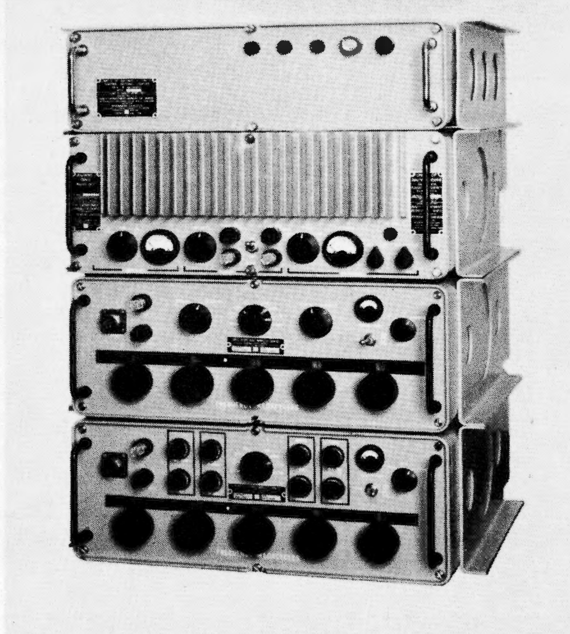
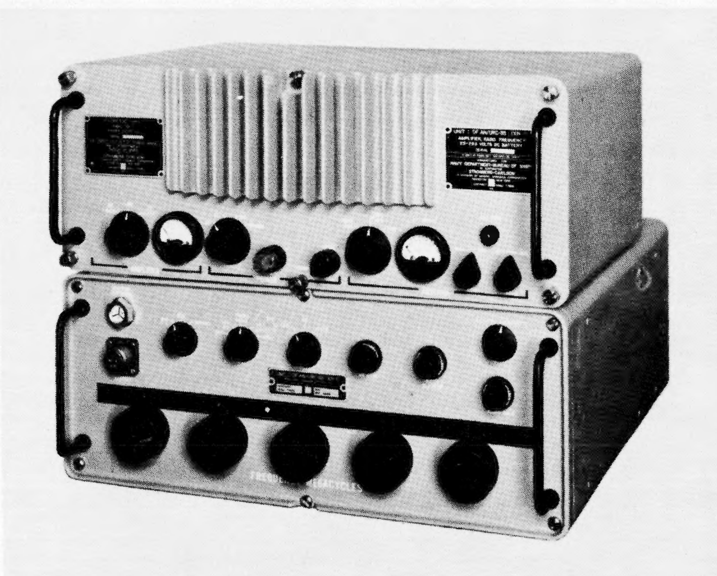


AN/WRC-1 RADIO SET

FINAL REPORT



AN/URC-35 RADIO SET

GENERAL DYNAMICS | ELECTRONICS-ROCHESTER

FINAL DEVELOPMENT REPORT

for

AN/WRC-1 SSB RADIO SET

and

AN/URC-35 SSB RADIO SET

THIS REPORT COVERS THE PERIOD OF 7-1-61 TO 7-1-62

GD

GENERAL DYNAMICS | ELECTRONICS-ROCHESTER

1400 North Goodman Street

Rochester 1, New York

NAVY DEPARTMENT BUREAU OF SHIPS ELECTRONICS DIVISIONS

Contract No. NObsr-77628

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1 August 1962

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ABSTRACT

This final report covers a period of 7-1-61 to 7-1-62 on the AN/WRC-1 and AN/URC-35 SSB program.

The major effort on the program during this period was that of supporting the operational testing at NEL on the subject equipments.

PURPOSE

On 1 July 1959, work was started at General Dynamics/Electronics (then Stromberg-Carlson Company) on the design and development of two different single sideband radio sets, the AN/WRC-1 and the AN/URC-35.

The AN/WRC-1 was intended for fixed station, general coverage throughout the range of 2-30 megacycles, with a peak power output of 100 watts. The system was to be composed of a receiver, exciter, power amplifier, and automatic antenna coupler. Tuning was to be accomplished digitally down to 1 kilocycle increments, in less than 20 seconds.

The AN/URC-35 was intended for mobile usage, operating from 2-18 megacycles, with a peak power output of 100 watts. The system was to be composed of a transceiver, power amplifier, remote box, semi-automatic antenna coupler, and a 15 foot fiberglass whip antenna. Tuning was to be accomplished digitally down to 1 kilocycle increments.

The development models of each radio set were built and submitted for evaluation. The first unit (AN/WRC-1) was shipped to the Navy Electronic Laboratory in San Diego, California 1 April 1961, and the last unit (AN/URC-35) was shipped 8 September 1961. The time period spanned was approximately 50 percent less than that perviously incurred in a program of this magnitude. Close cooperation between the Navy and the contractor, and the willingness of both to combineEngineering Model phase and Service Test Model phase had much to do with attaining the accelerated goal.

Shortly after the design phase was started, it became evident that certain changes in the general equipment makeup could produce, as an end result, an extremely flexible series of units, which, in many instances, could be interchanged with existing equipment, interchanged within themselves, and successfully integrated with new proposed equipment. Consequently, the final equipment differs in some aspects from the original specification, but the program has created a series of units which provide considerable flexibility to the user. As an example, the original intent was to use the Automatic Antenna Coupler with the AN/WRC-1 and the Semi-Automatic Antenna Coupler with the AN/URC-35. By recognizing and providing for the comparatively minor dissimilarities, it is now possible to use either coupler with the AN/WRC-1. Many similar changes will become evident later.

The following sections are, in general, divided down to the losest unit presently assigned nomenclature. Because of certain similarities between units, the first subject is covered in detail and similar items are thereafter referenced.

It is intended that this Final Report will serve as a description of what was attained by the subject development. No attempt is made to describe step-by-step development, since this information, if required, is adequately recorded in the Interim Development Reports already submitted.

GENERAL FACTUAL DATA

On March 24, 1961, a change designed to improve the efficiency of the Cost Accounting system of General Dynamics/Electronics was instituted.

While this change improves the effectiveness of Cost Control by providing cost data more rapidly, it prevents indentification of manpower charges in detail.

The hours worked by project personnel are listed as follows:

Supervisory Personnel:

J. E. Harrison	Chief Engineer
R. S. Arao	Section Manager
D. B. Carr	Supervising Mechanical Engineer

Project Personnel:		Hours Worked:
Section Head		41
Sr. EE		23
EE I		583
EE II		562
Sr. Me		290
ME I		109
EA		632
TECH		9
	Total	2,249

The following is a summary of the hours expended by General Dynamics/ Electronics on the AN/WRC-1 and AN/URC-35 Development Program.

Period	Hours Worked:
7- 1-59 to 9-30-59	10,637
10- 1-59 to 12-31-60	20,464
1- 1-60 to 3-31-60	17,377
4- 1-60 to 6-30-60	13,924
7- 1-60 to 9-30-60	12,254
10- 1-60 to 12-31-60	11,438
1- 1-61 to 3-31-61	16,948
4- 1-61 to 6-30-61	9,004
7- 1-61 to 7- 1-62	2,249
Grand Total	114,295

It should be noted that in addition to the hours shown above; an additional 464 hours were expended, at no cost to the Bureau of Ships, by General Dynamics/ Electronics personnel at NEL. In addition there were also a large number of hours expended in-plant by various personnel in support of the operational testing at NEL.

DETAILED FACTUAL DATA

The first service test model of the AN/WRC-1 was delivered to the Naval Electronics Laboratory on 30 March 1961. The second service test model of the AN/WRC-1 was shipped to the laboratory on 28 July 1961. These systems, as shipped, included a Receiver-Exciter, 100 W Power Amplifier, Automatic Antenna Coupler, Coupler Control Box, and Junction Box. In addition to these items, spare parts, shock mounts, and preliminary instruction books were delivered.

The first service test model of the AN/URC-35 was delivered to the Naval Electronics Laboratory on 5 September 1961. The second service test model of the AN/URC-35 was shipped to the laboratory on 8 September 1961. These systems, as shipped, included a Receiver-Exciter, 100 W DC Power Amplifier, Semi-Automatic Antenna Coupler, and Control Box.

The testing on the AN/WRC-1 proceeded satisfactorily with provisional acceptance of the system for use by the Navy in December 1961. Subsequently, a contract was received on 29 June 1962, covering preproduction models and 28 pilot production models of the AN/WRC-1.

Testing on the AN/URC-35 systems is continuing as of the date of this report.

The following is a description of each unit of the AN/WRC-1 and AN/URC-35. Because of certain similarities between the units, the first subject is covered in detail and similar items are thereafter referenced.

1.0 R-1051/URR RECEIVER

The R-1051/URR is a single sideband receiver operating between 2-30 megacycles, and digitally tuned in 1 kilocycle steps. Operation in upper sideband, lower sideband frequency shift keying, CW, AM, and independent sideband is provided. A photograph of the unit is shown in Figure 1, and a block diagram in Figure 2.

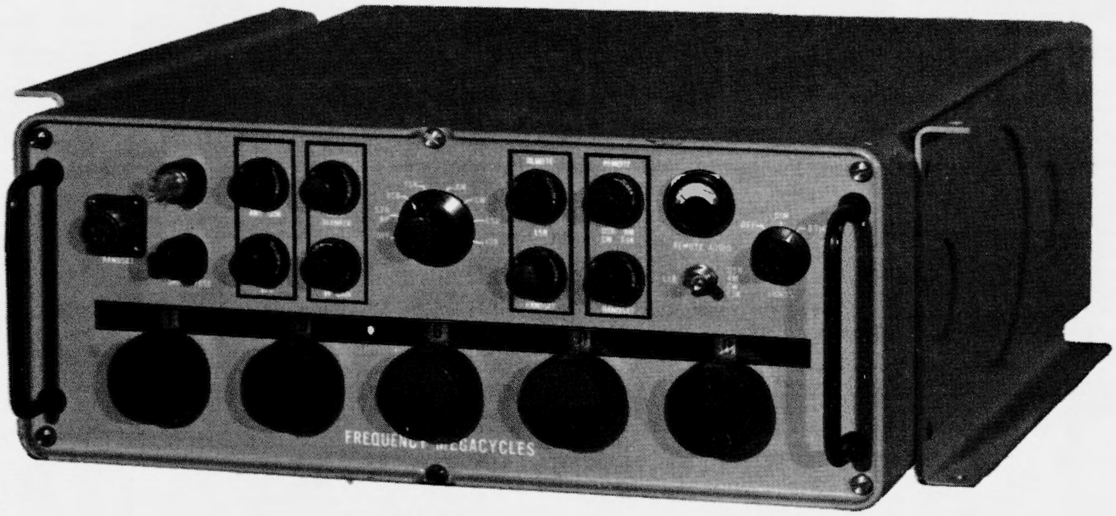


Figure 1. R-1051/URR

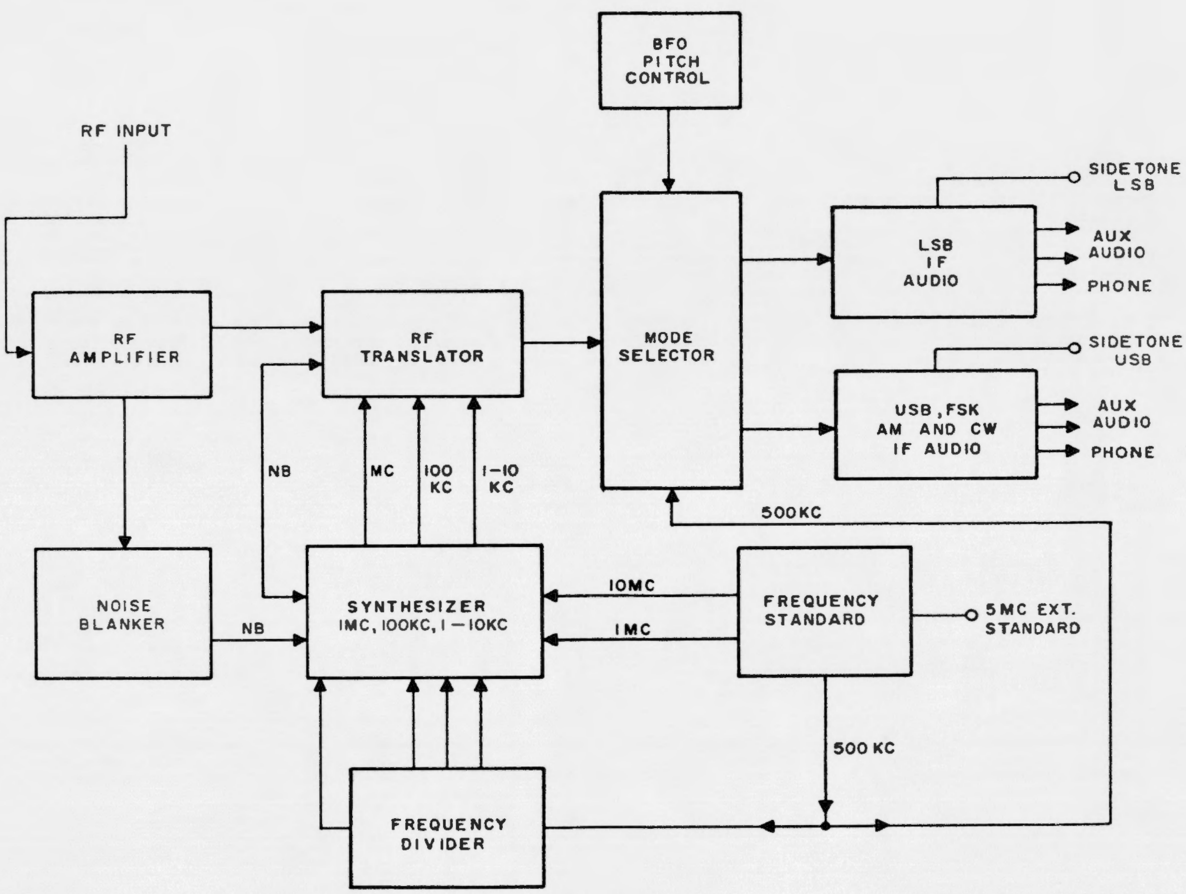


Figure 2. R-1051/URR, Block Diagram

The Receiver is composed of a frame, front panel, case and seven plug-in electronic assemblies.

The case proper is of drawn aluminum, with no sharp or protruding edges. Three coax connectors and one multipin connector protrude from the rear of the case. Internally there are a filter box, a retractable cable which plugs into the rear of the frame assembly, and drawer slides. Two types of end brackets were designed, one type for stack or table mounting and a second type for standard 19 inch rack mounting.

The frame and front panel essentially comprise a single assembly. The front panel provides all the controls required to operate the Receiver, as labelled in Figure 3. The frame contains the power supply, plugs for module insertion, and interconnecting cabling. Drawer slides, mounted on the sides of the frame, operate in conjunction with those previously mentioned on the case, and enable the unit to be locked horizontally or 90 degrees from horizontal when withdrawn from the case. Disabling of the drawer slide catches and the interconnecting cable enables the frame and panel to be completely separated from the case. A gasket extended around the internal perimeter of the front panel provides a moisture seal when the unit is secured. The frequency selection mechanism includes a means of providing 5-wire coded frequency information for indexing various motor-tuned assemblies.

The modules used with the Receiver are as follows:

1. RF Amplifier
2. Translator Synthesizer
3. Mode Selector
4. Receiver IF/Audio - 2 required.
5. Frequency Standard
6. Noise Blanker

1.1 RF AMPLIFIER

The RF amplifier is the only module in the receiver that uses tubes. During the early phases of the program, a study was performed to determine whether tubes or transistors would be used as RF amplifiers. On the basis of electrical tests, cost, time, availability of transistors, and a number of other factors, it was decided that tubes offered the greatest promise of success under the specified conditions. Contained within the module are two RF amplifier stages and an AGC voltage amplifier. The module measures 7.5 inches deep by 7.5 inches wide by 4.5 inches high and is shown in Figure 4.

Tuning in the RF amplifier is accomplished by two different means. Integral megacycle tuning, 2-29 megacycles, is accomplished by a turret surrounding the amplifier proper. There are 28 turret positions, one for each megacycle, over the frequency range. Frequency information, generated at the front panel, is electrically transferred, through coding on the turret, to the turret drive. When frequency change information is presented, the turret rotates to the correct band, at which point the drive information is interrupted. Tuning in 100 and 10 kc increments is accomplished by switching banks of fixed capacitors mounted within the turret.

Shown in Figure 5 is the basic tuning breakdown, illustrating a typical megacycle strip and the method employed for digitally tuning down to 10 kc. A double tuned circuit, as shown, is used at the antenna input to give minimum cross-modulation, distortion, and blocking of the front end. RF tuning beyond the input is similar except that single tuned, rather than double tuned, circuits are used.

1.2 TRANSLATOR/SYNTHESIZER

The Translator/Synthesizer module is made up of the following five sub-modules:

1. Translator
2. Spectrum Generator

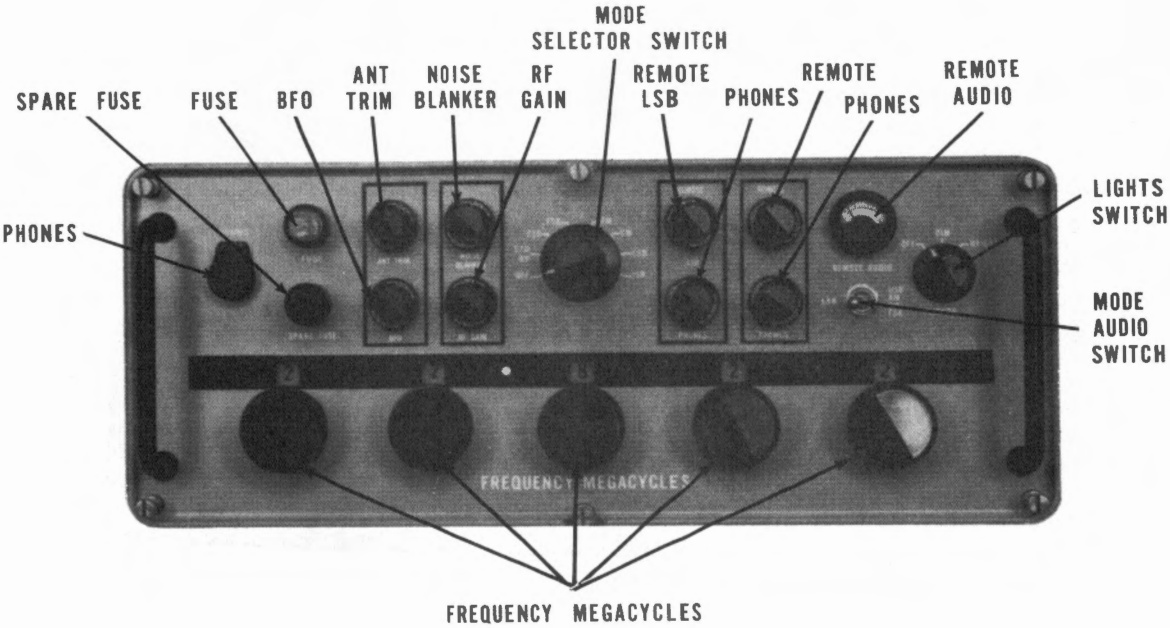


Figure 3. Receiver R-1051 URR, Front Panel

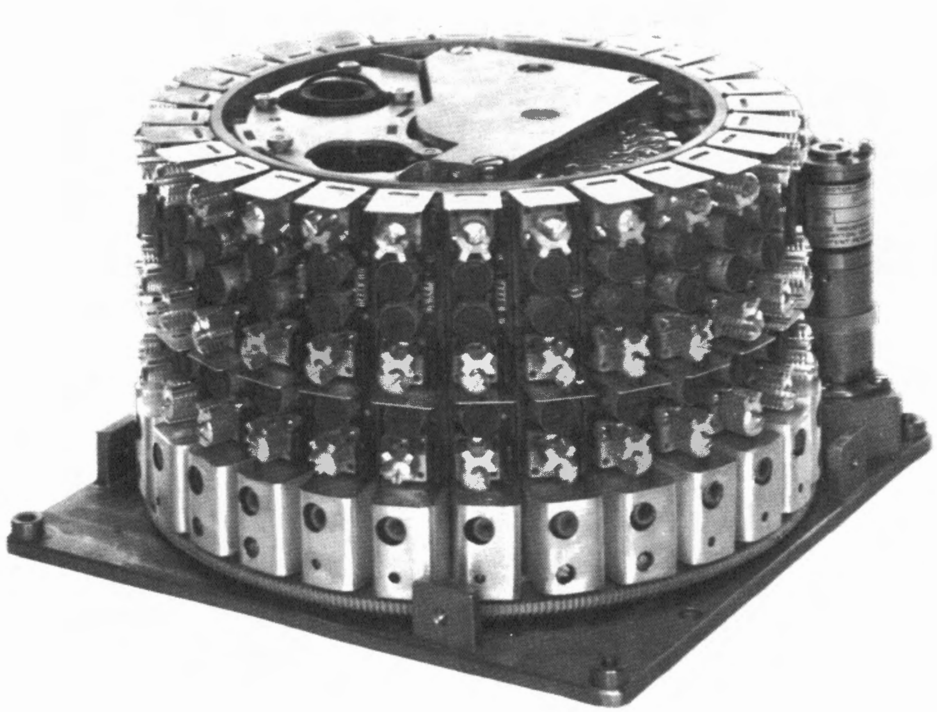
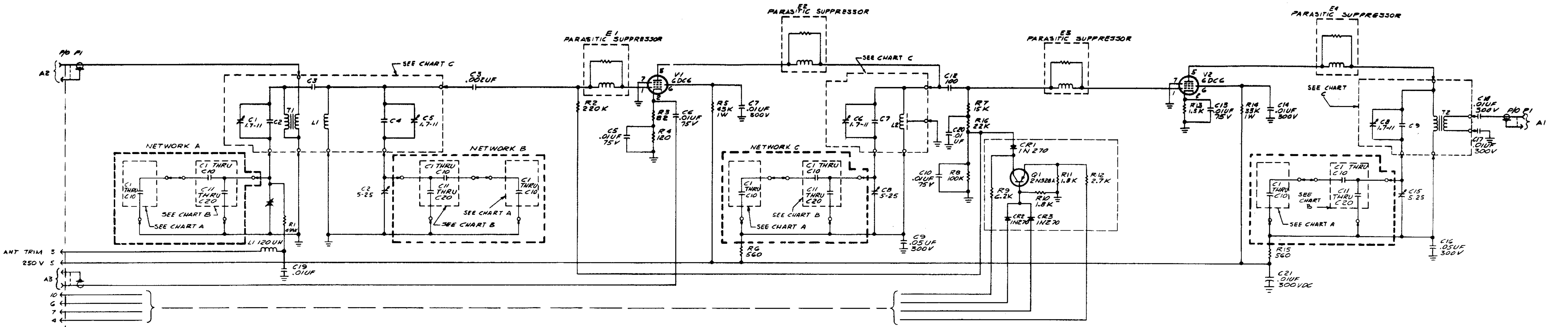


Figure 4. RF Amplifier Module



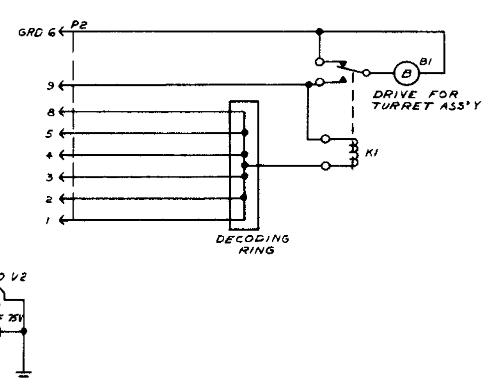


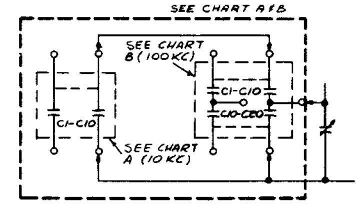
CHART A (10 KC)

FREQUENCY MC	CAPACITOR REF DESIG	NETWORK A CAP VAL	NETWORK B CAP VAL	NETWORK C CAP VAL	NETWORK D CAP VAL
.00	C1	1034	1034	1036	1034
.01	C2	998	998	998	998
.02	C3	964	964	964	964
.03	C4	932	932	932	932
.04	C5	902	902	902	902
.05	C6	874	874	874	874
.06	C7	847	847	844	847
.07	C8	821	821	818	821
.08	C9	797	797	793	797
.09	C10	774	774	770	774

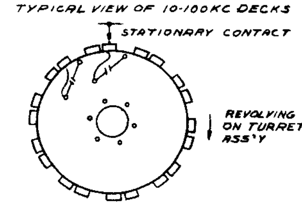
CHART B (100 KC)

FREQUENCY MC	CAPACITOR REF DESIG	NETWORK A CAP VAL	NETWORK B CAP VAL	NETWORK C CAP VAL	NETWORK D CAP VAL
.0	C1	874	874	856	874
	C11	246	246	249	246
.10	C2	761	761	747	761
	C12	212	212	214	212
.20	C3	673	673	661	673
	C13	183	183	184	183
.30	C4	601	601	591	601
	C14	157	157	158	157
.40	C5	542	542	534	542
	C15	135	135	136	135
.50	C6	492	492	485	492
	C16	117	117	117	117
.60	C7	451	451	444	451
	C17	101	101	100	101
.70	C8	415	415	409	415
	C18	86	86	86	86
.80	C9	384	384	378	384
	C19	73	73	73	73
.90	C10	357	357	352	357
	C20	62	62	62	62

TYPICAL VIEW OF NETWORK A-D
SEE CHART A & B



TYPICAL VIEW OF 10-100KC DECKS



DECK 1 OF 8

CHART C

FREQUENCY MC	ON ASS'Y	C2 VALUE	ON ASS'Y	C3 VALUE	ON ASS'Y	C4 VALUE	ON ASS'Y	C7 VALUE	ON ASS'Y	C9 VALUE
2	A2	.1UF	A2	12	A2	SHORTED	A2	SHORTED	A7	SHORTED
3	A3	1249	A3	10	A3	1249	A3	1249	A8	1249
4	A4	626	A4	6	A4	626	A4	626	A9	626
5	A5	418	A5	7	A5	418	A5	421	A10	418
6	A6	314	A6	6	A6	314	A6	314	A11	314
7	A7	252	A7	4	A7	252	A7	252	A12	252
8	A8	209	A8	4	A8	209	A8	212	A13	209
9	A9	180	A9	3.9	A9	180	A9	183	A14	180
10	A10	160	A10	2.2	A10	160	A10	160	A15	160
11	A11	142	A11	2.7	A11	142	A11	142	A16	142
12	A12	128	A12	2.7	A12	128	A12	130	A17	128
13	A13	116	A13	2.4	A13	116	A13	118	A18	116
14	A14	106	A14	2.7	A14	106	A14	109	A19	106
15	A15	97	A15	2.2	A15	97	A15	101	A20	97
16	A16	93	A16	2.2	A16	93	A16	93	A21	93
17	A17	86	A17	2.2	A17	86	A17	86	A22	86
18	A18	81	A18	2.7	A18	81	A18	81	A23	81
19	A19	75	A19	2.7	A19	75	A19	78.9	A24	75
20	A20	73	A20	2.0	A20	73	A20	73	A25	73
21	A21	70	A21	1.8	A21	70	A21	70	A26	70
22	A22	65	A22	2.2	A22	65	A22	67	A27	65
23	A23	62	A23	1.8	A23	62	A23	65	A28	62
24	A24	62	A24	2.0	A24	62	A24	62	A29	62
25	A25	57	A25	2,0	A25	57	A25	57	A2	57
26	A26	55	A26	2.0	A26	55	A26	57	A3	55
27	A27	53	A27	2.2	A27	53	A27	55	A4	53
28	A28	51	A28	2.4	A28	51	A28	53	A5	51
29	A23	49	A29	2.4	A29	49	A29	51	A6	49

NOTES:
1. REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX THE DESIGNATION WITH UNIT NUMBER OR ASSEMBLY OR BOTH.
2. UNLESS OTHERWISE SPECIFIED
   a. RESISTOR VALUES IN OHMS
   b. CAPACITOR VALUES IN MICRO-MICROFARADS.
   c. RESISTORS ARE 1/4 W, 5 %.

Figure 5. RF Amplifier Schematic

3. 1 and 10 kc Synthesizer
4. 100 kc Synthesizer
5. Megacycle Synthesizer

The Translator submodule basically converts the output of the RF amplifier to the 500 kc intermediate frequency. This is accomplished by converting the RF frequency three times, in three consecutive mixers. Figure 6 is a block diagram of the Translator. Injection frequencies are generated in the other Translator/Synthesizer submodules. In addition to the mixers, the Translator contains both relays and diode switching to permit bidirectional operation. This enables the same submodule to be used on both receive and transmit, and therefore, eliminates the need for as many as three different translators to meet the equipment requirements. Considerable success has been achieved in using diodes for switching in the signal path. Heretofore, this technique has been shunned because of the distortion and high frequency leakage problems associated with diodes. However, attenuation of better than -60 db and intermodulation distortion of less than -50 db have been obtained.

Spectrum Generator: The primary function of the Spectrum Generator submodule is to provide locked spectrum outputs centered about three frequencies. As shown in Figure 7 the 500 kilocycles from the Frequency Standard is fed into the Spectrum Generator, where it is squared and divided down to 100, 10, and 1 kilocycle repetition rates. These pulses are then used to key oscillators tuned approximately to 16, 3.8 and 0.115 megacycles respectively. The keyed oscillator outputs are filtered to pass the desired frequencies and then fed into the synthesizer submodules.

1 and 10 Kilocycle Synthesizer: The 1 kc and 10 kc Synthesizer (shown in Figure 8) performs two functions. First, this submodule contains two independent crystal oscillators, the frequencies of which are switched from the 1 and 10 kilocycle frequency controls located on the front panel. The output of the two oscillators are mixed, and a resultant signal is filtered and used as an injection

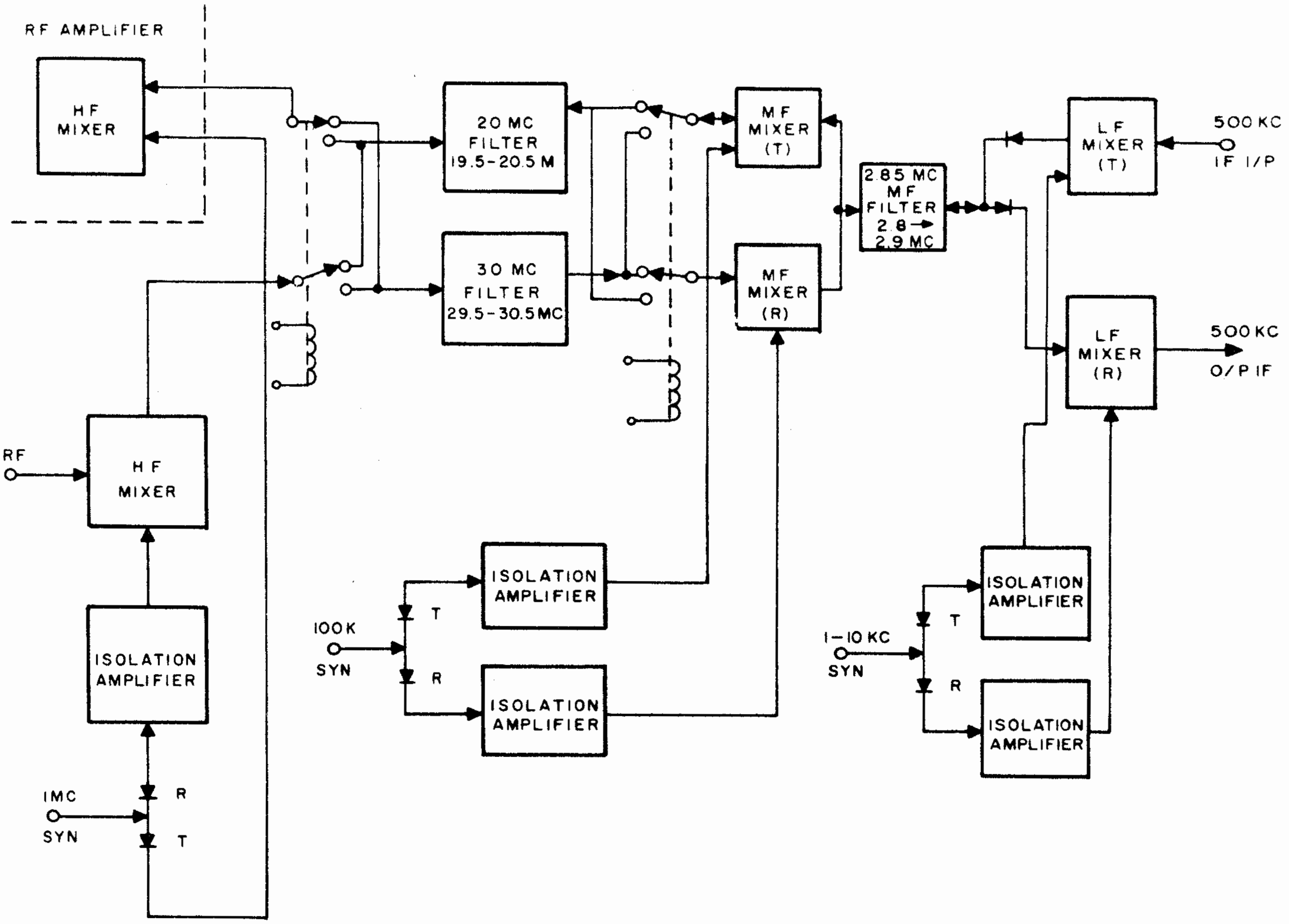


Figure 6. Translator Block Diagram

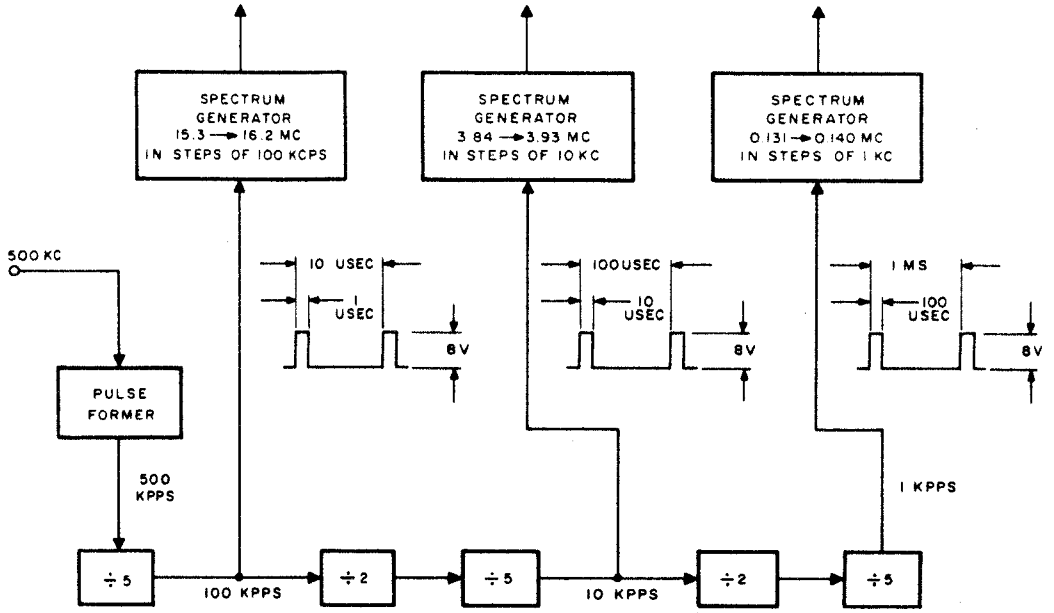


Figure 7. Spectrum Generator Block Diagram

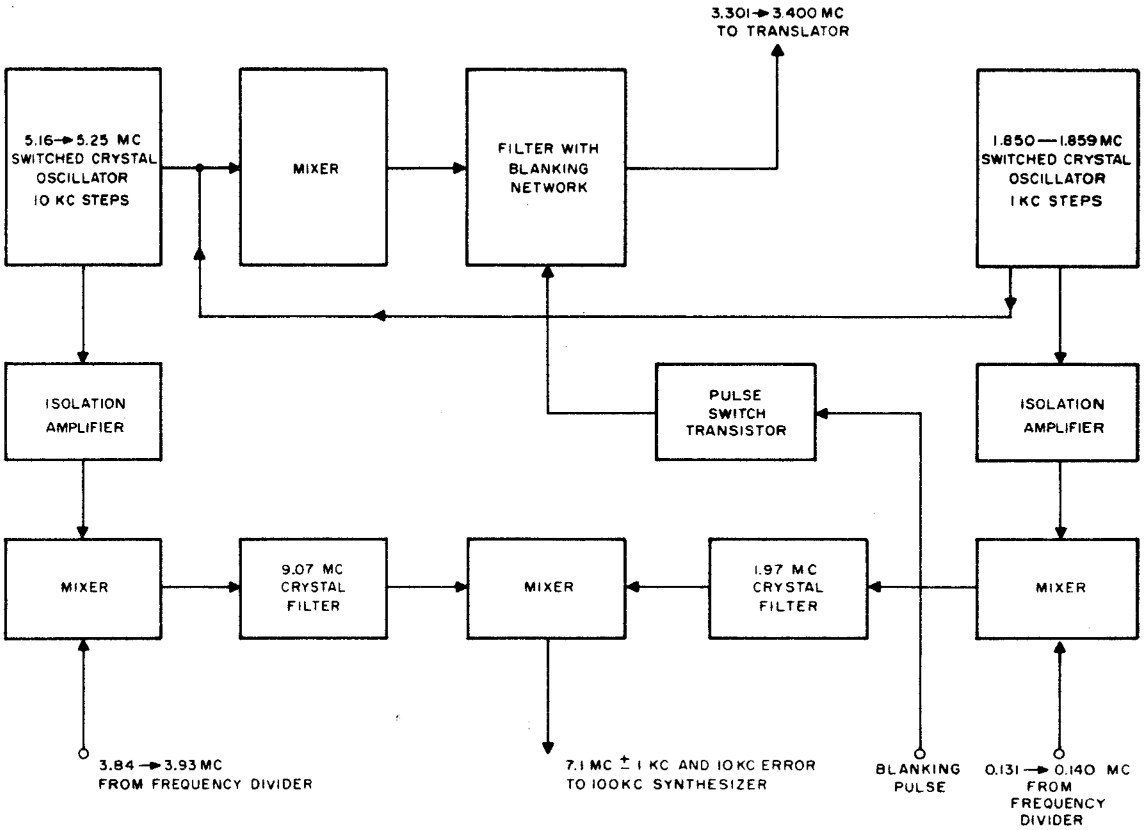


Figure 8. 1 kc and 10 kc Synthesizer Block Diagram

frequency in the Translator. This injection frequency is determined solely from the aforementioned crystal oscillators and consequently does not have the required accuracy. To compensate for the injection error, the two oscillator outputs are also mixed with the 0.115 and 3.8 megacycle spectra, respectively, and the resulting outputs mixed with each other, thus producing an end product whose frequency is a function of the original two frequencies, and consequently, a function of the error in frequency of the original two oscillators. This 7.1 mc error information is provided to the 100 kc Synthesizer submodule, to be covered below.

<u>100 Kilocycle Synthesizer</u>: The 100 kc Synthesizer (shown in Figure 9) contains a crystal oscillator, the frequency of which is determined by the setting of the 100 kc knob on the front panel. The output of the oscillator is mixed with the 100 kc spectrum generated in the Spectrum Generator and then again mixed with the 7.1 mc error signal from the 1 and 10 kc Synthesizer. The resultant frequency, now containing the frequency errors present in the 1 and 10 kc injection and the above 100 kc oscillator, is again mixed with the original 100 kc oscillator frequency to produce the injection frequency required in the translator. Thus the errors in the 100 kc injection oscillator is cancelled out, and the accuracy of the injection is comparable to the accuracy of the Frequency Standard. The error of the 10 kc and 1 kc oscillator is then cancelled in the signal path when the translated signal is mixed with the injection from the 10 and 1 kc Synthesizer. In addition, this submodule contains an AGC circuit to maintain the injection output at approximately a constant amplitude and a hi-low circuit to improve image and IF rejection.

<u>Megacycle Synthesizer</u>: The Megacycle Synthesizer (shown in Figure 10) is a phase-locked system as contrasted with the error cancelling system of the previous two synthesizers. This unit also contains a crystal oscillator, the frequency of which is determined by the setting of the megacycle knobs on the front panel. The oscillator is mixed with an internally generated 1 megacycle spectrum to

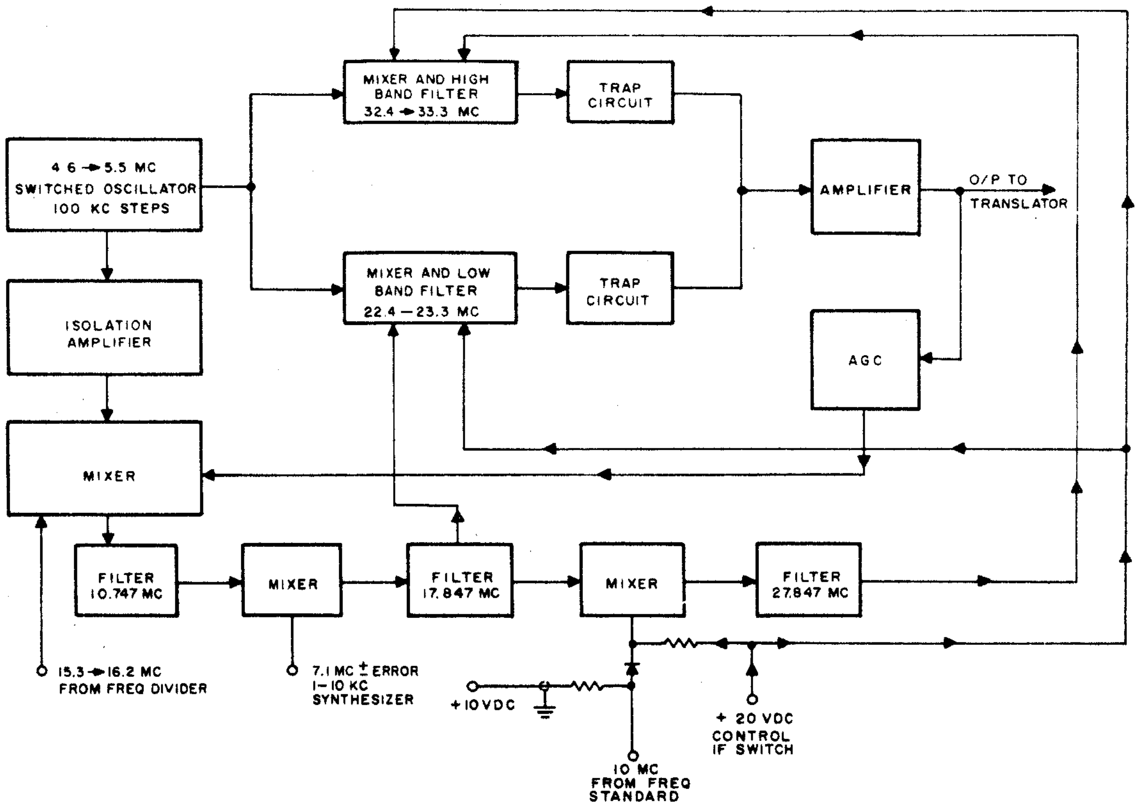
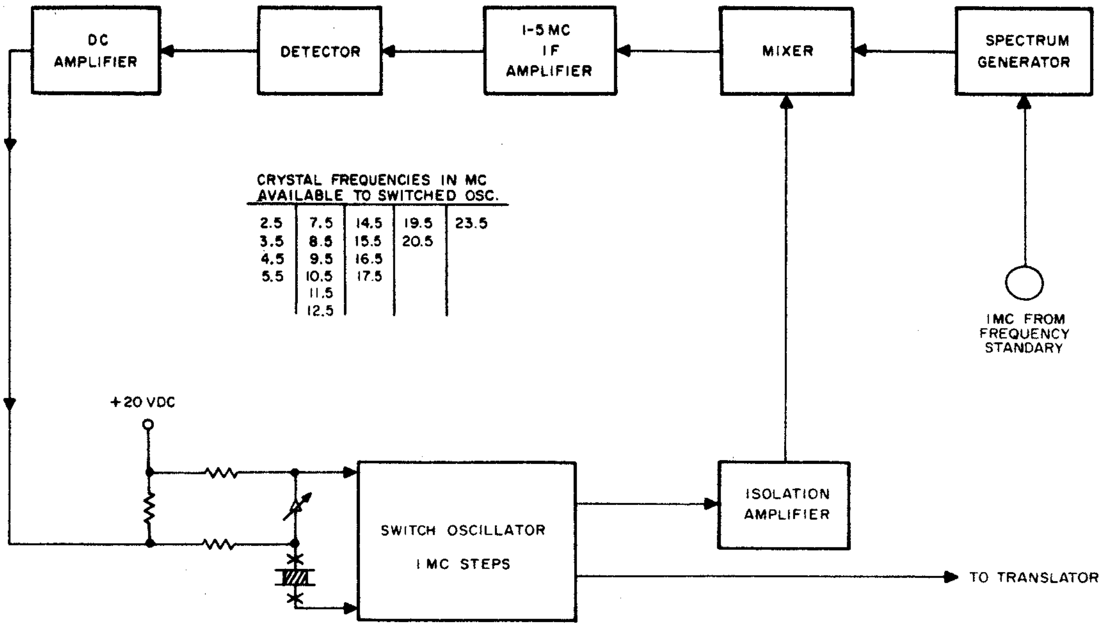


Figure 9. 100 kc Synthesizer Block Diagram



CRYSTAL FREQUENCIES IN MC AVAILABLE TO SWITCHED OSC.

2.5	7.5	14.5	19.5	23.5
3.5	8.5	15.5	20.5	
4.5	9.5	16.5		
5.5	10.5	17.5		
	11.5			
	12.5			

Figure 10. 1 mc Synthesizer Block Diagram

produce two intermediate frequencies composed of the plus and minus components of the oscillator and two spectrum products. These are filtered, amplified, and detected and the resultant audio is rectified and applied across a variable capacitance diode in the crystal oscillator circuit to pull the crystal to the exact frequency. When the crystal oscillator is on-frequency, there is no audio out of the detector circuit, and the feedback component is a DC voltage generated by the phase difference between the two intermediate frequencies.

1.3 MODE SELECTOR

The primary purpose of the Mode Selector is to provide the correct IF selectivity. Three filters, upper Sideband, lower Sideband, and AM are provided, at an IF Frequency of 500 kc. Diode switching is used to gate the desired filter into the signal path. In addition, the unit contains diode switching for the 500 kc from the Frequency Standard, which is ultimately used in the product detector in the Receiver IF/Audio electronic assembly, and a variable 500 kc oscillator used as the BFO.

1.4 IF/AUDIO

This electronic assembly contains the IF amplifier, AGC, detectors, and audio circuitry. Four IF amplifier stages, as shown in Figure 11, are used to produce approximately 60 db of gain and 50 db of AGC. The AGC, derived at the output of the third IF Amplifier, produces a "step" AGC function, with a comparatively fast rise time and a predetermined hand time after cessation of the signal. A balanced mixer is used for a product detector, and a diode detector for the AM mode. The audio amplifier has approximately 40 db of gain with the level adjust located on the front panel. Two assemblies are used in the Receiver to accomodate the Independent Sideband Requirement. The second assembly is used only in the LSB and ISB modes of operation.

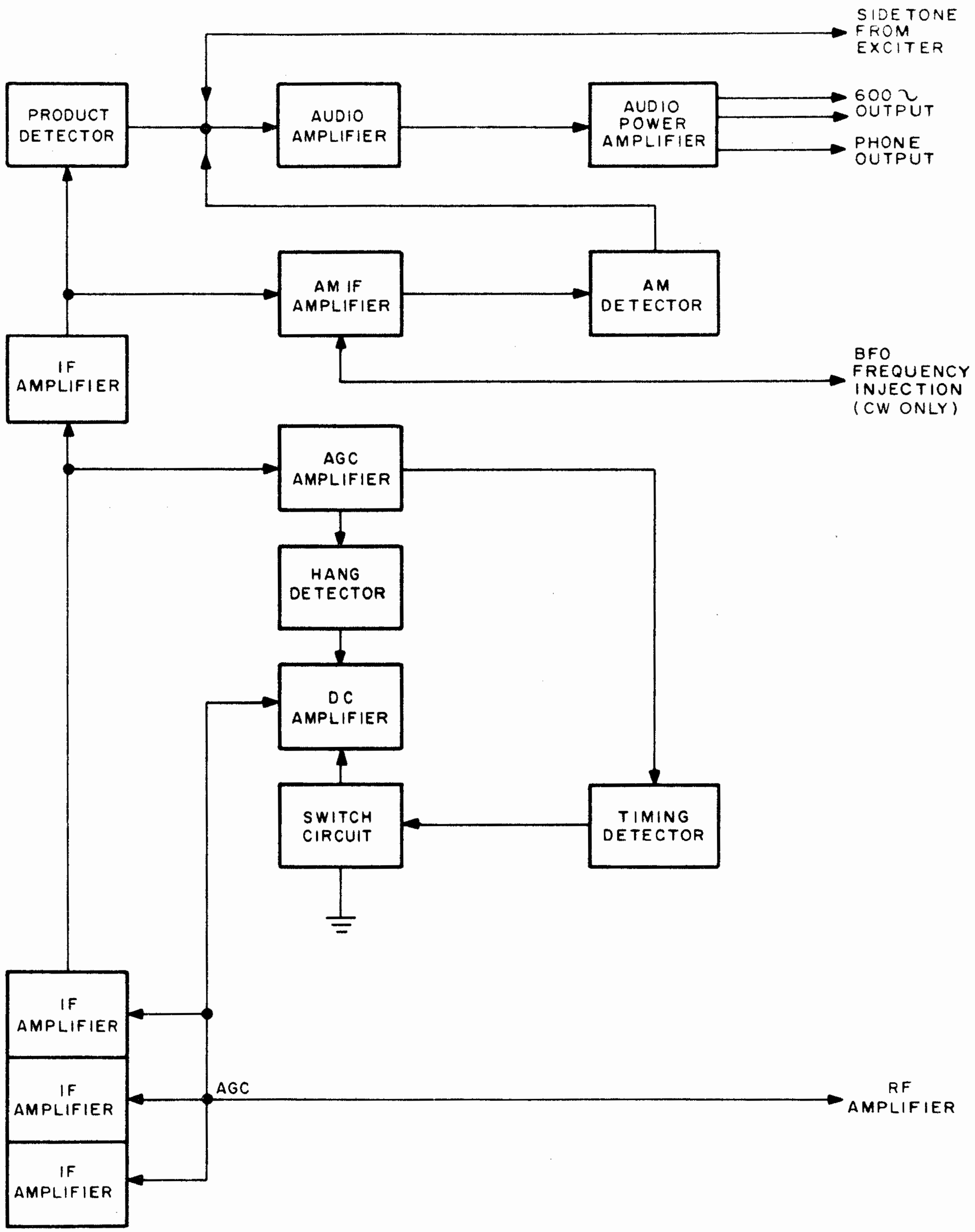


Figure 11. IF/Audio Block Diagram

1.5 FREQUENCY STANDARD

This module (shown in Figure 12) performs two basic functions. First, a 5 mc frequency standard provides the required frequency accuracy, and secondly, regenerative division and multiplication provide frequency locked 500 kc, 1 mc, and 10 mc outputs. The 5 mc standard is a crystal controlled oscillator operating within an oven accurately maintained at 85^{o}C. An internal switch enables the Receiver to be operated from an external standard, if desired, and permits comparison of the internal standard with an external more accurate source of 5 mc. A comparator circuit and indicator are included to permit adjustment of the frequency standard without complex analysis.

1.6 NOISE BLANKER

The purpose of this assembly (shown in Figure 13) is to reduce the effects of inpulse type noise in the Receiver. A wideband amplifier, 2-30 mc, provides approximately 45 db of gain to an input signal from the RF Amplifier assembly. The wideband amplifier drives a peak and an average detector. When impulse noise of amplitude 5 times or larger than the signal is applied to the detector circuitry, an output pulse is produced. This pulse is amplified and used to trigger a monostable multivibrator. The multivibrator output pulse removes the 100 kc injection from the second mixer in the Translator for about 100 sec at approximately the same period of time that the received noise pulse arrives at the mixer, thereby either removing or reducing the apparent noise amplitude.

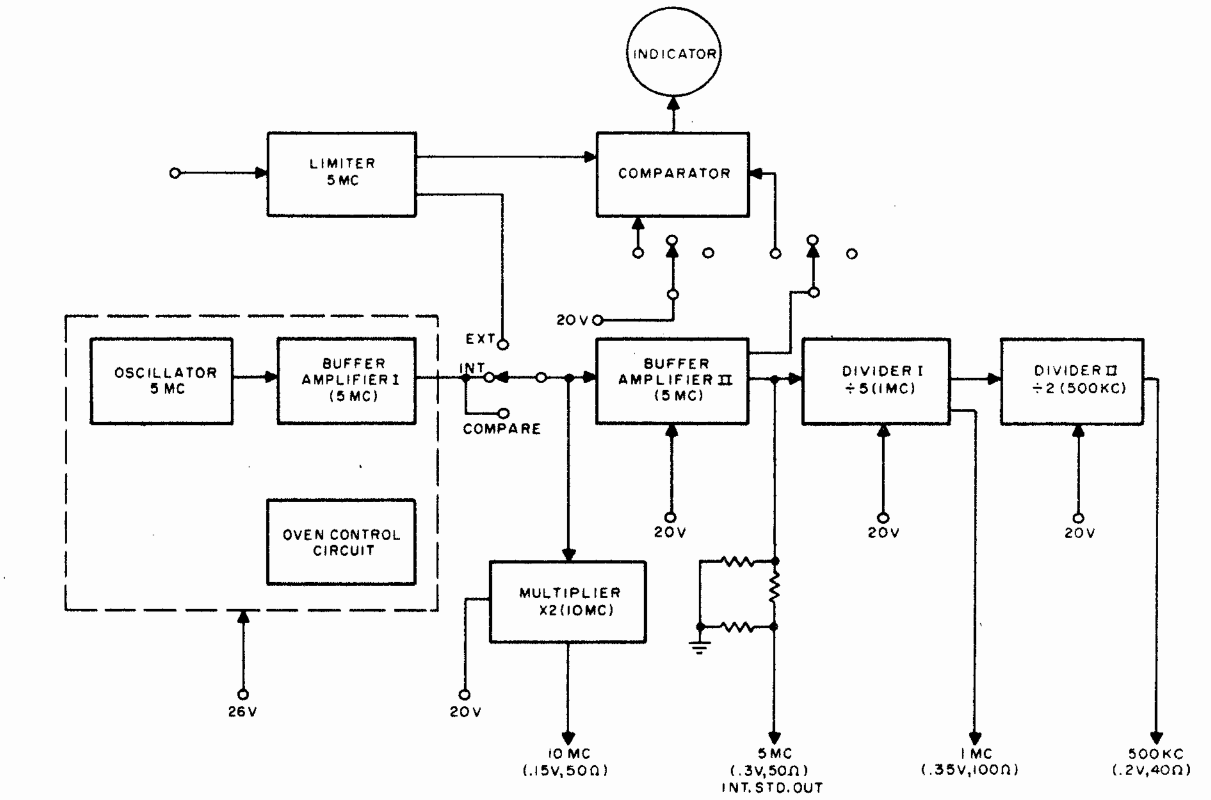


Figure 12. Frequency Standard Block Diagram

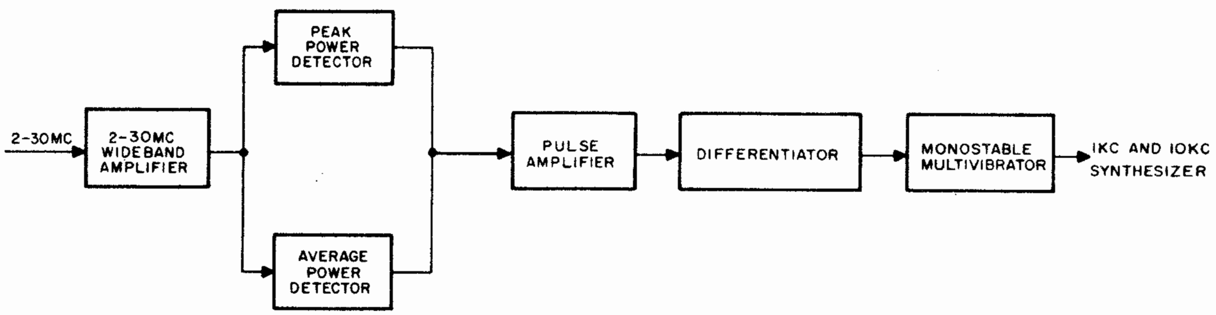


Figure 13. Noise Blanker Block Diagram

2.0 T-827/URT EXCITER

The T-827/URT is a single sideband exciter capable of operation in upper sideband, lower sideband, independent sideband, FSK, compatible AM (upper sideband plus carrier) and CW modes in the 2-30 megacycle range with a power output of 0.25 watt. Tuning is accomplished digitally in one kilocycle increments. The exciter is designed for use with any power amplifiers capable of supplying the required feedback power control to the exciter, such as the AM-3007/URT. Figure 14 is a photograph of the exciter and Figure 15 is a block diagram.

The exciter consists of a case, frame, front panel and seven plug-in electronic assemblies.

The case is similar to that described for the R-1051/URR receiver. The front panel and frame are assembled in a similar manner and perform similarly to the corresponding parts described for the R-1051/URR receiver. The 5-wire coded frequency information is made available externally for tuning a power amplifier as well as internally for indexing turrets.

The electronic assemblies used in the exciter are:

1. Transmitter Audio (2 required)
2. Exciter Mode Selector
3. Frequency Standard
4. Transmitter IF
5. Translator/Synthesizer
6. R. F. Amplifier

2.1 TRANSMITTER AUDIO

The Transmitter Audio electronic assemblies (shown in Figure 16) accomplish speech processing to furnish the modulator circuits with approximately constant level audio in spite of wide variations of input levels. The speech processing is done by a pair of varistors in a compressor circuit which maintains

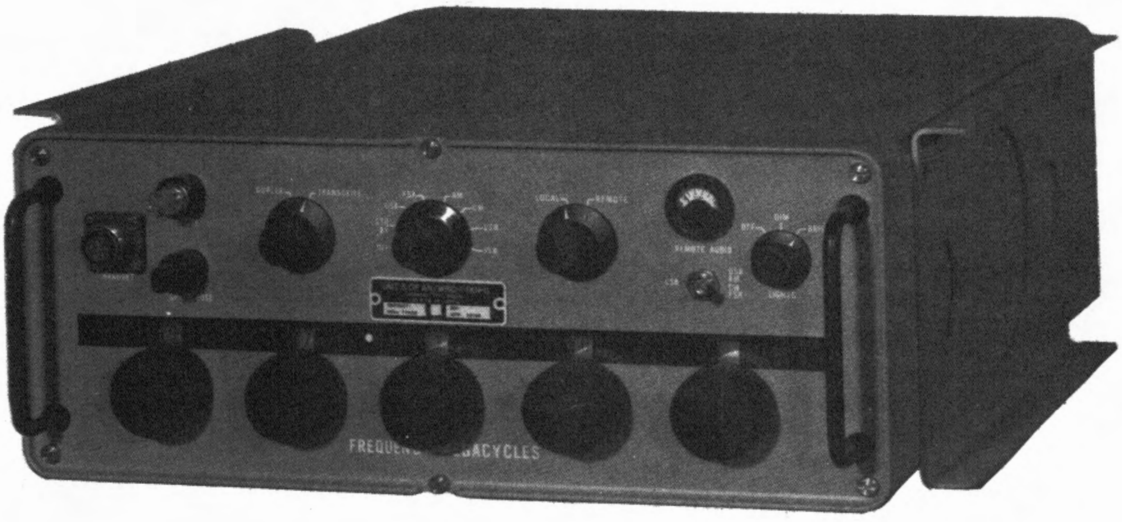


Figure 14. Exciter T-827/URT

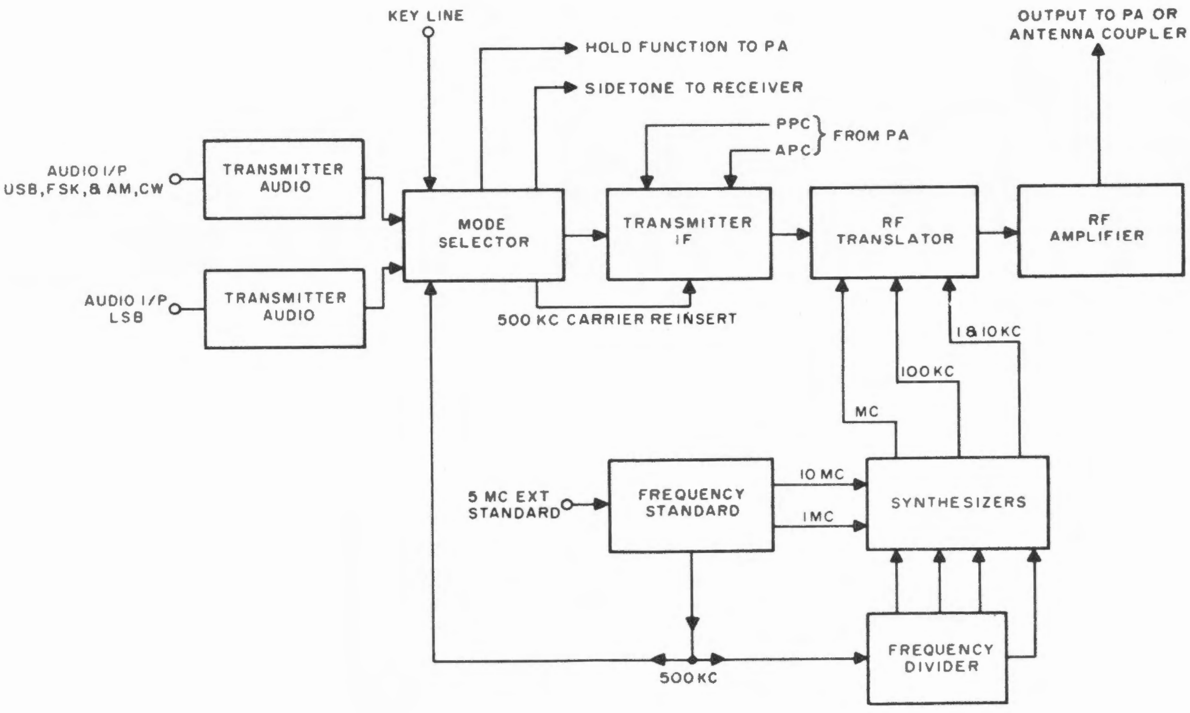
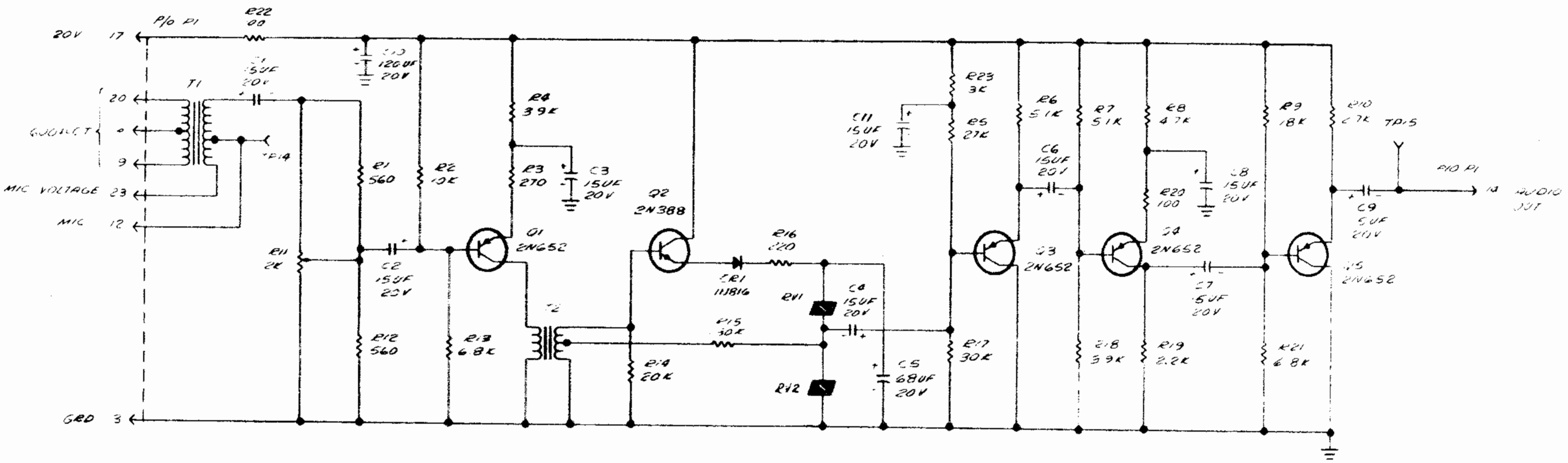


Figure 15. Exciter T-827/URT Block Diagram



NOTES

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX THE DESIGNATION WITH THE UNIT NUMBER OR ASSEMBLY DESIGNATION OR BOTH
2. UNLESS OTHERWISE SPECIFIED
   a. ALL RESISTORS ARE OHMS
   b. ALL RESISTORS ARE 1/4 W, 5%

Figure 16. Transmitter Audio Schematic

input constant with 20 db of input variation and keeps internal distortion below 1 percent. Two Transmitter Audio electronic assemblies are included to permit independent sideband operation.

2.2 EXCITER MODE SELECTOR

The Exciter Mode Selector electronic assembly (shown in Figure 17) performs modulation and sideband selection, as well as carrier reinsertion and various control functions. Two balanced modulators are used, each of which generates two sidebands but no carrier. The outputs from the modulators are fed to the upper sideband and lower sideband mechanical filters respectively, then mixed and fed to the transmitter IF electronic assembly. For single sideband or compatible AM operation, the other modulator is turned off. Diode gates are used to supply carrier reinjection to the transmitter IF in CW and AM modes, in the latter case the amount of injection being controlled by an internal potentiometer. Also within this assembly is the CW Hold circuit, which maintains the set in the transmit condition for about one second after the removal of a CW input and a pair of diode gates which provide sidetone for external monitoring.

2.3 FREQUENCY STANDARD

The Frequency Standard is identical to and directly interchangeable with the Frequency Standard used in the R-1051/URR Receiver, described in paragraph 2.17.

2.4 TRANSMITTER IF

The Transmitter IF electronic assembly (shown in Figure 18) is a variable gain 500 kc IF amplifier which accepts sideband signals and reinserted carriers from the Exciter Mode Selector, and which drives the Translator/Synthesizer electronic assembly. The gain of the Transmitter IF is controlled by the APC (Average Power Control) and PPC (Peak Power Control) signals developed in the power amplifier so that maximum power output will be maintained with minimum distortion.

2.5 TRANSLATOR/SYNTHESIZER

The Translator/Synthesizer electronic assembly is identical to and directly interchangeable with the Translator/Synthesizer used in the URC-35 Transceiver and the R-1051/URR Receiver described in paragraph 1.5.

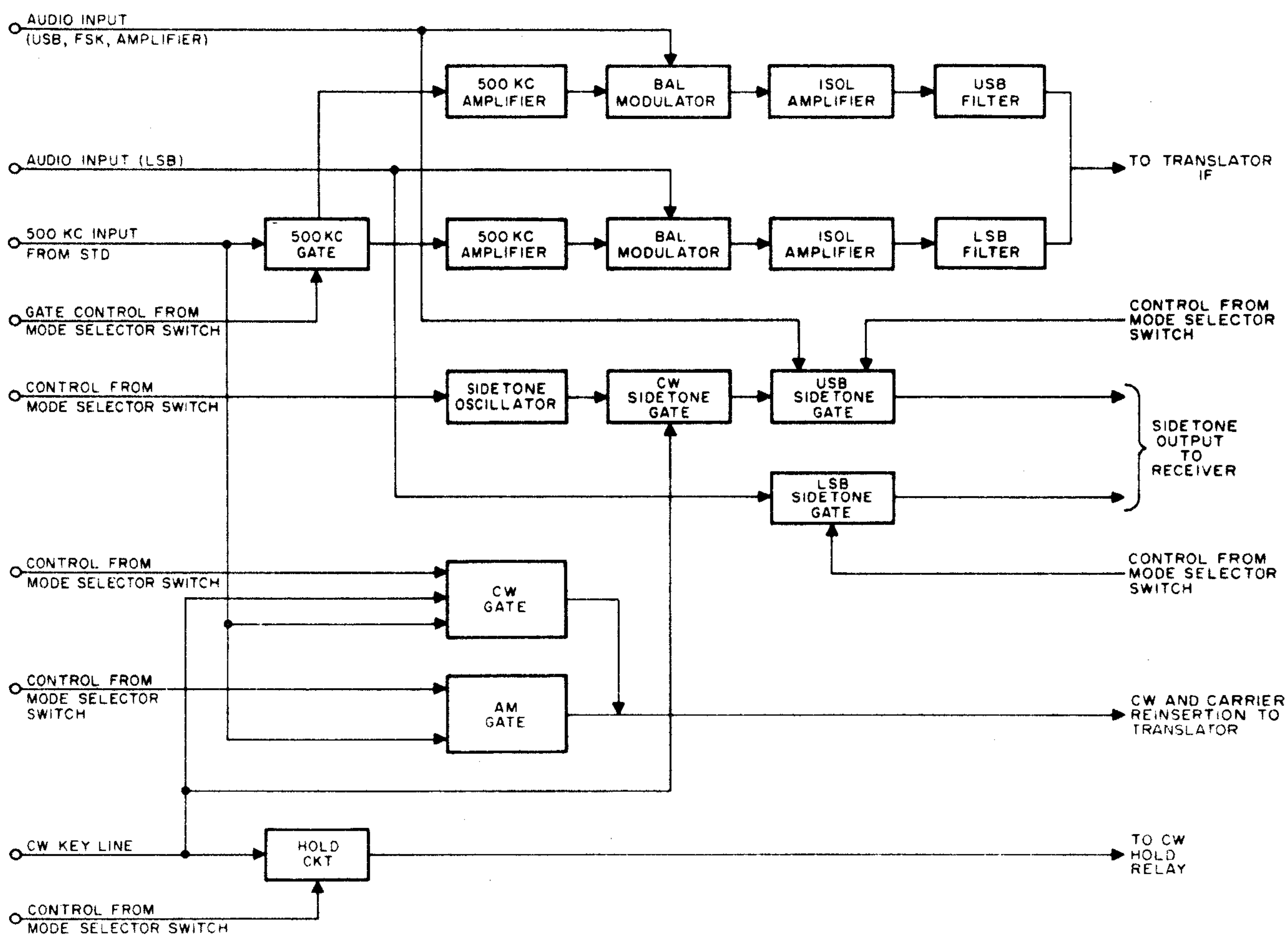


Figure 17. Exciter Mode Selector Block Diagram

2.6 RF AMPLIFIER

The exciter RF Amplifier electronic amplifier is in many respects like the RF Amplifier used in the R-1051/URR Receiver, described in paragraph 1.1. Significant differences are that the AGC amplifier is omitted, the last mixer of the Translator/Synthesizer is included within this assembly, and the gain is increased to produce power output of 0.25 watt.

3.0 AM-3007/URT POWER AMPLIFIER

The AM-3007/URT is a feedback-stabilized high frequency two-stage electron tube power amplifier which delivers 50 watts average power (100 W PEP) into 50 ohms with an input of 0.25 watts. Nineteen bands varying in width from 0.5 mc to 2.0 mc cover the range of 2-30 megacycles, the coils for these bands being carried in a motor-driven turret indexed according to frequency information supplied by the T-827/URT Exciter. No tracking or fine tuning within these nineteen bands is necessary. The input circuits are broadbanded in two bands, changing at 20 mc.

The AM-3007/URT Power Amplifier is composed mechanically of four units: 1.) a drawn aluminum case containing slides for the frame, a retractable cable, and input/output connectors, 2.) a front panel which forms a heat sink for the two electron tubes as well as supporting various meters and controls, 3.) a frame (which is rigidly attached to the front panel) which holds control circuits, power supplies, and indexing circuits for the turret, and 4.) the nineteen-position turret. Figure 19 is a photograph of the AM-3007/URT.

Among the controls on the front panel (as shown on Figure 20) is a group which is used in operating the Semi-Automatic Antenna Coupler (CU-937/UR). A forward power-reflected power meter driven by a VSWR detector in the Coupler is also included. Frequency information is available at one of the rear multipin connectors for connection to and operation of either the CU-937/UR or the

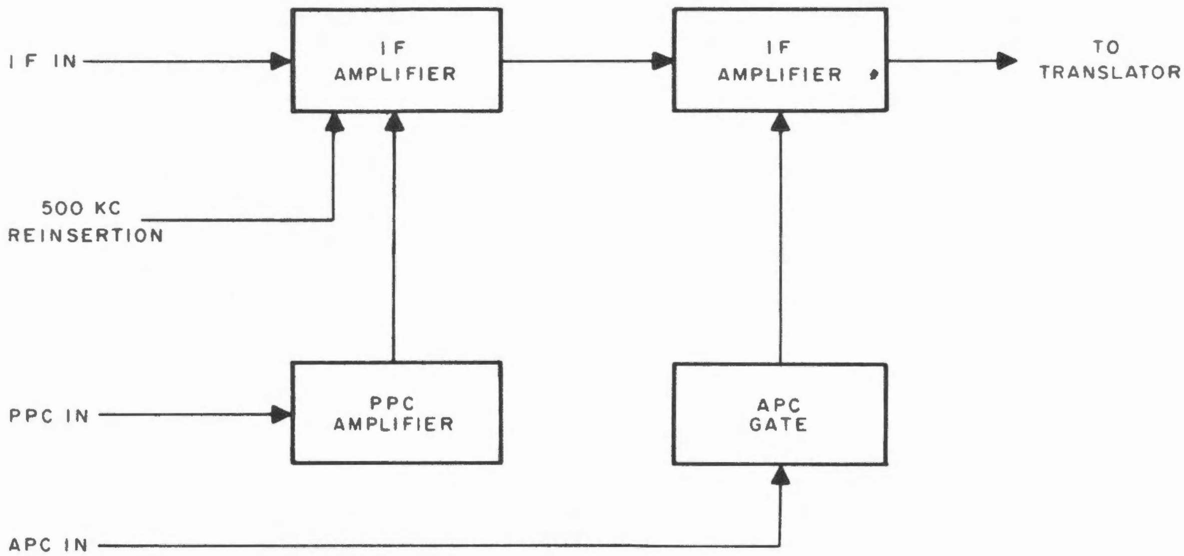


Figure 18. Transmitter IF Block Diagram

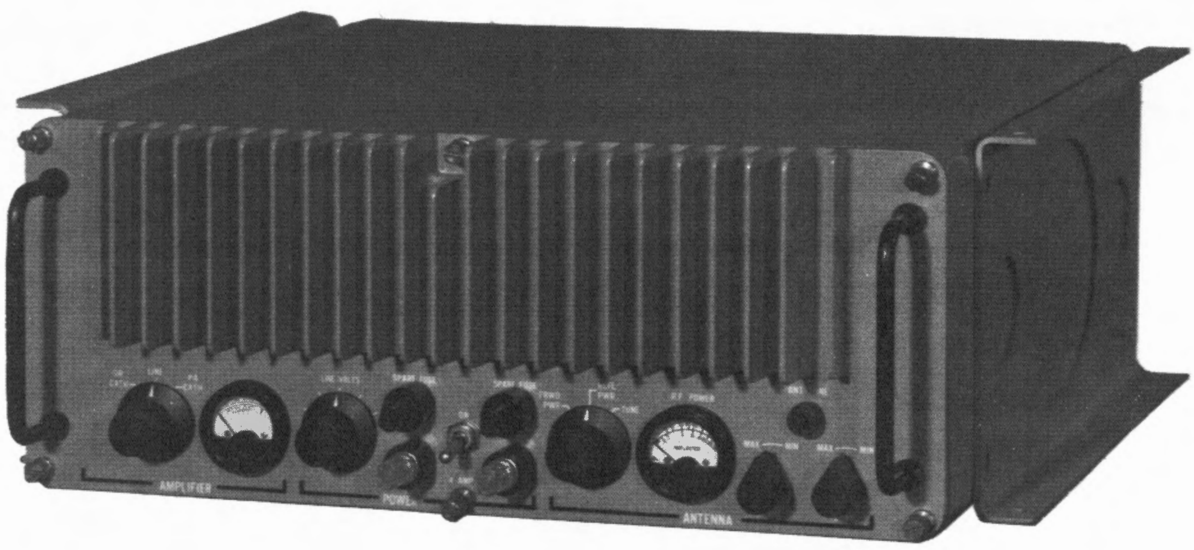


Figure 19. Power Amplifier AM-3007/URT

Automatic Antenna Tuner AN/URA-8, both of which are described in this report.

The power supplies in the AM-3007/URT power the entire Power Amplifier as well as the CU-937/UR Semi-Automatic Coupler and some of the control circuitry in other units of the AN/WRC-1 system.

Power level detection circuits are included in the AM-3007/URT to control the output level of the exciter unit and drive the power amplifier at maximum efficiency and minimum distortion. The Average Power Control (APC) system limits the output to 50 watts average whereas the Peak Power Control (PPC) system reduces peaks that would otherwise exceed 100 watts peak envelope power.

4.0 AN/WRC-1 RADIO SET

The AN/WRC-1 Radio Set is a high-frequency single sideband receiver-transmitter with 100 watts peak envelope power output. The set is intended for fixed shore or shipboard installation with either the AN/URA-38 Automatic Antenna Tuner or the CU-937/UR Semi-Automatic Antenna Tuner. Figure 21 is a photograph of the AN/WRC-1.

Operational simplicity has been stressed in the design; with the AN/URA-38 matching the antenna to the radio set, the entire system can be tuned up (in duplex operation, if desired, with receiver and exciter on different frequencies) in less than 20 seconds on any frequency in the operating range. No external frequency source is used in tuning, nor are any verniers or multiturn dials used. Tuning of the power amplifier and automatic antenna coupler is automatically controlled from the exciter frequency knobs.

Compatibility with other types of equipment has been assured by inclusion of AM, CW, and FSK modes as well as upper and lower sideband and ISB. Transmission and reception can be in different modes as well as on different frequencies.

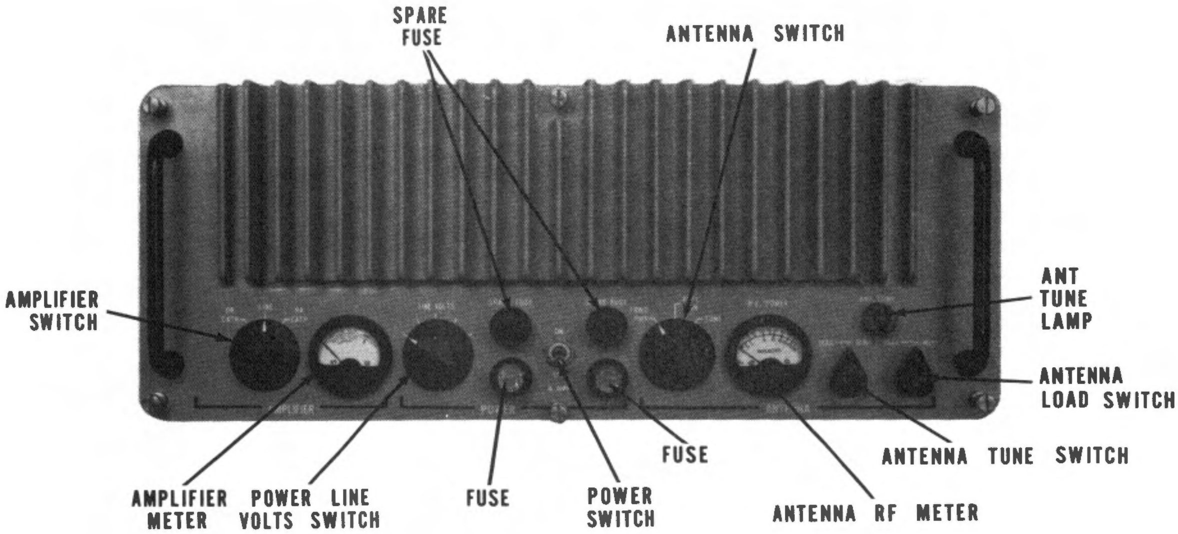


Figure 20. Power Amplifier AN-3007/URT, Front Panel

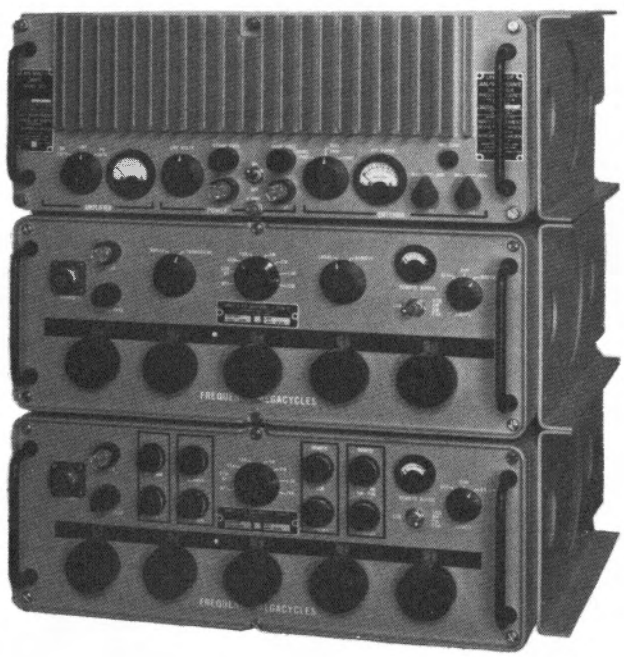


Figure 21. Radio Set AN/WRC-1 (XN-1)

5.0 RT-618/URC TRANSCEIVER

The RT-618/URC is a high-frequency transceiver intended primarily for mobile use. The 2 to 30 mc band is covered in 1 kc digitally, tuned steps, using the same techniques as previously discussed for the R-1051/URR Receiver and T-827/URT Exciter. The set is capable of operation in upper sideband, lower sideband and AM (compatible AM in the transmit mode). It is designed to operate with the AM-3008/URT Power Amplifier, from which it derives its operating voltages. Figure 22 is a photograph of the RT-618/URC Transceiver.

The Transceiver consists of a case, a chassis, a front panel and eight plug-in electronic assemblies:

1. RF Amplifier
2. Translator/Synthesizer
3. Transceiver Mode Selector
4. Receiver IF/Audio
5. Noise Blanker
6. Transmitter Audio
7. Transmitter IF
8. Frequency Standard

The case is of deep-drawn aluminum and supports tracks for the chassis as well as external input/output connectors, internal connectors and internal connectors which mate with the chassis. The chassis and front panel are rigidly mounted together and provide support for the various plug-in electronic assemblies, a low-voltage regulator and for the various controls and associated wiring. The chassis is supported by a pair of runners that bear on the tracks provided in the case. When the chassis, front panel and case are assembled together, the transceiver is completely sealed and will survive a 3-foot submersion. The front panel is provided with two handles, each of which is capable of supporting the entire weight of the chassis.

The RF Amplifier is similar to both RF Amplifiers already discussed for the Receiver and Exciter, the primary difference lying in its use in both receive and transmit. To this end, both the AGC circuit and the final (transmit) mixer of the Translator/Synthesizer are included in this assembly. The tuning method is identical to that previously discussed in paragraph 1.1.

The Translator/Synthesizer electronic assembly is identical to and directly interchangeable with that used in the R-1051 Receiver.

The Transceiver Mode Selector electronic assembly performs modulation in the transmit condition and sideband selection in both receive and transmit. Sideband selection is accomplished by the insertion of mechanical filters in the signal path, selectively switched in and out by diode gates. In addition, diode gate networks supply carrier reinsertion to the Transmitter IF module, 500 kc to the Receiver IF/Audio for the product detector and sidetone audio for monitoring transmissions.

The Receiver IF/Audio electronic assembly and Noise Blanker electronic assembly are identical to and directly interchangeable with that used in the R-1051 Receiver.

The Transmitter Audio, Transmitter IF and Frequency Standard electronic assemblies are identical to and directly interchangeable with their counterparts in the T-827 Exciter.

6.0 AM-3008/URT POWER AMPLIFIER

The AM-3008/URT is a feedback-stabilized high frequency two-stage electron tube power amplifier which delivers 50 watts average power (100 watts PEP) into 50 ohms with an input of 0.25 watts. Nineteen bands varying in width from 0.5 mc to 2.0 mc cover the range of 2 to 30 megacycles, the coils for these bands being carried in a motor-driven turret indexed according to frequency information supplied by the RT-618/URC Transceiver. No tracking or fine tuning within these nineteen bands is necessary. The input circuits are broadbanded in two bands, changing at 20 mc.

Figure 22. Transceiver RT-618/URC

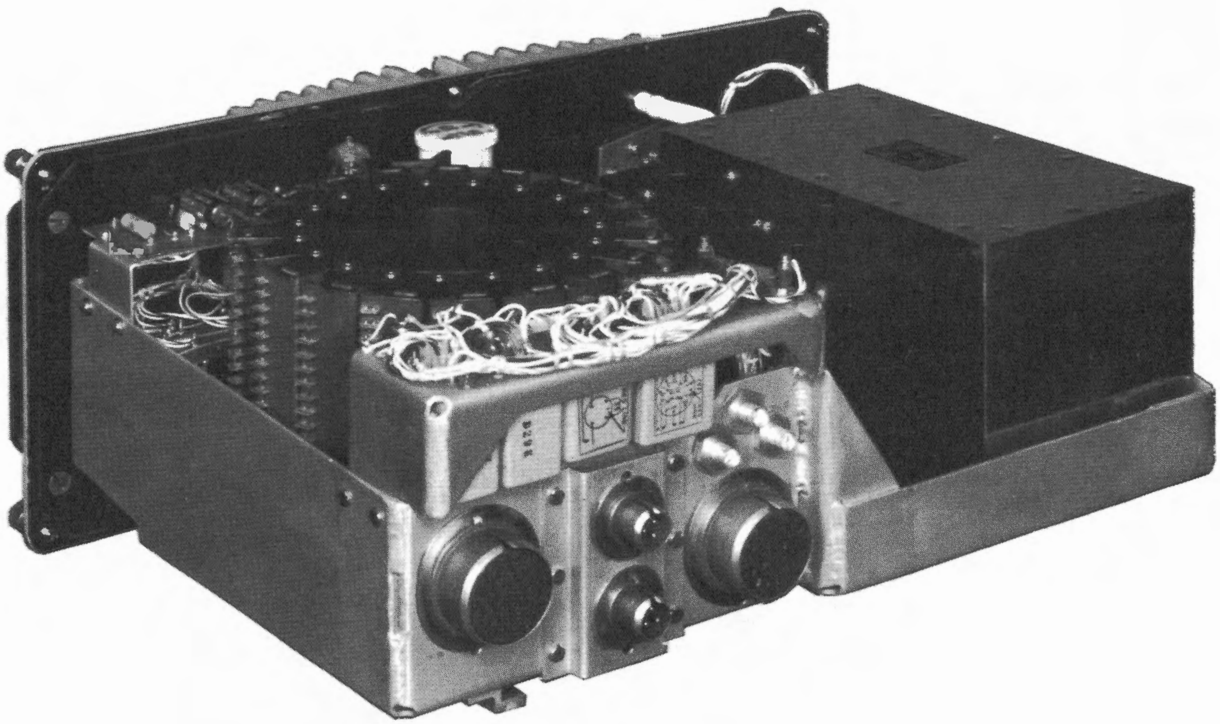


Figure 23. Power Amplifier AM-3008/URT

The AM-3008/URT Power Amplifier is composed mechanically of four units: (1) a drawn aluminum case containing slides for the amplifier assembly and mating input and output connectors on the inside rear of the case, (2) a front panel which forms a heat sink for the two electronic tubes as well as supporting various meters and controls, (3) a frame (which is rigidly attached to the front panel) which holds control circuits, DC power supplies, battery and indexing circuits for the turrets and (4) the nineteen-position turret. Figure 23 is a photograph of the rear of the AM-3008/URT Power Amplifier. The mating connectors as well as the nineteen-position turret and the DC battery are readily visible.

The basic circuits utilized in the AM-3008 are similar to those utilized in the AM-3007 Power Amplifier with the exception that a DC Power Supply and internal battery are utilized rather than an AC-DC Power Supply.

7.0 AN/URC-35 RADIO SET

The AN/URC-35 is a high frequency single sideband radio transceiver with 100 watts peak envelope power designed primarily for mobile and emergency use. It is powered from an external 24 VDC source, or in emergency use from a self-contained 24 V storage battery.

The AN/URC-35 consists of the following units:

1. RT-618/URC Transceiver
2. AM-3008/URT Power Amplifier
3. C-3697/URC Remote Control Unit
4. A-169/U Handset or M-109/U Microphone
5. AT-1047/U 15-foot fiberglass antenna

In view of its intended mobile use, a dash-mounted remote control unit with loudspeaker is supplied. Remote volume control, on-off switch and handset receptacle are also provided. Availability of upper sideband, lower sideband and AM permit communication with most existing HF radio sets. The radio set can be tuned within 20 seconds to any frequency within its normal operating range.

The AM-3008/URT Power Amplifier is basically the same as the AM-3007/URT already described, the principal difference lying in the use of a DC-DC converter which supplies all operating voltages for the radio set from a primary source of 24VDC. Located here also is the 24 V internal storage battery which will operate the set for about eight hours of intermittent use and a charging input for recharging the internal battery. The battery is supplied in a dry-charged state with a quantity of electrolyte to be added when battery operation is desired.

The CU-937/UR Semi-Automatic Antenna Tuner is normally used with the AN/URC-35 to provide a match between the power amplifier and the antenna.

8.0 CU-937/UR Semi-Automatic Antenna Coupler

The CU-937, shown in Figure 24, matches the 50-ohm output of a 100-watt PEP high frequency transmitter (capable of supplying the proper control functions) to either a 15, 25 or 35-foot whip antenna; in most cases, it is expected that a 15-foot whip will be used. The AM-3007/URT and AM-3008/URT Power Amplifiers are specifically designed to operate this coupler.

Tuning is accomplished in two stages. Upon receipt of frequency information from the power amplifier, the coupler will automatically insert series and/or shunt reactors in the antenna circuit, according to a program set up at the time of installation; it will also tune one of the variable coils to a previously established rough-tune position according to the same program. When rough tuning is completed, the operator can fine tune by using the controls on the front of the power amplifier to accurately position the loading and tuning coils. A reflected power meter, driven by a detector circuit within the coupler, is provided on the front of the power amplifier to indicate the tuned condition.

9.0 AN/URA-38 AUTOMATIC ANTENNA TUNER

The AN/URA-38 Antenna Tuner, (shown in Figure 25) was made by Remington Rand-Univac and is designed to provide a match between high frequency 100 W PEP transmitters such as the AM-3007/URT and 15, 25, or 35 foot whip antennas. The main features of this tuner are the ability to effect a rapid tune without operator intervention, and the ability to maintain a continuous match under conditions of varying antenna impedance such as might be encountered on aircraft carriers or on severely rolling ships.

The AN/URA-38 is composed of two sections: the control unit (C-3698/URA-38) is normally located atop the AN/WRC-1 radio set, while the coupler (CV-938/URA-38) mounts at the base of the antenna.

Tuning is accomplished in two stages. Upon receipt of frequency information from the Power Amplifier, the coupler will insert ahead of the antenna one of four series reactors, as dictated by the program set up at the time of installation. At the same time, the tuning and loading elements are run to their home positions of minimum reactance. Momentarily, keying the transmitter starts the tune sequence. The control unit will hold the key line down and cause a carrier to be provided for the tuner. The discriminators in the tuner will immediately sense a mismatch and cause the servos to drive the tuning elements toward a null. The control unit will release the key line as soon as a tune is reached and return control of the set to the operator; however, the discriminators are activated at all times during transmission, and if a mismatch is detected, it will be corrected immediately.

As a precaution against the effects of humidity, the tuner unit is sealed and charged with a slight overpressure of dry nitrogen.

Figure 24. Semi-Automatic Antenna Coupler CU-937/UR

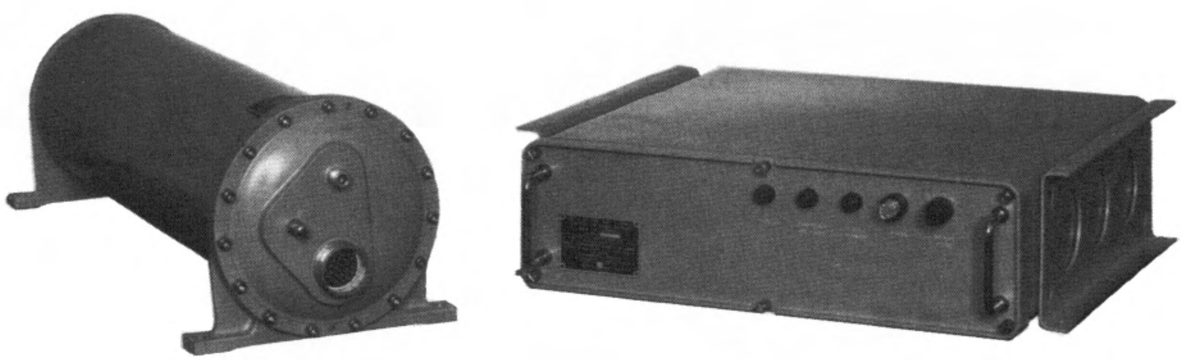


Figure 25. Antenna Tuner AN/URA-38

9.1 THE FOLLOWING IS THE FINAL REPORT FROM REMINGTON RAND UNIVAC

AN/WRC-1 Automatic Antenna Coupler
Final Report on Phase II

A. Summary

This report covers the period of work from the delivery of the experimental model antenna coupler in July 1960 through January 1962.

During this period, the development model, set of repair parts, data for the technical manual, set of installation drawings, and manuscript catalog sheets have been completed and shipped. In addition, an RRU sponsored production redesign program has been completed.

B. Development Model

1. Design Details

The development model was shipped to General Dynamics on February 8, 1961. The design details of this unit were as outlined in the report on Phase I, July 1, 1960 to September 30, 1960. The only additional problem encountered during the testing phase was that the servo motor brakes chattered when the unit was used with a 60 cps primary power source. Investigation disclosed that the chattering was due to the brake dropping out between power pulses of the full wave rectified AC. The problem was corrected by placing a 350 ohm resistor in parallel with the motor armature and in series with the brake.

2. Testing

Functional testing of the development model coupler was conducted with the transmitter at GD/E, Rochester, New York. Several minor compatibility problems were discovered and corrected. A high temperature test was conducted during which the coupler and transmitter were operated for six hours at a +65°C ambient, and a 100 watt PEP power level. Both units came through this test successfully.

Complete qualification testing was scheduled to be conducted at the Naval Electronics Lab, San Diego, California. In order to facilitate this testing, a dummy antenna simulating each of the three specified antennas, was shipped with the unit by RRU. As of the date of this report, no results of the qualification testing are available.

C. Documentation Requirements

1. Installation Drawings

Drawings were submitted on January 13, 1961 showing the overall dimensions and mounting information for the antenna coupler tuner and control. A revision of these two drawings was requested on November 1, 1961 by GD/E and the drawings have been revised and shipped.

2. Preliminary Data Sheets and Summary Bill of Materials

Two items, Electronic Equipment Preliminary Data Sheets per Navships 4457 and Summary Bill of Materials per Navships 4559, have been cancelled by GD/E since the required Navy Documents are not available.

3. Manuscript Catalog Sheets

One copy of Manuscript Catalog Sheets in accordance with the requirements of MIL-S-15822B was shipped on January 13, 1961.

4. Repair Parts

A set of repair parts for the development model was shipped on February 10, 1961.

5. Technical Manual

Complete draft material for use in preparing the technical manual was shipped on May 31, 1961.

6. Manufacturing Drawings

Two sets of manufacturing drawings per MIL-D-17419, type "D", (microfilm) were required by the purchase order. Submission of these drawings was held up until the microfilm job number was received from GD/E on November 1, 1961. Microfilm of the drawings was shipped in December 1961.

D. Production Redesign

A program to redesign the RRU 4000 series coupler was sponsored by Remington Rand Univac. The object of this program was to make the unit more suitable for quantity production. Under this program the following major items were accomplished:

1. SCR Amplifier Redesign

In the development model coupler, the discriminator outputs were amplified by separate "phase" and "R" amplifiers and were then used to operate sensitive relays. The sensitive relay contacts were used to provide a gate signal to fire the Silicon Controlled Rectifiers. This circuit was redesigned and repackaged into two identical modules, one for the "phase" and one for the "R".

With the redesigned circuitry the DC discriminator output signals are converted to AC by a diode chopper. The AC signal is then amplified and used to toggle a flip-flop circuit. The flip-flop output is converted to the SCR gate signal by a pulse transformer.

2. Molded Part Design

In the development model all of the parts constructed of insulating material were machined of silicone-glass laminate. These parts have all been redesigned to be molded from glass-reinforced diallyl phthalate and Mycalex.

3. General

All components and parts have undergone a design review. Each part has been evaluated by Design Engineering and Production Engineering to reduce cost and improve function.

Following the design review effort a value Engineering study was made. This study was made for the purpose of checking the design review.

Each of the above efforts disclosed some cost savings areas that have been incorporated in the design.

4. RRU Type Number Designation

Following is a cross reference between the GD/E designation and the RRU type number and drawing number for GD/E 909C series couplers:

GD/E Designation	RRU Group No.	RRU Type Number	Part Number	Schematic Number	Application
909C	4050A1	Tuner - 4000A1	243900	242550	WRC-1 Development
		Control - 4010A1	244100	242551	Model (100 Watt)
	4051B2	Tuner - 4001B2	24000	242571	WRC-1 Production
		Control - 4011A2	244300	242569	Model (100 Watt or 1 KW)

P. H. Richardson
Project Engineer
Communications Department

A. B. Sorensen
Supervising Engineer
Communications Department

E. M. Stryker
Manager
Communications Department

RECOMMENDATIONS

As in any development program the final results are achieved only after construction, test, redesign and further tests both operational and in the laboratory. Testing at NEL and by OPTEVFOR as well as final testing by the contractor has pointed out several weaknesses in the present design which should be investigated during the preproduction design phase.

Step AGC

The step AGC system provides distortion free gain control on SSB, AM and CW operation with rapid break-in capability. In the present design the AGC detectors respond to peak input and have extremely fast rise time. Should a noise pulse enter the AGC system it is detected and develops an AGC potential proportional to its amplitude, thus it desensitizes the receiver for the hang period of the AGC.

It is recommended that the rise time be decreased and the detector changed to give an average level dependent on the energy during a period of time equal to the rise time.

Noise Blanker

An RF noise limiter was included in the Service test models of the R1051 and RT-618/URC to remove impulse noise prior to the selective IF filters. Laboratory tests of the noise blanker showed it to be highly effective on repetative noise pulses. Field testing in the presence of complex noise has indicated that the noise blanker is inadequate. For this reason, it is being removed as directed by NEL.

It is felt that further study should be performed to give a quantitative indication of circuit performance in the presence of complex noise such that improvements could be incorporated. The need for a noise blanker in the HF region is still present since noise ringing of the narrow IF filter could completely cover a desired signal.

Squelch Circuitry

It has been recommended that a signal to noise type of squelch circuit be incorporated in the receiver to remove noise output between periods of intelligence.

Synthesizer Changes

A. General Dynamics has conducted further company-sponsored work on the frequency synthesizer. This work combined with test results from NEL have pointed out several areas where internal spurious frequencies can be reduced. These changes will of course be incorporated in future units.

B. The necessity for vernier frequency control of the receiver when working with less stable transmitters has been recognized in field tests. It is recommended that an additional frequency control be incorporated to permit continuous tuning between 1 KC increments.

C. It has been recommended that tuning increments of both the receiver and transmitter be reduced to .5 KC.

Average Power Control

General Dynamics/Electronics sponsored study and testing of the average power control system used in the WRC-1 and URC-35 has shown that a major system modification would be advantageous. The APC presently maintains the power output of the transmitter at a constant level independent of changes of gain within the system. This is accomplished by changing the gain of the transmit IF amplifier and thus varying its output. By this method of control the signal level through the frequency translator is varied from about 12 MV per tone to below .5 MV per tone. Since the spurious level in the translator and the carrier leakage and noise are at a fixed value, the ratio of spurious to desired is changed with APC setting. To correct this fault it is recommended that the level to the translator be maintained at the maximum consistent with cross modulation requirements and gain control be accomplished by varying the injection level into the final mixer. By this method the spurious will always be as low as possible independent of gain.

RFI Protection

Increased RFI protection should be incorporated into all units where space permits.

In particular, the DC to DC converter of the URC-35 should be reworked to reduce the radiated noise such that operation is possible in close proximity to the antenna.

RF Amplifier Module Modifications

Study of the mechanical design of the RF amplifier used in the receiver, exciter and transceiver has been carried on by GD/E. A new layout providing increased shielding and reduced lead length has been devised. The changes reduce receiver leakage and regeneration as well as intermodulation in the exciter.

FFK Adapters

Additional work should be done on the FSK keyer to permit operation on 2550 cps ±425 cps.

Battery Charger

No battery charger has been developed for the URC-35.

CONCLUSIONS

The AN/WRC-1 and AN/URC-35 development programs have produced a pair of versatile HF communications sets. These rugged sets are very compact, yet they achieve a new ease of operation.

The reliability of the sets is due chiefly to the almost exclusive use of semiconductors. The inherent low sensitivity of solid state circuitry to damage from shock and vibration is used to good advantage, permitting small, rugged plug-in modular construction. The extremely low heat dissipation obviates the necessity of cooling fans, permitting all the units to be completely sealed against the outside atmosphere. In the power amplifiers, the heat from the vacuum tubes is drawn into a large heat sink cast integrally with a finned radiator on the front panel.

Simplicity of operation has been an important consideration from the outset. The digital tuning scheme has made it possible to tune the entire AN/WRC-1 system to any frequency within its operating range within 20 seconds. Perhaps more important than tuning speed, however, is the accuracy of the frequency control system and the ease with which the operator can select a frequency. The operator has only to turn five detented knobs so as to display the desired frequency in corresponding windows. No fine tuning is necessary, no meter dipping, no crank spinning, no bandswitching; there are no multiturn controls whatever in either radio set. The digital readout eliminates interpolation on "slide-rule" dials as well as any errors of parallax. Also, the operating frequency can be read in a single glance, without having to add up mentally the indications of several counters. All operating frequencies are locked to the intimal frequency standards and have proportional accuracy and stability.

The use of broadband coils in the power amplifiers permits automatic tuning simultaneous with the tuning of the exciter or transceiver.

Form types of automatic gain control are used in various parts of the radio sets. While their inclusion greatly reduces the number of controls the operator must contend with, they are provided primarily to maintain operation constantly at optimum levels. Audio compression in the transmit mode reduces the effects of differences in speech loudness among operators, while average and peak power control circuits (APC and PPC) act to maintain maximum power output commensurate with good distortion characteristics. A wide range AGC system in the receive mode makes possible reception of a 120 db range of input signals; the step AGC system has been shown to reduce distortion and hence improve intelligibility of SSB signals.

As an added aid to maintaining constant, effective communications, the Automatic Antenna Coupler (AN/URA-38) will automatically correct for changes in antenna characteristics that may occur during transmission.

The cost of the radio set has been kept to a minimum through the use of interchangeable modules. The same frequency standard is used in the receiver, exciter, and transceiver; the translator/synthesizer is also used in all three units, due to its ability to handle signals in either direction. Most of the remaining modules in the transceiver are identical to their respective counterparts in the receiver and exciter. The extensive use of interchangeable modules not only reduces production costs but also reduces the number of spares that must be kept at a repair facility.

The AN/WRC-1 and AN/URC-35 development program has produced a family of HF Single Sideband equipment which is advanced to the state of the art. This has been possible by integrated design, testing and fabrication on an accelerated cycle of only 26 months from award of contract to final delivery of service test models. The program should set a precedent in contract management which, although not flawless, can be used as guidance in future contracts.

The family of equipment is basically sound and could be produced, with limited redesign, within a few months of completion of the development contract.

Future savings, both operationally and logistically, should be achieved through the use of common modules throughout the family. Further to this, it has already been shown that the family can be expanded to the 1 KW and 5 KW level of power output without a large expenditure of time or money and without modification of the existing equipment.