NATIONAL RADIO ASTRONOMY OBSERVATORY

MEMORANDUM

To: NRAO Council January 25, 1967

From: S. Weinreb

At the council meeting on next Monday I would like to discuss whether we should construct all or any part of the interference measurement system described on the attached pages.

The cost of the complete system is high (~ $100 K) and will have no value with regard to our biggest interference problem — automobiles. Maybe we could better spend this money by putting fences along some of the roads?

On the other hand, a well instrumented interference truck would be useful for many years and would be valuable for the planning and protection of Green Bank and other radio astronomy sites.

SW/cjd

Attachment
A Proposed Interference
Measurement System

A PROPOSED INTERFERENCE MEASUREMENT SYSTEM

A block diagram of the proposed system is shown in Figure 1. The system provides for simultaneous monitoring of 14 frequency bands with sensitivities as listed in Table 1. A plot showing these sensitivities in relation to the Quiet Zone interference limits is shown in Figure 2. Block diagrams of the RF units of the system are shown in Figures 3 thru 9. Finally, a cost summary of the system is given in Table 2 with cost breakdowns in Tables 3 thru 7.

The system has two types of outputs:

1) A swept-frequency spectrum analyzer output which can be put on a scope or X-Y recorder.
2) Radiometric outputs which can be recorded on digital magnetic tape or displayed on a chart recorder.

The spectrum analyzer will be used for searches for interference over wide frequency ranges, pin-pointing the frequency of the interference, and identifying the type of modulation on the signal. Some of the new spectrum analyzers that are available can sweep up to 2 Gc/s bandwidth with resolutions of 1 kc/s to 1 Mc/s and provide a linear or logarithmic display of power. The sensitivity of these units is poor (Noise Figure 40-60 dB) and an RF amplifier with ~ 50 dB gain must proceed the analyzer. The RF amplifiers will reduce the swept frequency ranges to 50 to 250 Mc/s, 250 to 500 Mc/s, 500 to 1000 Mc/s, 1 Gc/s to 2 Gc/s, 2 Gc/s to 4 Gc/s, and any .5 Gc/s band from 4 to 12 Gc/s. The sensitivity of the spectrum analyzer will be further increased by building in a "radiometric" adaptor consisting of a synchronous detector and low-pass filter.

The 14 radiometer outputs (separate from the spectrum analyzer) allow the radiation intensities in 14 frequency bands to be simultaneously monitored. These outputs are recorded on magnetic tape and analyzed in a computer to give interference statistics over long periods of time. These statistics would answer questions such as the following:

How many one-minute intervals per week have interference above 0.1 °K in a 20 Mc/s band centered at 1410 Mc/s? How much has this number increased in the past year? Is there a seasonal or diurnal effect? From what direction does the interference predominate? What is the amplitude distribution of the interference?

Is there likely to be low-level interference which is contaminating our data but is not directly noticeable? What are these same statistics evaluated at another site (Camroc, for example)?

The spectrum analyzer and 14 radiometer back-ends utilize the same RF units as is indicated in Figure 1. The RF units are driven through multiplexers from two broadband, circularly polarized, antennas. These antennas would be mounted on a common shaft which is rotatable in azimuth. All of the equipment with the possible exception of the 8-channel recorder and magnetic tape system could be mounted in a van-type truck.

As indicated in Figure 2, the sensitivity of the system is up to 26 dB poorer than required to detect a signal at the Quiet Zone limit. This difference is explained as follows:

Quantity	Interference Measurement System	Assumed Value Quiet Zone Limit	Sensitivity Difference
Integration time	1 sec	1000 sec	-15 dB
System temperature	1200°	50°	-14 dB
Antenna gain	+8 to +27	0 dB	+8 to +27 dB
Other minor assumptions	--	--	-5 dB
			-26 to -7 dB

The interference system could be made more sensitive by increasing the antenna gain. However, the beamwidth is then narrower and it is more difficult to search for the interference source. The 0 dB assumption for the gain for off the main beam of our large telescopes is probably about 10 dB high (according to J. Ruze).

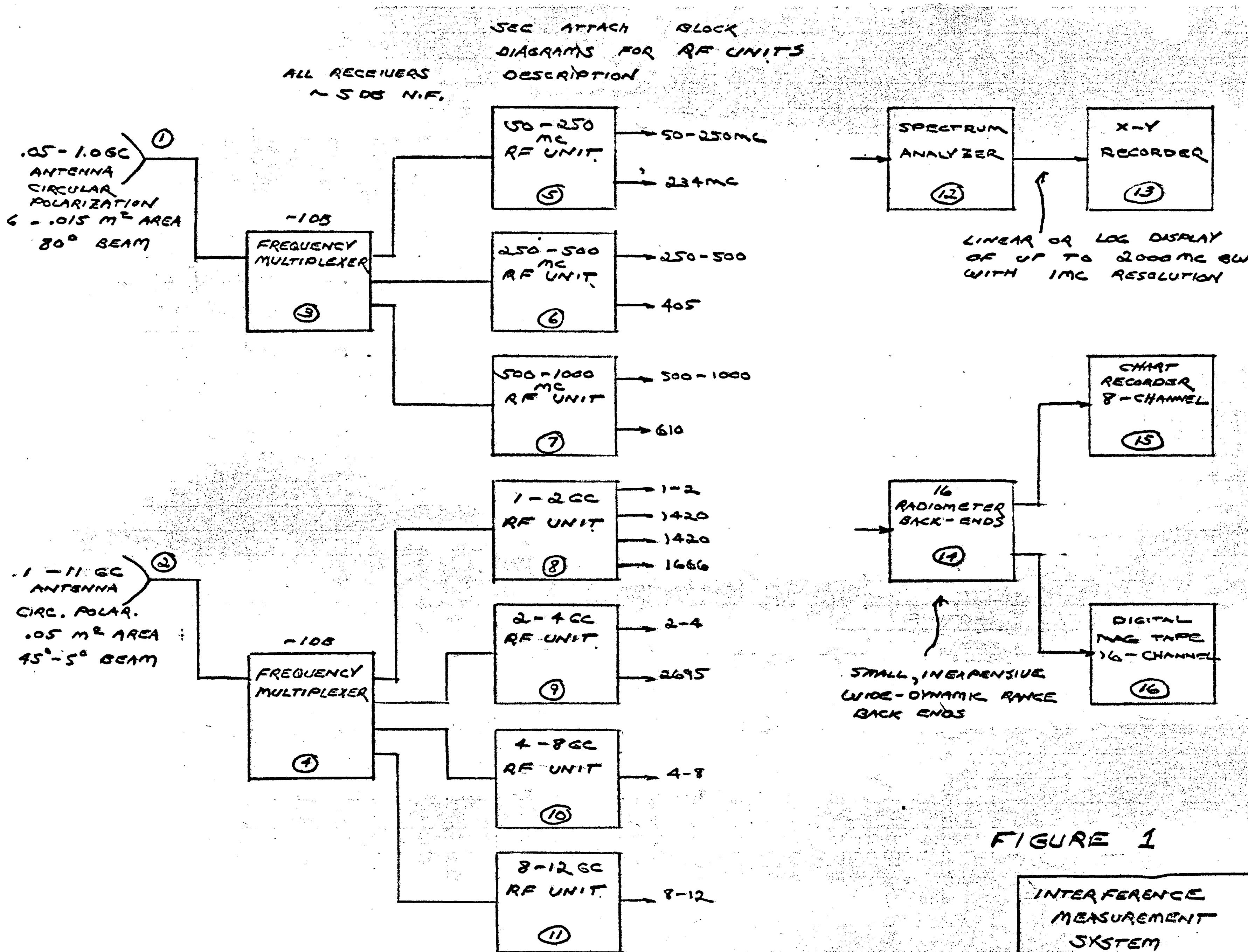


FIGURE 1

INTERFERENCE MEASUREMENT SYSTEM

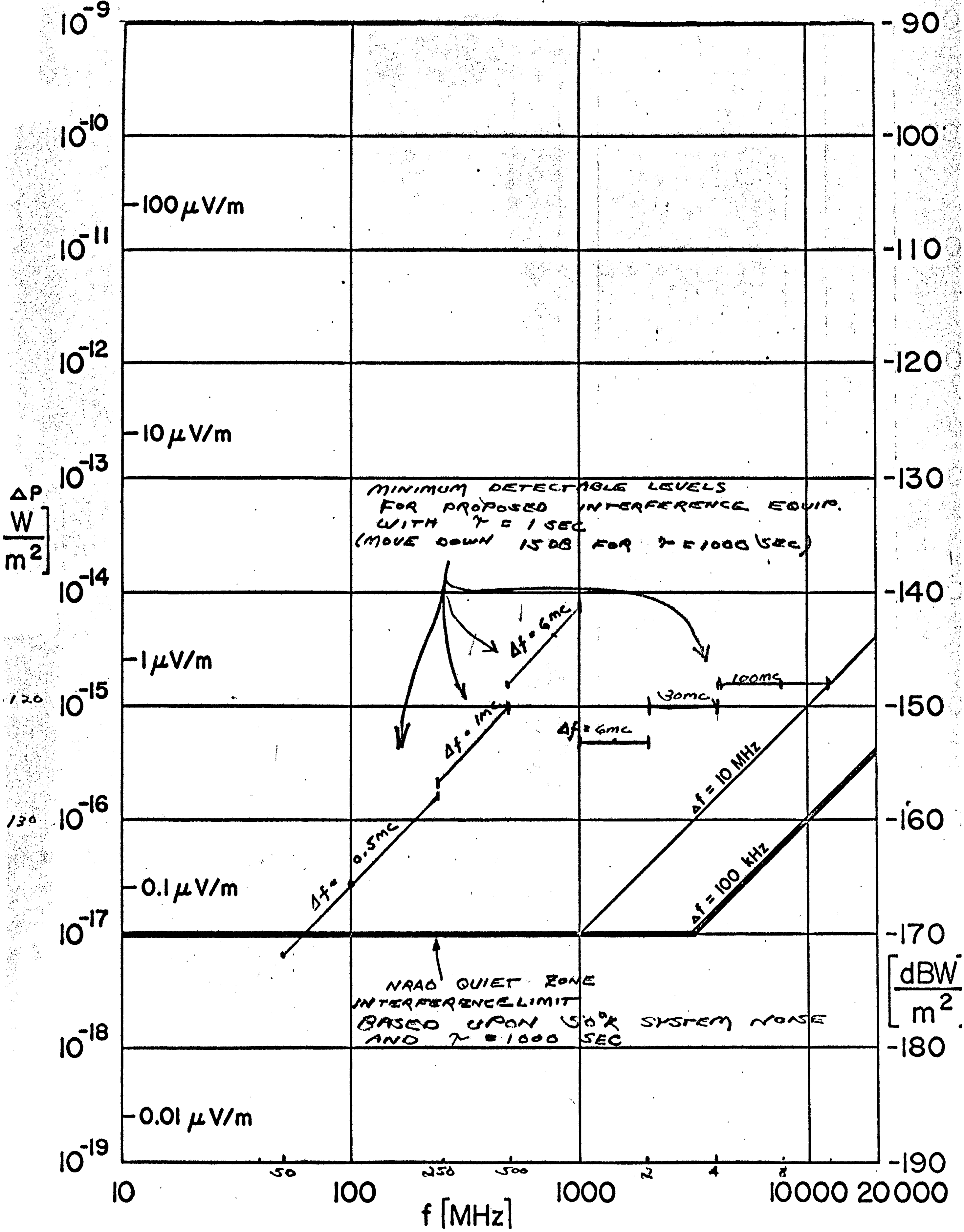
JAN 23, 1967

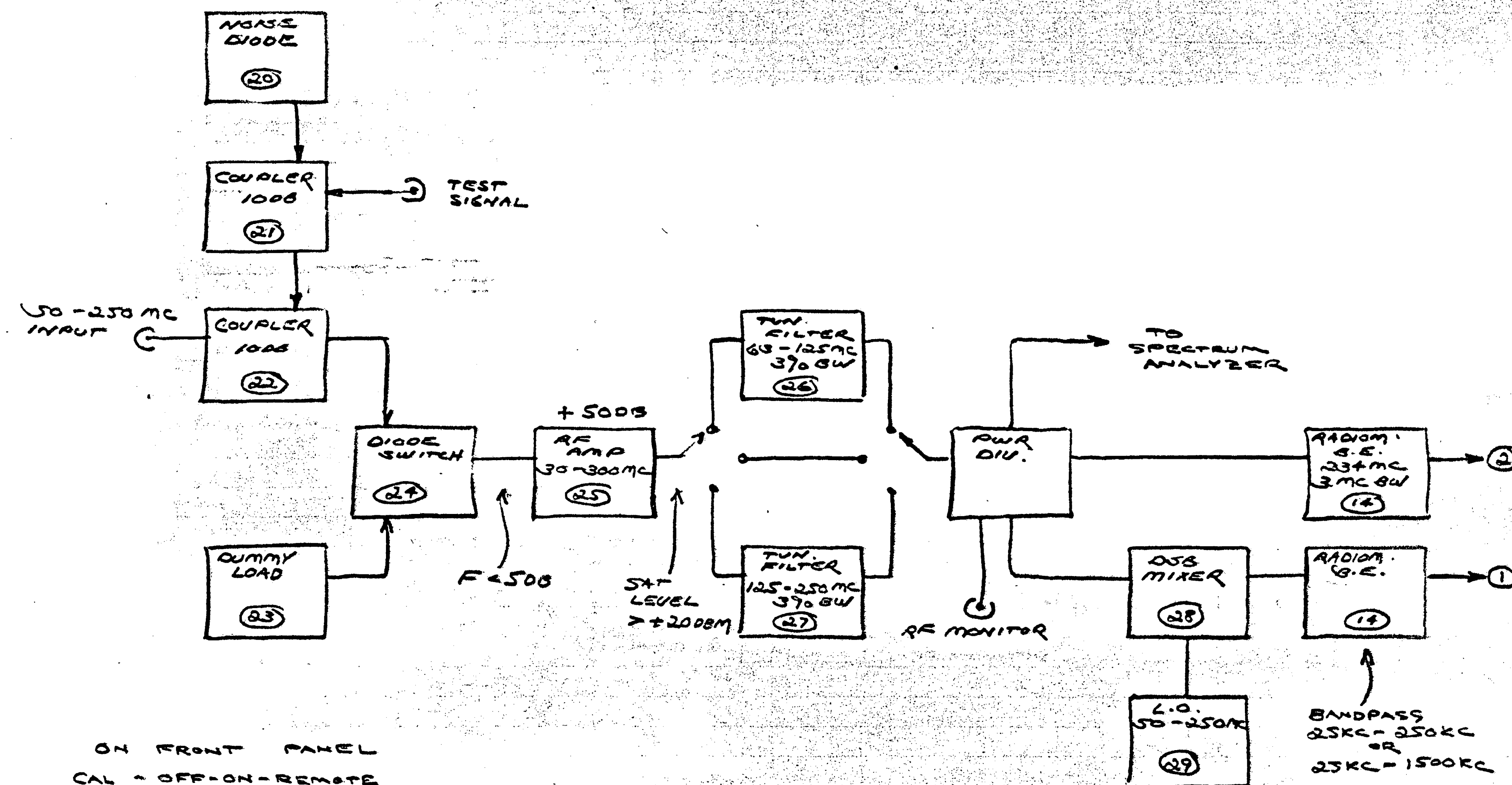
TABLE I

FREQUENCIES, BANDWIDTHS, AND SENSITIVITIES OF THE PROPOSED INTERFERENCE MEASUREMENT SYSTEM

Frequency Band	RF Bandwidth BW Mc/s	ΔT °K	ΔP DBM/M²	Protected T_{sys}
50-250 Mc/s - Tunable	0.5 or 3	3.8 or 1.6	-136 or -132	60°
234 Mc/s	3	1.1	-126	60°
250-500 Mc/s - Tunable	1 or 10	2.7 or 0.85	-124 or -119	60°
405 Mc/s	10	0.85	-118	60°
500-1000 Mc/s - Tunable	6 or 20	1.1 or 0.60	-114 or -112	60°
610 Mc/s	10	0.85	-114	60°
1-2 Gc/s - Tunable	6 or 50	1.1 or 0.4	-124 or -119	30°
1410 Mc/s 1410 Mc/s	20 50	0.6 0.4	-121 or -119	30° 30°
1666 Mc/s	6 or 120	1.1 or 0.25	-124 or -117	24°
2-4 Gc/s - Tunable	30 or 300	0.5 or 0.16	-120 or -115	4°
2695 Mc/s	30 or 150	0.5 or 0.2	-120 or -116	4°
4-8 Gc/s - Tunable	100 or 500	0.30 or 0.12	-118 or -114	1.2°
8-12 Gc/s - Tunable	100 or 500	0.30 or 0.12	-118 or -114	1.2°

Figure 2 — System Sensitivity in Relation to Quiet Zone Limits





ON FRONT PANEL

CAL - OFF-ON-REMOTE

SWITCH - ANT., LOAD, MOD.

FILTER - OUT, 63-125, 125-250

63-125 TUNING

125-250 TUNING

50-250 L.O. TUNING

CRYSTAL CURRENT

RF MONITOR JACK

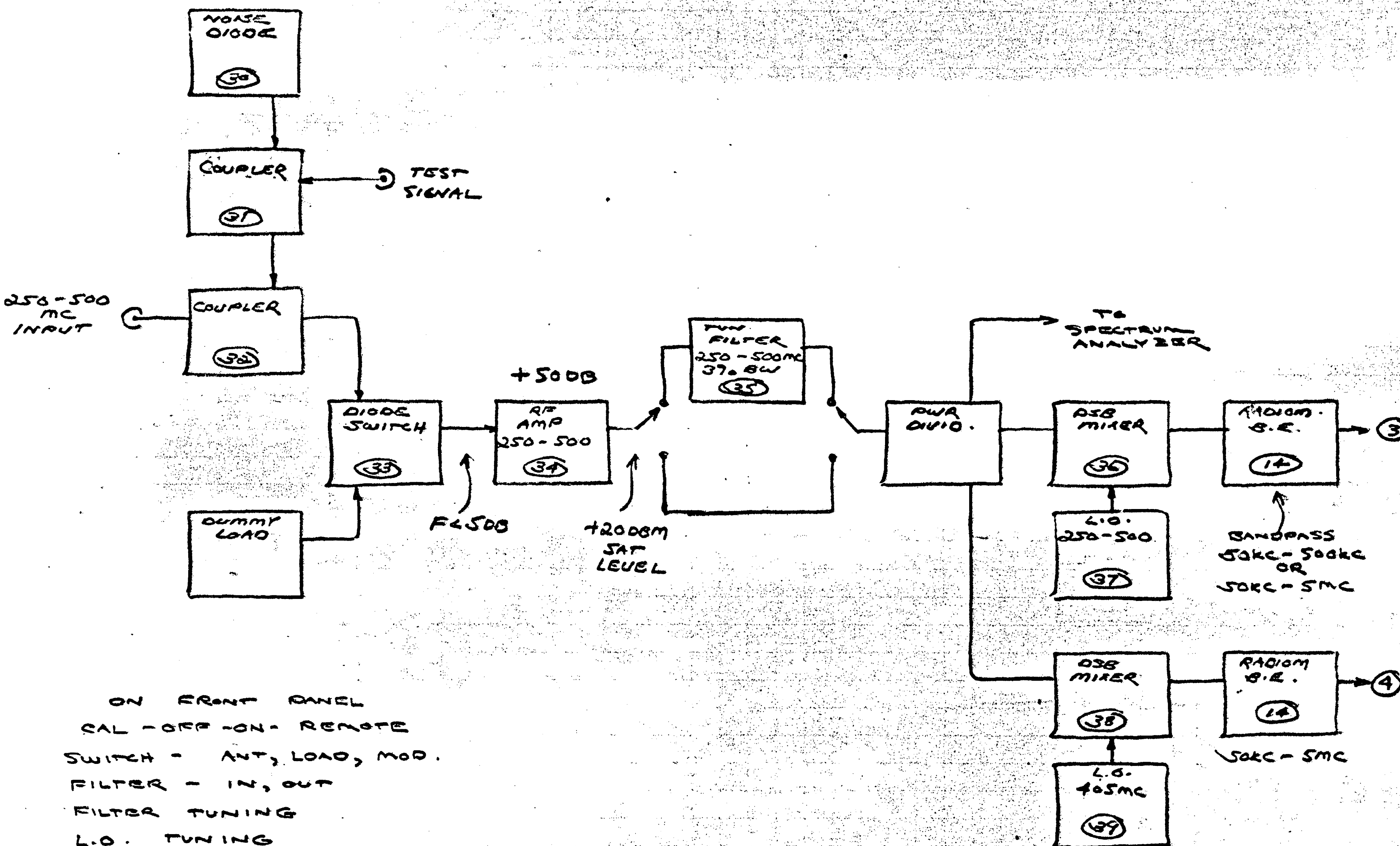
L.O. STANDBY SWITCH

TEST INPUT JACK

NOISE DIODE CURRENT MTR.

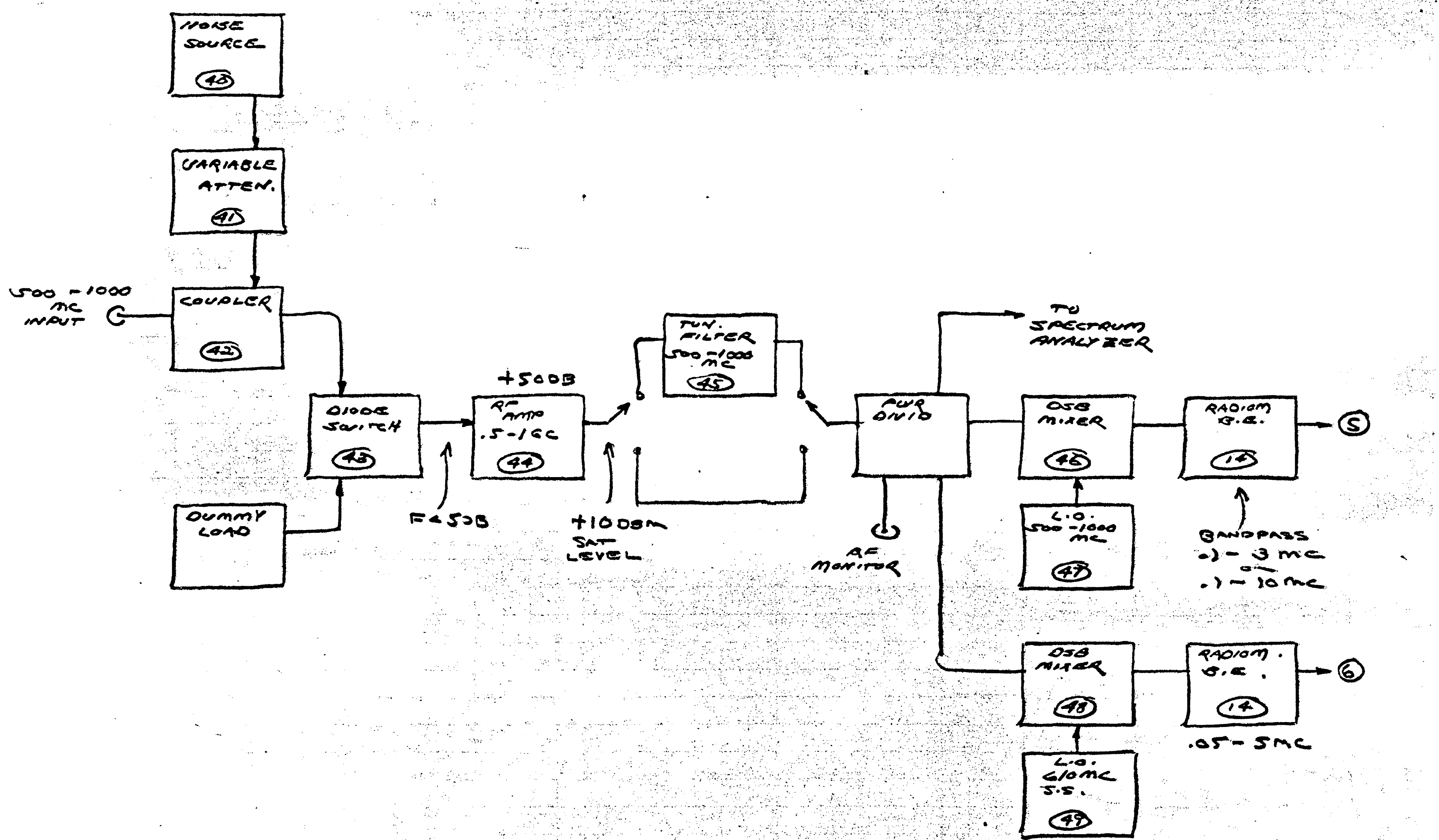
" ADJ.

50MC - 250MC
RF UNIT
FIGURE 3



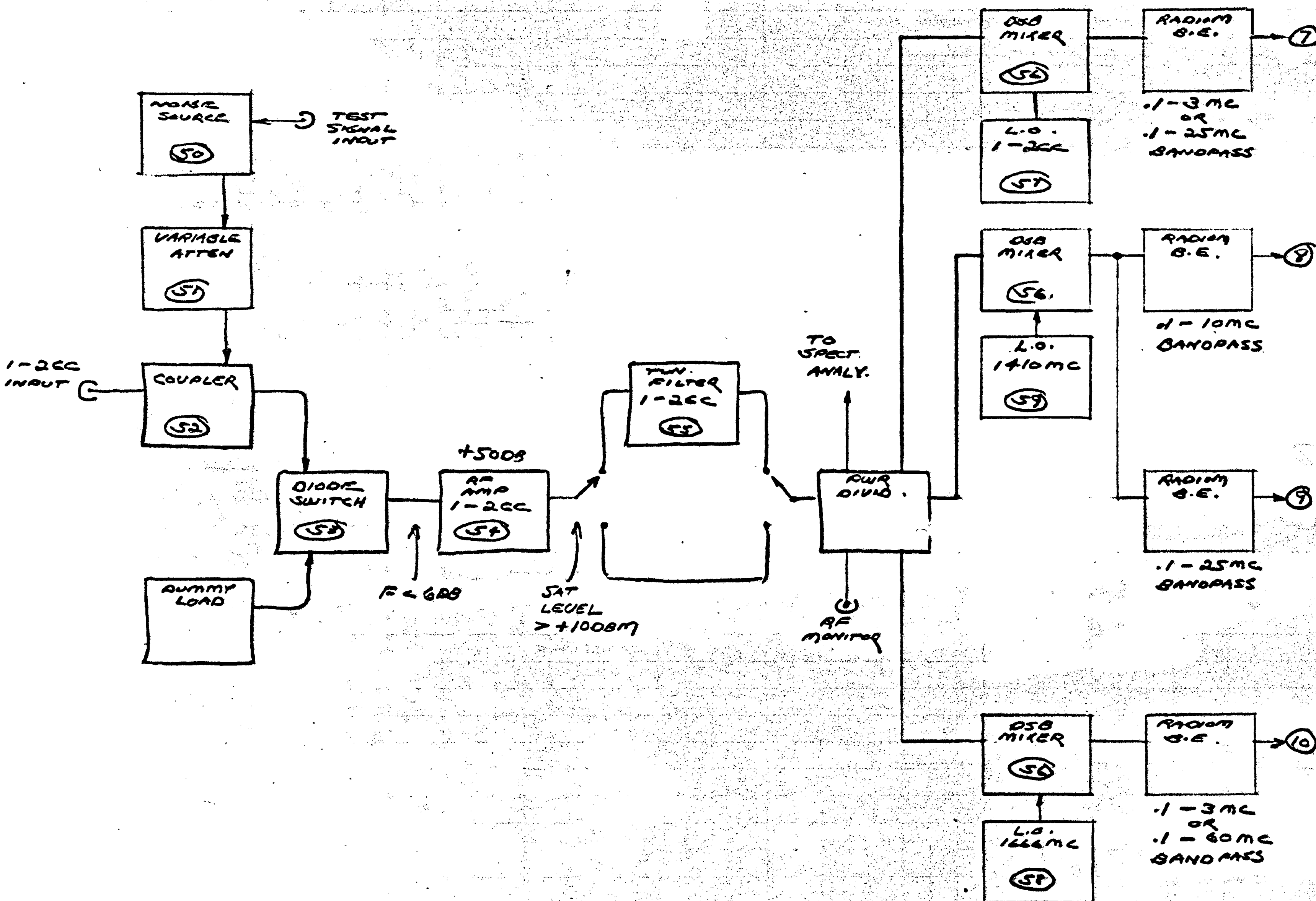
ON FRONT PANEL
CAL - OFF - ON - REMOTE
SWITCH - ANT, LOAD, MOD.
FILTER - IN, OUT
FILTER TUNING
L.O. TUNING
CRYSTAL CURRENT
RF MONITOR JACK
L.O. STANDBY SWITCH
TEST INPUT JACK
NOISE DIODE CUR. MTR
" ADJ.

250MC - 500 MC
INTERFERENCE RCVR
RF UNIT
FIGURE 4



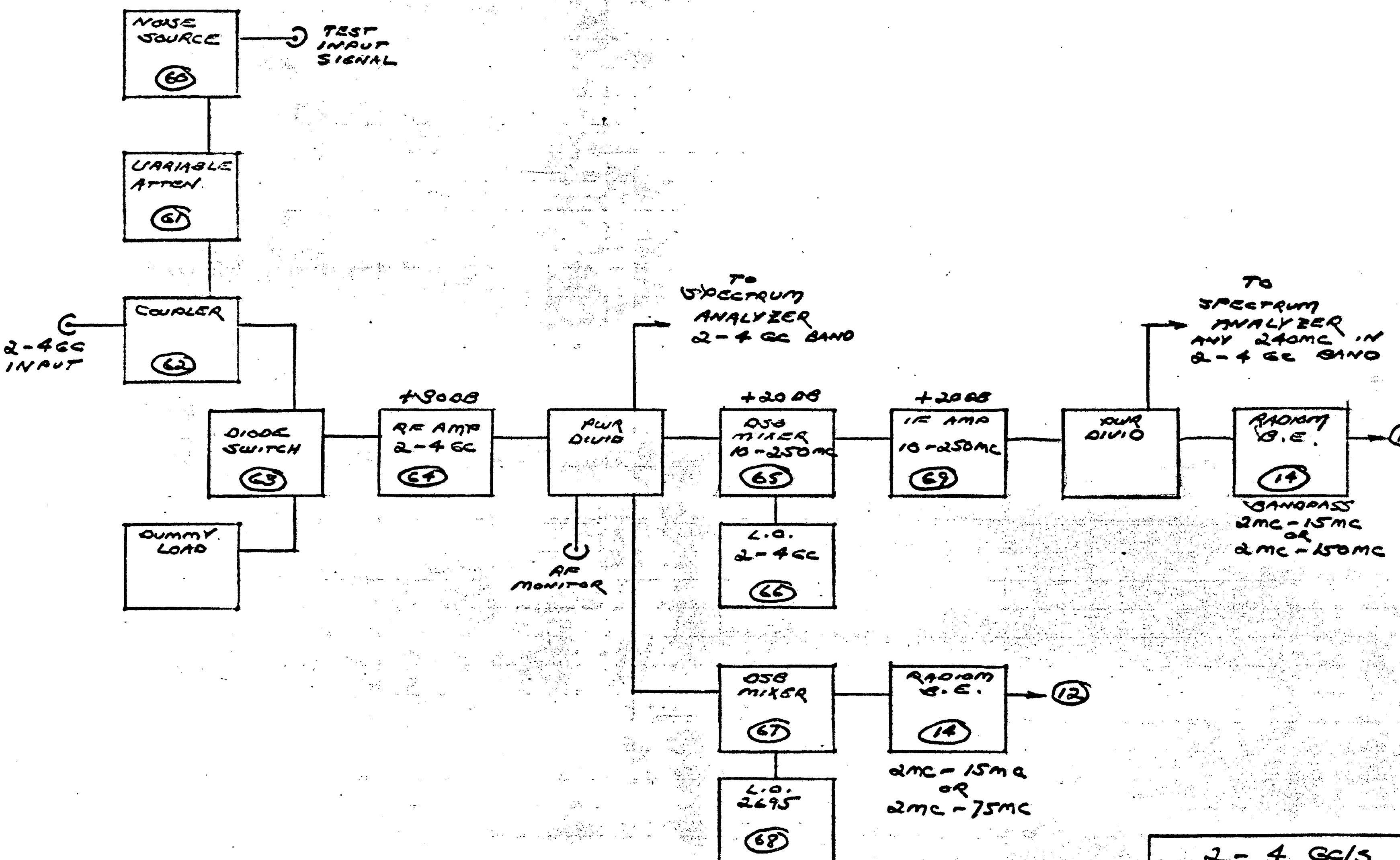
500 - 1000 MC
RF UNIT

FIGURE 5



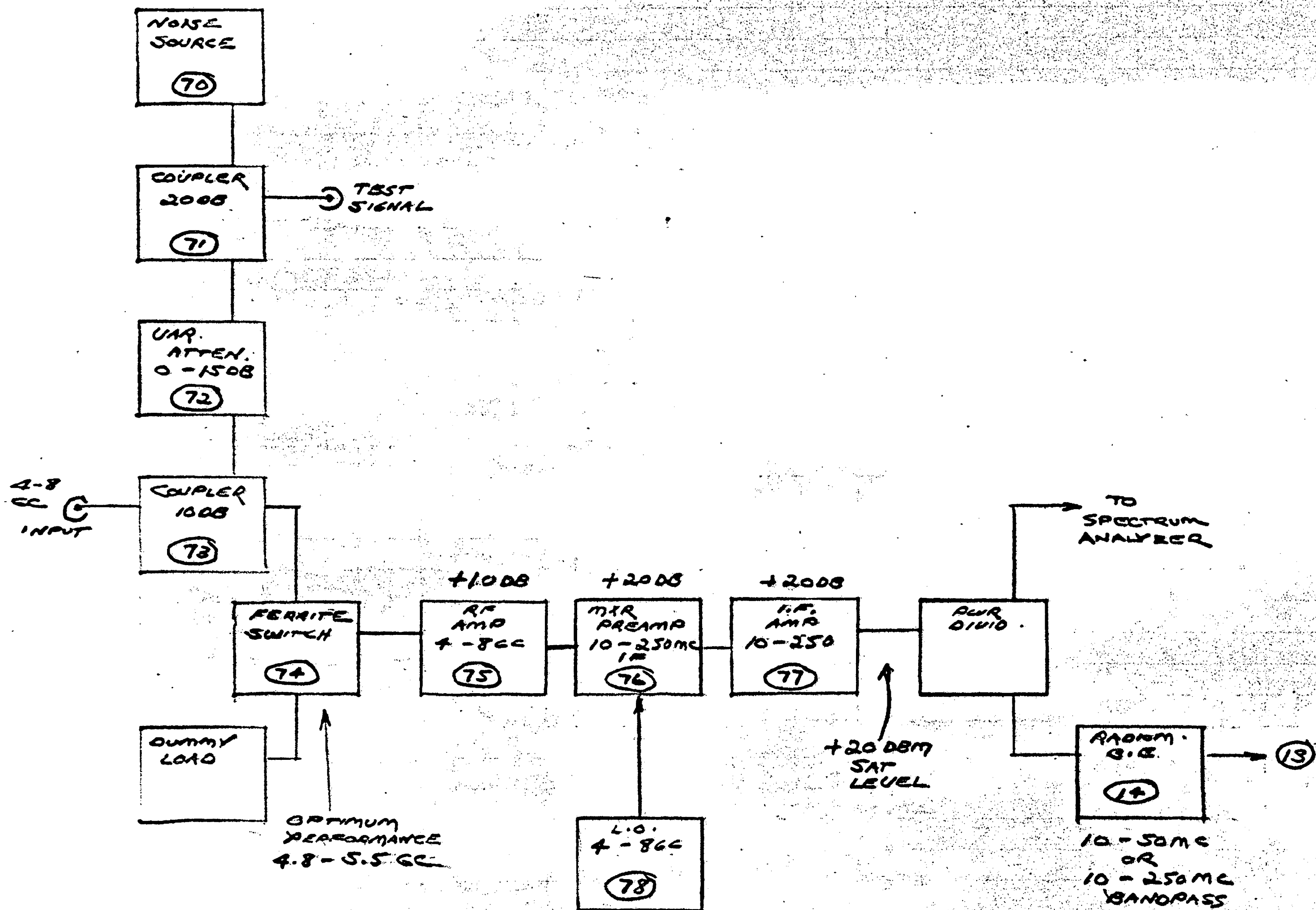
1-2 GC/S
RF UNIT

FIGURE 6



2-4 Gc/s
RF UNIT

FIGURE 7



4-8 Gc/s RF UNIT

FIGURE 8

TABLE 2

COST SUMMARY

Item	Description	Manufacturer	Cost
(1)	.05-1.0 Gc/s Antenna	AEL	2.0
(2)	1-11 Gc/s Antenna	AEL	2.0
(3)	Multiplexer	Microphase	1.5
(4)	Multiplexer	Microphase	1.5
(5)	50-250 Mc/s RF Unit	NRAO	4.3
(6)	250-500 Mc/s RF Unit	NRAO	4.6
(7)	500-1000 Mc/s RF Unit	NRAO	4.7
(8)	1-2 Gc/s RF Unit	NRAO	10.3
(9)	2-4 Gc/s RF Unit	NRAO	10.0
(10)	4-8 Gc/s RF Unit	NRAO	8.3*
(11)	8-12 Gc/s RF Unit	NRAO	8.1*
(12)	Spectrum Analyzer	HP	9.5
(13)	X-Y Recorder	Houston	1.0
(14)	16-Channel Radiometric Back End	NRAO	10.0*
(15)	8-Channel Chart Recorder (One may be on hand and available.)	Sanborn	8.0*
(16)	Mag Tape Recording System (Use existing A/D converter and tape records.)	NRAO	5.0*
---	Vehicle, Cabinets, Antenna Azimuth Rotator, Air Conditioner, Power, etc.		10.0
		Total --------	$100.8 K

* Items which should be delayed until FY 68. Thus, cost is:

FY 67 61.4 K

FY 68 39.4 K

TABLE 3

50-250 MC RF UNIT

Item	Description	Manufacturer	Cost
(20)	Diode Noise Generator	Aerospace	.5
(21),(22) (23)	Couplers, Dummy Load	Merrimac or Narda	.3
(24)	Diode Switch	Teltronics	.1
(25)	RF Amp	C-Cor or Avantek	1.0
(26),(27)	Tunable Filters - 5 Section	Telonic	1.2
(28)	Mixer	HP	.2
(29)	LO	GR or Boonton	.5
---	Chassis, Cables, Switches, Meters	--	.5
		Total----------	4.3

TABLE 4

250-500 MC RF UNIT

(30)	Diode Noise Generator	Aerospace	.5
(31),(32)	Couplers	Narda	.3
(33)	Diode Switch	Teltronics	.1
(34)	RF Amp	Avantek	1.2
(35)	Filter	Telonic	.6
(36),(38)	Mixers	HP	.4
(37)	LO	GR or Boonton	.5
(39)	LO	Sanders or Freq. Sources	.5
---	Chassis, Cables, Switches, etc.	--	.5
		Total ----------	4.6

TABLE 5

500-1000 MC/S RF UNIT

Item	Description	Manufacturer	Cost
(40)	Noise Source	AIL	.4
(41)	Variable Attenuator	Arra	.2
(42)	Coupler	Narda	.2
(43)	Diode Switch	Teltronics	.1
(44)	RF Amp	Avantek	1.7
(45)	Filter	Telonic	.6
(46),(48)	Mixers	Anzac	.6
(49)	LO — 500-1000 Mc/s	GR	On Hand
(49)	LO — 610 Mc/s	Freq. Sources	.4
---	Misc.		.5
		Total ----------	4.7

TABLE 6

1-2 GC/S RF UNIT

50	Noise Source	AIL	.4
51	Variable Attenuator	Narda	.5
52	Coupler	Narda	.2
53	Switch	MDL	.5
54	RF Amp	Avantek	4.8
55	Filter	Telonic	.6
56	3 Mixers	Anzac or RHG	1.2
57	1-2 Gc/s LO	Boonton or GR	.6
58	1666 Mc/s LO	Freq. Sources	.5
(59)	1410 Mc/s LO	Freq. Sources	.5
---	Misc.		.5
		Total ----------	10.3

TABLE 7

2-4 GC/S RF UNIT

Item	Description	Manufacturer	Cost
60	Noise Source	AIL	.5
61	Variable Attenuator	Arra	.3
62	Coupler	Narda	.2
63	Diode Switch	MDL	.6
64	Tunnel Diode Amp	Aertech	5.0
65, 67	Mixer Preamp	RHG	1.7
66	2-4 Gc/s LO	GR	On Hand
68	2695 LO	Freq. Sources	.6
69	IF Amplifier	Avantek	.6
---	Misc.		.5
		Total ----------	10.0

TABLE 8

4-8 GC/S RF UNIT

(70)	Noise Source	Aertech	.5
71, 73	Couplers	Narda	.4
72	Variable Attenuator	Arra	.3
74	Ferrite Switch	Microwave Tech.	1.0
75	TDA	Aertech	2.0
76	Mixer Preamp	RHG	1.0
78	4-8 Gc/s Osc.	FXR	1.5
77	IF Amp	Avantek	.6
---	Misc.		1.0
		Total ----------	8.3

TABLE 9

8-12 GC/S RF UNIT

Item	Description	Manufacturer	Cost
80	Noise Source	AIL	.5
81, 83	Couplers	FXR	.3
82	Variable Attenuator	FXR	.2
84	Ferrite Switch	AML	1.0
85	TDA	Aertech	2.0
86	Mixer Preamp	RHG	1.0
87	IF Amp	Avantek	.6
88	8-12 Gc/s Oscillator	FXR	1.5
--	Misc.	--	1.0
		Total ----------	8.1