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256-CHANNEL FILTER RECEIVERS

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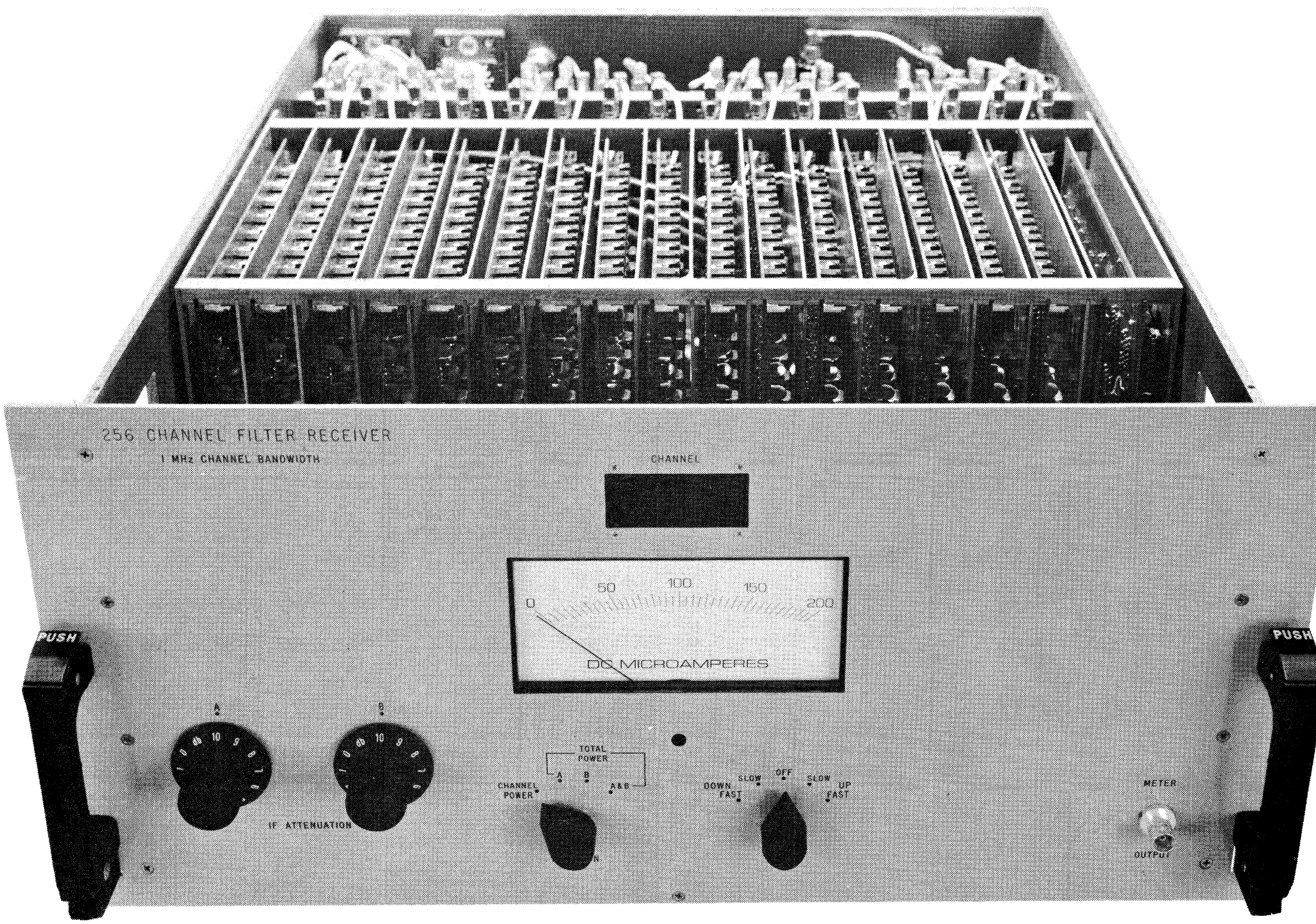
256 CHANNEL FILTER RECEIVER
1 MHz CHANNEL BANDWIDTH
CHANNEL
DC MICROAMPERES
PUSH
PUSH
IF ATTENUATION
TOTAL POWER
CHANNEL POWER
DOWN FAST
SLOW
OFF
SLOW
UP FAST
METER
OUTPUT

256-CHANNEL FILTER RECEIVERS

Bob Mauzy

Introduction

This report discusses the design of a series of four 256-channel filter receivers having individual channel bandwidths of 0.1, 0.25, 0.5 and 1.0 MHz. These systems have an input IF center frequency of 150 MHz and can be operated as two parallel, independent, overlapping 128-channel systems or as a single series 256-channel system. They, along with a 512-channel integrator-multiplexer system [1/] and computer, are being used for spectrum analysis at millimeter wavelengths. Each filter system is contained in a 19 inch rack mounted drawer 8 3/4 inches high by 21 inches deep. A front view is shown on the facing page. Power supplies are in a separate 5 1/4 inch drawer, one drawer providing power for two receivers.

Channel Filters

The individual channel filters are two pole networks designed for about 0.1 dB ripple so that with coil Q variations and other tolerances the band shape remains flat. The band edges or adjacent channel crossover points are defined as 3 dB down. To obtain a constant bandwidth per channel for a series of side-by-side channels the Q's and L's must change while parallel C's and R's remain constant. Figures 1A, B, C and D show component values for sets of 16 channels for each system.

The inductors chosen are Cambion 7107 series coils. They were preferred because of metal can shielding, small size, low cost and specified ferrite

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1/ A 512-Channel Integrator and Multiplexer by C. Pace and J. Payne, EDIR No. 134.

material. The core materials used for the values required are either Carbonyl SF or TH having permeability stabilities of .0025 and .0015%/°C. Q stability is -.04%/°C for both types. Silvered mica capacitor stability is typically +40 ppm/°C. These coefficients will produce filter shifts of less than 2% of a channel width for 10°C change. Measurements on a 1 MHz bandwidth filter at 23.5 MHz gave less than 1% of channel width shift for a 10°C change. Special coils were obtained for the 0.1 MHz system to meet higher Q requirements.

Examples of filter shapes are shown in Figure 2. The two extremes in center frequency are shown superimposed here to show the maximum shape change due to the required difference in Q's. The filter is driven from a transistor collector and its output feeds a Darlington follower. Channel circuit schematics are shown in Figure 3. The extra resistor and capacitor at the Darlington input are to suppress high frequency oscillations. Adjustments are made with a slow sweeper and with maximum post detector bandwidth (op amp input and feedback C's removed).

Detector

In previous NRAO filter systems the GE BD-7 back diode has been used as a square law detector. It is more stable with temperature than conventional diodes and provides a fairly wide square law range. The curve is adjusted by varying the DC load on the output. This adjustment did not always give satisfactory results, and in our tests it was found that the load changed the shape of the error curve as well as the tilt. It appeared to be an indirect method of curve control.

In the process of experimenting with the circuit it was discovered that source impedance was also a handle on the curve. As this was pursued, more accurate square law curves were obtained with the diode working from a controlled source impedance and into a high resistance DC load. Optimum source impedance for

for the BD-7 appeared to be around 200 ohms. This seemed rather high so some lower impedance and more economical BD-4's were ordered. These worked well with a source impedance around 25 ohms so could be driven directly from an emitter follower. DC current in the driver then became the curve control adjustment if required. A sample of diodes in the new circuit showed that the error spread without adjustment was not excessive. Replacing a few diodes could be less expensive than adding another adjustment.

The first large quantity experience with the circuit was in the 1.0 MHz system. The average error curve for CW had a 1.2% positive slope from the peak output to a level 10 dB below. This slope is less on noise but warranted a change in later systems. The emitter resistor on the detector driver was changed from 2.7 K to 2.2 K ohms. The remaining systems gave the average CW error curve and met the limits shown in Figure 4. The equivalent curve for a 0.5 MHz bandwidth noise signal is also shown. The data was recorded at minimum op amp gain but has been shifted to represent an average gain setting. Using the limits shown about 10% of the diodes were rejected. In most cases a resistor change rather than the diode would have given a flat curve but there would have been more spread in the peak point level. The BD-3 may be equally satisfactory with somewhat lower source impedance and at lower cost but samples were not received in time for test.

Op Amp

The Analog Devices 741KN op amp was selected because of its excellent drift spec vs. cost. Maximum voltage drift is less than 15 μV/°C. One order had very poor reliability which led to our testing of all op amps. The problem was due to a chip change to fix another problem and the result was spurious oscillations that would show up in the first few hours of operation. It resulted in the input current increasing and the output becoming noisy and drifting to saturation.

As reliability was very important a test board was made to burn in 72 op amps at a time. Each chip was operated at least 24 hours, sufficient time to catch nearly all bad actors as the manufacturer stated and our experience supported. As an additional test the IC's were cycled from 25 to 45°C, the drifts measured and all units exceeding 1/2 the voltage drift specifications were not used. This rejected about 10%. All oscillating chips were replaced by Analog Devices without charge. Had the reliability problem been suspected at the time the p.c. board layout was made, space for some type of socket or individual pins would have been provided.

The op amp is operated at a gain of about 400, so 15 μV/°C would produce 6 mV/°C at the output. If the normal output is 4 V this represents 0.15%/°C. This figure could be reduced by use of a more expensive op amp such as the Precision Monolithics OP-05CJ but the improvement was not considered justified. The detector diode has a dirft of about 0.15%/°C. Also, new computer programs measure and correct for zero and square law errors. Molded carbon resistors drift about .02%/°C so precision resistors would be desirable if significant improvement were attempted.

Filter Board

The channel circuit, as with all other parts of the system, was designed with compactness, simplicity, and cost in mind. To build 256 channels in the space of some previous 50 channel receivers made packaging a prime consideration. On the filter boards it was necessary to provide convenient access to op amp gain and zero controls. Individual channel monitoring on the boards would permit uninterrupted output wiring from the filter card connector to the back panel connector. As many as 25 filter cards have been stacked side-by-side across the width of a drawer but without shields and with very limited height for components.

The 256 channels makes 16 a convenient number to work with and a 16-channel multiplexer chip suitable for monitoring became available at that time. So as originally suggested in the job outline the cards were designed for 16 channels each.

The logical arrangement for best high frequency performance and location of adjustments was to feed a signal down the middle of the board and have the channel circuits branch out in opposite directions. Refer to Figure 5 for the board layout. There was concern over coupling between adjacent channels with close physical spacing, so three things were done to reduce the probability. First, shields were added between cards. Second, the channel layout was arranged to return all grounds to one side of the circuit so that ground currents from two sections would not flow in common land areas. Third, the channels were staggered so that adjacent frequencies were not physically adjacent. There are at least two channel widths between adjacent circuits. Breadboard checks showed the coupling between adjacent circuits tuned to adjacent channels to be negligible but staggering was included as no cost insurance. Board channel numbers are identified by the color coded test points, channels 1 thru 9 along the long edge and 10 thru 16 along the short edge. White dots mark the zero pots to distinguish them from the gain controls.

The large IC is a multiplexer chip used for monitoring the output of each channel individually. Siliconix introduced the DG 506, 16-channel multiplexer shortly before this design was begun. Procurement was very slow and units failed frequently. Harris Semiconductor came to the rescue by releasing their version (HI 506) with built-in protective circuits. These proved much less susceptable to burnout and are the only recommended replacement. These chips are controlled through the digital control card by the front panel slew switch. Channel outputs are also summed thru resistors adjacent to the multiplexer IC for total power monitoring.

A second circuit near the edge connector is the input amplifier. The IF signal enters the board via small coax, is amplified 17 dB and fed to the filter circuit inputs. See Figure 25. A snap-on coax connector, mating with the Oscillator-Mixer unit, permits easier card removal.

Each filter board contains about 690 components and 160 wires and jumpers mounted in 2000 holes in an area 7.6 x 7.85 inches. The 16 filter cards, a multiplexer driver and a power monitor card are mounted in a hinged card holder. See Figure 6. This arrangement allows convenient access to zero and gain pots and channel output test points.

Channel Monitor Digital Controller

The channel monitor provides a conventional analog readout (meter) of all 256 channels selectively by connecting any one channel to the monitor meter via analog gate integrated circuits. There are 16 integrated circuits, one located on each of 16 filter bank cards; each integrared circuit comprises 16 analog gates for monitoring any one of 16 channels on a particular filter bank card.

In the schematic, Figure 7, the 16 outputs "EN-0" through "EN-15" select one only of the filter bank cards by selection of the particular analog gate integrated circuit located on the card. The 4 outputs labeled A_0, A_1, A_2, and A_3 are binard controls which select, within a filter bank card, which channel is to be monitored.

In Figure 7, chips "C" and "R" are octal decoders which convert the binary counter "D" output to provide the "EN-" signals via inverters "J", "P", and "U" to the analog gate circuits. Binary counter "L" provides the binary count to the analog gates to select one of sixteen channels within a filter bank card.

The count control input, pin 1, is grounded in the 1.0 and 0.5 MHz systems and open in the others to modify the counting sequence. The Rev "B" input, pin E, is grounded in the parallel mode by the Series-Parallel switch on the back panel to reverse the B section. Figures 11A, B, C, and D show the system channel numbers vs. card and card channel numbers.

The binary count provided by the up/down counters is converted to "Human" decimal terms (BCD) by "ROM" chips "A", "B", and "H". the "LCR" circuits 20 and 21 suppress any possible RFI which may issue from the TTL logic system.

Clock oscillator "E" is the system time base providing the fast (when enabled by the "ENB Fast" control input) channel step up/down sequency as controlled by the up/down select input pin 5. The "ENB Slow" signal causes the channel monitor select sequence to occur at a slower rate (4, 5, 6, 8, 10, 12, or 16 times slower) with the dividing action of chip "M" according to an arrangement of the "Speed Ratio Selector" strap pins "2", "3", and "4" and the select pin "D" and chip "M" type. Chips "N" and "BB" retime the control signals, thus preventing spurious counts when changing the monitor system control selector switch.

System

In an effort to minimize equipment the card input spectrums and oscillator frequencies were arranged to require a minimum number of oscillators. The arrangements are shown in Figures 8A, B, C, and D. The system is split into two identical sections of 128 channels each with the input center frequency at 150 MHz. By going thru the IF Processor the two sections are arranged side-by-side, still centered on 150 MHz. Ignoring the Processor for the moment, the figures show that the inputs to sections A and B are mixed with four oscillators to obtain the frequency bands for the cards. In the 1.0 and 0.5 MHz systems the oscillators are 1/2 of a card width from the closest channel. For the 0.25 and 0.1 MHz systems the spacing is 3/2 of a card bandwidth. The close spacing in the first two systems limits the maximum frequencies on the filter cards to 24 and 12 MHz. If this arrangement were used on the second two systems the cards would have input frequencies as low as 0.8 MHz, requiring large capacitors. A second and more serious problem exists with the card filters located in the 150 MHz region. These would have to provide unusual sharpness to reject images one card bandwidth anyway. For this reason the 3/2 spacing was used. The filters provide greater than 25 dB rejection at the edge of the image band. In-band filter flatness was spec'ed at $<$ 1 dB, or 0.5 dB when convenient, to limit variations in power between channels.

The maximum spread of signal levels out of the detectors was limited to 1.5 dB. This was obtained by tight in-band flatness limits on the card filters, adjusting the slope on the Amplifier-Splitter units to compensate for increased mixer and filter losses at higher frequencies, and trimming some filter card input amplifier gains and individual channel gains. Close tolerances on the levels and some restricting of detector variations made it possible to operate at higher average detector levels. The 1.5 dB remaining was removed by the op amp gain controls.

Parallel input signals A and B of -30 to -40 dBm are level adjustable by 10 dB variable attenuators on the front panel. The signals are then band limited, amplified, divided and fed to four splitters. System block diagrams are shown in Figures 9A, B, C, and D. The splitters are active dividers to give good reverse isolation. Reference to an IF processing diagram will show that an LO for two card bandpasses is in the center of a third bandpass. The LO's are too close to the desired bands to obtain high rejection in the bandpass filters. It is, therefore, necessary to provide good isolation in the Splitters and Amp-Splitters. Figure 10 shows typical signal power levels and LO leakage.

Channel designations for the A and B receivers as read on the front panel and frequency charts (Figures 11A, B, C, and D) go from 0 thru 127 and 128 thru 255. Increasing channel numbers denotes increasing IF frequency for both sections in either series or parallel mode. A toggle switch on the back panel controls the reversal of the B section counting in the channel monitor circuits and provides a closure for the computer so it can arrange the data properly.

IF Processor and Oscillator-Multipliers

The IF processor input is limited by a filter to reject the image and out-of-band signals. The desired band is amplified, converted, filtered, and divided; one output feeding the B section and the second output feeding a second mixer to position the specturm for the A section. See Figure 12. This simplified re-arrangement of the spectrum is possible because mixer RF-IF isolation is > 30 dB.

The Oscillator-Multiplier units provide LO signals for the Processor. A crystal oscillator signal in the 75 to 107 MHz range is fed thru two balanced doublers and an amplifier to provide an output of about +8 dBm. See Figure 13 for a typical schematic. Unwanted signals are more than 50 dB down. One in-band signal at twice the crystal frequency is suppressed by shielding to obtain at least -65 dB. Photos of the Processor and Oscillator-Multiplier units are shown in Figure 14.

Other Units

The Amplifier-Splitters, Splitter units, Oscillator-Mixers, Power Monitor card and zero check circuit are conventional circuits that are self-explanatory by referring to their schematics in Figures 15 thru 19. Photos are shown in Figures 20 and 21.

Drawer Layout

Figures 22 and 23 show the location of major assemblies in the drawer. Access to assemblies in the bottom of a deep, crowded chassis is a problem. It was reduced on these systems by mounting the tubular card filters, Splitters and Oscillator-Mixers on two bars extending across the width of the drawer. By disconnecting the snap-on card cables, 4 Amp-Splitter output cables, a power connector and 4 screws the entire assembly can be removed. Access to the active circuits with the system operating is available by lowering the rear panel as in Figure 23. The back panel is shown in Figure 24.

Power

The power supply drawer contains two sets of supplies and a voltage monitor circuit. The supplies have isolated ground to prevent ground currents from flowing in the rack.

Power required per system	
+15 V	0.95 A
-15 V	2.4 A
+5 V	0.8 A

Cost

An estimate of parts cost is as follows:

Channel circuit	$ 16.00	
Filter board	$ 314.00 ...	$19.62/channel
System	$8500.00 ...	$33.20/channel

A spare filter card and power supplies are included in the system cost.

Acknowledgements

Recognition is given to Lewis Beale who did a major part of the construction and all of the testing. Ray Hallman contributed the digital card and readout design, and wrote the description given here.

$Q = 1.5 f_0/0.1 \cdot 15 f_0 \qquad L = 1/39.5 f_0^2$

<u>0.1Mc/ch</u> $\qquad C' = 71/f_0$

Ch.	f_0	Q	C	L	L-	R	$R_{LC\,meas.}$*	R_1	R_2		C'
1	2.45MHz	36.7	1000p	4.22μ	-20	2387	4754*	5.1k	6.2k	15	29.p
2	2.55	38.2	↑	3.90	-20	↑	4432	5.6	6.2		27.8
3	2.65	39.7		3.61	-20		4110*	6.2	7.5		26.8
4	2.75	41.2		3.35	-19		4800*	5.1	5.6		25.8
5	2.85	42.7		3.12	-19		4470*	5.6	6.2		24.9
6	2.95	44.2		2.91	-18		4540*	5.1	6.2		24.1
7	3.05	45.7		2.72	-18		4260	5.6	6.8	15	23.3
8	3.15	47.2		2.55	-18		3980*	6.2	7.5	10	22.5
9	3.25	487		2.40	-17		4145*	6.2	7.5		21.8
10	3.35	50.2		2.26	-17		3921	6.2	8.2		21.2
11	3.45	51.7		2.13	-17		3698	7.5	9.1		20.6
12	3.55	53.2		2.01	-17		3475*	8.2	11.		20.0
13	3.65	54.7		1.90	-16		3768*	6.8	9.1		19.5
14	3.75	56.2		1.80	-16		3581	7.5	10.		18.9
15	3.85	57.7	↓	1.71	-16	↓	3393	9.1	12.		18.4
16	3.95	59.2	1000	1.62	-16	2387	3206*	10.	15.	10	18.0

FIG. 1A

2-12-73 [illegible]

0.25 MHz/ch

$Q = 6.08 f_0 \qquad R = .194\, Q/f_0 \qquad q_1 = 1.52$

$L = 1/32.4 f_0^2 \qquad C' = 145.6/f_0 \qquad k_{12} = .71$

Ch	f_0	Q	C	L	L-	R	$R_{LC\,meas.}$	R_1		R_2		C'
1	6.125MHz	37.2	820p	.823μ	-12	1180	1670	4.02k	3.9	4.82	4.7	23.8p
2	6.375	38.8	↑	.759	-12	↑	1670	4.02	3.9	4.82	4.7	22.8
3	6.625	40.3		.703	-11		1560	4.84	4.7	6.04	6.2	22.0
4	6.875	41.8		.653	-11		1550	4.94	5.1	6.20	6.2	21.2
5	7.125	43.3		.608	-10		1480	5.82	5.6	7.65	7.5	20.4
6	7.375	44.8		.567	-10		1430	6.75	6.8	9.33	9.1	19.7
7	7.625	46.4		.531	-10		1390	7.81	7.5	11.49	12.	19.1
8	7.875	47.9		.498	-9		1390	7.81	7.5	11.49	12.	18.5
9	8.125	49.4		.468	-9		1340	9.88	10.	16.62	16.	18.0
10	8.375	50.9		.440	-9		1290	13.84	15.	31.99	33.	17.4
11	8.625	52.4		.415	-8		1290	13.84	15.	31.99	33.	16.9
12	8.875	54.0		.392	-8		1260	18.58	18.	78.12	82.	16.4
13	9.125	55.5		.371	-8		1230	29.03	30	—	—	16.0
14	9.375	57.0		.351	-7		1300	12.78	13.	26.87	27.	15.5
15	9.625	58.5	↓	.333	-7	↓	1250	21.07	22.	155.00	—	15.1
16	9.875	60.0	820	.316	-7	1180	1200	70.80	—	—	—	14.7

FIG. 1B

1238

0.5 Mc/ch

$Q = \frac{1.5}{.5} f_o = 3.0 f_o$ $L = 1/4\pi^2 \cdot 47 \cdot 10^{-9} f_o^2 = 1/185 f_o^2$ $C' = 166.8/f_o$

2-5-73
1-11-74

Ch	f_o	Q	C	L	L−	R	$R_{LC meas}$		R_1		1061 R_2			C'
1	4.25 MHz	12.75	470p	2.98μ	−19	1016		4.16	1344	1.3	1424	1.5	22	39.25p
2	4.75	14.25		2.39	−17			3.50	1432	1.5	1523	1.5		35.1
3	5.25	15.75		1.96	−16			2.96	1547	1.6	1654	1.6		31.8
4	5.75	17.25		1.63	−15			3.00	1536	1.5	1642	1.6	22	29.0
5	6.25	18.75		1.38	−15		2.9	3.15	1500	1.5	1600	1.6	10	26.7
6	6.75	20.25		1.18	−14			2.64	1652	1.6	1774	1.8		24.7
7	7.25	21.75		1.03	−13		2.55	2.58	1676	1.6	1802	1.8		23.0
8	7.75	23.25		.898	−12			2.49	1716	1.8	1849	1.8		21.5
9	8.25	24.75		.792	−12		2.25	2.40	1762	1.8	1902	2.0		20.2
10	8.75	26.25		.704	−11			2.28	1833	1.8	1984	2.0	10	19.1
11	9.25	27.75		.630	−11		2.2	2.22	1873	1.8	2032	2.0		18.0
12	9.75	29.25		.567	−10			2.07	1995	2.0	2177	2.2		17.1
13	10.25	30.75		.513	−10		1.96	2.02	2044	2.0	2235	2.2		16.3
14	10.75	32.25		.466	−9			1.93	2145	2.2	2356	2.4		15.5
15	11.25	33.75		.426	−9 or −8		1.67	1.80	2373	2.4	2584	2.7		14.8
16	11.75	35.25	470	.390	−8	1016	1.67k	1.81	2316	2.4	2564	2.7		14.2

FIG 1C

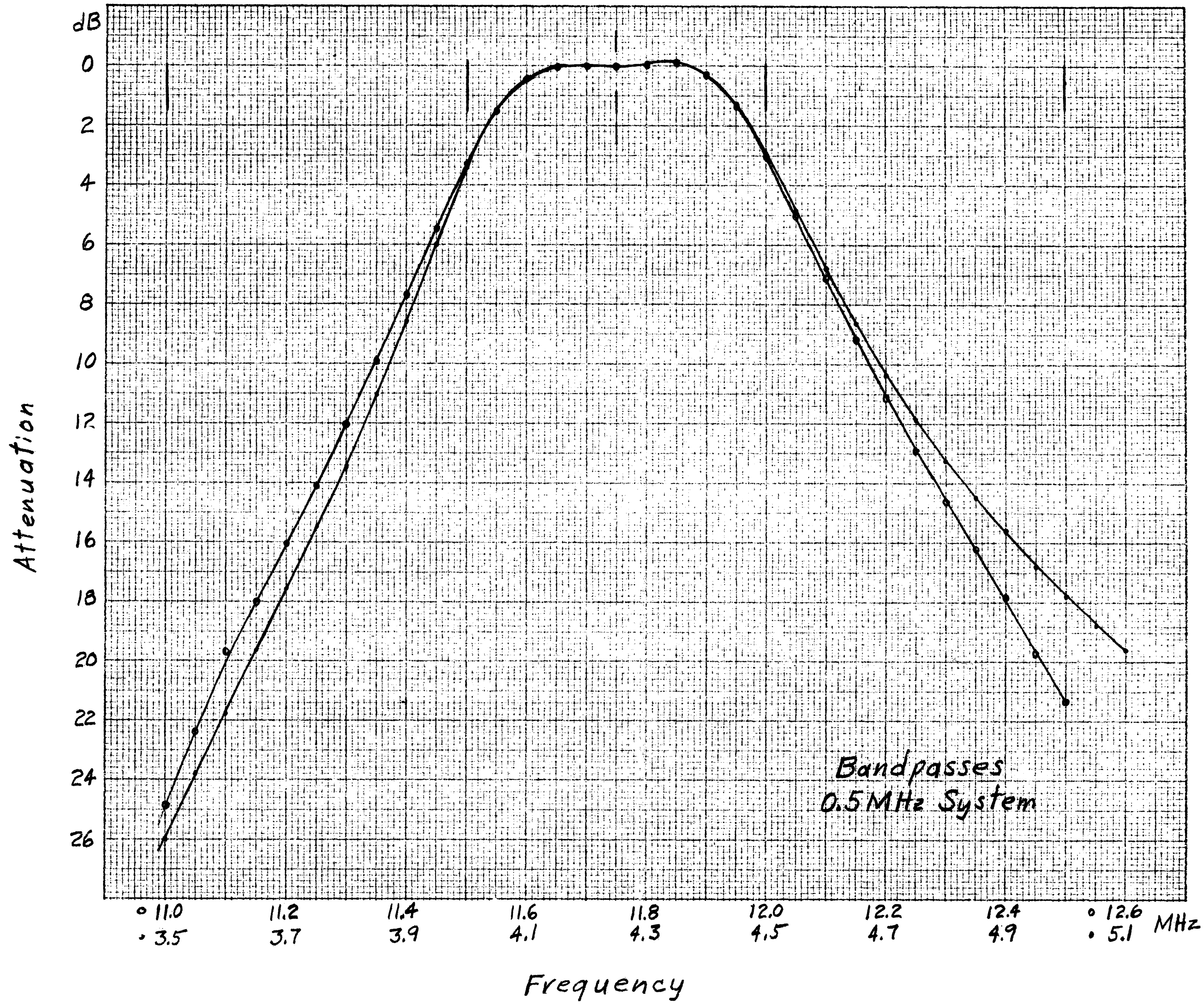
1.0 MHz/ch.

$Q = 1.62 f_o$ $C' = 184/f_o$

$L = 1/10.17 f_o^2$

Ch.	f_o	Q	C	L	L−	R	R_{Lmeas}	R_1	R_2		C'
1	8.5 MHz	13.8	250p (258)	1.361μ	15	1000	4.55kΩ	1.31 kΩ	1.43 kΩ	10.	21.6p
2	9.5	15.4		1.089	13		4.00	1.36	1.50	10.	19.3
3	10.5	17.0		.892	12		3.58	1.42	1.57	6.8	17.5
4	11.5	18.6		.743	11		3.45	1.44	1.60	4.7	16.0
5	12.5	20.2		.629	11		3.32	1.47	1.62		14.7
6	13.5	21.9		.539	10		3.20	1.49	1.65		13.6
7	14.5	23.5		.468	9		3.10	1.52	1.68		12.7
8	15.5	25.1		.409	8		2.95	1.56	1.73		11.8
9	16.5	26.7		.361	7		2.85	1.59	1.77		11.1
10	17.5	28.3		.321	7		2.70	1.64	1.83		10.5
11	18.5	30.0		.287	6		2.60	1.68	1.88		9.9
12	19.5	31.6		.258	6		2.48	1.74	1.94		9.4
13	20.5	33.2		.234	5		2.35	1.81	2.03		9.0
14	21.5	34.8		.213	5		2.23	1.90	2.14		8.5
15	22.5	36.5		.194	4		2.11	2.00	2.26		8.2
16	23.5	38.1	250	.178	4	1000	2.00	2.12	2.41		7.8

FIG. 1D



dB
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Attenuation
∘ 11.0
• 3.5
11.2
3.7
11.4
3.9
11.6
4.1
11.8
4.3
12.0
4.5
12.2
4.7
12.4
4.9
∘ 12.6
• 5.1
MHz
Frequency
Bandpasses
0.5MHz System

FIG. 2

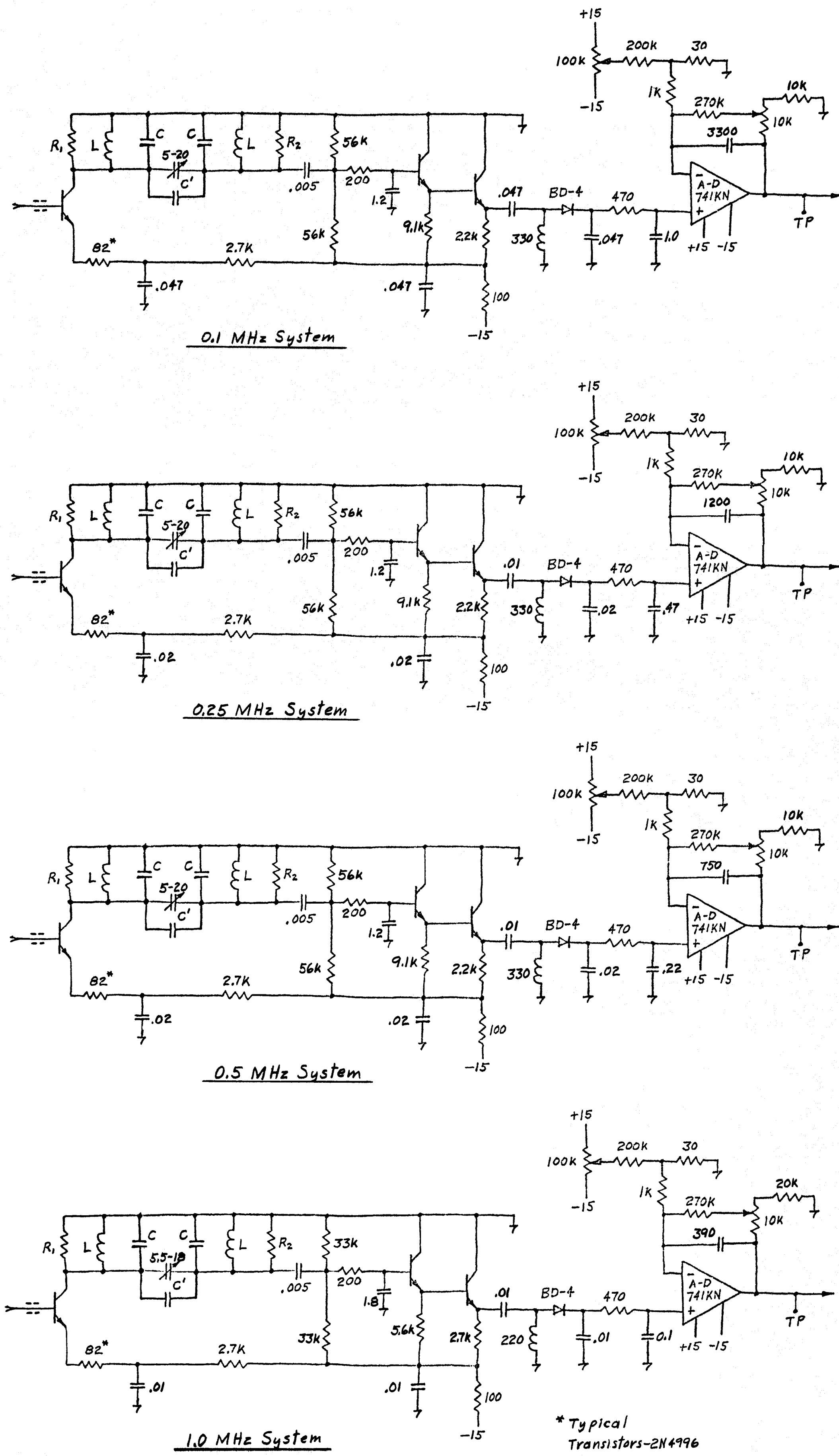
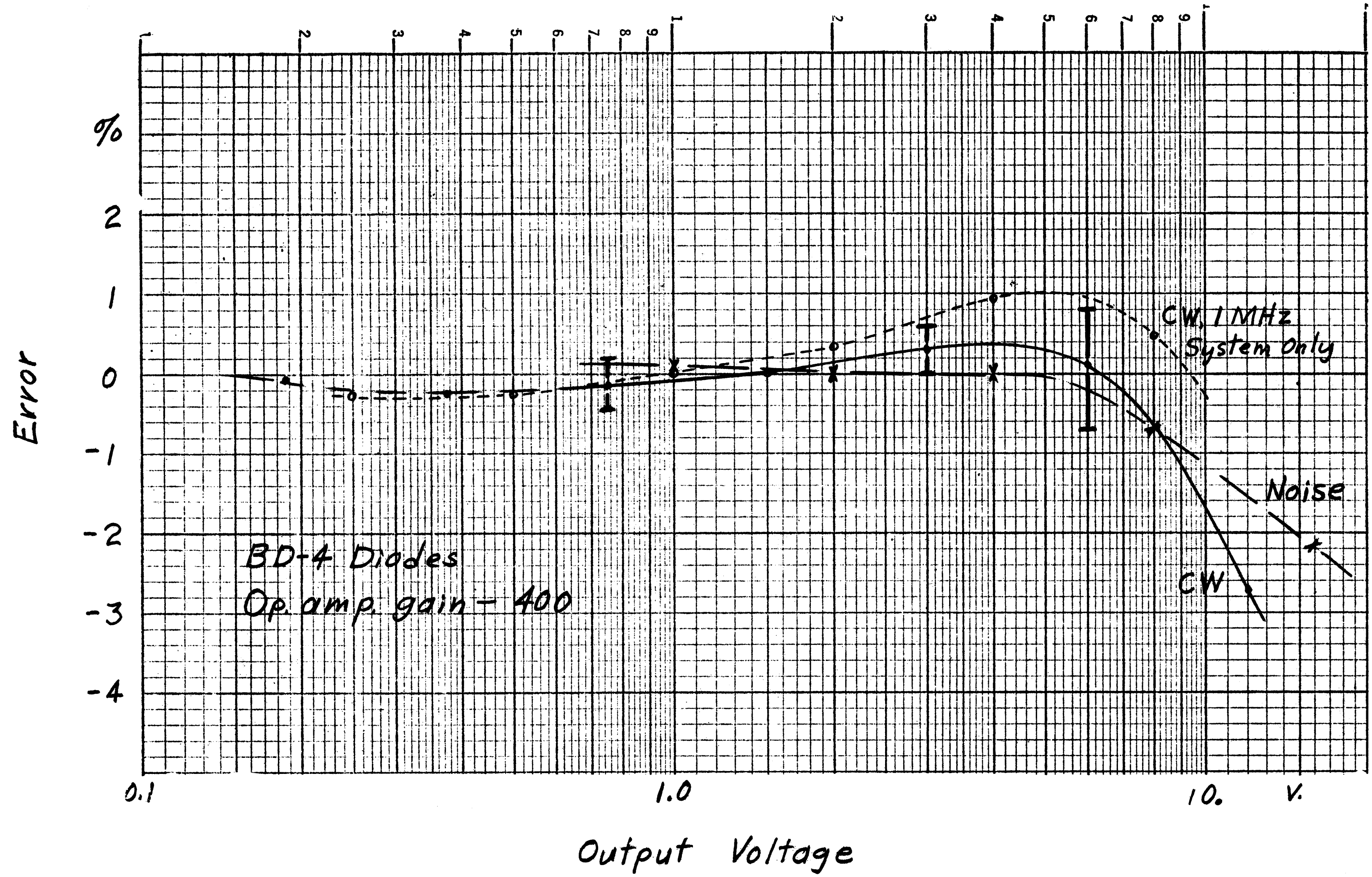
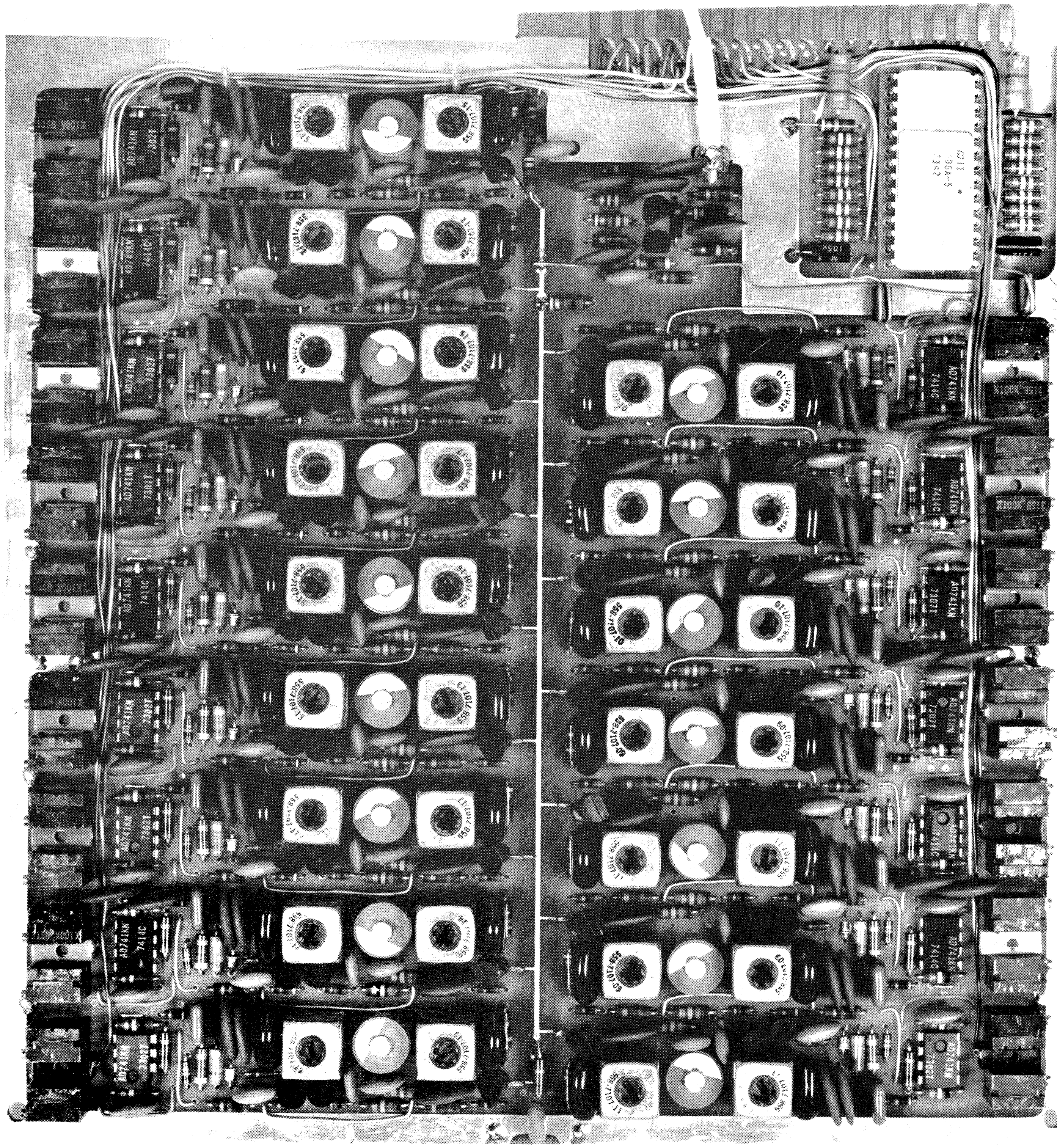

0.1 MHz System
0.25 MHz System
0.5 MHz System
1.0 MHz System
BD-4
A-D
741KN
TP
* Typical
Transistors-2N4996

FIGURE 3



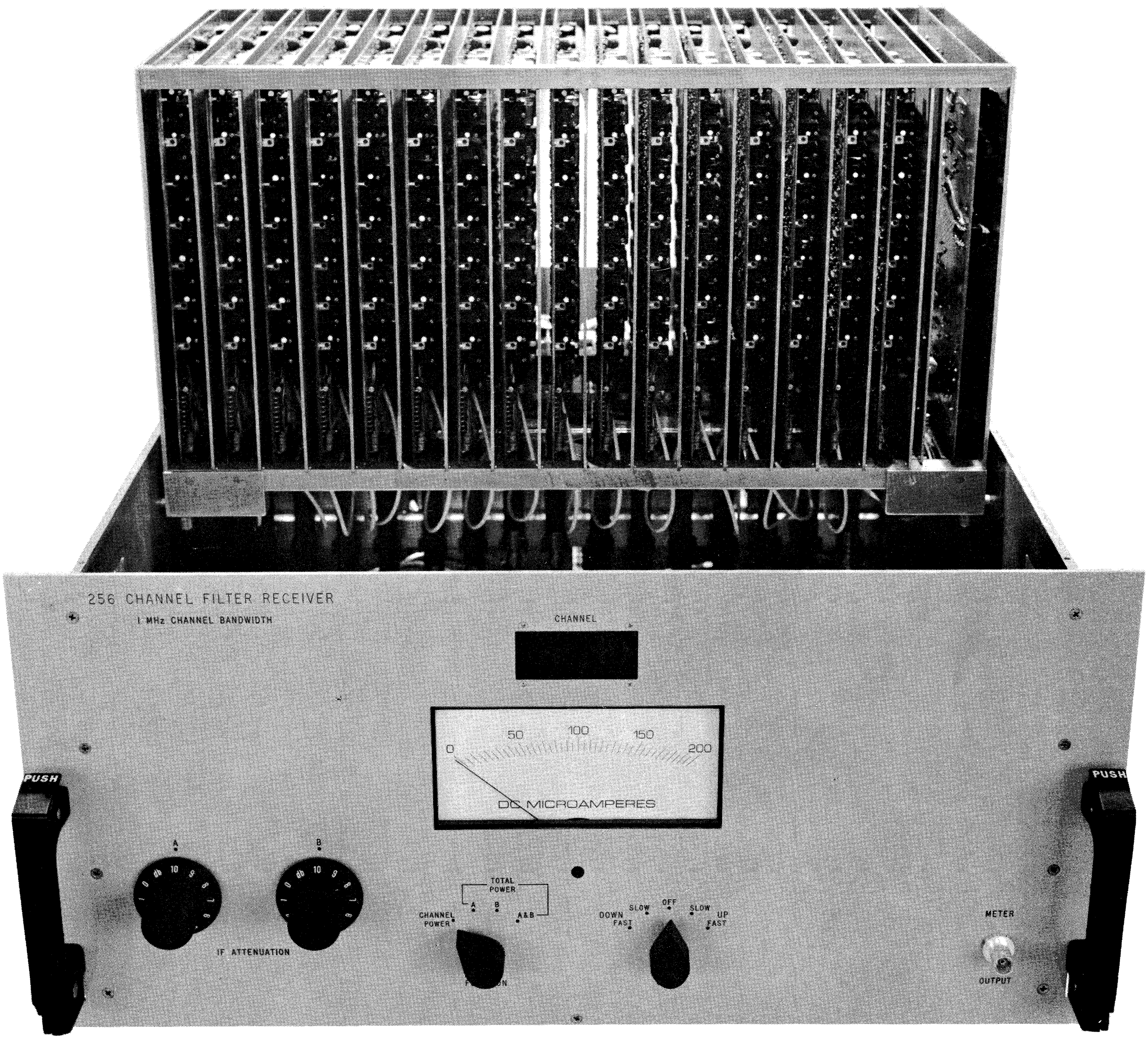
Square Law Detector Error

FIG. 4



FILTER CARD

FIGURE 5



CARD HOLDER UP

FIGURE 6

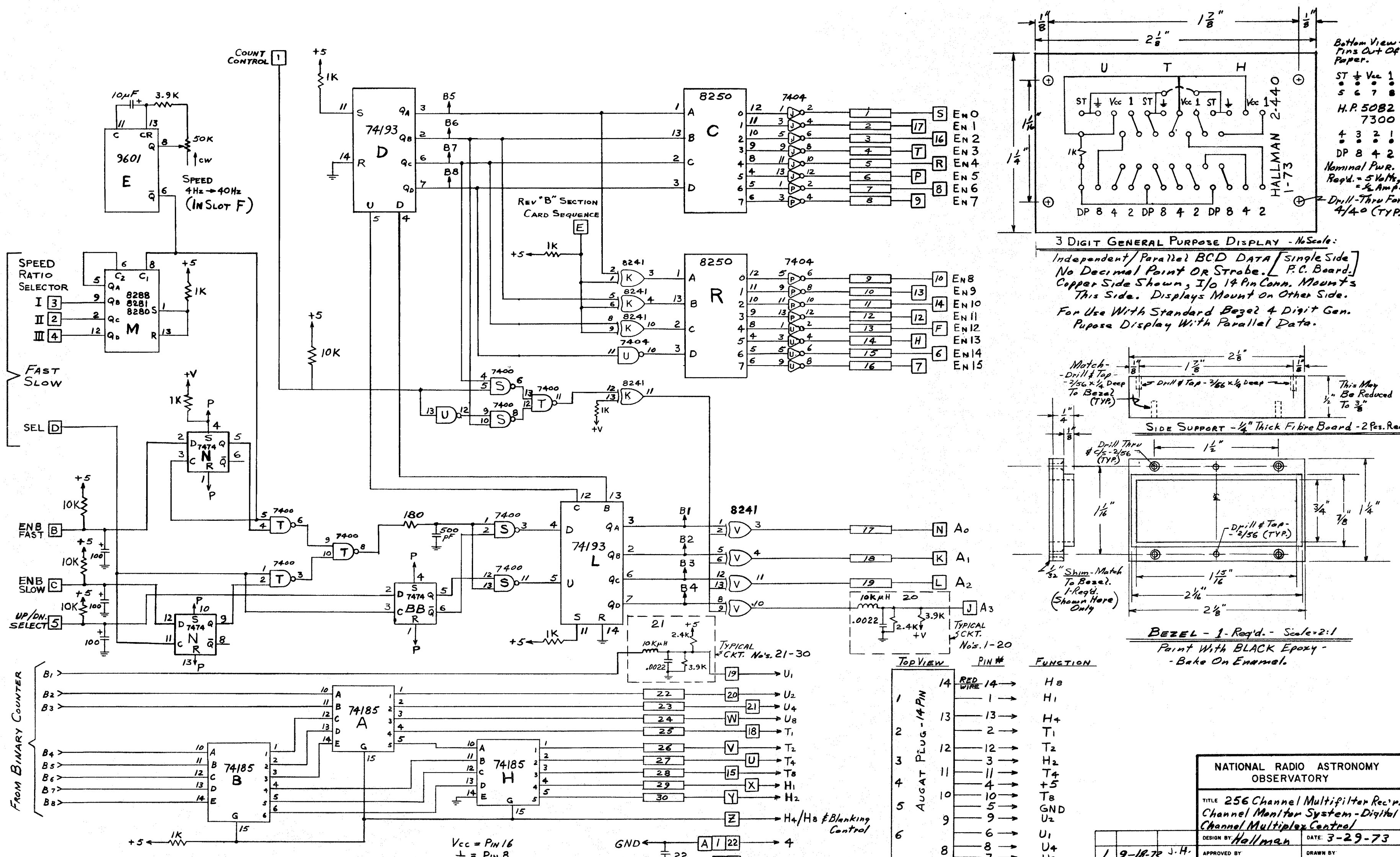
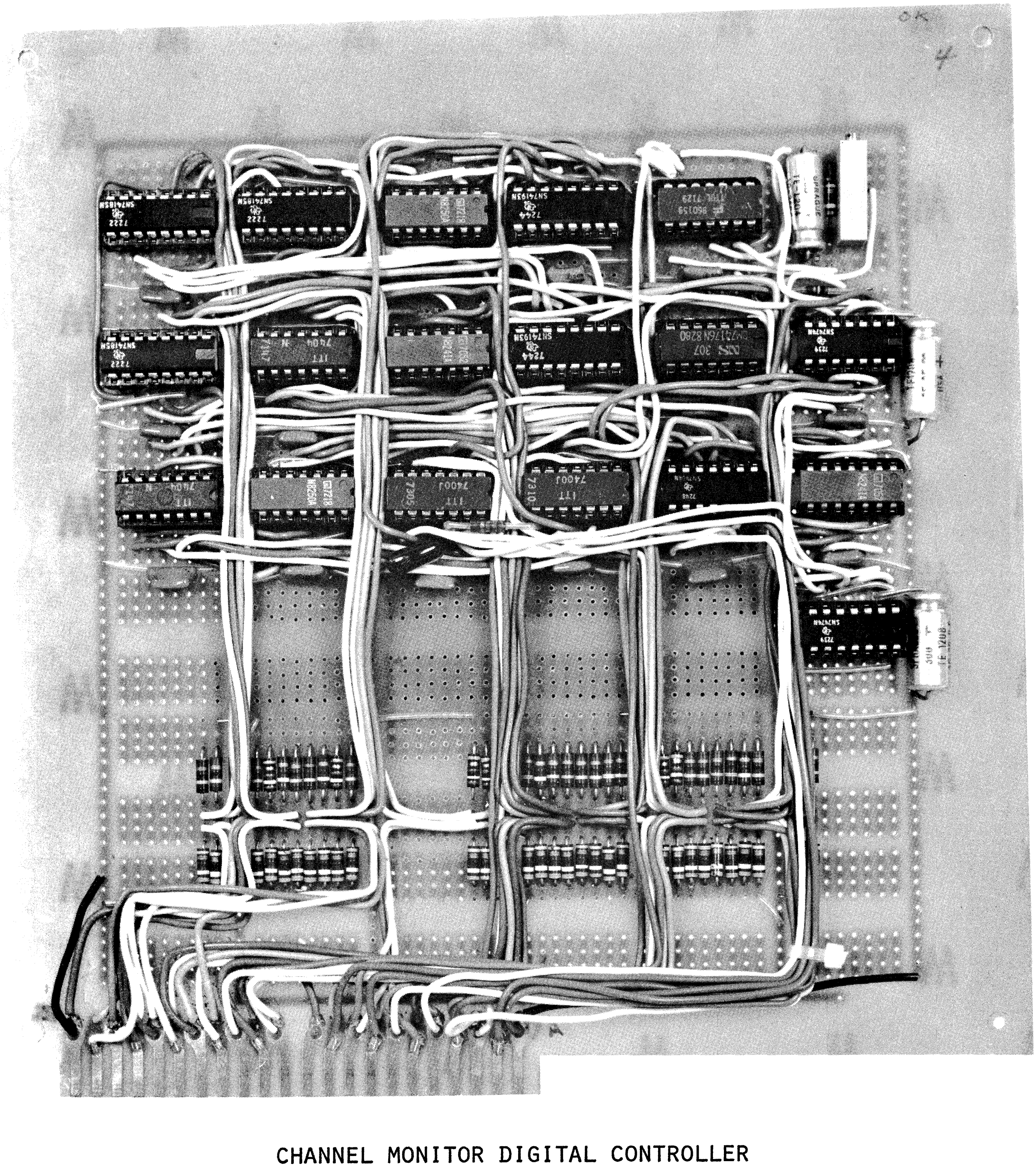

COUNT CONTROL
SPEED 4Hz → 40Hz (IN SLOT F)
SPEED RATIO SELECTOR
FAST
SLOW
SEL
ENB FAST
ENB SLOW
UP/DN. SELECT
REV "B" SECTION CARD SEQUENCE
FROM BINARY COUNTER
TYPICAL CKT. No's. 21-30
TYPICAL CKT. No's. 1-20
Vcc = PIN 16
⏚ = PIN 8
TOP VIEW
PIN #
FUNCTION
AUGAT PLUG - 14 PIN
14 PIN AUGAT/SCOTCH CABLE FAN-OUT
H4/H8 & Blanking Control
3 DIGIT GENERAL PURPOSE DISPLAY - No Scale:
Independent/Parallel BCD DATA
No Decimal Point Or Strobe.
Single Side P.C. Board.
Copper Side Shown, I/O 14 Pin Conn. Mounts This Side. Displays Mount On Other Side.
For Use With Standard Bezel 4 Digit Gen. Purpose Display With Parallel Data.
Bottom View - Pins Out Of Paper.
H.P. 5082 7300
Nominal Pwr. Req'd. = 5 Volts, = 1/2 Amp.
Drill-Thru For 4/40 (TYP.)
HALLMAN 2-440 1-73
SIDE SUPPORT - 1/4" Thick Fibre Board - 2 Pcs. Req'd.
This May Be Reduced To 3/8"
BEZEL - 1 - Req'd. - Scale = 2:1
Paint With BLACK Epoxy - Bake On Enamel.
Shim - Match To Bezel. 1 Req'd. (Shown Here Only)
NATIONAL RADIO ASTRONOMY OBSERVATORY
TITLE 256 Channel Multifilter Rec'r. Channel Monitor System - Digital Channel Multiplex Control
DESIGN BY: Hallman
DATE: 3-29-73
APPROVED BY
DRAWN BY
DWG. No. S2-579-1
1 9-18-73 J.H.
REVISIONS

FIG. 7



CHANNEL MONITOR DIGITAL CONTROLLER

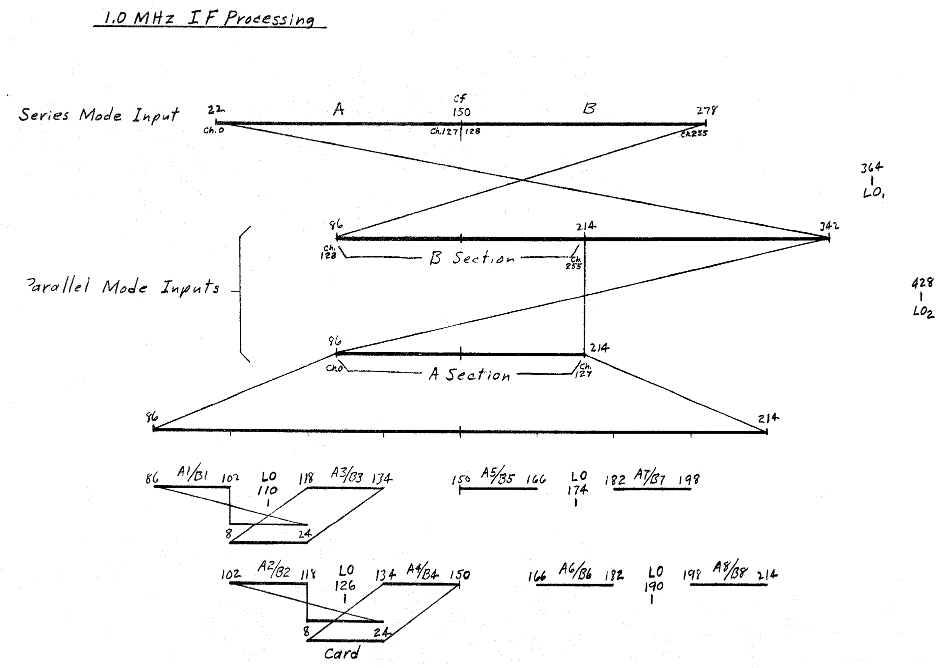


FIGURE 8A

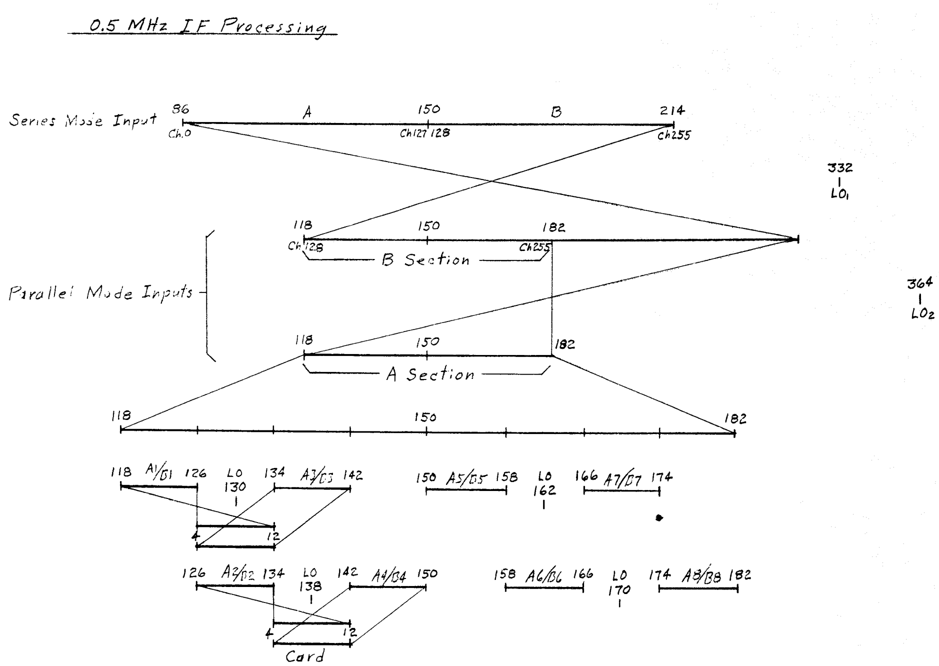


FIGURE 8B

0.25 MHz IF Processing

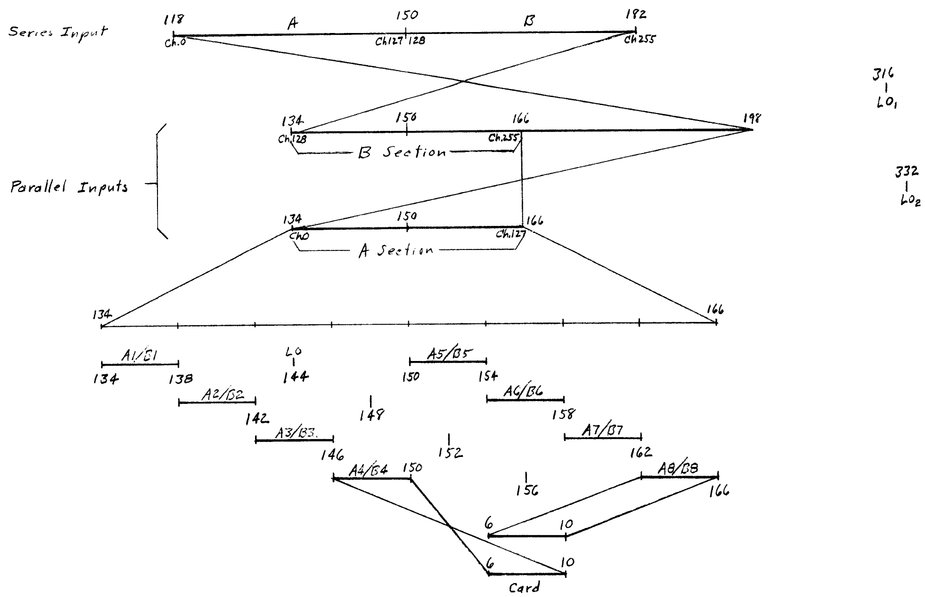


FIGURE 8C

0.1 MHz IF Processing

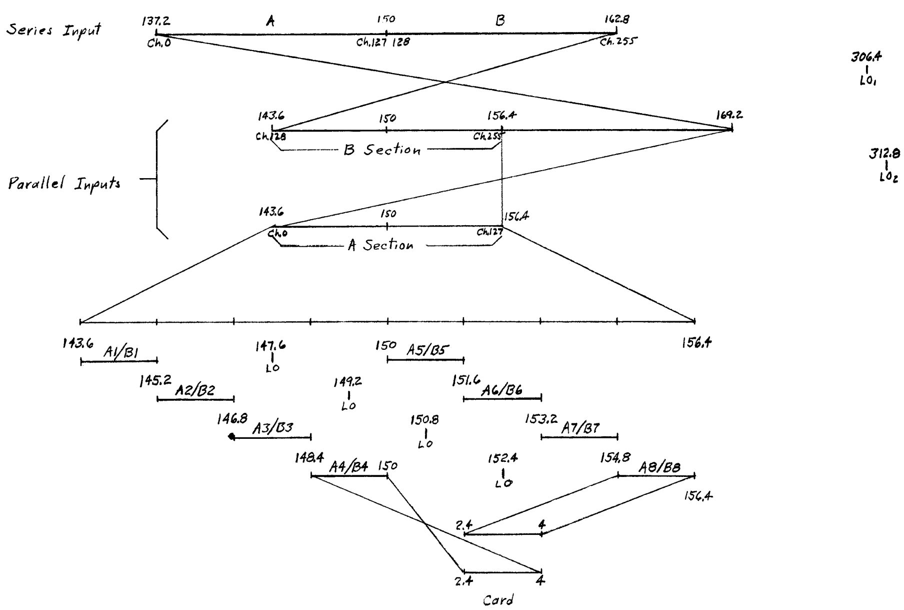
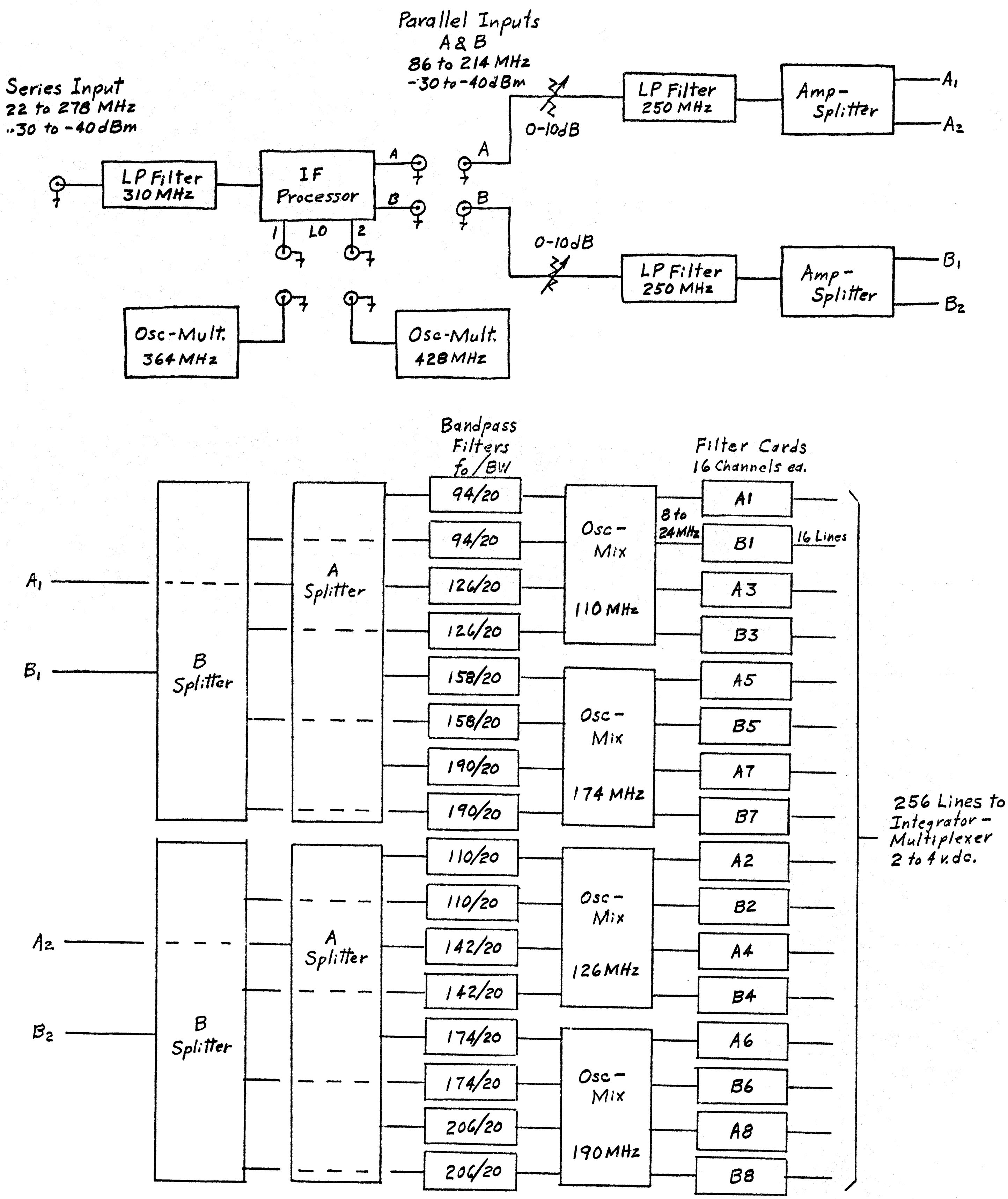
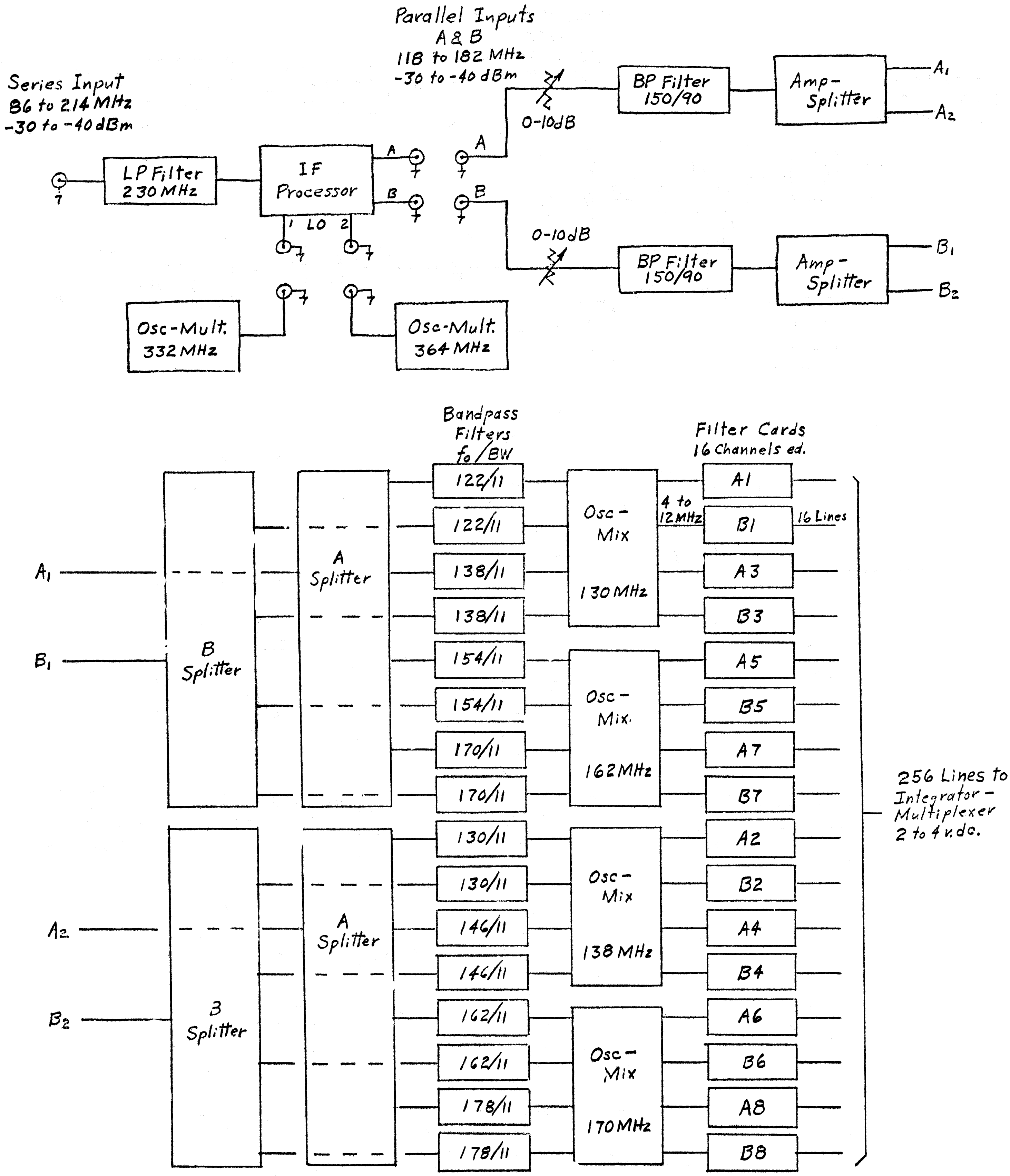


FIGURE 8D



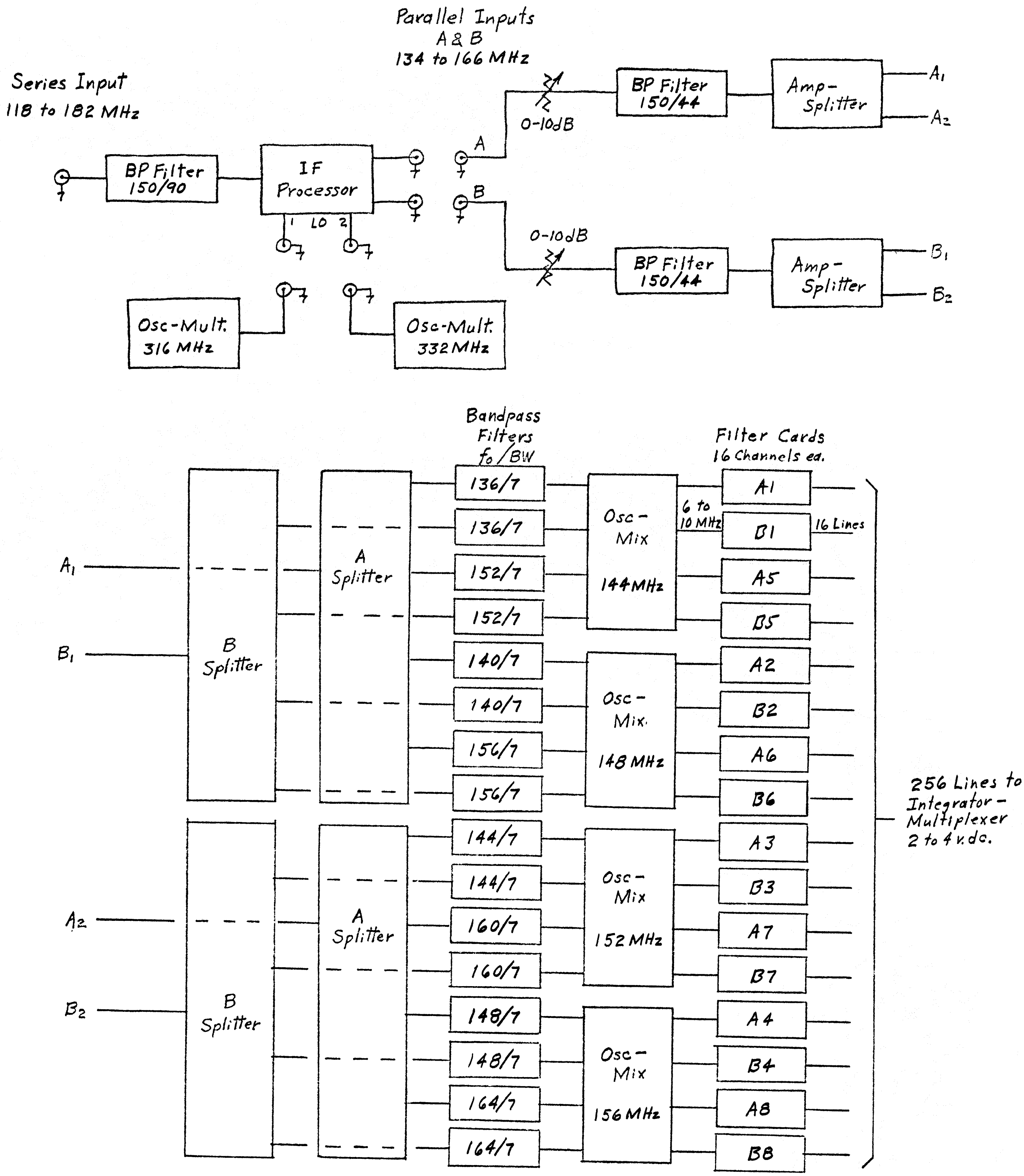
256 Channel Filter Receiver
1.0 MHz Channel Bandwidth

FIG. 9A



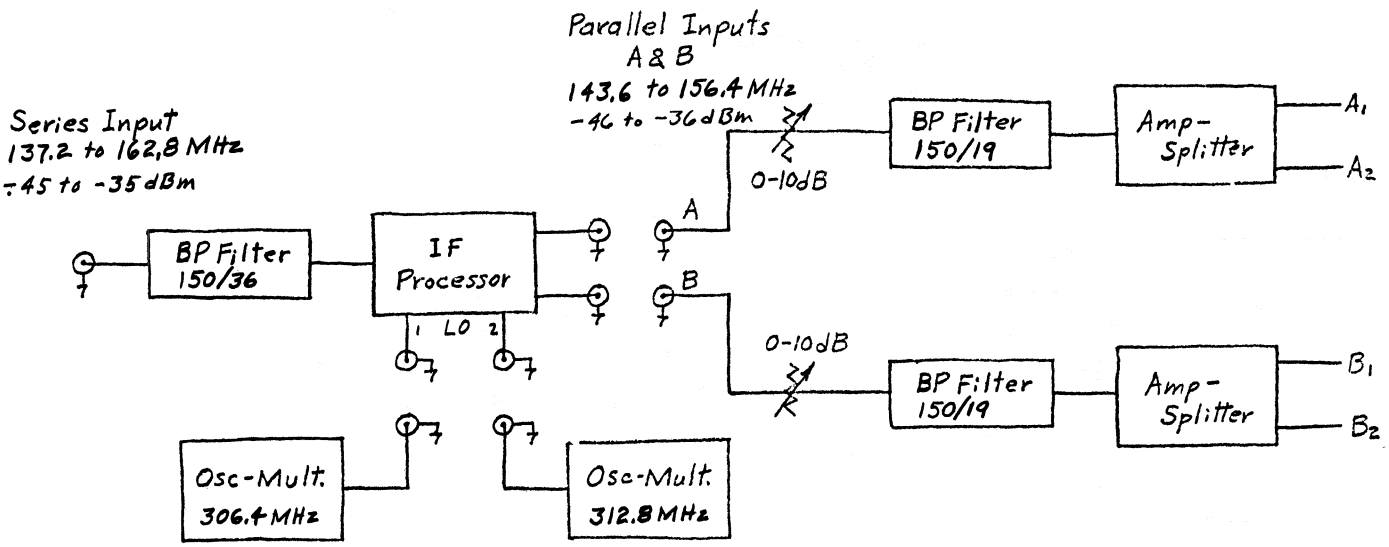
256 Channel Filter Receiver
0.5 MHz Channel Bandwidth

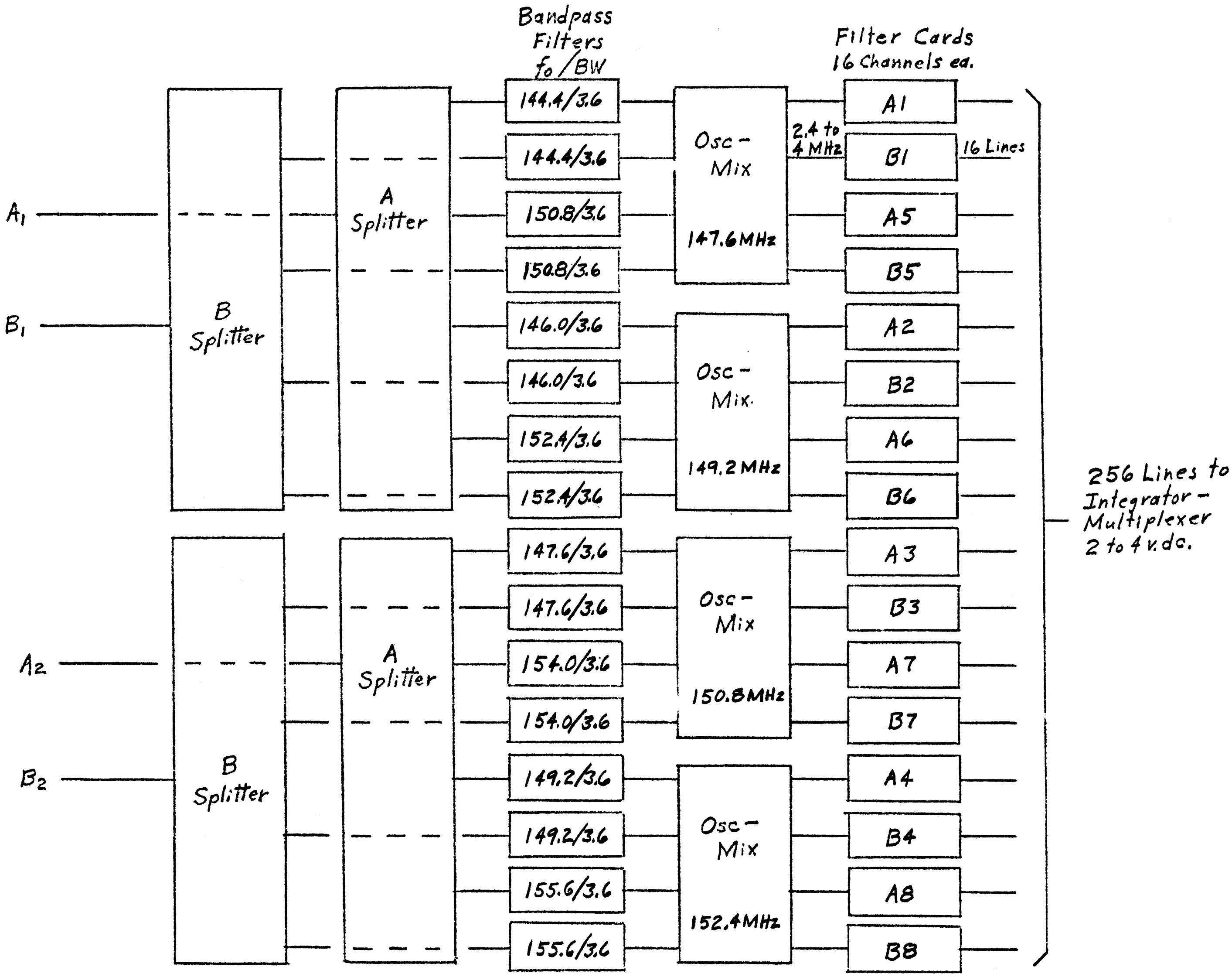
FIG. 9B



256 Channel Filter Receiver
0.25 MHz Channel Bandwidth

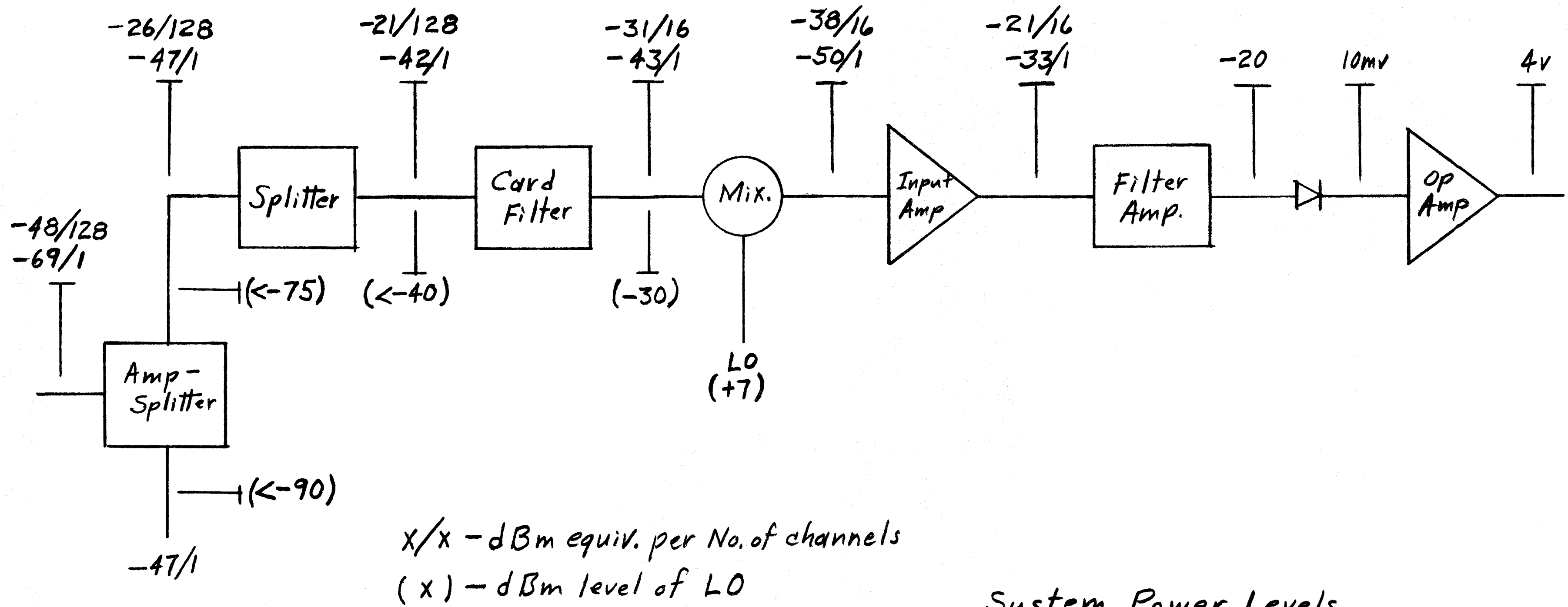
FIG. 9C





256 Channel Filter Receiver
0.1 MHz Channel Bandwidth

FIG. 9D



System Power Levels

FIG. 10

256 CHANNEL FILTER RECEIVER

1 MHz/CHANNEL

INCREMENT= 1.000

FREQUENCY CHART

CHANNEL NO. REC.A	REC.B	PARALLEL	SERIES A	SERIES B	CARD NO. (PARALLEL)	PARALLEL	CARD NO. (SERIES)	B
0	128	86.500	22.500	150.500		16		16
1	129	87.500	23.500	151.500		15		15
2	130	88.500	24.500	152.500		14		14
3	131	89.500	25.500	153.500		13		13
4	132	90.500	26.500	154.500		12		12
5	133	91.500	27.500	155.500		11		11
6	134	92.500	28.500	156.500		10		10
7	135	93.500	29.500	157.500	A1-	9	B8-	9
8	136	94.500	30.500	158.500	B1-	8		8
9	137	95.500	31.500	159.500		7		7
10	138	96.500	32.500	160.500		6		6
11	139	97.500	33.500	161.500		5		5
12	140	98.500	34.500	162.500		4		4
13	141	99.500	35.500	163.500		3		3
14	142	100.500	36.500	164.500		2		2
15	143	101.500	37.500	165.500		1		1
16	144	102.500	38.500	166.500		16		16
17	145	103.500	39.500	167.500		15		15
18	146	104.500	40.500	168.500		14		14
19	147	105.500	41.500	169.500		13		13
20	148	106.500	42.500	170.500		12		12
21	149	107.500	43.500	171.500		11		11
22	150	108.500	44.500	172.500		10		10
23	151	109.500	45.500	173.500	A2-	9	B7-	9
24	152	110.500	46.500	174.500	B2-	8		8
25	153	111.500	47.500	175.500		7		7
26	154	112.500	48.500	176.500		6		6
27	155	113.500	49.500	177.500		5		5
28	156	114.500	50.500	178.500		4		4
29	157	115.500	51.500	179.500		3		3
30	158	116.500	52.500	180.500		2		2
31	159	117.500	53.500	181.500		1		1
32	160	118.500	54.500	182.500		1		1
33	161	119.500	55.500	183.500		2		2
34	162	120.500	56.500	184.500		3		3
35	163	121.500	57.500	185.500		4		4
36	164	122.500	58.500	186.500		5		5
37	165	123.500	59.500	187.500		6		6
38	166	124.500	60.500	188.500	A3-	7		7
39	167	125.500	61.500	189.500	B3-	8		8
40	168	126.500	62.500	190.500		9	B6-	9
41	169	127.500	63.500	191.500		10		10
42	170	128.500	64.500	192.500		11		11
43	171	129.500	65.500	193.500		12		12
44	172	130.500	66.500	194.500		13		13
45	173	131.500	67.500	195.500		14		14
46	174	132.500	68.500	196.500		15		15
47	175	133.500	69.500	197.500		16		16
48	176	134.500	70.500	198.500		1		1
49	177	135.500	71.500	199.500		2		2
50	178	136.500	72.500	200.500		3		3
51	179	137.500	73.500	201.500		4		4
52	180	138.500	74.500	202.500		5		5
53	181	139.500	75.500	203.500		6		6
54	182	140.500	76.500	204.500		7		7
55	183	141.500	77.500	205.500	A4-	8		8
56	184	142.500	78.500	206.500	B4-	9	B5-	9
57	185	143.500	79.500	207.500		10		10
58	186	144.500	80.500	208.500		11		11
59	187	145.500	81.500	209.500		12		12
60	188	146.500	82.500	210.500		13		13
61	189	147.500	83.500	211.500		14		14
62	190	148.500	84.500	212.500		15		15
63	191	149.500	85.500	213.500		16		16
64	192	150.500	86.500	214.500		16		16
65	193	151.500	87.500	215.500		15		15
66	194	152.500	88.500	216.500		14		14
67	195	153.500	89.500	217.500		13		13
68	196	154.500	90.500	218.500		12		12
69	197	155.500	91.500	219.500		11		11
70	198	156.500	92.500	220.500		10		10
71	199	157.500	93.500	221.500	A5-	9		9
72	200	158.500	94.500	222.500	B5-	8	B4-	8
73	201	159.500	95.500	223.500		7		7
74	202	160.500	96.500	224.500		6		6
75	203	161.500	97.500	225.500		5		5
76	204	162.500	98.500	226.500		4		4
77	205	163.500	99.500	227.500		3		3
78	206	164.500	100.500	228.500		2		2
79	207	165.500	101.500	229.500		1		1
80	208	166.500	102.500	230.500		16		16
81	209	167.500	103.500	231.500		15		15
82	210	168.500	104.500	232.500		14		14
83	211	169.500	105.500	233.500		13		13
84	212	170.500	106.500	234.500		12		12
85	213	171.500	107.500	235.500		11		11
86	214	172.500	108.500	236.500		10		10
87	215	173.500	109.500	237.500	A6-	9		9
88	216	174.500	110.500	238.500	B6-	8	B3-	8
89	217	175.500	111.500	239.500		7		7
90	218	176.500	112.500	240.500		6		6
91	219	177.500	113.500	241.500		5		5
92	220	178.500	114.500	242.500		4		4
93	221	179.500	115.500	243.500		3		3
94	222	180.500	116.500	244.500		2		2
95	223	181.500	117.500	245.500		1		1
96	224	182.500	118.500	246.500		1		1
97	225	183.500	119.500	247.500		2		2
98	226	184.500	120.500	248.500		3		3
99	227	185.500	121.500	249.500		4		4
100	228	186.500	122.500	250.500		5		5
101	229	187.500	123.500	251.500		6		6
102	230	188.500	124.500	252.500		7		7
103	231	189.500	125.500	253.500	A7-	8		8
104	232	190.500	126.500	254.500	B7-	9	B2-	9
105	233	191.500	127.500	255.500		10		10
106	234	192.500	128.500	256.500		11		11
107	235	193.500	129.500	257.500		12		12
108	236	194.500	130.500	258.500		13		13
109	237	195.500	131.500	259.500		14		14
110	238	196.500	132.500	260.500		15		15
111	239	197.500	133.500	261.500		16		16
112	240	198.500	134.500	262.500		1		1
113	241	199.500	135.500	263.500		2		2
114	242	200.500	136.500	264.500		3		3
115	243	201.500	137.500	265.500		4		4
116	244	202.500	138.500	266.500		5		5
117	245	203.500	139.500	267.500		6		6
118	246	204.500	140.500	268.500		7		7
119	247	205.500	141.500	269.500	A8-	8		8
120	248	206.500	142.500	270.500	B8-	9	B1-	9
121	249	207.500	143.500	271.500		10		10
122	250	208.500	144.500	272.500		11		11
123	251	209.500	145.500	273.500		12		12
124	252	210.500	146.500	274.500		13		13
125	253	211.500	147.500	275.500		14		14
126	254	212.500	148.500	276.500		15		15
127	255	213.500	149.500	277.500		16		16

FIG. 11 A

256 CHANNEL FILTER RECEIVER

500 kHz/Channel

INCREMENT= 0.500

FREQUENCY CHART

CHANNEL NO. REC.A	REC.B	PARALLEL	SERIES A	SERIES B	CARD NO. (PARALLEL)	PARALLEL	CARD NO. (SERIES)	B
0	128	118.250	86.250	150.250		16		16
1	129	118.750	86.750	150.750		15		15
2	130	119.250	87.250	151.250		14		14
3	131	119.750	87.750	151.750		13		13
4	132	120.250	88.250	152.250		12		12
5	133	120.750	88.750	152.750		11		11
6	134	121.250	89.250	153.250		10		10
7	135	121.750	89.750	153.750	A1-	9	B8-	9
8	136	122.250	90.250	154.250	B1-	8		8
9	137	122.750	90.750	154.750		7		7
10	138	123.250	91.250	155.250		6		6
11	139	123.750	91.750	155.750		5		5
12	140	124.250	92.250	156.250		4		4
13	141	124.750	92.750	156.750		3		3
14	142	125.250	93.250	157.250		2		2
15	143	125.750	93.750	157.750		1		1
16	144	126.250	94.250	158.250		16		16
17	145	126.750	94.750	158.750		15		15
18	146	127.250	95.250	159.250		14		14
19	147	127.750	95.750	159.750		13		13
20	148	128.250	96.250	160.250		12		12
21	149	128.750	96.750	160.750		11		11
22	150	129.250	97.250	161.250		10		10
23	151	129.750	97.750	161.750	A2-	9	B7-	9
24	152	130.250	98.250	162.250	B2-	8		8
25	153	130.750	98.750	162.750		7		7
26	154	131.250	99.250	163.250		6		6
27	155	131.750	99.750	163.750		5		5
28	156	132.250	100.250	164.250		4		4
29	157	132.750	100.750	164.750		3		3
30	158	133.250	101.250	165.250		2		2
31	159	133.750	101.750	165.750		1		1
32	160	134.250	102.250	166.250		1		1
33	161	134.750	102.750	166.750		2		2
34	162	135.250	103.250	167.250		3		3
35	163	135.750	103.750	167.750		4		4
36	164	136.250	104.250	168.250		5		5
37	165	136.750	104.750	168.750		6		6
38	166	137.250	105.250	169.250	A3-	7		7
39	167	137.750	105.750	169.750	B3-	8	B6-	8
40	168	138.250	106.250	170.250		9		9
41	169	138.750	106.750	170.750		10		10
42	170	139.250	107.250	171.250		11		11
43	171	139.750	107.750	171.750		12		12
44	172	140.250	108.250	172.250		13		13
45	173	140.750	108.750	172.750		14		14
46	174	141.250	109.250	173.250		15		15
47	175	141.750	109.750	173.750		16		16
48	176	142.250	110.250	174.250		1		1
49	177	142.750	110.750	174.750		2		2
50	178	143.250	111.250	175.250		3		3
51	179	143.750	111.750	175.750		4		4
52	180	144.250	112.250	176.250		5		5
53	181	144.750	112.750	176.750		6		6
54	182	145.250	113.250	177.250	A4-	7		7
55	183	145.750	113.750	177.750	B4-	8	B5-	8
56	184	146.250	114.250	178.250		9		9
57	185	146.750	114.750	178.750		10		10
58	186	147.250	115.250	179.250		11		11
59	187	147.750	115.750	179.750		12		12
60	188	148.250	116.250	180.250		13		13
61	189	148.750	116.750	180.750		14		14
62	190	149.250	117.250	181.250		15		15
63	191	149.750	117.750	181.750		16		16
64	192	150.250	118.250	182.250		16		16
65	193	150.750	118.750	182.750		15		15
66	194	151.250	119.250	183.250		14		14
67	195	151.750	119.750	183.750		13		13
68	196	152.250	120.250	184.250		12		12
69	197	152.750	120.750	184.750		11		11
70	198	153.250	121.250	185.250		10		10
71	199	153.750	121.750	185.750	A5-	9		9
72	200	154.250	122.250	186.250	B5-	8	B4-	8
73	201	154.750	122.750	186.750		7		7
74	202	155.250	123.250	187.250		6		6
75	203	155.750	123.750	187.750		5		5
76	204	156.250	124.250	188.250		4		4
77	205	156.750	124.750	188.750		3		3
78	206	157.250	125.250	189.250		2		2
79	207	157.750	125.750	189.750		1		1
80	208	158.250	126.250	190.250		16		16
81	209	158.750	126.750	190.750		15		15
82	210	159.250	127.250	191.250		14		14
83	211	159.750	127.750	191.750		13		13
84	212	160.250	128.250	192.250		12		12
85	213	160.750	128.750	192.750		11		11
86	214	161.250	129.250	193.250		10		10
87	215	161.750	129.750	193.750	A6-	9		9
88	216	162.250	130.250	194.250	B6-	8	B3-	8
89	217	162.750	130.750	194.750		7		7
90	218	163.250	131.250	195.250		6		6
91	219	163.750	131.750	195.750		5		5
92	220	164.250	132.250	196.250		4		4
93	221	164.750	132.750	196.750		3		3
94	222	165.250	133.250	197.250		2		2
95	223	165.750	133.750	197.750		1		1
96	224	166.250	134.250	198.250		1		1
97	225	166.750	134.750	198.750		2		2
98	226	167.250	135.250	199.250		3		3
99	227	167.750	135.750	199.750		4		4
100	228	168.250	136.250	200.250		5		5
101	229	168.750	136.750	200.750		6		6
102	230	169.250	137.250	201.250	A7-	7		7
103	231	169.750	137.750	201.750	B7-	8	B2-	8
104	232	170.250	138.250	202.250		9		9
105	233	170.750	138.750	202.750		10		10
106	234	171.250	139.250	203.250		11		11
107	235	171.750	139.750	203.750		12		12
108	236	172.250	140.250	204.250		13		13
109	237	172.750	140.750	204.750		14		14
110	238	173.250	141.250	205.250		15		15
111	239	173.750	141.750	205.750		16		16
112	240	174.250	142.250	206.250		1		1
113	241	174.750	142.750	206.750		2		2
114	242	175.250	143.250	207.250		3		3
115	243	175.750	143.750	207.750		4		4
116	244	176.250	144.250	208.250		5		5
117	245	176.750	144.750	208.750		6		6
118	246	177.250	145.250	209.250	A8-	7		7
119	247	177.750	145.750	209.750	B8-	8	B1-	8
120	248	178.250	146.250	210.250		o		9
121	249	178.750	146.750	210.750		10		10
122	250	179.250	147.250	211.250		11		11
123	251	179.750	147.750	211.750		12		12
124	252	180.250	148.250	212.250		13		13
125	253	180.750	148.750	212.750		14		14
126	254	181.250	149.250	213.250		15		15
127	255	181.750	149.750	213.750		16		16

FIG. 11 B

256 CHANNEL FILTER RECEIVER
250 KHz/CHANNEL

INCREMENT= 0.250

FREQUENCY CHART

CHANNEL NO. REC.A	REC.B	PARALLEL	SERIES A	SERIES B	CARD NO. & CHANNEL PARALLEL	CARD NO. & CHANNEL SERIES B
0	128	134.125	118.125	150.125	16	16
1	129	134.375	118.375	150.375	15	15
2	130	134.625	118.625	150.625	14	14
3	131	134.875	118.875	150.875	13	13
4	132	135.125	119.125	151.125	12	12
5	133	135.375	119.375	151.375	11	11
6	134	135.625	119.625	151.625	10	10
7	135	135.875	119.875	151.875	A1- 9	B8- 9
8	136	136.125	120.125	152.125	B1- 8	8
9	137	136.375	120.375	152.375	7	7
10	138	136.625	120.625	152.625	6	6
11	139	136.875	120.875	152.875	5	5
12	140	137.125	121.125	153.125	4	4
13	141	137.375	121.375	153.375	3	3
14	142	137.625	121.625	153.625	2	2
15	143	137.875	121.875	153.875	1	1
16	144	138.125	122.125	154.125	16	16
17	145	138.375	122.375	154.375	15	15
18	146	138.625	122.625	154.625	14	14
19	147	138.875	122.875	154.875	13	13
20	148	139.125	123.125	155.125	12	12
21	149	139.375	123.375	155.375	11	11
22	150	139.625	123.625	155.625	10	10
23	151	139.875	123.875	155.875	A2- 9	B7 9
24	152	140.125	124.125	156.125	B2- 8	8
25	153	140.375	124.375	156.375	7	7
26	154	140.625	124.625	156.625	6	6
27	155	140.875	124.875	156.875	5	5
28	156	141.125	125.125	157.125	4	4
29	157	141.375	125.375	157.375	3	3
30	158	141.625	125.625	157.625	2	2
31	159	141.875	125.875	157.875	1	1
32	160	142.125	126.125	158.125	16	16
33	161	142.375	126.375	158.375	15	15
34	162	142.625	126.625	158.625	14	14
35	163	142.875	126.875	158.875	13	13
36	164	143.125	127.125	159.125	12	12
37	165	143.375	127.375	159.375	11	11
38	166	143.625	127.625	159.625	10	10
39	167	143.875	127.875	159.875	A3- 9	B6- 9
40	168	144.125	128.125	160.125	B3- 8	8
41	169	144.375	128.375	160.375	7	7
42	170	144.625	128.625	160.625	6	6
43	171	144.875	128.875	160.875	5	5
44	172	145.125	129.125	161.125	4	4
45	173	145.375	129.375	161.375	3	3
46	174	145.625	129.625	161.625	2	2
47	175	145.875	129.875	161.875	1	1
48	176	146.125	130.125	162.125	16	16
49	177	146.375	130.375	162.375	15	15
50	178	146.625	130.625	162.625	14	14
51	179	146.875	130.875	162.875	13	13
52	180	147.125	131.125	163.125	12	12
53	181	147.375	131.375	163.375	11	11
54	182	147.625	131.625	163.625	10	10
55	183	147.875	131.875	163.875	A4- 9	B5- 9
56	184	148.125	132.125	164.125	B4- 8	8
57	185	148.375	132.375	164.375	7	7
58	186	148.625	132.625	164.625	6	6
59	187	148.875	132.875	164.875	5	5
60	188	149.125	133.125	165.125	4	4
61	189	149.375	133.375	165.375	3	3
62	190	149.625	133.625	165.625	2	2
63	191	149.875	133.875	165.875	1	1
64	192	150.125	134.125	166.125	1	1
65	193	150.375	134.375	166.375	2	2
66	194	150.625	134.625	166.625	3	3
67	195	150.875	134.875	166.875	4	4
68	196	151.125	135.125	167.125	5	5
69	197	151.375	135.375	167.375	6	6
70	198	151.625	135.625	167.625	7	7
71	199	151.875	135.875	167.875	A5- 8	8
72	200	152.125	136.125	168.125	B5- 9	B4- 9
73	201	152.375	136.375	168.375	10	10
74	202	152.625	136.625	168.625	11	11
75	203	152.875	136.875	168.875	12	12
76	204	153.125	137.125	169.125	13	13
77	205	153.375	137.375	169.375	14	14
78	206	153.625	137.625	169.625	15	15
79	207	153.875	137.875	169.875	16	16
80	208	154.125	138.125	170.125	1	1
81	209	154.375	138.375	170.375	2	2
82	210	154.625	138.625	170.625	3	3
83	211	154.875	138.875	170.875	4	4
84	212	155.125	139.125	171.125	5	5
85	213	155.375	139.375	171.375	6	6
86	214	155.625	139.625	171.625	7	7
87	215	155.875	139.875	171.875	A6- 8	8
88	216	156.125	140.125	172.125	B6- 9	B3- 9
89	217	156.375	140.375	172.375	10	10
90	218	156.625	140.625	172.625	11	11
91	219	156.875	140.875	172.875	12	12
92	220	157.125	141.125	173.125	13	13
93	221	157.375	141.375	173.375	14	14
94	222	157.625	141.625	173.625	15	15
95	223	157.875	141.875	173.875	16	16
96	224	158.125	142.125	174.125	1	1
97	225	158.375	142.375	174.375	2	2
98	226	158.625	142.625	174.625	3	3
99	227	158.875	142.875	174.875	4	4
100	228	159.125	143.125	175.125	5	5
101	229	159.375	143.375	175.375	6	6
102	230	159.625	143.625	175.625	7	7
103	231	159.875	143.875	175.875	A7- 8	8
104	232	160.125	144.125	176.125	B7- 9	B2- 9
105	233	160.375	144.375	176.375	10	10
106	234	160.625	144.625	176.625	11	11
107	235	160.875	144.875	176.875	12	12
108	236	161.125	145.125	177.125	13	13
109	237	161.375	145.375	177.375	14	14
110	238	161.625	145.625	177.625	15	15
111	239	161.875	145.875	177.875	16	16
112	240	162.125	146.125	178.125	1	1
113	241	162.375	146.375	178.375	2	2
114	242	162.625	146.625	178.625	3	3
115	243	162.875	146.875	178.875	4	4
116	244	163.125	147.125	179.125	5	5
117	245	163.375	147.375	179.375	6	6
118	246	163.625	147.625	179.625	7	7
119	247	163.875	147.875	179.875	A8- 8	8
120	248	164.125	148.125	180.125	B8- 9	B1- 9
121	249	164.375	148.375	180.375	10	10
122	250	164.625	148.625	180.625	11	11
123	251	164.875	148.875	180.875	12	12
124	252	165.125	149.125	181.125	13	13
125	253	165.375	149.375	181.375	14	14
126	254	165.625	149.625	181.625	15	15
127	255	165.875	149.875	181.875	16	16

FIG. 11C

256 CHANNEL FILTER RECEIVER
100 kHz /Channel

INCREMENT= 0.100

FREQUENCY CHART

CHANNEL NO. REC.A	REC.B	PARALLEL	SERIES A	SERIES B	CARD NO. & CHANNEL PARALLEL	CARD NO. & CHANNEL SERIES B
0	128	143.650	137.250	150.050	16	16
1	129	143.750	137.350	150.150	15	15
2	130	143.850	137.450	150.250	14	14
3	131	143.950	137.550	150.350	13	13
4	132	144.050	137.650	150.450	12	12
5	133	144.150	137.750	150.550	11	11
6	134	144.250	137.850	150.650	10	10
7	135	144.350	137.950	150.750	A1- 9	B8- 9
8	136	144.450	138.050	150.850	B1- 8	8
9	137	144.550	138.150	150.950	7	7
10	138	144.650	138.250	151.050	6	6
11	139	144.750	138.350	151.150	5	5
12	140	144.850	138.450	151.250	4	4
13	141	144.950	138.550	151.350	3	3
14	142	145.050	138.650	151.450	2	2
15	143	145.150	138.750	151.550	1	1
16	144	145.250	138.850	151.650	16	16
17	145	145.350	138.950	151.750	15	15
18	146	145.450	139.050	151.850	14	14
19	147	145.550	139.150	151.950	13	13
20	148	145.650	139.250	152.050	12	12
21	149	145.750	139.350	152.150	11	11
22	150	145.850	139.450	152.250	10	10
23	151	145.950	139.550	152.350	A2- 9	B7- 9
24	152	146.050	139.650	152.450	B2- 8	8
25	153	146.150	139.750	152.550	7	7
26	154	146.250	139.850	152.650	6	6
27	155	146.350	139.950	152.750	5	5
28	156	146.450	140.050	152.850	4	4
29	157	146.550	140.150	152.950	3	3
30	158	146.650	140.250	153.050	2	2
31	159	146.750	140.350	153.150	1	1
32	160	146.850	140.450	153.250	16	16
33	161	146.950	140.550	153.350	15	15
34	162	147.050	140.650	153.450	14	14
35	163	147.150	140.750	153.550	13	13
36	164	147.250	140.850	153.650	12	12
37	165	147.350	140.950	153.750	11	11
38	166	147.450	141.050	153.850	10	10
39	167	147.550	141.150	153.950	A3- 9	B6- 9
40	168	147.650	141.250	154.050	B3- 8	8
41	169	147.750	141.350	154.150	7	7
42	170	147.850	141.450	154.250	6	6
43	171	147.950	141.550	154.350	5	5
44	172	148.050	141.650	154.450	4	4
45	173	148.150	141.750	154.550	3	3
46	174	148.250	141.850	154.650	2	2
47	175	148.350	141.950	154.750	1	1
48	176	148.450	142.050	154.850	16	16
49	177	148.550	142.150	154.950	15	15
50	178	148.650	142.250	155.050	14	14
51	179	148.750	142.350	155.150	13	13
52	180	148.850	142.450	155.250	12	12
53	181	148.950	142.550	155.350	11	11
54	182	149.050	142.650	155.450	10	10
55	183	149.150	142.750	155.550	A4- 9	B5- 9
56	184	149.250	142.850	155.650	B4- 8	8
57	185	149.350	142.950	155.750	7	7
58	186	149.450	143.050	155.850	6	6
59	187	149.550	143.150	155.950	5	5
60	188	149.650	143.250	156.050	4	4
61	189	149.750	143.350	156.150	3	3
62	190	149.850	143.450	156.250	2	2
63	191	149.950	143.550	156.350	1	1
64	192	150.050	143.650	156.450	1	1
65	193	150.150	143.750	156.550	2	2
66	194	150.250	143.850	156.650	3	3
67	195	150.350	143.950	156.750	4	4
68	196	150.450	144.050	156.850	5	5
69	197	150.550	144.150	156.950	6	6
70	198	150.650	144.250	157.050	A5- 7	B4- 7
71	199	150.750	144.350	157.150	B5- 8	8
72	200	150.850	144.450	157.250	9	9
73	201	150.950	144.550	157.350	10	10
74	202	151.050	144.650	157.450	11	11
75	203	151.150	144.750	157.550	12	12
76	204	151.250	144.850	157.650	13	13
77	205	151.350	144.950	157.750	14	14
78	206	151.450	145.050	157.850	15	15
79	207	151.550	145.150	157.950	16	16
80	208	151.650	145.250	158.050	1	1
81	209	151.750	145.350	158.150	2	2
82	210	151.850	145.450	158.250	3	3
83	211	151.950	145.550	158.350	4	4
84	212	152.050	145.650	158.450	5	5
85	213	152.150	145.750	158.550	6	6
86	214	152.250	145.850	158.650	A6- 7	B3- 7
87	215	152.350	145.950	158.750	B6- 8	8
88	216	152.450	146.050	158.850	9	9
89	217	152.550	146.150	158.950	10	10
90	218	152.650	146.250	159.050	11	11
91	219	152.750	146.350	159.150	12	12
92	220	152.850	146.450	159.250	13	13
93	221	152.950	146.550	159.350	14	14
94	222	153.050	146.650	159.450	15	15
95	223	153.150	146.750	159.550	16	16
96	224	153.250	146.850	159.650	1	1
97	225	153.350	146.950	159.750	2	2
98	226	153.450	147.050	159.850	3	3
99	227	153.550	147.150	159.950	4	4
100	228	153.650	147.250	160.050	5	5
101	229	153.750	147.350	160.150	6	6
102	230	153.850	147.450	160.250	A7- 7	B2- 7
103	231	153.950	147.550	160.350	B7- 8	8
104	232	154.050	147.650	160.450	9	9
105	233	154.150	147.750	160.550	10	10
106	234	154.250	147.850	160.650	11	11
107	235	154.350	147.950	160.750	12	12
108	236	154.450	148.050	160.850	13	13
109	237	154.550	148.150	160.950	14	14
110	238	154.650	148.250	161.050	15	15
111	239	154.750	148.350	161.150	16	16
112	240	154.850	148.450	161.250	1	1
113	241	154.950	148.550	161.350	2	2
114	242	155.050	148.650	161.450	3	3
115	243	155.150	148.750	161.550	4	4
116	244	155.250	148.850	161.650	5	5
117	245	155.350	148.950	161.750	6	6
118	246	155.450	149.050	161.850	A8- 7	B1- 7
119	247	155.550	149.150	161.950	B8- 8	8
120	248	155.650	149.250	162.050	9	9
121	249	155.750	149.350	162.150	10	10
122	250	155.850	149.450	162.250	11	11
123	251	155.950	149.550	162.350	12	12
124	252	156.050	149.650	162.450	13	13
125	253	156.150	149.750	162.550	14	14
126	254	156.250	149.850	162.650	15	15
127	255	156.350	149.950	162.750	16	16

FIG. 11D

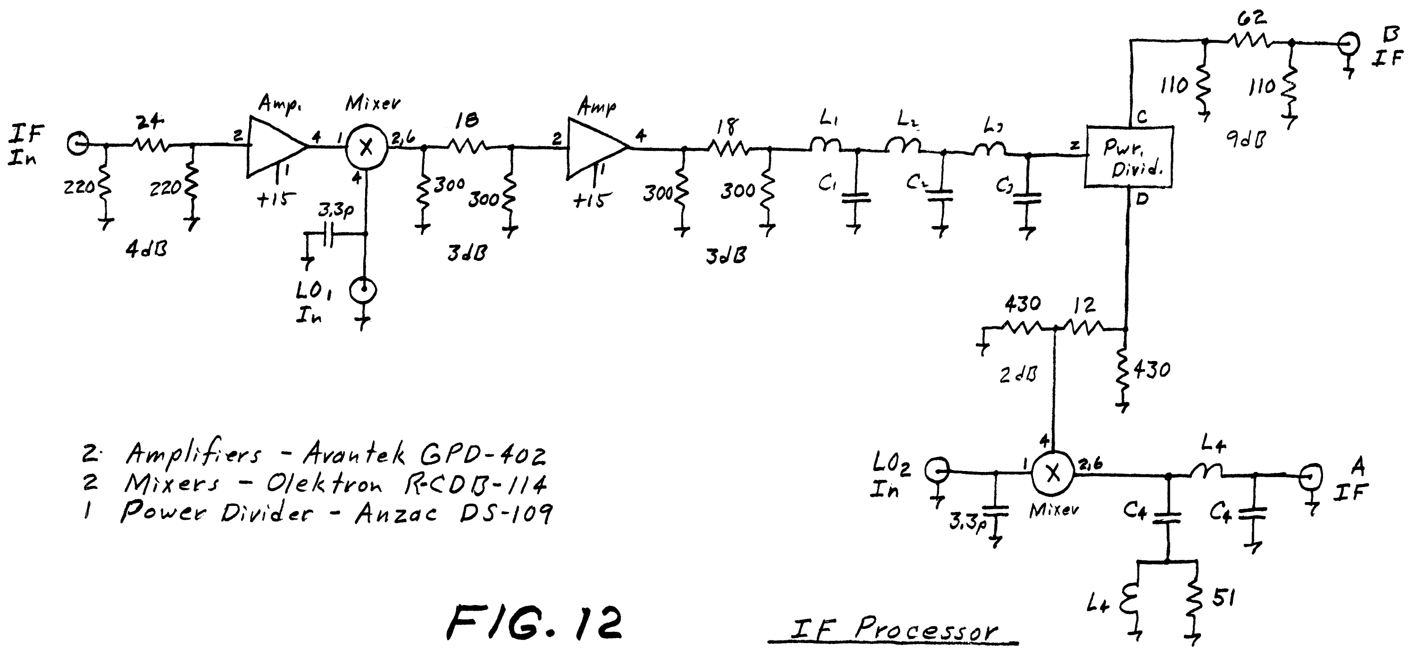


FIG. 12 IF Processor

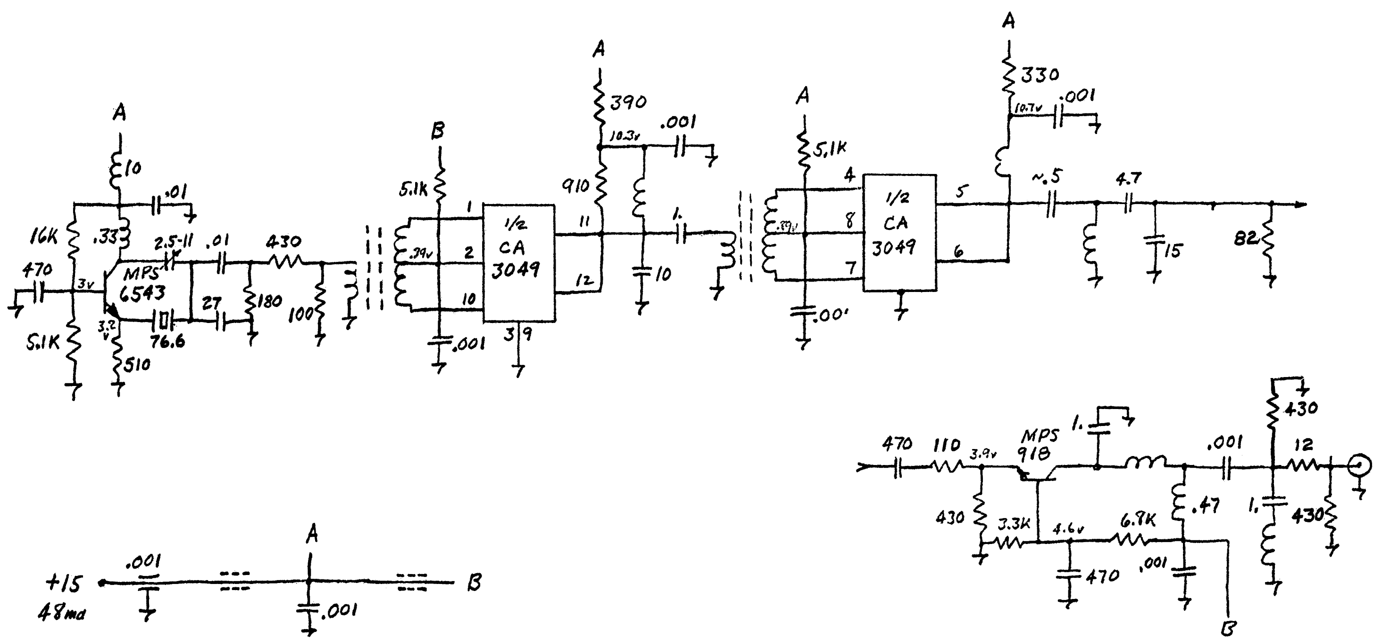
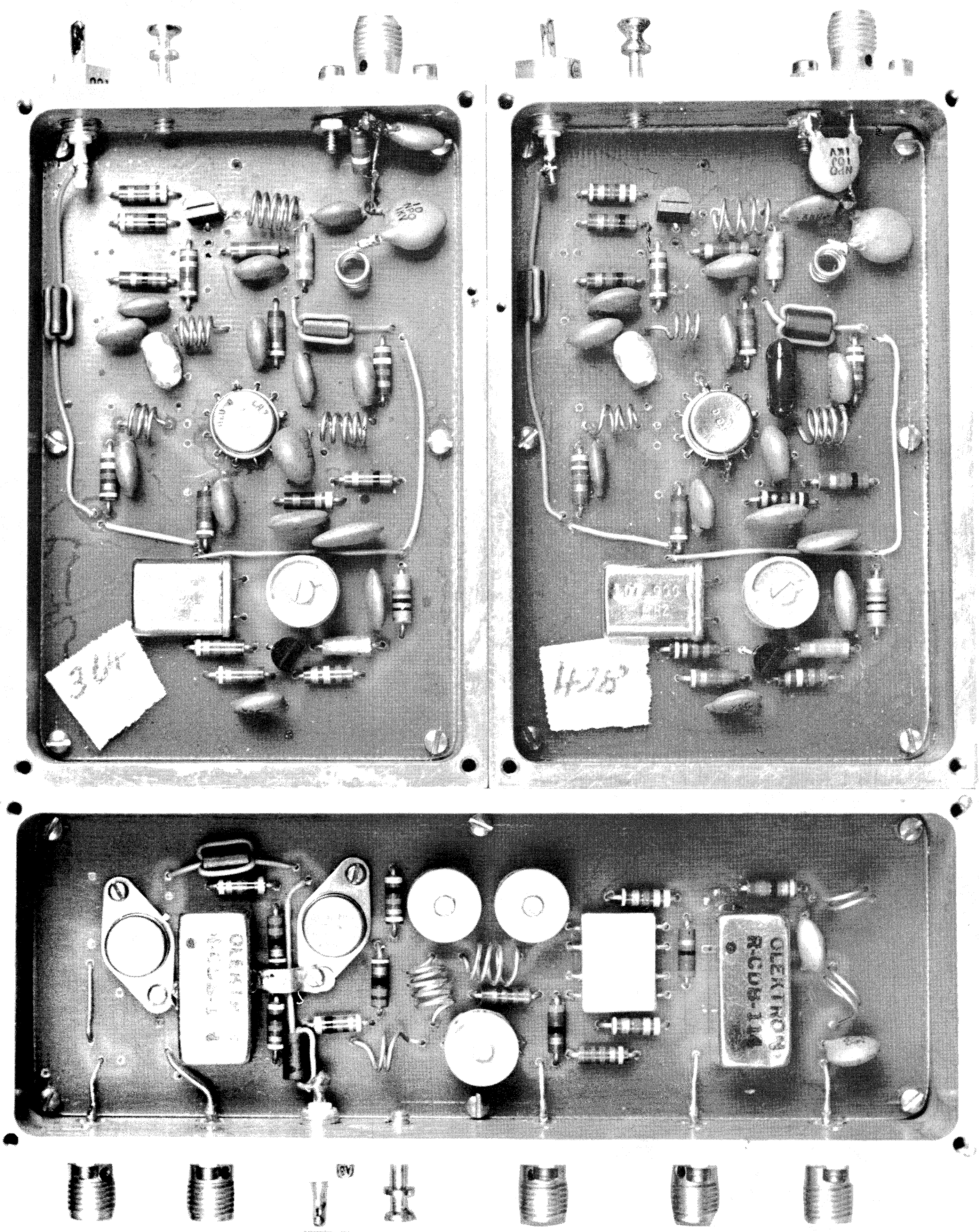
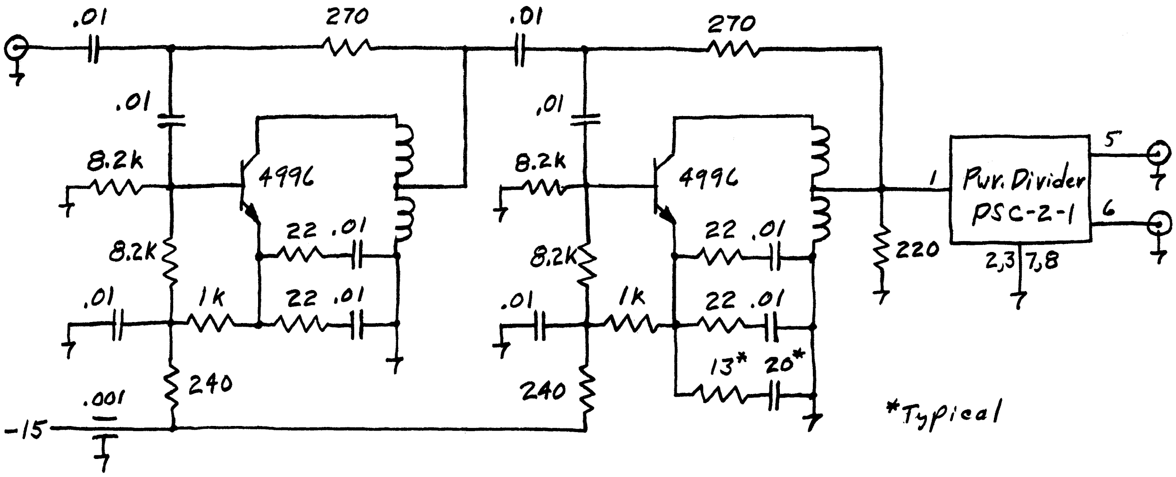


FIG. 13 306.4 MHz Oscillator-Multiplier



IF PROCESSOR AND OSCILLATOR-MULTIPLIERS

FIGURE 14



Amplifier - Splitter

50 to 250 MHz

FIG. 15

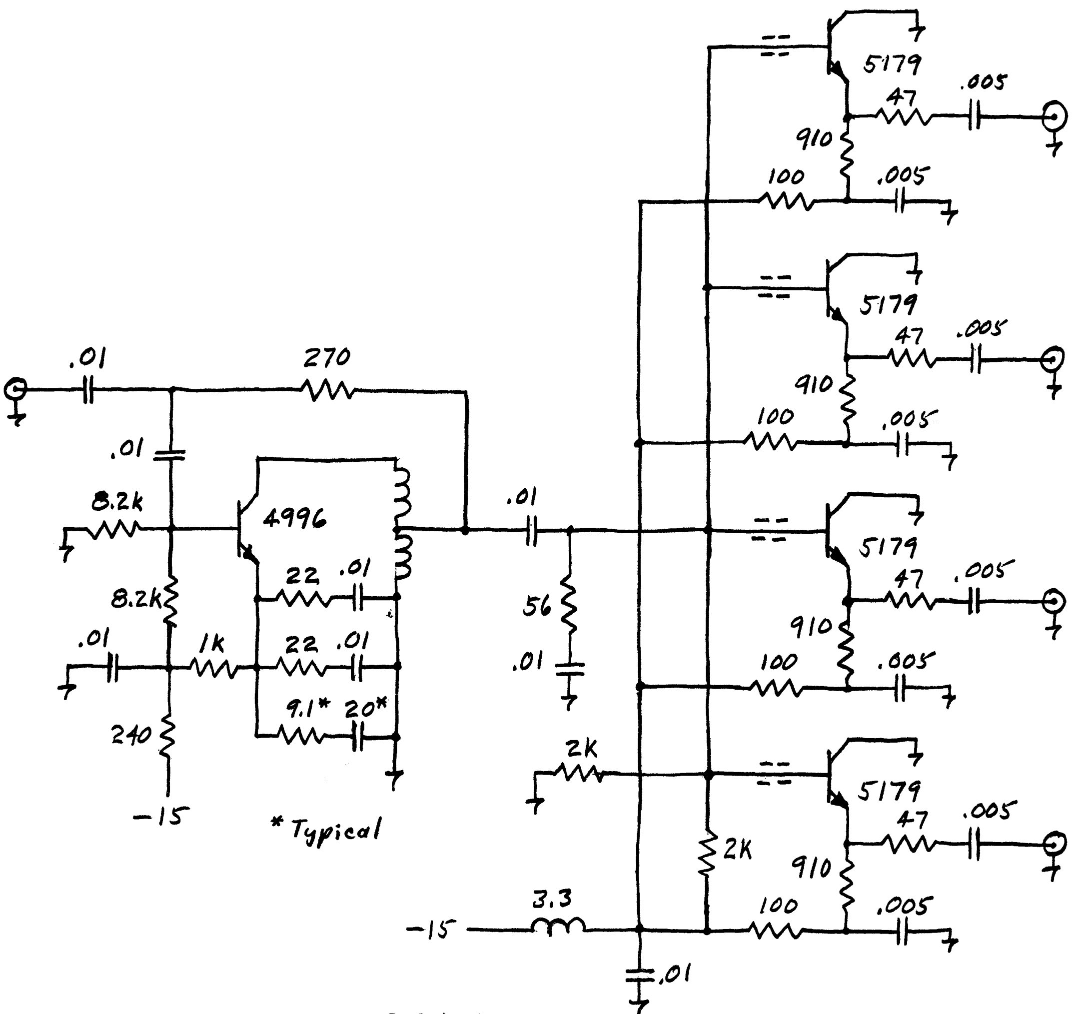


FIG. 16 Splitter

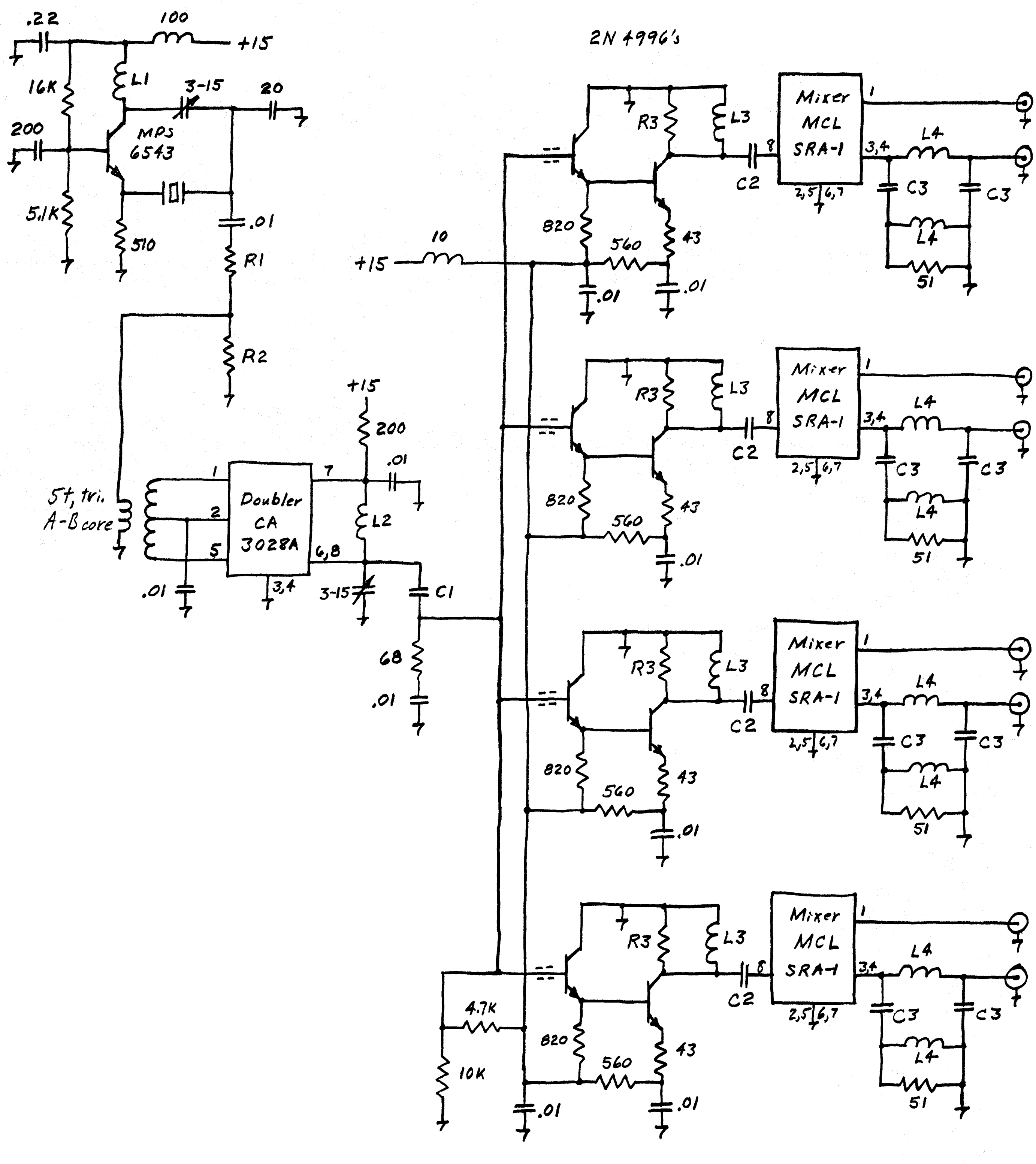


FIG. 17 Oscillator-Mixer

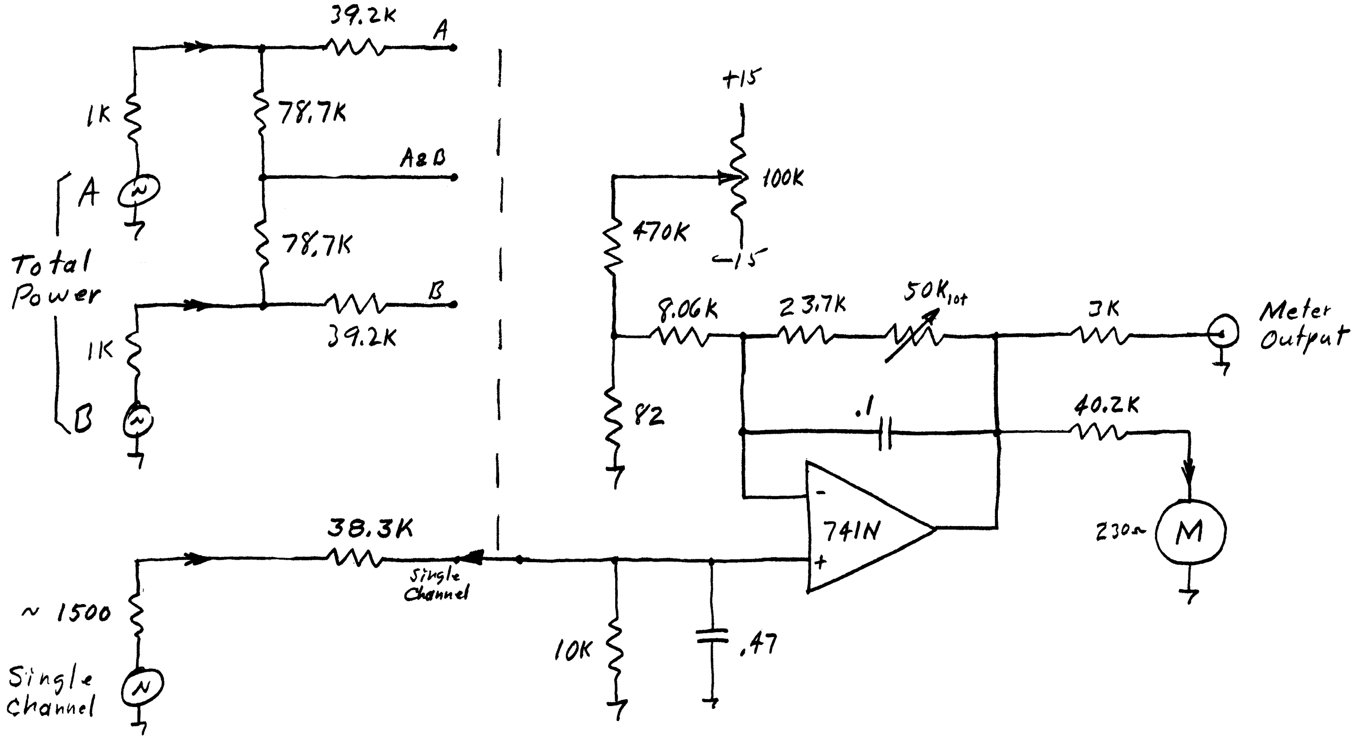


FIG. 18 Power Monitor

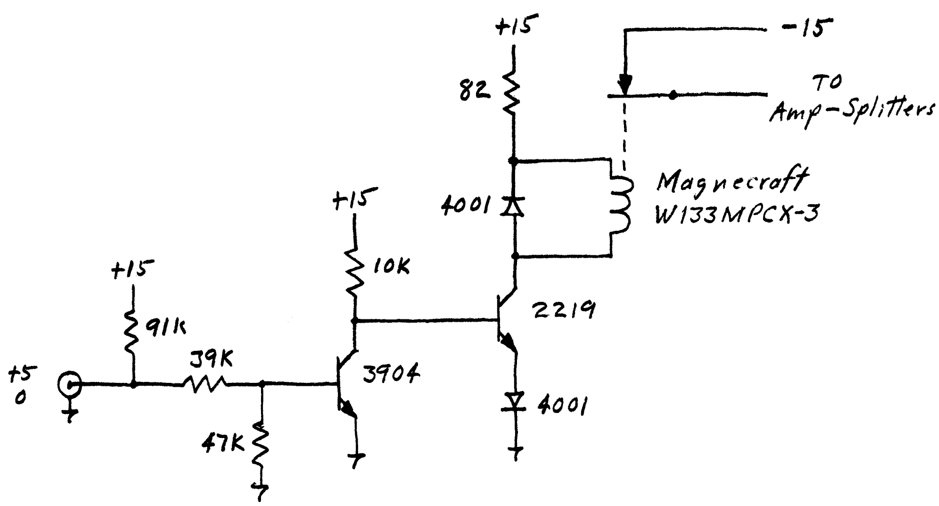
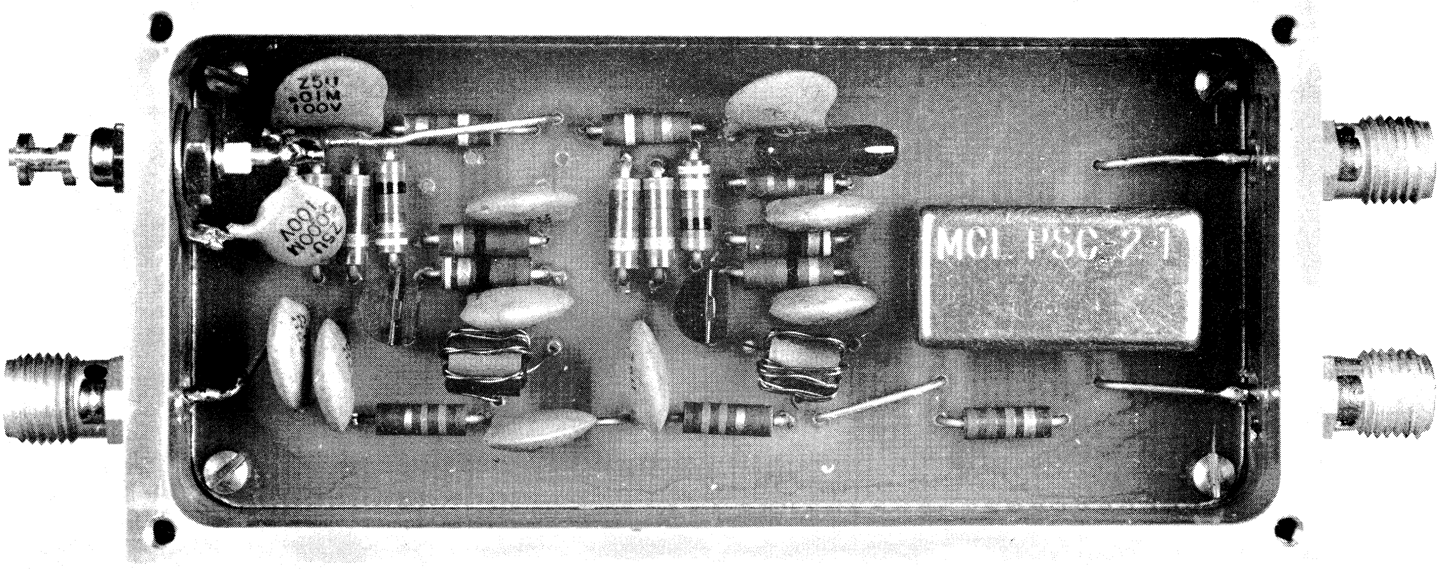
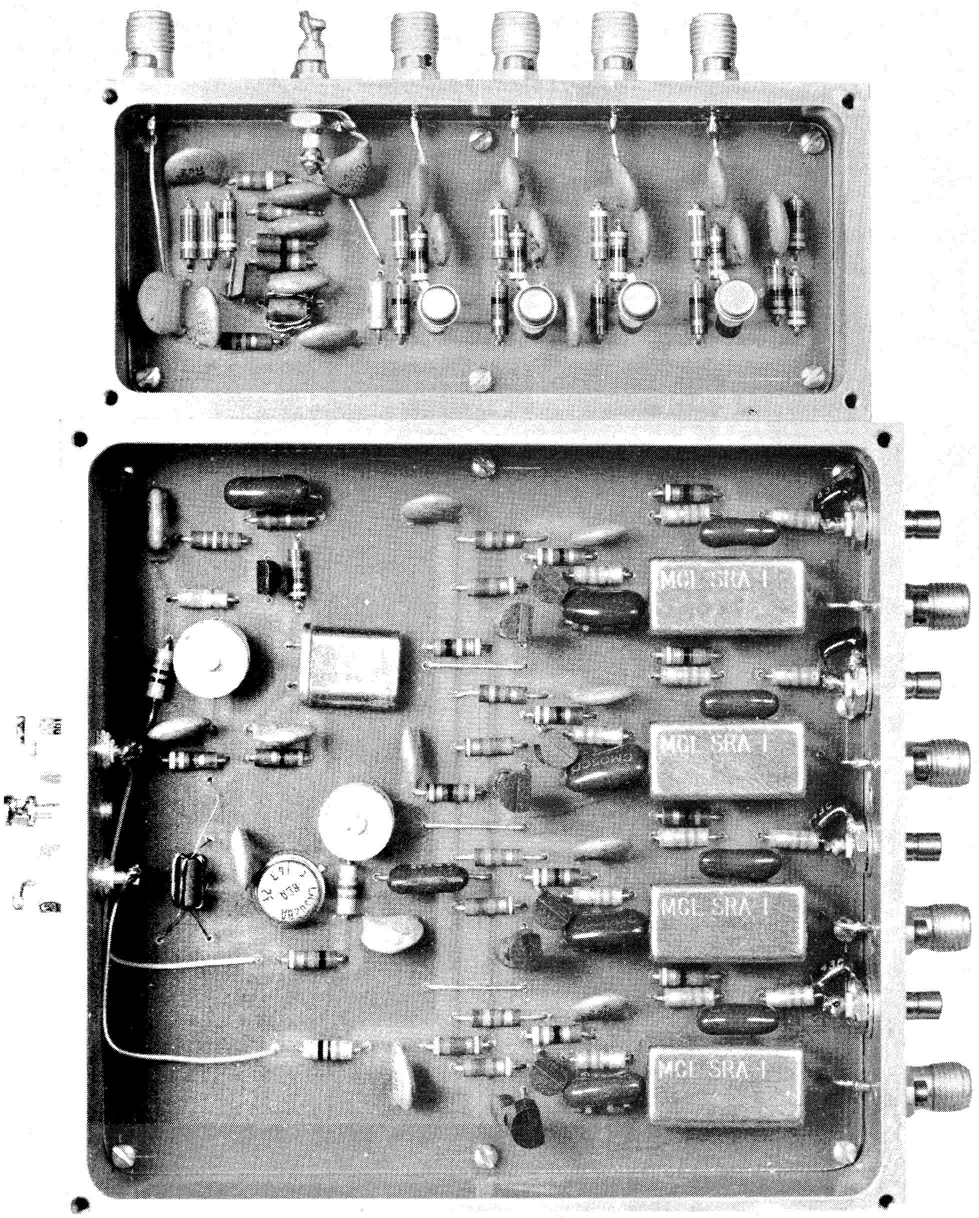


FIG. 19 Zero Check Ckt.



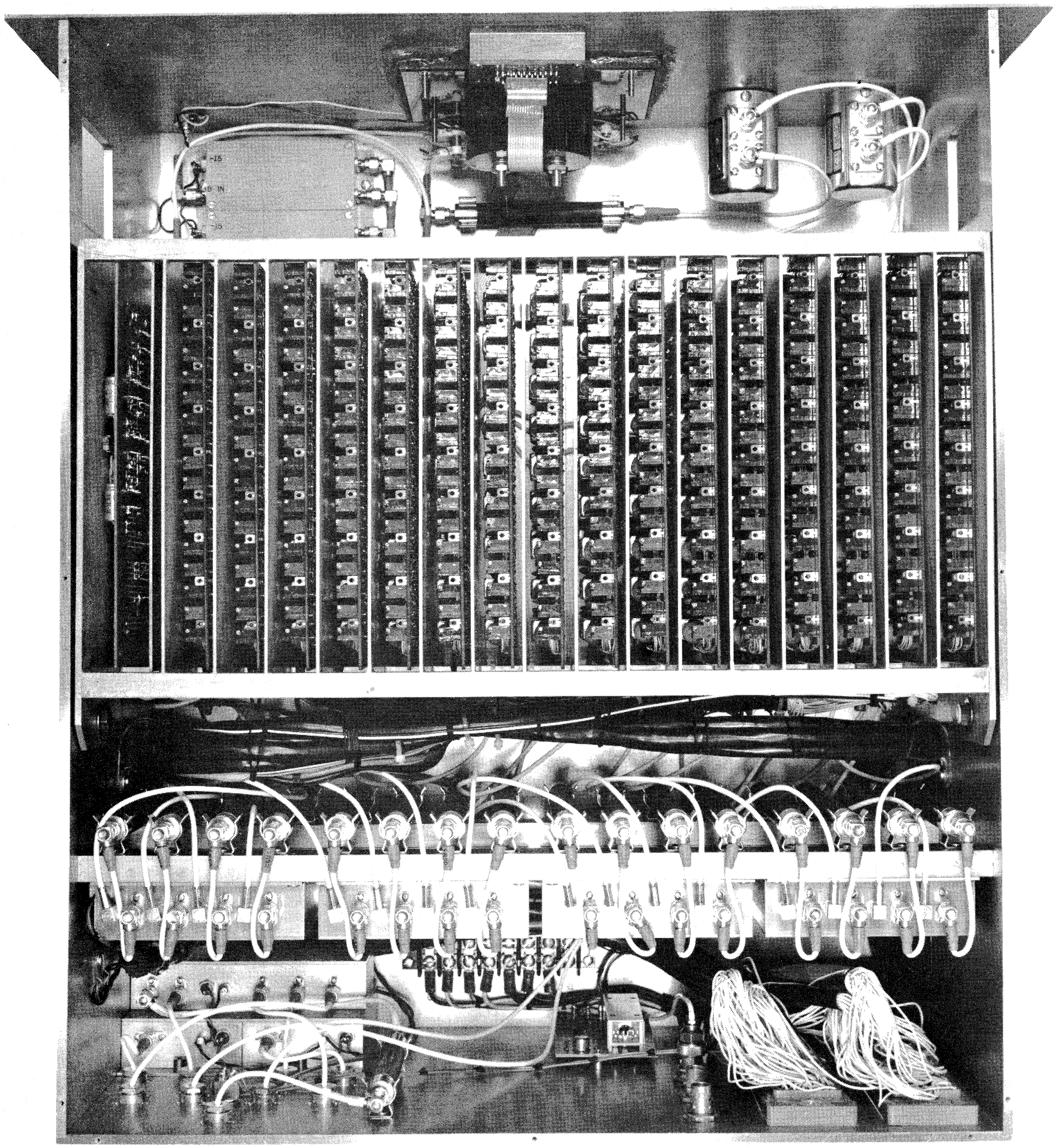
AMPLIFIER-SPLITTER

FIGURE 20



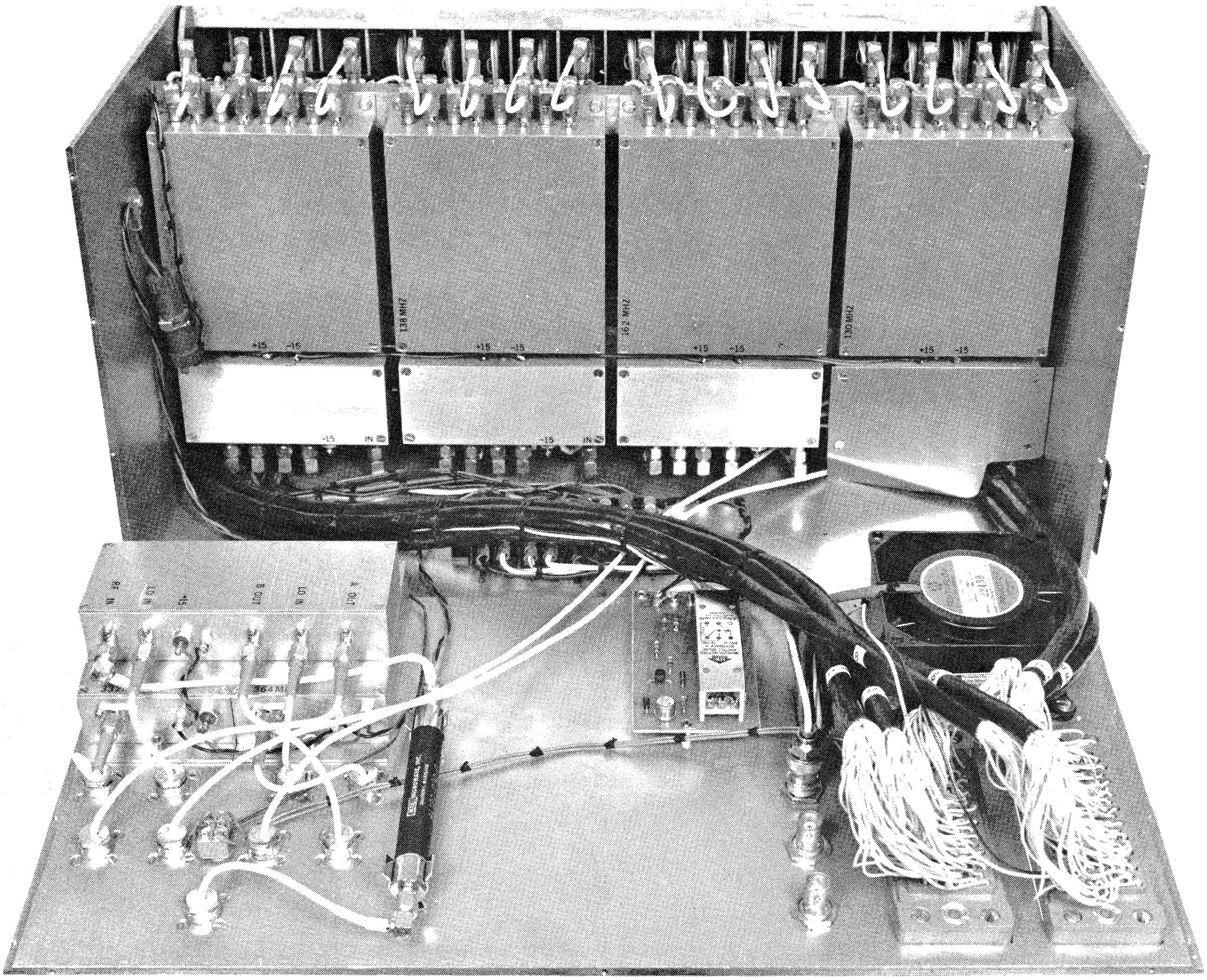
OSCILLATOR-MIXER AND SPLITTER

FIGURE 21



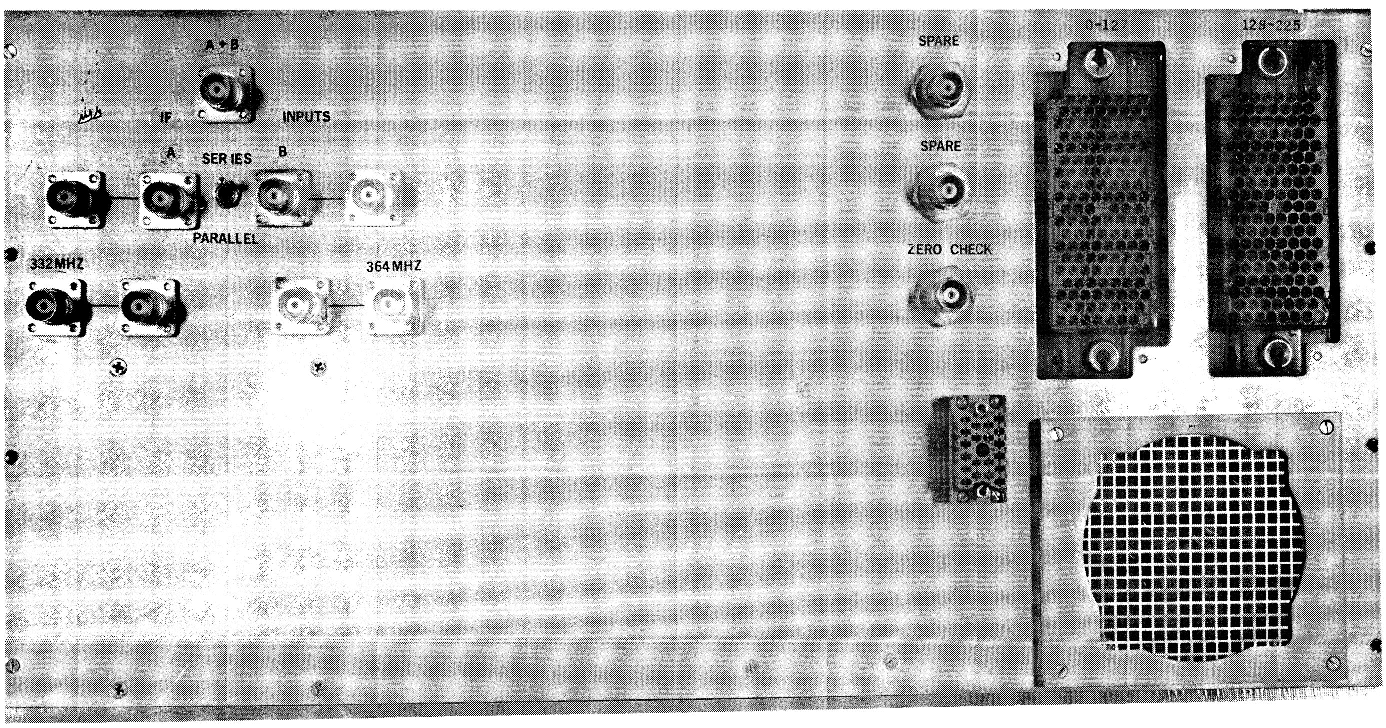
TOP VIEW

FIGURE 22



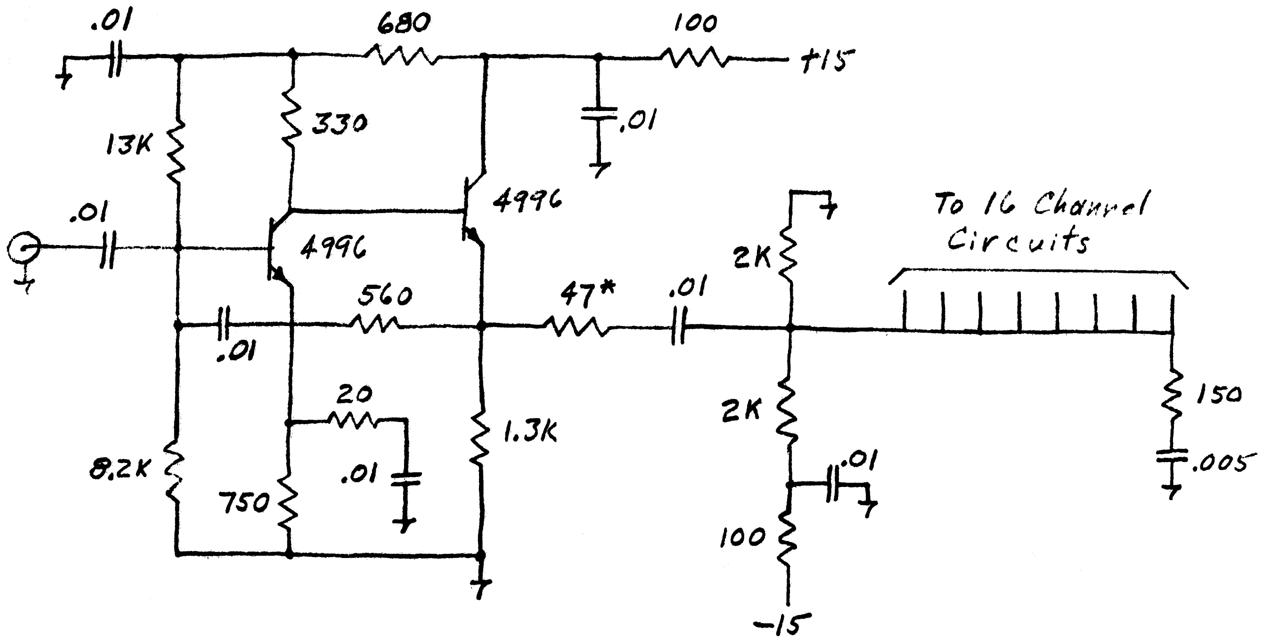
INSIDE BACK

FIGURE 23



BACK PANEL

FIGURE 24



* May vary for gain adjustment

Filter Board Input Amp

FIGURE 25