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DEPARTMENT OF COMMERCE ★ UNITED STATES OF AMERICA ★

CROSSWIND PROFILER MODEL II

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S. Abbott
R. George

Wave Propagation Laboratory
Boulder, Colorado
March 1988

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UNITED STATES
DEPARTMENT OF COMMERCE

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ABSTRACT

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We describe an optical instrument that measures the crosswind simultaneously at five locations along optical paths from 200 m to 1.5 km.

1. INTRODUCTION

A number of optical systems have been developed at the Wave Propagation Laboratory of NOAA that use the intensity scintillation of a light source to measure the wind at right angles to the line-of-sight to a receiver (1-7). A laser light source was used in the original system that measured the average of the crosswind over the light path, with greater weight given to the winds in the central portion of the path. The system worked well and was especially well suited to measure the average crosswind component of highly variable winds, but with some limitations. The integrated refractive-index turbulence could not exceed the value at which the scintillation saturated, since at this point, both the wind calibration and the weighting function, i.e., where the wind was being measured along the path, was affected severely. The system was also affected by the distribution of refractive-index turbulence (C_n^2) along the path. A later system was developed that reduced these undesirable effects significantly. This was accomplished by employing an incoherent light source to restrict the measurement of refractive-index irregularities to those large compared to Fresnel-zone size $(\lambda L)^{1/2}$, where λ is the light wavelength and L is the path length, which reduces the sensitivity of the measurement to scintillation saturation. Later systems replaced the quartz-halogen light bulb source with a modulated light-emitting diode, and the sensitivity to variations in C_n^2 along the path was reduced by using more of the information contained in the covariance function, from which wind speed is derived (7,8).

The weighting functions for systems that employ incoherent apertures that are large compared to Fresnel-zone size can be arranged to peak at locations other than the center of the path if the transmitting and receiving apertures are not the same size. In this case the measurement is biased toward the smaller aperture. A system for profiling wind and C_n^2 was designed and built that was based upon this technique. The weighting functions tend to be rather broad, however, although they may be sharpened somewhat by linear combination of the signals from the individual weighting functions (6).

The Crosswind Profiler Model II employees more complex filtering techniques that form narrower weighting functions and sharper spatial filters, resulting in more accurate wind measurement with less sensitivity to irregularities of C_n^2 along the light path. The method is a variation of a technique first proposed by Lee (9). Fig. 1 shows the principle. Two pairs of transmitters illuminate all the receivers shown on the right. The receivers identify each pair of transmitting signals and add them up according to the signs shown. If an irregularity in refractive index carried by the wind passes across the spatial filter formed in the center of the path it will generate a fluctuating signal in the receivers of mean frequency f where $f = v/w$, v is the translation speed and w is the spatial wavelength of the filter. The location of the spatial filter can be changed by changing the ratio of transmitter and receiver element spacing .

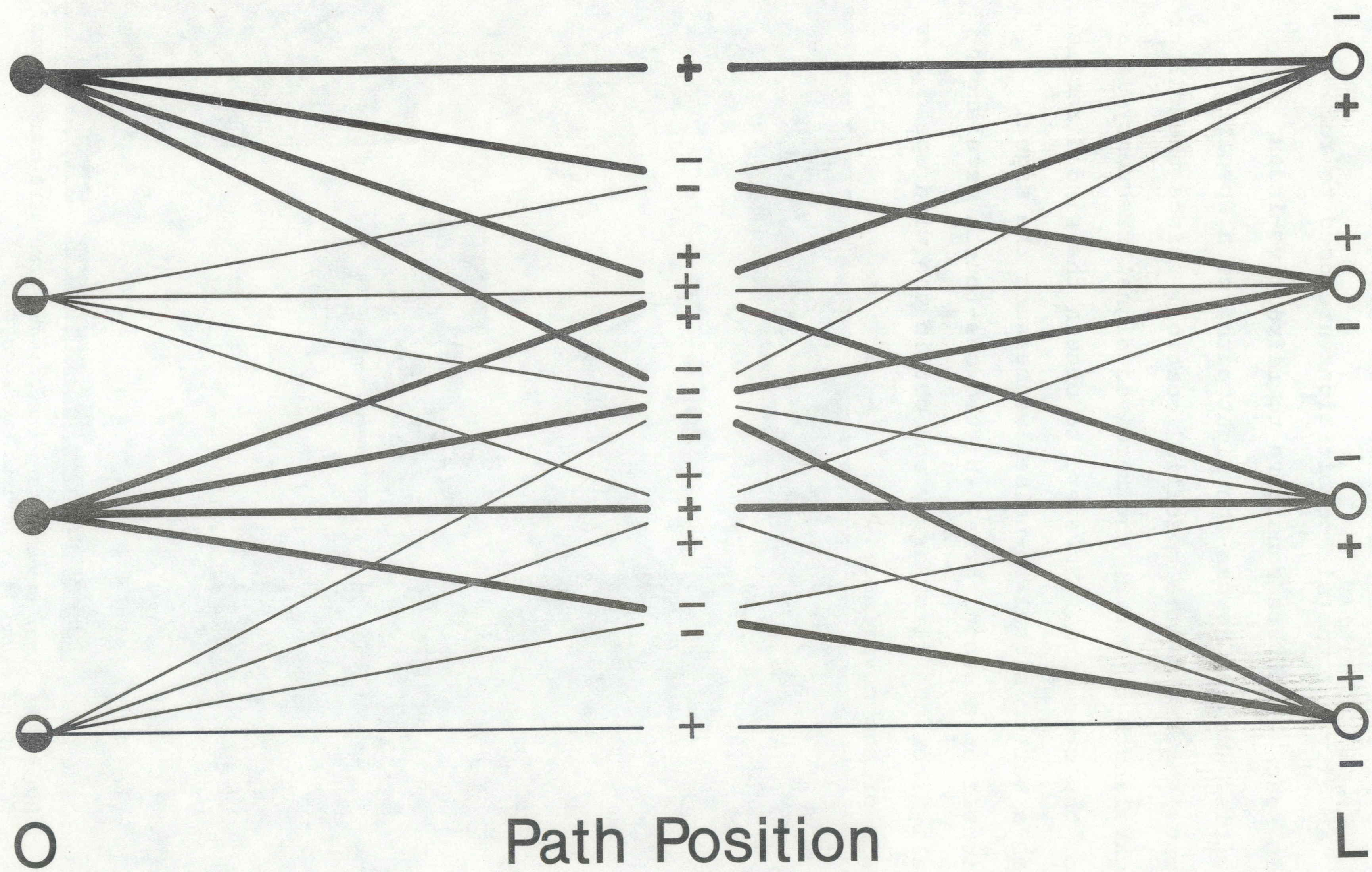

Figure 1. Principle of path profiling by the use of transmitting and receiving spatial filters, first proposed by Lee.

The actual implementation is somewhat more complicated. Two transmitting filters and three pairs of receiving filters are employed, and five of the six combinations are used to form filters in space which are sensitive to refractive-index irregularities, moving across the light path, of a specific spatial wavelength and at a specific location. Since the filter spatial wavelength is known, the received signal frequency is a measure of the crosswind. However, to obtain the wind direction as well as a better signal-to-noise, we measure the signal fluctuations from a second array shifted one-fourth wavelength horizontally from the first array and obtain the wind speed from an analysis of the covariance.

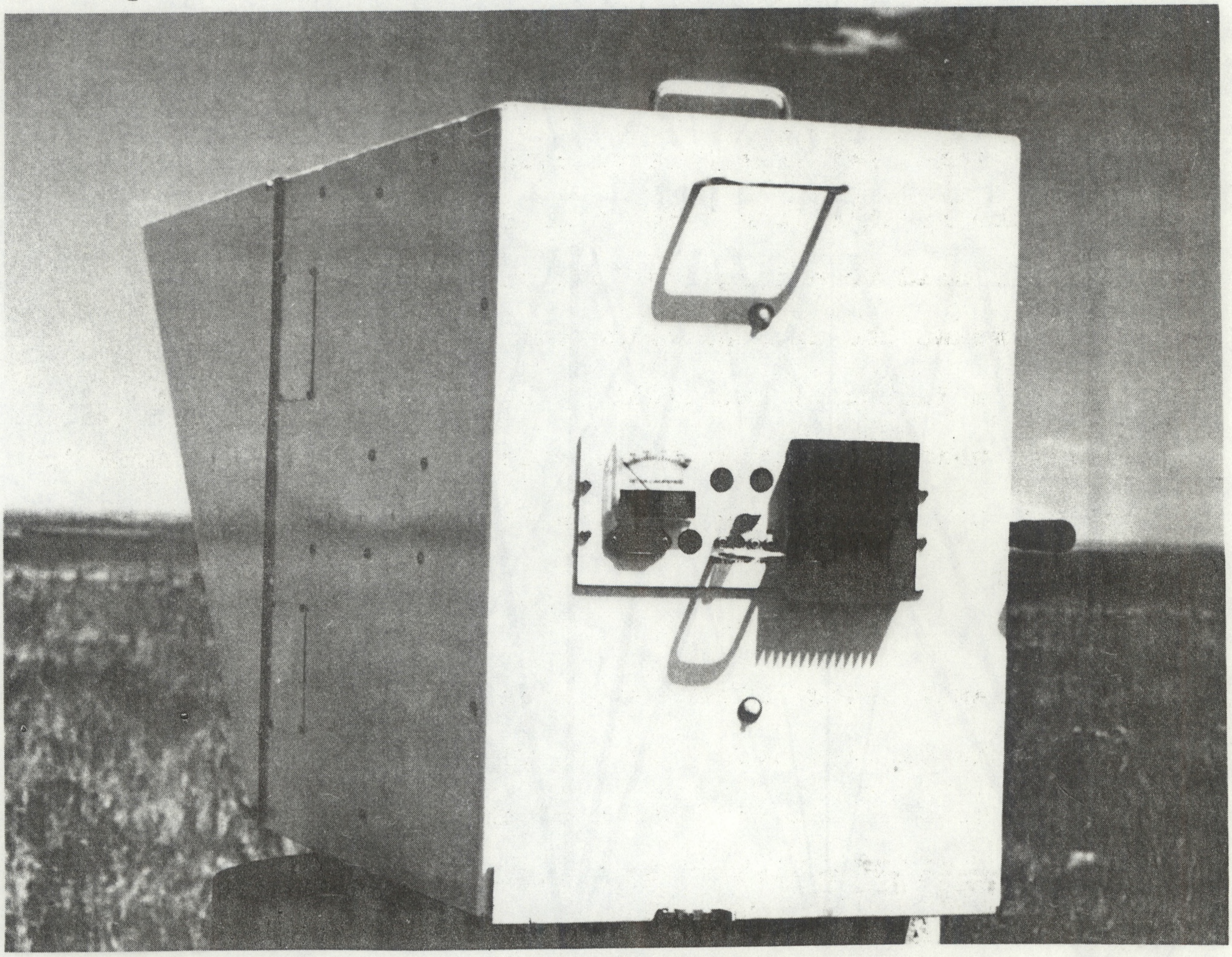

Figure 2. Incoherent light transmitter consisting of two zero-mean spatial filters of 5 and 20 cm spatial wavelength.

2. DESCRIPTION OF INSTRUMENT

The transmitter is shown in Fig. 2. It consists of two spatial filters. Separate 29 x 40-cm Fresnel lenses are used to form the filters. The lower and upper apertures have spatial wavelengths (w) of 20 and 5 cm respectively. Both filters are made zero mean by driving alternate stripes (of width = w/2) with different light-emitting diodes (LEDs). This is done optically (see Fig. 3) by placing a piece of glass with alternate reflective and clear portions in the optical train with one LED transmitter at the transmitted focus and the other at the reflected focus. We use TIES 16A LEDs operating at 0.94 um wavelength. The radiating area is a hemisphere 1.8 mm in diameter. This area is not large enough to mask the angular error of the Fresnel lens. For this reason, a ground glass diffuser is used to enlarge the effective area of the emitter. This also makes the optical alignment less critical, at the expense of a factor of two light loss. The four LEDs are identified using the simple pulse-code shown in Fig 4, where T1 and T2 are for the 20-cm wavelength filter, and T3 and T4 for the 5-cm filter.

The transmitting filters are made zero-mean at the receiver by taking the differences T1-T2 and T3-T4, so it is important that the received mean irradiance of the T1-T2 and T3-T4 pairs be equal. This is accomplished by adjusting the LED drive currents with the recessed screwdriver adjustments on the back of the transmitting unit. The drive current to any one of the LEDs

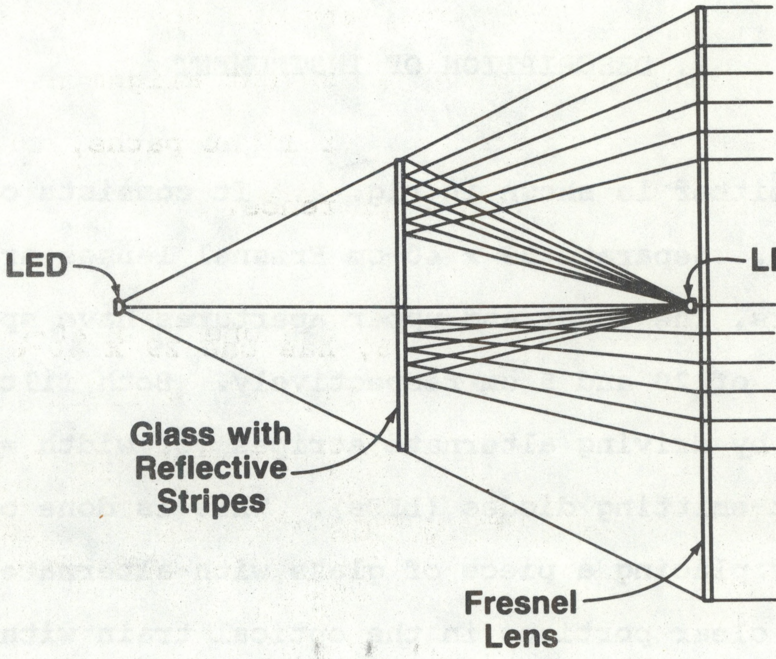

Figure 3. Top view of 20-cm wavelength transmitter optical system.

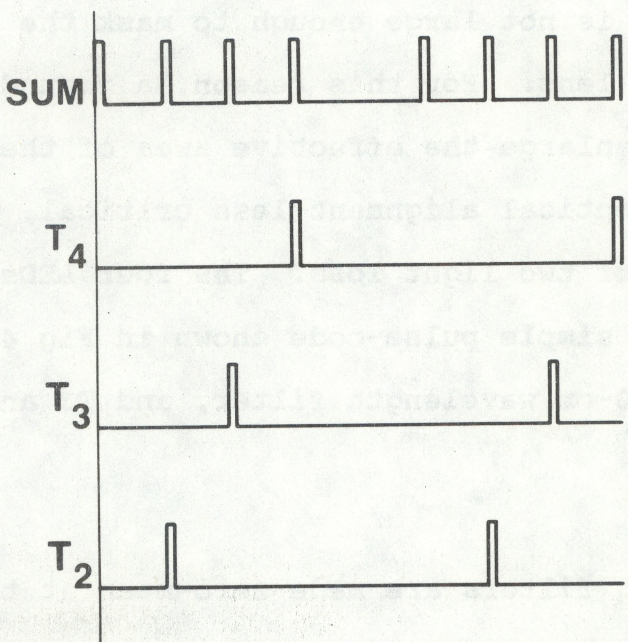

Figure 4. Pulse trains from each of the four transmitters. All receiver array elements receive all four transmitter signals.

should not exceed 300 ma. The larger angular spread caused by the ground glass diffusers also helps prevent alignment differences between the four transmitter light paths, that are a major source of mean pulse height difference.

The receiver, pictured in Fig. 5, has one 29 x 40-cm Fresnel lens. The optical system is shown in Fig. 6. A 15-mm focal length

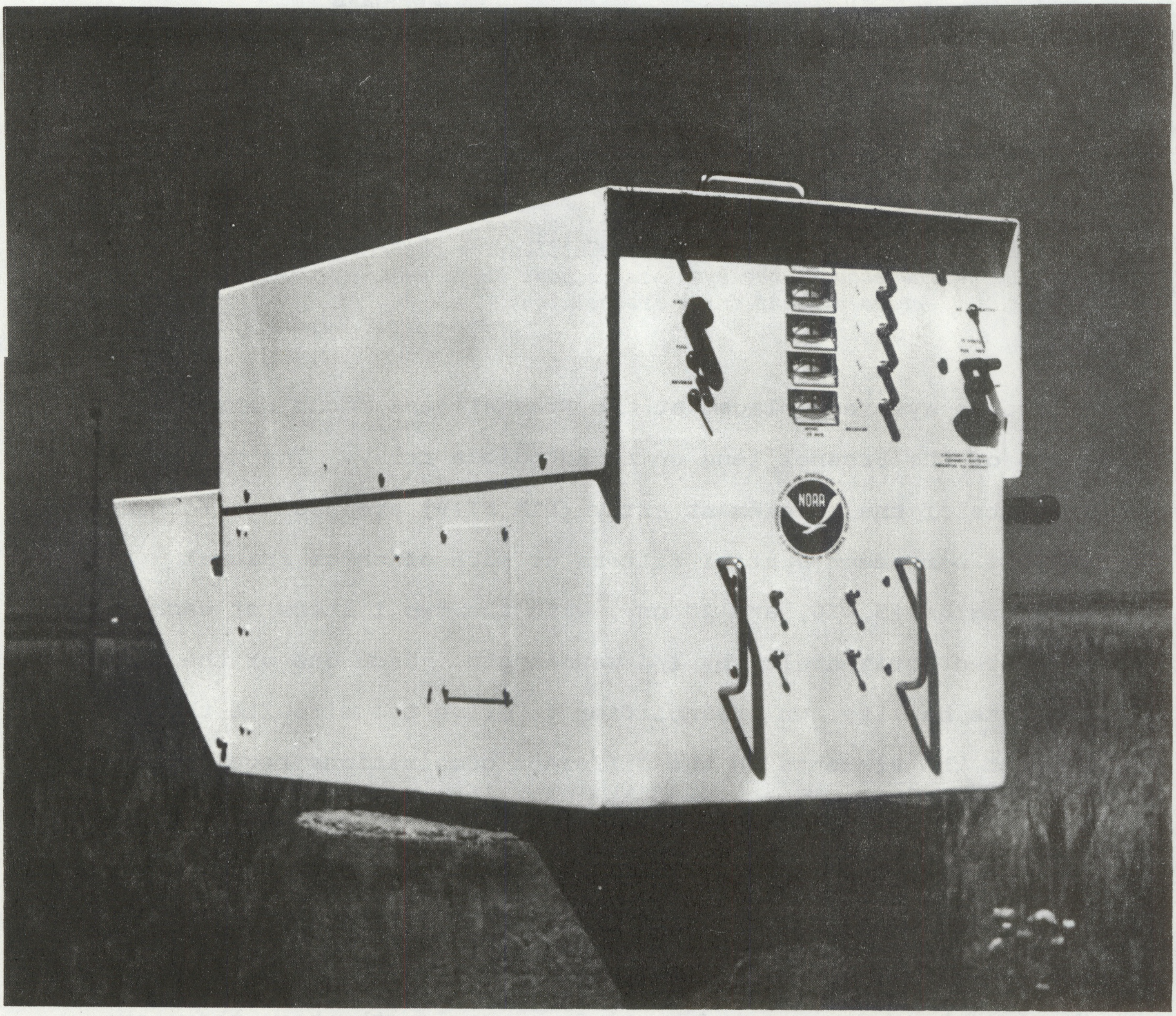

Figure 5. Spatial filter receiver. Three pairs of 5, 20 and 20-cm wavelength filters, together with the 5 and 20-cm transmitting filters, measure the crosswind at 1/5, 1/3, 1/2, 2/3, and 4/5 of the path length from transmitter to receiver.

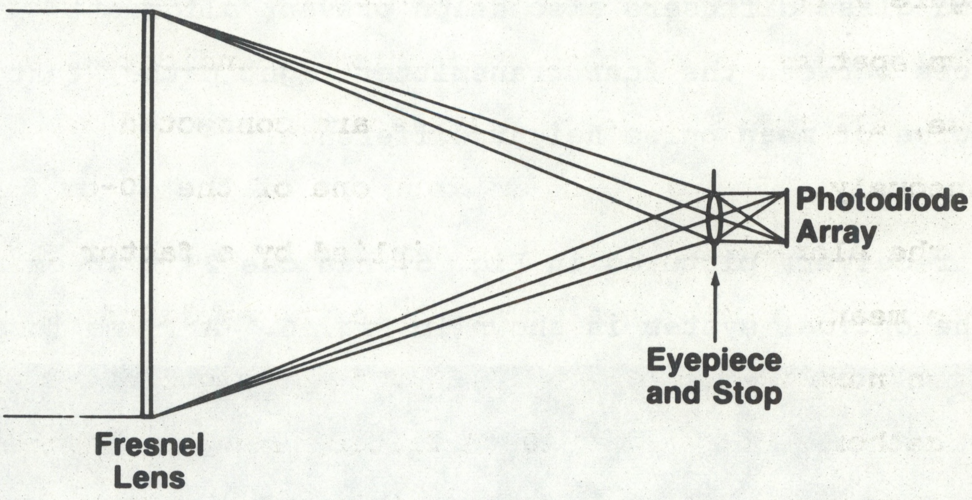

Figure 6. Top view of receiver optical system. The eyepiece focuses an image, reduced in size, of the scintillation pattern on the Fresnel lens. The stop in the eyepiece is just large enough to include the angular errors present inthe Fresnel lens.

telescope eyepiece placed at the Fresnel lens focus forms an image of the Fresnel lens on a photodiode array. The central 32 elements of the 76-element array (PIN 5749) are used to form a pair of zero-mean spatial filters at each of three spatial wavelengths (5, 10, and 20 cm), with the two filters of each pair separated horizontally by 1/4 wavelength. Each one of the 32 elements has its own preamplifier to drive the circuits that connect the elements in the different combinations required to form the six filters. Ideally, the filters should have a sine-wave response, and the gains from the elements have been set to approximate a sine-wave response. The approximation is best for the 20-cm wavelength, since there are 16 photodiode elements per wavelength, and poorest for the 5-cm wavelength where there are only 4 elements per wavelength.

Figure 7 is a simplified block diagram of the receiver. Only the 10-cm spatial filter pair connection is indicated, although, of course, all three pairs of filters are connected simultaneously. For example, to form one of the 10-cm filters, each of the element signals is multiplied by a factor (minus if below the mean) that is proportional to the amplitude of the sine-wave shown next to the array. All of these signals are then added together. The second 10-cm filter, and the remaining 5 and 20-cm filter pairs are formed in a similar way. The automatic gain control (AGC) maintains a constant root-mean-square (RMS) signal amplitude on the mean-zero signal for a given spatial wavelength and transmitter power, within the allowed limits. The signal amplitude is proportional to

$$(C_n^2)^{1/2}L^{3/2}L^{-2}=(C_n^2)^{1/2}L^{-1/2},$$

where $L^{3/2}$ is due to the increase in scintillation with range, while L^{-2} accounts for the inverse square irradiance reduction with range. Thus as a function of range (.2 to 1.5 km) the RMS signal will not change very much, approximately $(1.5/.2)^{1/2} = 2.7$. Of greater significance are changes in C_n^2, that may well range from 10^{-12} to 10^{-16}, so that signal RMS levels may vary by a factor of about 100 from this source. Thus a much more uniform signal fluctuation level is maintained by the AGC through the use of the mean-zero RMS signal than from signal strength alone.

Each of the four transmitted signals, represented by a single pulse in the 4-pulse train, is sorted out and the

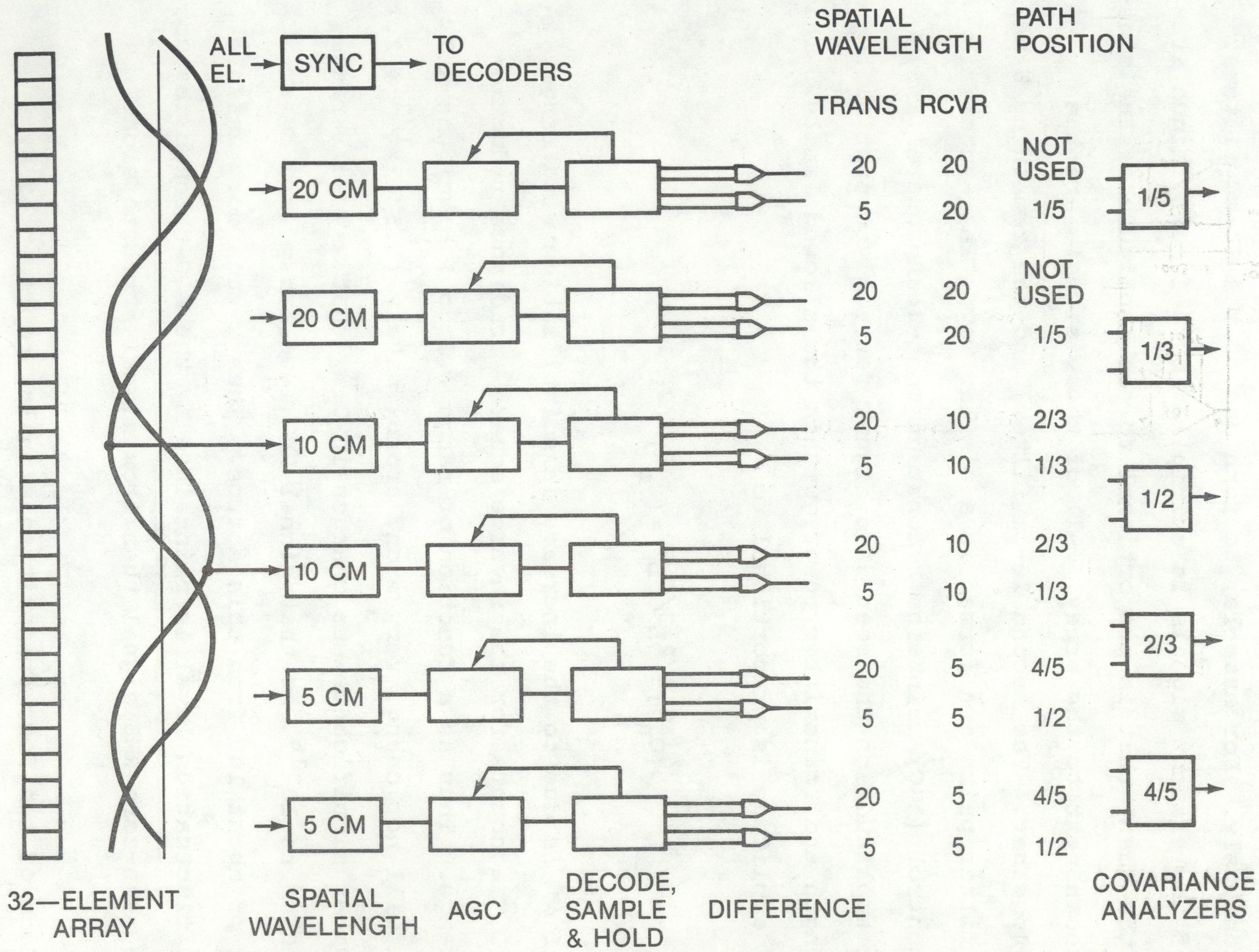

Figure 7. Block diagram of receiver. Five of the six available transmitter-receiver spatial wavelength pairs are used to make the crosswind measurement at 1/5, 1/3, 1/2, 2/3, and 4/5 of the transmitter-receiver separation.

amplitude fluctuations of each transmitter pulse train is obtained by the decode and sample and hold circuits. The 20 and 5-cm zero-mean transmitter filtering action is completed by taking the differences of the two transmitter signal pairs at this point.

There are six of these decode and sample and hold circuits so that all combinations of transmitting and receiving spatial wavelengths are available, as indicated in Fig 7. We obtain the wind speed by analyzing the covariance of each of five combinations of two transmitter filters and three receiver filter pairs, where each pair is separated 1/4 wavelength. For example, the two 10-cm wavelength pairs shown receive both transmitter signals. With proper decoding, transmitter and receiver wavelength pairs of 5 and 10 cm and 20 and 10 cm, respectively, are available. These combinations form filters in space at the 1/3 and 2/3 path positions respectively. The other combinations are formed in a similar fashion. The center position can be formed from transmitter and receiver filters of 20 and 20 cm, or 5 and 5 cm, respectively. The 5 cm wavelength was chosen as this wavelength performed best over the path length range of the instrument.

From Lee(9), the path position is $L(1+K_t/K_r)^{-1}$, and the spatial wavelength is $2\pi(K_t+K_r)^{-1}$, where L is the path length and K_t and K_r are the wavenumbers of the transmitter and receiver spatial filters. All of the spatial filter combinations are listed in Table I, together with the resultant spatial wavelength at each path location.

Table 1.

Path Position	Spatial Wavelength, cm Transmitter	Receiver	at Path Position
1/5	5	20	4
1/3	5	10	3.33
1/2	5	5	2.5
2/3	20	10	6.67
4/5	20	5	4

The covariance analyzer boards obtain the wind speed by measuring the mean frequency and direction of crossing of irregularities in refractive index passing through each of the filters formed at the five path positions. Since the spatial wavelength w of each filter is known, the transverse wind speed v can be calculated from a measurement of the mean frequency f as

$$v = kfw.$$

A correction factor k is required because the scintillation-pattern irregularities are not frozen but change as the pattern moves across the receiver spatial filter. These changes in the pattern are caused by the decay of refractive-index irregularities, and irregularities in wind speed and direction within the measurement volume. This causes the mean measured spatial wavelength to be slightly smaller than the spatial wavelength of the filter. A mean value for k has been determined experimentally, though some variation in value may be expected.

Figure 8 is a block diagram of the covariance analyzer. The two input signals V_1 and V_2 are filtered by a band-pass (BP) analog and a low-pass digital filter (LP), precision clipped, and then passed through digital low-pass filters. The shift registers delay the incoming signals so that the signals are delayed with both positive and negative time lags relative to each other. We use exclusive-or circuits to obtain the normalized covariance at 14 time lags on the covariance function. These 14 signals (a,b,c,d,e,f,g,h,i,j,k,l,m,n), are combined as (l+m+n)-(h+i+j+k)+(d+e+f+g)-(a+b+c). This summation will be positive if the time lags are short relative to the signal covariance and negative for time lags long compared to signal covariance. The signal is integrated, converted to a frequency proportional to the integrated signal (A/f), and used to clock the shift registers. If the polarity and time constants are properly arranged, the error voltage in this servo loop will change the shift register delay until the summation is zero. The shape of the covariance function will of course influence the delay for zero sum. This arrangement efficiently measures the mean frequency of the coherent portions of the signals, weighting most heavily the signals that are 90 degrees out of phase. If the analog-to-frequency converter is linear, then its input

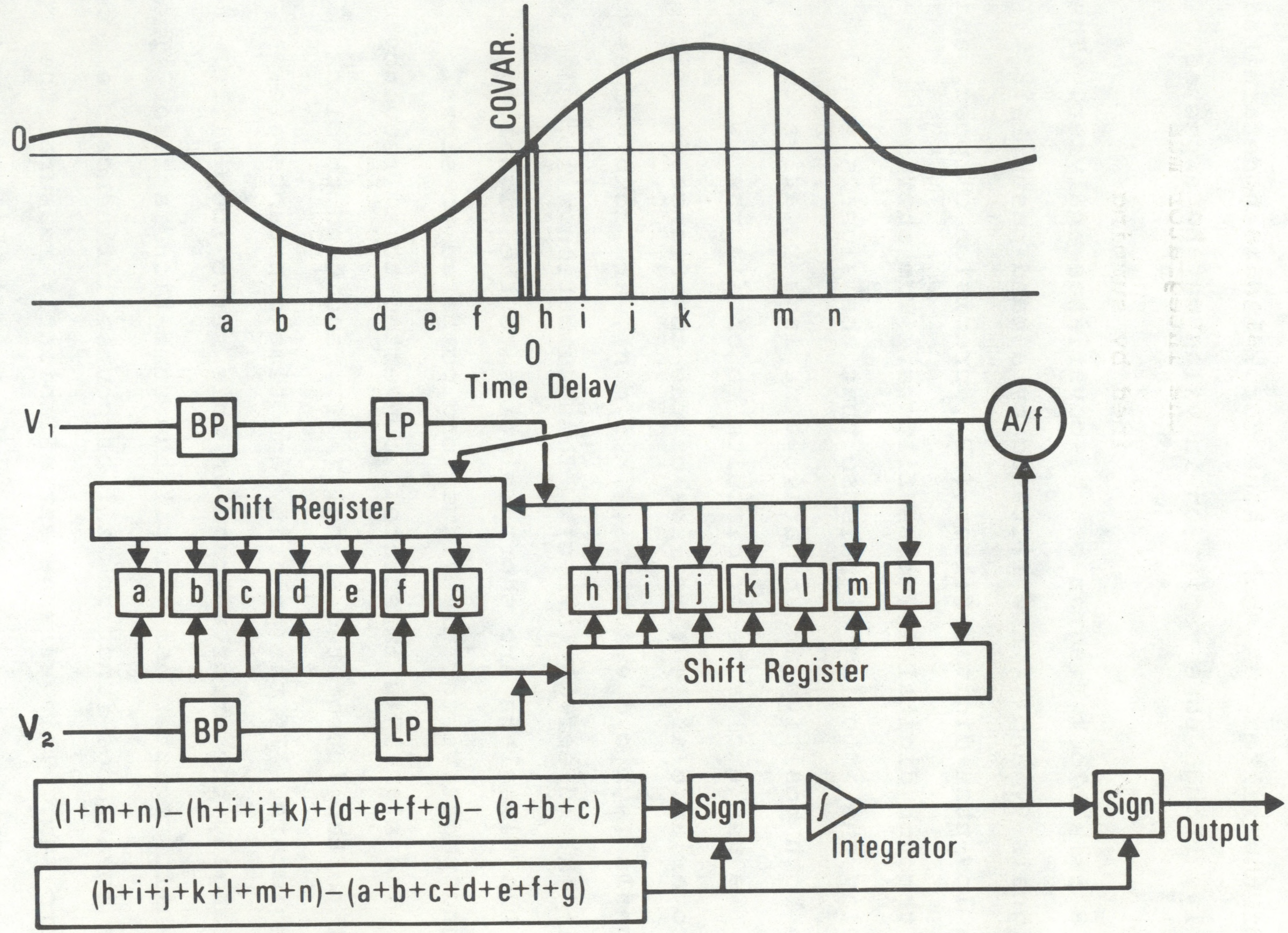

Figure 8. The normalized covariance of each pair of filter signals is analyzed at 14 points of delay. A servo system continually adjusts the shift register delay so that the summation (l+m+n)-... is zero. The second summation indicates the wind crossing direction.

voltage will be proportional to the mean frequency of the coherent portion of the signals.

If the phase relationship of the input signals reverses sign, the sign of the servo voltage to the integrator must also be reversed. This information is obtained by summing (h+i+j+k+l+m+n)-(a+b+c+d+e+f+g). The sign of this sum is used to change the sign of the error voltage in the servo loop. It is also used to change the sign of the output. Thus the amplitude of the output voltage is proportional to the mean frequency of the coherent quadrature components of the signals, and its sign indicates whether input A or B is leading.

This measurement technique, by using the knowledge that the signals are coherent and in phase quadrature, very effectively discriminates against noise likely to be present that does not have these characteristics. Examples are uncorrelated noise present in the two signals, arising from the detectors and amplifiers, and identical signals in phase that are present at both inputs, such as 60 Hz power line noise. In addition, if smaller out of phase coherent signals are present, the system tends to ignore these, and remain locked on the dominant signals in phase quadrature.

The above discussion outlines the principles of operation, but of course the actual circuit design must consider such things as optimum servo time constants, servo capture problems, optimum shift-register frequency response, and sign switching time

constants.

3. OPERATING PROCEDURE

The transmitter and receiver should be mounted on solid vibration-free supports to maintain pointing and prevent movements that will cause amplitude fluctuations in the optical signal and reduce the signal-to-noise. The system can be set up over path lengths from 200 m to 1.5 km and can be aligned using the sighting telescopes. When aligned, the receiver signal meter should read nearly full scale.

CAUTION: Direct sunlight should not fall on either the transmitting or receiving Fresnel lenses. Sunlight even partially focused through these large-aperture short focal length lenses can generate very high temperatures and damage the equipment.

The receiver sighting telescope alignment can be checked by moving the receiver from side to side and up and down until the signal meter starts to drop, and noting whether the cross-hairs are set to be midway between these extremes. The same adjustment can be done for the transmitter telescope, but this of course requires communication between transmitter and receiver.

The wind measurements for the five path locations are displayed on the panel meters. Full scale is 20 m/s and a plus meter indication (to the right of center zero) indicates a wind component crossing direction from left to right as viewed from the receiver. The signals are available on the output BNCs where the wind speed v in m/s is

$$v = 6.67\ V$$

for output voltage V.

The CAL RUN, FULL SCALE, and REVERSE FORWARD switches are used to check the operation and calibration of the five covariance analyzers. To check the calibration and/or to carry through calibration voltages to recording equipment, set the CAL RUN switch to CAL and hold in the FULL SCALE button until all meters are full scale. When the button is released, the meters and output voltages should read as listed in Table 2. If not, adjustments can be made by following the covariance analyzer calibration procedure listed in the appendix.

Table 2.

Position	Meter Reading m/s	Output Voltage Volts
1/5	12	1.8
1/3	10	1.5
1/2	7.5	1.13
2/3	20	3
4/5	12	1.8

4. FIELD ALIGNMENT PROCEDURE

A detailed discussion of the circuits and initial alignment is contained in the Appendix. The methods discussed below, while not required routinely, may be used in the field to check and adjust the system.

When the system is aligned, the four signal pulses, as observed with an oscilloscope at the signal BNC, should be nearly the same height (within 10% or so). If not, the transmitter pointing should be checked and if it is correct, then the unbalance may be corrected by observing the pulse heights at the receiver and adjusting the height of the individual pulses at the transmitter. This is accomplished by adjusting the LED drive currents with the recessed screwdriver adjustments on the back of the transmitting unit. The efficiencies of the LEDs vary so that in general equal light outputs require different drive currents. If, when adjusting the pointing of the transmitter, a point cannot be found where all four pulses peak up at the same time, it will be necessary to realign the transmitter optics. This can be done by turning off transmitters 2, 3, and 4 and adjusting the transmitter pointing to peak up pulse 1. Then turn up 2, 3, and 4 in turn and peak them up by loosening the LED mounting screws and moving them around in the oversize holes. The transmitter power supply must be removed to get at the rear LEDs. Of course the crosshairs of the sighting telescope must be readjusted to center on the receiver after this procedure is completed.

The receiver optical alignment is not likely to get out of adjustment as there is only one optical train. However, as discussed previously, it is important that the sighting telescope crosshairs be at the center of the receiver field of view.

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APPENDIX A: Circuit Diagrams and Initial Calibration

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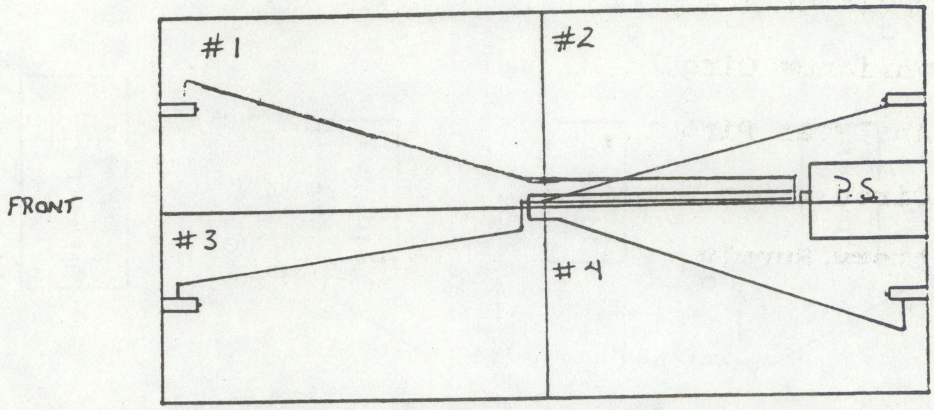
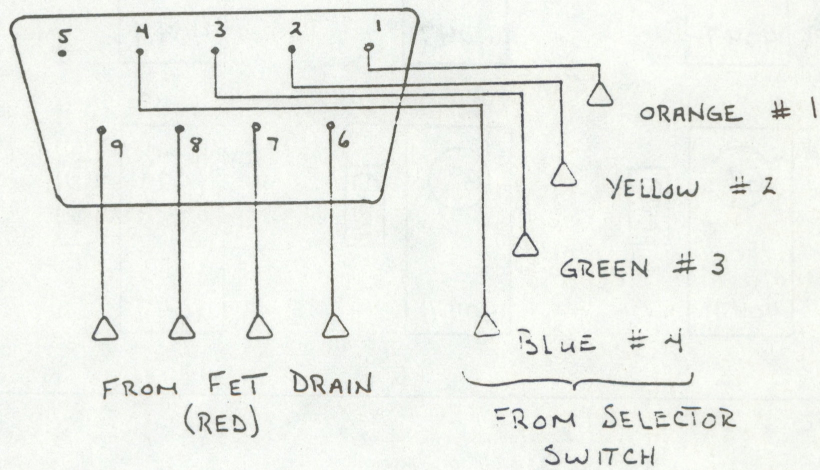
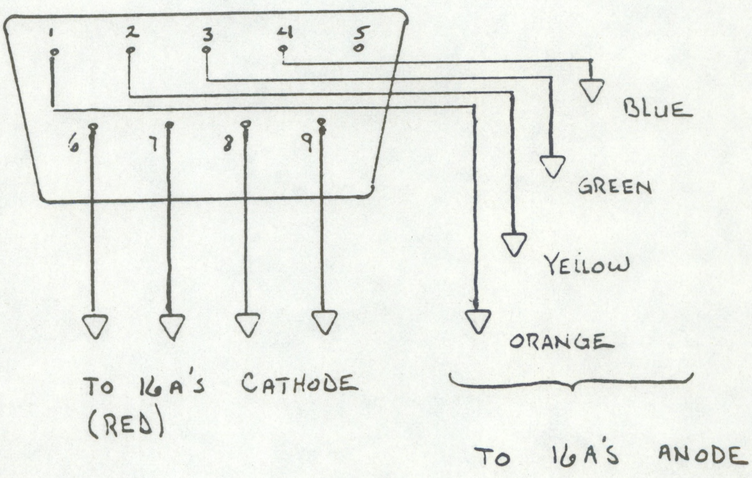
TRANSMITTER WIRING



Power Supply
(output plug)



TRANSMITTER



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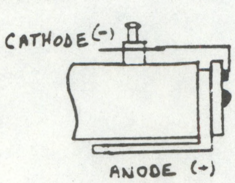
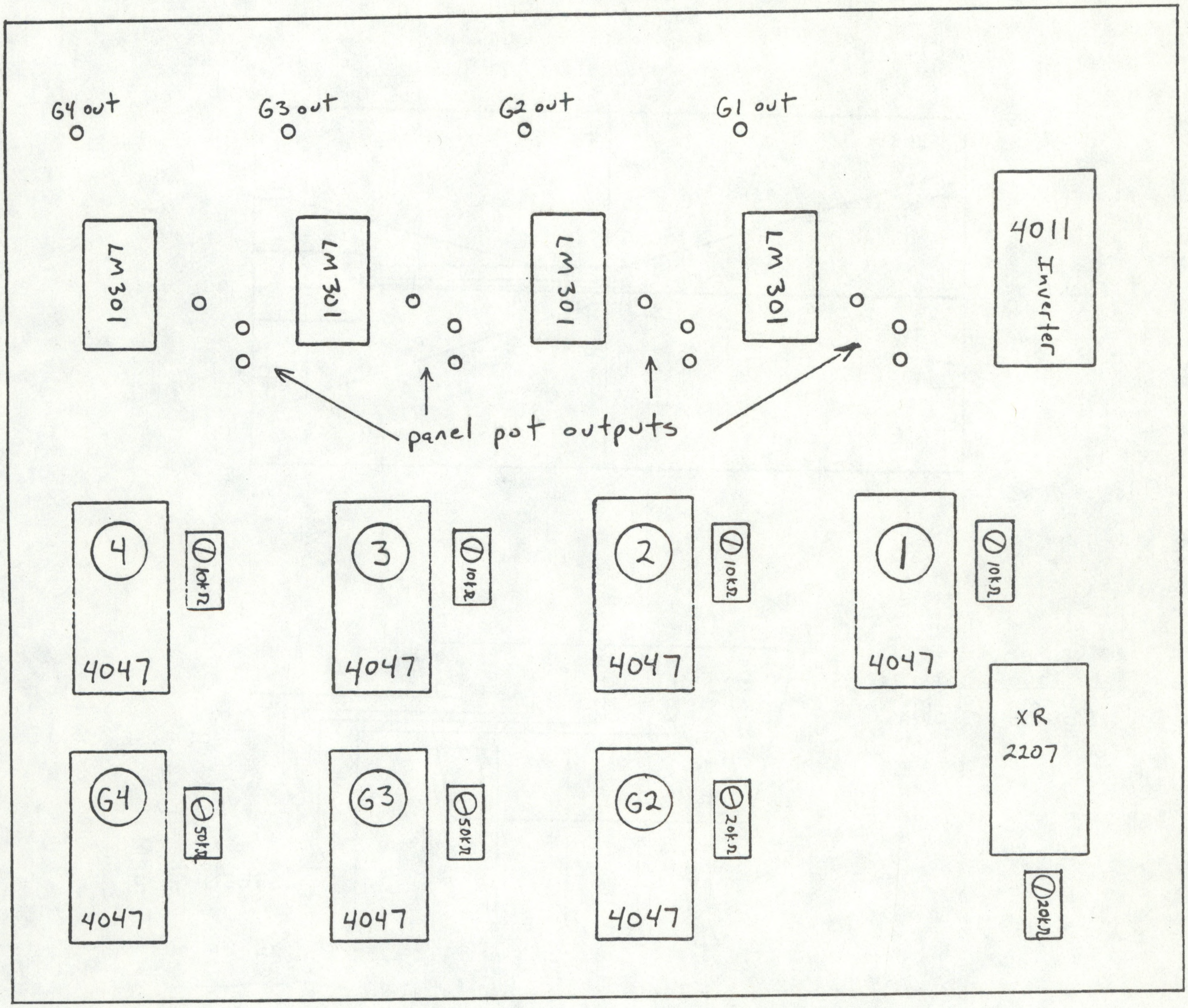
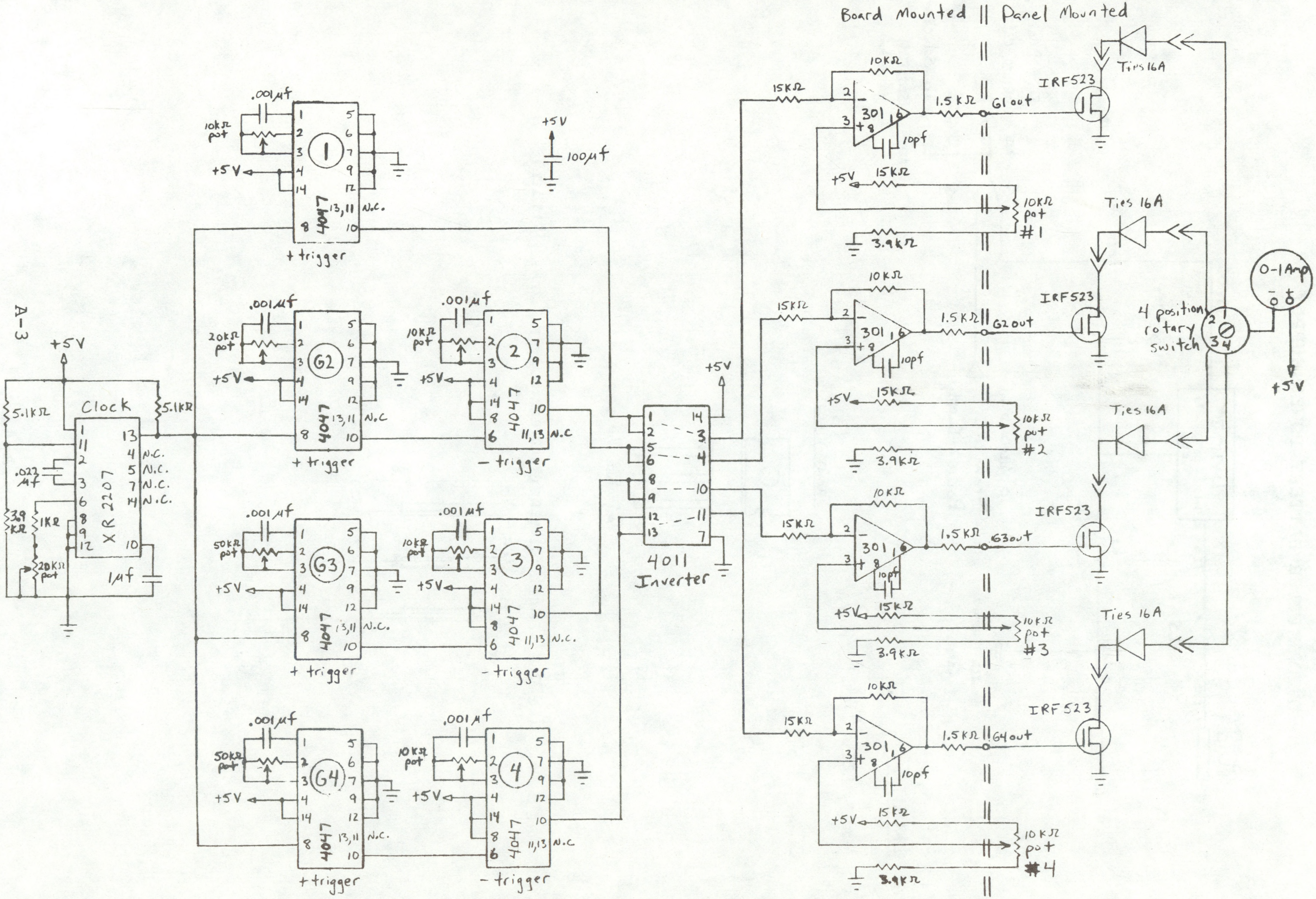


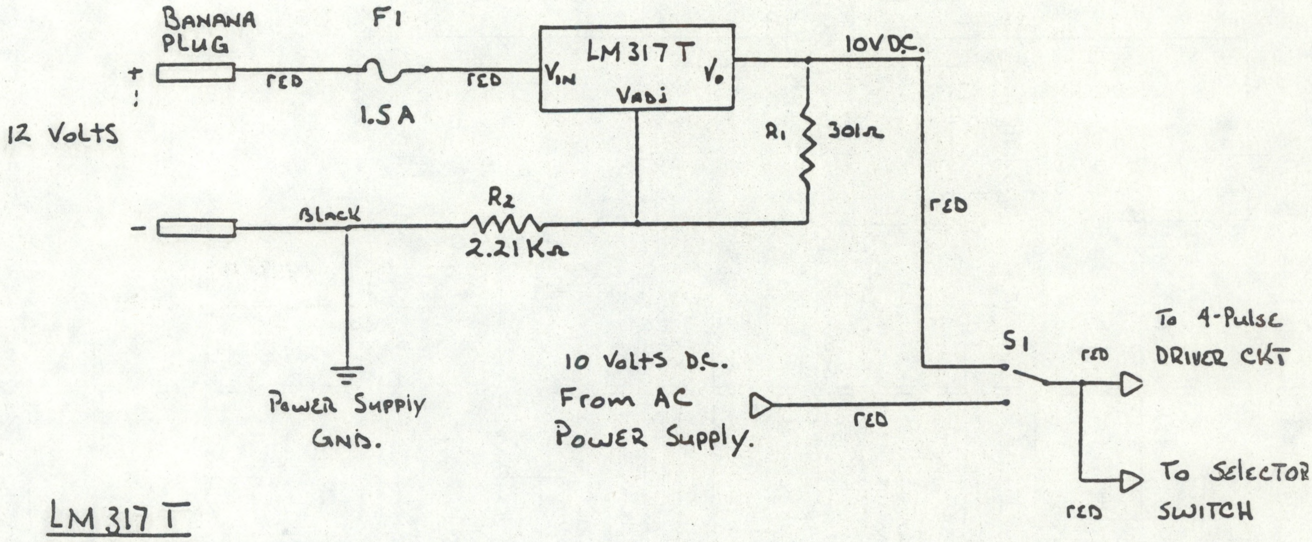


TRANSMITTER 4-PULSE DRIVER BOARD LAYOUT



TRANSMITTER 4-PULSE DRIVER CIRCUIT

TRANSMITTER BATTERY POWER SUPPLY

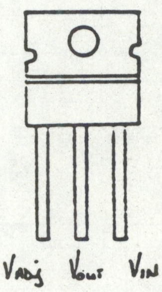


LM 317 T

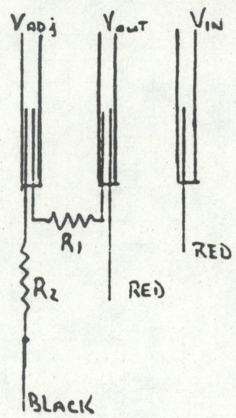
$V_{OUT} = 1.25v\,(1 + R_2/R_1)$

I_{max} 1.5 A

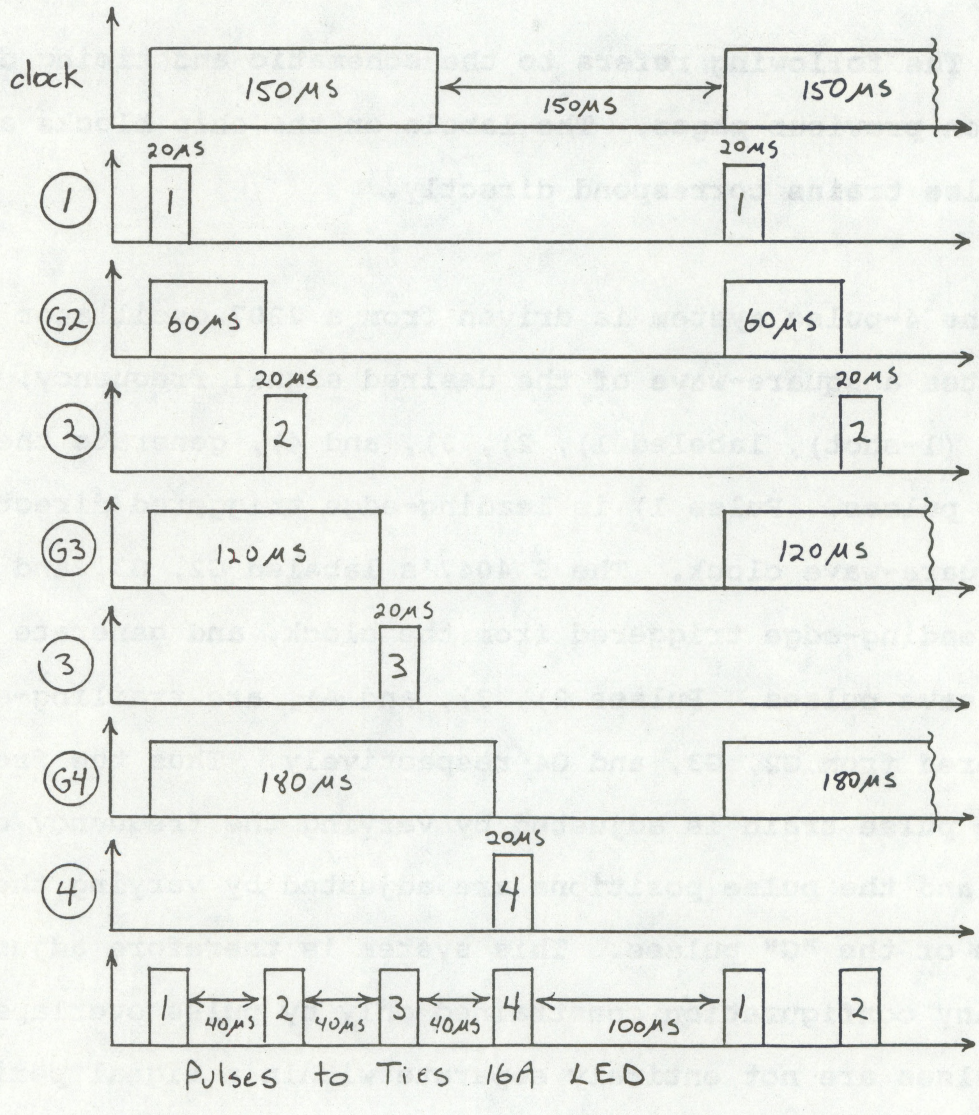
FRONT VIEW



NOTE: R1 AND R2 ARE SOLDERED DIRECTELY TO THE LM317T.



TRANSMITTER 4-PULSE DRIVER TIMING DIAGRAM

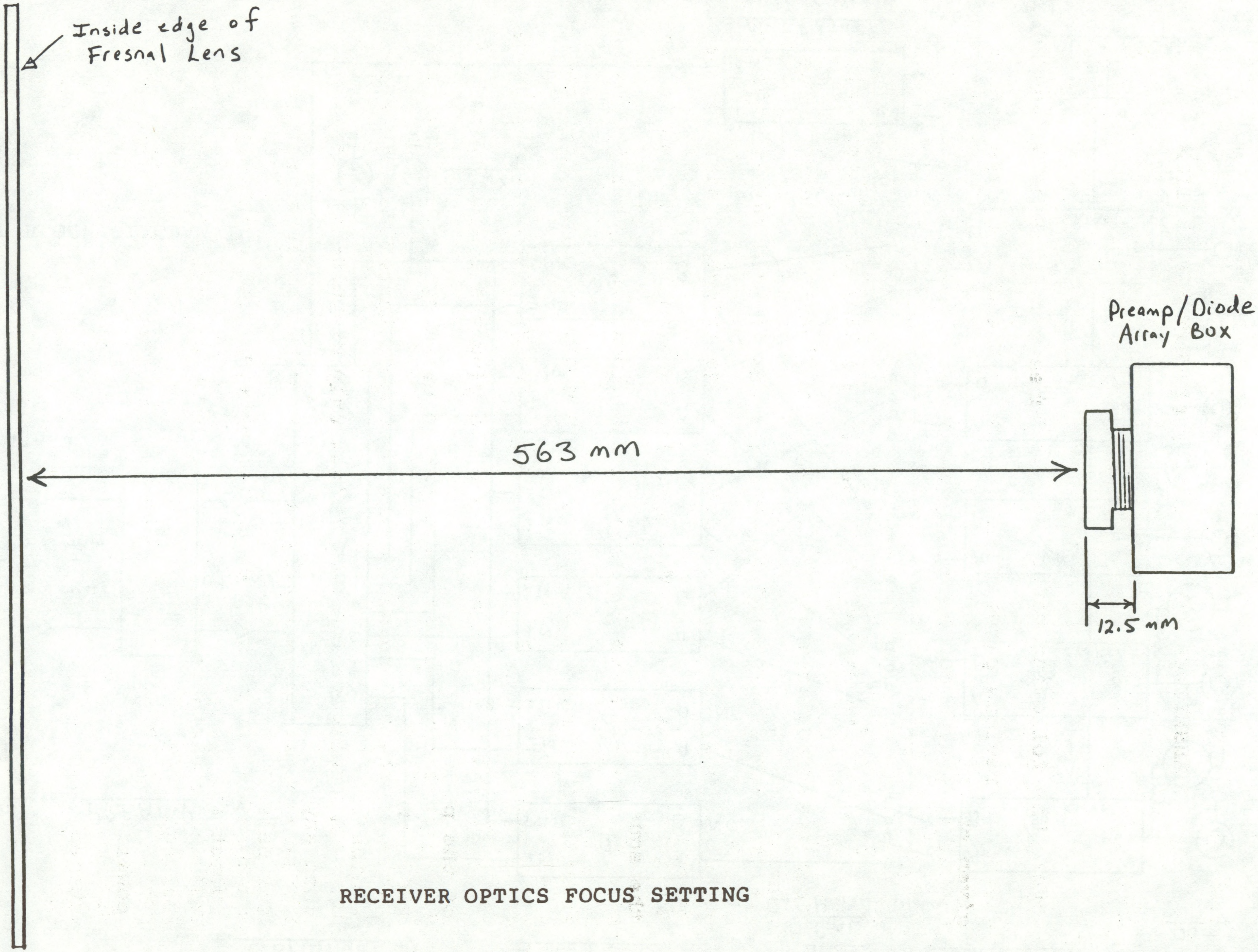


Note: Each diagram represents the output of the chip it's letter or number corresponds to.

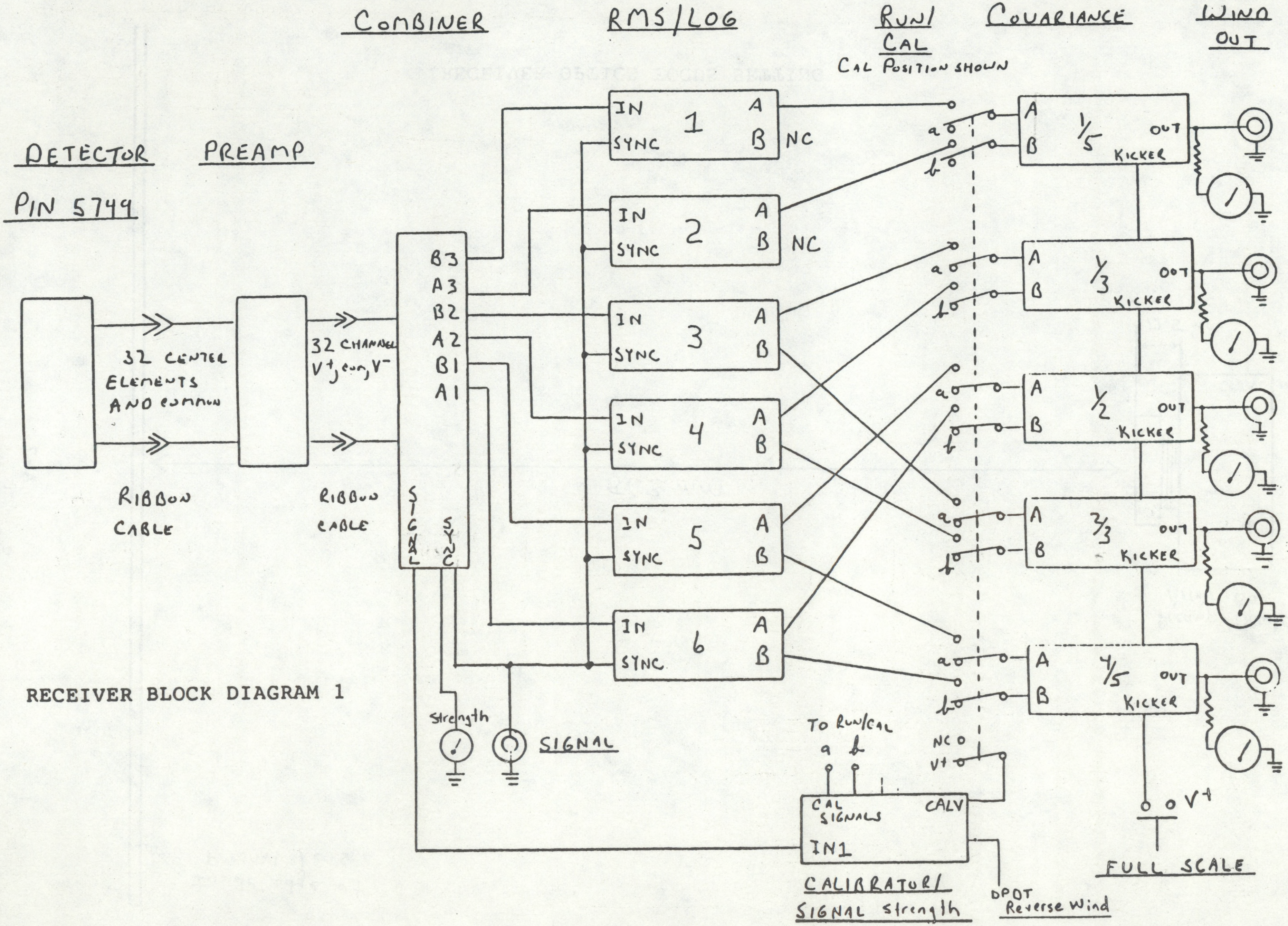
TRANSMITTER 4-PULSE DRIVER CIRCUIT EXPLANATION

Note: The following refers to the schematic and timing diagrams given on previous pages. The labels on the chip blocks and on the pulse trains correspond directly.

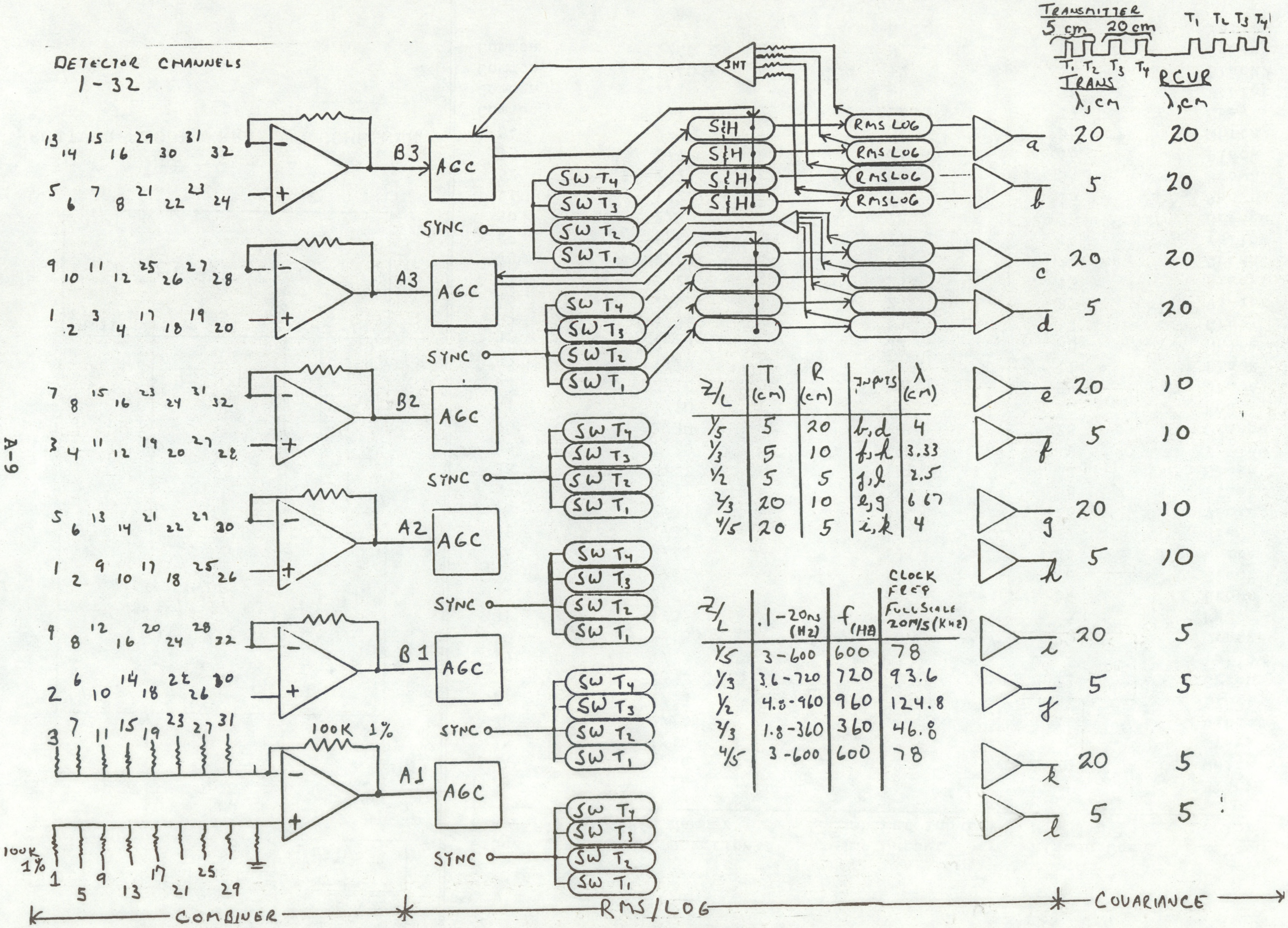
The 4-pulse system is driven from a 2207 oscillator which generates a square-wave of the desired signal frequency. The 4 4047's (1-shot), labeled 1), 2), 3), and 4), generate the actual output pulses. Pulse 1) is leading-edge triggered directly from the square-wave clock. The 3 4047's labeled G2, G3, and G4, are also leading-edge triggered from the clock, and generate the interleave pulses. Pulses 2), 3), and 4), are trailing-edge triggered from G2, G3, and G4 respectively. Thus the frequency of the pulse train is adjusted by varying the frequency of the 2207, and the pulse positions are adjusted by varying the pulse-widths of the "G" pulses. This system is therefore adjustable into any configuration constrained only by pulse overlaps. If the pulses are not entirely separate within a signal period, the output will not be that which is desired. The op-amps provide a voltage to the gates of the FETS, which controls LED output power. The inverter serves as a buffer between the other two stages.



RECEIVER OPTICS FOCUS SETTING



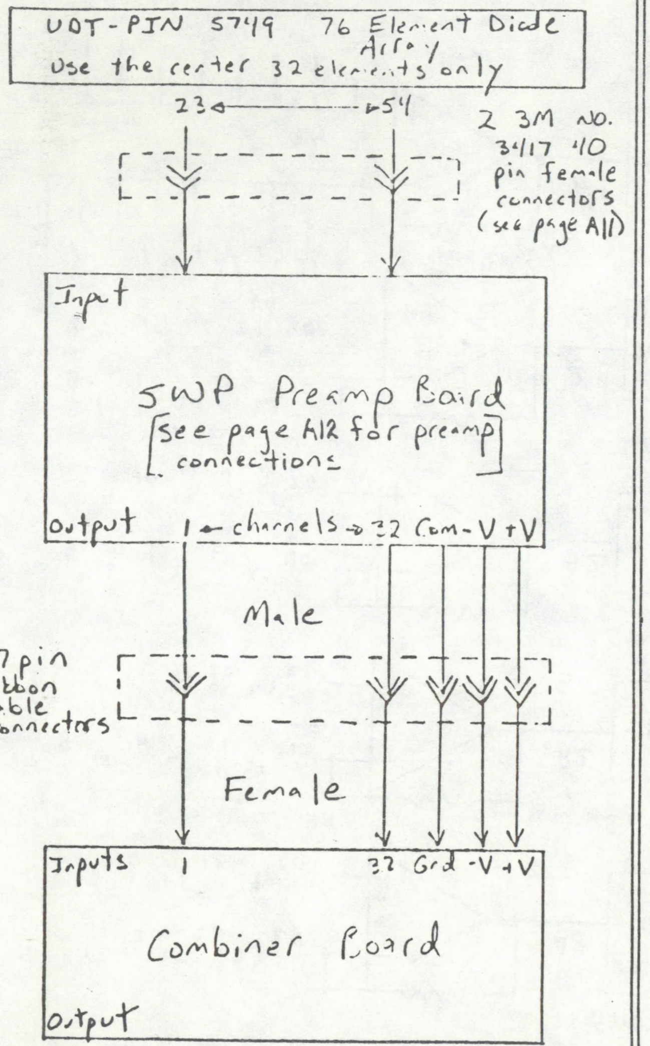
RECEIVER BLOCK DIAGRAM 1



Z/L	T (cm)	R (cm)	INPUTS	λ (cm)
1/5	5	20	b, d	4
1/3	5	10	f, h	3.33
1/2	5	5	j, l	2.5
2/3	20	10	e, g	6.67
4/5	20	5	i, k	4

Z/L	.1-20ns (Hz)	f (Hz)	CLOCK FREQ FULLSCALE 20M/S (KHz)
1/5	3-600	600	78
1/3	3.6-720	720	93.6
1/2	4.8-960	960	124.8
2/3	1.8-360	360	46.8
4/5	3-600	600	78

RECEIVER BLOCK DIAGRAM 2

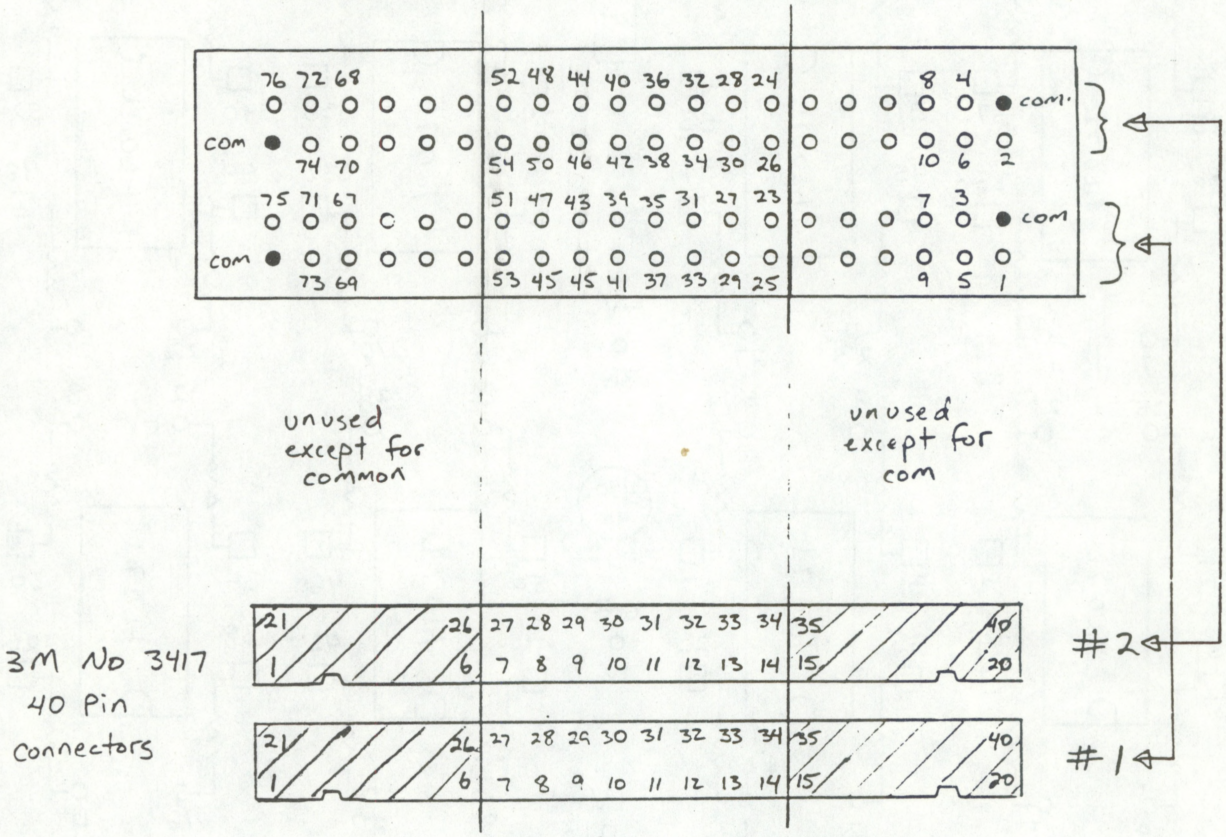


RECEIVER DIODE ARRAY TO COMBINER

Diode Array Element #	3M Connection # /Pin Number	Preamp Output # & Combiner input #	Ribbon Conn. Pin #'s	Ribbon Color
23	1/34	1	1	Black
24	2/34	2	20	White
25	1/14	3	2	Grey
26	2/14	4	21	Violet
27	1/33	5	3	Black
28	2/33	6	22	Green
29	1/13	7	4	Yellow
30	2/13	8	23	Orange
31	1/32	9	5	Red
32	2/32	10	24	Brown
33	1/12	11	6	Black
34	2/12	12	25	White
35	1/31	13	7	Grey
36	2/31	14	26	Violet
37	1/11	15	8	Black
38	2/11	16	27	Green
39	1/30	17	9	Yellow
40	2/30	18	28	Orange
41	1/10	19	10	Red
42	2/10	20	29	Brown
43	1/29	21	11	Black
44	2/29	22	30	White
45	1/9	23	12	Grey
46	2/9	24	31	Violet
47	1/28	25	13	Black
48	2/28	26	32	Green
49	1/8	27	14	Yellow
50	2/8	28	33	Orange
51	1/27	29	15	Red
52	2/27	30	34	Brown
53	1/7	31	16	Black
54	2/7	32	35	White
Common	1/1 X	Grnd	17	Grey
Common	2/1 X	-V	36	Violet
Common	1/40 X	+V	18	Black
Common	2/40 X	N.C.	37	Green
		N.C.	19	Yellow

RECEIVER DIODE ARRAY AND PREAMP CONNECTORS

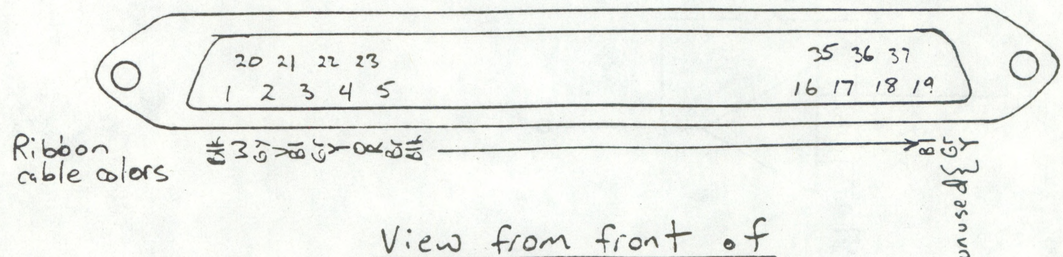
Rear View of Pin 5749 Diode Array



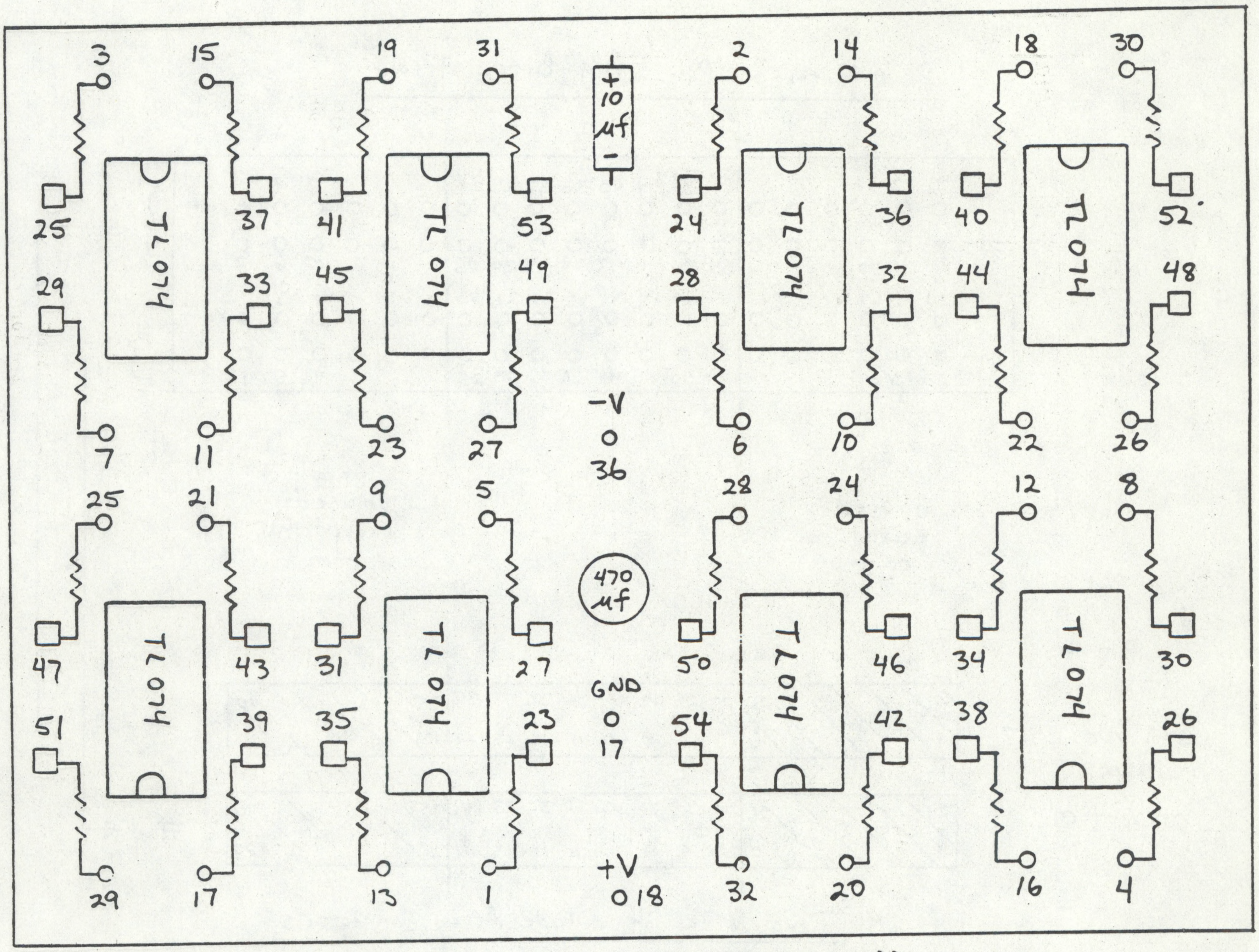
Rear View of Diode Array Connectors

Preamp Output to Combiner Connector

37 pin ribbon connector



View from front of female

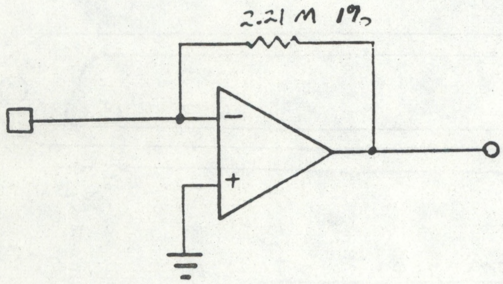


Top View (Preamp Board)

Key : o → Output to Combiner board;
Numbers indicate the ribbon cable connector pin #'s

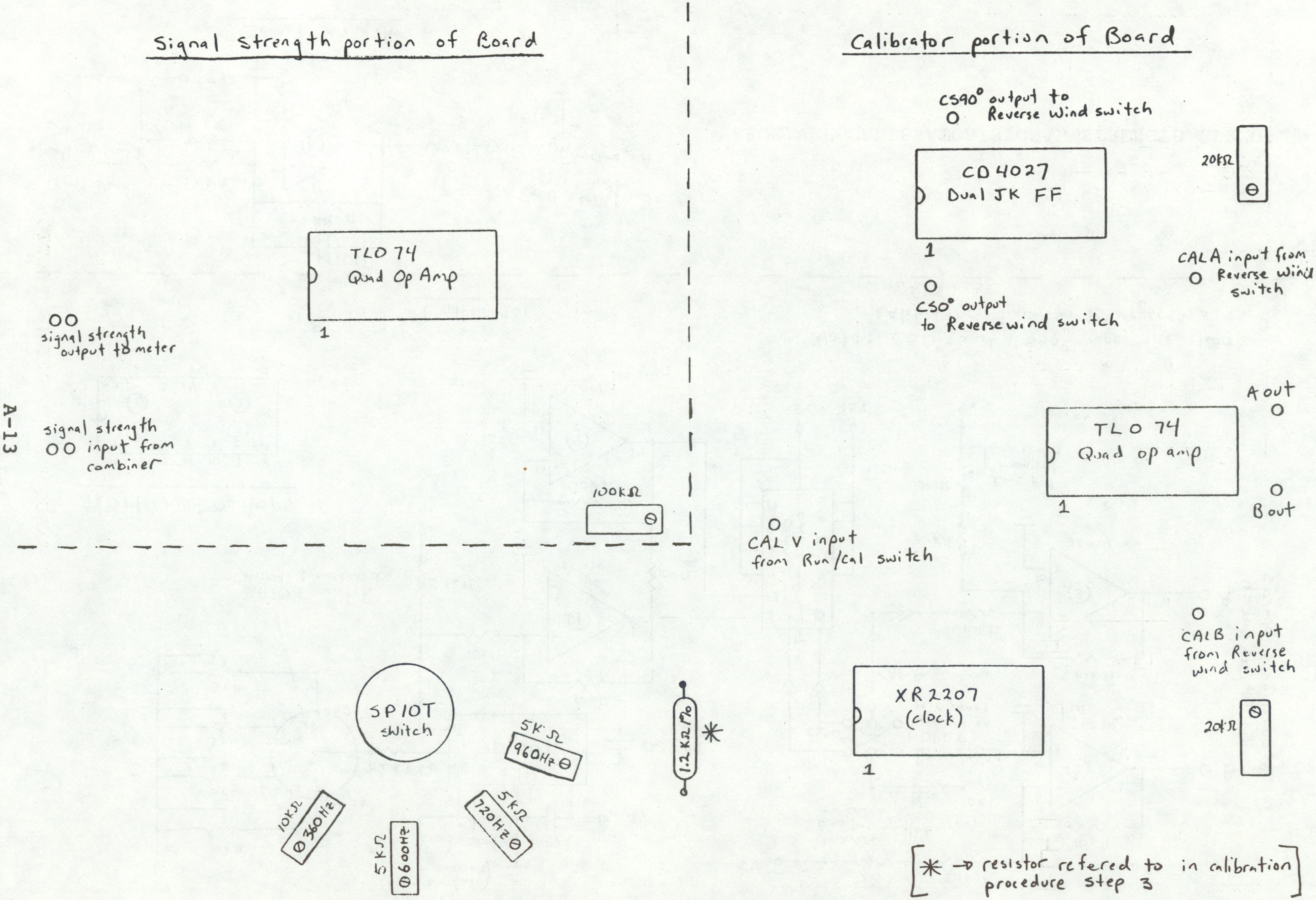
□ → Input from Diode Array;
Numbers indicate the diode array element number used as input

All resistors are 2.21 Meg 1%



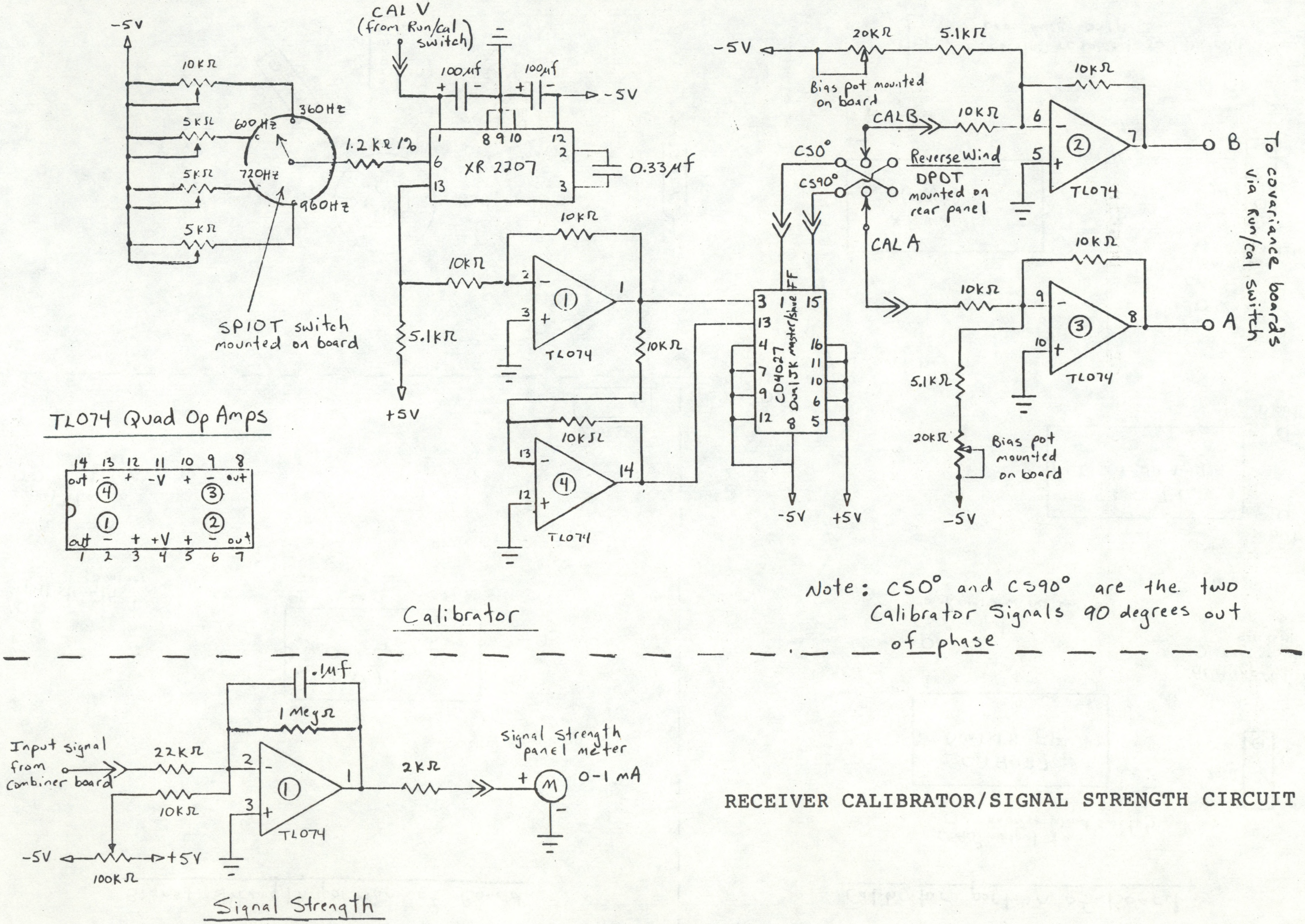
1/4 of TL074 Circuit (32 total)

RECEIVER PREAMP INPUT AND OUTPUT CONNECTIONS



RECEIVER CALIBRATOR/SIGNAL STRENGTH BOARD LAYOUT

10/13/87

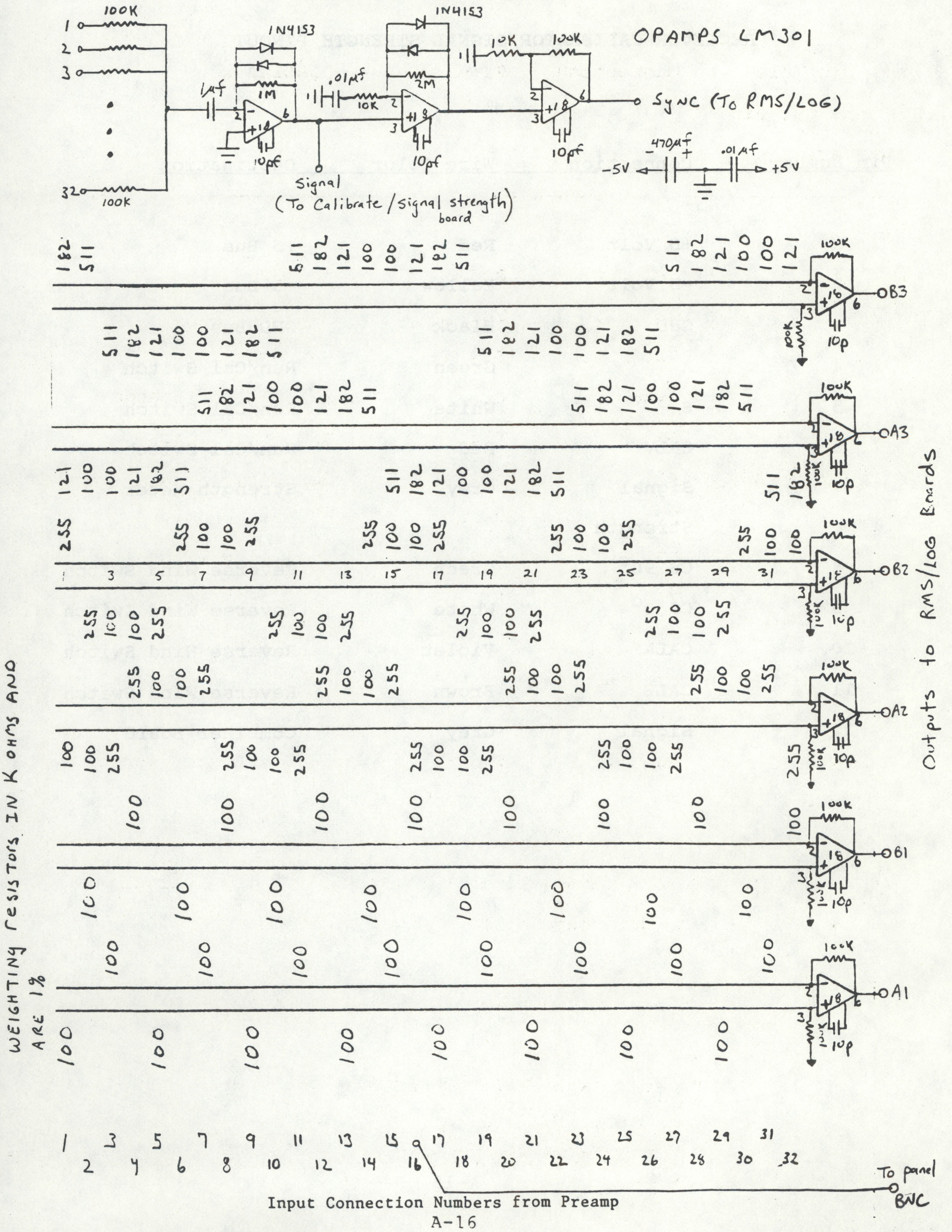


RECEIVER CALIBRATOR/SIGNAL STRENGTH CIRCUIT

RECEIVER CALIBRATOR/SIGNAL STRENGTH PINOUT

Pin Number	Connection	Wire Color	Destination
1	+5 Volt	Red	+5 Bus
2	-5 Volt	Yellow	-5 Bus
3	GND	Black	GND Bus
4	A	Green	Run/Cal Switch
5	B	White	Run/Cal Switch
6	CALV	Red	Run/Cal Switch
7	Signal Strength	Grey	Strength Meter
8	CS 90^o	Green	Reverse Wind Switch
9	CS 0^o	White	Reverse Wind Switch
10	CALA	Violet	Reverse Wind Switch
11	CALB	Brown	Reverse Wind Switch
12	Signal	Grey	Combiner Board

RECEIVER COMBINER CIRCUIT



Input Connection Numbers from Preamp

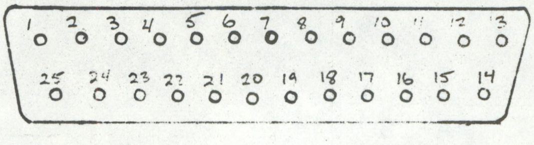
RECEIVER CALIBRATOR/SIGNAL STRENGTH PINOUT

25 Pin Male Connector Pin Numbers	Connection	Wire Color	Destination
1	+5 Volt	Red	+5 Bus
2	-5 Volt	Yellow	-5 Bus
3	GND	Black	GND Bus
4	Sync	Grey	All RMS/Log Boards
5	B3	Blue	RMS Board 1 in
6	A3	Blue	RMS Board 2 in
7	B2	Blue	RMS Board 3 in
8	A2	Blue	RMS Board 4 in
9	B1	Blue	RMS Board 5 in
10	A1	Blue	RMS Board 6 in
11	Channel 16 from Preamp	Grey	To Panel BNC Signal
12	Signal	Grey	To Calibrator Board
13-25	N.C.		

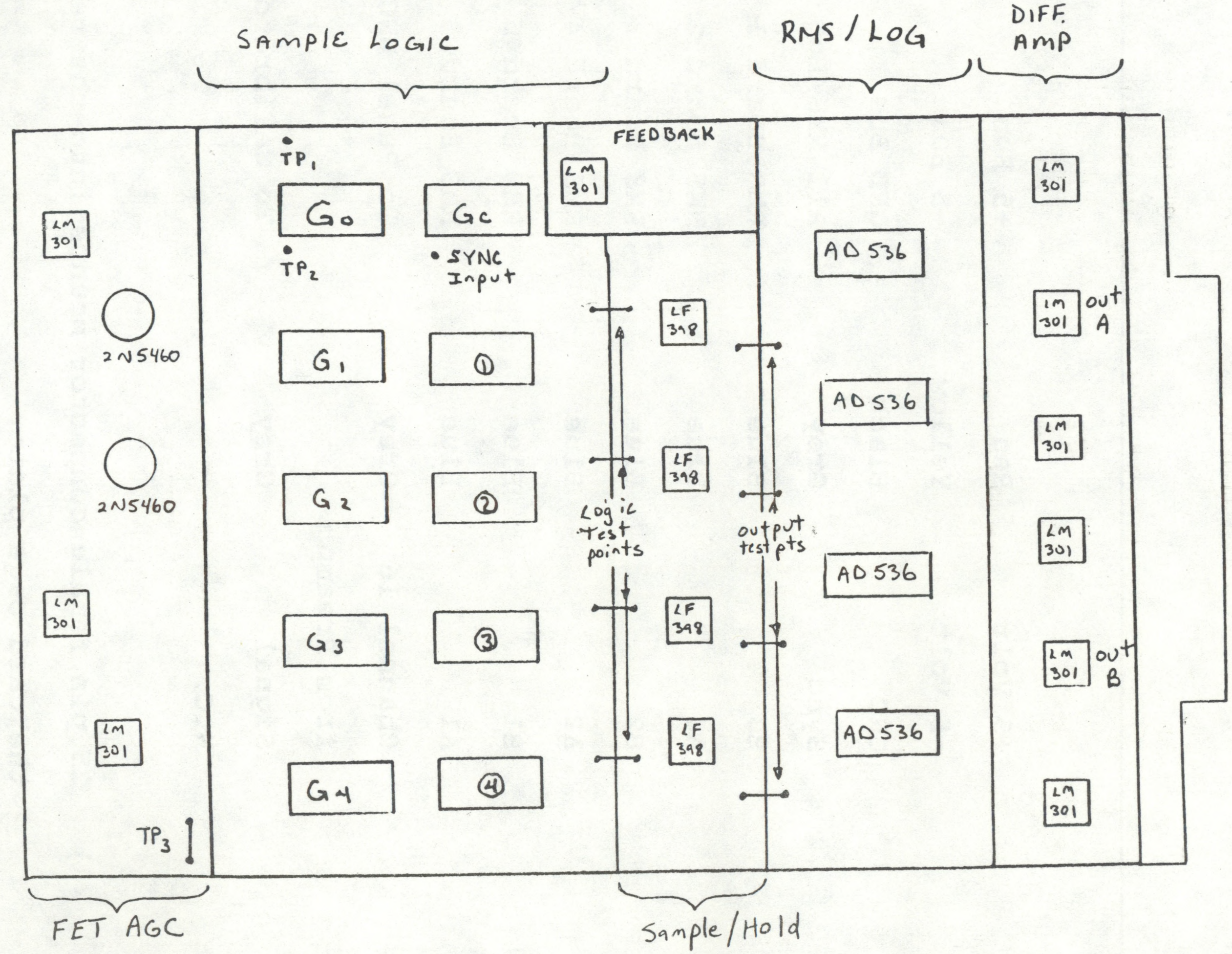
Notes: 1) 25 pin female connector mounts into the rear of the card cage plate.

2) Connector pin numbers (TRW 8651 DB25P)

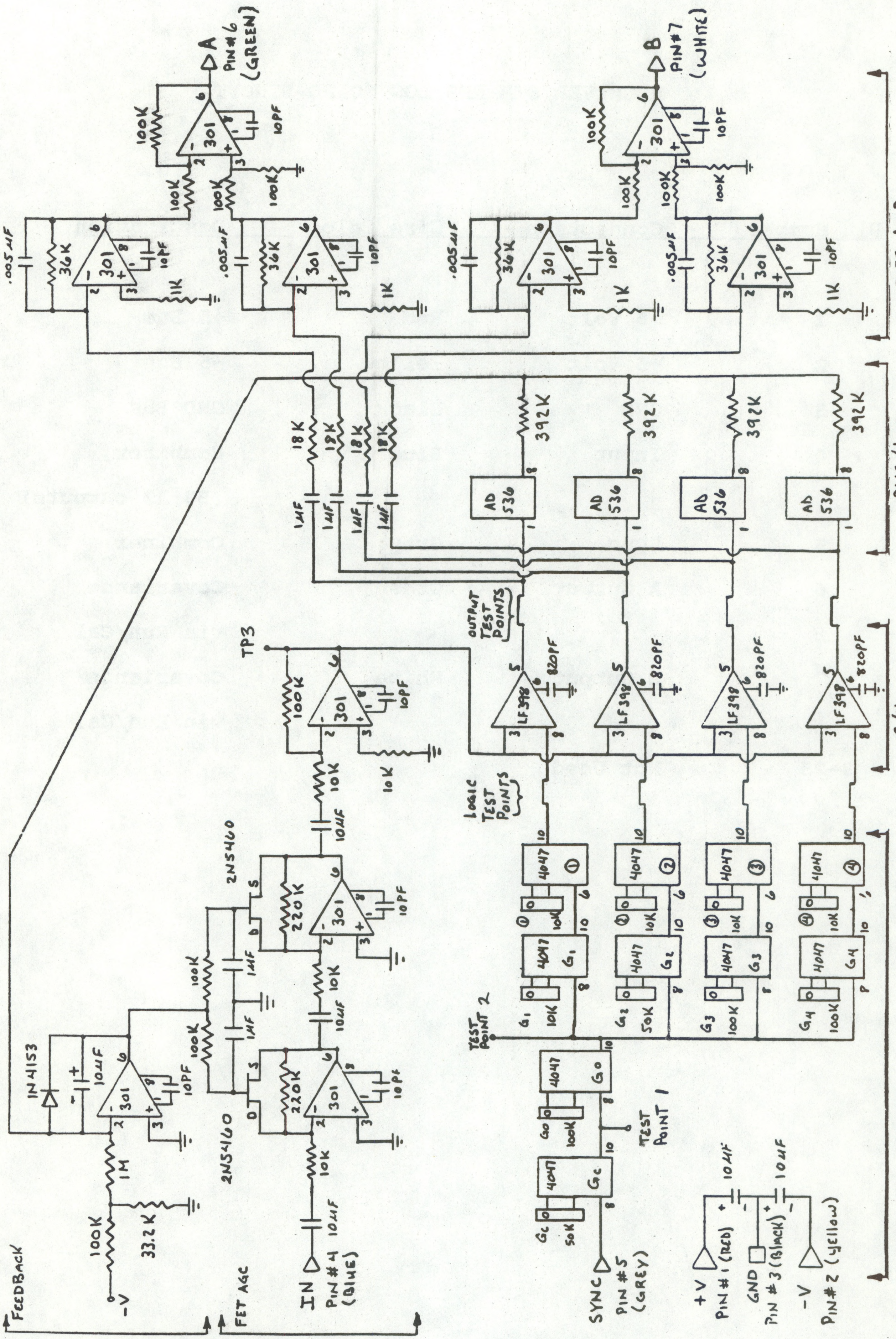
Front View of Male Connector



RECEIVER S/H RMS LOG BOARD LAYOUT



S/H RMS LOG

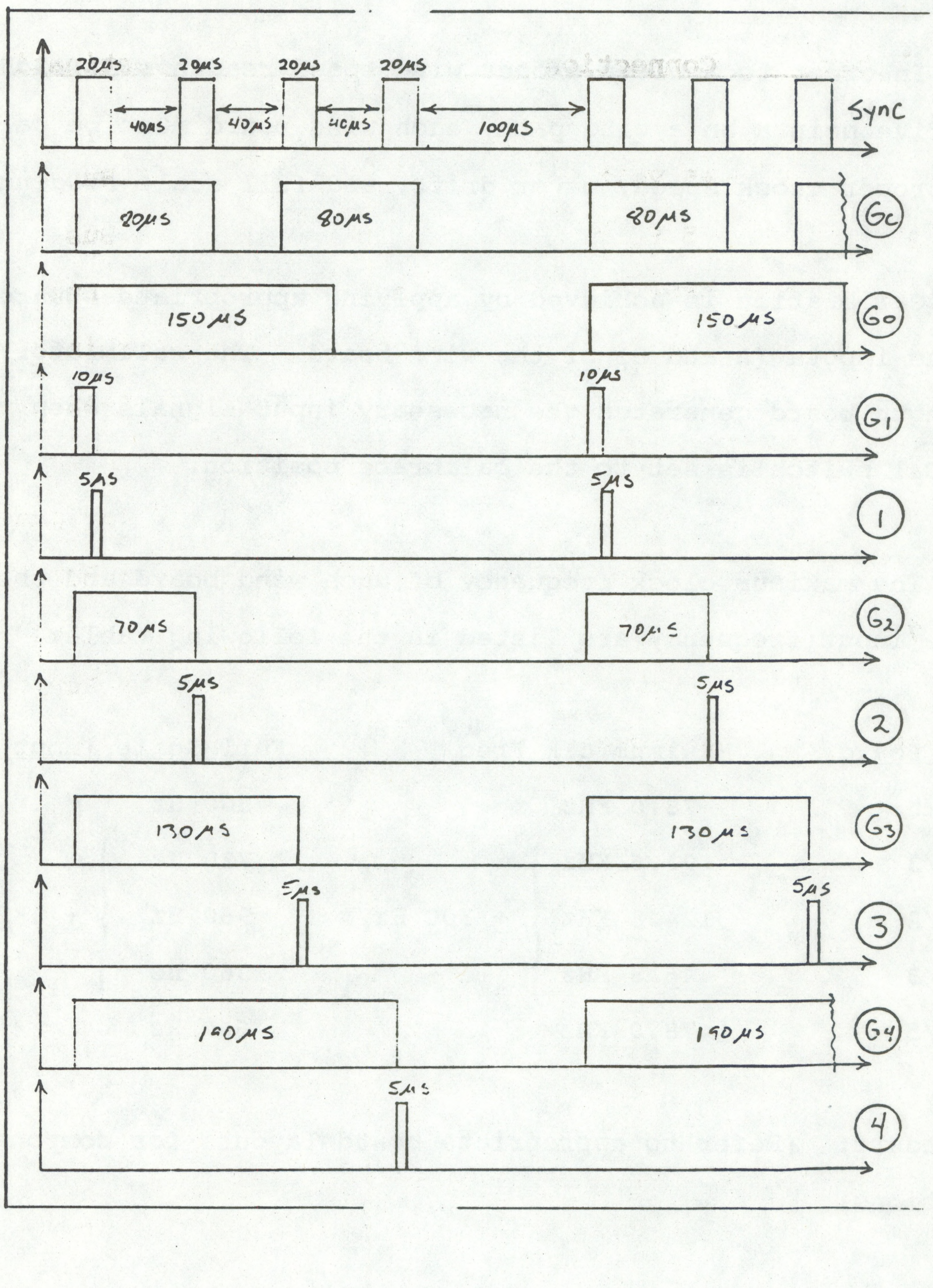


RECEIVER S/H RMS LOG CIRCUIT

RECEIVER S/H RMS LOG BOARD PINOUT

Pin Number	Connection	Wire Color	Destination
1	+5 Volt	Red	+5 Bus
2	-5 Volt	Yellow	-5 Bus
3	GND	Black	GND Bus
4	Input	Blue	Combiner (B3-A2 outputs)
5	Sync	Grey	Combiner
6	A Output	Green	Covariance via Run/Cal
7	B Output	White	Covariance via Run/Cal
9-25	Not Used		

RECEIVER S/H RMS LOG TIMING DIAGRAM



RECEIVER COVARIANCE ANALYZER BOARD CALIBRATION PROCEDURE

In order to achieve proper wind speed readings at each of the five points on a wind path, each wind board must be calibrated for proper clock speed, meter drift, and full scale readings.

Calibration is achieved by applying appropriate square waves to the inputs (A and B) of the wind board. The calibrator/signal strength board generates the necessary input signals when the Run/Cal switch is set to the calibrate position.

The maximum clock frequency of each wind board and the full scale input frequency are listed in the following table:

Wind Board	Maximum Clk Freq.		Full Scale Input Freq.	
1/5	78.0 KHz		600 Hz	
1/3	93.6 KHz	± 300 Hz	720 Hz	± 1 Hz
1/2	124.8 KHz	± 300 Hz	960 Hz	± 1 Hz
2/3	46.8 KHz	± 300 Hz	360 Hz	± 1 Hz
4/5	78.0 KHz		600 Hz	

Procedure: (Refer to appropriate board layouts for component locations)

1) Set Run/Cal switch to calibrate position.

2) Using the extension connector, plug a wind board into one of

the wind board sockets.

3) Cal/Signal strength board:

Place a jumper across the 1.2 KΩ resistor and set the frequency control switch to 600 Hz.

By jumping across the resistor, the input frequency to the wind board is increased to at least 2500 Hz. This frequency will be filtered by the low pass filters (circuit 1) of the wind board and DC signals will be applied to the digital circuitry (circuit 2).

4) Connect a frequency counter to the clock output test point of the wind board. (Jumper near pin 8 of chip 5.)

5) Press and hold the full scale button mounted on the rear panel. The maximum clock frequency is now indicated on the frequency counter. Compare this value to the value listed in the table for the wind board being calibrated. Adjust the clock frequency to the required value.

6) Adjusting Meter Drift

Note: IT IS CRITICAL THAT THE METER DRIFT BE TOWARD ZERO.

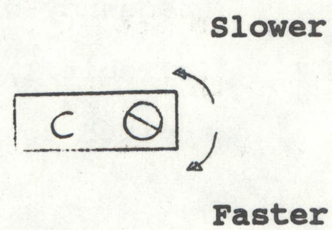
Meter drift adjustment is a two part process:

1) Connect a jumper wire from pin 2 of op-amp EE (on wind

board) to +5 volts.

Press the full scale button and hold for several seconds. The meter should swing to full scale on the negative (left) side. The meter should begin to slowly drift toward zero. If correct, it takes approximately 10 sec. for the meter to drift from 16 m/s to 12 m/s.

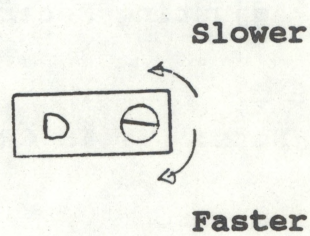
Negative drift is adjusted at pot C on the wind board.



2) Disconnect jumper wire from +5 volts and connect to -5 volts.

Press the full scale button for several sconds and release. The meter will now swing to full scale on the positive (right) side, and will then drift toward zero. Correct drift is again approximately 10 sec. from 16 m/s to 12 m/s.

Positive drift is adjusted at pot D on the wind board.



Repeat both adjustments because they are slightly interactive.

Remove jumper wire from op-amp EE and power supply.

7) **Full Scale Adjustment**

Remove jumper wire from 1.2 KΩ resistor on calibrator/signal strength board.

Turn the frequency select switch on the calibrator/signal strength board to the proper full scale input frequency for the board being calibrated.

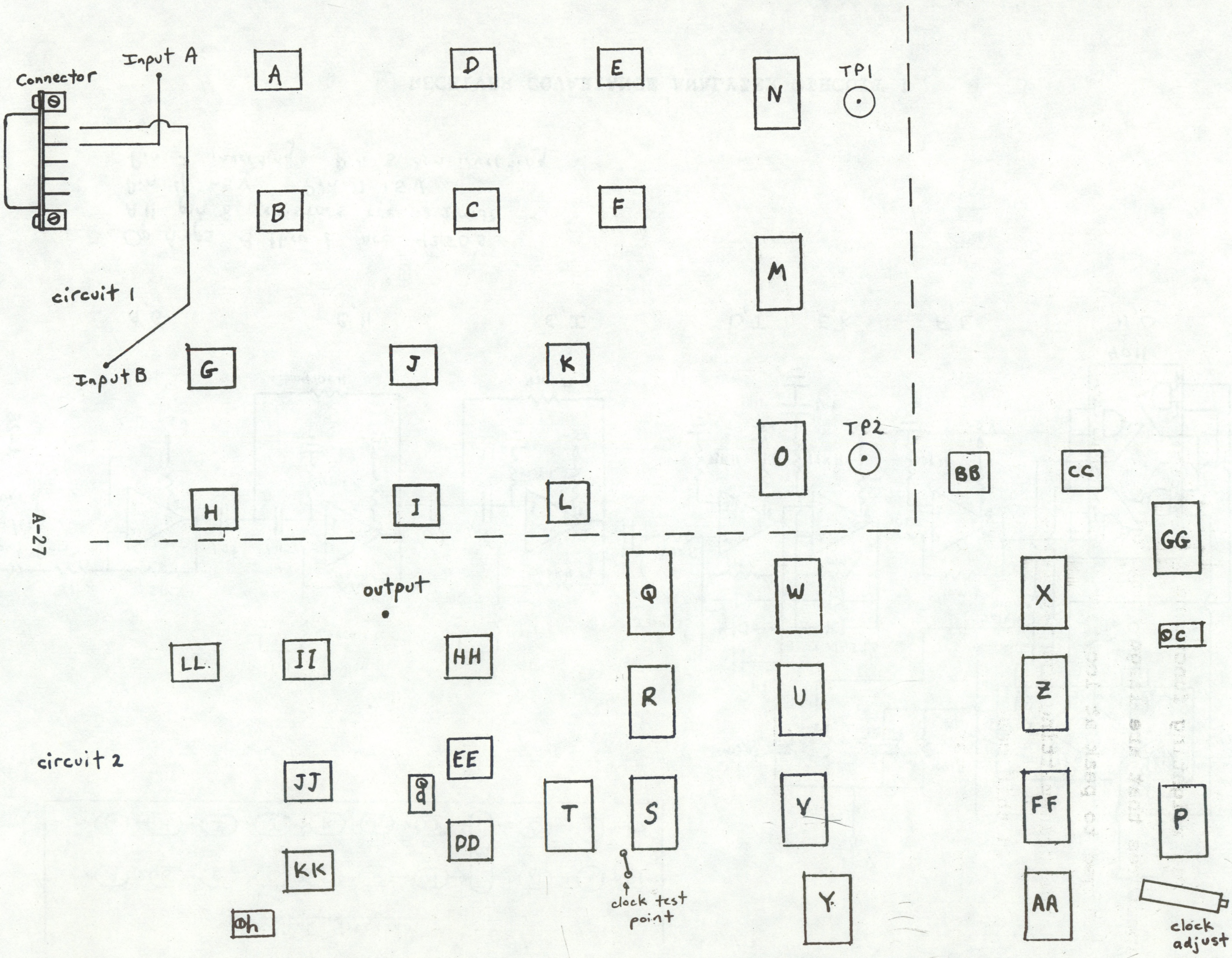
The calibration signals from the outputs (A and B) of the calibrator/signal board to the inputs (A and B) of the wind board are 90 degrees out of phase with equal frequencies. Using a frequency counter at the output (A or B) of the calibrator/signal board, check that the intended frequency is within the ±1 Hz tolerance. If not, the appropriate pot must be adjusted.

With the correct input frequency to the wind board, press and release the full scale button. The wind meter will swing either positive or negative.

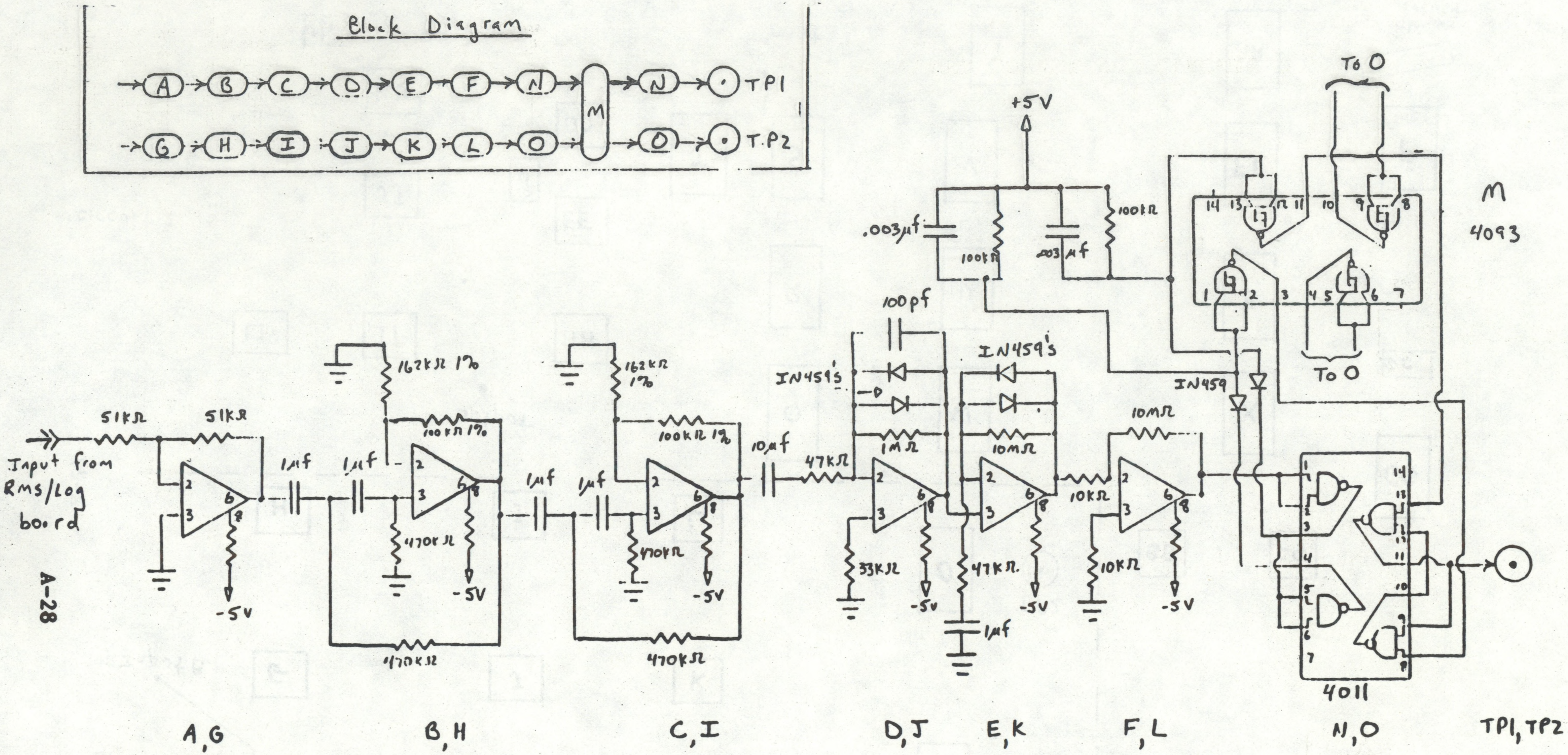
Connect a digital volt meter to the BNC located next to the wind meter being used. A full scale reading of 3 volts (positive or negative) ±.05 volts should present. Pot H on the wind board can be adjusted to obtain the proper full scale reading.

Set the reverse direction switch to the opposite position. Press and release the full scale button. Both the meter and the output voltage should swing to the opposite polarity and be within ±.05 V of 3 volts.

8) Calibration is now complete. Repeat the procedure for each wind board to be calibrated.

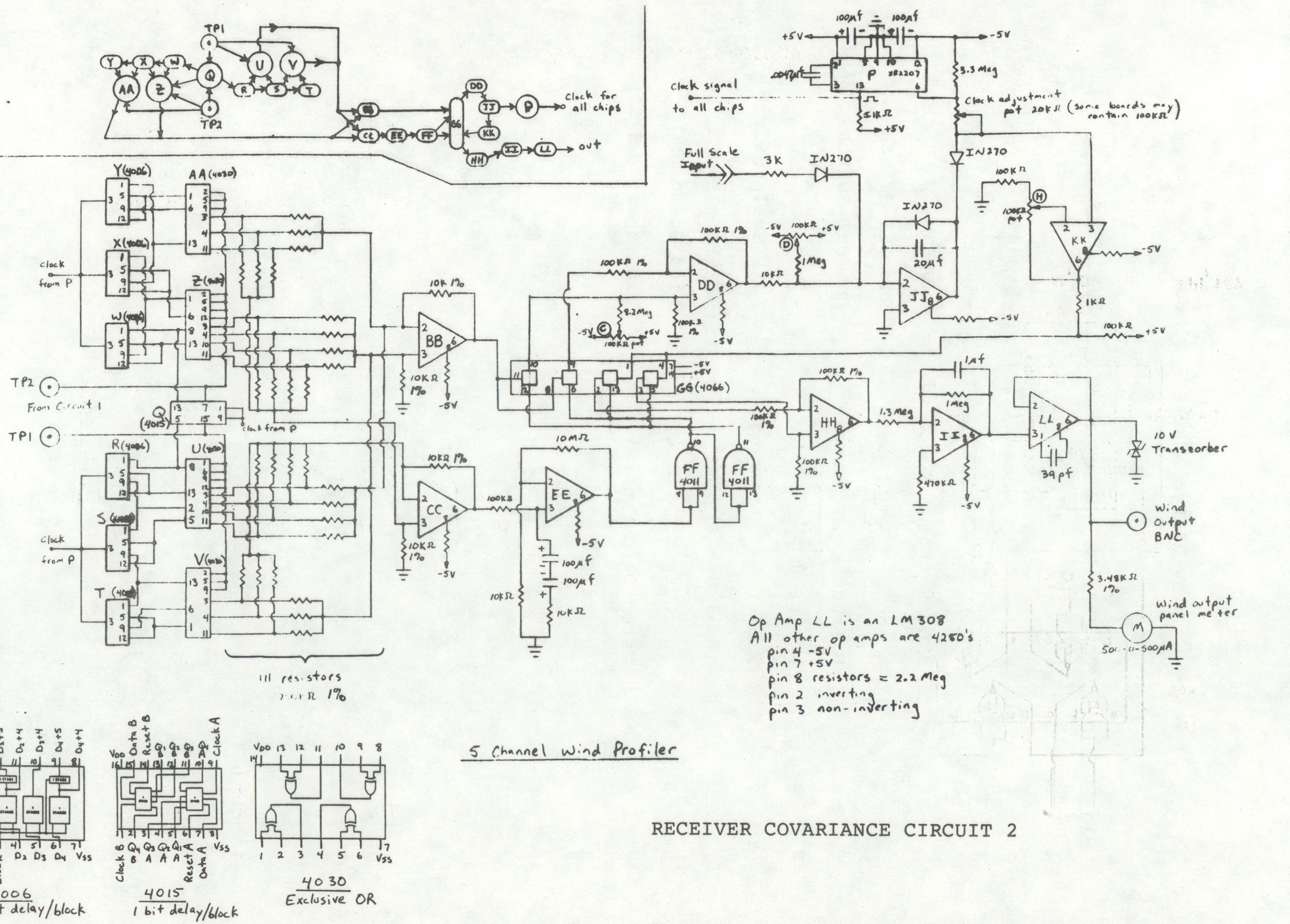


RECEIVER COVARIANCE ANALYZER CIRCUIT BOARD LAYOUT



Op Amps A thru L are 4250's
All pin 8 resistors are 2.2MΩ
Pin 4 -5V Pin 7 +5V
Pin 2 inverting Pin 3 non-inverting

RECEIVER COVARIANCE ANALYZER CIRCUIT 1

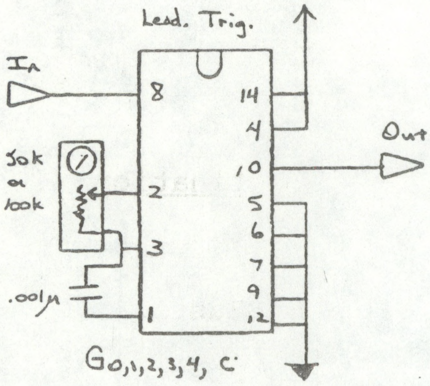


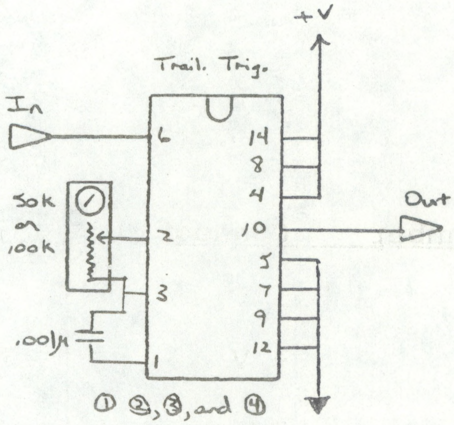
RECEIVER COVARIANCE CIRCUIT 2

COVARIANCE ANALYZER PINOUT

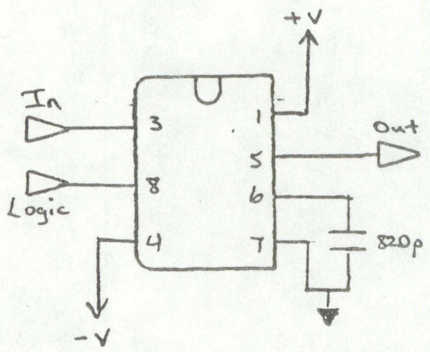
Pin Number	Connection	Wire Color	Destination
1	+ V	Red	+5 Bus
2	- V	Yellow	-5 Bus
3	GND	Black	GND Bus
4	A Input	Green	Run/Cal Switch
5	B Input	White	Run/Cal Switch
6	Not used	-	-
7	Kicker (Full Scale)	Orange	Full Scale Switch (Panel)
8	BNC Output	Blue	Wind Speed BNC
9	Meter Output	Grey	Wind Speed Meter

4047's:

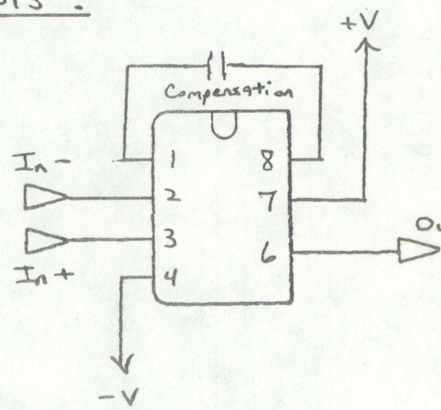




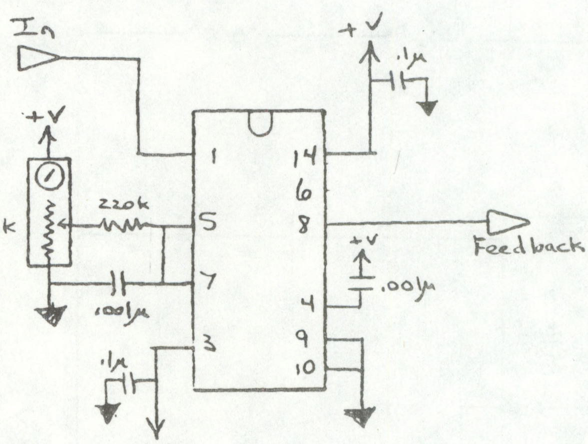
LF398's:



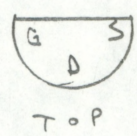
LM301's:



AD536's:



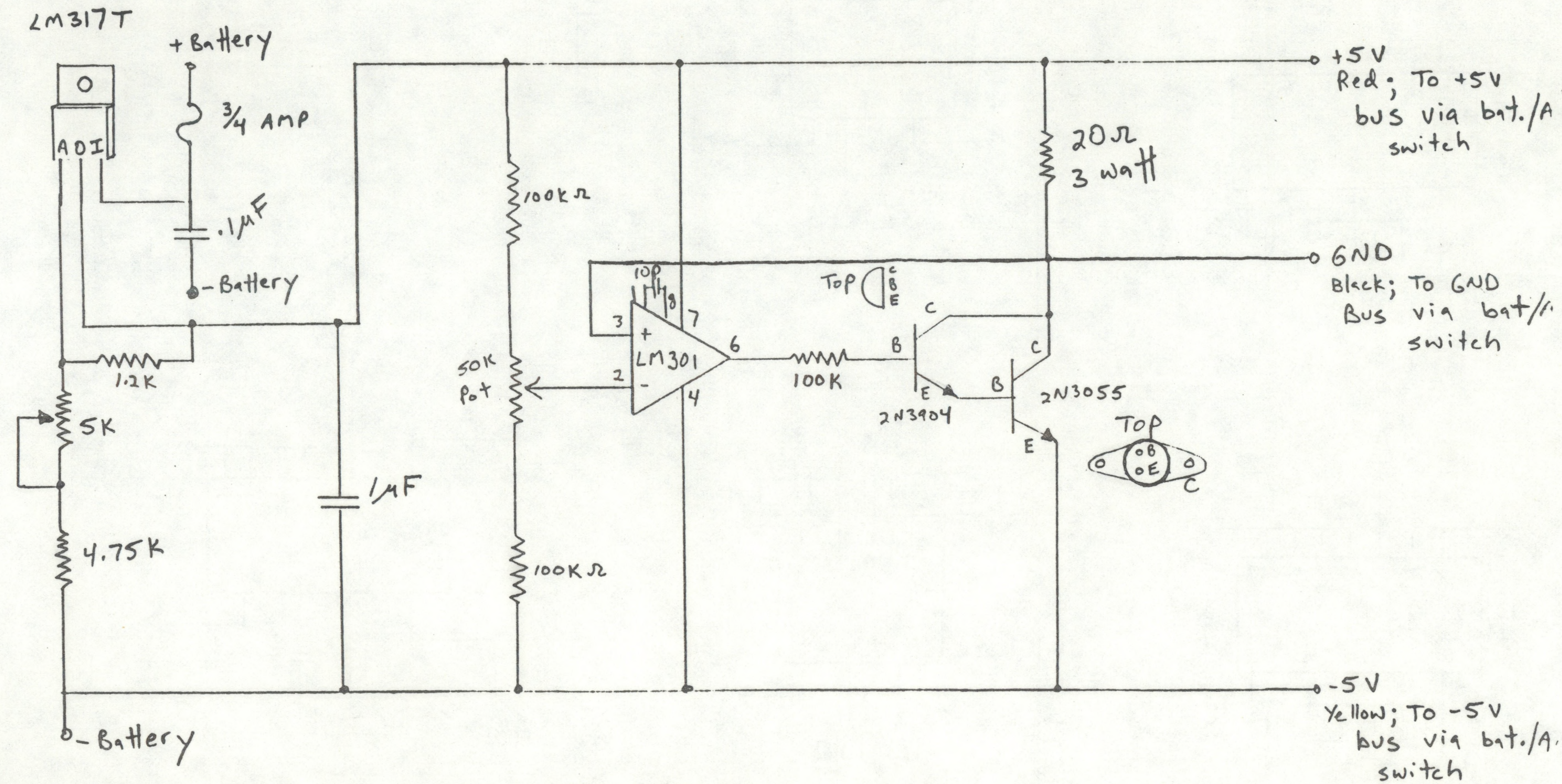
2N5460's:



INTEGRATED CIRCUIT PIN CONNECTIONS

Note: 12 Volt Automobile Battery or equivalent must be used.

NOTE: OUTPUT VOLTAGES ARE ADJUSTED TO MATCH AC Power Supply voltages.



RECEIVER BATTERY SUPPLY CIRCUIT

✡U.S. GOVERNMENT PRINTING OFFICE: 1988--573-002 / 80527