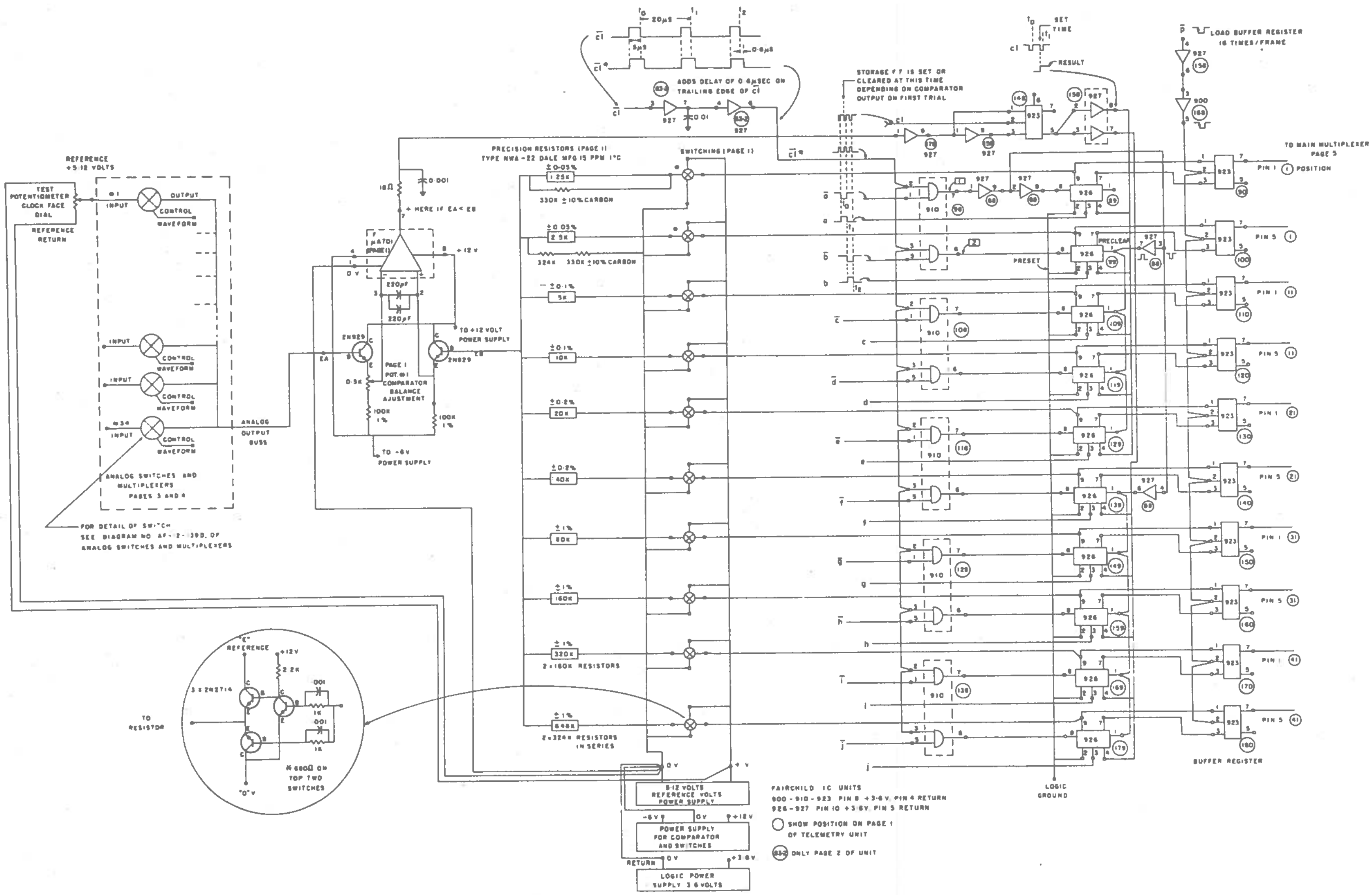
SAMPLING PATTERN

FRAME SYNC	1	9	10	11	12	13		14	22	30	31	32	33	34
FRAME SYNC	2	9	10	11	12	13		15	23	30	31	32	33	34
FRAME SYNC	3	9	10	11	12	13		16	24	30	31	32	33	34
FRAME SYNC	4	9	10	11	12	13		17	25	30	31	32	33	34
FRAME SYNC	5	9	10	11	12	13		18	26	30	31	32	33	34
FRAME SYNC	6	9	10	11	12	13		19	27	30	31	32	33	34
FRAME SYNC	7	9	10	11	12	13		20	28	30	31	32	33	34
FRAME SYNC	8	9	10	11	12	13		21	29	30	31	32	33	34

AF-12-139D

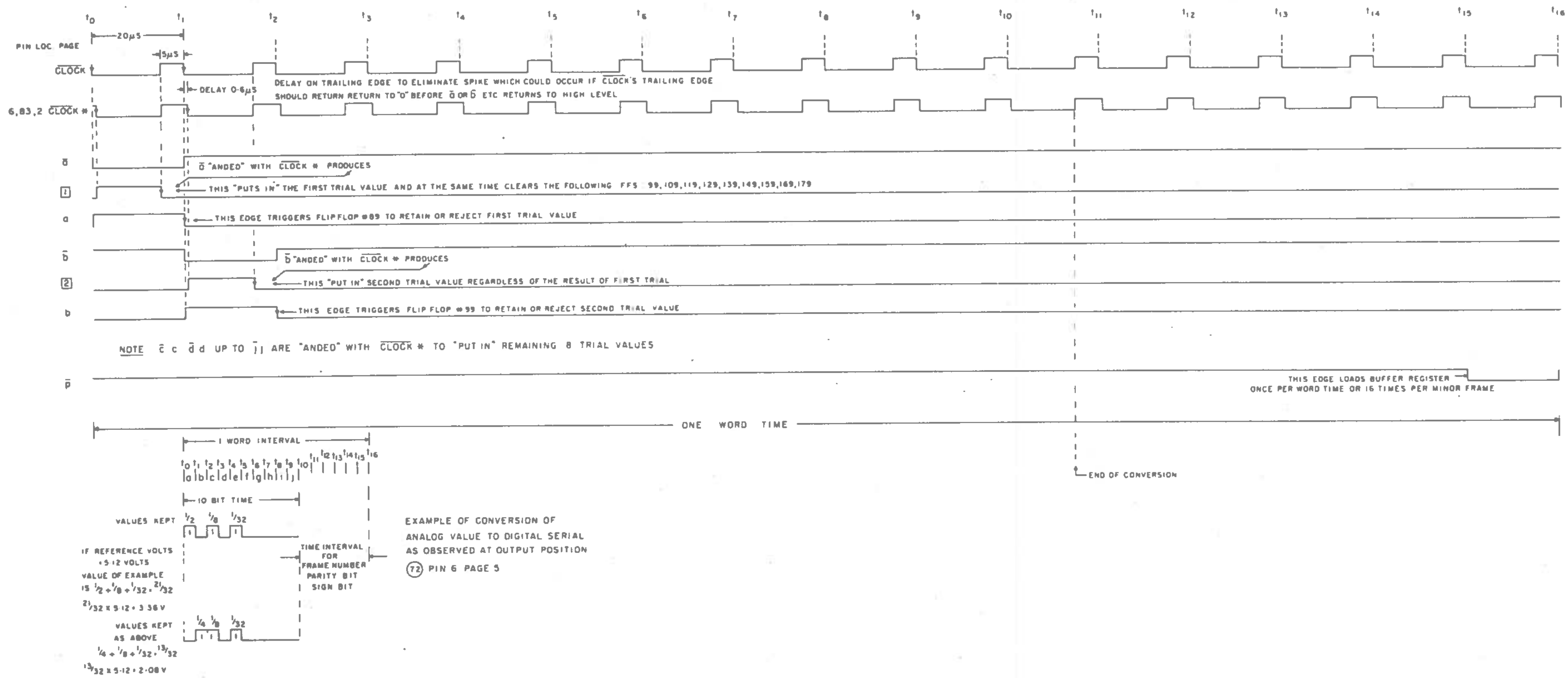

PIN
LOCATION
PAGE
FRAME WAVE FORMS $\bar{F}_0$ TO $\bar{F}_7$ (8 MINOR FRAMES)
5,120μSEC
CHANGE SCALE TO SHOW 1 MINOR FRAME (COMPOSED OF 16 WORD TIMES)
16 WORDS x 16 BITS x 20μSEC = 5,120μSEC (F_0)
320μSEC
SUB COMMUTATION
$\bar{C}$ AND $\bar{F}_0$ TO $\bar{F}_7$ SUB COMMUTATES ANALOG INPUTS 1-8 IE #1 ANALOG INPUT SAMPLED ONCE EVERY 8 MINOR FRAMES
$\bar{J}$ AND $\bar{F}_0$ TO $\bar{F}_7$ SUB COMMUTATES ANALOG INPUTS 14-21 IE #14 ANALOG INPUT SAMPLED ONCE EVERY 8 MINOR FRAMES
$\bar{K}$ AND $\bar{F}_0$ TO $\bar{F}_7$ SUB COMMUTATES ANALOG INPUTS 22-29 IE #22 ANALOG INPUT SAMPLED ONCE EVERY 8 MINOR FRAMES
NORMAL COMMUTATION
SAMPLE ANALOG INPUT #9 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #10 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #11 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #12 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #13 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #30 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #31 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #32 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #33 ONCE PER MINOR FRAME
SAMPLE ANALOG INPUT #34 ONCE PER MINOR FRAME
SUPER COMMUTATION
D, H, L, P CAN BE GROUPED TO SAMPLE 1,2,3 OR 4 TIMES PER MINOR FRAME #9 INPUT
E, M CAN BE GROUPED TO SAMPLE ONCE OR TWICE PER MINOR FRAME #10 INPUT
F, N CAN BE GROUPED TO SAMPLE ONCE OR TWICE PER MINOR FRAME #11 INPUT
G, O CAN BE GROUPED TO SAMPLE ONCE OR TWICE PER MINOR FRAME #12 INPUT
H, P CAN BE GROUPED TO SAMPLE ONCE OR TWICE PER MINOR FRAME #13 INPUT
(IF NOT USED TO SAMPLE #9 INPUT ABOVE)
TO SHOW ONE WORD
16 BITS x 20μSEC = 320μSEC
TO OPEN GROUND OF "FET" DRIVERS TO SHORTEN "ON" TIME AND TO PROVIDE AN "OFF" TIME BETWEEN SUCCESSIVE GATES
TO DISCHARGE ANALOG OUTPUT LINE DURING OFF TIME BETWEEN SWITCHING
20μSEC

AF-12-141D



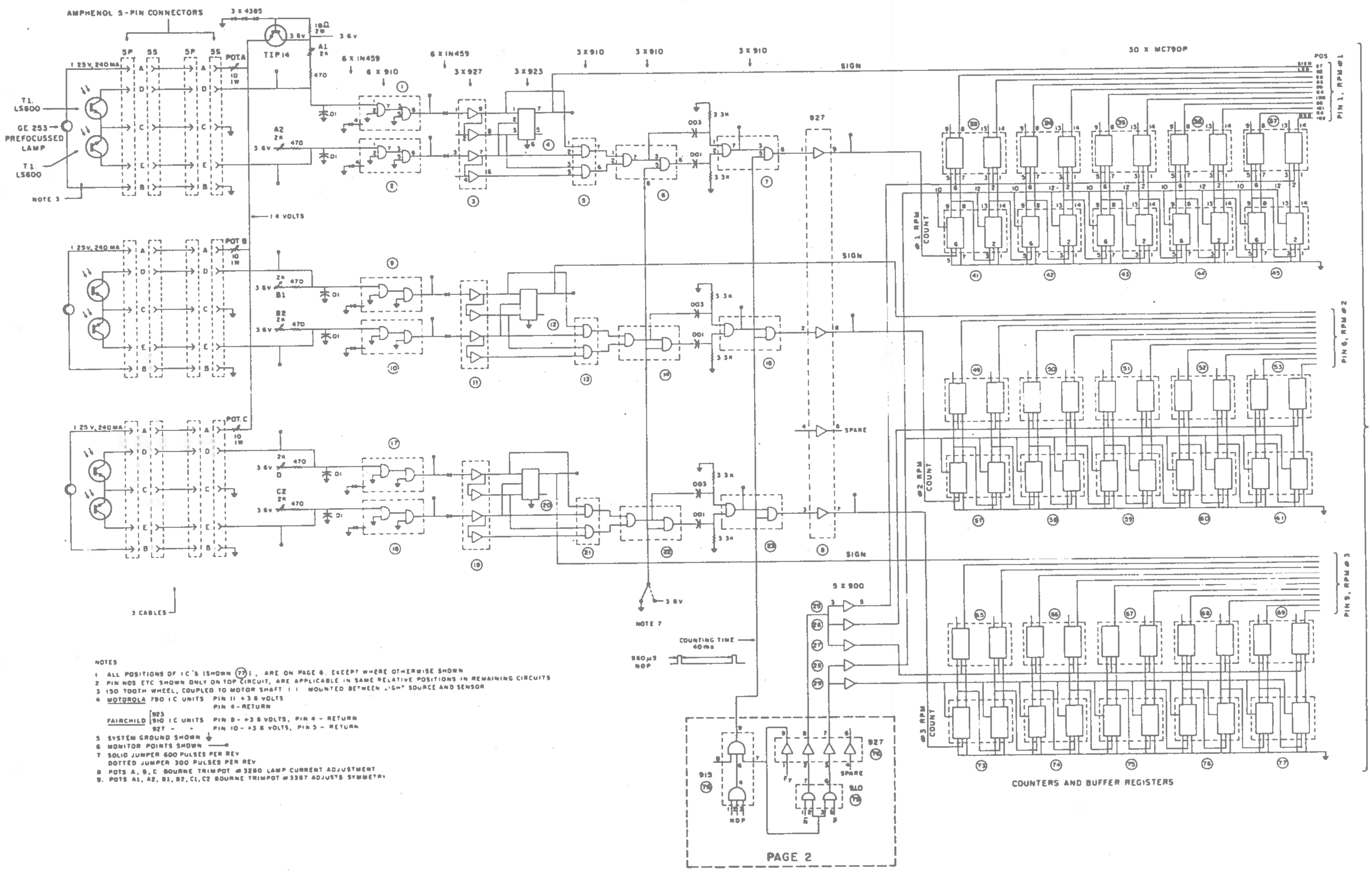
REFERENCE +5.12 VOLTS
TEST POTENTIOMETER CLOCK FACE DIAL
REFERENCE RETURN
INPUT
OUTPUT
CONTROL WAVEFORM
ANALOG SWITCHES AND MULTIPLEXERS PAGES 3 AND 4
ANALOG OUTPUT BUSS
FOR DETAIL OF SWITCH SEE DIAGRAM NO AF-2-139D, OF ANALOG SWITCHES AND MULTIPLEXERS
+ HERE IF EA < EB
TO +12 VOLT POWER SUPPLY
TO -6V POWER SUPPLY
PAGE 1 POT. #1 COMPARATOR BALANCE ADJUSTMENT
PRECISION RESISTORS (PAGE 1) TYPE NWA-22 DALE MFG 15 PPM 1°C
SWITCHING (PAGE 1)
330K ±10% CARBON
2×160K RESISTORS
2×324K RESISTORS IN SERIES
ADDS DELAY OF 0.6μSEC ON TRAILING EDGE OF $\overline{CI}$
STORAGE F F IS SET OR CLEARED AT THIS TIME DEPENDING ON COMPARATOR OUTPUT ON FIRST TRIAL
SET TIME
RESULT
LOAD BUFFER REGISTER 16 TIMES/FRAME
TO MAIN MULTIPLEXER PAGE 5
PRECLEAR
PRESET
BUFFER REGISTER
LOGIC GROUND
TO RESISTOR
"E" REFERENCE
"0" V
#680Ω ON TOP TWO SWITCHES
5.12 VOLTS REFERENCE VOLTS POWER SUPPLY
POWER SUPPLY FOR COMPARATOR AND SWITCHES
LOGIC POWER SUPPLY 3.6 VOLTS
RETURN
FAIRCHILD IC UNITS
900-910-923 PIN 8 +3.6V PIN 4 RETURN
926-927 PIN 10 +3.6V PIN 5 RETURN
SHOW POSITION ON PAGE 1 OF TELEMETRY UNIT
ONLY PAGE 2 OF UNIT

AF-23-142D



PIN LOC PAGE
CLOCK
6,83,2 CLOCK #
20μs
5μs
DELAY 0·6μs
DELAY ON TRAILING EDGE TO ELIMINATE SPIKE WHICH COULD OCCUR IF CLOCK'S TRAILING EDGE SHOULD RETURN RETURN TO "0" BEFORE ā OR b̄ ETC RETURNS TO HIGH LEVEL
ā "ANDED" WITH CLOCK # PRODUCES
THIS "PUTS IN" THE FIRST TRIAL VALUE AND AT THE SAME TIME CLEARS THE FOLLOWING FFS 99,109,119,129,139,149,159,169,179
THIS EDGE TRIGGERS FLIPFLOP #89 TO RETAIN OR REJECT FIRST TRIAL VALUE
b̄ "ANDED" WITH CLOCK # PRODUCES
THIS "PUT IN" SECOND TRIAL VALUE REGARDLESS OF THE RESULT OF FIRST TRIAL
THIS EDGE TRIGGERS FLIP FLOP #99 TO RETAIN OR REJECT SECOND TRIAL VALUE
NOTE c̄ c d̄ d UP TO j̄ j ARE "ANDED" WITH CLOCK # TO "PUT IN" REMAINING 8 TRIAL VALUES
THIS EDGE LOADS BUFFER REGISTER
ONCE PER WORD TIME OR 16 TIMES PER MINOR FRAME
ONE WORD TIME
END OF CONVERSION
1 WORD INTERVAL
10 BIT TIME
VALUES KEPT
IF REFERENCE VOLTS = 5·12 VOLTS
VALUE OF EXAMPLE
IS 1/2 + 1/8 + 1/32 = 21/32
21/32 x 5·12 = 3·36 V
VALUES KEPT AS ABOVE
1/4 + 1/8 + 1/32 = 13/32
13/32 x 5·12 = 2·08 V
TIME INTERVAL FOR FRAME NUMBER PARITY BIT SIGN BIT
EXAMPLE OF CONVERSION OF ANALOG VALUE TO DIGITAL SERIAL AS OBSERVED AT OUTPUT POSITION
72 PIN 6 PAGE 5

AF-12-151E

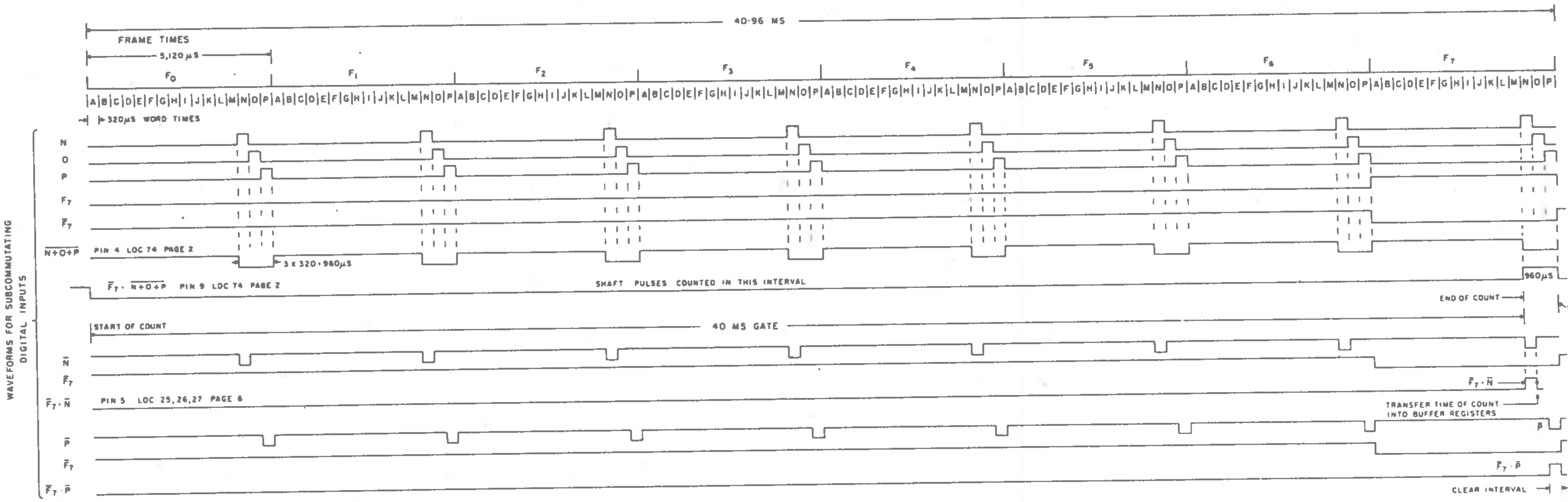


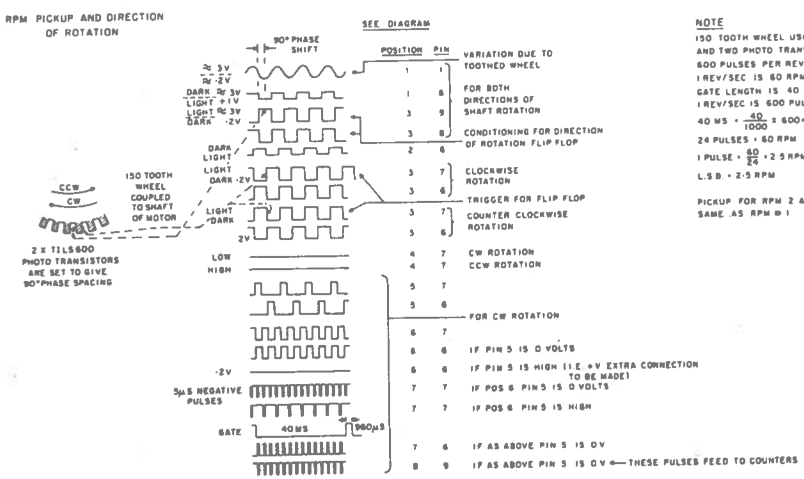
NOTES

1. ALL POSITIONS OF I C 'S (SHOWN (77)), ARE ON PAGE 6, EXCEPT WHERE OTHERWISE SHOWN
2. PIN NOS ETC SHOWN ONLY ON TOP CIRCUIT, ARE APPLICABLE IN SAME RELATIVE POSITIONS IN REMAINING CIRCUITS
3. 150 TOOTH WHEEL, COUPLED TO MOTOR SHAFT 1:1 MOUNTED BETWEEN LIGHT SOURCE AND SENSOR
4. MOTOROLA 790 I C UNITS PIN 11 +3.6 VOLTS
   PIN 4 - RETURN

   FAIRCHILD [923 / 910 I C UNITS PIN 8 - +3.6 VOLTS, PIN 4 - RETURN
   927 - " PIN 10 - +3.6 VOLTS, PIN 5 - RETURN
5. SYSTEM GROUND SHOWN
6. MONITOR POINTS SHOWN
7. SOLID JUMPER 600 PULSES PER REV
   DOTTED JUMPER 300 PULSES PER REV
8. POTS A, B, C BOURNE TRIMPOT #3280 LAMP CURRENT ADJUSTMENT
9. POTS A1, A2, B1, B2, C1, C2 BOURNE TRIMPOT #3367 ADJUSTS SYMMETRY

AF-12-144D





NOTE

150 TOOTH WHEEL USING EACH TRANSITION AND TWO PHOTO TRANSISTORS FINISH WITH 600 PULSES PER REVOLUTION

1 REV/SEC IS 60 RPM

GATE LENGTH IS 40 MILLISECONDS

1 REV/SEC IS 600 PULSES/SEC

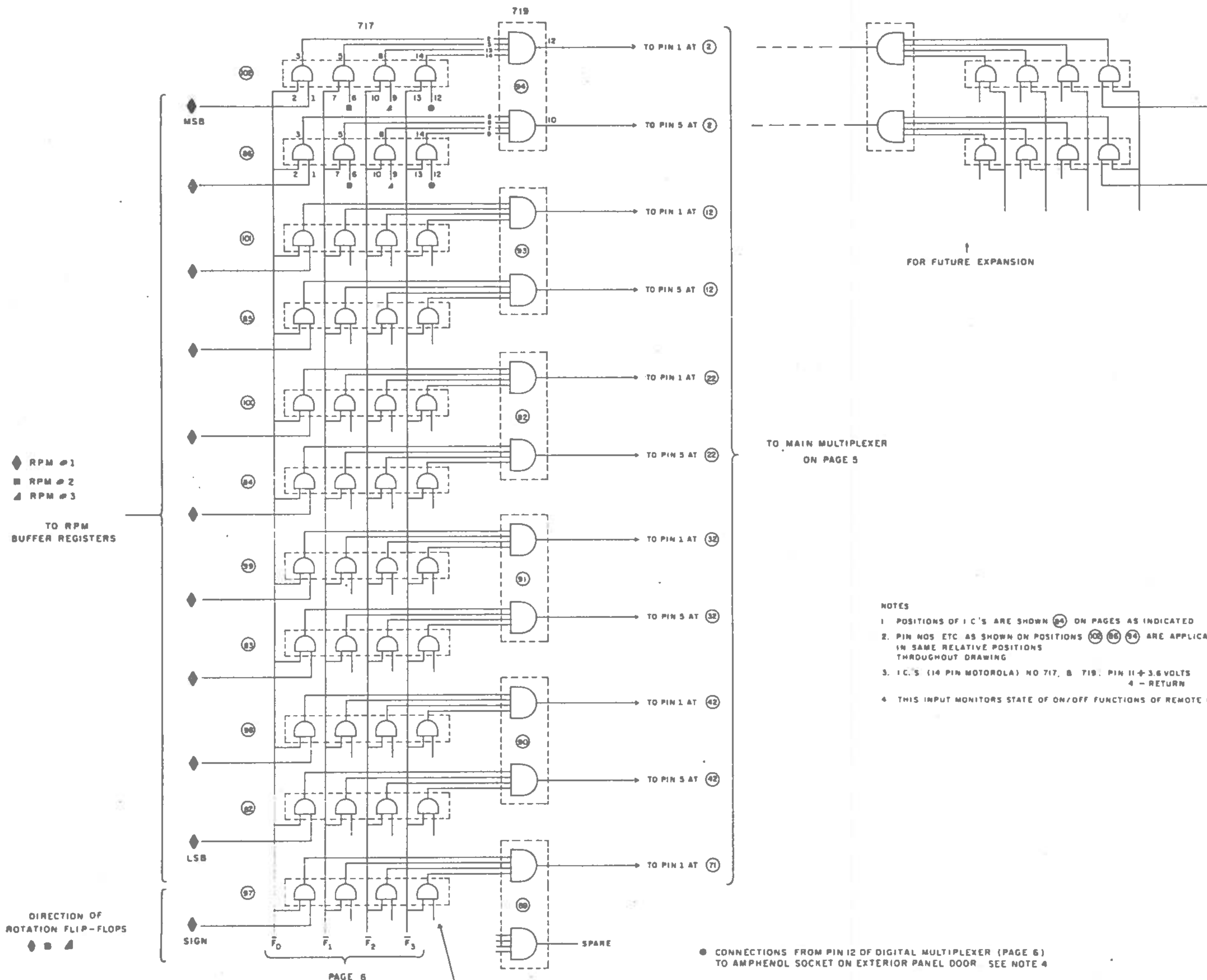
$40\ MS = \frac{40}{1000} \times 600 = 24\ PULSES$

24 PULSES = 60 RPM

$1\ PULSE = \frac{60}{24} = 2{\cdot}5\ RPM$

L.S.B. = 2·5 RPM

PICKUP FOR RPM 2 AND 3 SAME AS RPM # 1



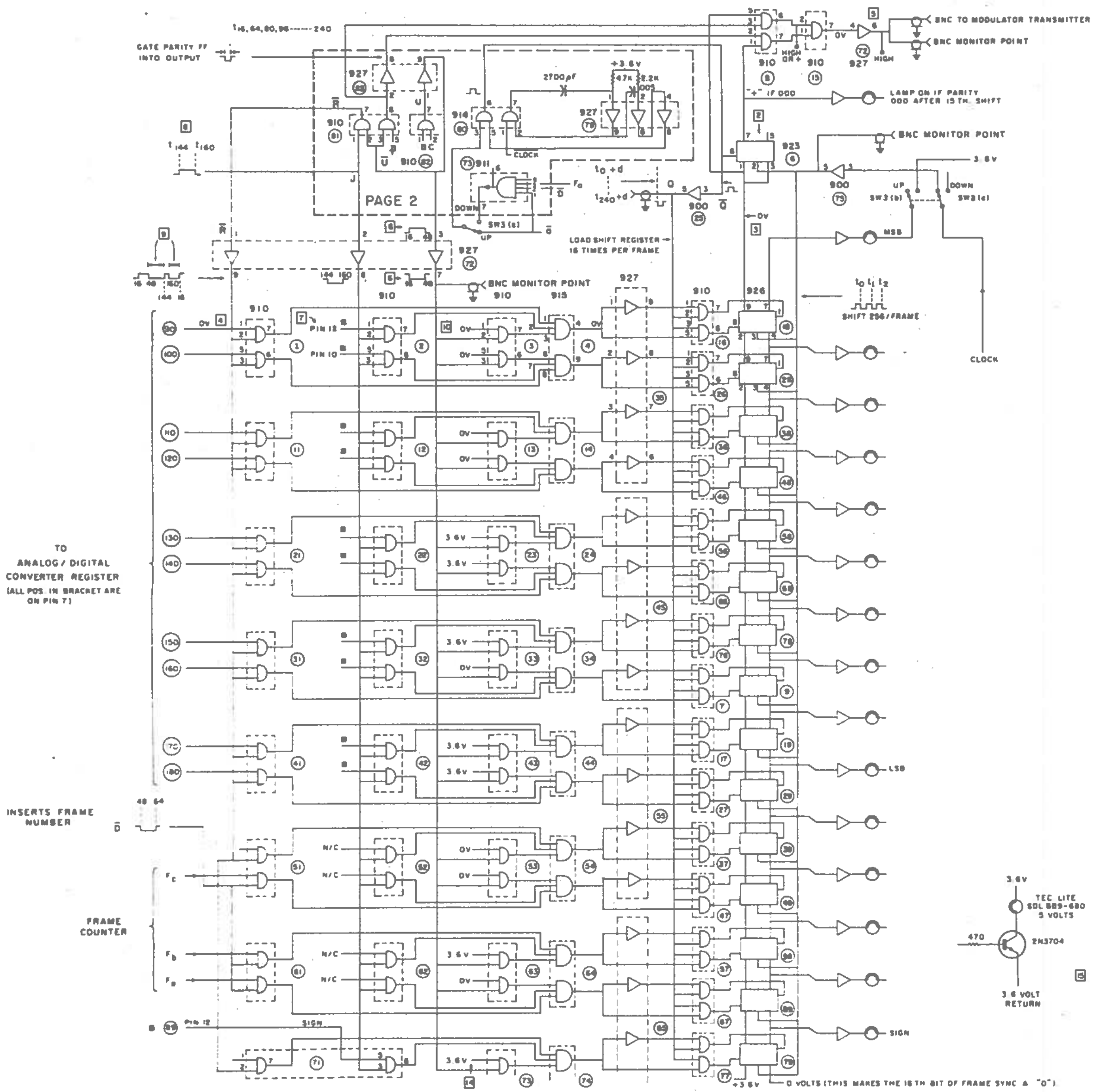
NOTES

1. POSITIONS OF I C'S ARE SHOWN (94) ON PAGES AS INDICATED
2. PIN NOS ETC AS SHOWN ON POSITIONS (102) (86) (94) ARE APPLICABLE IN SAME RELATIVE POSITIONS THROUGHOUT DRAWING
3. I.C.'S (14 PIN MOTOROLA) NO 717, & 719. PIN 11 + 3.6 VOLTS
   4 – RETURN
4. THIS INPUT MONITORS STATE OF ON/OFF FUNCTIONS OF REMOTE CONTROL SYSTEM

● CONNECTIONS FROM PIN 12 OF DIGITAL MULTIPLEXER (PAGE 6) TO AMPHENOL SOCKET ON EXTERIOR PANEL DOOR SEE NOTE 4

POSITIONS ON PAGE 6		(102)	(86)	(101)	(85)	(100)	(84)	(99)	(83)	(98)	(82)	(97)	
TO EXTERIOR PANEL DOOR	AMPHENOL TERMS.	A	B	C	D	E	F	H	J	K	L	M	N
	COLOUR	BN	R	OR	Y	GN	BU	PU	GY	WH	BK	W/R	
		MSB									LSB	SIGN	

AF-12-149D



NOTES -

[1] SW3(a), (b) & (c) GANGED. IN UP POSITION: NORMAL OPERATION. IN DOWN POSITION: SHIFTING STOPS, CHANNEL #1 IS LOADED INTO SHIFT REGISTER, INDICATOR LIGHTS ARE ENERGIZED. THIS PERMITS CHECKING A/D CONVERSION OF CHANNEL #1 WITHOUT THE USE OF TELEMETRY R.F. LINK

[2] THIS FLIP-FLOP PUTS IN ODD PARITY (ODD NUMBER OF "1"S) FOR DATA WORDS. FRAME SYNC WORDS HAVE EVEN PARITY

[3] FLIP-FLOP IS IN THE "1" STATE

[4] 0 VOLTS ON THIS WIRE MEANS THAT THE MSB HAS BEEN KEPT. CALL THIS A "1"

[5] A POSITIVE LEVEL (3 VOLTS) ON THIS POINT MEANS THAT THE MSB HAS BEEN KEPT, I.E. A "1"

[6] FRAME SYNC PATTERN IS CONNECTED DURING WAVE FORM B AND C

[7] TO SUB COMMUTATED MULTIPLEXER (PAGE 6) - SHOWN ■

[8] SUB COMMUTATED MULTIPLEXER IS CONNECTED TO OUTPUT DURING WAVE FORM J

[9] A/D CONVERTER IS CONNECTED DURING THE TIME INTERVAL SHOWN

[10] 0 VOLTS. FIRST BIT OF FRAME SYNC PATTERN

11. POWER SUPPLY TO I.C. UNITS 900, 910, 911, 914, 923: PIN 8 - 3.6V, 4 - RETURN; 915, 926, 927, PIN 10 - 3.6 VOLTS, 5 - RETURN

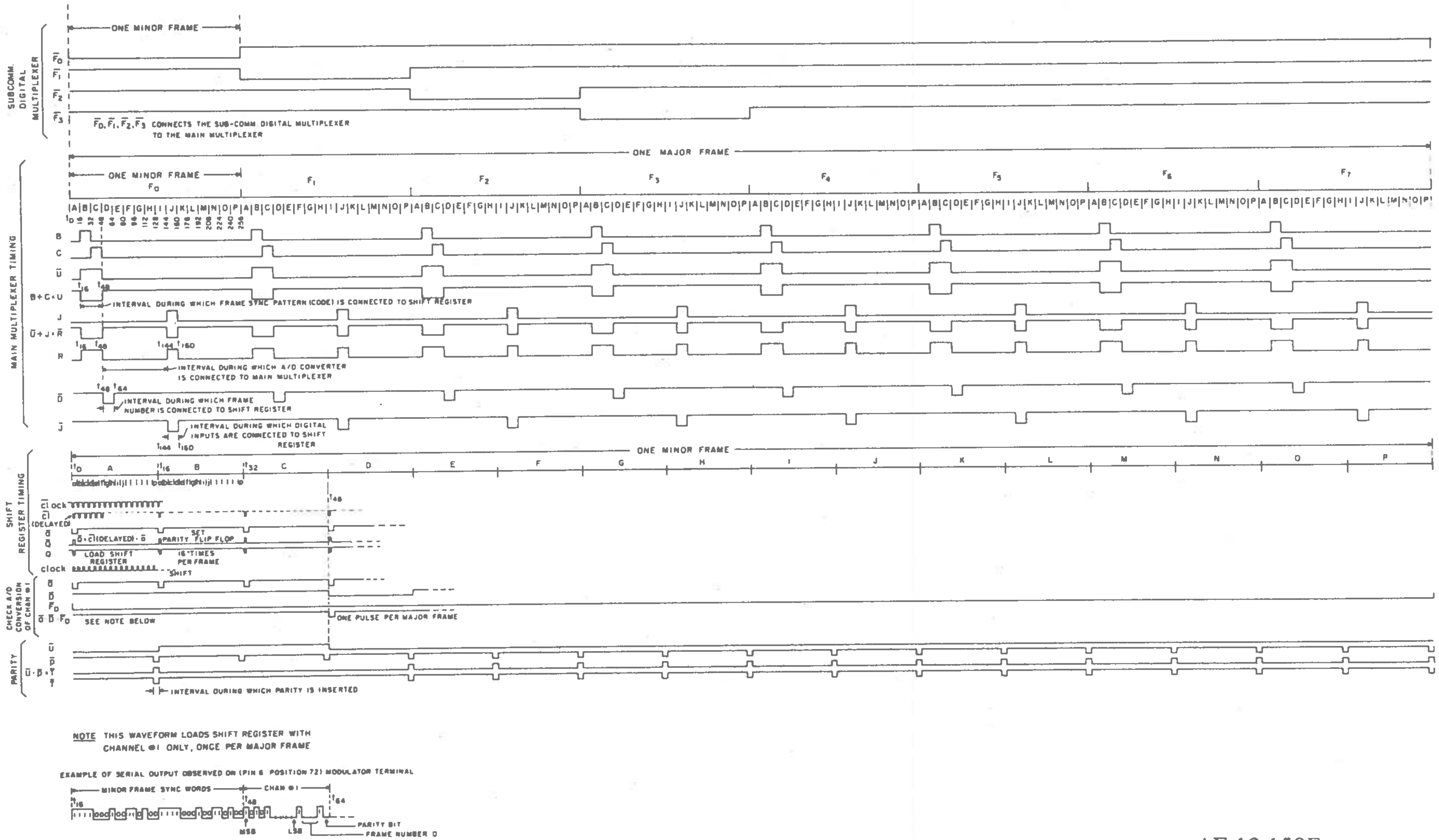
12. ALL I.C. UNITS ARE ON PAGE 5 OF TELEMETRY UNIT EXCEPT WHERE OTHERWISE SHOWN

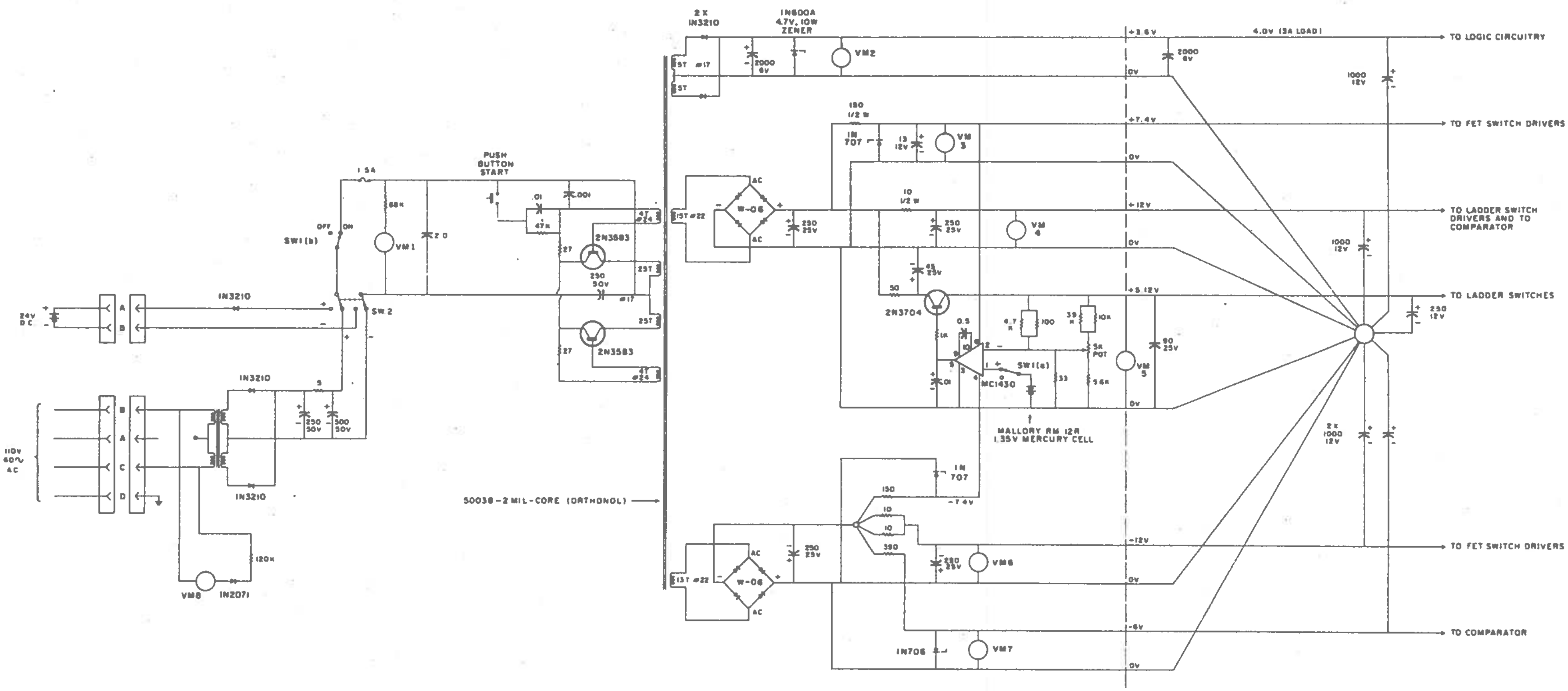
13. PIN NOS ETC. SHOWN ACROSS CIRCUIT FROM POS (1) TOWARDS THE RIGHT, ARE APPLICABLE IN SAME RELATIVE POSITIONS THROUGHOUT DRAWING

[14] 15 TH BIT OF FRAME SYNC IS A "0"

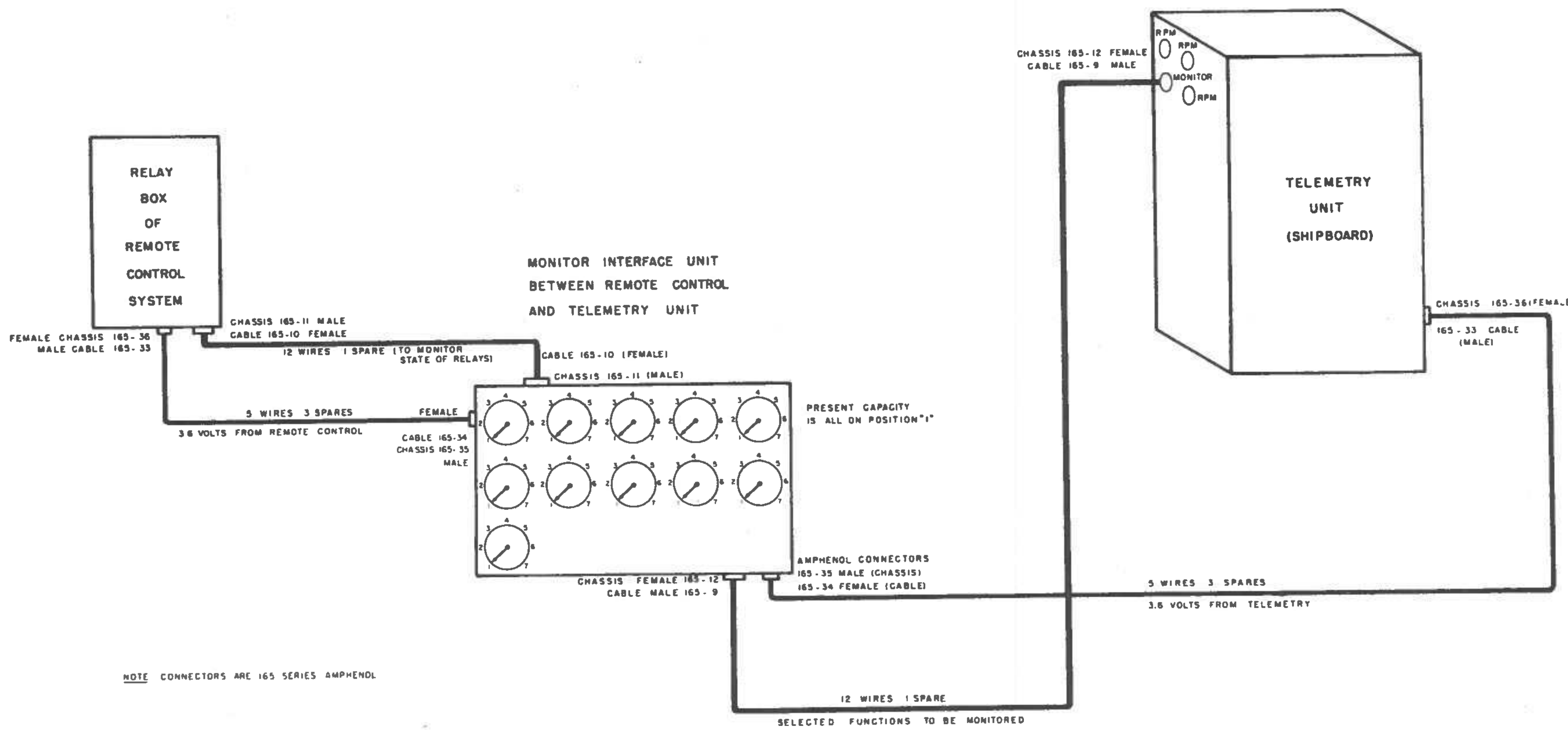
[15] TYPICAL LAMP DRIVER CIRCUIT

AF-12-145D


SUBCOMM. DIGITAL MULTIPLEXER
ONE MINOR FRAME
F0, F1, F2, F3 CONNECTS THE SUB-COMM DIGITAL MULTIPLEXER TO THE MAIN MULTIPLEXER
ONE MAJOR FRAME
MAIN MULTIPLEXER TIMING
INTERVAL DURING WHICH FRAME SYNC PATTERN (CODE) IS CONNECTED TO SHIFT REGISTER
INTERVAL DURING WHICH A/D CONVERTER IS CONNECTED TO MAIN MULTIPLEXER
INTERVAL DURING WHICH FRAME NUMBER IS CONNECTED TO SHIFT REGISTER
INTERVAL DURING WHICH DIGITAL INPUTS ARE CONNECTED TO SHIFT REGISTER
SHIFT REGISTER TIMING
LOAD SHIFT REGISTER
16 TIMES PER FRAME
SET PARITY FLIP FLOP
SHIFT
CHECK A/D CONVERSION OF CHAN #1
SEE NOTE BELOW
ONE PULSE PER MAJOR FRAME
PARITY
INTERVAL DURING WHICH PARITY IS INSERTED
NOTE THIS WAVEFORM LOADS SHIFT REGISTER WITH CHANNEL #1 ONLY, ONCE PER MAJOR FRAME
EXAMPLE OF SERIAL OUTPUT OBSERVED ON (PIN 6 POSITION 72) MODULATOR TERMINAL
MINOR FRAME SYNC WORDS
CHAN #1
MSB
LSB
PARITY BIT
FRAME NUMBER 0

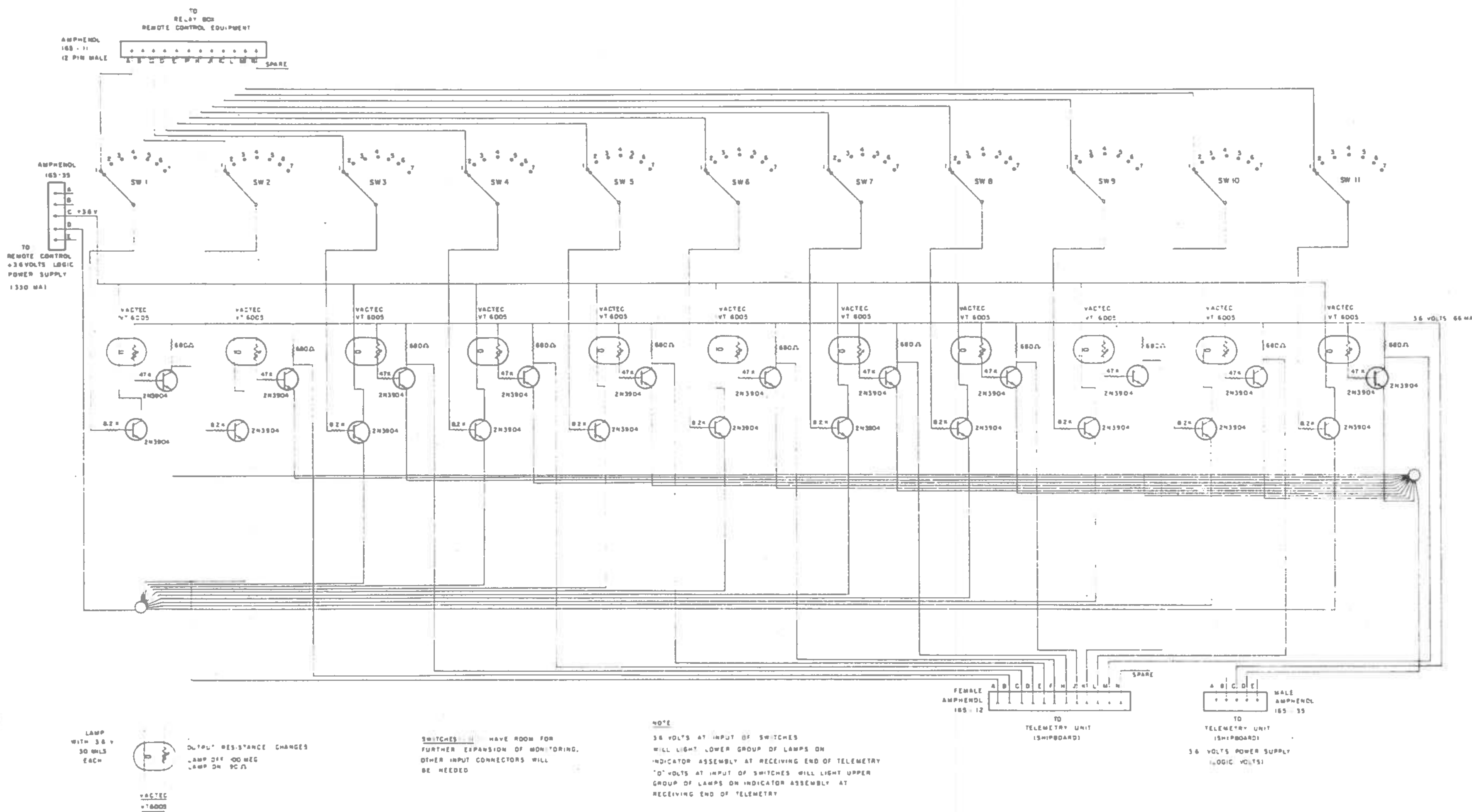

TO LOGIC CIRCUITRY
TO FET SWITCH DRIVERS
TO LADDER SWITCH DRIVERS AND TO COMPARATOR
TO LADDER SWITCHES
TO FET SWITCH DRIVERS
TO COMPARATOR
4.0V (3A LOAD)
PUSH BUTTON START
50038-2 MIL-CORE (ORTHONOL)
MALLORY RM 12R 1.35V MERCURY CELL
1N600A 4.7V, 10W ZENER
2N3583
2N3704
MC1430
24V DC
110V 60~ AC

AF-12-148D

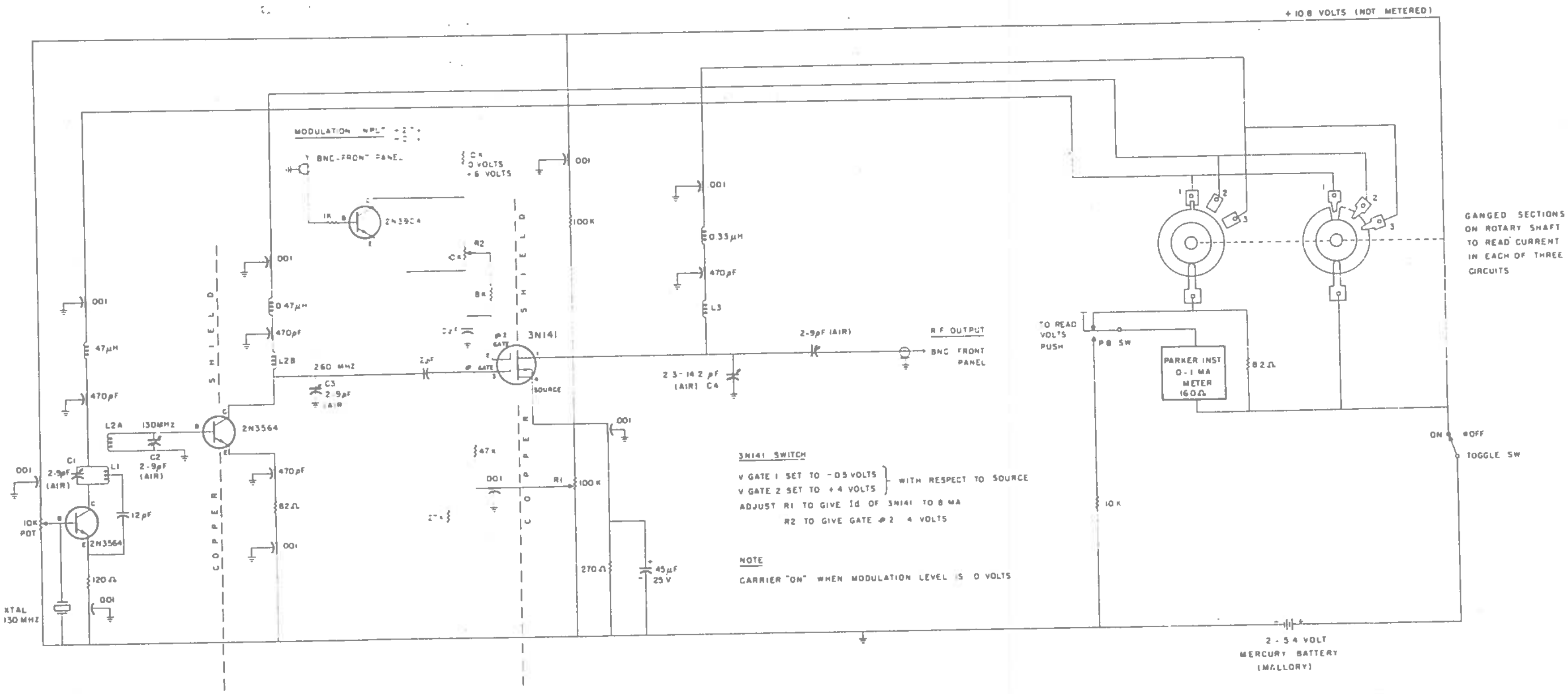


NOTE CONNECTORS ARE 165 SERIES AMPHENOL

AF-12-134D


TO
RELAY BOX
REMOTE CONTROL EQUIPMENT
AMPHENOL
165-11
12 PIN MALE
SPARE
AMPHENOL
165-35
C +36 V
TO
REMOTE CONTROL
+36 VOLTS LOGIC
POWER SUPPLY
1330 MA)
SW 1
SW 2
SW 3
SW 4
SW 5
SW 6
SW 7
SW 8
SW 9
SW 10
SW 11
VACTEC
VT 6005
680Ω
47K
2N3904
82K
36 VOLTS 66 MA
FEMALE
AMPHENOL
165-12
TO
TELEMETRY UNIT
(SHIPBOARD)
MALE
AMPHENOL
165-35
TO
TELEMETRY UNIT
(SHIPBOARD)
36 VOLTS POWER SUPPLY
(LOGIC VOLTS)
LAMP
WITH 36 V
30 MILS
EACH
OUTPUT RESISTANCE CHANGES
LAMP OFF 100 MEG
LAMP ON 90 Ω
VACTEC
VT6005
SWITCHES HAVE ROOM FOR
FURTHER EXPANSION OF MONITORING.
OTHER INPUT CONNECTORS WILL
BE NEEDED
NOTE
36 VOLTS AT INPUT OF SWITCHES
WILL LIGHT LOWER GROUP OF LAMPS ON
INDICATOR ASSEMBLY AT RECEIVING END OF TELEMETRY
"0" VOLTS AT INPUT OF SWITCHES WILL LIGHT UPPER
GROUP OF LAMPS ON INDICATOR ASSEMBLY AT
RECEIVING END OF TELEMETRY

AF-12-133D

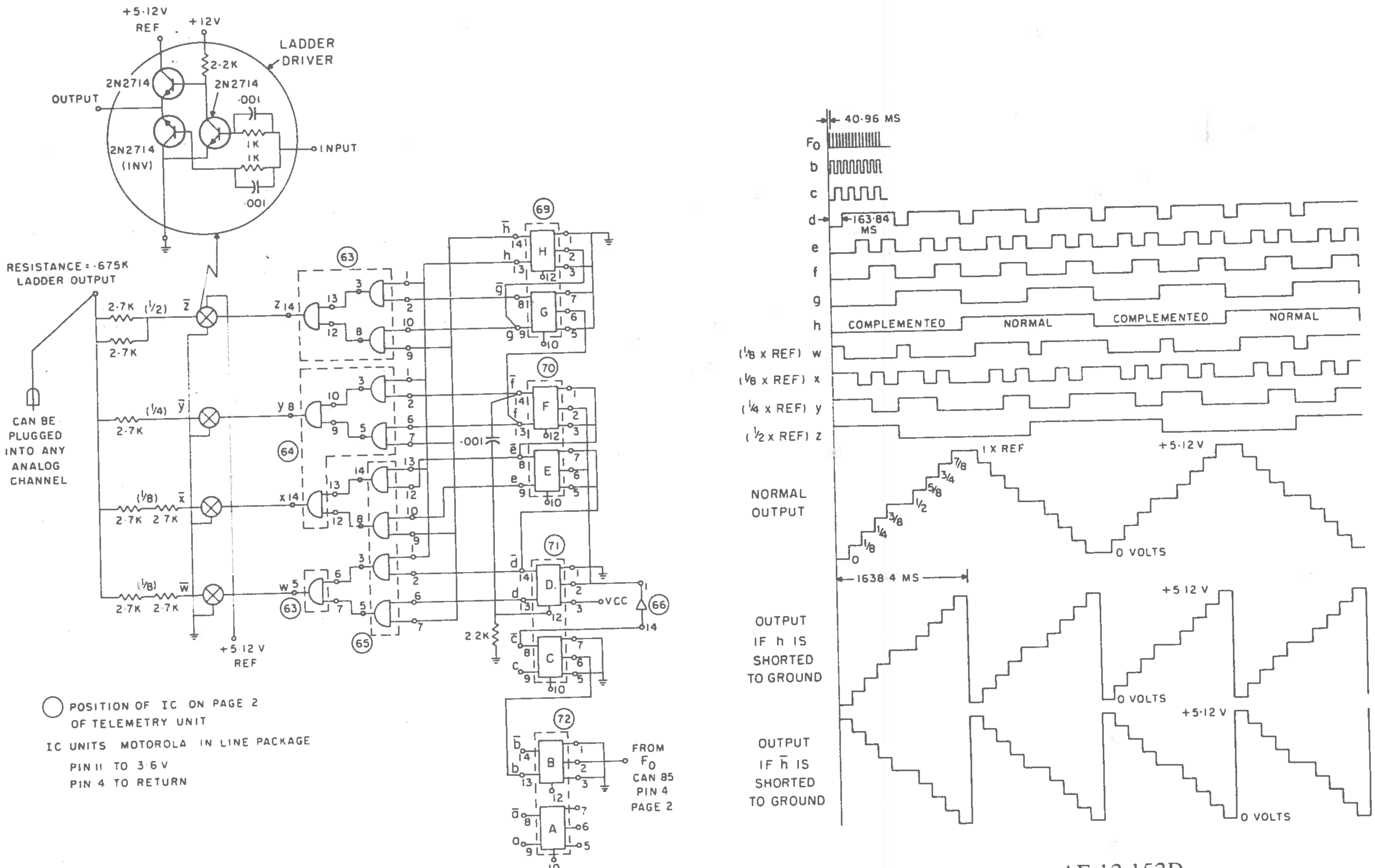


L1 - 4 TURNS 1/2" DIA OF 3/32" x 1/32" COPPER STRIP
TAP 1/2 TURN FROM COLLECTOR END
L2A - 3 TURNS 1/2" DIA OF 1/8" x 1/32" COPPER STRIP
L2B - 1 TURN 3/4" DIA OF 1/8" x 1/32" COPPER STRIP
L3 - 1 TURN 3/4" DIA OF 1/8" x 1/32" COPPER STRIP

NOTE
ABOVE AF CIRCUITRY BUILT ON COPPER CLAD SIDE OF THE BOARD
MODULATION INPUT CIRCUITRY TO 3N141 AND [illegible] COMPONENTS ON OPPOSITE SIDE OF BOARD

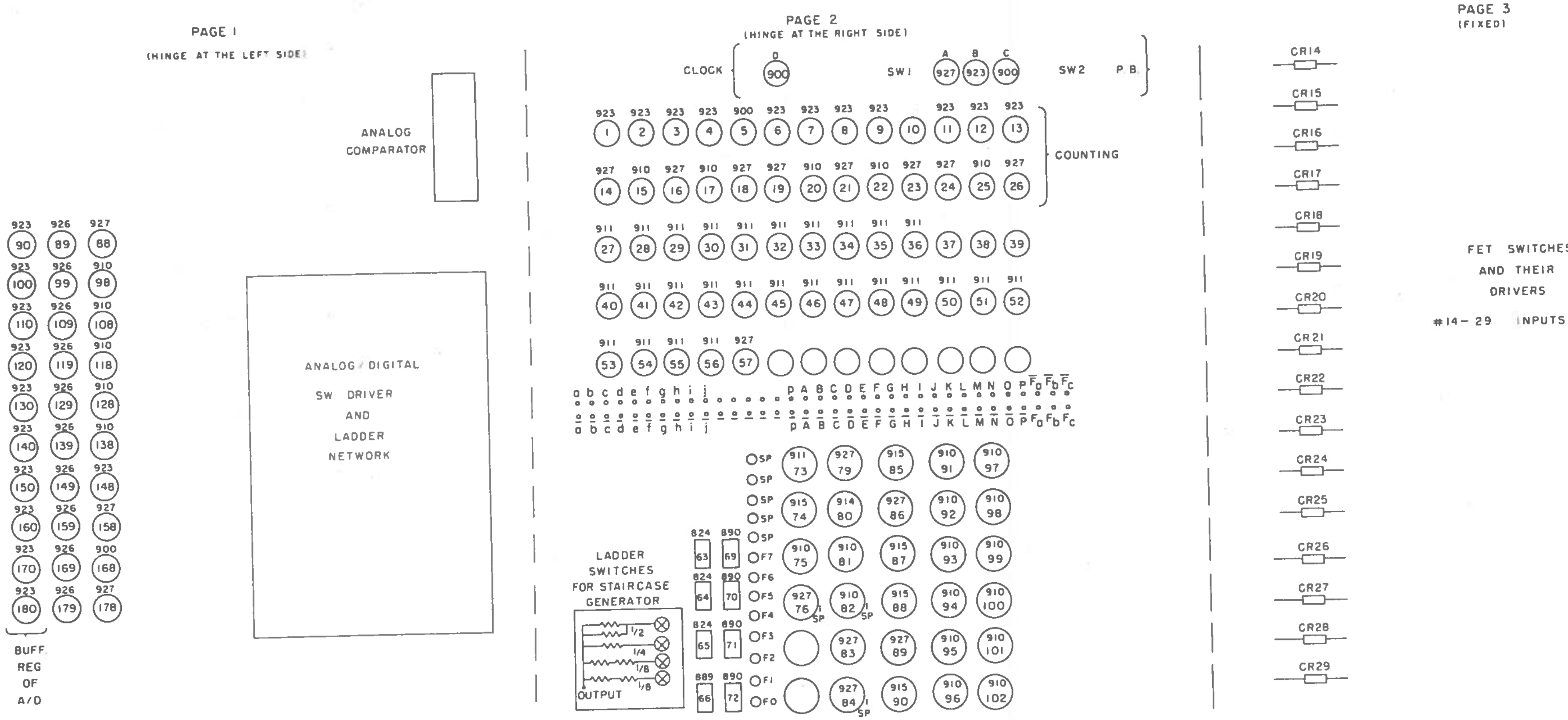
METER SCALE SET AT 20 MILS FULL SCALE
POSITION 1) READS OSCILLATOR CURRENT
2) READS DOUBLER CURRENT
3) READS MODULATOR SWITCH CURRENT

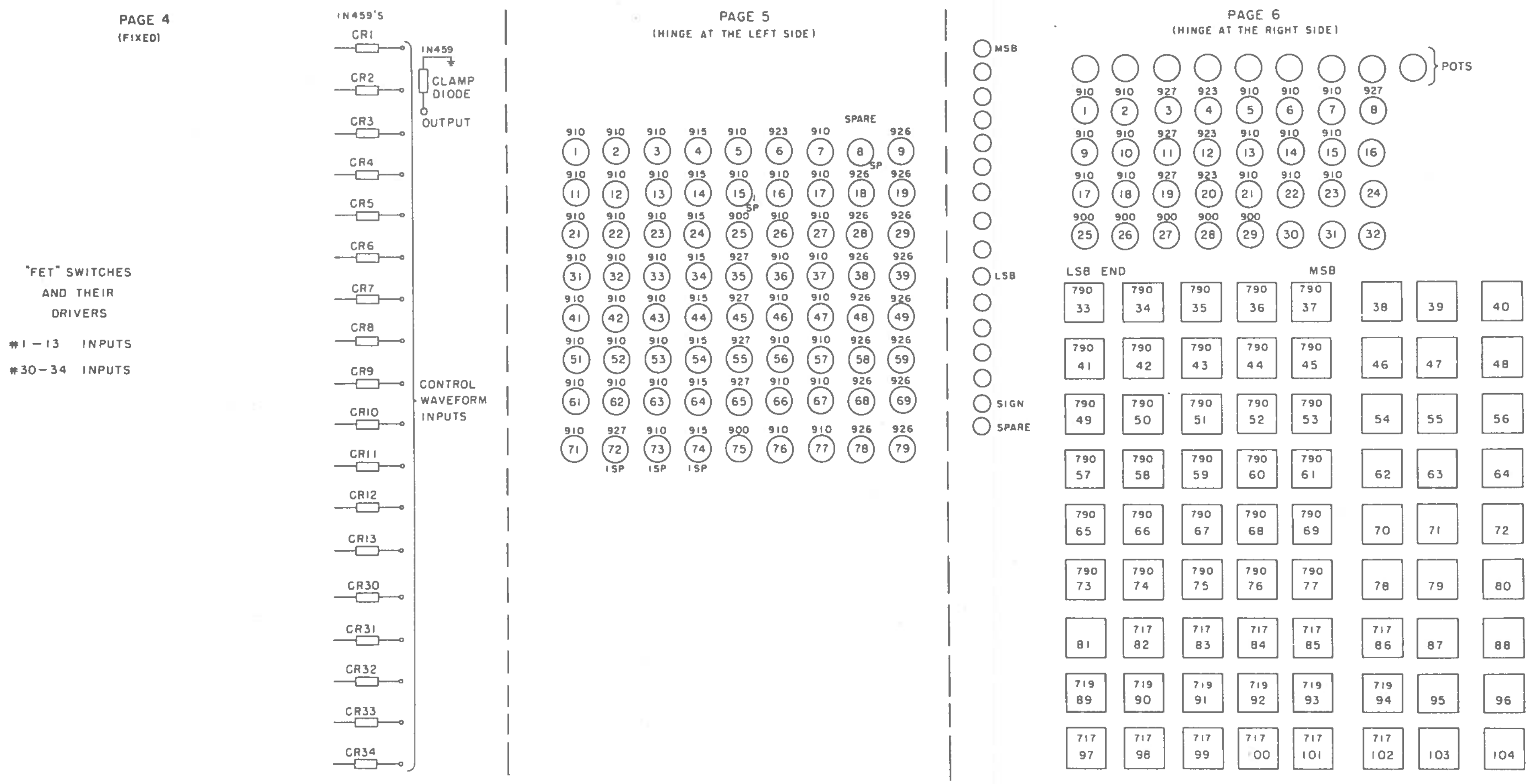
PUSH BUTTON - METER READS 10.8 VOLTS APPROX FULL SCALE



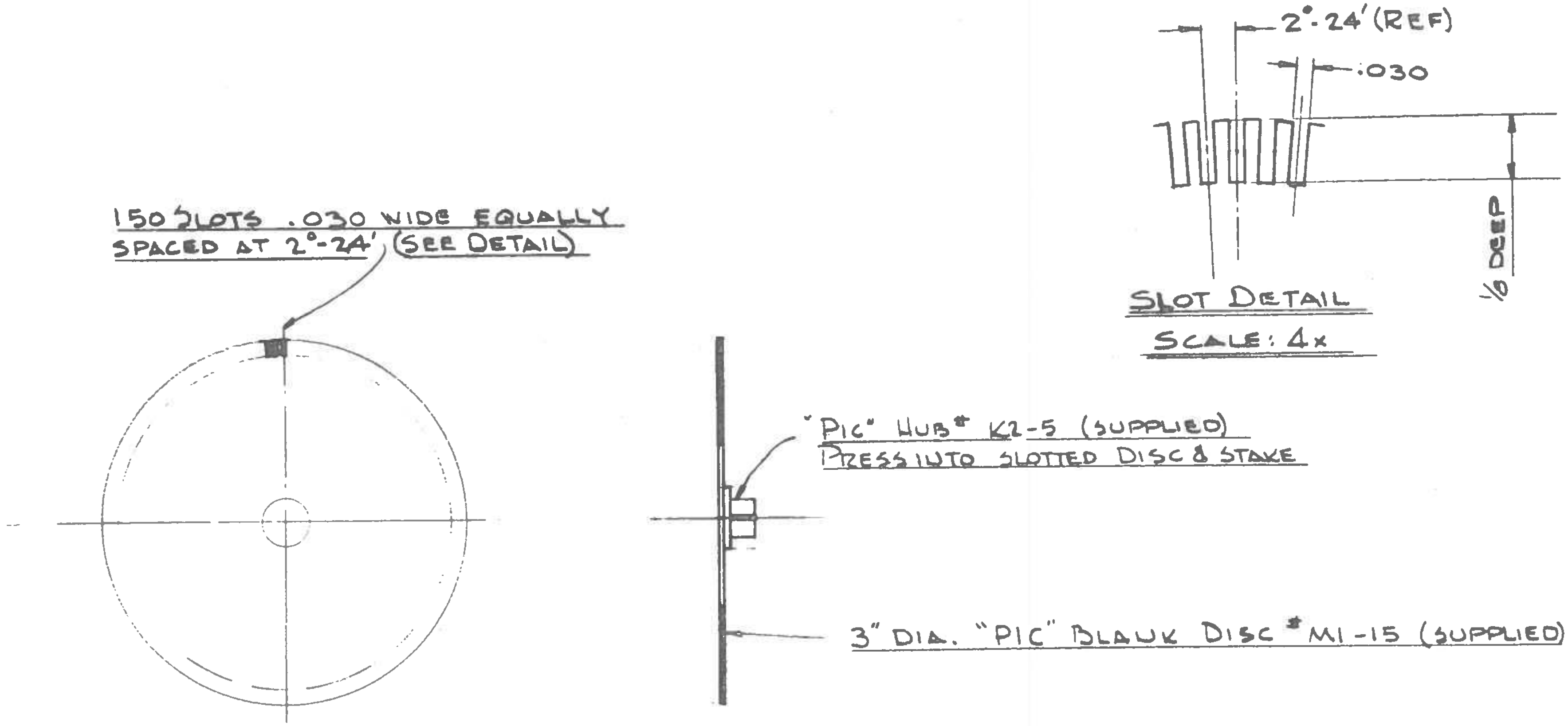
+5.12V REF
+12V
LADDER DRIVER
2.2K
2N2714
OUTPUT
.001
1K
INPUT
2N2714 (INV)
RESISTANCE = .675K LADDER OUTPUT
CAN BE PLUGGED INTO ANY ANALOG CHANNEL
2.7K
+5.12 V REF
.001
2.2K
VCC
FROM F_O CAN 85 PIN 4 PAGE 2
POSITION OF IC ON PAGE 2 OF TELEMETRY UNIT
IC UNITS MOTOROLA IN LINE PACKAGE
PIN 11 TO 3.6V
PIN 4 TO RETURN
40.96 MS
163.84 MS
COMPLEMENTED
NORMAL
(1/8 x REF) w
(1/8 x REF) x
(1/4 x REF) y
(1/2 x REF) z
1 X REF
+5.12 V
NORMAL OUTPUT
0 VOLTS
1638.4 MS
OUTPUT IF h IS SHORTED TO GROUND
OUTPUT IF $\bar{h}$ IS SHORTED TO GROUND

AF-12-152D


PAGE 1
(HINGE AT THE LEFT SIDE)
ANALOG COMPARATOR
ANALOG / DIGITAL SW DRIVER AND LADDER NETWORK
BUFF REG OF A/D
PAGE 2
(HINGE AT THE RIGHT SIDE)
CLOCK
SW1
SW2
P.B.
COUNTING
LADDER SWITCHES FOR STAIRCASE GENERATOR
OUTPUT
PAGE 3
(FIXED)
FET SWITCHES AND THEIR DRIVERS
#14-29 INPUTS


PAGE 4
(FIXED)
"FET" SWITCHES AND THEIR DRIVERS
#1 – 13 INPUTS
#30 – 34 INPUTS
IN459'S
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
CR9
CR10
CR11
CR12
CR13
CR30
CR31
CR32
CR33
CR34
IN459
CLAMP DIODE
OUTPUT
CONTROL WAVEFORM INPUTS
PAGE 5
(HINGE AT THE LEFT SIDE)
SPARE
PAGE 6
(HINGE AT THE RIGHT SIDE)
POTS
MSB
LSB
SIGN
SPARE
LSB END
MSB

AF-12-147D



REMOVE BURRS AFTER SLOTTING BUT RETAIN SHARP EDGES

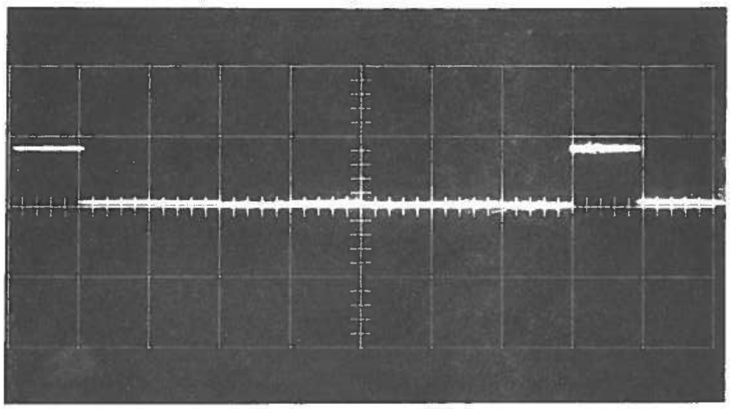
APPENDIX C

LIST OF WAVEFORM PHOTOGRAPHS

TRANSMITTING END OF TELEMETRY

Waveform F_O.

Showing two intervals.



Scope external trigger, leading edge of F_O waveform.

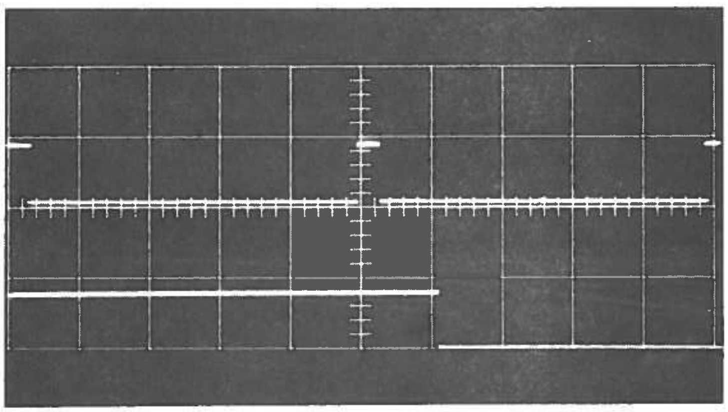
HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
5 msec/cm	2 v/cm.

TRANSMITTING END OF TELEMETRY

Waveform A

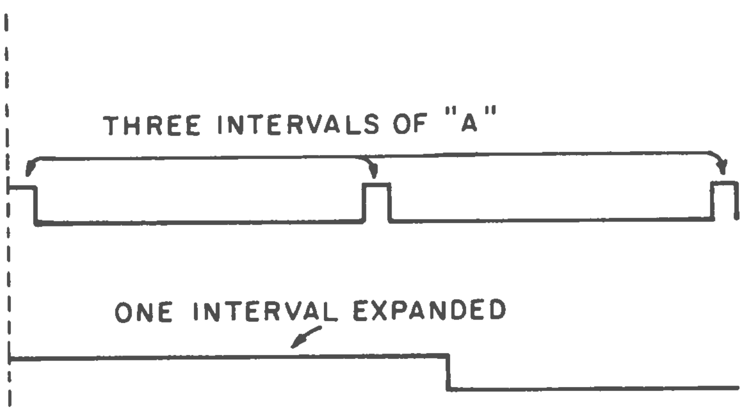
Showing (Top) Three intervals of A

(Bottom) "A" Interval expanded.



Scope external trigger, leading edge of F_O waveform.

	HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
(Top)	1 msec/cm.	2 v/cm.
(Bottom)	50 μsec/cm.	2 v/cm.

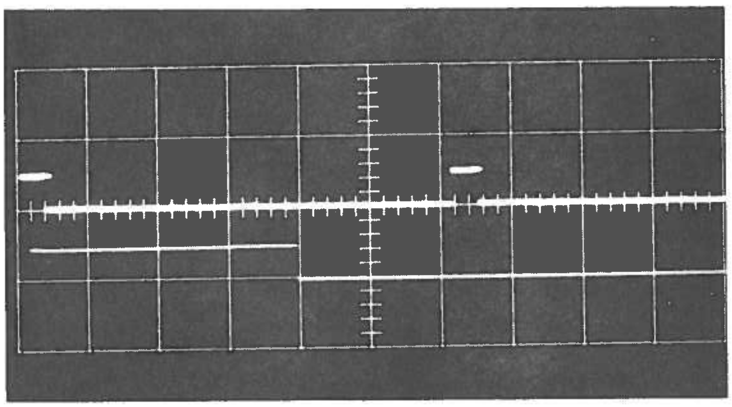


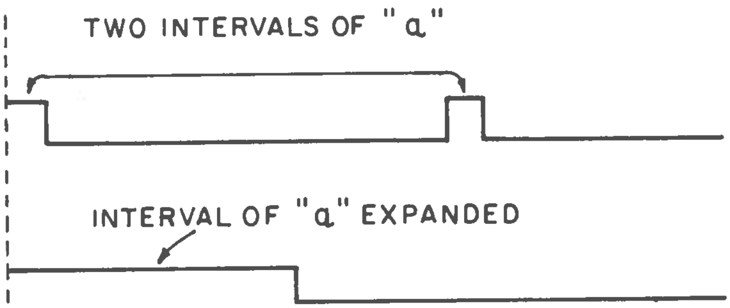
TRANSMITTING END OF TELEMETRY

Waveform "a"

Showing (Top) two intervals of "a"

Showing (Bottom) one interval expanded





Scope external trigger, leading edge of Fo waveform

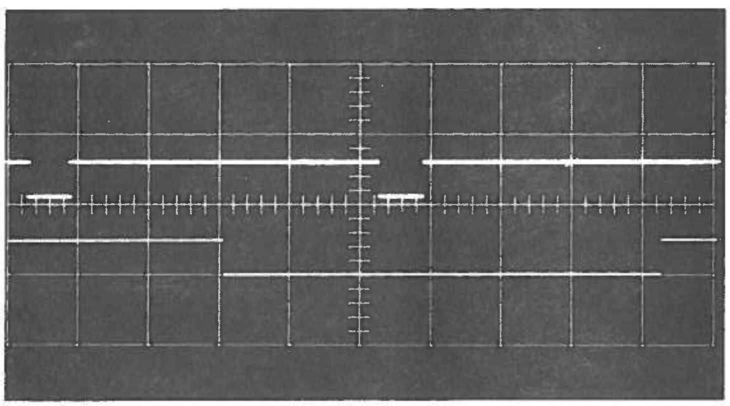
	HORIZ SWEEP SPEED	VERT DEFL. SENS.
(Top)	50 μsec/cm	2 v/cm
(Bottom)	5 μsec/cm	2 v/cm

TRANSMITTING END OF TELEMETRY

Waveform **U**

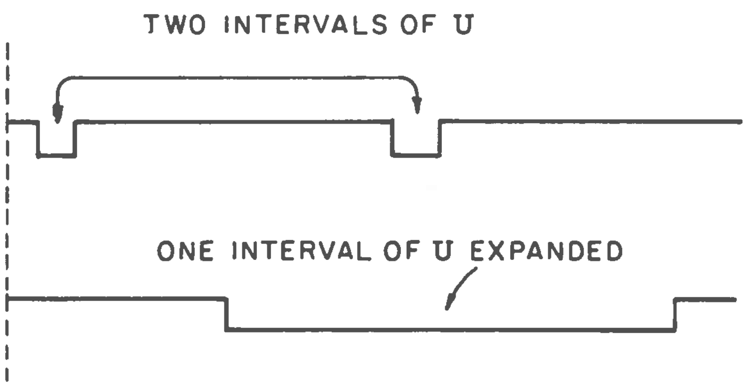
Showing (Top) Two intervals of **U**

Showing (Bottom) **U** interval expanded



Scope external trigger, leading edge of F_O waveform.

	HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
(Top)	1 msec/cm	2 v/cm
(Bottom)	100 μsec/cm	2 v/cm

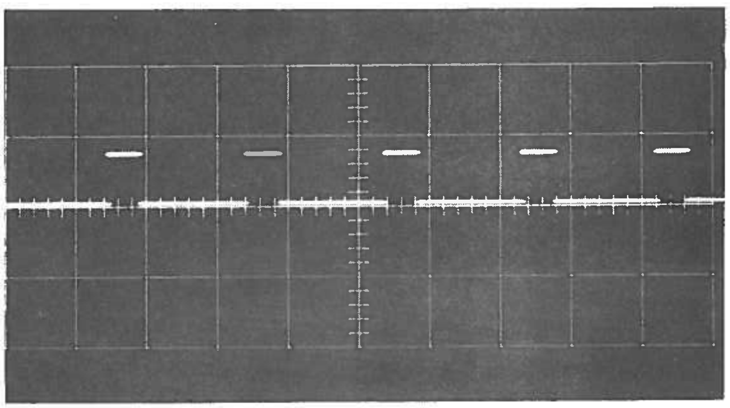


TRANSMITTING END OF TELEMETRY

Shift Pulses Waveform

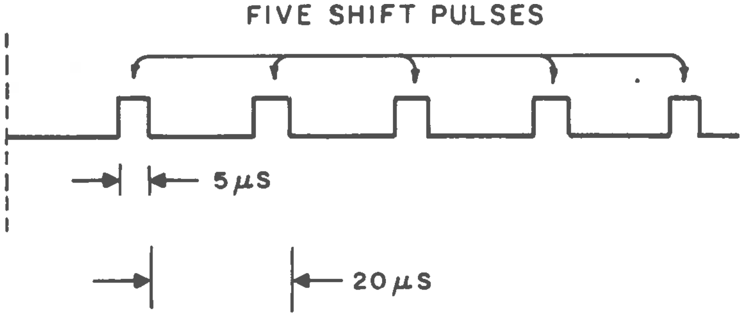
Length of pulse 5 μsec.

Inter pulse period 20 μsec.



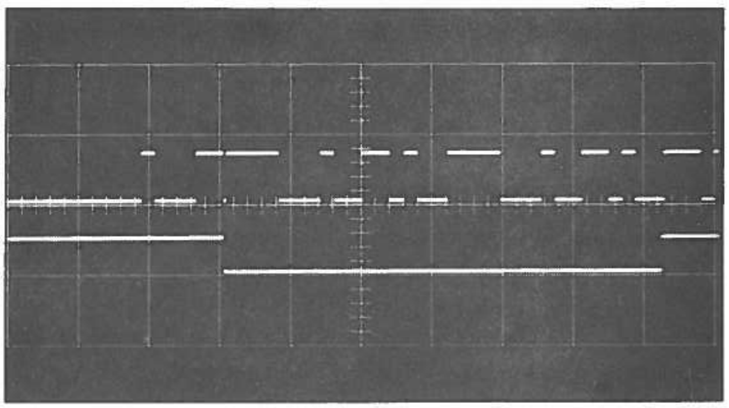
Scope external trigger, leading edge of F_O waveform.

HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
10 μsec/cm	2 v/cm



TRANSMITTING END OF TELEMETRY

Modulation Output Waveform
for frame sync. pattern
shifted out during waveform U



Scope external trigger leading edge of F_O waveform.

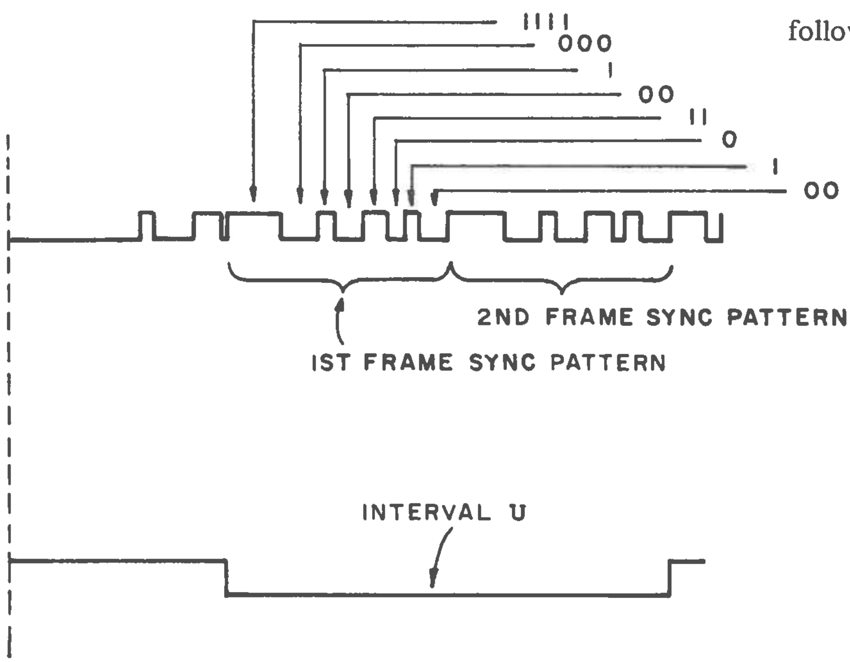
HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
100 μsec/cm	2 v/cm

Frame Sync. Pattern

1111 000 1 00 11 0 1 00

8 one's , 8 zero's

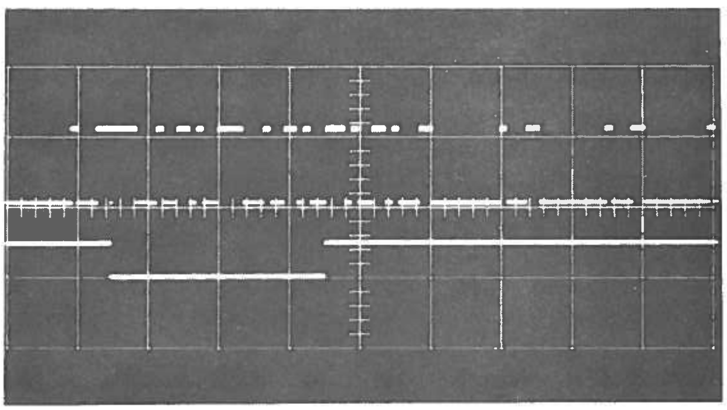
followed by same pattern.



TRANSMITTING END OF TELEMETRY

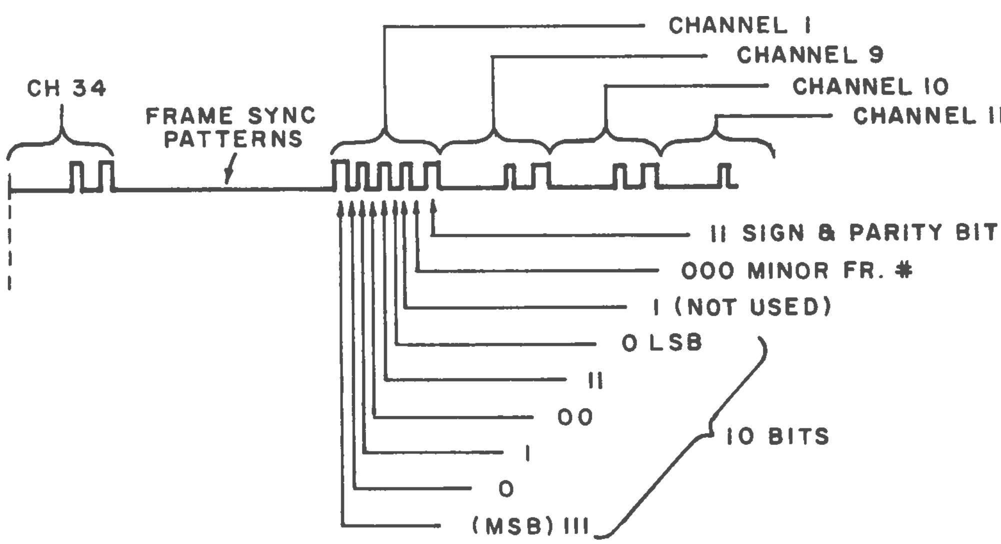
Modulation Output Waveform,

Showing Channel 1 which follows immediately after the end of bottom waveform **U.** Waveform is digital representation of analog value of test potentiometer setting. It shows **111 0 1 00 11 0** in first ten bits of interval, followed by a *one* (not used) then three *zero*'s for frame number, followed by two one's for sign, and parity.



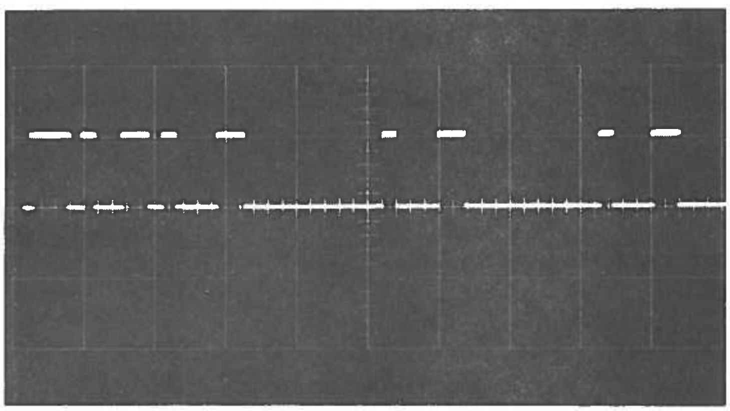
Scope external trigger, leading edge of F_O waveform.

HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
200 µsec/cm	2 v/cm



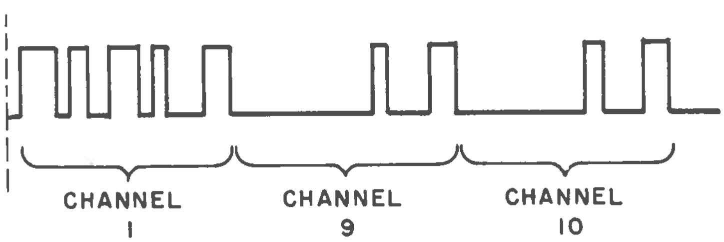
RECEIVING END OF TELEMETRY

Waveform of Receiver Output
Showing Channels 1, 9, 10, showing digital representation of analog value of test potentiometer in Channel 1, which is **111 0 1 00 11 0**.
Using first ten bits, then a *one* bit (not used), then three *zero*'s, frame number, then two *one*'s for sign and parity bit.



Scope external trigger leading edge of F_O waveform

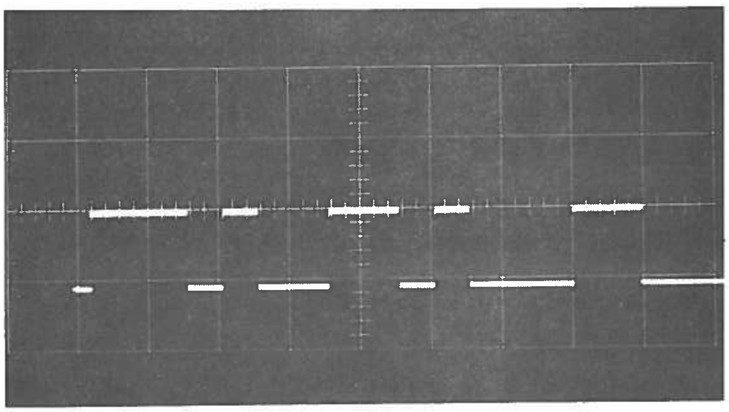
HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
100 μsec/cm	2 v/cm



RECEIVING END OF TELEMETRY

Waveform of Receiver Output

Showing Channel 1 with test potentiometer at input set to give digital representation of **1110100110** as previous photograph

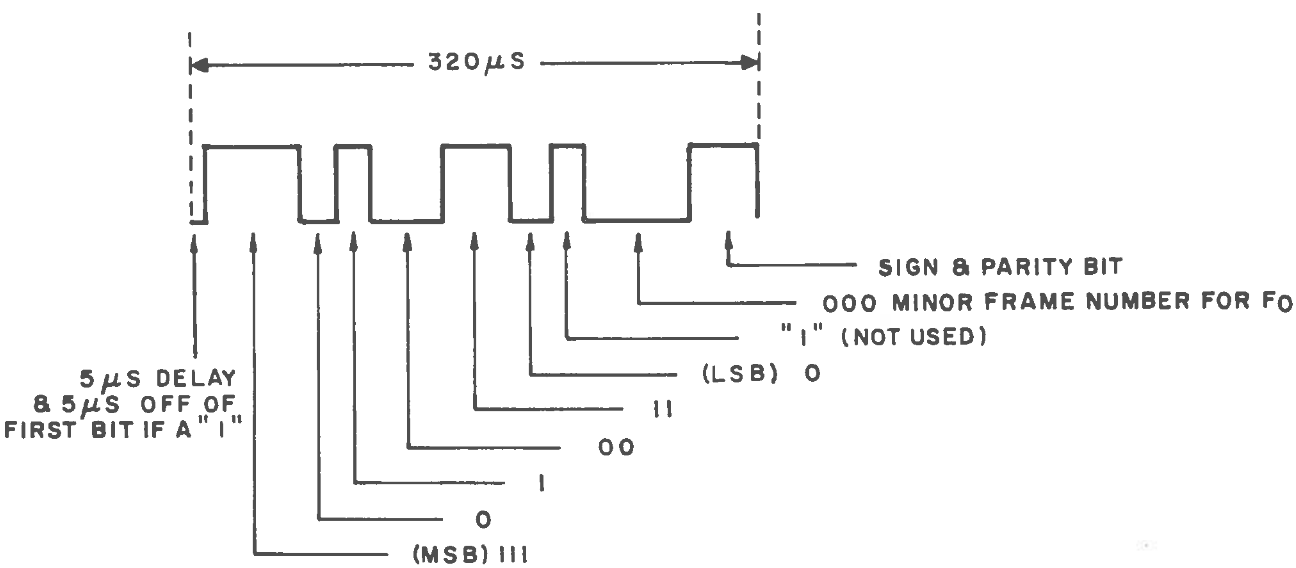


Scope external trigger leading edge of F_O

HORIZ.
SWEEP
SPEED

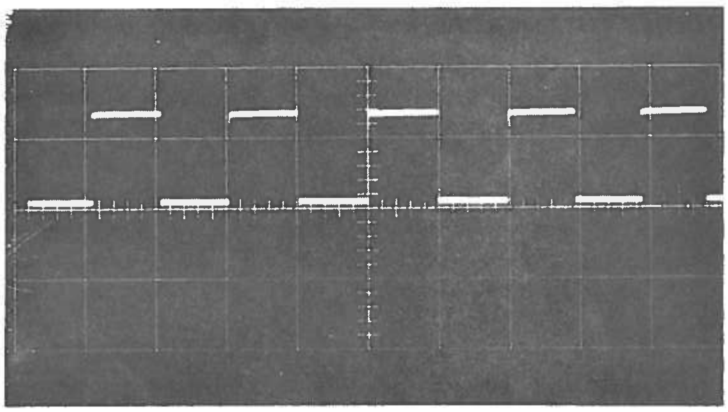
Adj. to position

Channel 1 over 8 cm (320 μsec)



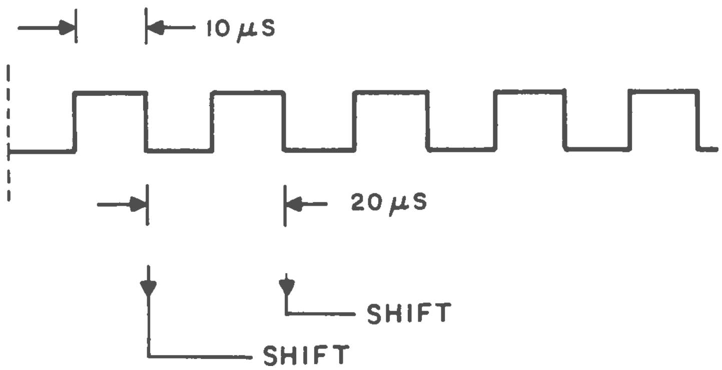
RECEIVING END OF TELEMETRY

Waveform showing *Bit Timing*



Scope external trigger from leading edge of F_O waveform

HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
10 μsec/cm	2 v/cm

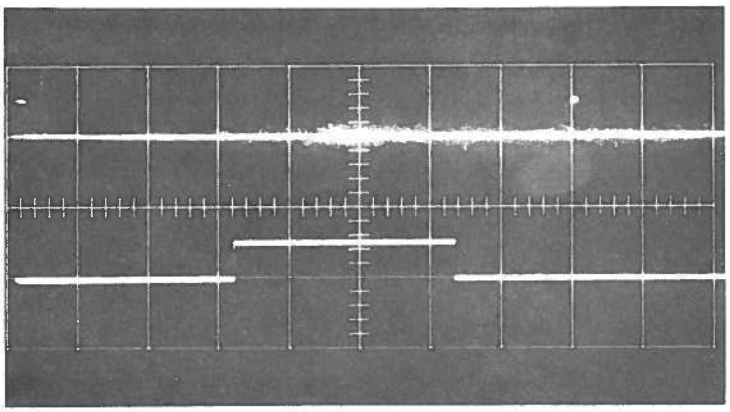


RECEIVING END OF TELEMETRY

Waveform of Channel Sync. 1

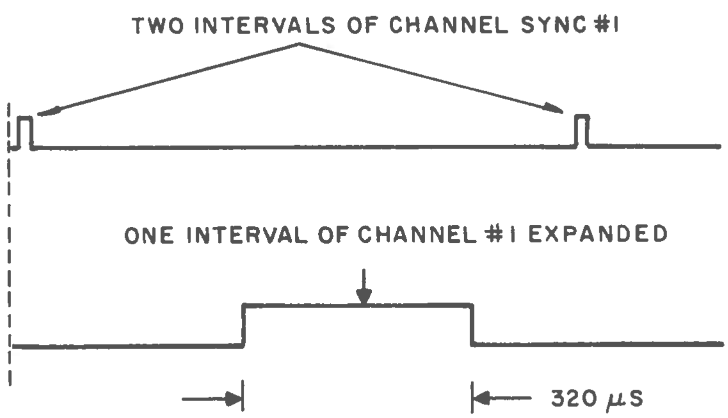
Showing two intervals (Top)

Showing interval expanded (Bottom)



Scope external trigger leading edge of F_O waveform

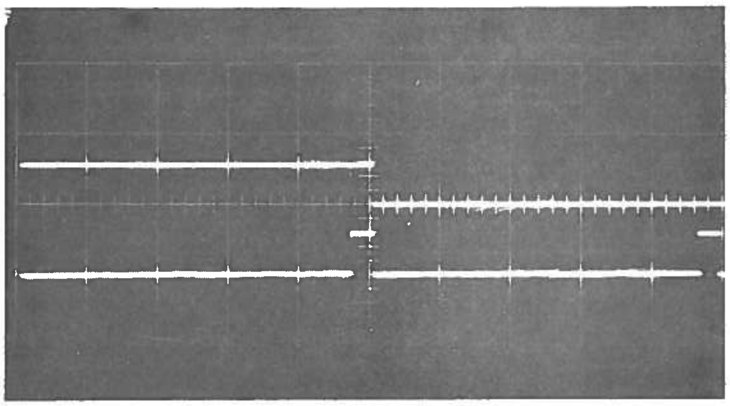
	HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
(Top)	5 msec/cm	2 v/cm
(Bottom)	100 μsec/cm	2 v/cm



RECEIVING END OF TELEMETRY

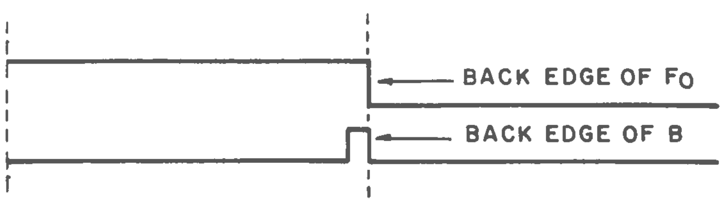
Waveform showing F_O (Top)

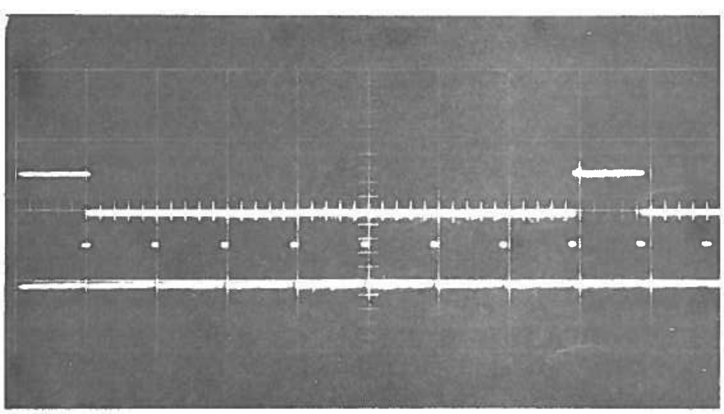
Waveform showing **B** (Bottom)



Scope external trigger leading edge of F_O waveform

HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
1 msec/cm	2 v/cm

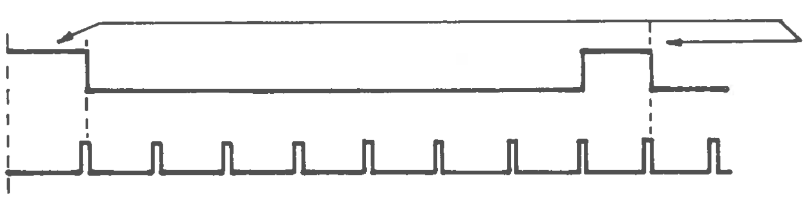




Waveform F_O (Top)

Waveform **B** (Bottom)

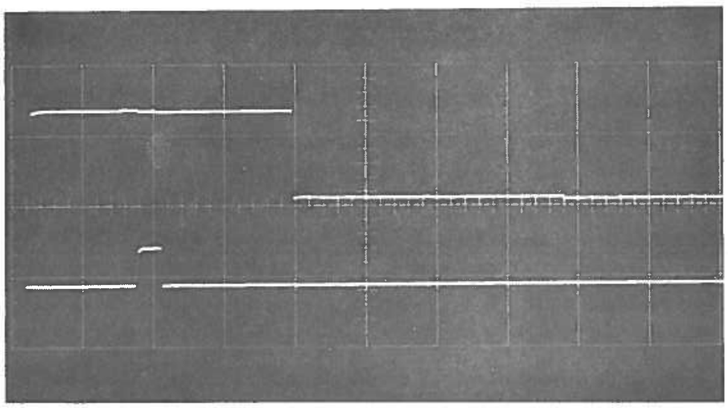
HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
5msec/cm	2 v/cm



RECEIVING END OF TELEMETRY

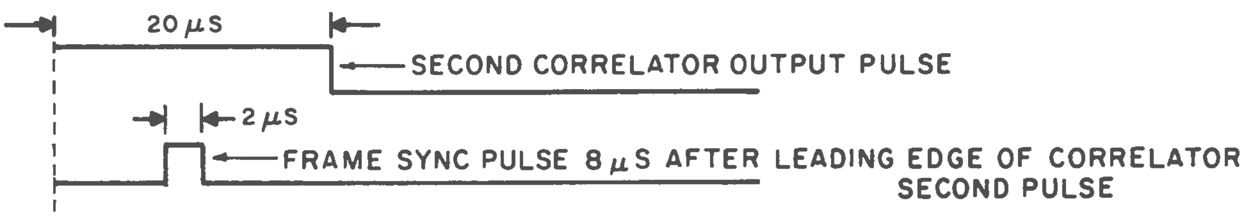
Waveform showing Correlator (Top)

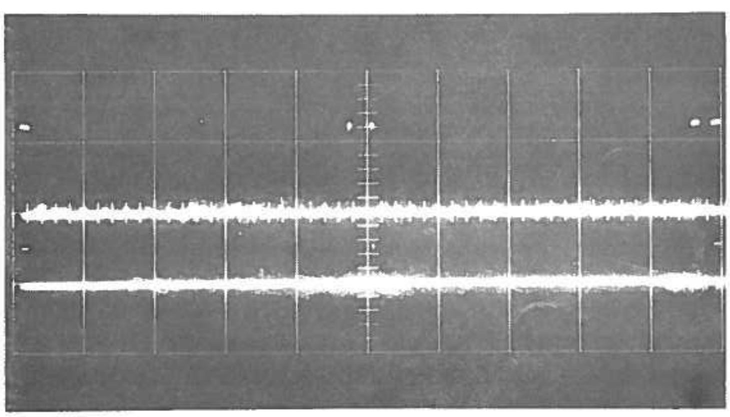
Waveform showing frame Sync. (Bottom)



External trigger leading edge F_O

SWEEP SPEED	VERT. DEFL. SENS.
5 μsec/cm	2 v/cm

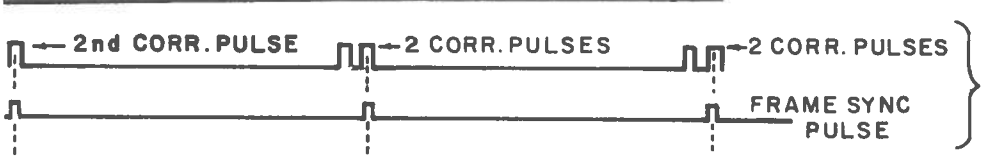




Correlator (Top)

Frame Sync. (Bottom)

SWEEP SPEED	VERT. DEFL. SENS.
1 msec/cm	1 v/cm (Top)
	2 v/cm (Bottom)



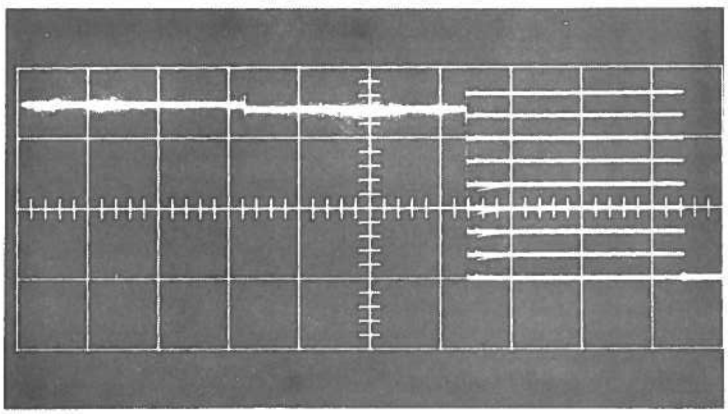
RELATIONSHIP OF 2nd CORRELATOR PULSE TO FRAME SYNC PULSE

RECEIVING END OF TELEMETRY

(First 320 μsec) Showing analog representation of second section of Frame Sync. Pattern

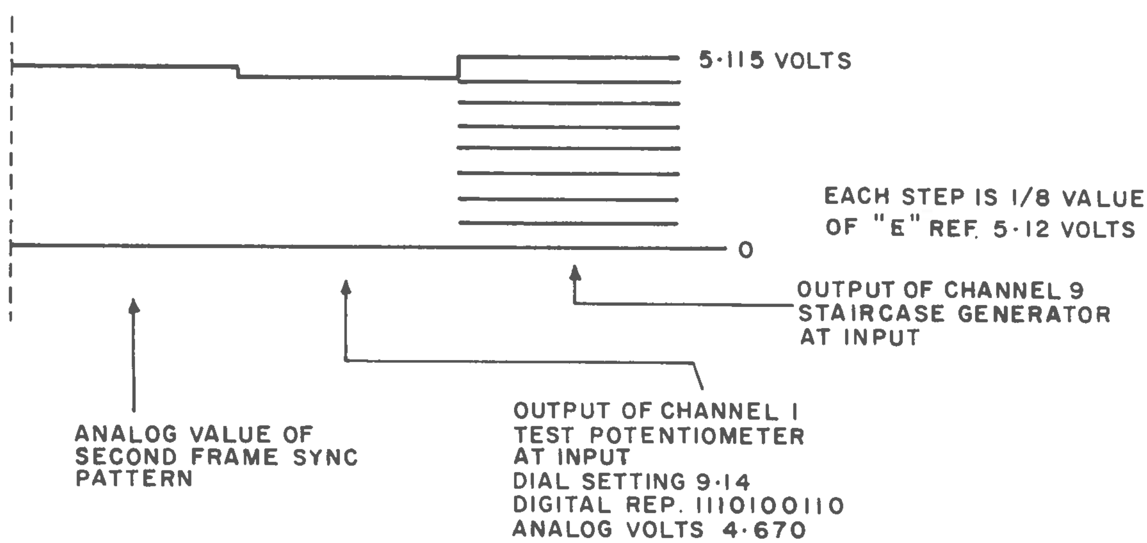
(Second 320 μsec) Showing analog representation of received digital word in Channel 1

(Third, 320 μsec) Showing changing analog values representing the digitized values
Channel 9 received from staircase generator.



Scope external trigger leading edge of F_O waveform

HORIZ. SWEEP SPEED	VERT. DEFL. SENS.
100 μsec/cm	2 v/cm



APPENDIX D

LIST OF PLATES

Plate 1 Front view of receiving end

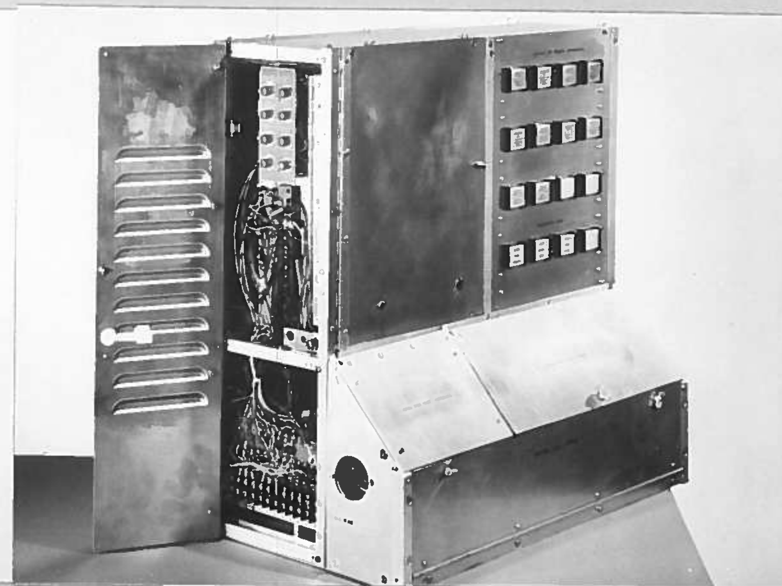


Plate 2 Angular view of receiving end

Plate 3 Front view of meter rack and output connectors to paper recorders

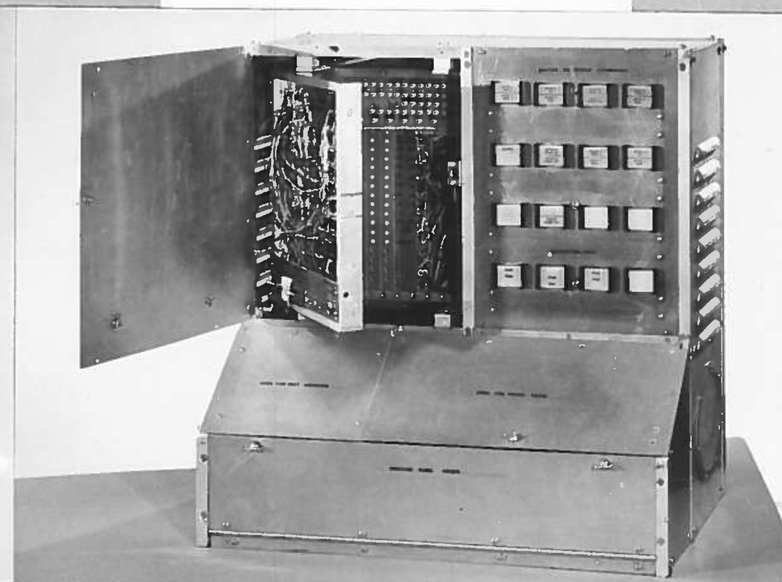


Plate 4 Front view of receiving end logic section open

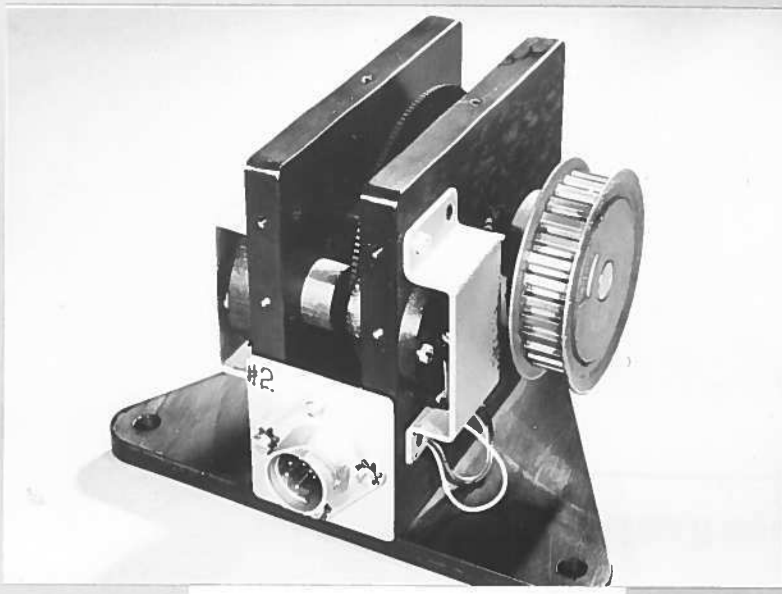


Plate 5 R.p.m. transducer assembly

Plate 6 Transmitter unit

Plate 7 Angular view of transmitting end

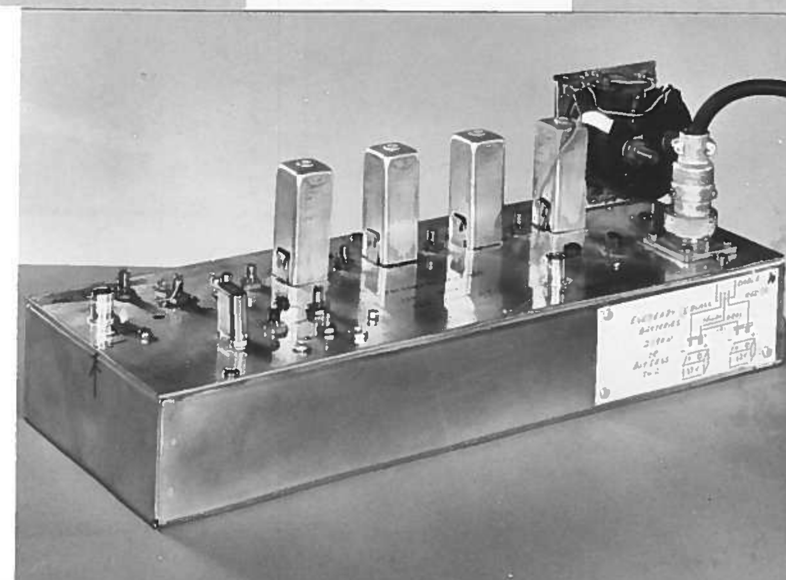


Plate 8 Receiver unit

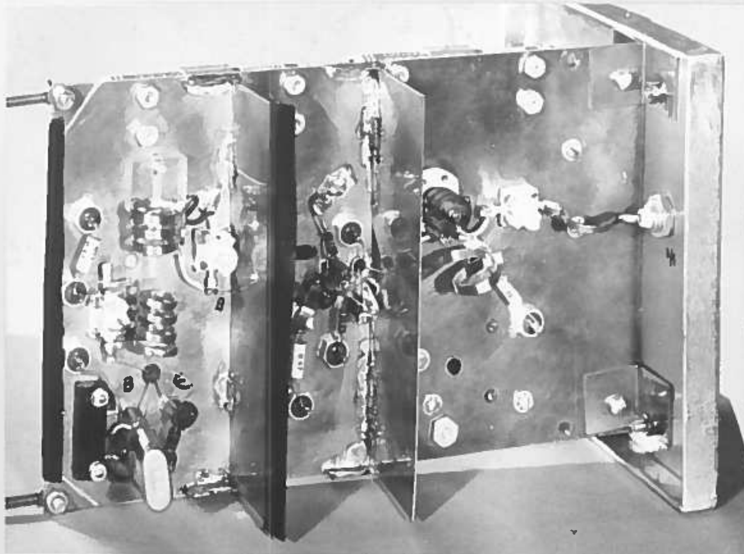


Plate 9 Interior of transmitter unit

Plate 10 Monitor interface unit

Plate 11 Angular view of transmitting end

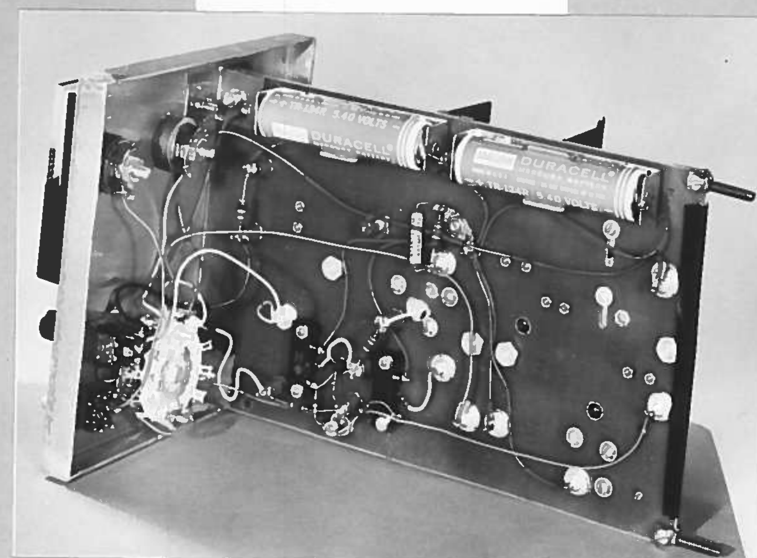


Plate 12 Interior view of transmitter unit

Plate 13 Right side view of transmitting end

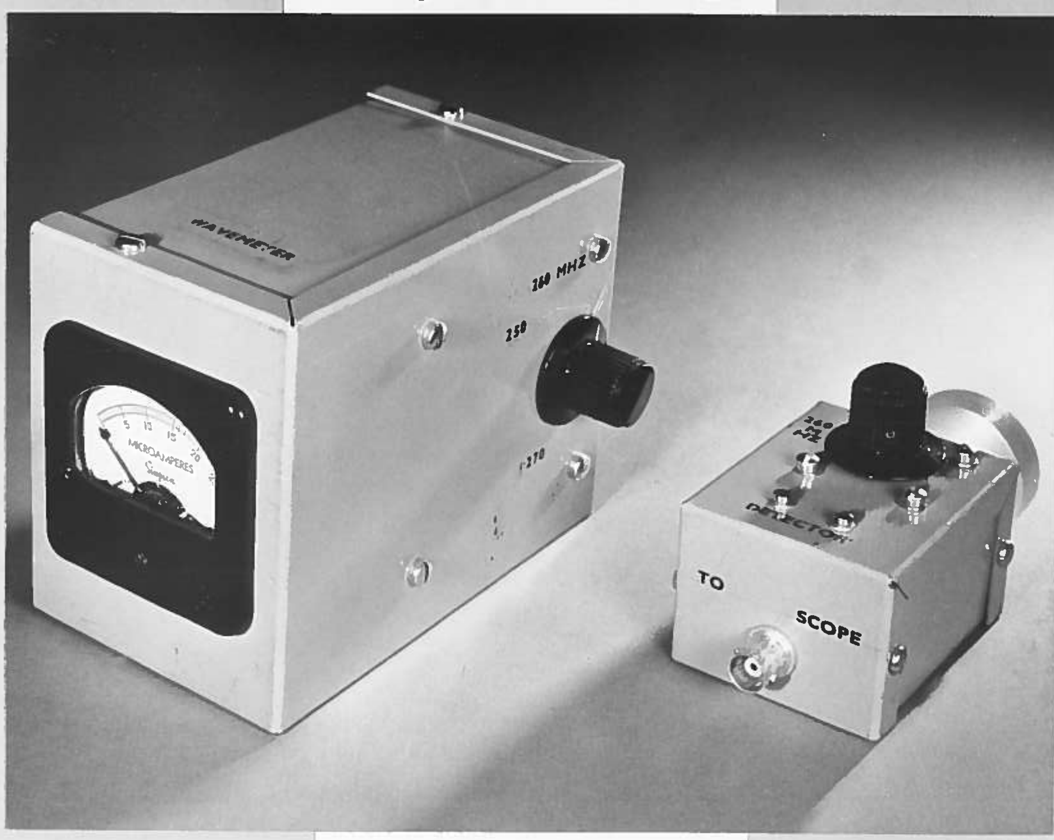


Plate 14 Wavemeter and detector unit