NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

ELECTRONICS DIVISION INTERNAL REPORT No. 230

256-CHANNEL, 2 MHz PER CHANNEL, FILTER RECEIVER

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OCTOBER 1982

NUMBER OF COPIES: 150

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Introduction

This report covers the new 256-channel, 2 MHz per channel, filter system, an updated version of the systems described in EDIR No. 146. The general design and construction is the same though most of the printed circuit boards have been changed to accommodate the wider bandwidth and higher frequencies. Figures 1 and 2 show the spectrum processing for the series and parallel modes and the block diagram.

IF Processor Unit

The IF Processor, Figure 3, is used for changing the series spectrum into the parallel mode. Switching between series and parallel is done by a TO-5 relay assembly under control of a TTL signal fed in the back panel. This signal also changes the digital card to accommodate the inverted channel counting in the series mode. The processor schematic shows a small capacitor on the second mixer output line. Other components not shown were added around some of the mixers to suppress the feedthru level to more than 30 dB below the desired output. Extensive shielding was also added.

Oscillator-Multiplier Unit

The two processor associated LO's are generated from a crystal oscillator operating just above 100 MHz followed by three active doublers, a filter and power amplifier. One of these circuits is also shown in Figure 3. Tuned matching circuits are used between multiplier stages, and the final multiplier output is bandpass filtered to provide suppression of the unwanted harmonics. The output amplifier provides +10 dBm to the mixers. During system testing it was discovered that "birdies" were showing up in some channels. Most of these could be traced to subharmonics of the processor LO's. The filter in the LO's was not doing an adequate job because of its close proximity to the multiplier chain. External filters were added to provide the very high rejection required.

Amplifier-Splitter Unit

The Amplifier-Splitter Unit, Figure 4, contains a 520 MHz low pass filter, amplifier and power splitter for each section. A trap was added to the A section to prevent the 128 MHz difference frequency from generating in-band harmonics in the following amplifier. The 128 MHz is the result of incomplete LO rejection in the first mixer of the processor unit.

Splitter Unit

The Splitter Units are a new design to give adequate gain, match and isolation to 470 MHz. These circuits use a grounded base stage with matching transformer on the output. See Figure 5. Reflection from an out-of-band bandpass filter back into an in-band circuit is down 40 dB or more at other outputs. The very low output VSWR prevents deterioration of the shape of the following bandpass filters.

Oscillator-Mixer Unit

The Oscillator-Mixer Units use circuits similar to the oscillator-multipliers except that only two doublers are required. A representative circuit is shown in Figure 5. A power amplifier and divider furnish +7 dBm to the four mixers. Shunt capacitors and series resistors were added on the mixer inputs to improve the match. Small attenuators on the mixer outputs are chosen to compensate for loss variations in the mixers and all previous units. With levels normalized at this point the filter cards need not be gain trimmed for a particular slot.

Filter Card

The filter cards were redesigned to provide sockets for the op amp and detector diode, provide a new input amplifier and to eliminate ground and power jumpers. The filter and detector circuits are the same except for space for loading the DC side of the detector. See Figures 6 and 7. This loading allows use of some diodes that would otherwise be rejected for poor square law accuracy. The op amps may be either Fairchild μA 714C or Harris HA-5135-5. The Fairchild unit is equivalent to an OP-07C and the most economical but is available only in a TO-99 can at this time. These units provide an offset temperature coefficient of less than 1.8 μV/°C compared to 15 μV/°C for the 741 KN previously used at about the same cost. Some improvement in stability may have been gained by using metal film resistors. Corning type C4 resistors are better than ± 100 ppm/°C, physically interchangeable with 1/4 W carbon compositions and have better long-term stability at a cost 20% above the molded carbons.

The filter cards operate over the input frequency range of 16 to 48 MHz. At the higher frequencies the signal distribution line down the middle of the board produced a significant standing wave. This problem was eliminated by terminating the line in 43 ohms. This lower impedance increased the signal loss but was offset by a higher gain, wider band input amplifier. See Figure 6. Temperature tests were made on a channel circuit to determine gain instability. The coils measured worse than predicted from data on the core material. Unfortunately, the amplifier also drifted in the negative direction. These errors exceed the positive coefficient of the detector by about two times. The first inclination was to compensate one of the stages with a temperature sensitive resistor but a satisfactory type was not found. Also, the compensation required at 48 MHz is considerably higher than at the low end. This would imply separate and different compensation for each channel, a significant complication. The solution was to provide circuit space for a temperature/frequency compensation network at the output of the input amplifier using a thermistor-capacitor-resistor combination. The necessity for compensation will be determined later.

Monitor Controller Card

The Channel Monitor Digital Controller is unchanged. A schematic and description are given in the previous report. Figure 9 relates channel number to input frequency and card channel number.

Buffer and Monitor Card

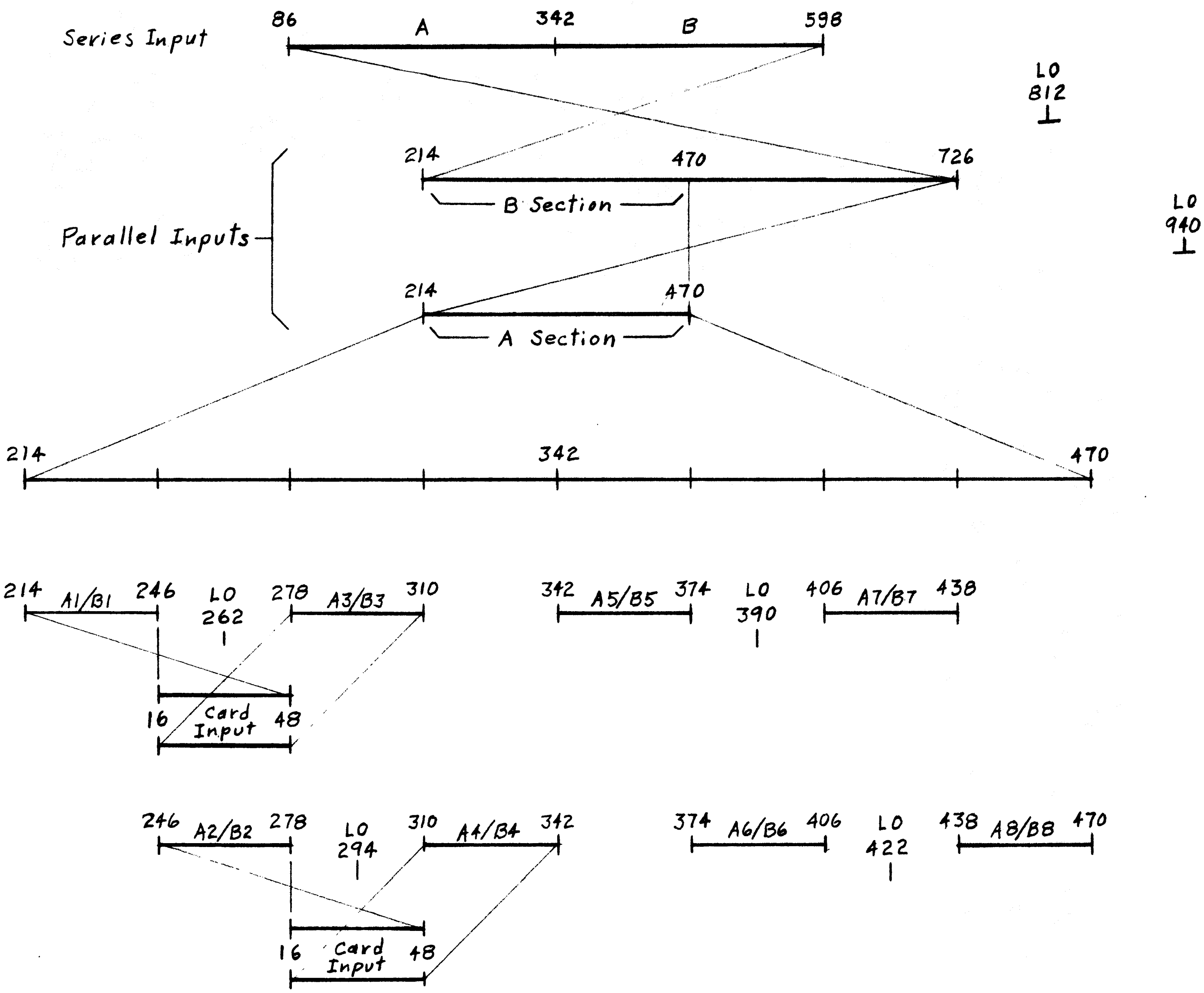
The Power Monitor card of the previous system has become the Buffer and Monitor card of this system. In addition to providing single channel or A and B section total power monitoring to the front panel meter and coax jack, it provides simultaneously buffered total power outputs from each card (16 channels summed) to OSM connectors on the back panel. The schematic is given in Figure 8.

Cost

Since 1973 the cost of components for this system has increased about 1.5X to around $13,000. The BD4 back diodes were one of the major factors, increasing from $3.30 to $8.66 each.

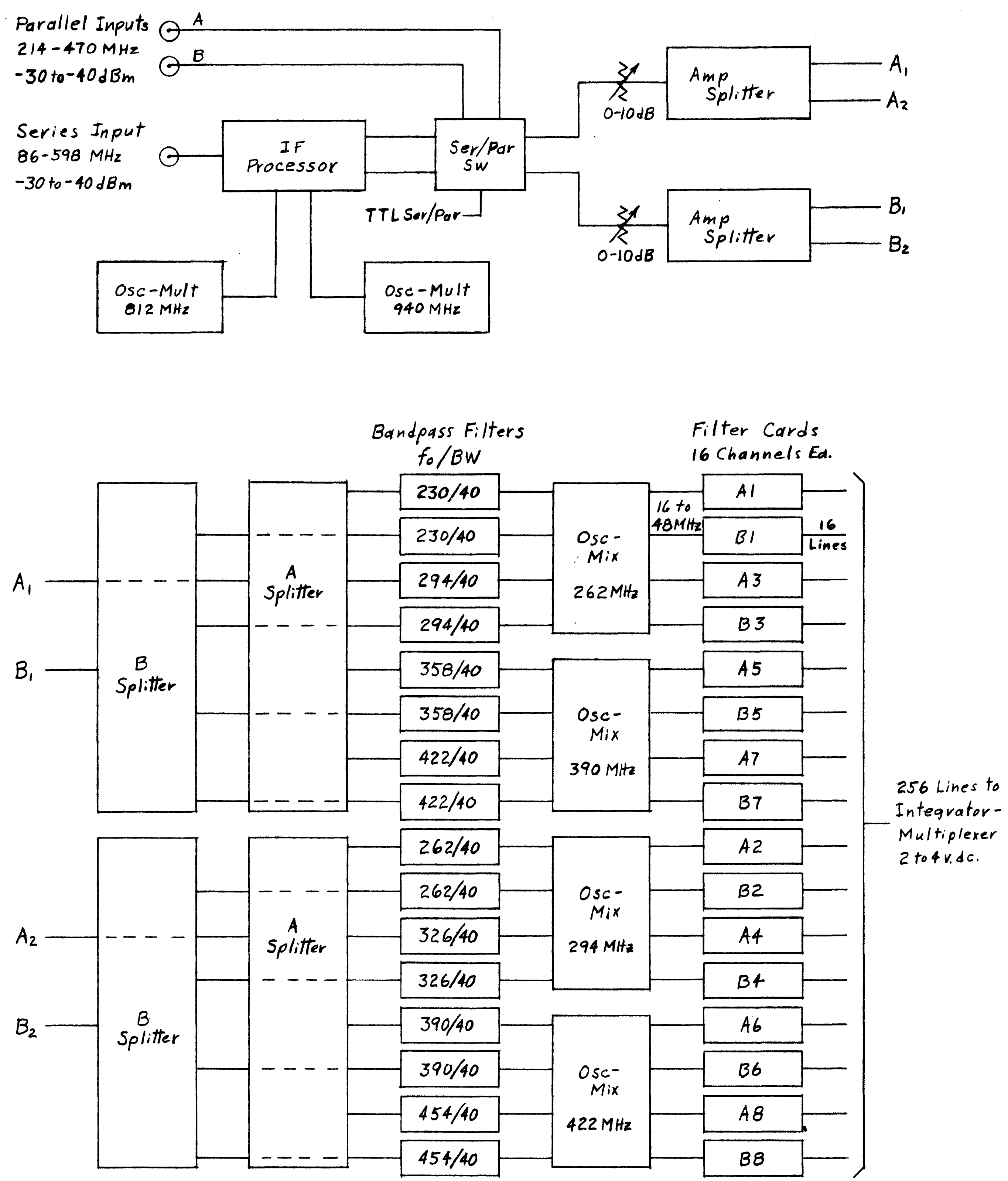
Acknowledgements

I wish to recognize L. Beale for his construction efforts again. A. Weinreb and R. Lacasse provided an automated square law measuring system to speed up testing and D. Ross and D. Webb were very helpful in arranging for purchase of printed circuit boards and in contracting for the assembly of parts on the filter boards.



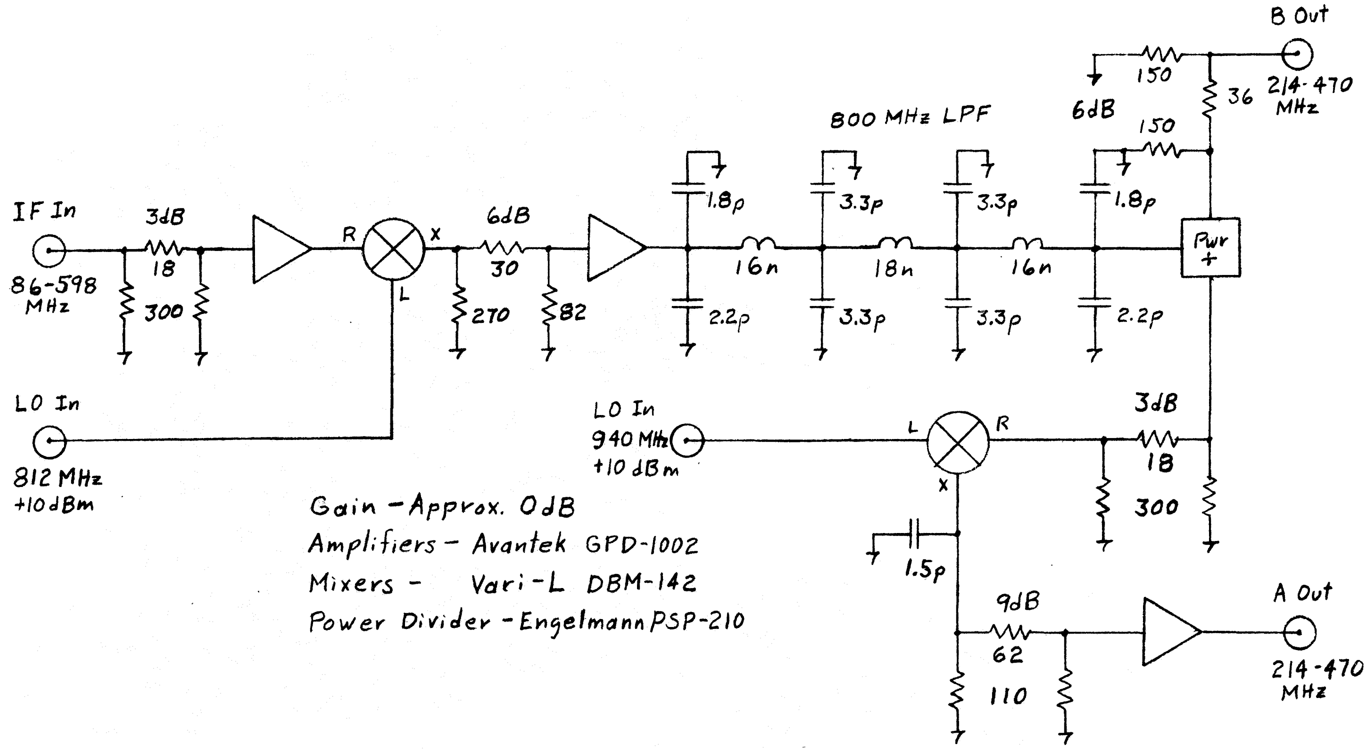
SPECTRUM PROCESSING

Figure 1

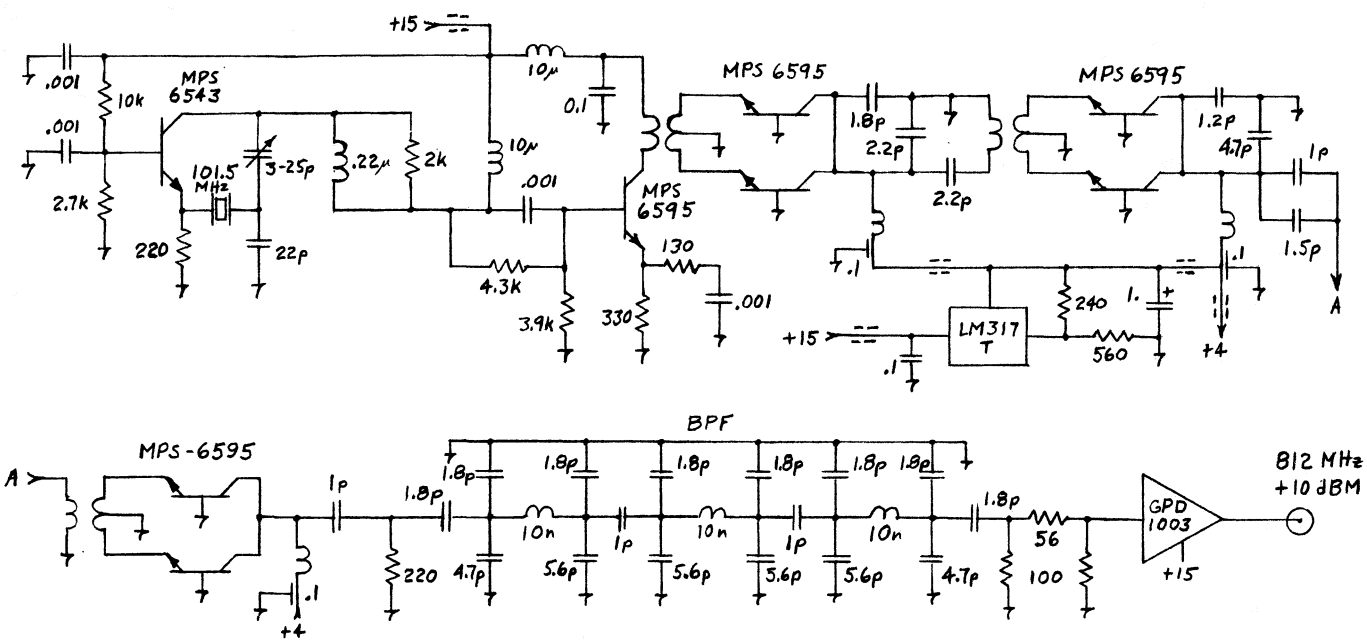


BLOCK DIAGRAM

Figure 2

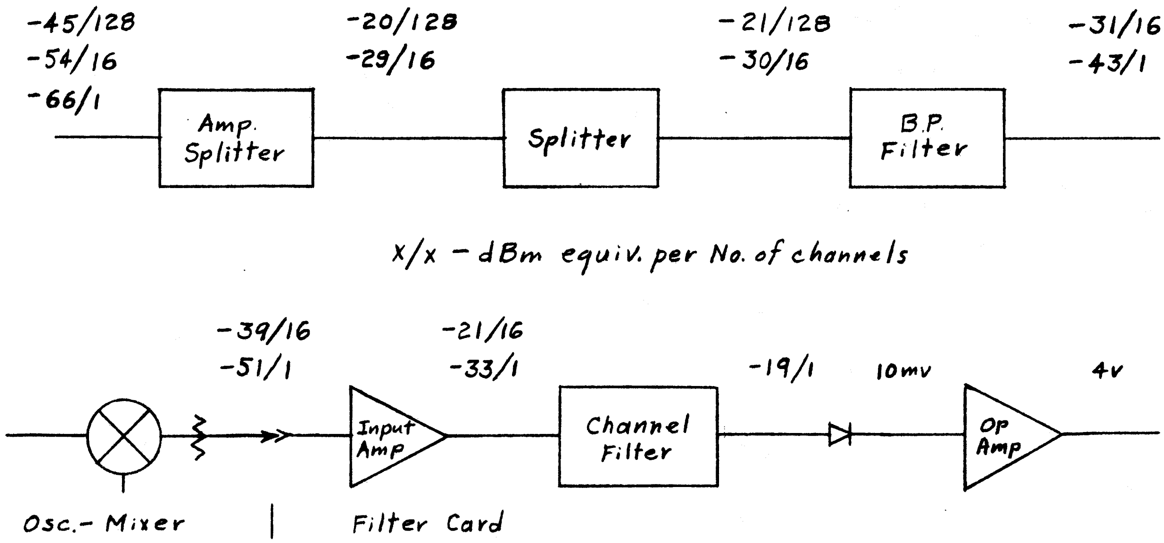


IF PROCESSOR

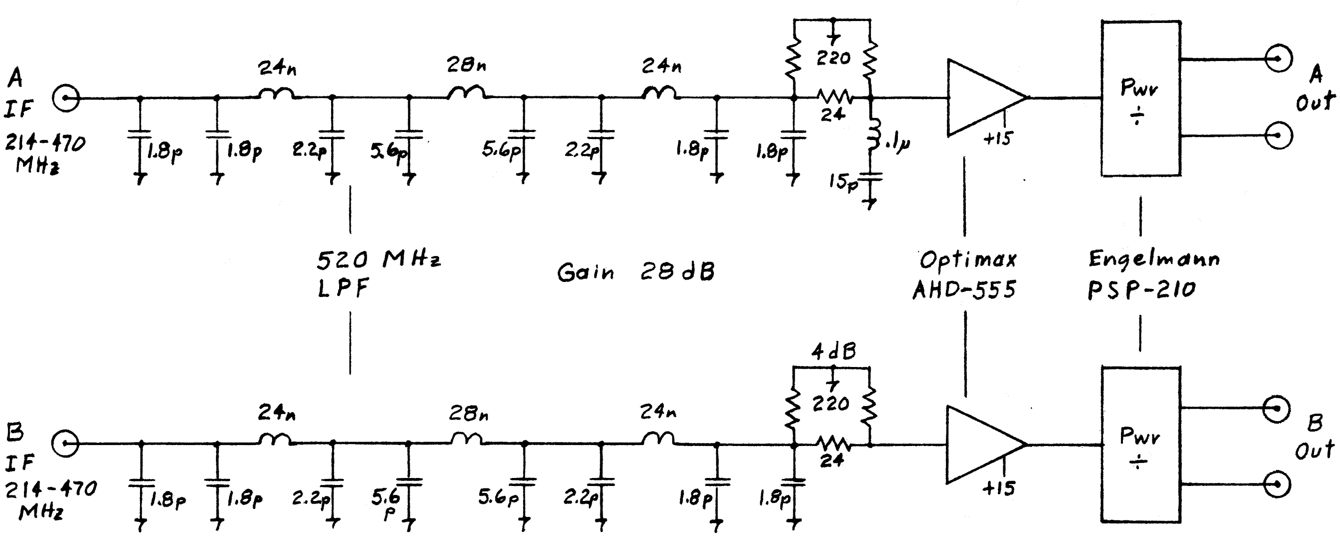


OSCILLATOR - MULTIPLIER

Figure 3

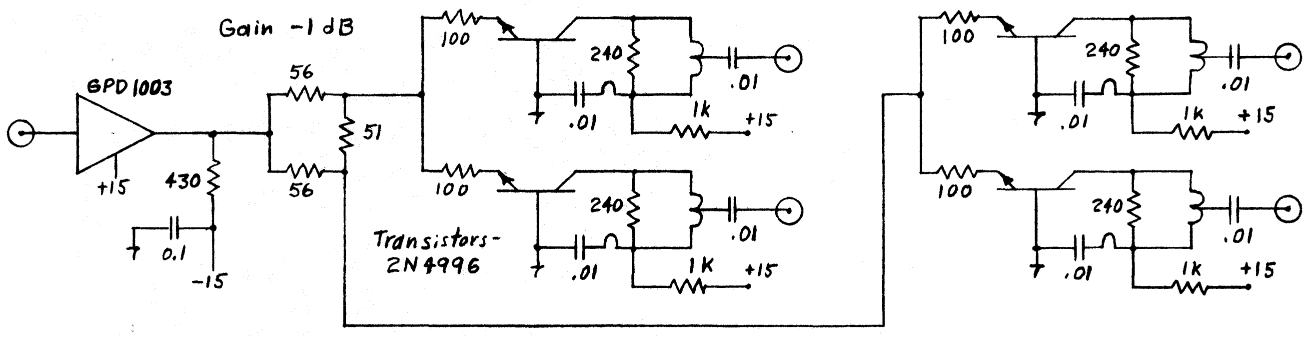


SYSTEM POWER LEVELS

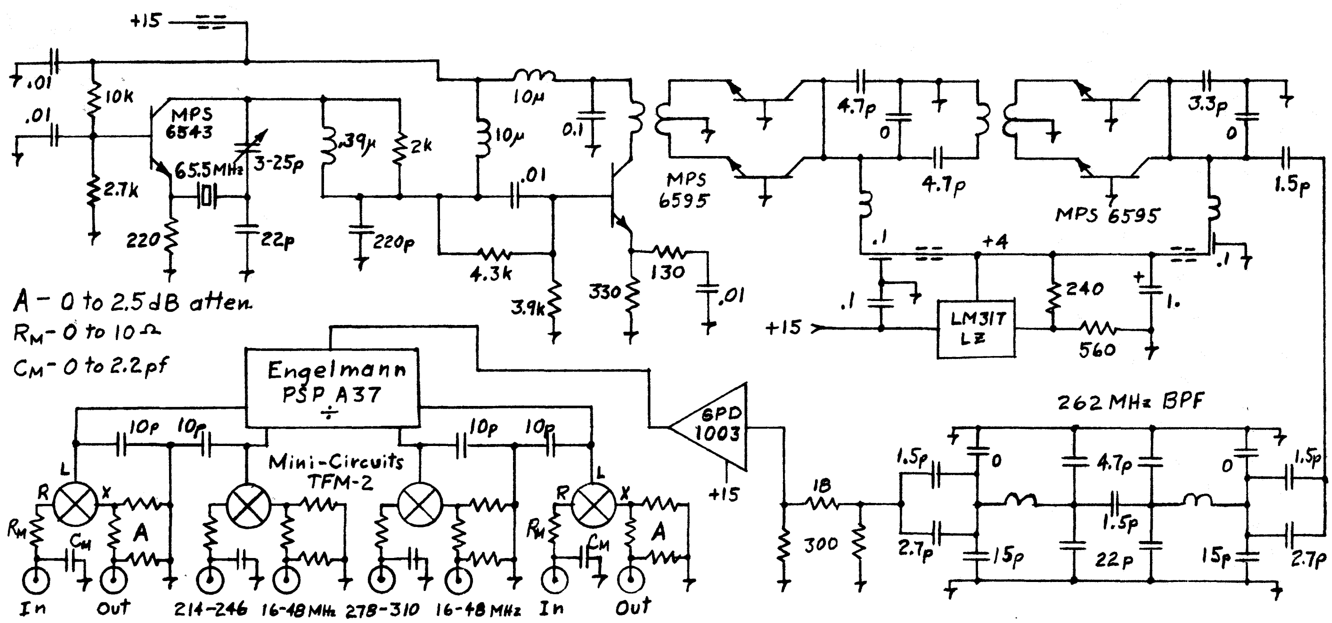


AMPLIFIER-SPLITTER

Figure 4

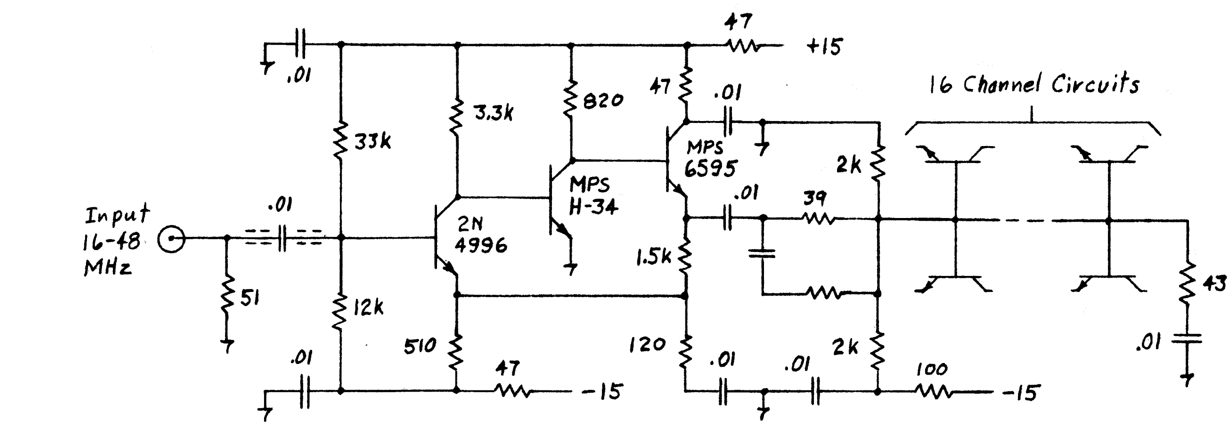


SPLITTER

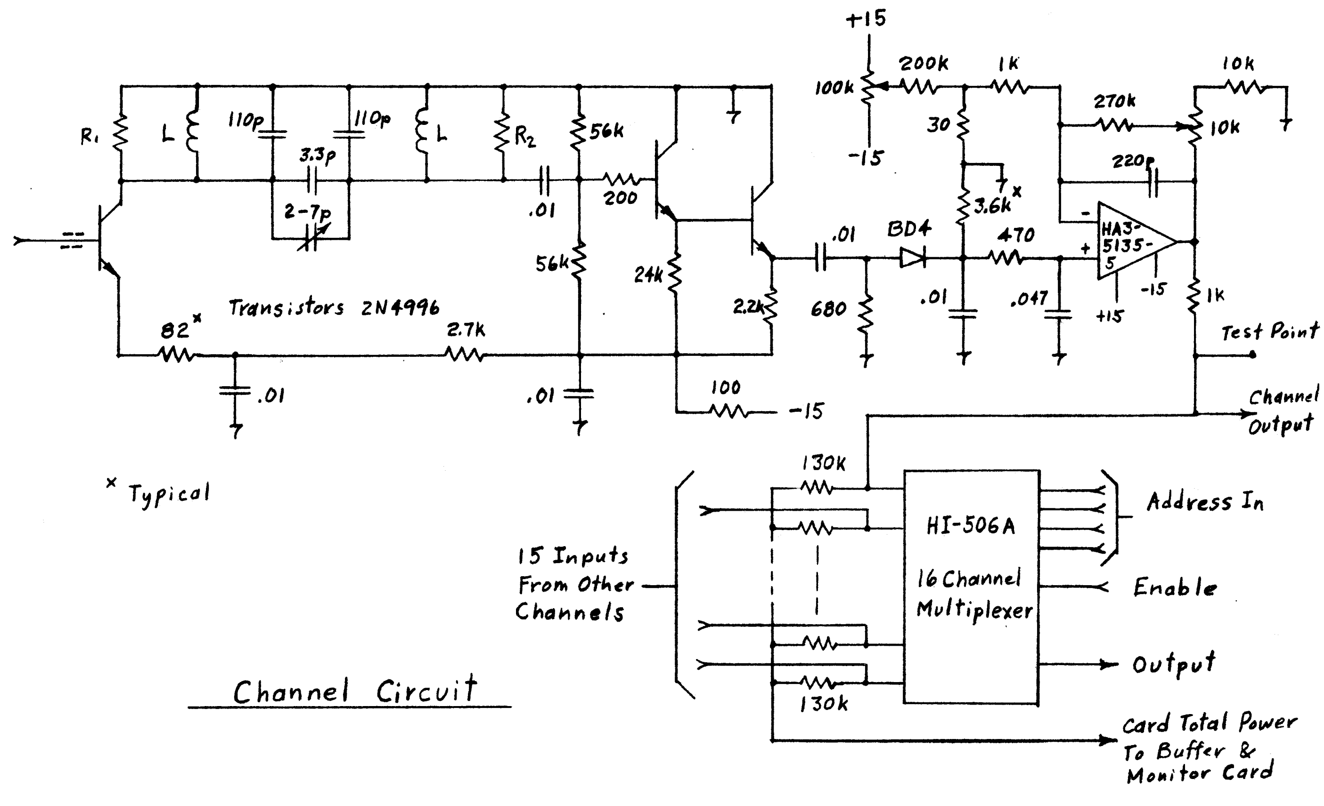


OSCILLATOR-MIXER

Figure 5



Input Amplifier



Channel Circuit

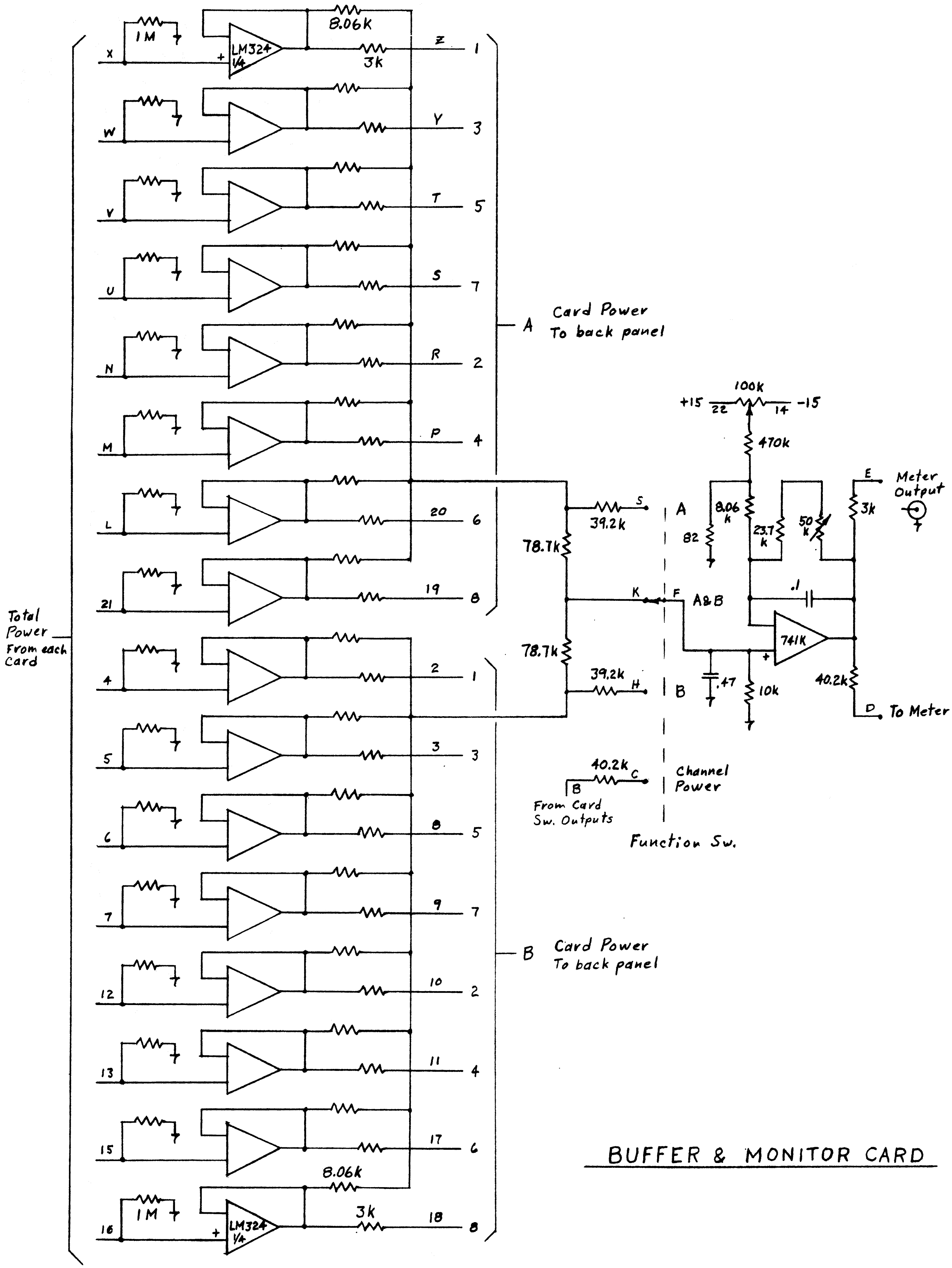
FILTER CARD

Figure 6

Channel No.	f_o MHz	C pf	L μh	L No. 558-7107-	R_p Ω	R_1 kΩ	R_2 kΩ	C_c pf
1	17	110	.716	11	1070	1.3	1.3	9.4
2	19		.578	10			1.3	8.5
3	21		.476	9			1.5	7.6
4	23		.399	8				7.0
5	25		.339	7		1.3		6.4
6	27		.292	6		1.5		5.9
7	29		.254	6				5.5
8	31		.223	5				5.2
9	33		.197	4		1.5	1.5	4.9
10	35		.176	4		1.6	1.6	4.6
11	37		.158	3		1.5		4.3
12	39		.142	3		1.6		4.1
13	41		.129	2		1.6	1.6	3.9
14	43		.117	2		1.8	1.8	3.7
15	45		.107	1		1.8	1.8	3.6
16	47	110	.098	1	1070	1.8	1.8	3.4

CHANNEL FILTER CIRCUIT VALUES

Figure 7



8.06K
3k
1M
LM324 1/4
Card Power To back panel
Total Power From each Card
100k
+15
-15
470k
8.06 k
23.7 k
50 k
3k
Meter Output
39.2k
78.7k
82
A
A&B
741K
.1
.47
10k
40.2k
To Meter
B
40.2k
From Card Sw. Outputs
Channel Power
Function Sw.
BUFFER & MONITOR CARD

Figure 8

FREQUENCY CHART

CHANNEL NO. REC.A	REC.B	PARALLEL	SERIES A	SERIES B	PARALLEL A & B		SERIES A B	
0	128	215.000	87.000	343.000		16		16
1	129	217.000	89.000	345.000		15		15
2	130	219.000	91.000	347.000		14		14
3	131	221.000	93.000	349.000		13		13
4	132	223.000	95.000	351.000		12		12
5	133	225.000	97.000	353.000		11		11
6	134	227.000	99.000	355.000		10		10
7	135	229.000	101.000	357.000	A1-	9		9
8	136	231.000	103.000	359.000	B1-	8	B8-	8
9	137	233.000	105.000	361.000		7		7
10	138	235.000	107.000	363.000		6		6
11	139	237.000	109.000	365.000		5		5
12	140	239.000	111.000	367.000		4		4
13	141	241.000	113.000	369.000		3		3
14	142	243.000	115.000	371.000		2		2
15	143	245.000	117.000	373.000		1		1
16	144	247.000	119.000	375.000		16		16
17	145	249.000	121.000	377.000		15		15
18	146	251.000	123.000	379.000		14		14
19	147	253.000	125.000	381.000		13		13
20	148	255.000	127.000	383.000		12		12
21	149	257.000	129.000	385.000		11		11
22	150	259.000	131.000	387.000		10		10
23	151	261.000	133.000	389.000	A2-	9		9
24	152	263.000	135.000	391.000	B2-	8	B7-	8
25	153	265.000	137.000	393.000		7		7
26	154	267.000	139.000	395.000		6		6
27	155	269.000	141.000	397.000		5		5
28	156	271.000	143.000	399.000		4		4
29	157	273.000	145.000	401.000		3		3
30	158	275.000	147.000	403.000		2		2
31	159	277.000	149.000	405.000		1		1
32	160	279.000	151.000	407.000		1		1
33	161	281.000	153.000	409.000		2		2
34	162	283.000	155.000	411.000		3		3
35	163	285.000	157.000	413.000		4		4
36	164	287.000	159.000	415.000		5		5
37	165	289.000	161.000	417.000		6		6
38	166	291.000	163.000	419.000		7		7
39	167	293.000	165.000	421.000	A3-	8		8
40	168	295.000	167.000	423.000	B3-	9	B6-	9
41	169	297.000	169.000	425.000		10		10
42	170	299.000	171.000	427.000		11		11
43	171	301.000	173.000	429.000		12		12
44	172	303.000	175.000	431.000		13		13
45	173	305.000	177.000	433.000		14		14
46	174	307.000	179.000	435.000		15		15
47	175	309.000	181.000	437.000		16		16
48	176	311.000	183.000	439.000		1		1
49	177	313.000	185.000	441.000		2		2
50	178	315.000	187.000	443.000		3		3
51	179	317.000	189.000	445.000		4		4
52	180	319.000	191.000	447.000		5		5
53	181	321.000	193.000	449.000		6		6
54	182	323.000	195.000	451.000		7		7
55	183	325.000	197.000	453.000	A4-	8		8
56	184	327.000	199.000	455.000	B4-	9	B5-	9
57	185	329.000	201.000	457.000		10		10
58	186	331.000	203.000	459.000		11		11
59	187	333.000	205.000	461.000		12		12
60	188	335.000	207.000	463.000		13		13
61	189	337.000	209.000	465.000		14		14
62	190	339.000	211.000	467.000		15		15
63	191	341.000	213.000	469.000		16		16
64	192	343.000	215.000	471.000		16		16
65	193	345.000	217.000	473.000		15		15
66	194	347.000	219.000	475.000		14		14
67	195	349.000	221.000	477.000		13		13
68	196	351.000	223.000	479.000		12		12
69	197	353.000	225.000	481.000		11		11
70	198	355.000	227.000	483.000		10		10
71	199	357.000	229.000	485.000	A5-	9		9
72	200	359.000	231.000	487.000	B5-	8	B4-	8
73	201	361.000	233.000	489.000		7		7
74	202	363.000	235.000	491.000		6		6
75	203	365.000	237.000	493.000		5		5
76	204	367.000	239.000	495.000		4		4
77	205	369.000	241.000	497.000		3		3
78	206	371.000	243.000	499.000		2		2
79	207	373.000	245.000	501.000		1		1
80	208	375.000	247.000	503.000		16		16
81	209	377.000	249.000	505.000		15		15
82	210	379.000	251.000	507.000		14		14
83	211	381.000	253.000	509.000		13		13
84	212	383.000	255.000	511.000		12		12
85	213	385.000	257.000	513.000		11		11
86	214	387.000	259.000	515.000		10		10
87	215	389.000	261.000	517.000	A6-	9		9
88	216	391.000	263.000	519.000	B6-	8	B3-	8
89	217	393.000	265.000	521.000		7		7
90	218	395.000	267.000	523.000		6		6
91	219	397.000	269.000	525.000		5		5
92	220	399.000	271.000	527.000		4		4
93	221	401.000	273.000	529.000		3		3
94	222	403.000	275.000	531.000		2		2
95	223	405.000	277.000	533.000		1		1
96	224	407.000	279.000	535.000		1		1
97	225	409.000	281.000	537.000		2		2
98	226	411.000	283.000	539.000		3		3
99	227	413.000	285.000	541.000		4		4
100	228	415.000	287.000	543.000		5		5
101	229	417.000	289.000	545.000		6		6
102	230	419.000	291.000	547.000		7		7
103	231	421.000	293.000	549.000	A7-	8		8
104	232	423.000	295.000	551.000	B7-	9	B2-	9
105	233	425.000	297.000	553.000		10		10
106	234	427.000	299.000	555.000		11		11
107	235	429.000	301.000	557.000		12		12
108	236	431.000	303.000	559.000		13		13
109	237	433.000	305.000	561.000		14		14
110	238	435.000	307.000	563.000		15		15
111	239	437.000	309.000	565.000		16		16
112	240	439.000	311.000	567.000		1		1
113	241	441.000	313.000	569.000		2		2
114	242	443.000	315.000	571.000		3		3
115	243	445.000	317.000	573.000		4		4
116	244	447.000	319.000	575.000		5		5
117	245	449.000	321.000	577.000		6		6
118	246	451.000	323.000	579.000		7		7
119	247	453.000	325.000	581.000	A8-	8		8
120	248	455.000	327.000	583.000	B8-	9	B1-	9
121	249	457.000	329.000	585.000		10		10
122	250	459.000	331.000	587.000		11		11
123	251	461.000	333.000	589.000		12		12
124	252	463.000	335.000	591.000		13		13
125	253	465.000	337.000	593.000		14		14
126	254	467.000	339.000	595.000		15		15
127	255	469.000	341.000	597.000		16		16

Figure 9