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HANDBOOK OF OPERATING AND MAINTENANCE INSTRUCTIONS

for

TS-148/UP TEST EQUIPMENT SPECTRUM ANALYZER

CONFIDENTIAL

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FAILURE REPORT

FOR U. S. ARMY AIR FORCE PERSONNEL

In the event of malfunctioning, unsatisfactory design or unsatisfactory installation of any of the component units of this equipment, or if the material contained in this book is considered inadequate or erroneous, an unsatisfactory report, AAF Form No. 54 or a report in similar form shall be submitted in accordance with the provisions of Army Air Force Regulation No. 15-54, listing:

1. Station and organization.
2. Nameplate data (type number or complete nomenclature if nameplate is not attached to the equipment).
3. Date and nature of failure.
4. Airplane model and serial number.
5. Remedy used or proposed to prevent recurrence.
6. Handbook errors or inadequacies, if applicable.

FOR U. S. NAVY PERSONNEL

Report of failure of any part of this equipment during its guaranteed life shall be made on Form N. Aer. 4112 "Report of Unsatisfactory or Defective Material" or a report in similar form and forwarded in accordance with the latest instruction of the Bureau of Aeronautics. In addition to other distribution required, one copy shall be furnished to the Resident Inspector of Naval Material, 2519 Wilkens Ave., Baltimore, Md., and the Bureau of Ships.

Such reports of failure shall include:

1. Reporting activity.
2. Nameplate data.
3. Date placed in service.
4. Part which failed.
5. Nature and cause of failure.
6. Replacement needed (Yes or No).
7. Remedy used or proposal to prevent recurrence.

FOR BRITISH PERSONNEL

Form 1022 procedure shall be used when reporting failure of radio equipment.

DESTRUCTION OF ABANDONED MATERIAL IN THE COMBAT ZONE

In case it should become necessary to prevent the capture of this equipment and when ordered to do so by proper authorities, DESTROY IT SO THAT NO PART OF IT CAN BE SALVAGED, RECOGNIZED OR USED BY THE ENEMY. BURN ALL PAPERS AND BOOKS.

Means:—

1. Explosives, when provided.
2. Hammers, axes, sledges, machetes, or whatever heavy objects are readily available.
3. Burning by means of incendiaries such as gasoline, oil, paper, or wood.
4. Grenades and shots from available arms.
5. Burying all debris or disposing of it in streams or other bodies of water, where possible and when time permits.

Procedure:—

1. Obliterate all identifying marks. Destroy nameplates and circuit labels.
2. Demolish all panels, castings, switch and instrument boards.
3. Destroy all controls, switches, relays, connections, and meters.
4. Rip out all wiring and cut interconnections of electrical equipment. smash gas, oil and watercooling systems in gas-engine generators, etc.
5. Smash every electrical or mechanical part, whether rotating, moving, or fixed.
6. Break up all operating instruments such as keys, phones, microphones, etc.
7. Destroy all classes of carrying cases, straps, containers, etc.
8. Bury or scatter all debris.

DESTROY EVERYTHING!

WARNING!

DO NOT OPERATE THE EQUIPMENT IF THE SUPPLY VOLTAGE CANNOT BE KEPT BETWEEN 105 AND 125 VOLTS. IF THE VOLTAGE APPROACHES 105 OR 125 VOLTS, BE READY TO TURN EQUIPMENT OFF. OPERATING THE EQUIPMENT ON VOLTAGES BELOW 105 OR ABOVE 125 VOLTS MAY DAMAGE CIRCUITS AND TUBES AND RENDER THE EQUIPMENT INOPERATIVE.

SAFETY NOTICE

WARNING - 2000 VOLTS

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES THAT ARE DANGEROUS TO LIFE. OPERATING PERSONNEL MUST AT ALL TIMES OBSERVE ALL SAFETY REGULATIONS. DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE THE EQUIPMENT WITH THE HIGH VOLTAGE SUPPLY ON. VOLTAGES UP TO 2000 VOLTS ARE PRESENT ON MANY POINTS INSIDE THE EQUIPMENT. DO NOT DEPEND UPON SWITCHES FOR PROTECTION BUT ALWAYS SHUT DOWN MAIN POWER SUPPLY, OR PULL OUT POWER CABLE FROM SUPPLY LINE CONNECTOR. DANGEROUS POTENTIALS MAY EXIST IN CIRCUITS WITH POWER OFF, BECAUSE OF CHARGES RETAINED BY CAPACITORS. TO AVOID CASUALTIES ALWAYS DISCHARGE AND GROUND CIRCUITS BEFORE TOUCHING THEM.

CONTRACTUAL GUARANTEE

The equipment, including all parts and spare parts except vacuum tubes, is guaranteed for a service period of one year with the understanding that, as a condition of this contract, all items found to be defective as to design, material, workmanship or manufacure will be replaced without delay and at no expense to the Government provided that such guarantee and agreement will not obligate the contractor to make replacement of defective material unless the failure, exclusive of normal shelf life deterioration, occurs within a period of two years from the date of delivery of the equipment to and acceptance by the Government, and provided further that if any part or parts (except vacuum tubes) fail in service or are found defective in 10 per cent or more of the total number of equipments furnished under the contract, such part or parts, whether supplied in the equipment or as spares, shall be conclusively presumed to be of defective design, and as a condition of contract subject to 100 per cent replacement of all similar units supplied on subject contract by suitable redesigned replacements. Failure due to poor workmanship, while not necessarily indicating poor design, will be considered in the same category as failure due to poor design. Redesigned replacements which will assure proper operation of the equipment will be supplied promptly, transportation paid, to the Naval activities using such equipment, upon receipt of proper notice and without cost to the Government. All defective parts originally furnished under contract shall be held subject to rejection and return to the contractor.

This period of two years and the service period of one year will not include any portion of the time that the equipment fails to give satisfactory performance due to defective items and the necessity for replacement thereof, and provided further, that any replacement part will be guaranteed to give one year of satisfactory service.

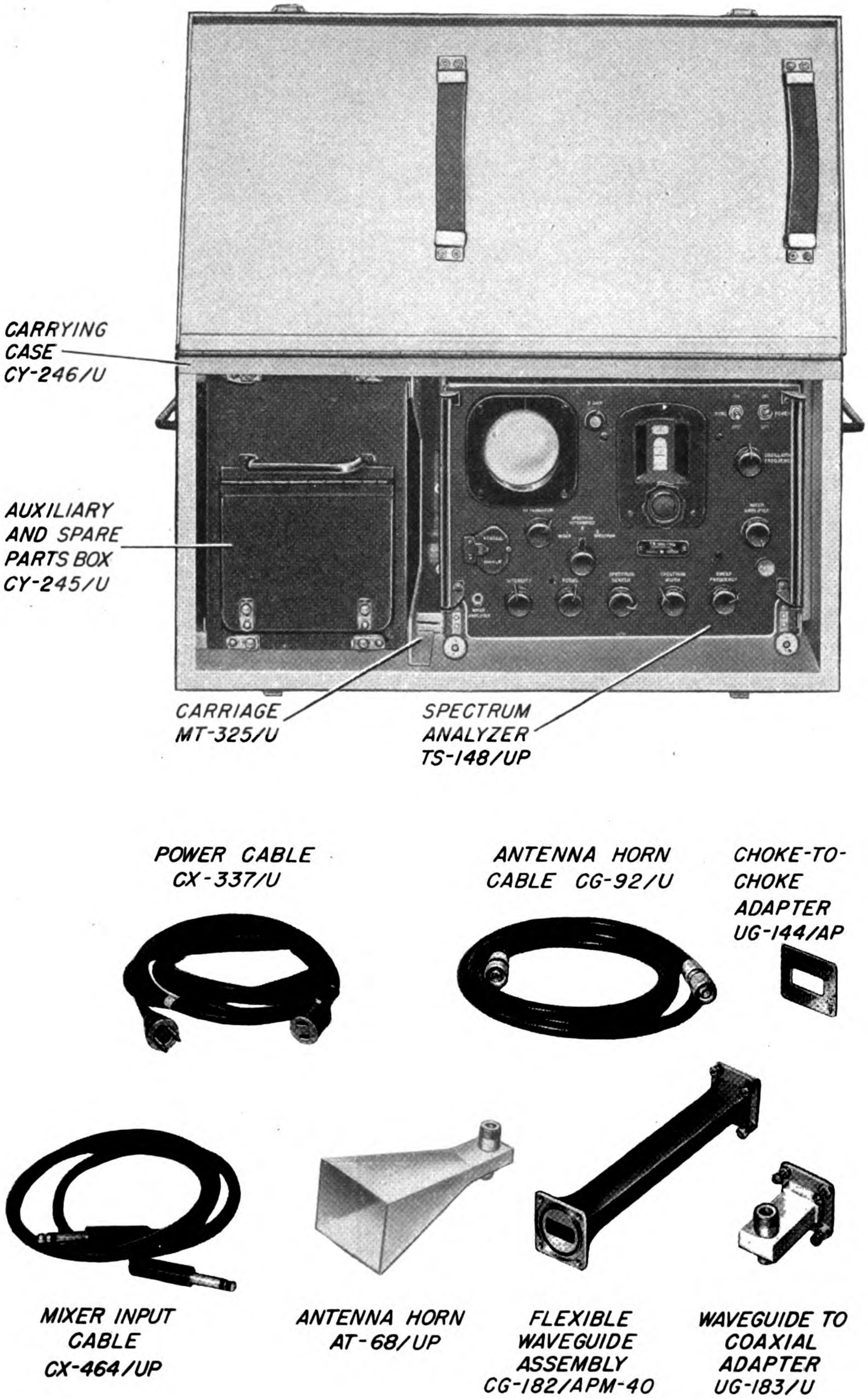


Figure 1-1. Spectrum Analyzer, Cables and Auxiliary Parts

SECTION I
GENERAL DESCRIPTION OF TEST EQUIPMENT TS-148/UP SPECTRUM ANALYZER

1. GENERAL INFORMATION.

a. PURPOSE.

(1) The TS-148/UP Spectrum Analyzer is test equipment designed specifically for use with aircraft radar and beacon equipment operating over a frequency range of 8470 to 9630 mc/s.

(2) The Spectrum Analyzer provides a visual indication of the spectra of radio frequency oscillators within its range. It incorporates a frequency meter which permits it to be used as a frequency measuring device. The Spectrum Analyzer may also be used to measure the frequencies of resonant cavities, echo boxes, magnetrons, and local oscillators, if their frequency lies within the range of the Analyzer.

(3) The instructions in this handbook describe the procedures for the installation, operation, adjustment, and maintenance of the equipment. A section is included that describes the theory of operation of the Analyzer, for the information and guidance of personnel using the equipment.

(4) The TS-148/UP Test Equipment is the first production unit of its type. Therefore the information in this handbook does not alter or supersede any previous instructions issued to the Armed Forces.

2. EQUIPMENT SUPPLIED.

a. The major operating components of the equipment are listed below, and illustrated in Figs. 1-1 and 1-2. Table I, in this section, lists the equipment supplied by the manufacturer, together with the weights and dimensions of the various items.

TABLE I

Qty. per Equip.	Name of Unit	Army-Navy Type Designation	Overall Dimensions	Weights Pounds	Numerical Series of Reference Symbols
1	Spectrum Analyzer	TS-148/UP	9"x13"x14"	38	100-199
1	Wave-guide to Coaxial Adapter	UG-183/U	2½"x1"x1½"	—	
1	Antenna Horn	AT-68/UP	3 21/64"x1 3/64"x2 13/16"	4 oz.	
1	Antenna Horn Cable	CG-92/U	6 ft. long	1	
1	Mixer Cable, Type SJ PL-55 Telephone Plugs Attached	CX-464/UP	4 ft. long	2 oz.	
1	Power Cable	CX-337/U	6 ft. long	½	
1	Flexible Wave-guide Assembly	CG-182/APM-40	15" long	¼	
1	Auxiliary—Spare Parts Box	CY-245/U	17 29/32"x7¼"x10 1/16"	6	
1	Carriage, Shock Absorbing	MT-325/U	16 11/32"x13¾"x11 11/16"	26½ (with Carrying Case)	
1	Carrying Case	CY-246/U	25 9/16"x19"x13½"		
1	Choke-to-Choke Adapter	UG-144/AP		4 oz.	
1	Allen Wrench for #8 Set Screw			—	
1	Allen Wrench for #6 Set Screw			—	
1	Allen Wrench for #4 Set Screw			—	
1	Tuning Wrench	—	2 9/16"x⅛"	—	

TABLE II

Qty. per Equip.	Name of Unit	Army-Navy Type Designation	Required Characteristics
1	Directional Coupler (Waveguide Selector)	CG-176/AP	Directional One Per Cent Waveguide Coupling

3. EQUIPMENT NOT SUPPLIED.

a. The equipment listed in Table II is illustrated in Fig. 5-3. It is required only when extremely stable coupling is necessary.

4. PHYSICAL DESCRIPTION.

a. SPECTRUM ANALYZER.

(1) The Test Equipment TS-148/UP is illustrated in Fig. 1-1. The Spectrum Analyzer is a self-contained unit, built into a sheet aluminum housing. Two handles are provided on the control panel to facilitate its removal from the Carrying Case. The electrical components are built on an aluminum chassis located inside the removable dust cover. The Analyzer is transported with the Auxiliary and Spare Parts Box in a Carrying Case. It is secured in the Carrying Case with two thumb-screws. The bezel on the cathode-ray tube is equipped with supporting pins upon which a light shield from an AN/APS-6 equipment may be mounted.

b. ASSOCIATED EQUIPMENT.

(1) The Carrying Case is made of sheet aluminum and is finished with grey paint. The lid has a piano type hinge and is secured with two trunk fasteners. The Carrying Case is shown in Fig. 1-1. It is arranged so that the Analyzer may be operated without removing it from the Carrying Case if the Auxiliary and Spare Parts Box has been removed.

(2) The Carriage is used to provide a shock-mounting for the Analyzer, in or out of the Carrying Case. It is fabricated from light gauge channeled aluminum with rubber cushions placed between the Analyzer and the Carrying Case. These cushions are secured to the Carriage frame. The Carriage can be removed from the Carrying Case if it is necessary to provide a shock-mounting for the Spectrum Analyzer when it is used outside of the Carrying Case. The cushions must be removed from the Carriage in order to free it from the Carrying Case. They are replaced after the Carriage has been removed.

(3) The Auxiliary and Spare Parts Box is illustrated in Fig. 1-2. This box is packed in the Carrying Case beside the Analyzer. It is held in place with four snap fasteners. The front panel has a handle to facilitate its removal from the Carrying Case. The box is made of sheet aluminum and is provided with two access doors. One door is located on the front below the carrying handle. The other door is located on top of the box.

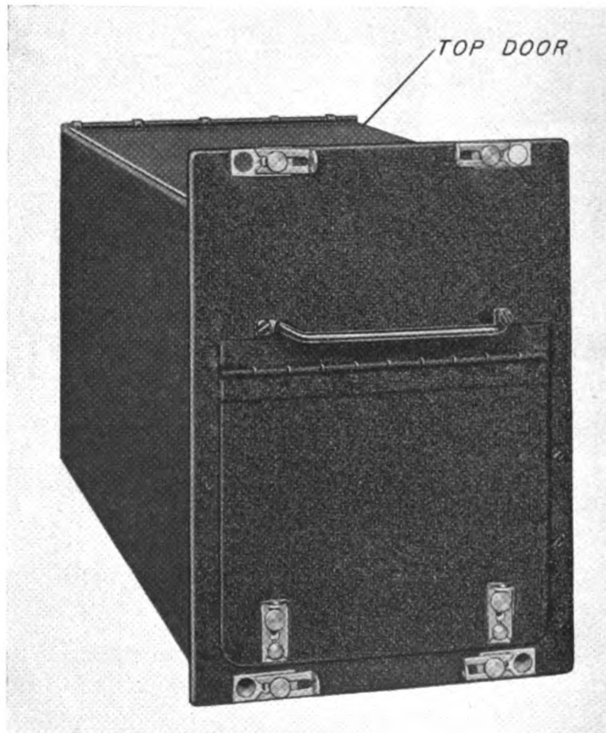


Figure 1-2. Spectrum Analyzer, Auxiliary and Spare Parts Box

5. ELECTRICAL DESCRIPTION.

a. Test Equipment TS-148/UP is a self-contained portable spectrum analyzer. It is a very sensitive micro-wave receiver whose output is displayed on a cathode-ray tube. The Analyzer has a frequency meter which is calibrated to read directly in megacycles, a frequency-swept r-f oscillator, a crystal mixer and associated plumbing, narrow band i-f amplifiers, an oscilloscope tube, and the necessary power supplies.

b. The Spectrum Analyzer resolves an r-f signal into its frequency components and displays the results on an oscilloscope screen so as to show amplitude plotted against frequency. The relative position of each pip (which represents a frequency component), with respect to the sweep, indicates its frequency. The height of the pip represents its contribution in power to the total power of the r-f signal under test.

6. APPLICATION.

a. GENERAL.

(1) The Spectrum Analyzer is easy to use because it is so sensitive that the magnetron signal can usually be picked up at some distance from the source, without the use of connecting cables. This feature permits observations to be made on the bench, in the plane, on the carrier deck, hangar apron, or wherever necessary.

b. SPECTRUM ANALYZER AS A FREQUENCY METER.

(1) Spectrum Analyzer TS-148/UP can be used to visually examine the spectra of magnetrons, local oscillators, test sets, and other equipment operating within its frequency range. The frequency meter in the Spectrum Analyzer may be used to measure accurately the frequencies of any of the above, or to set the frequency of radar and beacon local oscillators in radar sets.

c. FREQUENCY-MODULATED OSCILLATOR.

(1) The Spectrum Analyzer can also be used as a frequency-modulated oscillator to tune T/R Boxes and R/T (anti-T/R) Boxes in transmitter-converters. It can be used to check magnetron pulling and AFC circuits. If the resonant frequency of any component (such as an echo box) lies within the frequency range of the Analyzer, it can be easily and accurately checked.

7. GENERAL CHARACTERISTICS.

a. The general operating characteristics of the Spectrum Analyzer are listed in Table III.

TABLE III

Power Supply	50-1200 Cps; 105-125 Volts; 125 Watts.
Tuning Range	Limited by local oscillator. The range varies with different Type 2K25 tubes.
Frequency-meter Range	Calibrated directly from 8470 mc/s to 9630 mc/s.
Sweep Frequencies	Continuously Variable from 10 to 20 Cps.
Attentuation (Spectrum Amplitude)	Uncalibrated. Variable from 3 to 70 db.
Operating Temperature Range	−40°C. to +55°C.
Frequency swing of analyzer r-f oscillator (sawtooth FM)	40 to 50 mc/s.
Overall i-f bandwidth at half power points	50 kc/s.
Sensitivity to CW	90 db. below 1 watt (10^{-9} watts or .001 microwatt).
Indicator	Cathode ray tube.
Maximum dispersion of spectra	1.5 mc/s per inch.
Power output	Approximately 1 milliwatt.
Tube Complement	See Page 5-1

SECTION II
OPERATION AND ADJUSTMENT

WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. PERSONNEL MUST OBSERVE ALL SAFETY REGULATIONS AT ALL TIMES.

1. INSTALLATION.

a. The Spectrum Analyzer should be removed from its carriage and carefully inspected for broken or damaged parts before any attempt is made to put it into operation. As stated in Section I, Par. 4, the Analyzer may be used in or out of the Carrying Case. If it is to be used in the Carrying Case, remove the Auxiliary and Spare Parts Box. Open the door that allows access to the r-f plumbing, and the a-c power receptacle. This door is shown in Fig. 2-1. Insert the connector on the power cord into the power socket. Then insert the power cord plug into a 105-125 volt, 50-1200 cps a-c source.

b. The carriage can be removed from the Carrying Case if shock-mounting is desired when the equipment is to be used outside the Carrying Case.

c. The flexible wave guide is fastened to the Type UG-40/U Choke flange on the plumbing of the Analyzer by means of four captive screws in the flange of the wave guide. The Antenna Horn is connected to the Analyzer through the coaxial cable and the coaxial cable-to-wave guide adapter. See Fig. 7-4. Four captive screws in the flange of the Adapter are used to secure it to the plumbing. Other methods of coupling are shown in Figs. 7-5 and 7-6.

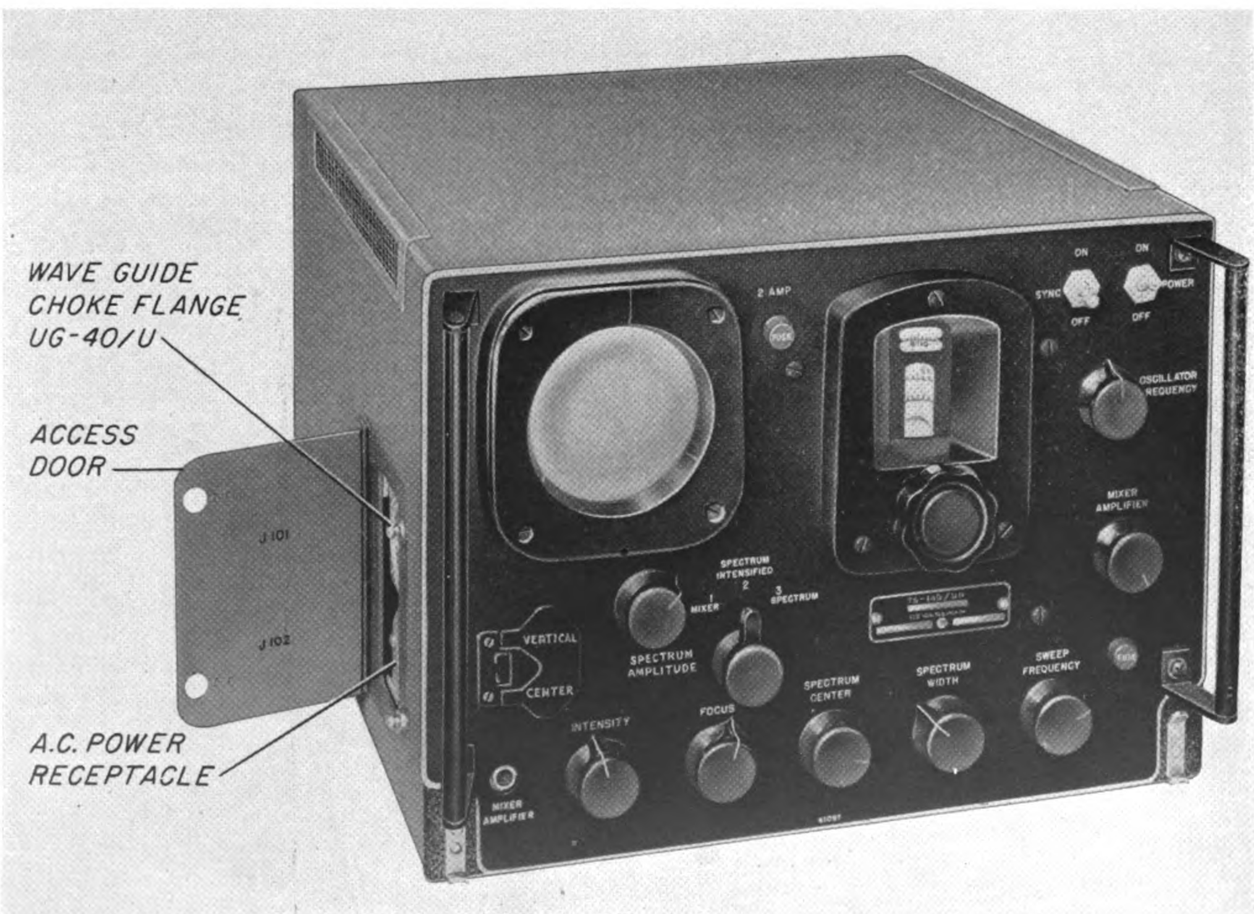


Figure 2-1. Spectrum Analyzer, Control Panel

2. PRE-OPERATION CHECK.

a. GENERAL.

(1) The test in Par. 2*c* of this section may be performed by personnel in charge of test equipment before the Analyzer is issued for use. The user may omit this test if there is definite assurance that it has been made.

b. TURNING THE ANALYZER ON.

(1) Turn the POWER switch to its ON position. The locations of this switch and the other operating controls are shown in Figs. 2-1, 2-2 and 2-3. The analyzer r-f oscillator tube should heat up and operate normally in approximately one minute.

c. SWEEP AND INDICATOR CIRCUITS, ANALYZER R-F OSCILLATOR.

(1) Turn the MIXER AMPLIFIER control counter-clockwise to zero.

(2) Adjust the INTENSITY control until the desired brilliancy is obtained.

(3) Place the SELECTOR switch in the MIXER position. A horizontal trace should appear on the screen about one inch from the bottom of the tube.

(4) Turn the MIXER AMPLIFIER and SPECTRUM WIDTH controls as far as they will go in a clockwise direction.

(5) Adjust the SPECTRUM CENTER control until a symmetrical bell-shaped hump appears on the screen of the scope. See Fig. 2-4. This control adjusts the d-c reflector voltage in the analyzer r-f oscillator. Two different humps may be obtained at two different settings of the SPECTRUM CENTER control. Either hump is satisfactory.

(6) Adjust the MIXER AMPLIFIER control until the pattern on the screen is approximately two inches high.

Note

The controls described in steps (7) to (11) have been accurately set at the factory and it should not be necessary to make these adjustments unless the cathode-ray tube has been replaced.

(7) If the vertical position of the trace is too high or too low, locate it properly with the screwdriver control marked VERTICAL-MIXER when the SELECTOR switch is in the MIXER position. If the SELECTOR switch is in either the SPECTRUM-INTENSIFIED or SPECTRUM positions, adjust the trace with the control marked VERTICAL SPECTRUM. Note that two controls are necessary to accomplish vertical centering for all switch positions. These controls are shown in Fig. 2-2.

(8) If the horizontal position of the pattern is not centered properly, remove the dust cover, insert a screwdriver in the control marked HORIZONTAL CENTERING and adjust it until the pattern is centered correctly. This control is directly in front of V-112 in Fig. 2-3. The dust cover slides off when the three screw fasteners at the rear have been loosened.

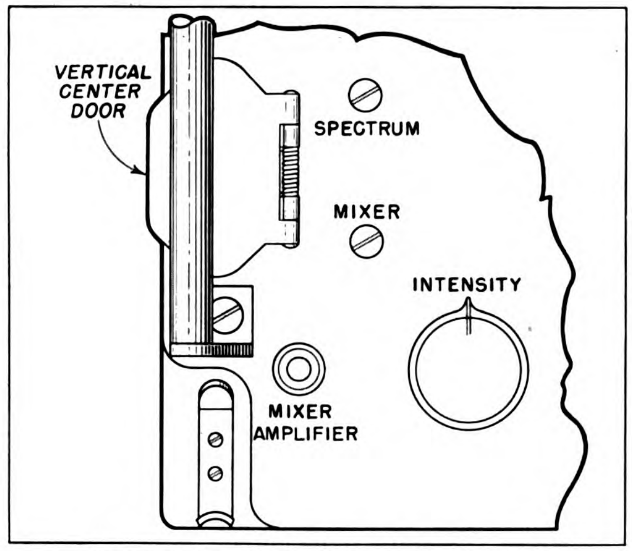


Figure 2-2. Vertical Centering Controls

(9) If the trace is too long or too short, turn the HORIZONTAL AMPLITUDE control until the length of the trace is slightly less than the width of the screen. This control is directly in front of V-108 as shown in Fig. 2-3.

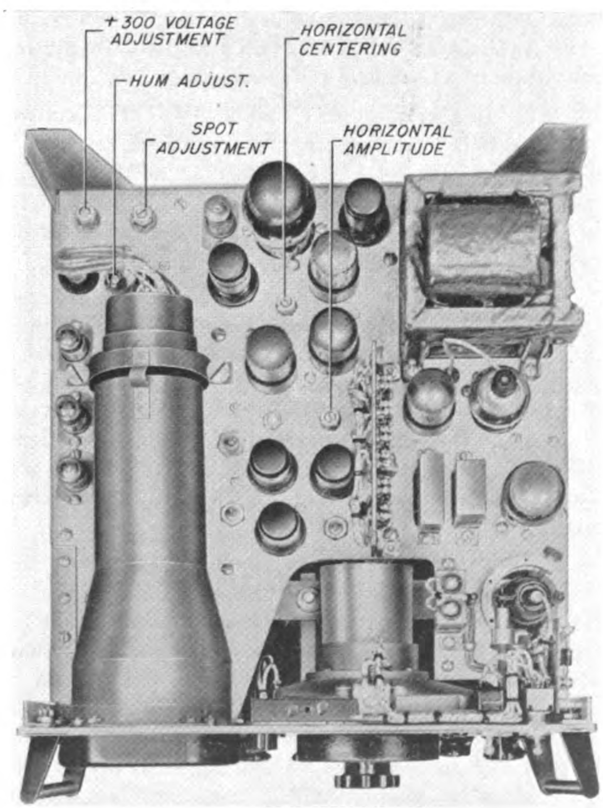


Figure 2-3. Spectrum Anaylzer, Dust Cover Removed to Show Chassis Controls

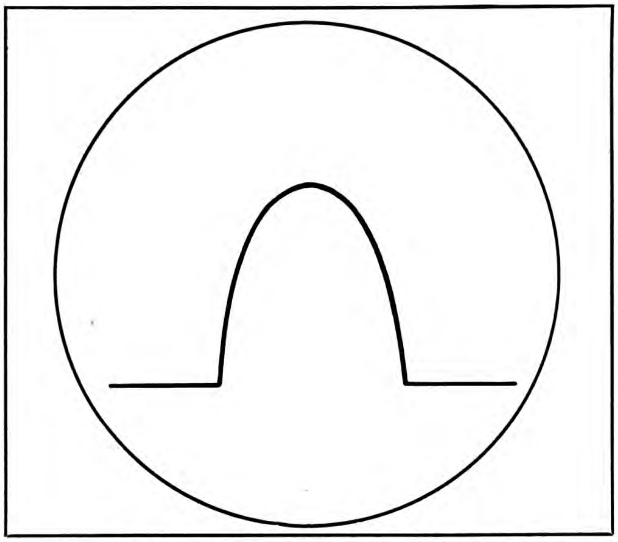


Figure 2-4. Analyzer R-F Oscillator Pattern

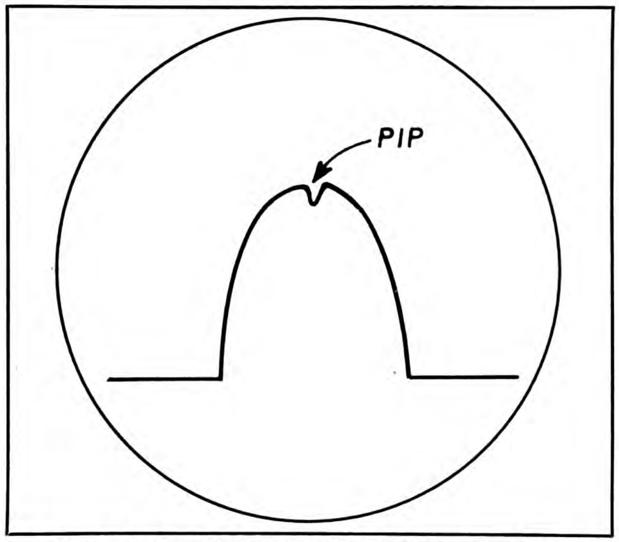


Figure 2-5. Frequency Meter Pip in Analyzer R-F Oscillator Pattern

(10) If the hum level appears to be too high turn the control labeled HUM ADJUSTMENT with a screwdriver until the hum is reduced to a minimum. See Fig. 2-3 for the location of this control.

(11) If the pattern on the screen is out of focus, even when the trace itself is sharply focused, turn the SPOT ADJUSTMENT control until the pattern is sharp and clear. This control is located next to the +300 VOLTAGE ADJUSTMENT control in the left rear corner of the chassis as shown in Fig. 2-3.

(12) Adjust the SPECTRUM WIDTH control until the pattern covers the full width of the screen as shown in Fig. 2-4. The appearance of this pattern, centrally located and spread over the full width of the screen, shows whether or not the analyzer r-f oscillator is operating properly.

(13) Check the frequency sweep of the analyzer r-f oscillator by turning the FREQUENCY control until the frequency meter pip appears on the screen as shown in Fig. 2-5. Observe the dial reading when the pip coincides with the extreme left side of the pattern. Shift the pip to the right side and observe the dial reading again. The difference in dial readings represents the frequency sweep of the analyzer r-f oscillator.

(14) Set the SELECTOR switch to either the SPECTRUM-INTENSIFIED or the SPECTRUM position. The Analyzer is normally operated in the SPECTRUM-INTENSIFIED position. The frequency meter pip illustrated in Fig. 2-5 should now appear as shown in Fig. 2-6. However, it is customary to operate the Analyzer with the SPECTRUM WIDTH control adjusted so that the two indentations, which indicate the useful portion of the trace, are just beyond the ends of the trace. The resulting pattern is shown in Fig. 2-7. Only the baseline and the frequency meter pip appear in these patterns.

d. INDICATION OF CORRECT OPERATING CONDITION.

(1) If the steps outlined in Par. 2 of this section produce the required patterns on the scope screen, the sweep, indicator, analyzer r-f oscillator, i-f amplifier, and video circuits, together with the r-f plumbing can be assumed to be in good operating condition and ready for use.

3. DESCRIPTION OF CONTROLS.

a. PANEL CONTROLS.

(1) The INTENSITY knob varies the intensity of the electron beam and the brilliance of the pattern on the scope screen. See Fig. 2-1.

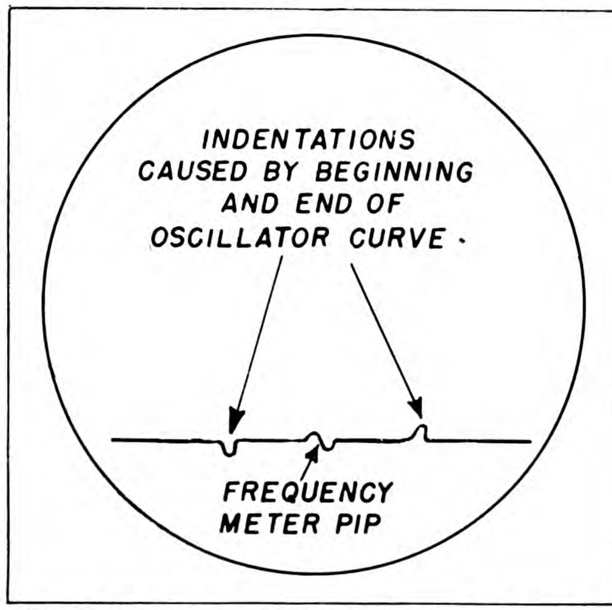


Figure 2-6. Frequency Meter Pip, Selector Switch in Spectrum Intensifier or Spectrum Position

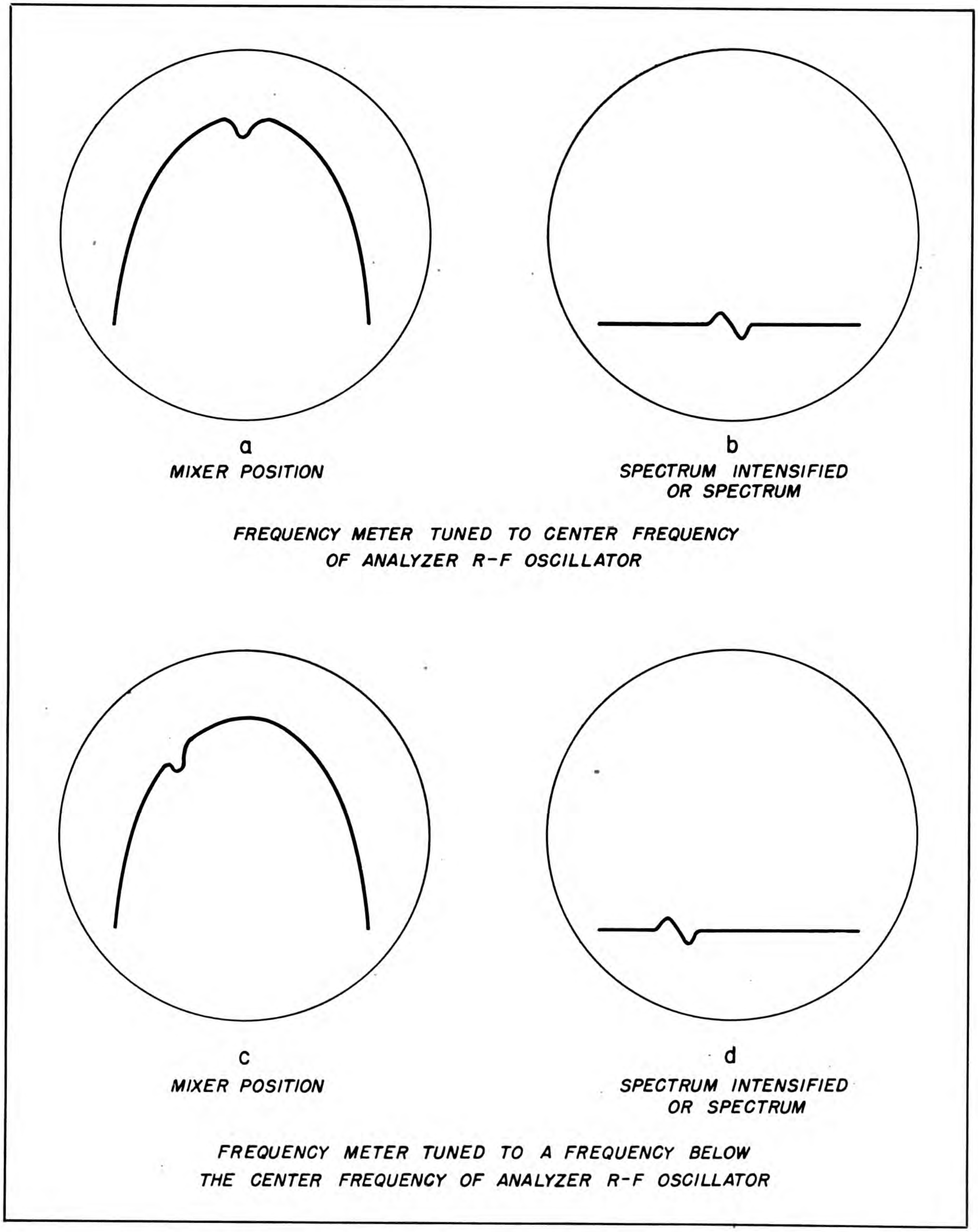


Figure 2-7. Analyzer R-F Oscillator Pattern, Spectrum Width Control Properly Adjusted

(2) The OSCILLATOR FREQUENCY knob controls the frequency of oscillations in the analyzer r-f oscillator tube. This adjustment is illustrated in Fig. 2-1. Turning this control counter-clockwise increases the frequency. A clockwise rotation decreases the frequency. This control selects the desired frequency range of the Analyzer.

CAUTION

Never force the OSCILLATOR FREQUENCY control or the Type 2K25 tube in the analyzer r-f oscillator may be damaged. All Type 2K25 tubes will not cover the full frequency range of the frequency meters, so care should be exercised, particularly towards the ends of the frequency range, to be certain the tuning mechanism is not being forced or broken.

(3) The SELECTOR switch has three positions:

(a) The first position is the MIXER position. This position is used when adjustments on the analyzer r-f oscillator are being made.

(b) The second position is the SPECTRUM-INTENSIFIED position. This is the position that is normally used. When the switch is set to this position the intensity of the *signal portion* of the trace is increased to a usable brightness.

(c) The third position is the SPECTRUM position. This position is similar to the second position except that the intensity of the trace remains constant at all times.

(4) The MIXER AMPLIFIER control regulates the amount of signal voltage that is applied to the grid of the d-c amplifier. This voltage is the d-c voltage taken from the crystal mixer in either the Analyzer or the radar set. In either case the rectified d-c signal voltage is developed from the output of the analyzer r-f oscillator.

(5) The SPECTRUM WIDTH knob controls the amplitude of the sweep voltage that is applied to the reflector of the analyzer r-f oscillator. This voltage determines the width of the frequency band through which the analyzer r-f oscillator sweeps. This control increases or decreases the number of megacycles per inch that is displayed.

(6) The SPECTRUM CENTER knob controls the d-c potential on the reflector of the analyzer r-f oscillator and determines its mode of oscillation. This control provides a fine adjustment for the OSCILLATOR FREQUENCY control to center the spectrum on the screen. Turning this control clockwise causes the pattern to move to the right. Counterclockwise rotation moves the pattern to the left.

(7) The FREQUENCY knob tunes the frequency meter by varying the length of its resonant cavity. A clockwise rotation increases the resonant frequency of the cavity. This control is directly calibrated in megacycles. Its range is 8470 mc/s to 9630 mc/s.

(8) The SPECTRUM AMPLITUDE knob controls the attenuation of the r-f input to the analyzer. The attenuator provides attenuation from three to 70 db. This control is not calibrated. It is used to control the amplitude of the pattern on the oscilloscope.

(9) The FOCUS knob adjusts the potential on the second grid of the cathode-ray tube and controls the sharpness of the trace.

(10) The MIXER JACK provides an external connection to the input circuit of the d-c mixer amplifier. When this jack is used, the crystal mixer in the radar transmitter-converter replaces the crystal mixer in the Analyzer.

11) The SYNC switch locks the start of the sweep to the a-c voltage in the power supply to synchronize the Analyzer with the line frequency when desirable.

(12) The POWER switch turns the a-c power ON and OFF.

(13) The SWEEP FREQUENCY knob controls the sweep frequency of the trace on the cathode-ray tube. This control adjusts the sweep frequency between 10 and 20 cps. The sweep frequency is usually kept as low as possible.

Note

It is recommended that the two controls, VERTICAL MIXER and VERTICAL SPECTRUM, located behind the hinged plate marked VERTICAL CENTER should be adjusted by experienced personnel, or by operating personnel under the direct supervision of experienced personnel.

(14) The VERTICAL MIXER control is a screwdriver adjustment accessible from the front panel. It provides vertical centering when the SELECTOR switch is in the MIXER position.

(15) The VERTICAL SPECTRUM is a screwdriver control that provides vertical centering when the SELECTOR switch is in the SPECTRUM-INTENSIFIED or SPECTRUM positions.

WARNING

THIS EQUIPMENT EMPLOYS HIGH VOLTAGES WHICH ARE DANGEROUS AND MAY BE FATAL IF CONTACTED BY OPERATING PERSONNEL. EXTREME CAUTION SHOULD BE EXERCISED WHEN WORKING INSIDE THE CHASSIS.

b. CHASSIS CONTROLS.

Note

The dust cover must be removed to obtain access to the chassis controls. The location of these controls is shown in Fig. 2-3.

(1) The +300 VOLTAGE ADJUSTMENT is a screwdriver adjustment located in the rear corner on the left-hand side of the chassis. It controls the regulated 300-volt output from the power supply. A con-

venient terminal, marked +300 volts may be found on the analyzer r-f oscillator terminal board on top of the chassis.

(2) The SPOT ADJUSTMENT control is on the right side of the +300 VOLTAGE ADJUSTMENT control when looking over the control panel toward the rear of the chassis. See Fig. 2-3. It controls the sharpness of the pattern on the cathode-ray tube. This control is set when a cathode-ray tube is installed and need not be disturbed again until the tube is replaced.

(3) The HUM ADJUSTMENT control is directly in front of the two controls just described. It controls the hum level that appears on the oscilloscope.

(4) The HORIZONTAL CENTERING control is located directly in front of V-112 in Fig. 2-3. It centers the trace on the screen of the oscilloscope tube.

(5) The HORIZONTAL AMPLITUDE control is directly in front of V-108 in Fig. 2-3. It controls the length of the trace on the scope screen.

4. PERFORMANCE CAPABILITIES.

a. The Spectrum Analyzer, within the limitation of its frequency range, may be used to perform the following tests:

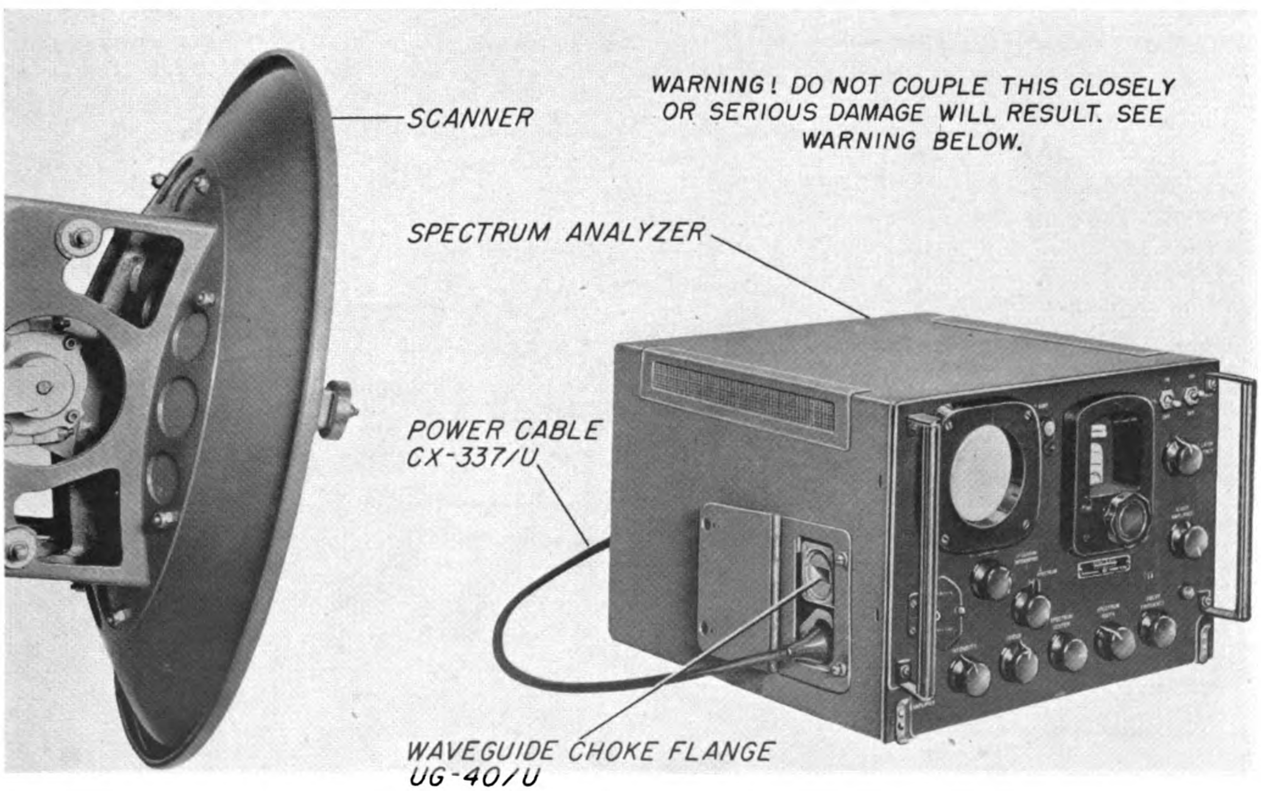
(1) Observation of the spectra of various types of micro-wave oscillators used in radar systems. The Analyzer is particularly useful for observing spectra of pulsed magnetrons. It is possible to adjust a magnetron spectrum for optimum operating efficiency with the aid of the Analyzer.

(2) Measurement of magnetron frequencies.

(3) Observation of the operation of radar local oscillators with respect to their associated magnetrons. In connection with the radar local oscillator, the Analyzer may also be used to check AFC operation and analyze troubles in the AFC circuit. External local oscillators can be tuned with an accuracy of ±1 mc/s if their frequency is near the zero check point (9310) on the dial of the frequency meter.

(4) Tuning plumbing in a radar transmitter-converter. This procedure requires a previous knowledge of the frequency of the magnetron.

(5) Checking or setting the resonant frequencies of frequency meters, T/R Boxes, R/T Boxes and echo boxes. This test is performed by observing the reaction of the device under test on the output curve of the analyzer r-f oscillator, and then measuring the



WARNING

THIS FIGURE ILLUSTRATES A PRINCIPLE OF COUPLING. IN PRACTICE THE EQUIPMENTS ARE NEVER PLACED THIS CLOSE TOGETHER. TO DO SO WOULD BURN OUT THE ATTENUATOR AND CRYSTAL MIXER IN THE ANALYZER.

Figure 2-8. Use of Open Wave Guide to Pick Up Output of Magnetron frequency with the frequency meter in the Analyzer. The Analyzer may be operated as a CW or FM signal generator for this test. The Analyzer approaches CW operation when the SPECTRUM WIDTH control is in its minimum position.

(6) Performance tester for local oscillator tubes. Type 2K25 and 723A/B tubes may be tested by inserting them in the analyzer r-f oscillator socket and checking their output curves on the scope when the SELECTOR switch is in the MIXER position.

(7) Measurement of band-widths of resonant cavities.

(8) Measurements of pulse-widths. This measurement is an approximation and is satisfactory for most practical purposes.

(9) Measurement of the distribution of useful transmitted power. The vertical height of each frequency component in the spectrum is proportional to its contribution to the total transmitted power.

5. PROCEDURE FOR THE OBSERVATION OF SPECTRA.

a. To observe the spectrum of a magnetron or other oscillator, make the following preliminary adjustments after the Analyzer has been installed and turned on as outlined in Par. 2 of this section.

(1) Place the SELECTOR switch in its MIXER position.

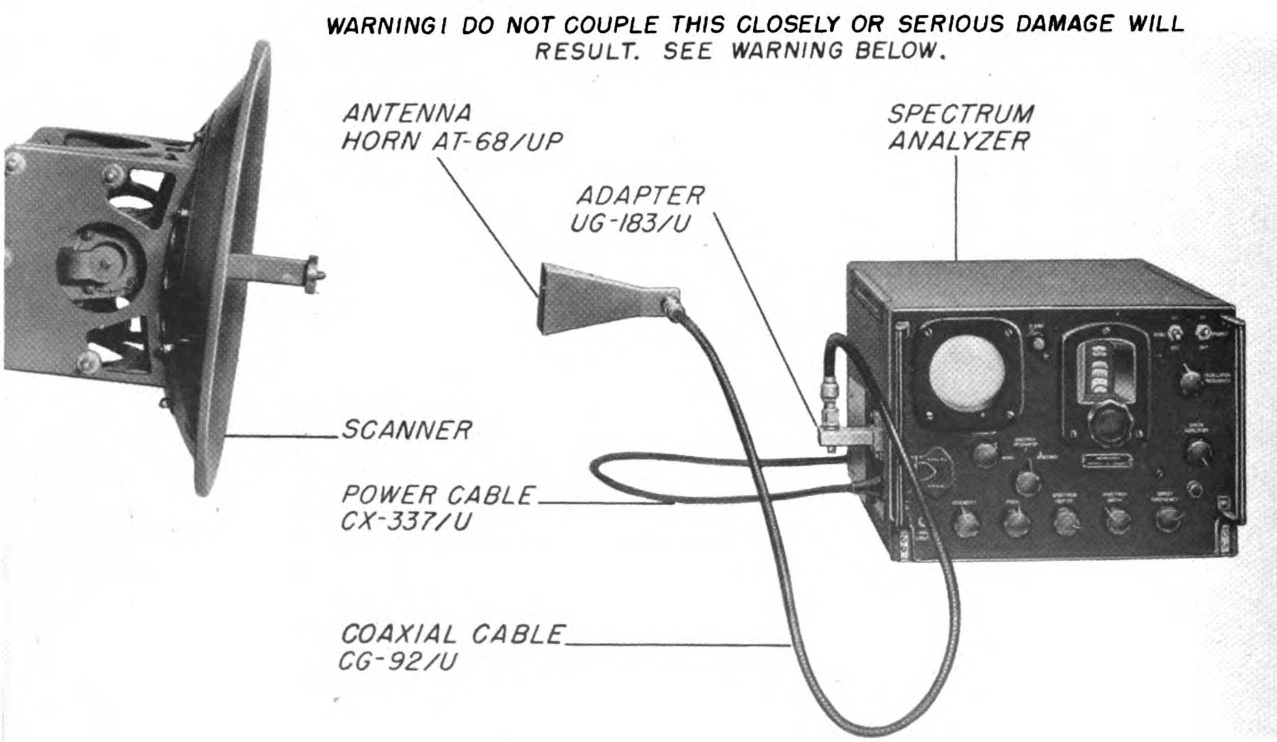
(2) Turn the SPECTRUM WIDTH control in a clockwise direction until its setting is nearly maximum.

(3) Center the bell-shaped hump on the trace with the SPECTRUM CENTER control.

(4) Place the SELECTOR switch in its SPECTRUM INTENSIFIED position.

(5) Point the wave-guide, which is accessible through the little side door, at the radar antenna or to the magnetron output. This method of coupling is illustrated in principle in Fig. 2-8. In practice the equipments are never placed so close together. To do so would burn out the attenuator and crystal mixer in the Analyzer.

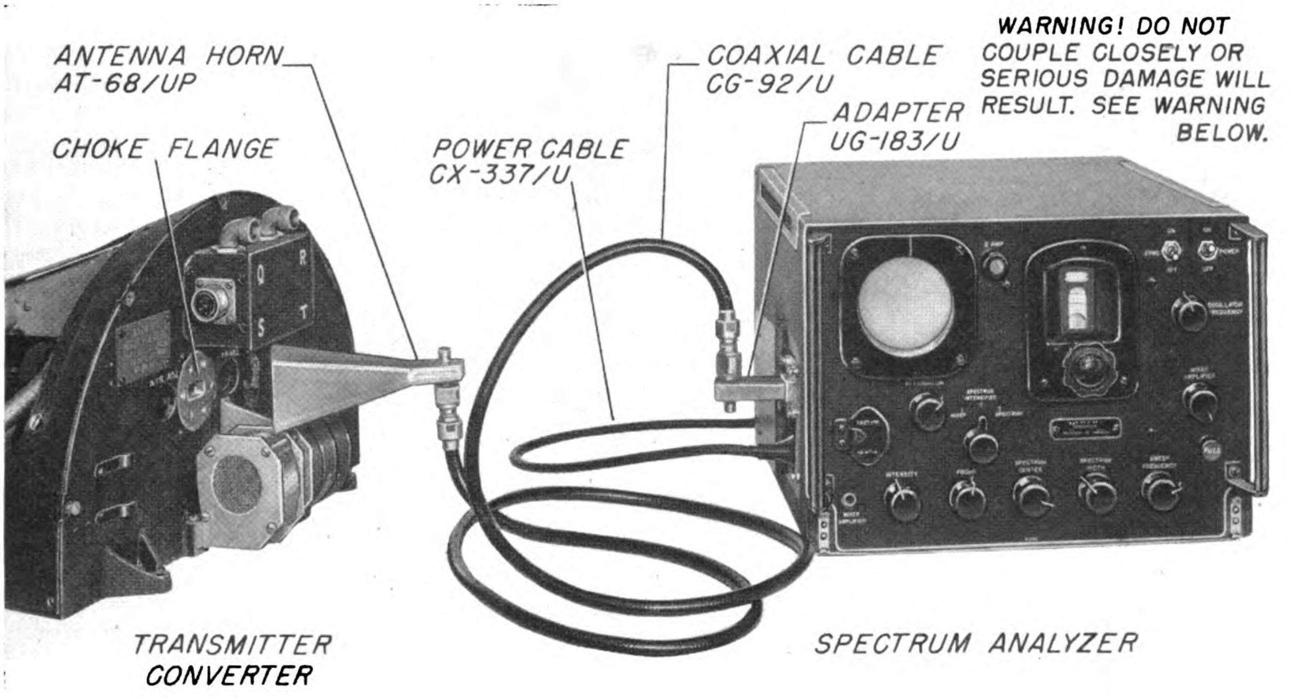
(6) If this method of coupling is not practical, the Antenna Horn and fittings may be used as illustrated in Fig. 2-9. These parts are carried in the Auxiliary and Spare Parts case. Fig. 2-9 illustrates the principle of a method of coupling. The Antenna Horn should never be placed so close to a radar antenna. This method can be used to pick up the output of the magnetron at distances up to 100 feet if the two antennas are pointing directly at each other.



WARNING

THIS FIGURE ILLUSTRATES A PRINCIPLE OF COUPLING. IN PRACTICE THE EQUIPMENTS ARE NEVER PLACED THIS CLOSE TOGETHER. TO DO SO WOULD BURN OUT THE ATTENUATOR AND CRYSTAL MIXER IN THE ANALYZER.

Figure 2-9. Use of Antenna Horn to Pick Up Magnetron Output from Scanner



WARNING

THIS FIGURE ILLUSTRATES A PRINCIPLE OF COUPLING. IN PRACTICE THE EQUIPMENTS ARE NEVER PLACED THIS CLOSE TOGETHER. TO DO SO WOULD BURN OUT THE ATTENUATOR AND CRYSTAL MIXER IN THE ANALYZER.

Figure 2-10. Antenna Horn Placed Near Choke Flange on Radar Transmitter-Converter

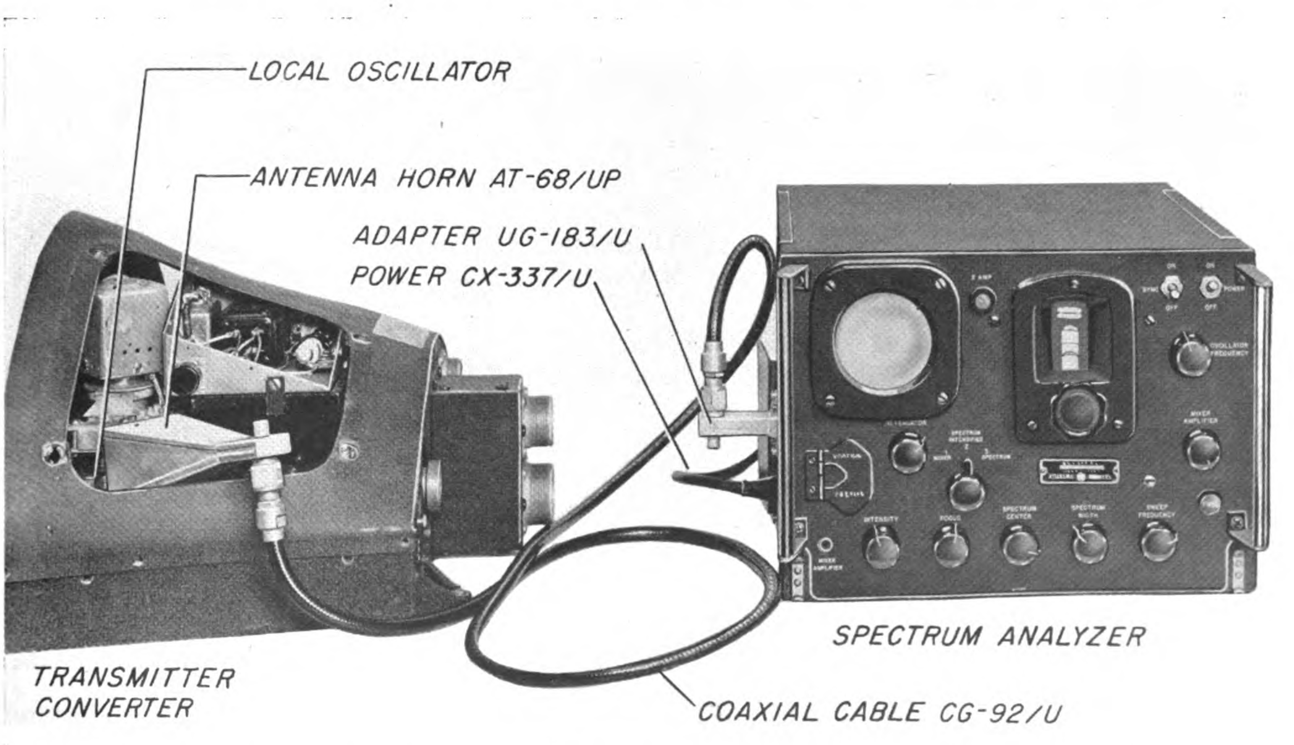


Figure 2-11. Use of Antenna Horn to Pick Up Output of Radar Local Oscillator and Magnetron

CAUTION

NEVER ATTEMPT TO INCREASE THE AMPLITUDE OF THE SPECTRUM BY INCREASING THE COUPLING UNTIL IT IS ASCERTAINED THAT THE AMPLITUDE CANNOT BE INCREASED BY ADJUSTING THE ATTENUATOR. CLOSE COUPLING WILL BURN OUT THE RESISTANCE CARDS IN THE ATTENUATOR AND RUIN THE CRYSTAL IN THE CRYSTAL MIXER OF THE ANALYZER.

(7) The Antenna Horn may also be pointed toward the choke flange joints in the radar transmitter-converter or be placed in a position just back of the radar antenna. It will pick up sufficient power in either position. These methods of coupling are illustrated in principle in Fig. 2-10. *Do not overcouple when using these methods.*

(8) The Antenna Horn may also be pointed at local oscillators in radar sets and other equipment in order to obtain their spectra for observation. See Fig. 2-11. It is seldom necessary to remove the shield cover of the local oscillator. The magnetron spectrum and local oscillator spectrum may both be observed simultaneously if a proper location for the Antenna Horn is found that produces sufficient attenuation of the output of the magnetron.

(9) If a very stable method of coupling is desired, remove the Antenna Horn from the coaxial cable and connect the cable to a Type CG-176/AP directional coupler or wave selector that has been inserted at some convenient place in the line. This connection is shown in Fig. 2-12. The Analyzer receives approximately one per cent of the power in the directional coupler. This method is very satisfactory when it is necessary to check the antenna when it is in motion, to see if it is pulling the frequency of the magnetron.

(10) Adjust the ATTENUATOR to obtain the desired amplitude on the screen.

CAUTION

Do not connect the output of the magnetron directly into the Spectrum Analyzer. To do so would burn up the resistance card in the attenuator and burn out the crystal even though the Spectrum Analyzer is turned off.

6. OBSERVATION OF PATTERNS.

a. OBTAINING CORRECT PATTERN APPEARANCE.

(1) Rotate the SPECTRUM WIDTH control counterclockwise until the spectrum gains sufficient detail to make observation easy. If more pulses are desired in the spectrum turn the SWEEP FRE-

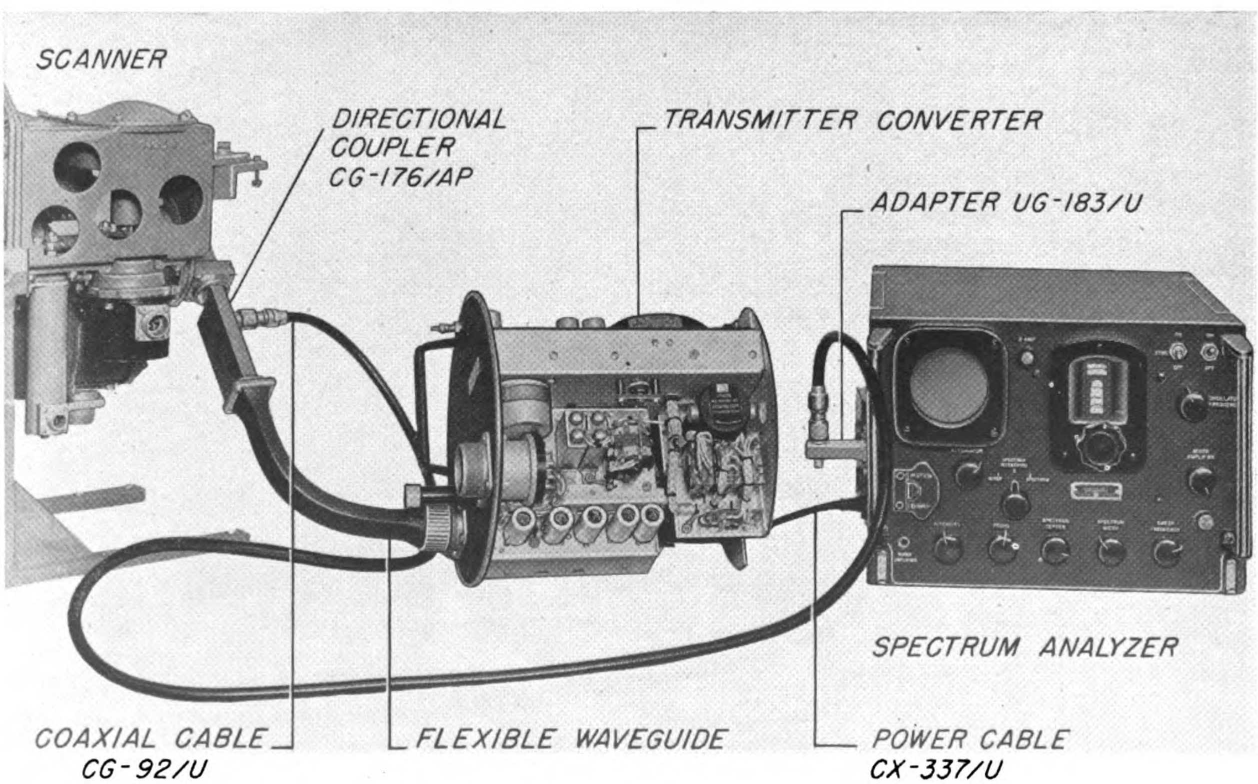


Figure 2-12. Obtaining Stable Coupling with Directional Coupler CG-176/AP

QUENCY control counterclockwise to a lower sweep frequency.

b. OBSERVATION OF FREQUENCY-PULLING IN A MAGNETRON.

(1) Frequency pulling describes the shift in magnetron frequency caused by improper loading and line voltage. Pulling is identified by the horizontal shift in the scope pattern when the antenna is rotated by hand. The coupling method in Fig. 2-12 permits tests with the antenna rotating at normal speed. Excessive pulling disrupts AFC action which impairs operating efficiency. See Par. 7*b*(3) of this section. When the SYNC switch is ON, line frequency pulling is eliminated from the displayed spectrum. When the SYNC switch is OFF, pulling due to line voltage effects and magnetron load changes will be present.

c. MEASUREMENT OF MAGNETRON FREQUENCY.

(1) The frequency meter pip, that is visible when the SELECTOR switch is in the MIXER position, represents the actual frequency of the frequency meter that is indicated on the dial. When the SELECTOR switch is in either of its other two positions for frequency measurements, the pip is adjusted to coincide with the unknown frequency by rotating the dial marked FREQUENCY. *The reading on this dial does not represent the frequency that is being measured.* The unknown frequency *must be computed from the dial reading* by adding or subtracting the 22.5-megacycle intermediate frequency of the Analyzer.

(2) It is possible to see two different images as will be explained presently. Whether the intermediate frequency is added or subtracted depends upon the image with which the frequency meter pip is made to coincide. If the image is the one on the right, indicated as R, in Fig. 2-13, it is necessary to subtract 22.5 mc/s from the dial reading. The remainder thus obtained represents the frequency of the unknown signal. If the image is the one on the left, indicated as L, in Fig. 2-13, it is necessary to add 22.5 mc/s to the dial reading. To determine which image is under observation, refer to Fig. 2-13 and the explanation that follows.

(3) Fig. 2-13 shows the scope screen with the SPECTRUM WIDTH control set to show both images. The frequency of the analyzer r-f oscillator increases as the sweep progresses from left to right across the screen. Therefore, both images can always be made to appear on the screen although, in actual practice, one is centered on the screen so that the other does not appear. These images are always identical and either one can be selected for the frequency measurement. The actual signal frequency is not represented by a vertical line. If it were, the vertical line would lie midway between L and R on the dotted line marked A.

(4) The reason two images appear is due to the action of the analyzer r-f oscillator. It sweeps through a band of frequencies in synchronism with the scope trace. As it reaches a frequency that is 22.5 mc/s below the frequency of the unknown signal, the image marked L appears. As the frequency sweep of the analyzer r-f oscillator continues, it passes through a frequency that is 22.5 mc/s above the frequency of the unknown signal. At this time, the signals again heterodyne and the image marked R appears on the trace.

(5) When the frequency of the analyzer r-f oscillator passes through the unknown frequency, a zero frequency beat is obtained and consequently no deflection voltage can be applied to the vertical plates of the cathode-ray tube. It is true that many beat frequencies are obtained during each frequency sweep, but since the i-f amplifier is sharply tuned for a band-width of 50 kc/s, indications cannot be obtained at any frequency other than 22.5 mc/s $\pm$ .025 mc/s as shown in Fig. 2-14.

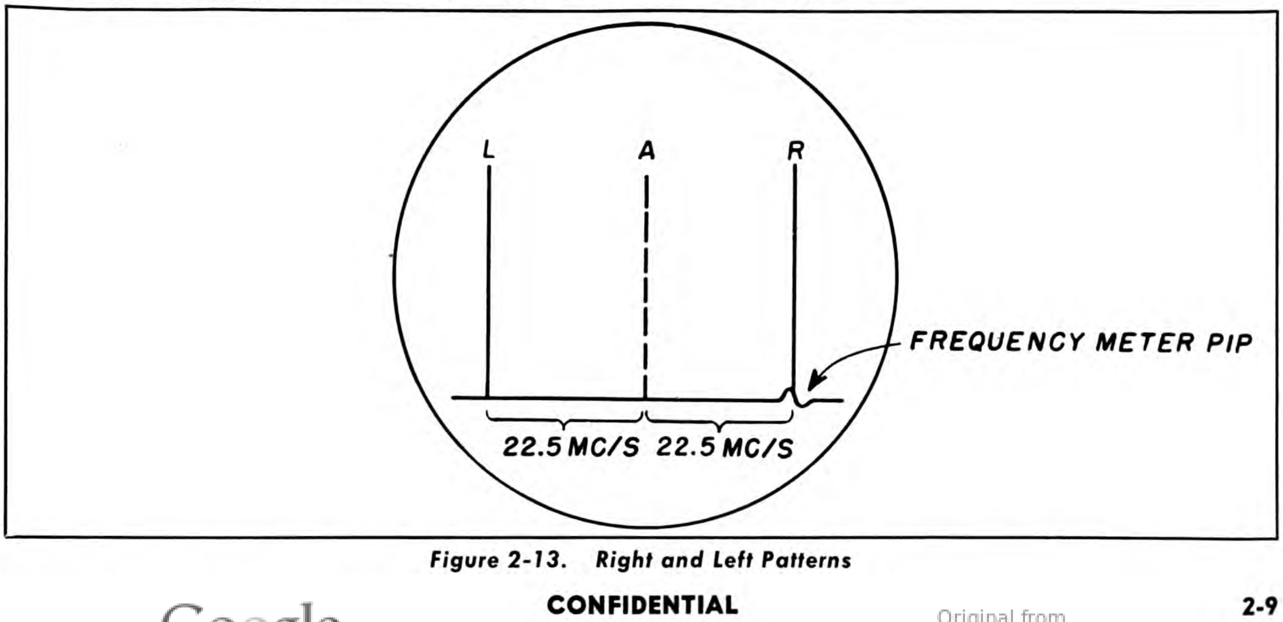
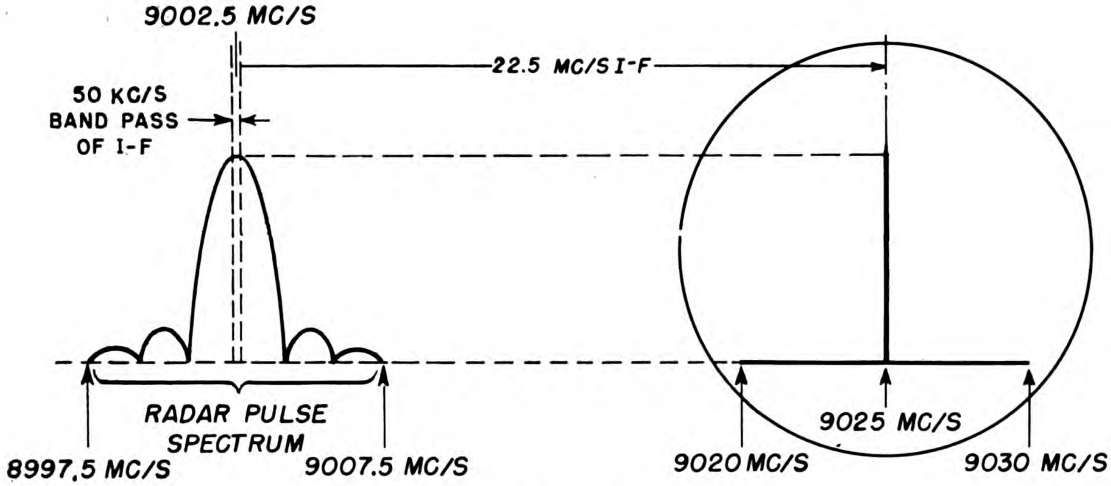
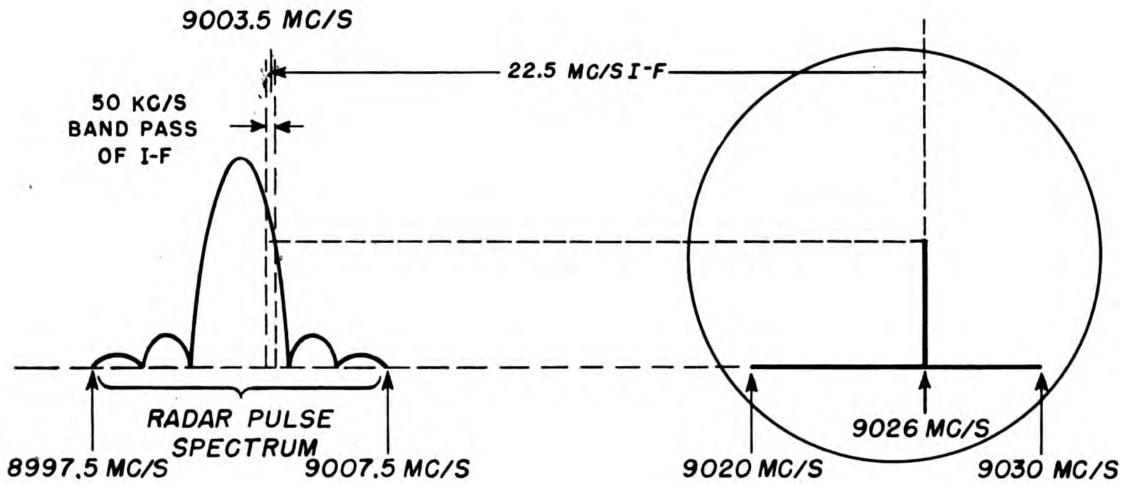


Figure 2-13. Right and Left Patterns



a. ANALYZER RF OSCILLATOR AT 9025 MCS.



b. SAME AS 2-14a EXCEPT THAT A DIFFERENT FREQUENCY COMPONENT HAS APPEARED BECAUSE THE ANALYZER RF OSCILLATOR IS NOW AT 9026 MC/S. NOTE THAT 50 KC/S SLIT THROUGH WHICH THE SPECTRUM CAN BE SEEN, HAS MOVED TO THE RIGHT.

Figure 2-14. Sweep of the Analyzer R-F Oscillator Over the Spectrum

(6) If the frequency meter is tuned so that its pip coincides with the right-hand image (R) as shown in Fig. 2-13, its dial reading represents the frequency of the analyzer r-f oscillator which is 22.5 mc/s above the unknown frequency. Therefore, 22.5 mc/s must be subtracted from the dial reading to obtain the frequency of the unknown signal.

(7) If the frequency meter is tuned so that its pip coincides with the left-hand image (L), its dial reading represents the frequency of the analyzer r-f oscillator which is now 22.5 mc/s below the frequency of the unknown signal. In this case, 22.5 mc/s must be added to the dial reading to obtain the unknown frequency.

(8) Another method for obtaining the unknown frequency is to take a reading on each image and average the two readings.

Example:

Dial reading for image L = 9000 mc/s.

Dial reading for image R = 9045 mc/s.

Unknown frequency

$$= \frac{9000 + 9045}{2} = \frac{18045}{2} = 9022.5 \text{ mc/s.}$$

(9) Another very accurate method may be used if the unknown signal is stably coupled to the Analyzer as, for example, with directional coupler Type CG-176/AP. This method consists of tuning the frequency meter until its pip is equidistant from the two images. Both images must be carefully observed while the frequency meter is being tuned. At the instant the resonant frequency of the frequency meter equals the frequency of the unknown signal, it will be possible to see both images dip simultaneously. The reduction in amplitude occurs because the frequency meter absorbs energy from the unknown signal frequency. In this case the reading on the FREQUENCY dial represents the actual frequency of the unknown signal.

(10) A variation of this method is to center one of the images with the SPECTRUM CENTER control and spread the spectrum with the SPECTRUM WIDTH control so that the dip can be distinguished easily when the frequency meter is tuned to the unknown frequency. This method is illustrated in Fig. 2-15.

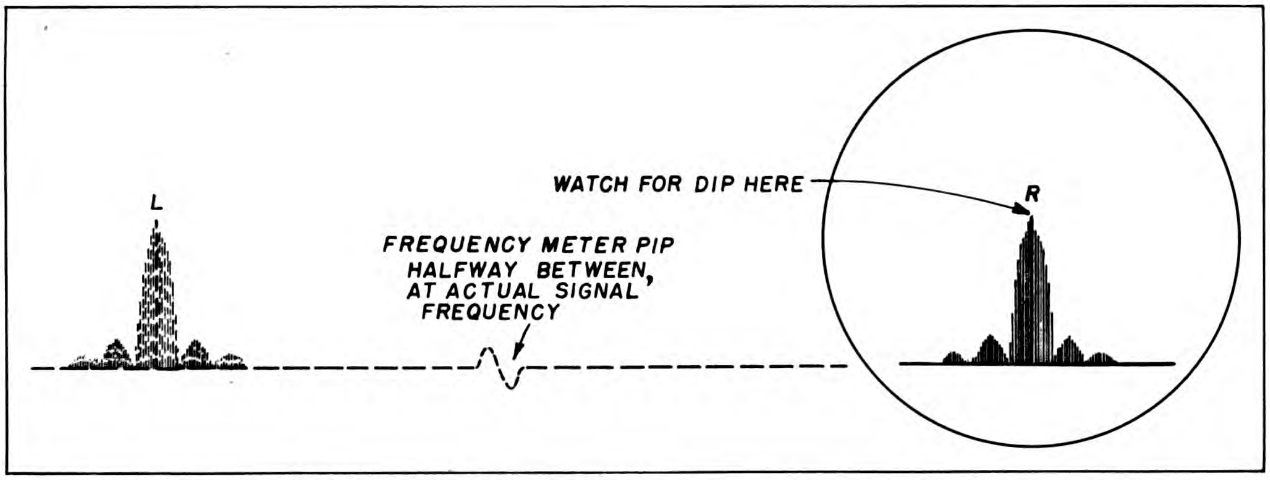


Figure 2-15. Determination of Frequency by Tuning Frequency Meter for Dip in Spectrum

7. OBSERVATION OF LOCAL OSCILLATOR SPECTRA.

a. GENERAL.

(1) The operation of radar local oscillators can be observed, using the method illustrated in Fig. 2-11. Turn the SPECTRUM WIDTH control counterclockwise until the width of the spectrum across the screen is approximately 3 mc/s. Under this condition, the spectrum of a radar local oscillator operating on AFC, will usually cover about one-half of a megacycle on the screen. See Fig. 2-16. When the AFC action is discontinued and the frequency is controlled manually, the local oscillator produces a single pip that is fairly stable unless its power supply has excessive ripple in its output voltage. See Fig. 2-17.

b. MEASUREMENTS OF RADAR LOCAL OSCILLATOR FREQUENCY.

(1) There are two similar methods for measuring the frequency of a radar local oscillator. The choice of methods depends upon whether the intermediate frequency is 30 mc/s or 60 mc/s.

(2) If the intermediate frequency is 60 mc/s it would be assumed, under normal conditions, that the radar local oscillator was running at a frequency 60 mc/s above the magnetron frequency. Since two frequencies that are 60 mc/s apart cannot be seen on the scope at the same time, a unique use is made of the fact that two spectrum images appear for each signal. In practice, the right-hand spectrum of the

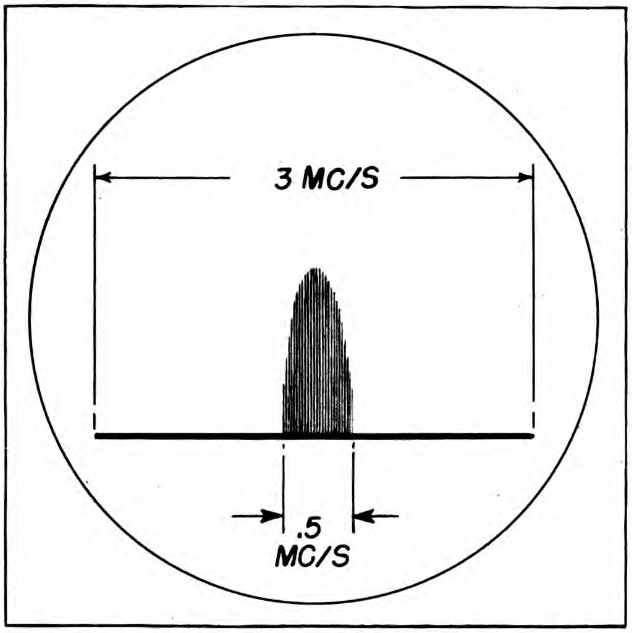


Figure 2-16. Spectrum of Radar Local Oscillator with AFC

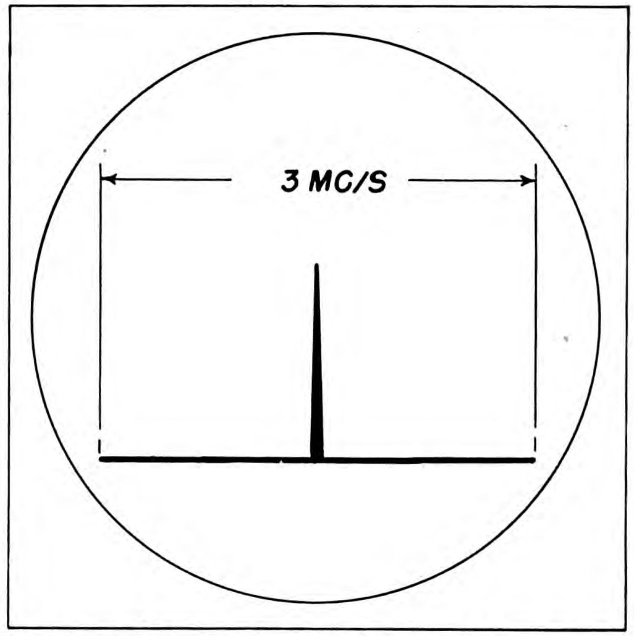


Figure 2-17. Spectrum of Radar Local Oscillator without AFC

magnetron is placed on the left-hand side of the scope. Then the left-hand spectrum of the radar local oscillator should appear on the right-hand side of the scope. The resulting pattern is illustrated in Fig. 2-18.

(3) An examination of Fig. 2-18 shows that it is easy to determine whether the AFC action is causing the radar local oscillator to follow closely the excursions of the magnetron frequency. The pattern inside the circle is the pattern selected by the SPECTRUM CENTER control to appear on the screen. The pattern represented by the dotted line does not appear but is shown to illustrate the frequency relationship of the two images that do appear.

(4) The accuracy with which the radar local oscillator tracks the magnetron can be determined by measuring the difference between the frequencies of

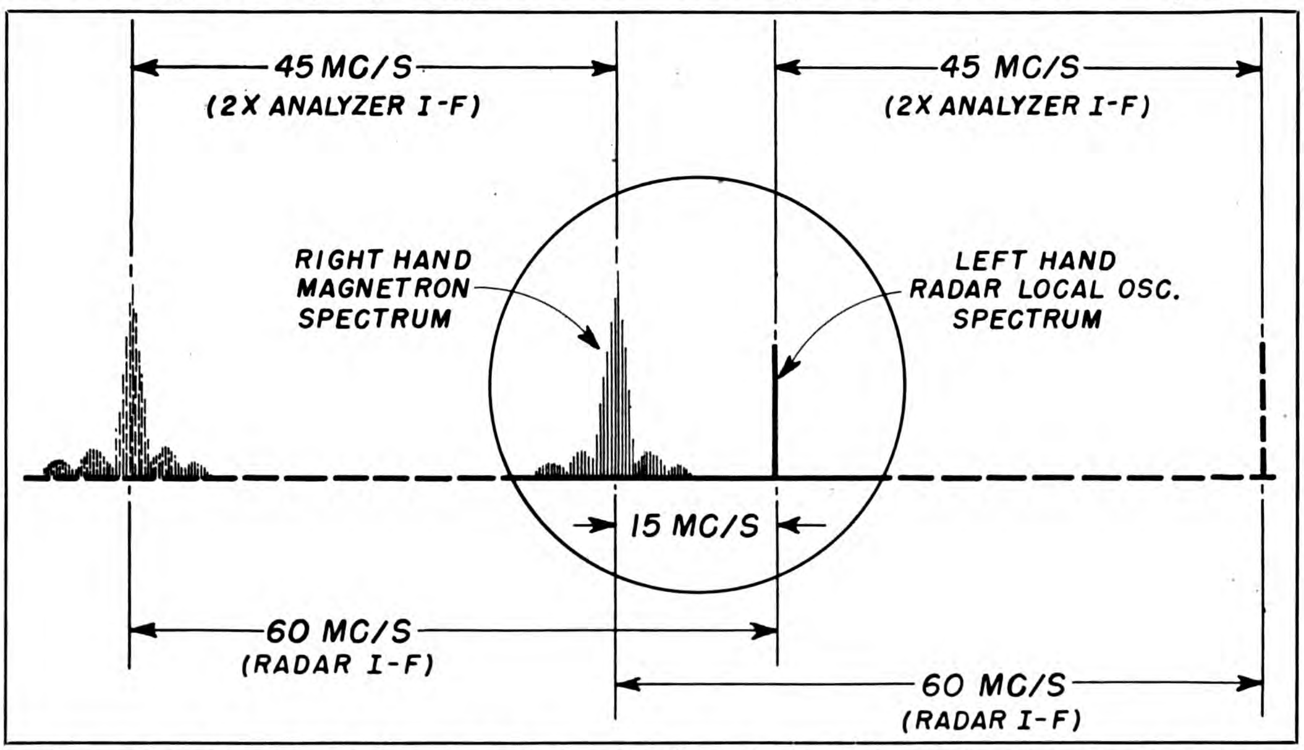


Figure 2-18. Measuring the Frequency of a Local Oscillator that is 60 Megacycles Above the Magnetron

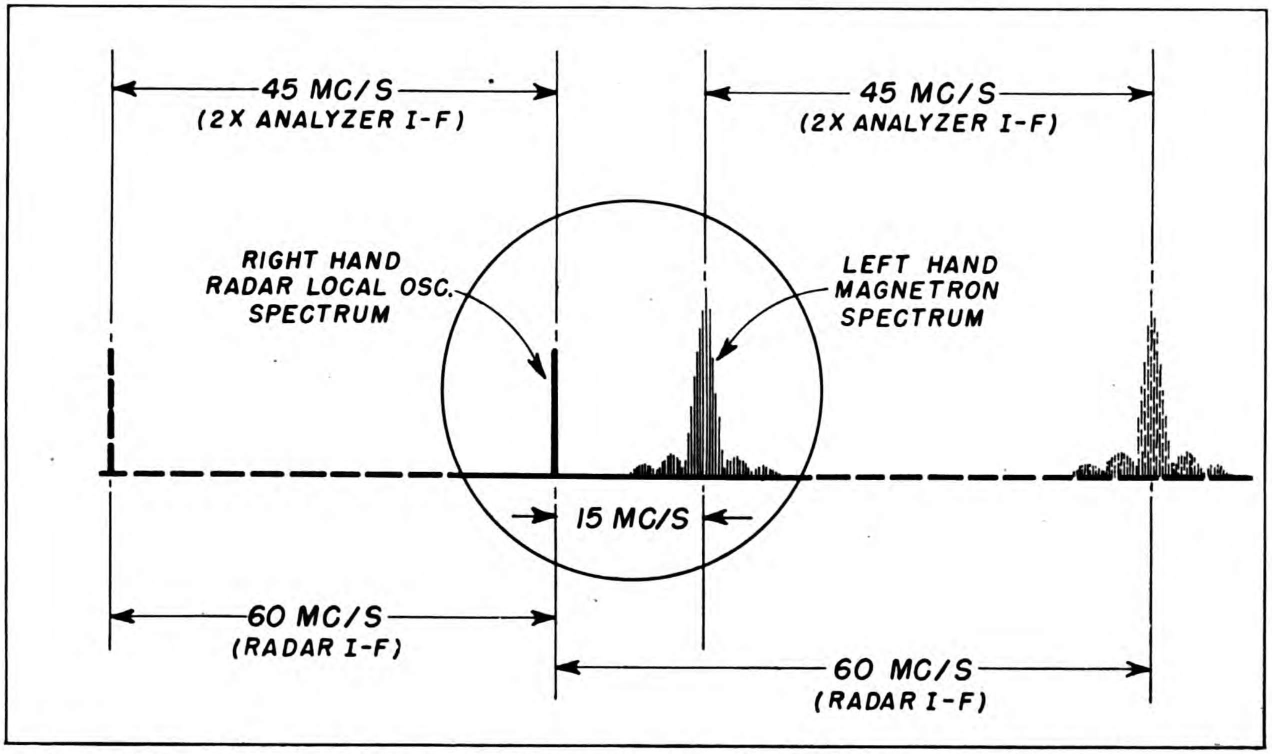


Figure 2-19. ***Measuring the Frequency of a Local Oscillator that is 60 Megacycles Below the Magnetron***

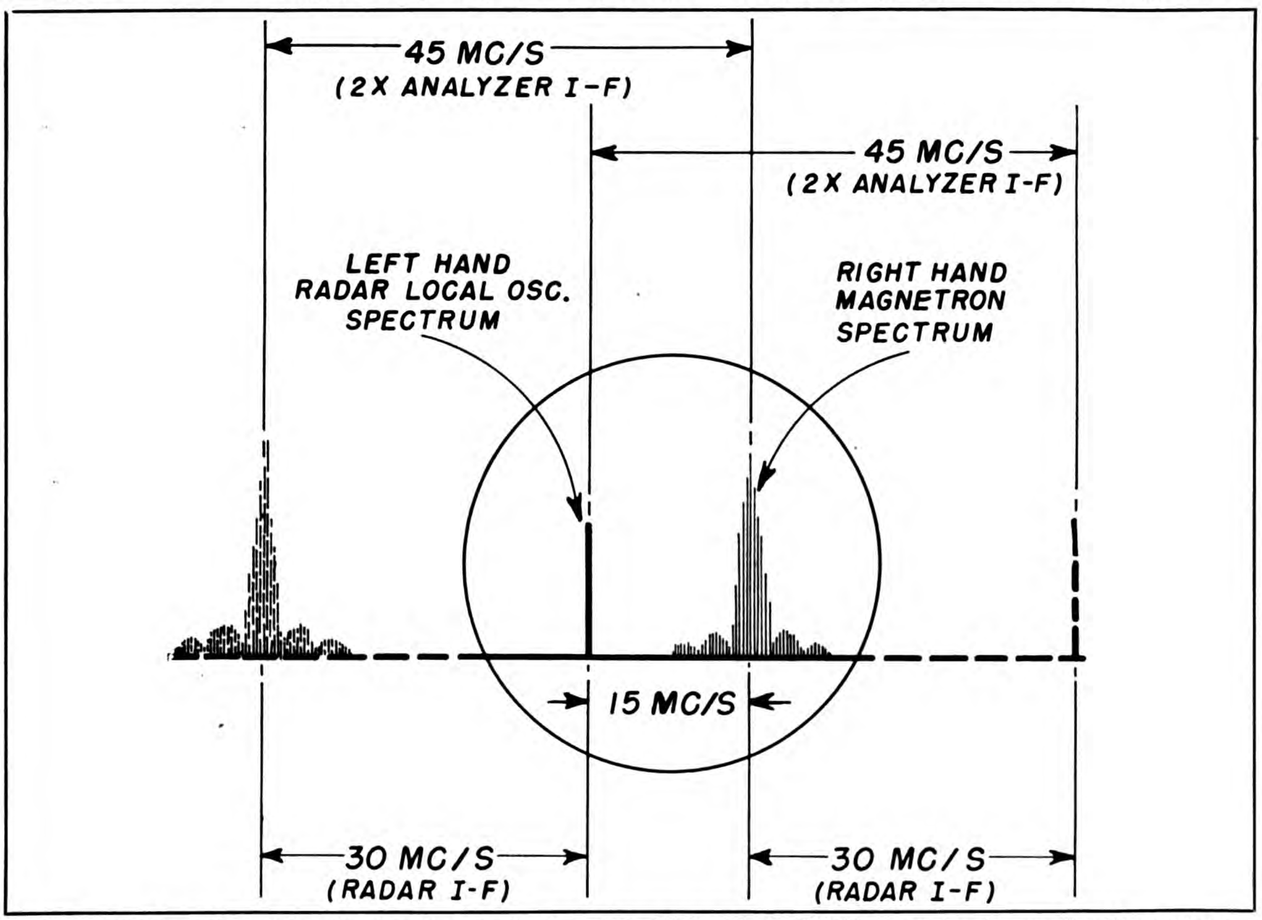


Figure 2-20. ***Measuring the Frequency of a Local Oscillator that is 30 Megacycles Above the Magnetron***

the two images on the screen. Rotate the FREQUENCY dial, to set the frequency meter pip under the center of the magnetron spectrum, and note the dial reading. Then set the pip under the radar local oscillator pip and again note the dial readings. If the difference between the dial readings is 15 mc/s, the radar local oscillator (or AFC discriminator) has been accurately set to the proper frequency. If the frequency of the radar local oscillator is set below the magnetron frequency the position of the images would be reversed as shown in Fig. 2-19.

(5) If the intermediate frequency is 30 mc/s the procedure is similar to the one above except that the position of the images on the screen is reversed. The left-hand spectrum of the radar local oscillator appears on the left side of the screen while the spectrum of the magnetron now appears on the right. This condition is shown in Fig. 2-20. The difference in frequencies is measured just as it was in the foregoing method and a frequency difference of 15 mc/s indicates that the local oscillator is running at a frequency 30 mc/s above the magnetron.

(6) If the radar local oscillator runs below the magnetron frequency, the position of the images would be reversed as shown in Fig. 2-21. That is, the radar local oscillator spectrum would be on the right and the magnetron spectrum would be on the left.

c. FREQUENCY MEASUREMENT OF BEACON LOCAL OSCILLATORS.

(1) The same method described in Par. 7*b* of this section may also be used to check the operation of the beacon local oscillator. If the beacon local oscillator is out of adjustment the Analyzer can be used to set it to an accuracy of ± 1 mc/s under normal conditions of temperature and humidity. If better accuracy is desired, it can be obtained by the use of a standard cavity tuned to the beacon local oscillator frequency. See Par 8*a*(12) of this section.

(2) It was assumed in the foregoing remarks that the beacon local oscillator was AFC controlled. Under this condition the beacon local oscillator spectrum will occupy a width of one-quarter to one-half of a megacycle due to the control modulation on the tube. Beacon oscillators which sweep over larger ranges may be seen to do so on the indicator tube and the range of the sweep may be measured.

8. TUNING R-F PLUMBING IN A RADAR SET.

a. For this application, the Spectrum Analyzer is used as a frequency-modulated signal generator. The

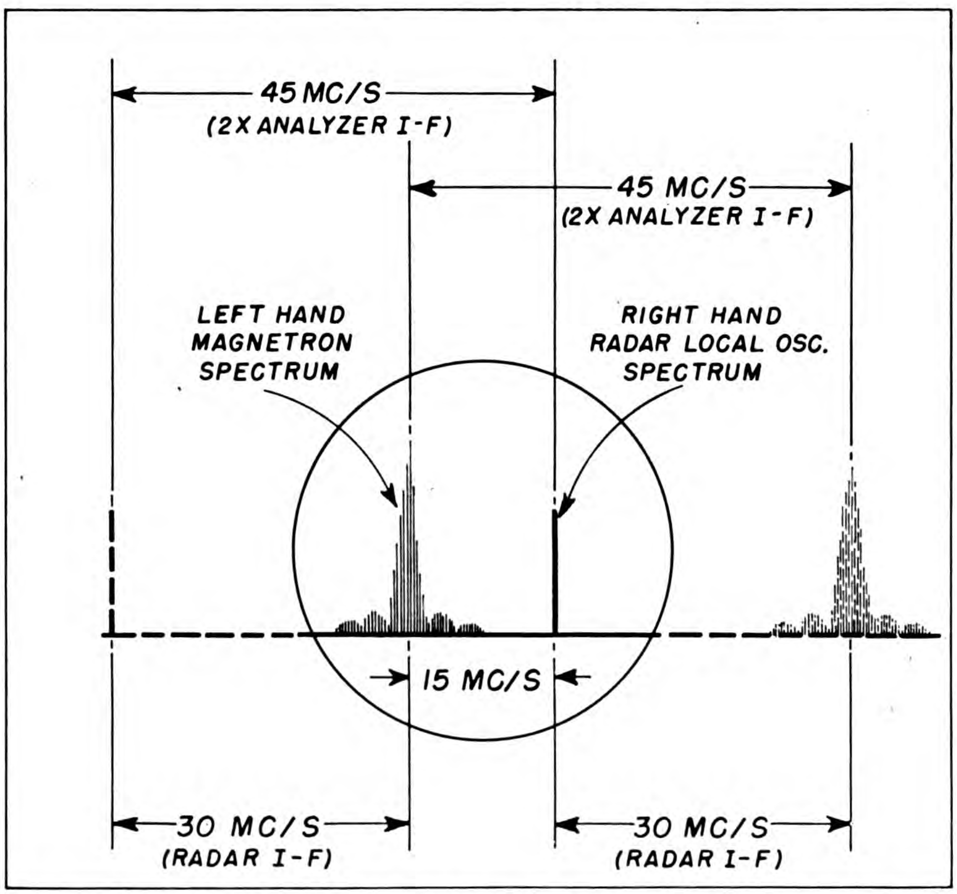


Figure 2-21. Measuring the Frequency of a Local Oscillator that is 30 Megacycles Below the Magnetron

scope screen presents a dynamic pattern of the band-pass characteristic of the r-f plumbing. To tune r-f plumbing proceed as follows:

(1) The first step is to measure the frequency of the magnetron, using the procedure outlined in Par. 6*c* of this section. The permissible tolerance is ±5 mc/s. Set the FREQUENCY dial to the *actual* frequency of the magnetron.

(2) Turn off the magnetron and local oscillator in the radar set and couple the Analyzer to the wave-guide of the radar transmitter-converter with the flexible wave-guide that comes with the Analyzer. The flexible wave-guide is packed in the Auxiliary and Spare Parts Box. Any flexible wave-guide that will fit a Type UG-40/U choke flange may be used. If the use of the flexible wave-guide is not practical, the coaxial line and wave-guide-to-coaxial line adapter may be used. The use of the wave-guide is recommended due to the attenuation present in the coaxial line.

(3) The proper use of the wave-guide is illustrated in Fig. 2-22. Avoid bending the wave-guide any more than is absolutely necessary. It should be bent gently and carefully to avoid damage. Fig. 2-10 illustrates the use of the coaxial line.

CAUTION

DO NOT APPLY POWER TO THE MAGNETRON WHILE THE ANALYZER IS DIRECTLY COUPLED TO THE TRANSMITTER-CONVERTER. TO DO SO WILL DAMAGE THE ANALYZER.

(4) Place the SELECTOR switch in its MIXER position, and adjust the bell-shaped pattern with the OSCILLATOR FREQUENCY and SPECTRUM CENTER controls until the frequency meter pip is exactly centered on top of the pattern, as shown in Fig. 2-5. DO NOT ADJUST THE FREQUENCY METER during this operation.

(5) Turn the SPECTRUM AMPLITUDE control to the minimum position and plug the Type CX-464/UP cable into the crystal current jack on the radar transmitter-converter and the MIXER AMPLIFIER jack on the Analyzer. This effectively replaces the Analyzer mixer with the mixer in the radar transmitter-converter.

(6) Tune the T/R Box until a pattern similar to the one in Fig. 2-23 is obtained.

(7) Adjust the T/R Box until the frequency meter pip appears at the top of the pattern. This is the pattern that represents the band-pass characteristic of the T/R Box and its width can be measured with the frequency meter. The pattern for a Type 1B24 T/R Box is not as wide as the pattern for a Type 724 T/R Box.

(8) Tune the R/T Box (anti T/R) for maximum amplitude of the resonant peak. In some cases, tuning the R/T Box has no effect. In others, it causes a broad dip to appear in the band-pass curve. The dip indicates that the action of the R/T Box is detrimental

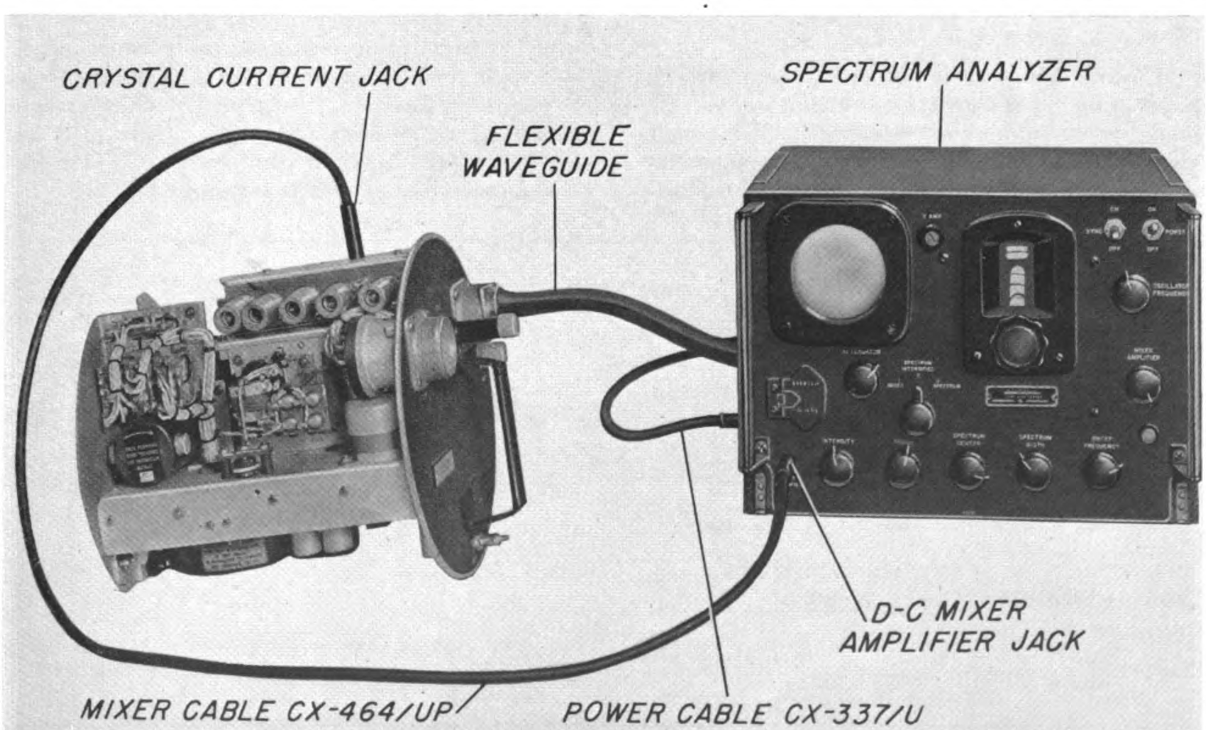


Figure 2-22. Spectrum Analyzer Coupled to Transmitter Converter to Tune R-F Plumbing

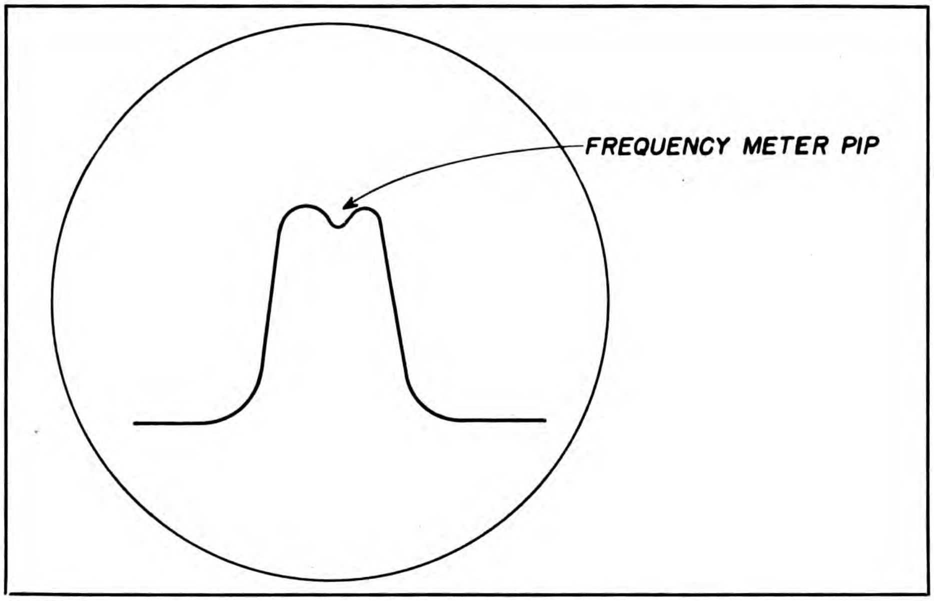


Figure 2-23. Bandpass Characteristic of a T/R Box

and it should be detuned to one side or the other. In a few cases, it will be found that the effect of the R/T Box is very pronounced.

(9) The amplitude of the band-pass pattern may be adjusted with the SPECTRUM AMPLITUDE control or with the MIXER AMPLIFIER control.

(10) The tuning procedure, outlined above, should be repeated each time a magnetron, crystal, T/R Box or R/T Box is replaced.

(11) Check the symmetry of the pattern. When the phone plug is removed from the Analyzer, the picture on the screen may be slightly distorted because of reflections back into the Analyzer. The symmetry of the pattern may be checked by turning the SPECTRUM AMPLITUDE control in a counterclockwise direction to eliminate the reflections.

(12) These reflections may be put to good use in checking the resonant frequencies of single components, such as frequency meters, T/R Boxes or echo boxes. A high Q component such as a frequency meter or echo box should produce a pip similar to the pip of the frequency meter in the Analyzer when coupled to the Analyzer's wave-guide. Sometimes it may be necessary to move the component under test back and forth in front of the Analyzer wave-guide to obtain the best pip. Its frequency may be measured by setting the Analyzer frequency meter to the same frequency and tuning it until the two pips coincide. A representative pattern is shown in Fig. 2-24.

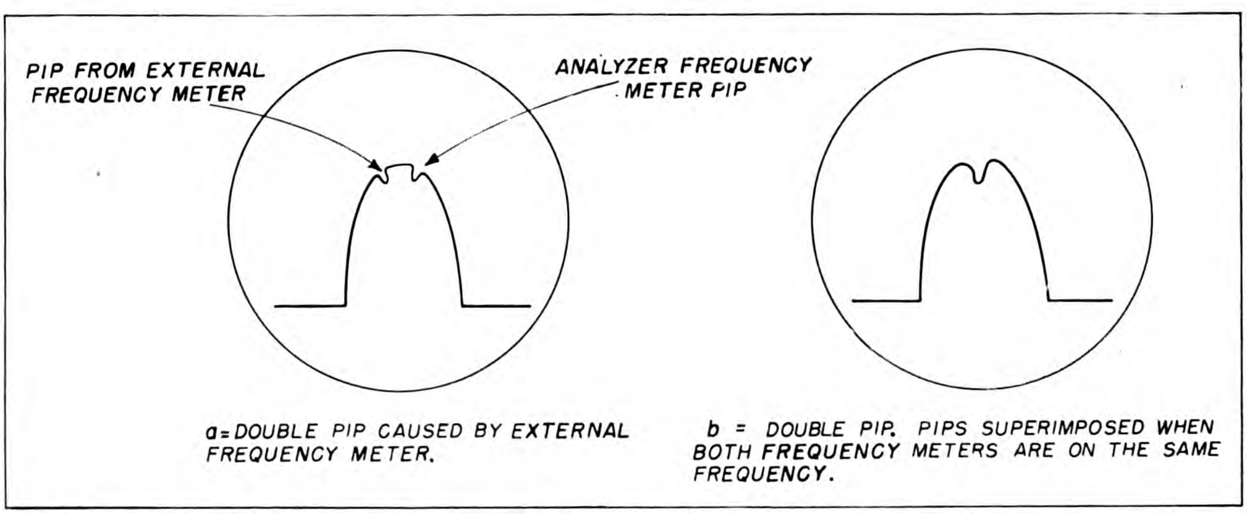
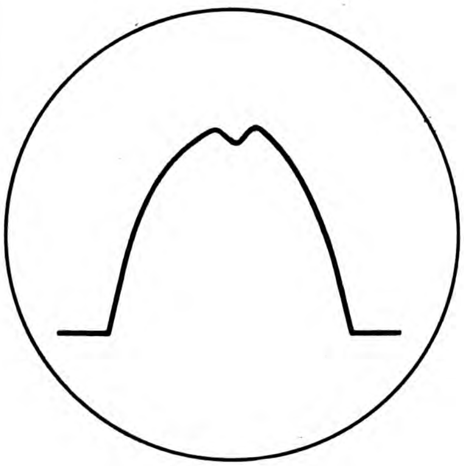
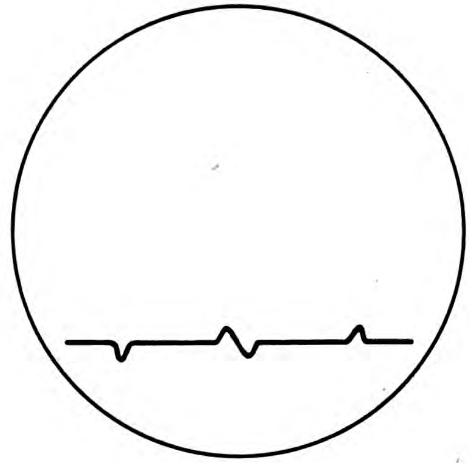


Figure 2-24. Double Pip on Analyzer R-F Oscillator Pattern when Another Resonant Cavity is Coupled to the Analyzer



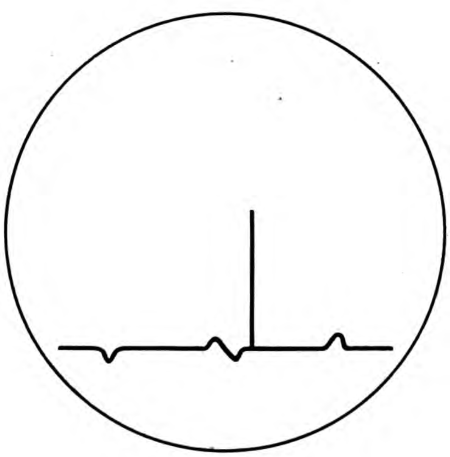
a. MIXER POSITION

NO SIGNAL PRESENT EXCEPT THAT OF ANALYZER R-F OSCILLATOR

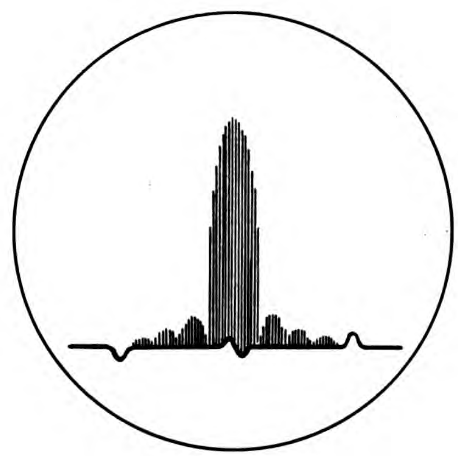


b. SPECTRUM INTENSIFIED OR SPECTRUM POSITION

NO OTHER SIGNAL PRESENT EXCEPT THAT OF ANALYZER R-F OSCILLATOR



c. CW SIGNAL



d. PULSED SIGNAL

MAXIMUM FREQUENCY SWEEP OF ANALYZER RF OSCILLATOR MAKES A LARGE NUMBER OF SIDE BANDS VISIBLE.

Figure 2-25. Representative CW and Pulsed Signals, Spectrum Width Control Full Clockwise

(13) It may be desirable to check the Analyzer frequency meter against a standard cavity by using the same procedure. A T/R Box produces a broad pip when held in front of the wave-guide. The ATTENUATOR must be set for minmium attenuation for these tests.

9. SPECTRUM ANALYZER USED AS A SIGNAL GENERATOR.

a. The Analyzer may be used as a CW or FM (frequency-modulated) signal generator depending upon whether the SPECTRUM WIDTH control is set at either of its extreme positions. If it is set completely counterclockwise then the frequency modulation is at a minimum (about 3 mc/s) and the output is essentially a CW signal. See Figs. 2-25 to 2-28.

b. If the control is turned all the way clockwise then the frequency-modulation is maximum and the output is an FM source 40 or 50 mc/s wide, depending upon the tube in the analyzer r-f oscillator. The output power ranges between 1 and 2 milli-watts.

10. USING THE SPECTRUM ANALYZER TO CHECK TEST SETS.

a. The Spectrum Analyzer may be used to check test sets. To check the output of CW or pulsed signal generators such as the TS-13/AP, or the TS-146/UP and TS-147/UP FM test sets, it is necessary to couple

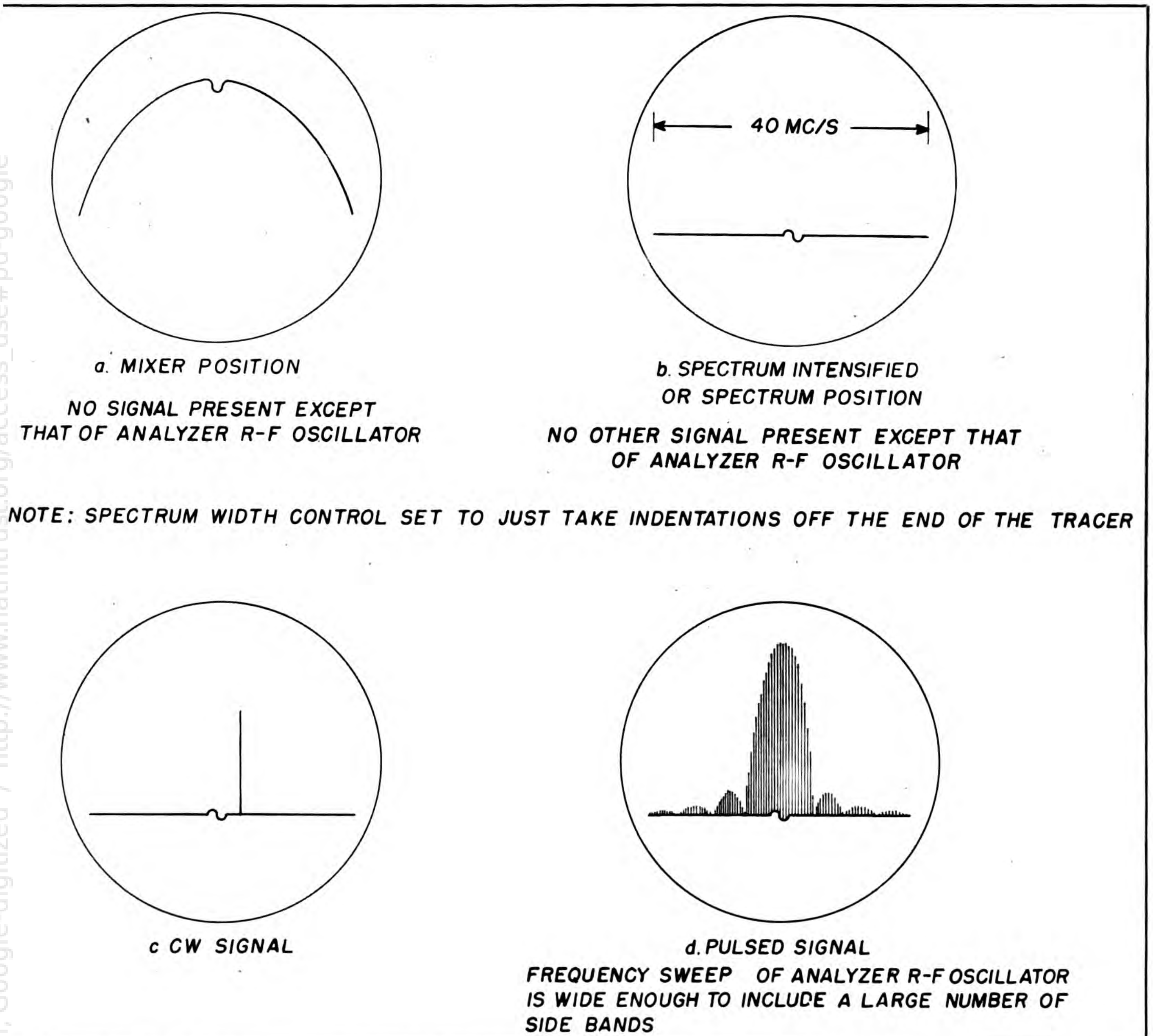


Figure 2-26. Representative CW and Pulsed Signals, Spectrum Width Control Adjusted to Take Outside Indentations Off the Screen

the set directly to the Spectrum Analyzer by means of the coaxial cable and the coaxial-to-wave-guide adapter.

b. Adjust the controls on the test set and observe, on the Analyzer, whether the proper spectrum appears on the screen. When switching from CW to pulse output on the TS-13/AP type of set, it will be necessary to decrease the amount of attenuation between the two sets before the pulsed spectrum will have sufficient amplitude to be seen.

c. A very good check of the FM signal generators can be made when they are delivering a CW output. That is, when no modulating voltage is being applied to the reflector of their oscillator tube. Figs. 2-24 to 2-27 show representative CW and pulsed signals for different settings of the SPECTRUM WIDTH Control.

11. THE ANALYZER AS A TUBE CHECKER FOR TYPE 2K25 OR 723A/B TUBES.

a. The Spectrum Analyzer may be used to determine whether a 2K25 or a 723A/B tube is working properly by placing it in the socket of the analyzer r-f oscillator, turning the SELECTOR switch to the MIXER position and adjusting the controls until the characteristic hump, or mode curve appears on the scope. Discontinuity in frequency, low power output, and non-oscillation at particular frequencies can be readily observed by this test.

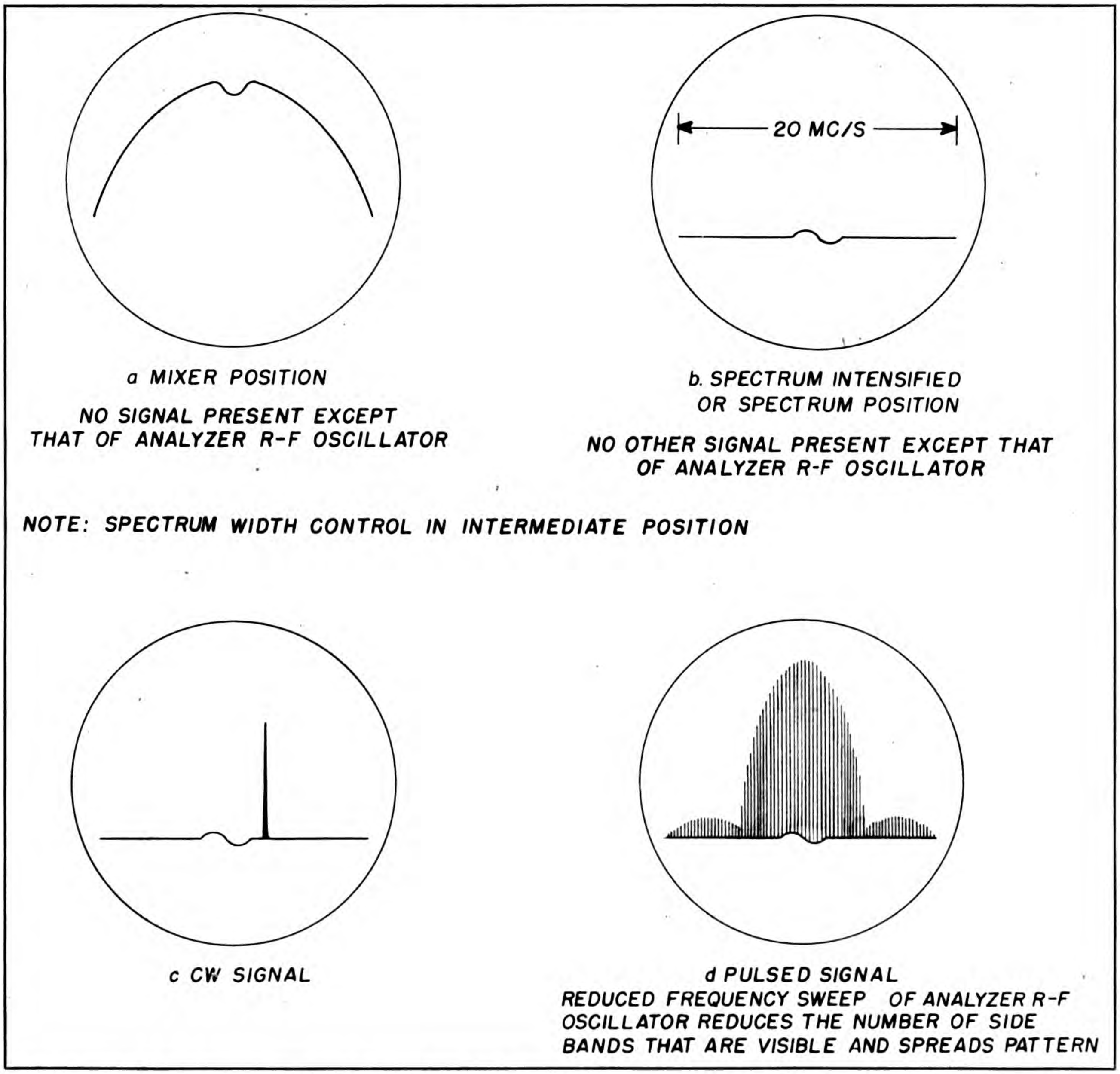


Figure 2-27. Representative CW and Pulsed Signals, Spectrum Width Control in Intermediate Position

b. The output of the tube may be checked roughly by comparing the amplitude of the pattern with the amplitude of the pattern of the analyzer r-f oscillator.

c. The mechanical tuning range may be checked by following it along with the frequency meter. The tube may be pre-set roughly to a given frequency by setting the FREQUENCY dial to the desired frequency and adjusting the mechanical tuning to place the frequency meter pip in the center of the hump or mode as it appears on the screen.

12. INTERPRETATION OF PATTERNS.

a. COMPOSITION OF A SPECTRUM.

(1) The factor of fundamental interest in the observation of the spectrum of a pulsed oscillator is the *envelope* of the pattern that appears on the scope. The individual lines are not particularly important.

(2) The spacing between the lines that appear to fill in the envelope of the spectrum, is due to the fact that the magnetron pulses are occurring at a frequency of 500 to 2000 cps. The sweep frequency of the scope may be as low as 10 cps. From 50 to 200 equally spaced pulses are thus *available* for the formation of the pattern of the spectrum. The number of lines that can be seen depends upon the following factors:

(a) Analyzer r-f oscillator sweep time.

(b) The number of magnetron pulses occurring during the period that the sweep is visible.

(c) Whether the analyzer r-f oscillator oscillates over the entire visible sweep.

(d) The setting of the SPECTRUM AMPLITUDE control.

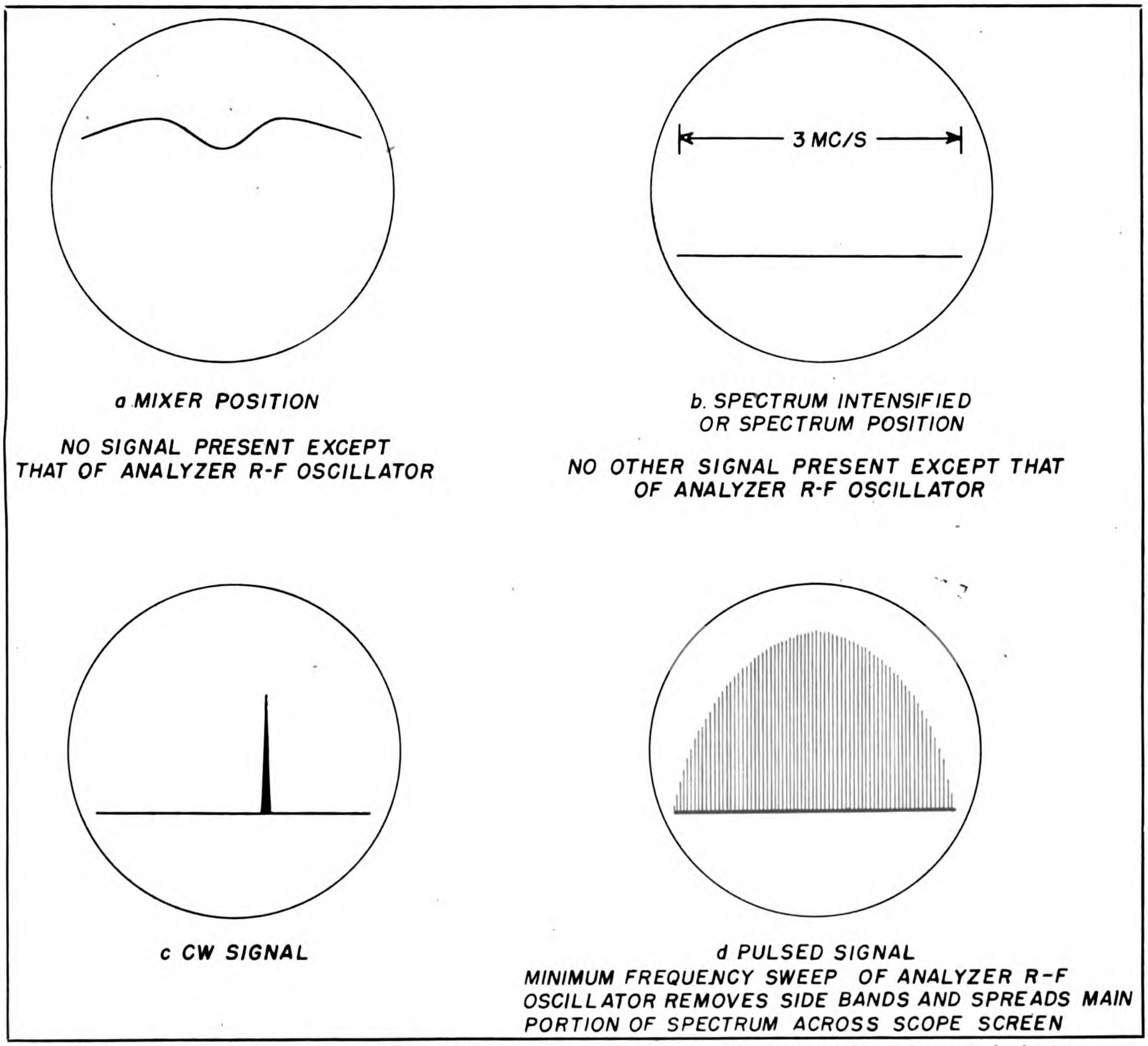


Figure 2-28. Representative CW and Pulsed Signals, Spectrum Width Control Full Counterclockwise

(3) It would be ideal to have a very slow sweep frequency for the oscilloscope, but sweep frequencies below 10 cps produce a very objectionable flicker in the pattern. Therefore the present system represents a practical compromise.

(4) The SPECTRUM WIDTH control permits the spectrum to be spread out on the screen to give a clearer picture of the envelope even though the actual number of pulses available for the pattern has not been changed. The SPECTRUM WIDTH control expands the spectrum to include, in the pattern, more of the available pulses. The SWEEP FREQUENCY control also varies the number of pulses that are visible on the screen but, as stated previously, its lower limit is 10 cps.

b. MAGNETRON SPECTRUM.

(1) When judging the merits of a magnetron spectrum, determine whether most of the magnetron power output is included in a frequency band that is equal to, or less than, the band-pass of the i-f amplifier in the radar receiver. If this is true, the radar set will operate at maximum efficiency and range. To determine the above, two observations are necessary.

(2) First determine whether the spectrum resembles closely the ideal spectrum shown in Fig. 2-29. If it doesn't, see Par. 12*c* of this section. If it does, determine whether the distance between the first two minima checks approximately, in frequency, with the frequencies and pulse lengths given in Fig. 2-30. These figures are ideal values but they compare favorably with those encountered in an actual system.

(3) A minimum may be defined as a point of lowest amplitude in the envelope of the spectrum. The final measurement of the distance between the first two minima is made with the frequency meter.

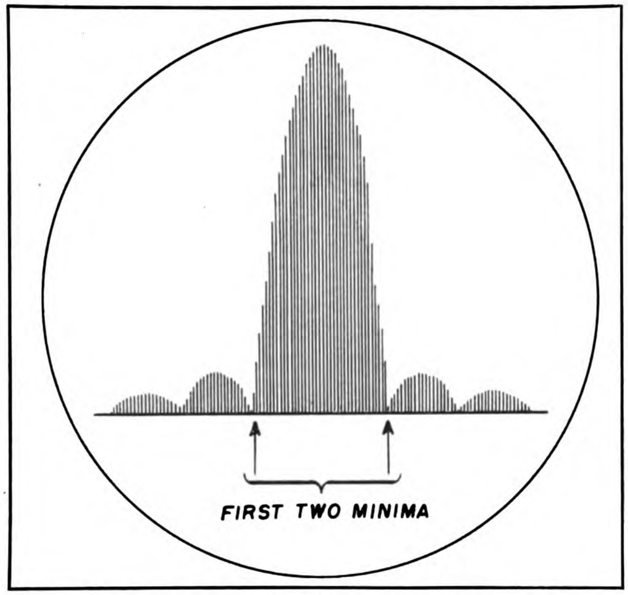
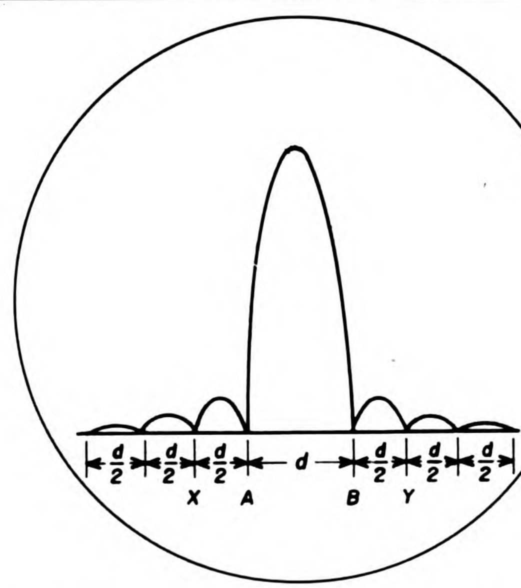


Figure 2-29. Ideal Magnetron Spectrum

In case of a narrow spectrum (long pulse length) it may be necessary to measure between several minima to get an accurate reading. The distance between any two adjacent minima is one-half of the distance between the first two minima.

PULSE LENGTH	d = DISTANCE IN MC/S BETWEEN FIRST TWO MINIMA
$\frac{1}{10}$ μS	20 MC/S
$\frac{1}{4}$ μS	8 MC/S
$\frac{1}{2}$ μS	4 MC/S
1 μS	2 MC/S
2 μS	1 MC/S
3 μS	$\frac{2}{3}$ MC/S
4 μS	$\frac{1}{2}$ MC/S
5 μS	$\frac{2}{5}$ MC/S



EXAMPLE: IF THE PULSE LENGTH IS 1 μS, THE FREQUENCY DIAL SHOULD SHOW 2 MC/S BETWEEN A & B OR 4 MC/S BETWEEN X & Y.

Figure 2-30. Relation Between Pulse Length and Spectrum Minima

(4) It is usually found that the band-pass of the receiver is slightly less than the distance between the first two minima for the shortest pulse to be used. The band-pass of a typical receiver for a .5 microsecond pulse is about 3 to 6 mc/s.

(5) The shape of the modulating pulse affects the shape of the spectrum. Up to this point only ideal spectra, produced by perfectly rectangular pulses, have been considered. In practice the keying pulses, applied to the magnetron, are not rectangular. The leading edge does not rise vertically, the top is not flat and the trailing edge droops off. All of these factors affect the output of the magnetron. The spectra of most magnetrons are altered by frequency and amplitude modulation. Since the shape of the pulse affects the frequency of the magnetron and its power output, it also affects the response and range of the radar receiver.

(6) Various pulse shapes produce characteristic spectra and a careful interpretation of imperfect spectra will often disclose the manner in which the pulse shape differs from the normal shape of the pulse.

(7) Consider a receiver with a 2-mc/s band-width to a one-microsecond pulse. Its response and range for a perfectly rectangular pulse may be considered to be 100 per cent. If the received pulse has linear frequency modulation of 1, 2, and 3 mc/s per microsecond, the response of the receiver will be 90%, 65%, and 50% respectively. The range of the equipment will be reduced to 97%, 90%, and 78% for the values given. Some abnormal pulses and their characteristic spectra are shown in Fig. 2-31.

(8) An examination of this figure shows that frequency modulation is evidenced by a decided increase in the amplitude of the side lobes while amplitude modulation causes more side lobes to appear and if frequency modulation is present the spectrum loses its symmetrical shape. If two large peaks appear, they may be caused by the pulse shape or the transmitter is being pulled in frequency. Pulling or double moding frequently occurs when the transmitter voltage or the line voltage is out of adjustment. The representative photographs of magnetron spectra in Fig. 2-32 illustrate examples of the effects of various pulse shapes. This figure is self-explanatory.

c. MAGNETRON ADJUSTMENTS.

(1) If the spectrum indicates pulling or if it does not indicate a pulse length and band-width that is reasonably close to the values in Fig. 2-30, the output voltage of the modulator may be adjusted. This is the only adjustment that can be made on most equipments and it seems to be most sensitive on the longer pulse lengths. If the adjustment is made while watching the Analyzer scope, the spectrum can be seen to go through a variety of shapes until, at the proper adjustment, the ideal spectrum appears.

(2) If an adjustment of the output voltage of the modulator does not produce a good spectrum, tests must be made to determine the cause of the trouble. Test the modulator or pulse transformers, the magnetron tube, and the wave-guide that is associated with the magnetron.

d. POWER MEASUREMENTS.

(1) The height of the pattern on the Analyzer scope corresponds to the power output of a signal. If one pulse in a spectrum is half as high as another pulse, the lower pulse has only half of the power in the other pulse. A magnetron spectrum should appear like the sketch of the ideal power spectrum for a pulsed magnetron shown in Fig. 2-29.

13. TUNING RADAR EQUIPMENT.

a. The Spectrum Analyzer is useful when tuning transmitter-converters in radar equipment. Since the AN/APS-6 series is representative of equipment which operates in the range covered by the Analyzer, its tuning procedures can be readily adapted to other equipments.

b. TUNING THE AN/APS-6.

(1) The following is a brief description of the method recommended for tuning the AN/APS-6. This description is primarily concerned with the Analyzer. For detailed instructions concerning the AN/APS-6 equipment as a whole, refer to Maintenance Instructions CO-AN08-30APS6-2.

(2) Turn the equipment on and operate it for 15 minutes to allow the magnetron to reach a stable operating temperature.

(3) Couple the Analyzer to the Scanner as shown in Fig. 2-9. Set the equipment on the 25-mile range.

(4) Adjust the output voltage of the modulator to produce a good spectrum as outlined in Par. 12 of this section.

(5) Measure the frequency of the magnetron. Do not change frequency meter during the remainder of this operation.

(6) *Turn the AN/APS-6 completely off.* See that the OPERATE-STANDBY switch is in the STANDBY position, and that cable P between the Transmitter-Converter and the Modulator is disconnected at the modulator.

(7) Couple the Transmitter-Converter directly to the Analyzer as shown in Fig. 2-22.

WARNING

DO NOT OPERATE THE MAGNETRON WHILE THE ANALYZER IS DIRECTLY CONNECTED. TO DO SO WILL CAUSE SERIOUS DAMAGE TO THE ANALYZER.

(8) Place the RADAR-BEACON switch in the RADAR position and check the oscillator relay to see that it is in the radar position.

(9) Energize the radar shutter relay with 24 volts to keep it from blocking the wave-guide to the mixer during the tuning operation.

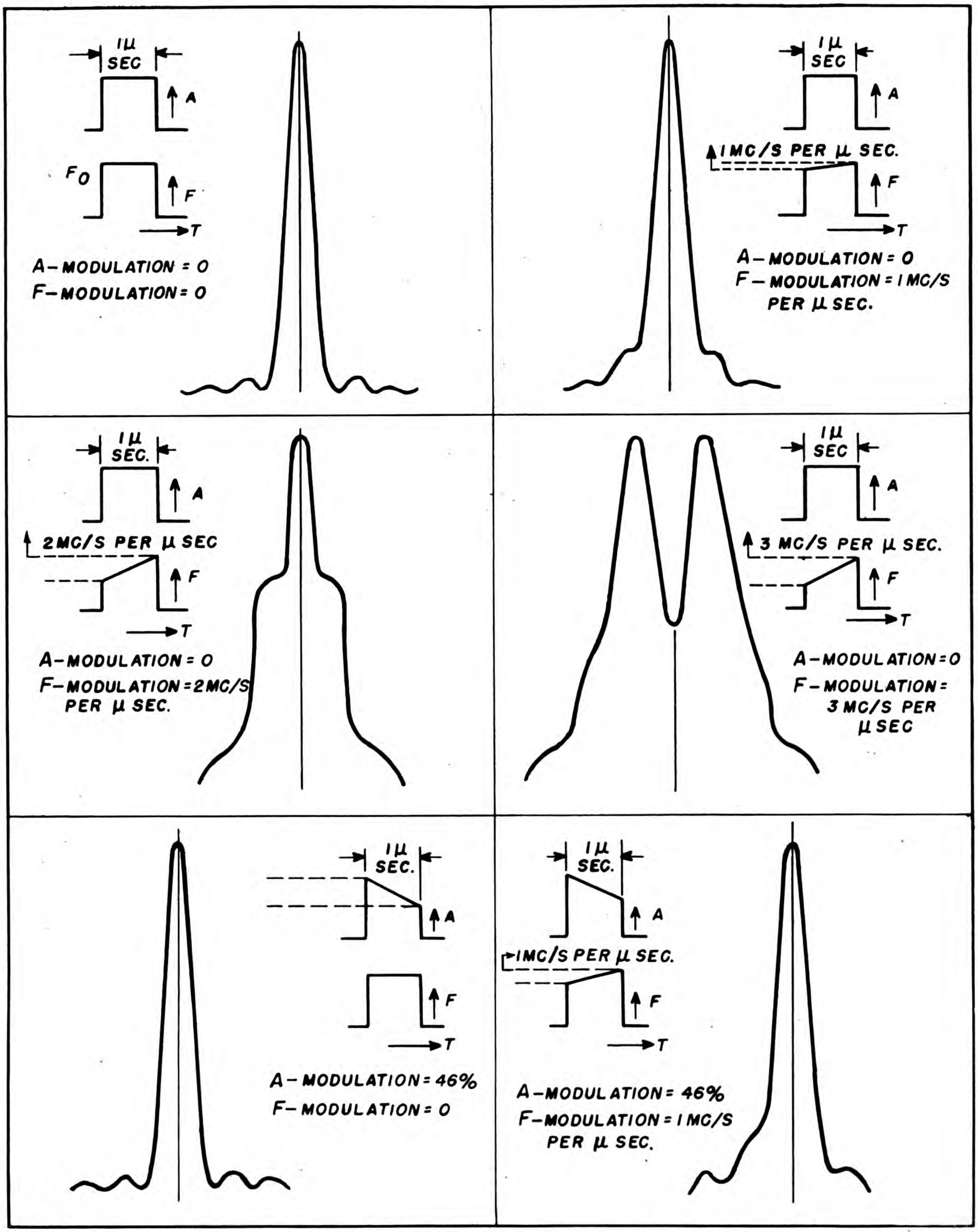
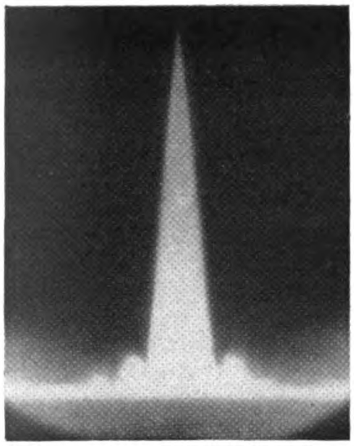
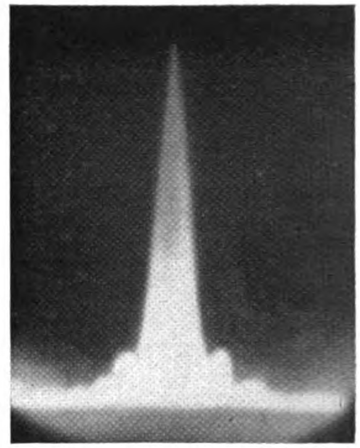


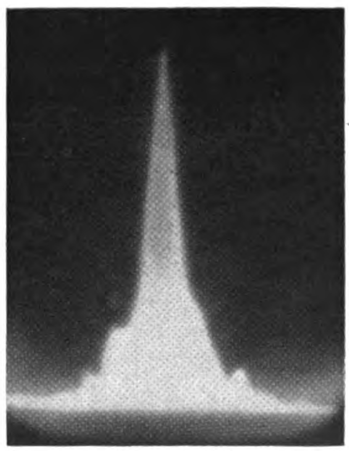
Figure 2-31. Representative Magnetron Spectra



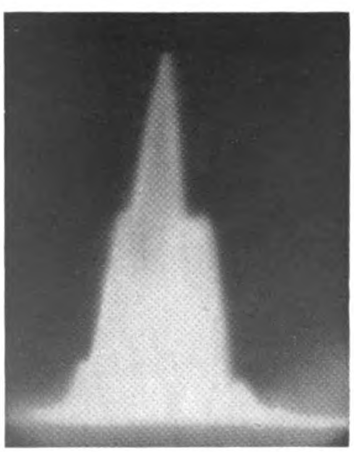
1. Good spectrum. Small side bands with distinct minima, indicating zero frequency and amplitude modulation. Receiver response 100 per cent.



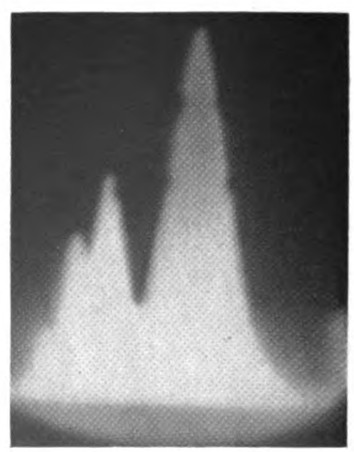
2. Fair spectrum. Frequency modulation of one megacycle per second per second shifts pattern to left and increases side band amplitude. Receiver response 88 per cent.



3. Poor spectrum. Slight amplitude modulation evidenced by disappearance of first minimum on right and appearance of additional side bands. Frequency modulation is one megacycle per second per second.



4. Very poor spectrum. Frequency modulation is two megacycles per second per second. Pattern shows marked shift to left and increased side band amplitude. Receiver response 68 per cent.



5. Bad spectrum. Forty-five per cent of amplitude modulation evidenced by additional peaks and unsymmetrical shape. Frequency modulation of three megacycles per second per second causes appearance of two large peaks three megacycles apart. Receiver response 45 per cent

Figure 2-32. Effects of Frequency and Amplitude Modulation on the Shape of Magnetron Spectra

These spectra are produced by a one-microsecond pulse. Frequency increases from left to right and the width of the screen is 9.5 megacycles. Receiver response is based on the performance of a receiver with a two-megacycle bandwidth.

(10) Tune the T/R Box and the R/T Box (anti-T/R) as outlined in Par. 8 of this section.

(11) Turn the equipment on. *Be certain that the OPERATE-STANDBY switch is in the STANDBY position.*

(12) Disconnect the Analyzer from the Transmitter-Converter.

(13) Turn the AFC on and remove the AFC crystal cable or one of the AFC tubes. *Do not remove either V-315 or V-316.*

(14) Set up the Analyzer to pick up the radar local oscillator. This oscillator is the one closest to the center of the Transmitter-Converter. Use the method as shown in Fig. 2-11.

(15) Plug a meter, with a one-ma. range, into the crystal current jack on the Transmitter-Converter.

(16) Set the TUNING control to the mid-scale position on MANUAL.

(17) Adjust the radar local oscillator's mechanical and electrical tuning controls to obtain the results outlined in Par. 7*b*. of this section. Do not disturb frequency meter setting.

(18) Adjust the crystal current screw to obtain the proper amplitude of crystal current as indicated on the meter. This current must not exceed 1 ma. When the oscillator is tuned manually only 1 mode should be obtained.

(19) Replace the AFC crystal cable, or tube, and note whether the frequency meter pip, as previously set, is in the center of the pattern. If it is not, adjust the AFC discriminator's screwdriver adjustment until the pattern centers on the frequency meter pip.

(20) Place the beacon local oscillator in operation by turning the RADAR-BEACON switch to BEACON.

(21) Place the TUNING control in the MANUAL position.

(22) Couple the Analyzer to the beacon local oscillator. The beacon local oscillator is the one farthest from the center of the Transmitter-Converter. Use the method shown in Fig. 2-11.

(23) Tune the beacon local oscillator in the same manner outlined above and in accordance with Pars. 7*b*. and 7*c*. of this section.

c. TUNING THE AN/APS-6A.

(1) The following procedure is recommended for tuning the AN/APS-6A.

(2) Turn the equipment on in accordance with the procedure outlined in its instruction manual. Allow it to operate for 15 minutes to insure that the magnetron has reached a stable operating temperature.

(3) Couple the Analyzer to the Scanner as shown in Fig. 2-9 and adjust the output voltage of the modulator to produce a good spectrum as outlined in Par. 12 of this section. Refer to the instruction manual of the AN/APS-6A for the proper procedure involved in this step.

(4) Measure the frequency of the magnetron as outlined in Par. 6*c*. of this section.

(5) *Turn the AN/APS-6A completely off*. See that the OPERATE-STANDBY switch is in the STANDBY position. Disconnect cable P at the Modulator.

(6) Couple the Analyzer directly to the Transmitter-Converter RT-32/APS-6A as shown in Fig. 2-22.

WARNING

DO NOT OPERATE THE MAGNETRON WHILE THE ANALYZER IS DIRECTLY CONNECTED. TO DO SO WILL CAUSE SERIOUS DAMAGE TO THE ANALYZER.

(7) Tune the T/R and R/T Boxes as outlined in Par. 8 of this section.

(8) Disconnect the Analyzer from the Transmitter-Converter.

(9) Set up the Analyzer to pick up the radar local oscillator. See Fig. 2-11 and Par. 7*b*. of this section.

(10) Turn the AN/APS-6A on, keeping the OPERATE-STANDBY switch in the STANDBY position.

(11) Check the RADAR-BEACON switch on the Control Unit to see that it is in the RADAR position and check the oscillator relay in the Junction Box to see that it has placed the radar local oscillator in operation.

(12) Plug a milliammeter with a one-ma. range into the crystal current jack.

(13) Place the TUNING control at the mid-position on the MANUAL scale.

(14) Turn the AFC on and remove one of the AFC tubes on the i-f strip in the Receiver Amplifier. *Do not remove either V-614 or V-615.*

(15) Adjust the radar local oscillator tuning controls to obtain the results outlined in Par. 7*b*. of this section. Do not disturb the position of the frequency meter pip after the final adjustment has been made. The meter should indicate maximum crystal current at this point.

(16) Replace the AFC crystal cable or tube and adjust the AFC screwdriver adjustment until the radar local oscillator pattern centers over the frequency meter pip.

(17) Turn the RADAR-BEACON switch to BEACON.

(18) Place the TUNING control in the MANUAL position. Set it in the same mid-scale position that was used for the radar local oscillator.

(19) Couple the Analyzer to the beacon local oscillator. The beacon local oscillator is the upper of the two local oscillators and is adjusted from the side. Use the method shown in Fig. 2-11.

(20) Tune the beacon local oscillator with the mechanical adjustment until the results outlined in Pars. 7*b*. and 7*c*. of this section have been obtained.

SECTION III
THEORY OF OPERATION

1. GENERAL.

a. FUNCTION OF THE SPECTRUM ANALYZER.

(1) The TS-148/UP Spectrum Analyzer is a test instrument that displays, on an oscilloscope, a pattern representative of the distribution of energy among the various frequencies in the output of a pulsed oscillator. As is explained in paragraph 1*b.*, below, the spectrum of a pulsed oscillator consists of energy distributed among many different frequencies. The Spectrum Analyzer presents, on an oscilloscope display, a pattern in which the relative amplitudes of many of the various frequencies of the spectrum are plotted on the vertical, or Y-axis, while the frequencies themselves are plotted on the horizontal, or X-axis, of the tube. The overall pattern of this display may be interpreted so as to indicate the proportion of power present at the various frequencies within the spectrum.

b. FORMATION OF A SPECTRUM.

(1) A common conception of the output of a pulsed oscillator is a single frequency which is turned on and off for periods of standard duration, similar to the output of a conventional c-w telegraph transmitter. The output of the radar oscillator does not consist of a fundamental frequency that is turned on and off but must be considered as a fundamental frequency that is amplitude-modulated by the waveform of the pulse repetition frequency.

(2) It must be understood that any fundamental frequency, when modulated by another frequency, will produce a fundamental frequency with sideband frequencies which are collectively called a spectrum. In other words, *the output will appear on more than one frequency.* The distribution of the power on these frequencies is a function of the modulation and is called a spectrum. Normally, modulation is plotted on an amplitude and time basis, as shown in Part 1 of Figure 3-1. Part 2 of this figure shows the spectrum produced by a fundamental frequency when it is modulated by frequencies Fp_1, Fp_2 and Fp_3.

(3) Assume F to be the fundamental frequency of an oscillator. A waveform of this fundamental frequency, plotted as amplitude against time, is shown in Ⓐ in Part 1 of Figure 3-1. The number of periods $\left(\frac{1}{F}\right)$ occurring within one second determines the frequency of the oscillation. The amplitude is represented as proportional to the distance between the negative and positive peak of one cycle of oscillation.

(4) In a spectrum pattern, this same frequency and amplitude would be represented as Ⓐ in Part 2 of Figure 3-1. Points along the horizontal coordinate represent frequency, which increases from left to right, while distances along the vertical coordinate above the baseline represent amplitude. Parts 1 and 2 of Figure 3-1 represents two methods of diagramming the results of amplitude-modulating a carrier frequency.

(5) Assume Fp_1 is a modulation frequency applied to the fundamental frequency, *F*. This is normally represented on an amplitude versus time basis as Ⓑ in Part 1 of Figure 3-1. Note that the maximum amplitude does not exceed the unmodulated amplitude as it does in the usual representation of the envelope of amplitude modulation. The reason for this is to provide a greater similarity between amplitude modulation and pulse modulation. This same type of modulation is represented by *two* lines on the spectrum pattern. These lines are marked $F + Fp_1$ and $F - Fp_1$ in Part 2 of the figure. The reason for this is that the modulated wave actually represents the results of *heterodyning,* two different frequencies. In other words, the modulation produces the same envelope that would be produced by heterodyning the side band and fundamental frequencies shown in Fig. 3-1. It follows that these frequencies are effectively present in the modulated envelope and can be detected by suitable receivers. The two frequencies producing the spectrum are *F* and Fp_1 the fundamental and modulating frequency, respectively. The result is the production of two additional frequencies as stated previously. One of these is the *sum* of the two frequencies, while the other is the *difference* between them. The amplitudes of the new frequencies are each half of the amplitude of the modulating frequency.

(6) Assume also, that a second harmonic of the modulating frequency also exists. This is usually of a lower degree of amplitude than the fundamental of the modulating frequency. Call this frequency Fp_2. Another set of waves is developed, as shown in Parts 1 and 2 in Fig. 3-1. The amplitude of the two new frequencies created is of a lower order than those created by Fp_1.

(7) Additional modulating frequencies will produce additional side band frequencies. Since these frequencies are normally present in a harmonic relationship, the net result is a number of different frequencies above and below the carrier. The difference between any two adjacent frequencies is equal to the fundamental modulating frequency.

c. SPECTRUM OF A PULSED OSCILLATOR.

(1) Usually a pulse modulated oscillator is pulsed by the application of a rectangular wave of

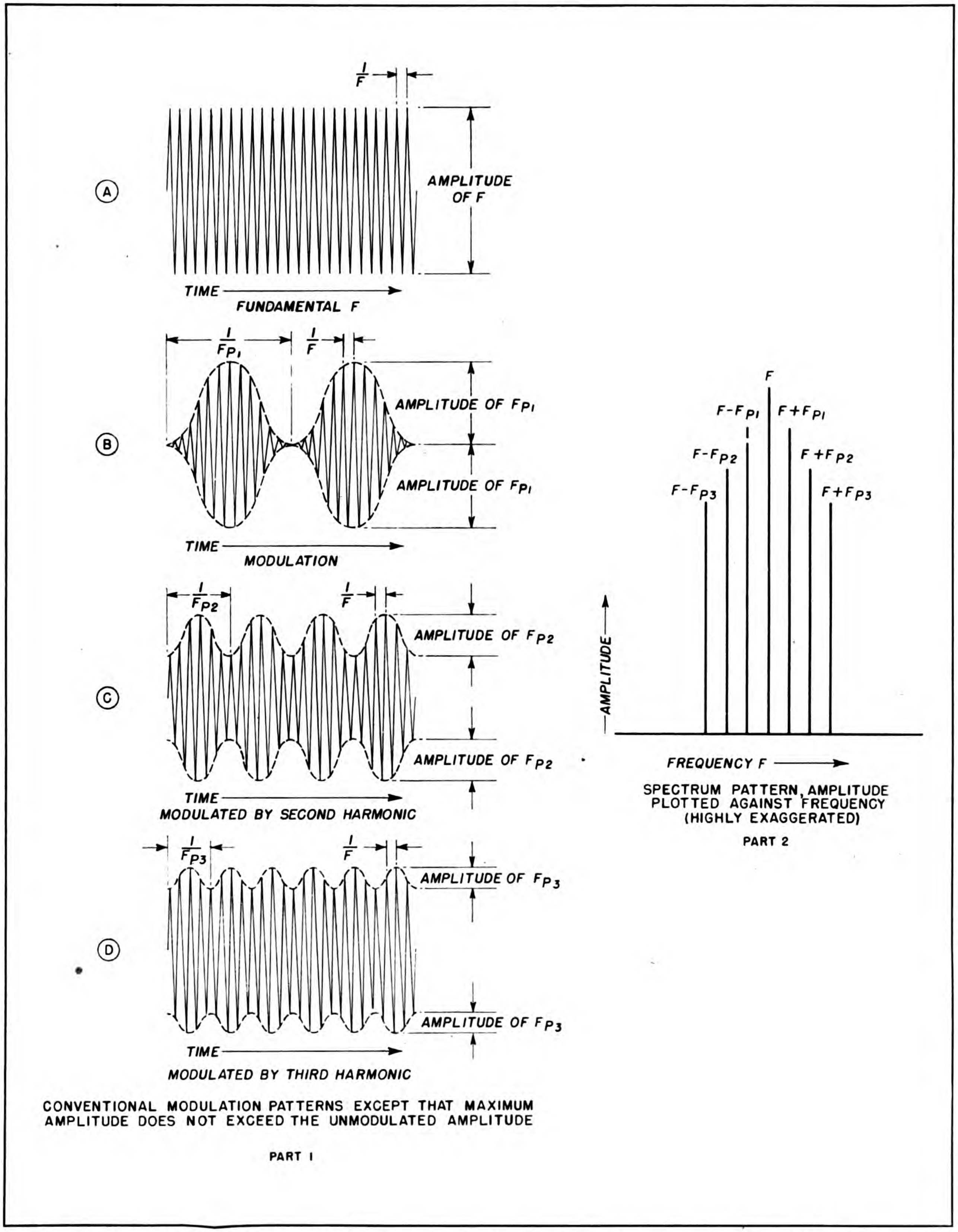


Figure 3-1. Comparison of a Plot of Amplitude vs. Time With a Plot of Amplitude Against Frequency

voltage to an oscillator circuit. A narrow rectangular wave of voltage contains an exceedingly wide range of harmonics, including harmonics of a very high order. A rectangular wave of voltage can be considered as a summation of a sine wave fundamental of the repetition frequency plus an infinite number of sine wave harmonics. Consequently a pulsed oscillator may be assumed to be an oscillator modulated by a modulation frequency which is exceedingly rich in harmonics. A pulsed oscillator, turned on and off as in Figure 3-2, produces an output similar to that which would be produced by a sine wave repetition frequency and its harmonics phased so that their summation would produce a waveform similar to the modulating pulses.

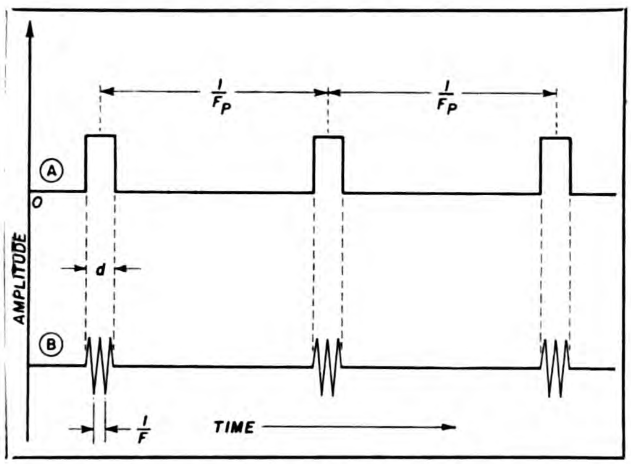


Figure 3-2. Output of Pulsed Oscillator

(2) In Figure 3-2, the pulse frequency and the basic frequency of the pulsed oscillator are shown on a time and amplitude graph. From this, it might appear that the output was simply a pure c-w wave, of constant amplitude and frequency turned on for brief intervals of time. This cannot be true because of the presence of the modulation frequency *Fp* and the very large number of harmonics of the modulation frequency, Fp_1, Fp_2, etc. The fundamental modulation frequency and its many harmonics may be considered to modulate the oscillator to produce a fundamental frequency with many side bands. The net result is a spectrum such as was developed in Figure 3-1, except that it is extended to a very large number of frequencies above and below the fundamental frequency. Such a spectrum is shown in Part Ⓐ of Figure 3-3. The pulse frequency that produces this spectrum is shown in Part Ⓑ of Figure 3-3. The output of the oscillator consists of an infinite number of lines representing different frequencies. However, due to the harmonic relationship between the modulation frequency and its harmonics, these lines will always be separated by a distance on the base line that is equal to the modulation frequency.

(3) From the above discussion, it may be deduced that the amplitude versus frequency plot, will provide an envelope which is of value in estimating the power distribution in the output of a pulsed oscillator. This spectrum, as plotted on the spectrum analyzer is a power spectrum due to the square law characteristics of the analyzer's detector. The true power spectrum, which represents the voltage, (or amplitude) squared (E^2) is shown as Part Ⓓ of Figure 3-3. This power spectrum emphasizes even more forcefully than the voltage spectrum in Part Ⓐ in the same figure, the importance of confining the majority of the power at the fundamental frequency of the pulsed oscillator. Actually the Spectrum Analyzer pattern, as shown in Figure 3-3, Part Ⓒ represents only a "sampling" of the spectrums. Each of the separated lines seen on the spectrum represents a section of the spectrum. The explanation of this pattern is given later in this section.

(4) The actual power amplitude of any frequency may be computed by mathematics using Fourier's formula for harmonic analysis. This formula may be found in any standard calculus book. Part Ⓓ of Figure 3-3 effectively shows the results of this calculation for a standard oscillator when pulsed by a standard pulsing circuit. The Spectrum Analyzer, by providing a power spectrum, provides an effective means of approximating the power components of the spectrum. It can be of great value in tuning up a pulsed oscillator so as to provide the greatest range of power output in the band-pass circuits of the receiver.

d. PRACTICAL ANALYSIS OF A SPECTRUM.

(1) The following analysis of a spectrum assumes a fundamental oscillator frequency of 9,000 mc/s (or 9,000,000 kc/s) and a pulse repetition frequency of 2,000 cps (or 2 kc/s). Two sidebands would be produced. One of these would be a frequency representing the fundamental plus the modulation frequency (9,000,002 kc/s) while the other would be a frequency equivalent to the difference (8,999,998 kc/s) between the two frequencies. Therefore, if this were the *only* frequency modulating the fundamental frequency, the output would appear on *three* frequencies, namely, the fundamental frequency, a frequency equal to the fundamental plus 2 kc/s, and the fundamental frequency minus 2 kc/s. The difference between any two adjacent frequencies would be 2 kc/s, or the repetition frequency.

(2) The second harmonic of the pulse frequency is 4 kc/s. The second harmonic produces two additional frequencies which are 4 kc/s above and 4 kc/s below the fundamental frequency of the oscillator. The third harmonic produces two more frequencies which are 6 kc/s above and below the oscillator frequency. It can be seen that all of these frequencies are 2 kc/s apart, which is the fundamental

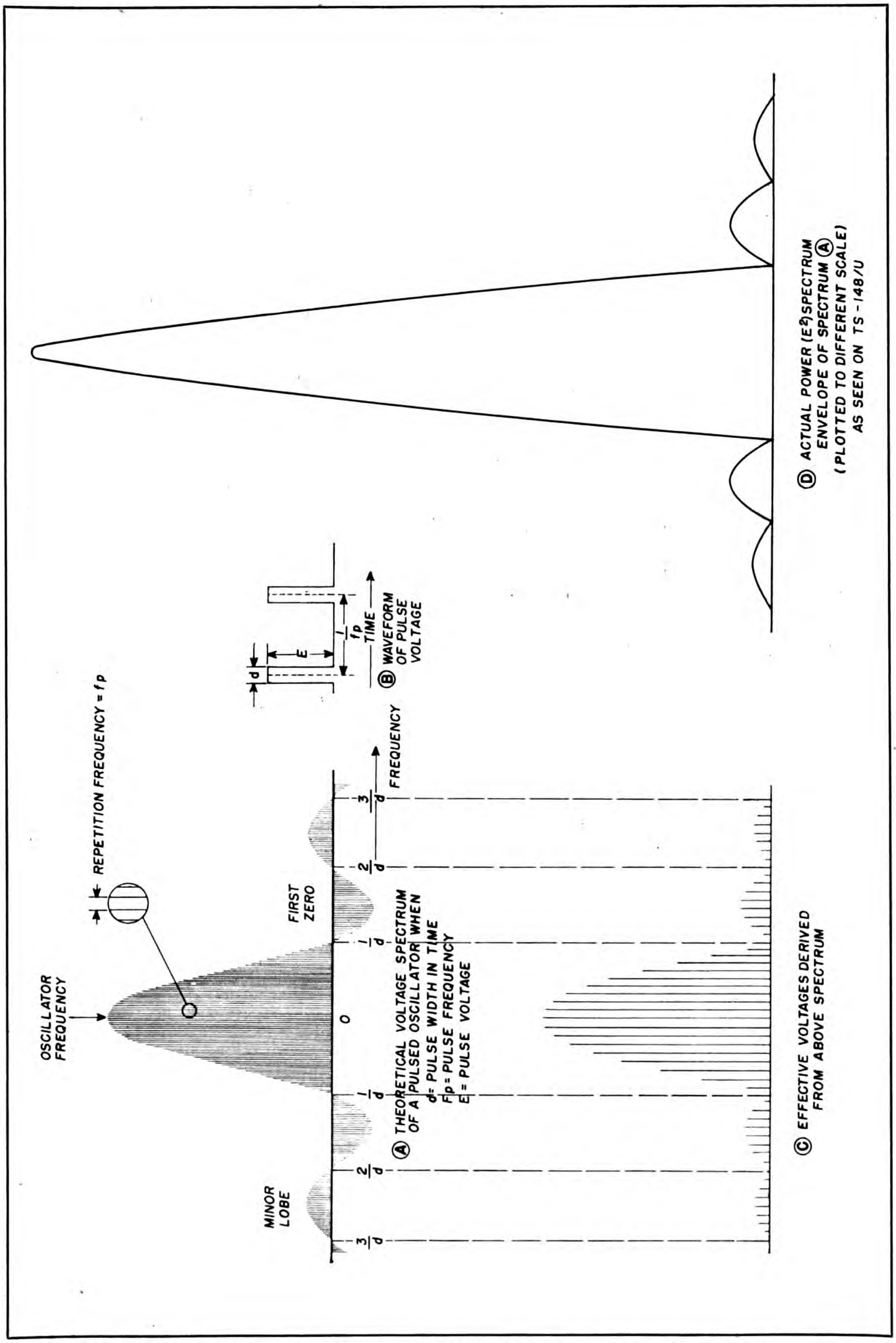


Figure 3-3. Relationship Between a Voltage Spectrum and a Power Spectrum

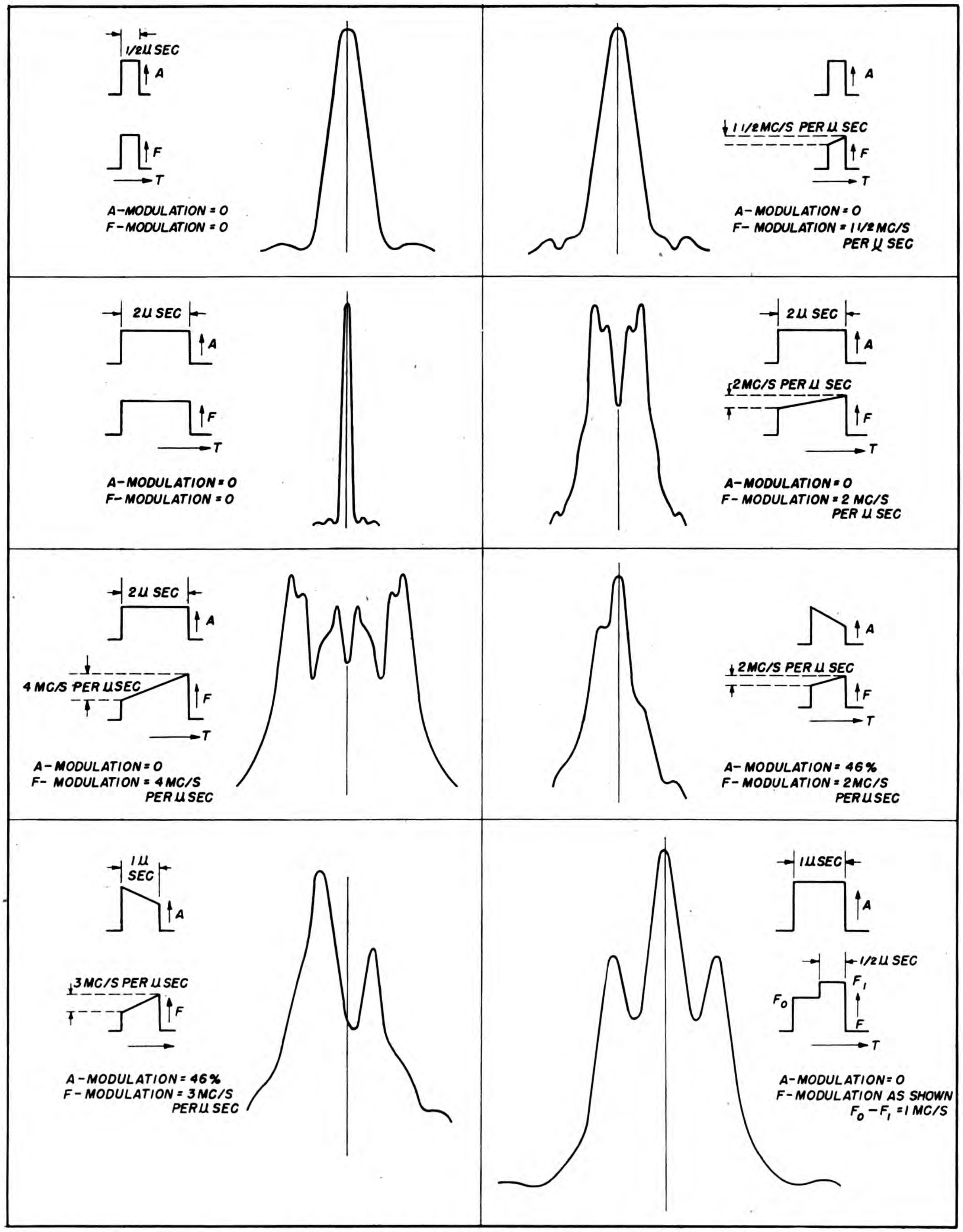


Figure 3-4. Spectra Showing the Effect of Frequency Modulation

pulsing frequency. Consequently the spectrum produced by a pulsed oscillator may be said to be formed of the amplitude of various frequencies which are separated on the baseline by a distance that represents the frequency of the repetition rate.

(3) This condition obtains only when a *true* rectangular pulse is applied to the oscillator. In actual practice, the pulse applied to the oscillator is not a true rectangular wave. The flat top usually has a negative or positive slope. The trailing edge is not vertical, but droops. In addition, certain transients are present in the pulse. These transients have a harmonic "family" of frequencies of their own, all of which are present in the pulse. These additional frequencies of the rectangular wave cause both amplitude and frequency modulation of the oscillator. The effect of amplitude modulation is to increase the number of side bands in the spectrum, while the effect of frequency modulation is to increase the amplitude of the sidelobes, since the actual fundamental frequency of the oscillator is shifted back and forth between points on each side of its true fundamental frequency.

(4) Certain spectra, showing the effects of frequency modulation are shown in Fig. 3-4, and the causes of unusual spectra are described with the various parts of this figure. Some general conclusions may be drawn from the spectra shown in these figures. These conclusions are as follows:

(a) The width of the center lobe of an ideal spectrum should not greatly exceed the bandwidth of the receiving section of the radar set. Otherwise power will be wasted which will result in a reduced output from the receiver.

(b) A spectrum without deep minimum points adjacent to the main lobe indicates frequency modulation of the oscillator.

(c) If two distinct peaks are observed on the

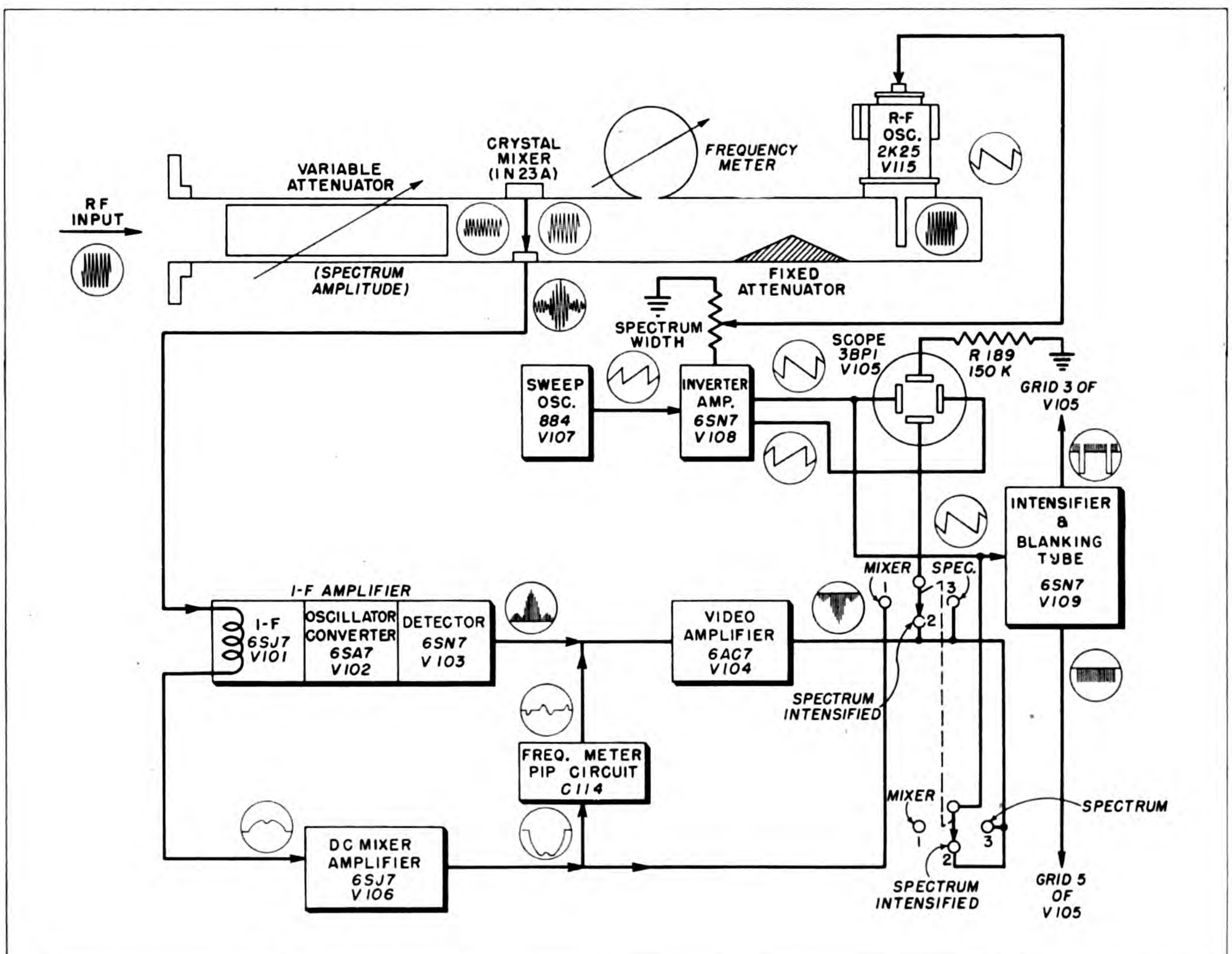


Figure 3-5. Spectrum Analyzer, Block Diagram

spectrum, the transmitting oscillator is operating in two modes, or is being pulled in frequency by some external force, such as a poorly matched rotating antenna or fluctuating voltages.

(d) The frequency difference between two peaks indicates the amount of frequency pulling, or scattering. The height of each of these peaks represents the proportional amount of power at the frequency of each of the peaks.

(e) The width of the modulating pulse may be determined by measuring the distance between the minima on each side of the main portion of a good spectrum. The measurement of pulse width and the conclusions which may be drawn are described in Section II, Par. 12*b*.

2. BLOCK DIAGRAM.

a. GENERAL.

(1) The TS-148/UP Spectrum Analyzer consists of a superheterodyne receiver with a frequency-modulated r-f oscillator. The analyzer r-f oscillator is modulated with a sawtooth voltage. As the frequency of the analyzer r-f oscillator increases, it beats with the incoming signal to produce an i-f signal for various frequency components present in the spectrum of the received r-f signal. These signals are presented on a cathode ray oscilloscope to produce the patterns described in Par. 1 of this section.

b. MAJOR OPERATING CIRCUITS.

(1) The block diagram in Fig. 3-5 shows the basic circuits of the Spectrum Analyzer. A clear understanding of each block or circuit will enable the reader to follow more easily the detailed theory of operation.

(2) ATTENUATOR.

(a) The attenuator consists of two carbonized resistance cards inserted in the r-f input end of the wave-guide. Varying the contour of these cards varies the degree of attenuation. Maximum attenuation is obtained when the cards are flexed together in the center of the wave-guide. The attenuator controls the amplitude of the r-f signal entering the analyzer, or leaving the analyzer.

(3) ANALYZER R-F OSCILLATOR.

(a) The analyzer r-f oscillator is a reflex type velocity-modulated tube. It is frequency-modulated by a portion of the sweep voltage that is applied to the oscilloscope. Modulating voltage is obtained from the output of the sweep amplifier, and it provides a frequency swing of 40 to 50 mc/s. Its output is attenuated to the proper level by the fixed resistance card (E-101C) in the wave-guide.

(4) CRYSTAL MIXER.

(a) Farther down the wave-guide is a fixed crystal. The incoming r-f signal and the output of the analyzer r-f oscillator are mixed at the crystal. The output is applied to the input circuit of the tuned 22.5-mc/s i-f amplifier to produce the intermediate frequency of 22.5 mc/s.

(5) FREQUENCY METER.

(a) The frequency meter is mounted on the wave-guide at a point between the crystal mixer and the analyzer r-f oscillator. The frequency meter is an absorption type meter and it consists of a cavity with dimensions that can be varied by a front-panel control. Each time the frequency of the analyzer r-f oscillator passes through the resonant frequency of the frequency meter, the frequency meter absorbs some r-f power and causes a sharp decrease in the amplitude of the output of the analyzer r-f oscillator that is applied to crystal. This change in amplitude is caused to appear on the scope as a sharp pip that is used as a frequency marker. A smaller pip occurs when the frequency of the r-f input coincides with the frequency of the frequency meter.

(6) FIRST I-F AMPLIFIER.

(a) The output of the crystal mixer is applied to the input circuit of the 22.5-mc/s intermediate frequency amplifier. This amplifier is resonant at 22.5 mc/s. The output of this stage is applied to the oscilator-converter.

(7) OSCILLATOR-CONVERTER.

(a) This stage is used to obtain the narrow band-width of 50 kc/s. It contains a local oscillator operating at a frequency of 19.5 mc/s. The intermediate frequency is changed to three megacycles in this stage by beating the 19.5-mc/s frequency against the 22.5-mc/s frequency. The sharply tuned plate circuit of this stage produces the narrow band-pass characteristic that is required. The output is applied to the detector stage.

(8) DETECTOR-VOLTAGE REGULATOR.

(a) The output of V-102 is connected to one of the grids of the double-triode V-103. The detector section functions as an infinite-input-impedance detector. The rectified output of the detector is taken from the cathode of the tube and coupled to the grid of the video amplifier V-104. The other section of V-103 is a voltage regulator. It controls the screen voltage of the video amplifier.

(9) VIDEO AMPLIFIER AND FREQUENCY METER PIP CIRCUIT.

(a) This stage has two input voltages. One is the output of the detector and the other is the frequency meter pip obtained from the d-c amplifier through a differentiating circuit. The output of the video amplifier is coupled to the vertical deflecting plates of the oscilloscope tube. A portion of the video output is used to trigger the intensifying section of V-109.

(10) D-C MIXER AMPLIFIER.

(a) When the SELECTOR switch is in MIXER position 1, in Fig. 3-5 the d-c mixer amplifier amplifies

the output of the crystal mixer and applies it through the SELECTOR switch to the vertical plates of the scope for test purposes. A jack allows the crystal mixer of a radar set to be connected to the input circuit of this stage instead of the crystal mixer of the Analyzer. When the SELECTOR SWITCH is in either of its other two positions, only the frequency meter pip is amplified by this tube and coupled to the video amplifier.

(11) SWEEP OSCILLATOR.

(a) The sweep oscillator V-107 is a gas-tube type relaxation oscillator that generates a sawtooth output at frequencies between 10 and 20 cps. The sweep oscillator may be locked in with the ripple voltage in the high voltage power supply. The output of the sweep oscillator is used to drive the sweep amplifier-inverter.

(12) SWEEP AMPLIFIER-INVERTER.

(a) The sweep amplifier-inverter V-108 provides push-pull deflection voltages for the horizontal plates of the cathode-ray tube. It also supplies modulating voltage to the analyzer r-f oscillator and trigger voltage for the blanking section of V-109.

(13) INTENSIFIER-BLANKING TUBE.

(a) The input voltage from the first section of the sweep amplifier-inverter V-108A, is differentiated and used to trigger the first section of V-109. The output of this section is applied as a blanking voltage for the return trace that would otherwise appear on the scope screen.

(b) When the SELECTOR switch is in the SPECTRUM INTENSIFIED position 2, in Fig. 3-5, the video signal is applied to the grid of the second section of V-109. The output from V-109 that is produced by this signal is coupled as intensifying voltage to the first or intensifying grid of the cathode-ray tube.

3. DETAILED FUNCTIONING OF THE CIRCUITS.

a. ATTENUATOR.

(1) When an r-f signal from an outside source enters the wave-guide it must pass the variable attenuator to reach the crystal mixer. The attenuator is shown in Fig. 3-6. The attenuator controls the amount of signal voltage that reaches the mixer and therefore controls the amplitude of the pattern on the screen. The control knob is marked SPECTRUM AMPLITUDE.

(2) The variable attenuator consists of two flat resistance strips which lie flat against the narrow sides of the guide. See Figs. 3-6 and 3-7. The ends are fastened down but still allow the strips to slide slightly as they are bowed into the center of the guide by means of the adjusting screw mechanism. As these strips with their carbonized resistance coating are moved in from the sides of the guide, they intersect more and more r-f energy (E-lines) and thus cause the attenuation to increase. The range of the attenuator is from 3 db to 70 db.

(3) The attenuator may be disassembled by loosening the two screws on the back plastic part and unscrewing the right and left hand plastic adjusting screws. The strips can be removed by poking a suit-

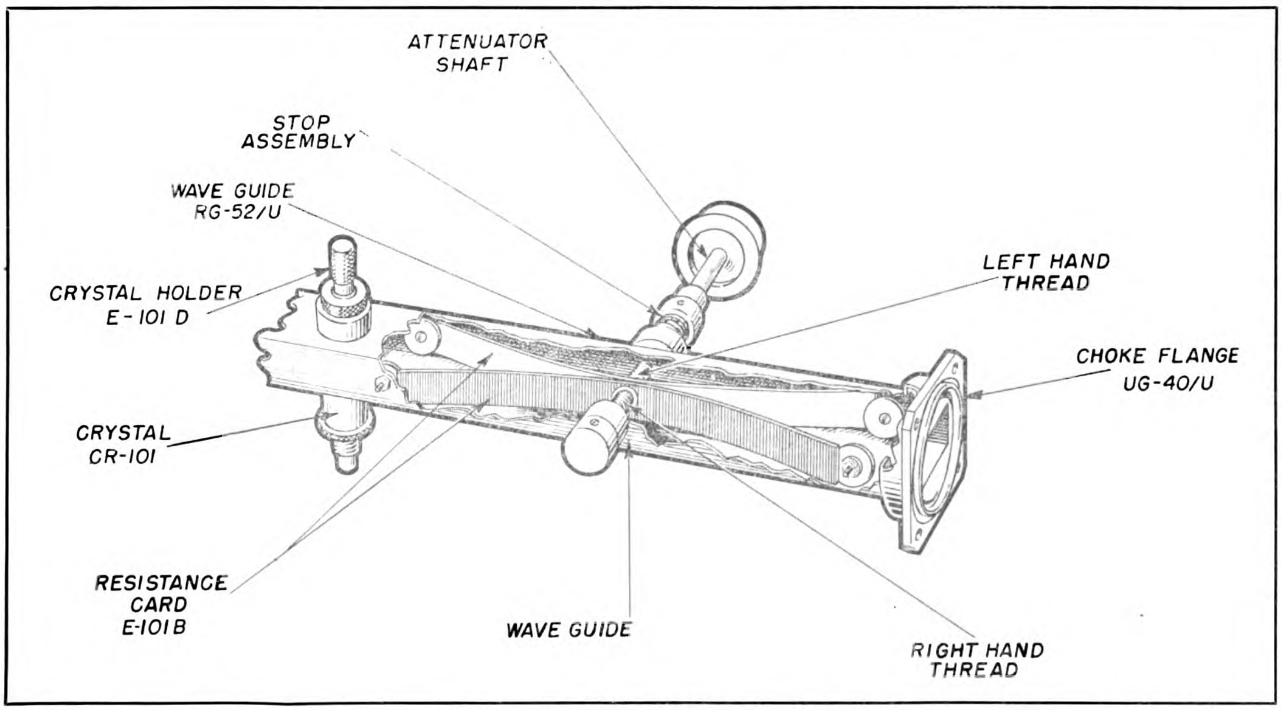


Figure 3-6. Variable Attenuator

able object through the center hole, against the strip. They are reassembled in a similar manner.

b. ANALYZER R-F OSCILLATOR.

(1) The analyzer r-f oscillator is a Type 2K25 or 723/A Shepard-Pierce tube. It is shown in Figs. 3-8, 7-6 and 7-7. Fig. 7-6 is a simplified schematic diagram. The output of the analyzer r-f oscillator is frequency-modulated by applying a sawtooth voltage taken from the sweep circuits of the oscilloscope to the reflector electrode of the tube. The output of the oscillator is mixed with the incoming r-f input signal to obtain the intermediate frequency. It is also used in conjunction with the frequency meter to produce the frequency meter pip that is used as an indicator in frequency measurements.

(2) The analyzer r-f oscillator employs a Type 2K25 tube as a Shepard-Pierce oscillator. A type 723A/B may be substituted. This tube is illustrated in Fig. 3-8. It is a reflex type variable-cavity oscillator. It contains an electron gun to emit electrons into the shell or cavity. The cavity is 300 volts positive with respect to the cathode. The electrode in the top of the tube is the reflecting anode and is about 140 volts negative with respect to the cathode. Heater power is obtained from transformer T-102.

(3) Each end of the cavity contains a grid as shown in Fig. 3-8. The electrons from the cathode are accelerated as they pass through these grids. The polarities of the grids are changing with respect to each other at the frequency of the oscillator. If a group of electrons arrive at the first grid when it is positive, the electrons are accelerated and pulled away from the electrons that immediately follow. If the second grid is still negative when the group of electrons arrive before it, the group will be slowed up and bunched closer together.

(4) If the second grid is not negative the electrons pass through to the negative reflector where they are repelled back into the cavity. If the electrons arrive back at the cavity in phase with the a-c potential of the cavity, they reinforce the bunching effect. That is, they deliver up energy to the cavity.

(5) The result of this action is a velocity-modulated stream of electrons flowing in the cavity. As the bunched electrons pass through each grid it becomes alternately positive and negative. The frequency of this oscillating action is determined by the spacing between the two grids, the volume and shape of the cavity, the spacing between the reflector and the cavity, and the voltage on the reflector. Assuming that the d-c po-

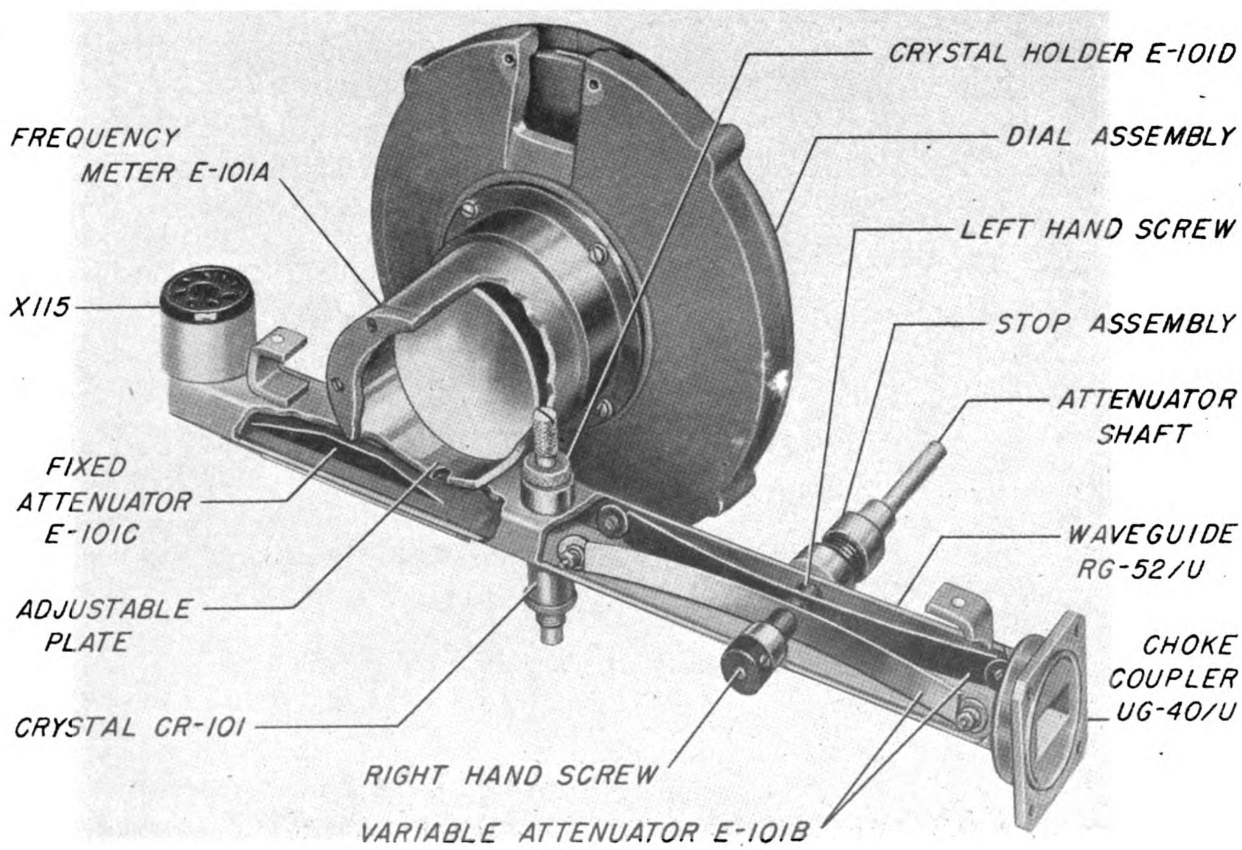


Figure 3-7. Wave Guide Assembly, Cut-Away View

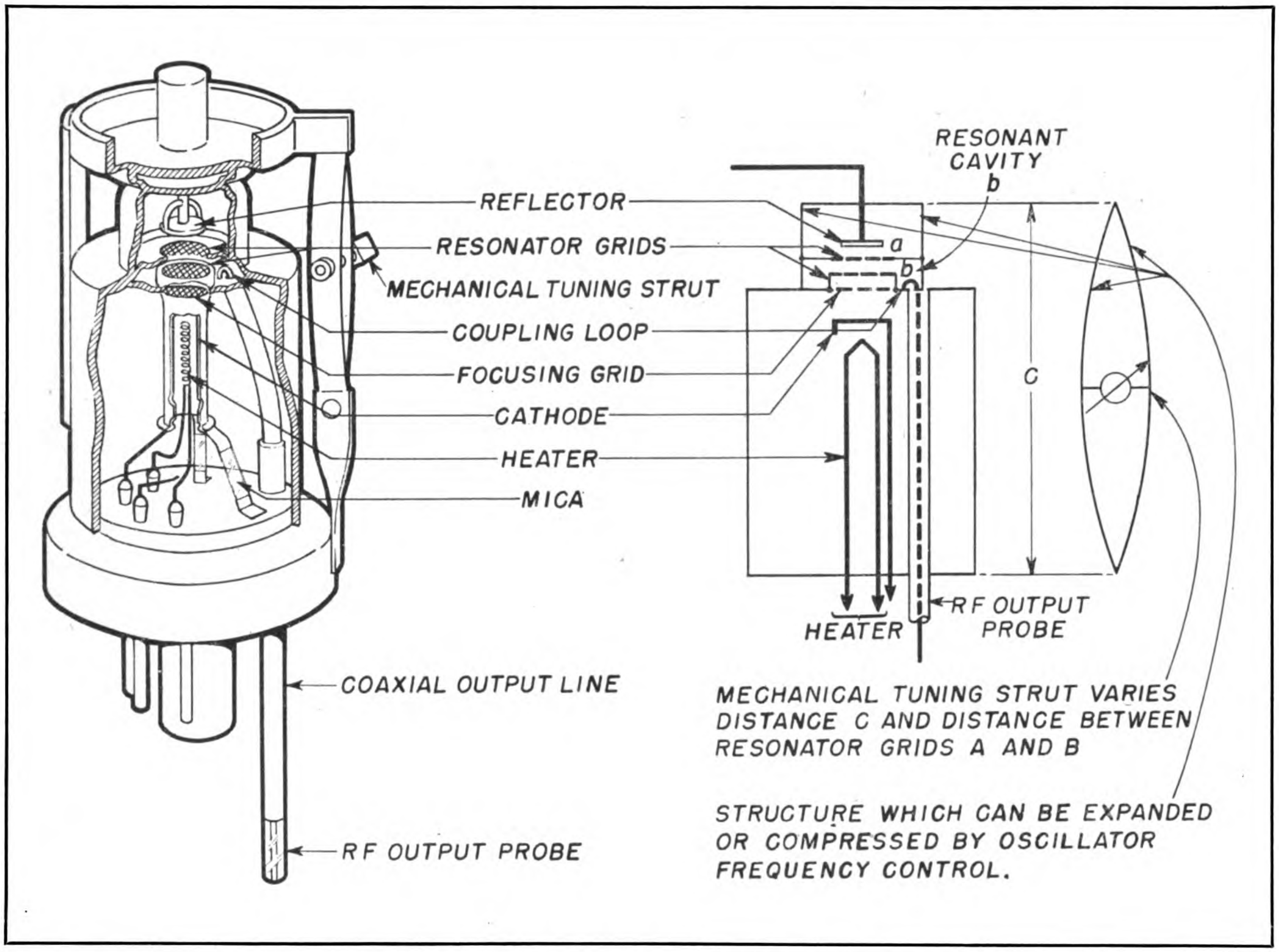


Figure 3-8. Analyzer R-F Oscillator Tube

tentials on the cathode and cavity are constant, the spacing and reflector voltage act to control the transit time of the electrons, which fixes the frequency of oscillation.

(6) The analyzer r-f oscillator may be tuned in either of two ways. One way is by means of a mechanical screw. This screw is rotated by the OSCILLATOR FREQUENCY control on the front panel. This control is the coarse frequency control. It places a stress on a pair of struts on the side of the tube. As these struts lengthen they expand the cavity to increase the spacing between the two grids and vary the capacity in the resonant circuit.

(7) The other method is to vary the voltage on the reflector electrode. The reflector voltage may be varied in two ways:

(*a*) The SPECTRUM CENTER control varies the negative d-c potential on the reflector. This control is the fine frequency control and is the first method for varying the reflector voltage. The d-c component of the reflector voltage is obtained from a voltage divider across the negative high voltage supply. The magnitude of this voltage is controlled by the setting of potentiometer R-167 (SPECTRUM CENTER) in the voltage divider. Actually the Type 2K25 or 723/A tube will only oscillate within definite ranges of reflector voltage. These ranges are called modes. This Analyzer makes use of the modes that appear in the —100 to —180 range. The mode or range moves as the mechanical tuning is varied so that it is necessary to keep it centered on the screen by means of the SPECTRUM CENTER control. It may be possible to find more than one mode in the range of —100 to —180 volts. If this is so, use either one since they are essentially the same.

(*b*) The SPECTRUM WIDTH control varies the modulating sweep-voltage on the reflector. Varying the setting of this control varies the width of the frequency band through which the oscillator sweeps. The sawtooth shaped output at the plate of V-103A is applied to the reflector of the Type 2K25 or 723/A as modulating voltage. This voltage appears across the voltage divider formed by resistors R-152, R-153 and R-154, in series with capacitor C-124. Potentiometer R-153 is the SPECTRUM WIDTH control. Its arm is capacitively coupled to the reflector of V-115.

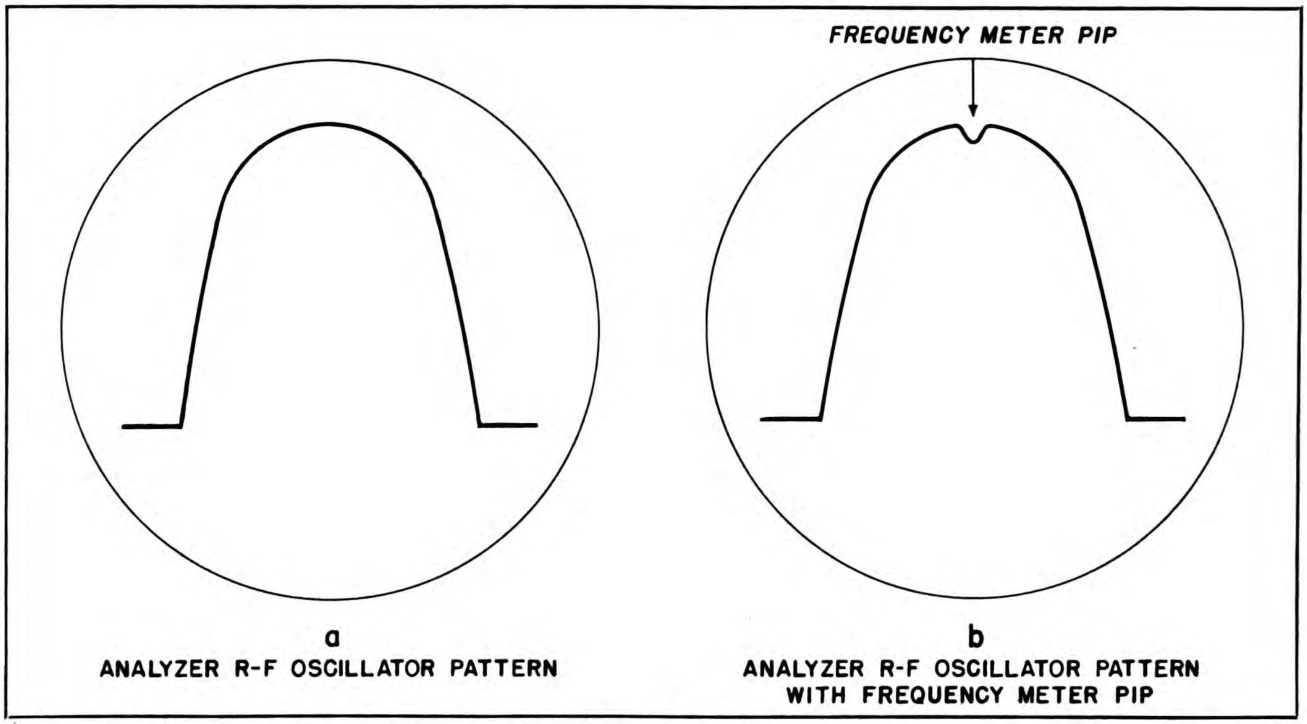


Figure 3-9. Analyzer R-F Oscillator Pattern

The setting of the arm on resistor R-153 controls the amplitude of the modulating sweep voltage that is applied to the reflector. The reflector voltage is the only variable voltage on the analyzer r-f oscillator, the spaced grids being connected to the regulated 300-volt supply.

(8) The output of the analyzer r-f oscillator varies in amplitude for different instantaneous values of reflector voltage. Due to the rectifying action of the crystal the d-c mixer amplifier produces the characteristic pattern in Fig. 3-9. If the slope of the curve differs greatly from the one in Fig. 3-9 the oscillator is not properly tuned or if tuning does not materially correct the pattern, the Type 2K25 or 723/A is probably defective and should be replaced.

(9) It is necessary to frequency-modulate the analyzer r-f oscillator in order to display on the scope screen each frequency component of the signal under observation. Frequency modulating the analyzer r-f oscillator produces a 22.5-mc/s i-f signal for each frequency component in the signal under test. If the analyzer r-f oscillator is swept from a low frequency to a high frequency, a series of i-f signals will be produced that represent the spectrum of the signal under observation.

(10) The signal at the beginning of the sweep represents the lowest side-band frequency and it will be followed in turn by the higher side-band frequencies until the fundamental frequency is reached. The succession of i-f signals continues through the upper side-bands until the highest frequency is reached. Since the trace on the scope is synchronized in time with the frequency swing of the analyzer r-f oscillator, the side-band frequencies will be spread out from left to right as shown in Fig. 3-10.

(11) It can be seen that there is a definite, fixed relationship between the modulating voltage and the deflecting voltage at any given instant, for any setting of the controls. Since the frequency of the analyzer r-f oscillator changes directly with the modulating voltage, it follows that the analyzer r-f oscillator frequency (and the intermediate frequency) bears a definite time relationship to the position of the trace-forming electron beam.

(12) It is necessary to think of the trace in terms of frequency divisions rather than time divisions. If the frequency components that cause the vertical deflection vary in amplitude the envelope of the pattern represents a curve of amplitude plotted against frequency.

c. FIXED ATTENUATOR.

(1) The fixed attenuator in Fig. 3-7 isolates the analyzer r-f oscillator from the rest of the wave-guide so that it is unnecessary to make any adjustments on the mixer when tuning over the frequency range. In fact, no adjustments are provided. The power from the analyzer oscillator goes past the frequency meter where a small portion of it is absorbed by the cavity of the frequency meter. A portion of the remainder is absorbed by the crystal and the part that is not absorbed by the crystal goes past the variable attenuator and out into the wave-guide. This is the part that is

utilized when the Analyzer is used as a signal generator.

d. FREQUENCY METER

(1) The frequency meter is a high Q cylindrical cavity type meter with a mechanically variable length. It is marked E-101A in Figs. 3-7 and 7-7. The dial has been accurately set at 9310 mc/s and will not vary more than ±5 mc/s under normal temperature and humidity conditions. However, the accuracy will vary with temperature and humidity. The frequency range of the meter is 8470 mc/s to 9630 mc/s.

(2) Each time the frequency of the analyzer r-f oscillator sweeps through the frequency to which the frequency meter is tuned, the meter absorbs some of the output power. This absorption results in a sharp reduction of the analyzer r-f oscillator component of the crystal current. This reduction, or pip, is applied to the d-c mixer amplifier and is used to indicate the coincidence of the frequency meter with unknown frequencies on the scope screen.

(3) The reduction of the amplitude of the analyzer r-f oscillator frequency causes a corresponding reduction in the amplitude of the i-f signal that is easily distinguishable if the scope pattern is watched carefully.

e. CRYSTAL MIXER.

(1) The crystal mixer consists of parts E-101D and CR-101 in Figs. 3-7 and 7-7. The crystal mixer is used to rectify the heterodyne frequency produced by mixing the r-f signal with the frequency-modulated output of the analyzer r-f oscillator. Whenever the r-f input signal is 22.5 mc/s above or below the frequency of the analyzer r-f oscillator, the i-f amplifier responds to the output of the crystal.

(2) The crystal is placed between the frequency meter and the variable attenuator, as shown in Fig. 3-7. The current through the crystal represents the rectified components of the signals produced by heterodyning the incoming r-f signal with the output of the analyzer oscillator. The i-f component of the crystal output is amplified by the i-f amplifier.

(3) The output of the crystal also contains a rectified component that is proportional to the power output of the analyzer r-f oscillator with respect to frequency. This voltage is amplified by the d-c mixer amplifier and appears on the scope when the SELECTOR switch is in the MIXER position. The pattern produced is used to determine the efficiency of the analyzer r-f oscillator and to set the various controls as described in Section II. It is also used to insure that the analyzer r-f oscillator is tuned to the desired frequency range. Another component present in the crystal output is the pip produced by the frequency meter. The production of this pip is explained later on in this section. The analyzer r-f oscillator components and the frequency meter pip are amplified by the d-c mixer amplifier. In addition to the pip just described two other pips appear, one on each side of the frequency meter pip. The one on the left indicates the start of the oscillator sweep while the one on the right indicates the end of the sweep.

(4) The crystal is a conventional 1N23A and it may be removed by first loosening the center part of the crystal holder with a screwdriver. The outside part can then be unscrewed with the fingers. This removes the crystal along with the holder. When replacing a crystal, the last operation should be to tighten the center part with a screwdriver. If this center section is tight when the holder is screwed in, the crystal may be broken.

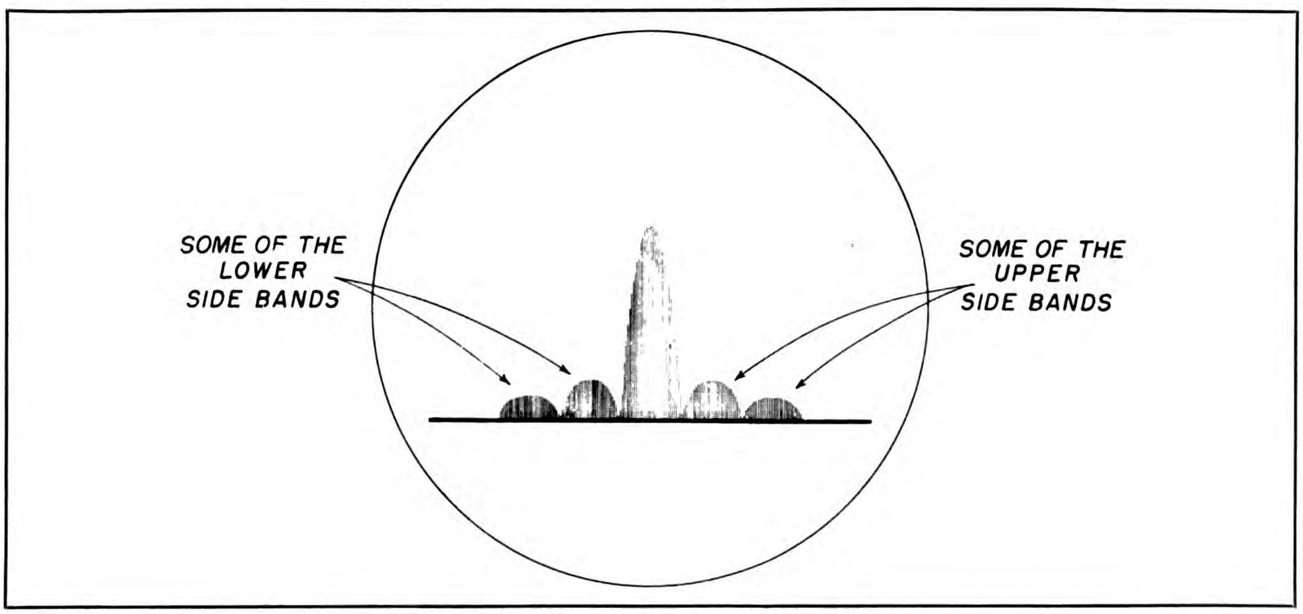


Figure 3-10. Spectrum Displayed on Oscilloscope

CAUTION

WHEN REMOVING OR REPLACING CRYSTALS, BE SURE TO PLACE THE HAND THAT TOUCHES THE CRYSTAL IN CONTACT WITH THE WAVE-GUIDE BEFORE REMOVING OR INSERTING THE CRYSTAL OR TOUCHING THE CRYSTAL TO ANY GROUND. IF THIS IS NOT DONE, A STATIC CHARGE OR POTENTIAL DIFFERENCE MIGHT EXIST THAT WOULD DAMAGE THE CRYSTAL.

f. I-F AMPLIFIER AND DETECTOR.

(1) GENERAL.

(a) The circuits comprising the i-f amplifier are shown in Figs. 7-6 and 7-7. The amplifier consists of a first i-f stage, an oscillator-converter and a detector. The band-pass or band-width of the i-f amplifier has been made very narrow so that two signals that are close together in frequency may be distinguished from each other and a true picture of a spectrum may be obtained.

(2) FIRST I-F AMPLIFIER.

(a) The first i-f amplifier, V-101, uses a Type 6SJ7 tube. This tube is shown in Figs. 7-6 and 7-7. V-101 is a conventional amplifier using iron core tuned coils and fixed d-c bias on the grid. It is included in the circuit to amplify the i-f signal to a level that can be handled satisfactorily by the oscillator-converter. It also prevents the output of the oscillator in the oscillator-converter from appearing in the wave-guide.

(b) Bias is obtained from the voltage divider across the negative high voltage supply. Resistor R-101 and capacitor C-103 decouple the grid circuit from the bias supply. The amplifier has a tuned inductive plate load, L-101, to produce its band-pass characteristic of 500 kc/s. Capacitor C-102 returns the secondary of transformer T-101 to the cathode of V-101.

(c) The resonant frequency of this amplifier is 22.5 mc/s. The output from the crystal-mixer is inductively coupled to the grid of the amplifier, through the tuned transformer T-101. The reactance of the primary of transformer T-101 is sufficiently high at 22.5 mc/s to act as an i-f choke in the grid circuit of the d-c mixer amplifier. Since the output of the analyzer r-f oscillator varies at an audio rate, the bell-shaped oscillator curve does not pass through the i-f amplifier.

(d) The reactance of capacitor C-102 is very low at 22.5 mc/s but it is correspondingly high at audio frequencies. Consequently the amplitude variation of the modulated analyzer r-f oscillator output has no effect at the grid of V-101, because the impedance in the grid circuit is so low that the oscillator sweep voltage can never appear at the grid. The output of V-101 is a series of pulses of 22.5 mc/s. Each pulse represents a section of the spectrum of the r-f signal that is being observed. These are capacitively coupled to the grid of V-102 by capacitor C-105.

(3) OSCILLATOR-CONVERTER.

(a) The second stage in the i-f amplifier uses a Type 6SA7 tube. This tube is V-102 in Figs. 7-6 and 7-7. The primary purpose of the oscillator-converter is to obtain a narrow band-width. The band-width of this stage is 50 kc/s at the half-power points. The oscillator circuit of V-102 is tuned to approximately 19.5 mc/s. The plate load inductor L-103 is fixed-tuned to approximately 3 mc/s.

(b) From Fig. 7-6 it can be seen that the oscillator voltage on grid 5 causes pulses of space current to flow at the positive peak of each oscillator cycle. Grid 8 has the 22.5-mc/s i-f signal voltage on it. The pulses of space current arriving before grid 8 form a virtual cathode whose emission to the plate is controlled by the signal voltage.

(c) Since the virtual cathode does not exist except on the peaks of the oscillator cycles, the plate current varies at the heterodyne frequencies of the original intermediate frequency and the oscillator frequency.

(d) The heterodyne frequency of three megacycles between the incoming intermediate frequency and the oscillator frequency is amplified 5 to 10 times by the oscillator-converter before being passed on to the detector.

(e) The narrow band-pass of this stage is obtained by employing the high Q inductor L-103 in the plate circuit of V-102.

(4) DETECTOR.

(a) The detector stage is shown in Figs. 7-6 and 7-7. It utilizes V-103A, the first half of V-103, which is a Type 6SN7GT tube. An infinite-input-impedance detector is used for simplicity and to minimize the loading effect on inductor L-103. The detector rectifies the i-f signal voltage and the rectified output is applied to the video amplifier for amplification. Since V-103A is a square law detector it produces a power spectrum from the incoming voltage spectrum.

(b) The i-f signal voltage is capacitively coupled to the grid of V-103A through capacitor C-110 and appears across inductor L-105. The junction of the low end of inductor L-105 and cathode resistor R-111 is connected to the arm of potentiometer R-117.

(c) Potentiometer R-117 is the VERTICAL SPECTRUM control on the front panel. It is in series with the negative high voltage terminal, resistor R-118, and ground. It controls the grid-cathode potential of V-103A. This control has no effect on the action of V-103A other than to change its plate-to-cathode voltage slightly. It is used to control the bias of the video amplifier.

(d) The voltage that appears across the 150,000-ohm cathode resistor keeps the tube biased very near plate current cut-off. Any a-c signal that appears at the grid is automatically rectified or detected because the

negative half of the cycle produces very little effect while the positive half causes plate current to flow.

(e) The cathode of V-103A is connected directly to the grid of the video amplifier V-104. Capacitor C-110 by-passes the intermediate frequencies around the cathode resistor. Since V-103A requires a low plate voltage, the plate is connected to the junction of resistors R-110 and R-112, which form a voltage divider between the +300-volt supply and ground. Capacitor C-112 places the plate of V-103A at i-f ground potential.

(5) ALIGNMENT.

(a) If it is suspected that the i-f amplifier is out of tune, it can be checked by picking up a signal and tuning transformer T-101 and inductor L-101 for maximum output on the oscilloscope. Another good way is to measure the frequency separation of the right and left spectrums of a signal. The i-f amplifier is tuned to one-half of this frequency.

(b) If there is reason to believe that inductor L-102 is out of adjustment, its frequency may be checked by picking it up with a communication receiver or frequency meter.

(c) A very good way to align the i-f amplifier is to couple a 22.5 mc/s amplitude-modulated signal into the Type RG-5/U crystal mixer cable. Tune transformer T-101 and inductors L-101 and L-103 for maximum amplitude on the oscilloscope. If inductor L-102 is out of tune, it should be tuned to beat with a frequency meter that is set at 19.5 mc/s. Always retune transformer T-101 on a signal after reconnecting the Type RG-5/U cable to the crystal mixer.

g. VIDEO AMPLIFIER.

(1) The video amplifier employs a Type 6AC7 tube designated V-104 in the circuit diagrams. Its circuit is shown in Figs. 7-6 and 7-7. Except for the direct coupling between its grid and the cathode of the detector, V-103A, this circuit is in every way conventional. Any change in the plate or grid voltage produces a deflection on the vertical plates of the oscilloscope.

(2) When the SELECTOR switch is in the SPECTRUM INTENSIFIED or the SPECTRUM positions, vertical centering is accomplished by adjusting the d-c bias on the grid of V-104. This bias is obtained from the arm of the VERTICAL SPECTRUM control, R-117, through the cathode resistor R-111, and resistor R-114.

(3) Potentiometer R-117 is connected to the negative high-voltage terminal and is in series with resistor R-118. The other end of resistor R-118 is grounded and therefore is positive with respect to the negative high voltage terminal. The voltage across this resistor is high enough to place potentiometer R-117 (and consequently the bias of V-104) at a potential that tends to keep the pattern centered for variations of the a-c power.

(4) Screen voltage is obtained from a simple voltage regulator V-103B, whose grid is held constant in voltage by being tapped off a divider in the +300-volt regulated supply.

(5) The output of the d-c mixer amplifier V-106 is coupled to the grid of V-104 through capacitor C-114. This capacitor, with the resistance in series with the grid and ground, forms a differentiating circuit. Referring to Fig. 3-9, it can be seen that the slope of the analyzer r-f oscillator curve is changing at a slow rate, while the slope of the frequency meter pip is very steep and abrupt. Capacitor C-114 and its associated resistance pass the high frequencies present at the beginning of the curve, the frequency meter pip, and the end of the curve. The result is a grid voltage at V-104 that produces the output shown in Fig. 3-11. Note the two pips on each side of the frequency meter pip that permit determination of the limits of the frequency sweep of the analyzer r-f oscillator and hence the limits of the observable spectrum.

(6) The output of V-104 is negative and is applied directly to the lower vertical plate of the cathode ray tube through the SELECTOR switch S-103, when it is in the SPECTRUM INTENSIFIED and SPECTRUM positions. It is also capacitively coupled to the grid of the intensifier tube, V-109B, which delivers an intensifying voltage when the SELECTOR switch is in the SPECTRUM INTENSIFIED position.

h. SWEEP OSCILLATOR.

(1) The sweep oscillator is shown in Figs. 7-6 and 7-7. It employs the Type 884 gas filled triode, V-107, in a simple relaxation type sawtooth generator. It generates a voltage to control both the scope trace and the frequency sweep of the analyzer r-f oscillator.

(2) Fixed bias is obtained from the negative voltage divider. Synchronizing voltage is obtained from the high voltage filter circuit by placing R-137, the cathode resistor of V-107, in series with filter capacitor C-135 and ground. SYNC switch S-101 short circuits this resistor to remove the synchronizing voltage. Sweep frequencies between 10 and 20 cps are selected by varying the charging time of capacitor C-120 through the adjustment of potentiometer R-135 in the plate circuit of the tube.

(3) Since capacitor C-120 is connected between the regulated 300-volt supply and ground, it is charged by the supply voltage through resistor R-134 and potentiometer R-135, the SWEEP FREQUENCY control. The voltage across capacitor C-120 is the voltage applied to the plate of V-107.

(4) With the SYNC switch S-102 in its OFF position the plate voltage of V-107 rises above the firing potential, fixed by the bias on the grid, and the tube conducts heavily. When capacitor C-120 has been sufficiently discharged by the tube to lower the plate voltage to the extinction point, the tube cuts off. Capacitor C-120 immediately begins to charge through resistor R-134 and potentiometer R-135. The rate of charge, and consequently the frequency, is controlled by the adjustment of potentiometer R-135. When

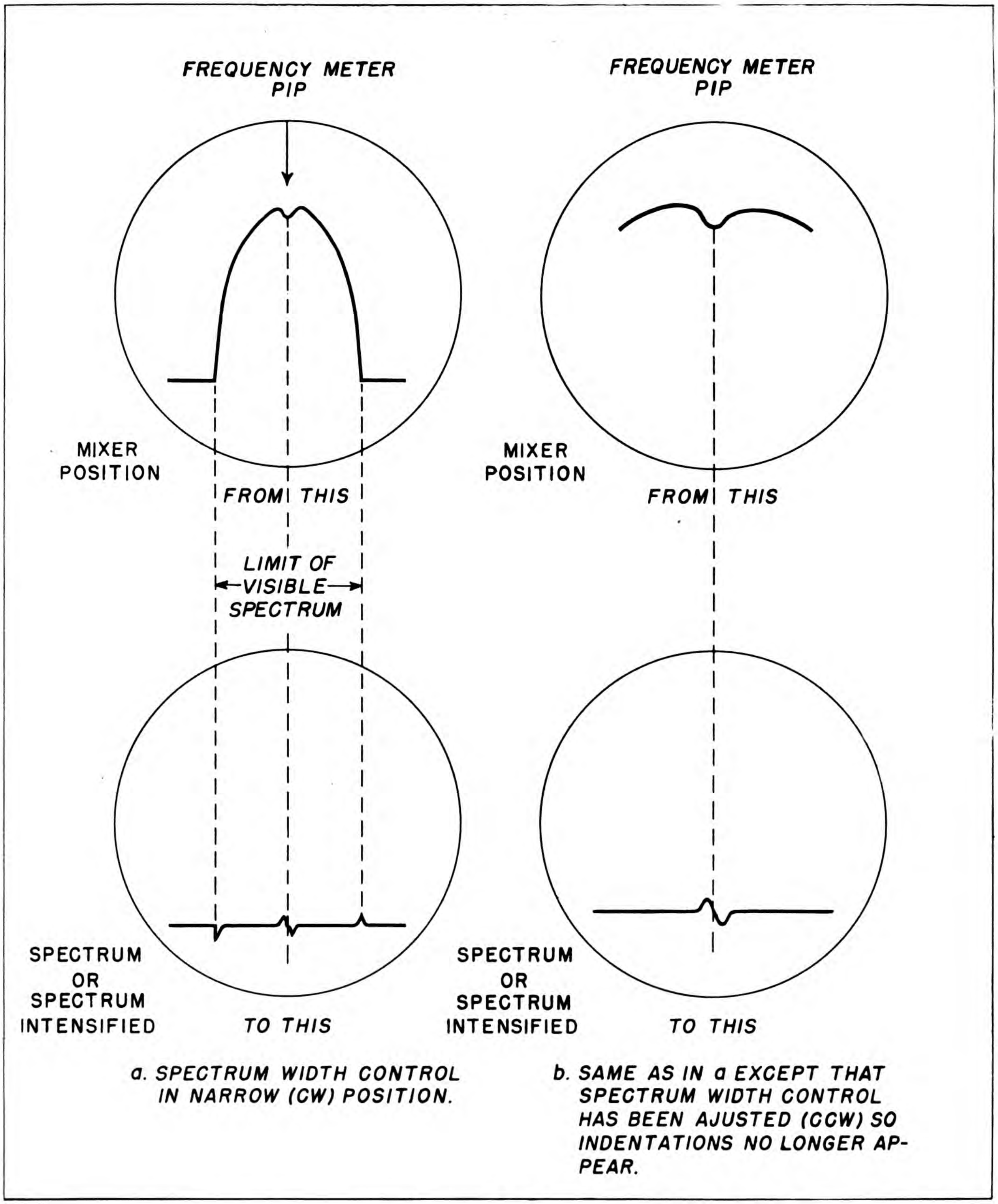


Figure 3-11. Differentiated Frequency Meter Pip in Output of Video Amplifier

capacitor C-120 has charged sufficiently to raise the plate voltage of V-107 to a point where it can overcome the fixed bias on the grid, the tube again acts as a closed switch across capacitor C-120 and the process described above is repeated.

(5) V-107 begins to conduct while the charging rate of the capacitor is still linear with respect to time. Therefore the output is essentially a symmetrical sawtooth wave. This output is applied to grid 1 of the sweep amplifier-inverter, V-108.

(6) The ripple voltage across capacitor C-135 in the high voltage power supply appears across resistor R-137. This resistor is in series with the capacitor and ground. The cathode of V-107 is also connected to this resistor and the ripple voltage appears as a synchronizing voltage at the cathode when SYNC switch S-102 is in the ON position. The frequency of the ripple voltage is the frequency of the line voltage. Therefore it may be used to synchronize the sawtooth modulation applied to the analyzer r-f oscillator with the pulse modulation of any radar equipment that is synchronized to the line frequency. SYNC switch S-102 short circuits resistor R-137 to remove the synchronizing voltage from the cathode of V-107 when it is not necessary to have synchronization.

(7) The synchronizing voltage appears across resistor R-137 as a negative pulse. This pulse lowers the cathode potential of V-107 to make it continue to conduct sooner than it normally would. This hastens the start of the charging action of capacitor C-120 and causes the next cycle of oscillation to start after the negative synchronizing pulse has passed.

(8) The synchronizing circuit of V-107 possesses the merit of providing a more nearly constant amplitude of synchronizing voltage for a wide range of line frequencies. As the line frequency increases the reactance of capacitor C-135 decreases and the charging current increases. The lowered impedance of capacitor C-135 and resistor R-137 would result in a lower voltage across resistor R-137 except for the fact that the circuit constants are so chosen that the increased current amplitude in resistor R-137 balances the effect of the lowered impedance of the circuit.

i. SWEEP AMPLIFIER-INVERTER.

(1) The sweep amplifier-inverter V-108 employs a type 6SN7GT tube in a push-pull circuit. The circuit of this stage may be seen in Figs. 7-6 and 7-7. The grids of V-108 are connected across a bridge circuit that is balanced for d-c voltage by adjusting the position of the arm of the HORIZONTAL CENTERING control, R-144.

(2) Since the plates of V-108 are directly connected to the horizontal deflection plates of the cathode-ray tube, the position of the trace depends upon the d-c potentials on the plates of the tube. When the bias on the grids is adjusted so that the potentials are equal, the trace will center on the scope screen.

(3) The output of the sweep generator, V-107, is applied to grid 1 of V-108. Its amplitude is controlled by the adjustment of the HORIZONTAL AMPLITUDE control, R-140. The output at plate 2 appears across capacitor C-123 in series with resistors R-147, R-148 and R-149. This circuit comprises a voltage divider to obtain the attenuated signal at grid 4 that is necessary to obtain a balanced output from plates 2 and 5. A portion of the output from plate 2 is used to trigger the back trace remover, V-109A, and to modulate the analyzer r-f oscillator, V-115.

j. BLANKING TUBE (BACK TRACE REMOVER).

(1) If the back trace should be visible on the screen, another spectrum would appear with sufficient intensity to blend into the desired pattern and render it practically worthless. The return of the trace is made invisible by the action of V-109A. V-109A is half of a Type 6SN7GT tube. Its circuit may be seen in Figs. 7-6 and 7-7.

(2) Fixed cut-off bias for this stage is obtained from the negative voltage supply. Plate 2 of V-109A is connected to plate 5 of V-109B since the output of both tubes is applied to the first grid of V-105.

(3) Capacitor C-126 and resistor R-155 form a differentiating circuit that removes the low frequency components of the sweep voltage to produce short positive pulses of voltage as shown in Fig. 3-12. These

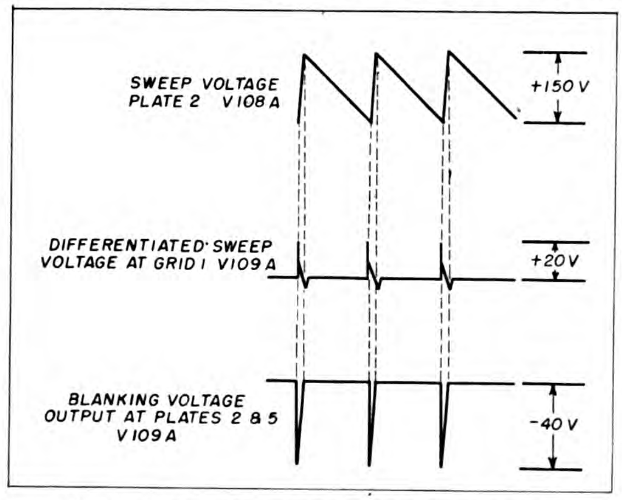


Figure 3-12. Formation of Blanking Trigger From Sweep Voltage

pulses are applied to grid 1 of V-109A. This stage is operated at plate current cut-off. The output at the plate of V-109A consists of negative pulses synchronized with the steep slope of the sawtooth sweep voltage. These pulses are capacitively coupled to the first grid of the cathode ray tube to cut off the electron beam for the duration of the back trace.

k. INTENSIFIER.

(1) The intensifier stage is provided to intensify or brighten the individual pulses that make up the spectrum on the screen. This provides better pattern

definition because it is unnecessary to turn up the manual INTENSITY control to an abnormal level of brightness in order to be able to distinguish the dim spectrum pulses. The intensifier stage is half of the Type 6SN7GT designated as V-109B in Figs. 3-13, 7-6 and 7-7. It is used as a cathode follower and as an amplifier.

(2) The negative output of the video stage is applied to the grid of V-109B. Positive pulses appear at the plate of this tube each time the video amplifier delivers a pulse of voltage to the vertical plates of V-105. These pulses are applied to the intensity grid of the scope, to increase the number of electrons in the beam and brighten the pattern.

(3) The negative pulses appearing at the cathode of V-109B are applied through capacitor C-121 to the focusing anode of the scope to provide an instantaneous focus correction while the grid is being intensified. The grid bias on this tube is about +40 volts. The cathode voltage rises to approximately +42 or +43 volts giving a resultant bias of —2 or —3 volts. When the negative incoming signal exceeds 40 or 45 volts, the grid is driven past cut-off so that the resulting pulses from the cathode and plate are limited to about —40 and +12 volts respectively.

l. D-C MIXER AMPLIFIER.

(1) The d-c mixer amplifier is a conventional circuit using a Type 6SJ7 tube which is designated V-106 in Figs. 7-6 and 7-7. It is used to produce a test pattern of the output of the analyzer r-f oscillator and to produce the frequency meter pip on the spectrum.

(2) The low frequency components in the crystal output pass through transformer T-101 and the resulting voltage appears across potentiometer R-127. Resistor R-126 and capacitor C-119A form a low pass filter circuit. This circuit readily passes low frequencies, but offers a high degree of attenuation to high frequencies. It prevents everything from appearing on the grid of V-106 except the rectified voltage that represents the amplitude envelope of the analyzer r-f oscillator output.

(3) The setting of the MIXER AMPLIFIER control R-127 determines the amplitude of the signal voltage on the grid of V-106. Screen voltage and cathode bias are obtained from the voltage divider that is connected between the regulated +300-volt line and ground. Potentiometer R-133 in the voltage divider makes the bias adjustable to control vertical centering. This control is marked VERTICAL MIXER on the control panel. Capacitor C-142 is connected between the plate and ground. The purpose of this capacitor is to place the plate at i-f ground potential. Phone jack J-101 removes the output of the Analyzer's crystal mixer and substitutes the radar crystal mixer, when a transmitter-converter is connected to the jack through a phone cable.

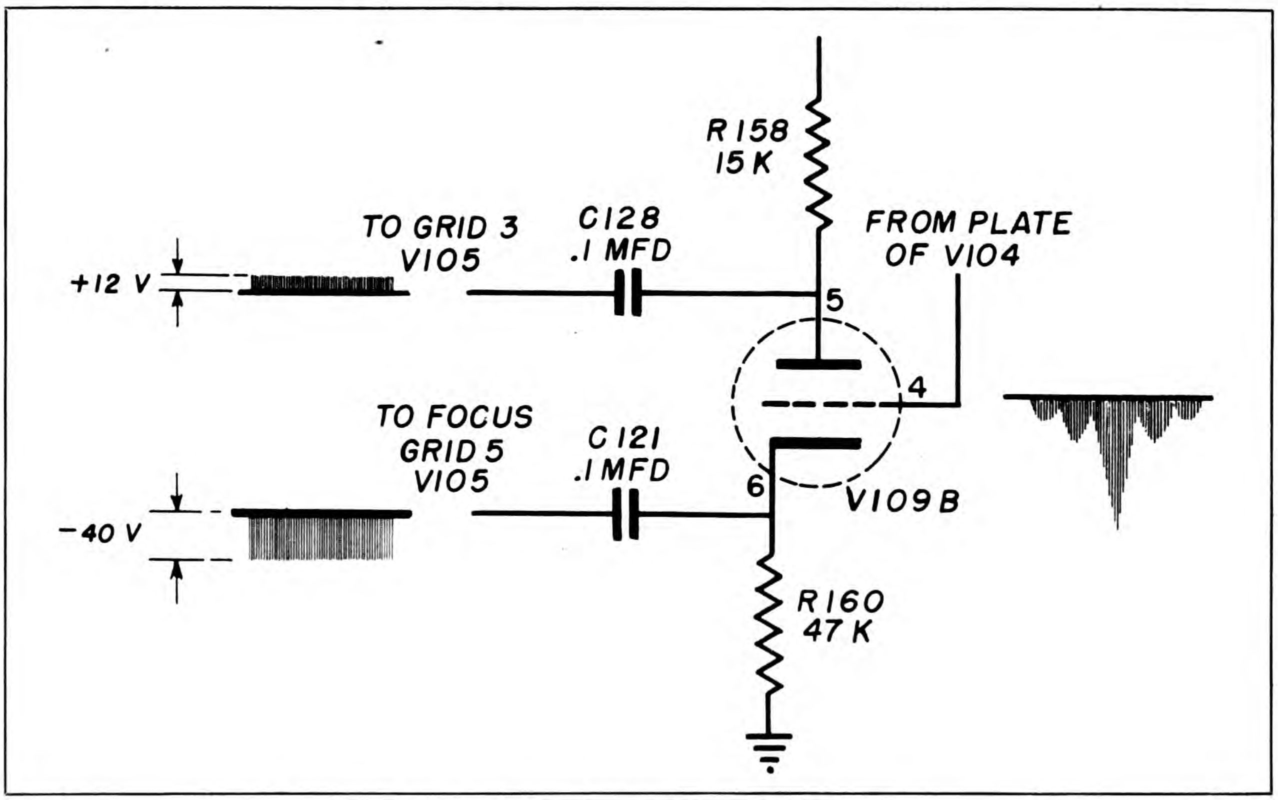


Figure 3-13. Action of Intensifier Tube

(4) The output is a slowly changing voltage that follows the envelope of the output of the analyzer r-f oscillator. The steep sections of the output wave of V-106 are differentiated by capacitor C-114 and the grid resistance of the video amplifier to produce the frequency meter pips. The output of V-106 is also applied directly to the vertical plates of the cathode-ray tube through the SELECTOR switch when it is in the MIXER position. In this position the bell-shaped curve in Fig. 3-9 is displayed on the screen of the scope.

m. POWER SUPPLY.

(1) GENERAL.

(a) The Spectrum Analyzer is operated from a built-in power supply. A simplified diagram is shown in Fig. 3-14. The complete schematic is shown in Fig. 7-7. The power supply delivers two unregulated output voltages and one regulated voltage. It is designed to operate with a line voltage of 105-125 volts a-c at 50 to 1,200 cps and draw approximately 125 watts. A-c input power is controlled by the ON-OFF switch, S-101. A single transformer, T-102, is used to obtain all a-c and d-c voltages required for operation of the equipment.

(2) HIGH VOLTAGE SUPPLY.

(a) The high voltage supply furnishes voltage for the anodes of the cathode-ray tube. The winding that supplies the a-c voltage for rectification consists of part of the center-tapped winding of transformer T-102 in series with another winding. These windings are the ones between terminals 4 and 6 in Fig 3-14. A Type 2X2 half-wave high-voltage rectifier is connected in a half-wave rectifier circuit. This tube is V-110 in Fig. 3-14. The rectified output is filtered with a capacitor input filter composed of capacitors C-134, C-135 and resistor R-172. The purpose of resistor R-137, in series with Capacitor C-135 and ground, is explained in Par. 3*b* of this section.

(b) The output voltage appears across a bleeder or voltage divider, from which the various values of voltages are taken. This voltage divider consists of resistors R-163, R-164, R-165, R-116, and R-166 to R-171 inclusive. The positive side of the high voltage is grounded. The ripple voltage at point F should not exceed 2 volts peak-to-peak.

(c) The three tubes V-116, V-117 and V-118 are Type 991 neon bulbs. They shunt the bottom portion of the voltage divider and are used as voltage regulators. The total voltage regulated by these tubes is approximately —180 volts. The stabilized portion of the voltage divider delivers negative voltage to the reflector of V-115, bias for V-101, V-107, V-108 and V-109. Bias for video amplifier V-104 is obtained from the voltage divider at the junction of resistors R-116 and R-166 in the unregulated portion of the divider.

(3) LOW VOLTAGE SUPPLY.

(a) The low voltage power supply uses a Type 5R4GY tube as a full-wave rectifier. This tube is V-111 in Fig. 3-14. The center-tapped winding between terminals 5 and 7 on transformer T-102 supplies the a-c power.

(b) The rectified output is filtered with a choke-input filter, consisting of inductors L-104 and L-106 and capacitors C-137A and C-137B. The output appears across a voltage divider consisting of resistor R-173 in series with potentiometer R-174 and resistor R-175 paralleled by resistors R-188 and R-189. The unregulated output voltage is taken from the junction of resistor R-173 with potentiometer R-174 and resistor R-188. This voltage source is used to supply voltage to the plates of V-103B, V-104, V-106 and V-108. Potentiometer R-174 is the SPOT ADJUSTMENT control. It controls the d-c potential on grid 9 of V-105. Grid 9 is the focusing anode.

(c) The input to the electronic voltage regulator is taken directly from the filter at choke L-104. The electronic voltage regulator consists of the series regulator tube V-112, the regulator control tube V-113, and the bias voltage regulator, V-114. The cathode of V-112 is connected to ground through the voltage divider which consists of resistors R-180 to R-183 inclusive. Potentiometer R-182 is the +300 VOLTAGE ADJUSTMENT control. Its arm varies the control grid and plate of V-113 and the control grid of V-112 at a positive potential with respect to ground. The voltage across the divider also appears across the shunt resistance of resistor R-179 and V-114 in series. The stabilized voltage across V-114 is used as cathode bias for the control tube, V-113.

(d) Any increase in the load reduces the current in the voltage divider, R-181 to R-183. The reduced potential at grid 4 of V-113 results in a reduced plate current flow since the cathode voltage is held constant by the action of V-114. The voltage gain of V-113 results in a correspondingly large positive swing on the grid of V-112 for a small negative swing on the grid of V-113. The increased positive potential at grid 1 of V-112 allows more current to flow which raises the cathode potential. The above action is reversed for a decrease in the load. The result is a very stable output that remains at +300 volts for wide variations in the load.

(e) As stated previously the voltage out of the regulator may be set to exactly +300 volts with the +300 VOLTAGE ADJUSTMENT control, R-182. The +300 volt terminal on the terminal board of the analyzer r-f oscillator is a convenient terminal for measuring the voltage when making this adjustment. The ripple voltage from this regulator should not exceed 50 millivolts rms.

(f) Transformer T-102 has five heater windings. One winding heats rectifier V-110, another the filament of V-112. The winding between terminals 1 and 2 heats the cathode-ray tube V-105. The remaining winding supplies filament potential for the pilot lamps and the remainder of the tubes. Potentiometer R-193 shunts this winding to reduce a-c hum. Its arm is grounded. When properly adjusted, it balances both sides of the filament circuit to ground.

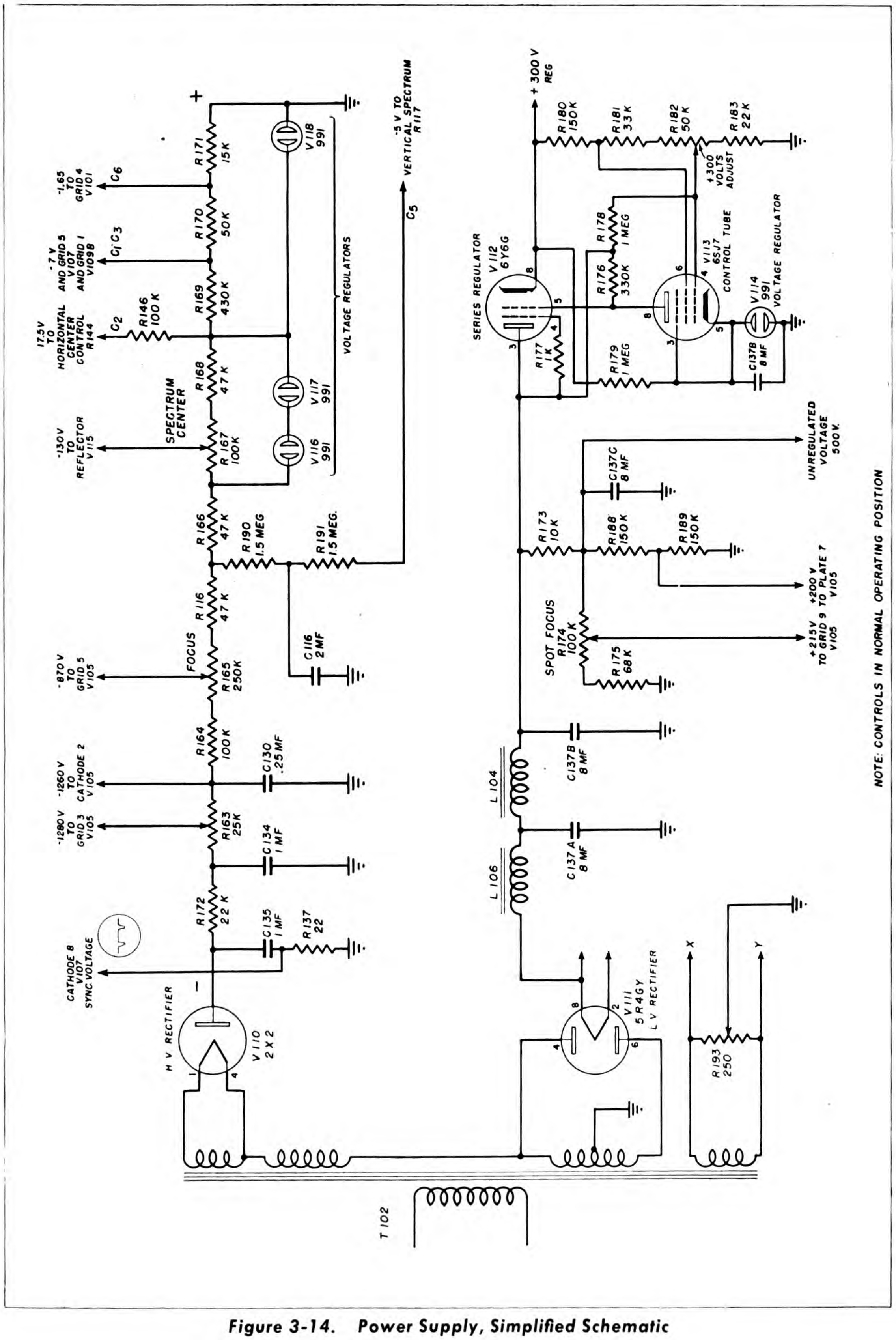


Figure 3-14. Power Supply, Simplified Schematic

SECTION IV
MAINTENANCE

WARNING

DANGEROUS VOLTAGES EXIST IN THE ANALYZER THAT MIGHT CAUSE DEATH. ALWAYS GROUND THE CHASSIS BEFORE TURNING THE A-C POWER ON. MEASURE HIGH VOLTAGES ON A METER WITH A HIGH-RESISTANCE 2,000-VOLT RANGE, OR ON A HIGH-RESISTANCE METER WITH AN EXTERNAL MULTIPLIER TO GIVE THE PROPER RANGE. IT IS BETTER TO CHECK THE OSCILLOSCOPE CIRCUITS WITH RESISTANCE MEASUREMENTS. IF IT IS NECESSARY TO MEASURE THE VOLTAGES, CERTAIN PRECAUTIONS MUST BE OBSERVED TO PROTECT THE LIFE OF PERSONNEL AND TEST EQUIPMENT.

1. PREVENTIVE MAINTENANCE.

a. The Spectrum Analyzer uses a wave-guide and a resonant cavity. To obtain maximum accuracy from the Analyzer certain precautions must be taken.

b. The small side door must be kept closed when the equipment is not in use. The entrance of dirt or moisture into the wave-guide will seriously affect the accuracy of the dial readings.

c. The interior of the Analyzer should be kept free from dust. All assembly screws should be kept tight and the tubes should be checked occasionally to see if they are pushed all the way down into their sockets. All cabling and auxiliary parts should be kept clean and stored away in the Auxiliary and Spare Parts Box when not in use.

2. REMOVING THE DUST COVER.

a. The dust cover is removed by loosening five screw fasteners at the front of the Analyzer and one dot fastener at the rear. When the fasteners are loosened the dust cover will slide off of the chassis. The bottom of the chassis is divided into two hinged sections that open up like the bomb bay doors on an airplane. The two hinged sections are secured to the chassis with screws which must be removed before the sections will swing outward. See Fig. 5-1.

3. ALIGNMENT.

a. Alignment of the Analyzer requires the use of a high frequency signal generator, 30% modulated with 400 cps, and the tuning wrench that is supplied with the Analyzer. The signal generator should be Navy Type LP-3 or its equivalent. In an emergency, an r-f signal may be used instead of the signal generator. The signal must be modulated.

b. To align the equipment proceed as follows:

(1) Remove the dust cover and open up the doors on the chassis.

(2) Remove the crystal mixer cable from the wave-guide and connect it to the output of the signal generator. The crystal mixer cable is shown in Fig. 5-1.

(3) Set the output frequency of the signal generator to 22.5 mc/s and turn the equipment on. Allow both instruments to warm up for approximately 5 minutes.

(4) Tune transformer T-101 for maximum response on the scope. The location of the tuning adjustment is shown in Fig. 5-2.

(5) Tune inductor L-101 for maximum response on the scope. See Fig. 5-2 for location of the tuning adjustment.

(6) Tune inductor L-102 for maximum response on the scope. Make this adjustment only when it is evident that the oscillator is off frequency. This can be determined with any good frequency meter. The adjustment of inductor L-102 is shown in Fig. 5-2.

(7) Remove the signal generator and replace the crystal mixer cable in the wave-guide.

(8) Pick up an r-f signal with the Analyzer and retune transformer T-101 on this signal.

4. TROUBLE SHOOTING.

a. GENERAL.

(1) Most of the troubles encountered in the Spectrum Analyzer make themselves apparent by the appearance or non-appearance of one or more of the characteristic curves on the oscilloscope screen. Some of the more common troubles, with the appropriate remedial actions, are listed in the trouble shooting chart below.

WARNING

DANGEROUS VOLTAGES ARE PRESENT IN THE EQUIPMENT, OBSERVE ALL POSSIBLE PRECAUTIONS WHEN WORKING WITH THE EQUIPMENT.

b. VOLTAGE AND RESISTANCE MEASUREMENTS.

(1) All voltages should be measured with a 20,000 ohms-per-volt meter. Connect the meter with a-c power off. Discharge all high voltage capacitors and attach a meter lead to the chassis first and then attach the other lead to the point under test. Observe the proper polarity. Place the meter on its highest range and reduce the range to obtain midscale deflection.

Do not touch the voltmeter when making high voltage measurements. Average voltages are given in Fig. 4-1. Figs. 5-1 and 5-2 show the location of the tubes and other parts.

(2) All resistances are measured from the test point to ground unless otherwise stated. Generally speaking, measured resistance values should be within plus or minus ten percent of the stated value. Average resistances are given in Fig. 4-1. Point to point resistance measurements are included in Par. 8 of this section.

c. REPLACEMENT OF TUBES.

(1) Tubes should be inspected periodically. They should be replaced whenever a good emission test, mutual conductance test or substitution test shows them to be defective.

Note

ALL TUBES OF A GIVEN TYPE SUPPLIED WITH THE EQUIPMENT SHALL BE CONSUMED PRIOR TO EMPLOYMENT OF TUBES FROM GENERAL STOCK.

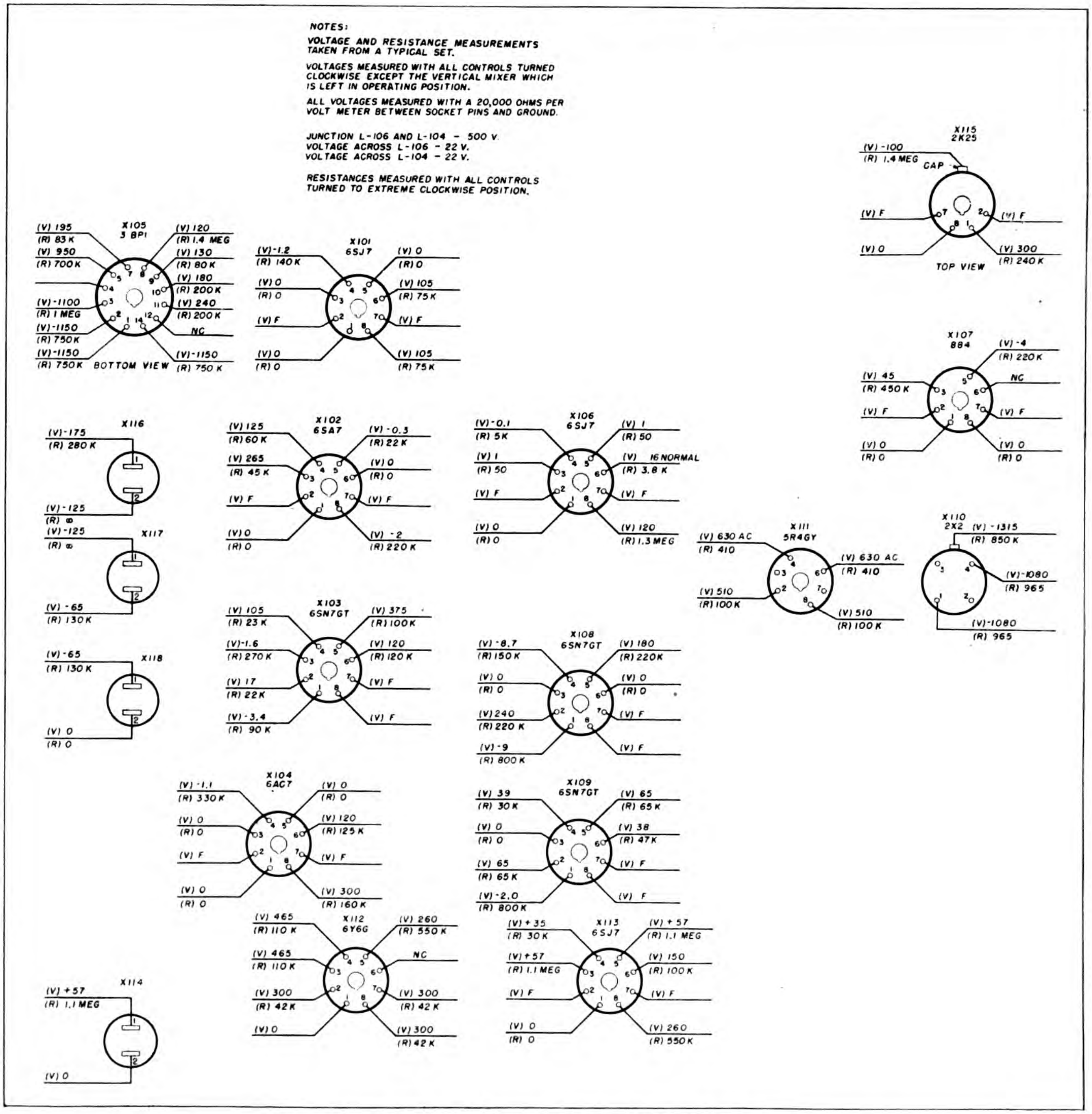


Figure 4-1. Voltage and Resistance Chart

5. TROUBLE SHOOTING CHART.

a. The following chart lists some of the more common troubles that may occur in the Spectrum Analyzer, with suggestions for locating and removing them.

SYMPTOM	*TROUBLE LOCATION*	*PROCEDURE*
(1) Very small output curve or none at all when SELECTOR switch is in MIXER position and MIXER AMPLIFIER all the way on (cw).	(1) Defective crystal.	(1) Replace crystal.
	(2) Abnormal voltages on V-115. (2K25).	(1) Measure voltages. (2) Check operation of power supply.
	(3) V-115 defective.	(1) Replace V-115.
	(4) V-106 or its circuits defective.	(1) Check voltages. Replace V-106 if necessary.
(2) With SELECTOR switch in MIXER position there is vertical deflection on scope but analyzer r-f oscillator curve does not appear.	(1) No modulating voltage on V-115.	(1) Check output of V-108 and coupling circuit to V-115 with a test scope.
	(2) V-106 defective.	(1) Replace V-106.
	(3) V-108 defective.	(1) Replace V-108.
	(4) Incorrect voltages on V-106 or V-108.	(1) Check voltages and resistances.
(3) Trace on scope jumps up and down. SELECTOR switch in SPECTRUM INTENSIFIED or SPECTRUM position.	(1) Low line voltage.	(1) Check line voltage to see that it is above 105 volts.
	(2) Oscillation in neon bulbs V-116, V-117, V-118.	(1) Substitute neon bulbs one at a time to determine defective bulb.
	(3) Low output from V-110.	(1) Check negative high voltage supply.
(4) Low spectrum amplitude. Operation all right when SELECTOR switch is in MIXER position.	(1) Defective crystal.	(1) Replace crystal.
	(2) Broken resistance card in variable attenuator.	(1) Examine attenuator and replace resistance card if broken.
	(3) I-F amplifier out of alignment.	(1) Align i-f amplifier. See Par. 3, of this section.
(5) Mechanical vibration of Analyzer causes trace to jump up and down.	(1) V-102, V-103 or V-104 microphonic.	(1) Substitute tubes one at a time. If microphonic, replace with good tube.
(6) No spectrum when SELECTOR switch is in SPECTRUM INTENSIFIED or SPECTRUM position. Oscillator pattern normal in MIXER position.	(1) Variable attenuator stuck in maximum attenuating position.	(1) Free resistance card or replace defective parts.
	(2) Abnormal voltages or defective tubes in i-f amplifier.	(1) Check tubes and voltages.
	(3) Open coupling capacitor in i-f amplifier.	(1) Trace signal with scope to determine location of defective capacitor.
	(4) 19.5-mc/s oscillator inoperative.	(1) Check oscillator circuit.
	(5) I-F amplifier out of alignment.	(1) Align i-f amplifier. See Par. 3, of this section.
(7) Right end of horizontal trace jitters back and forth.	(1) Sweep frequency not synchronized with line frequency.	(1) Turn SYNC switch ON or adjust SWEEP FREQUENCY Control until jitter disappears.

6. REPLACING THE CATHODE-RAY TUBE.

a. If V-105 requires replacement proceed as follows:

(1) Remove the dust cover. See Par. 2, of this section.

(2) Remove the socket assembly from the base of the tube.

(3) Remove the bezel on the control panel.

(4) Loosen the thumb screws on the clamps at the base until the tube is free to slide forward.

(5) Pull the tube out through the hole in the front panel.

(6) Reverse the above steps to replace the new tube.

7. DIAL ASSEMBLY.

a. The FREQUENCY dial is assembled to the frequency-meter and accurately calibrated at the factory. The dial is relatively free from mechanical defects and should seldom require replacement. If it must be replaced, the entire wave-guide assembly will have to be replaced since it is extremely difficult to replace a dial and calibrate it in the field. To replace the wave-guide assembly proceed as follows:

(1) Remove all control knobs.

(2) Remove hex nuts on the potentiometers.

(3) Remove nameplate.

(4) Remove the four screws that hold the dial assembly to the control panel.

(5) Remove the analyzer r-f oscillator tuning shaft.

(6) Remove the attenuator shaft.

(7) Remove the handles on the control panel.

(8) Pull the control panel forward.

(9) Remove the crystal-mixer cable.

(10) Remove the analyzer r-f oscillator socket assembly.

(11) Remove the two mounting screws that hold the wave-guide assembly to the chassis.

(12) Gently work the wave-guide assembly into a position where it will drop out of the chassis.

(13) Install the new wave-guide assembly by reversing the above procedure.

8. RESISTANCE MEASUREMENTS.

a. The point-to-point resistances given below should be made with a sensitive ohmmeter. All potentiometers should be turned clockwise as far as they will go.

TABLE IV

CHECK POINTS	*RESISTANCE*
Note: K = 1000	
(1) X-101 Pin 6 or 8 to X-112 Pin 8	30 K
(2) X-102 Pin 8 to L-101 Ter. 1	287 K
(3) X-102 Pin A to X-102 Pin 3	15 K
(4) X-103 Pin 1 to C-116 RT	1.5 Meg.
(5) X-103 Pin 1 to L-103 Ter. 1	375 K
(6) X-103 Pin 1 to X-103 Pin 3	150 K
(7) X-103 Pin 2 to L-103 Pin 2	332 K
(8) X-103 Pin 3 to X-104 Pin 4	47 K
(9) X-103 Pin 4 to X-106 Pin 6	22 K
(10) X-103 Pin 5 to X-104 Pin 8	55 K
(11) X-103 Pin 5 to X-104 Pin 2	100 K
(12) X-103 Pin 5 to X-106 Pin 8	1 Meg.
(13) X-103 Pin 5 to X-112 Pin 3	10 K
(14) X-103 Pin 6 to X-104 Pin 6	0
(15) X-104 Pin 8 to X-105 Pin 8 (S-103 in position 2 or 3)	0
(16) X-105 Pin 1 and 2 to X-110 Cap	72 K
(17) X-105 Pin 1 and 2 to X-105 Pin 3	253 to 268 K
(18) X-105 Pin 1 and 2 to X-105 Pin 5	200 to 450 K
(19) X-105 Pin 3 to C-128	33 K
(20) X-105 Pin 8 to X-106 Pin 8 (S-103 position 1)	0
(21) X-105 Pin 10 to X-105 Pin 11	200 K
(22) X-106 Pin 4 to T-101 Ter. 1 (Crystal Cable Disconnected)	5 K
(23) X-106 Pin 6 to X-106 Pins 3 and 5	3.3 K
(24) X-107 Pin 3 to C-122	100 ohms
(25) X-107 Pin 5 to C-115 C	133 K
(26) X-107 Pin 5 to C-119 B	33 K
(27) X-108 Pin 1 to C-122	1 Meg.
(28) X-108 Pin 1 to X-108 Pin 4	1.3 Meg.
(29) X-108 Pin 4 to C-123	2.2 Meg.
(30) X-109 Pin 1 to C-119	517 K
(31) X-109 Pin 1 to C-115 C	617 K
(32) X-109 Pin 4 to C-128	518 K
(33) X-109 Pin 2 to C-127	15 K
(34) X-109 Pin 4 to R-162 (S-103 position 1 or 3)	0
(S-103 position 2)	470 K
(35) X-111 Pin 2 to X-112 Pin 3	620 ohms
(36) X-111 Pin 2 to X-106 Pin 8	1 Meg.

TABLE IV (Continued)

CHECK POINTS	*RESISTANCE*
Note: K=1000	
(37) X-111 Pin 2 to X-108 Pin 2 or 5	110 K
(38) X-111 Pin 2 to X-103 Pin 5	10 K
(39) X-111 Pin 2 to X-104 Pin 8	65 K
(40) X-111 Pin 2 to X-105 Pin 8 (S-103 in position 2 or 3)	65 K
(41) X-112 Pin 3 to X-112 Pin 4	1 K
(42) X-112 Pin 3 to X-112 Pin 5	330 K
(43) X-112 Pin 3 to X-113 Pin 4	1 Meg.
(44) X-112 Pin 3 to C-137 A	310 ohms
(45) X-112 Pin 5 to X-113 Pin 8	0
(46) X-112 Pin 8 to X-113 Pin 6	150 K
(47) X-112 Pin 8 to X-113 Pin 3	1 Meg.
(48) X-112 Pin 8 to X-102 Pin 3	2.2 K
(49) X-112 Pin 3 to X-102 Pin 4	17.2 K
(50) X-112 Pin 8 to X-109 Pins 2 and 5	115 K
(51) X-112 Pin 8 to X-109 Pin 4	603 K
(52) X-112 Pin 8 to X-107 Pin 3	1.33 Meg.
(53) X-112 Pin 8 to X-101 Pin 6 or 8	30 K
(54) X-112 Pin 8 to X-103 Pin 2	53 K
(55) X-112 Pin 8 to X-106 Pins 3 and 5	69.3 K
(56) X-112 Pin 8 to X-106 Pin 6	66 K
(57) X-115 Cap to C-131 A	1.1 Meg.
(58) X-117 to C-115 C	430 K
(59) X-117 to C-119 C	100 K
(60) X-117 to R-143	150 K
(61) X-117 to R-145	150 K
(62) C-115 B to T-101 Ter. 1	100 ohms
(63) C-125 B to C-124	150 K
(64) C-125 B to ground	102.2 K
(65) C-131 A to C-116 (right)	1.547 Meg.
(66) C-131 A to C-131 B	147 K
(67) T-102 Ter. 14 to junction J-102 and C-132 (S-101 ON)	0
(68) T-102 Ter. 13 to junction J-102 and C-133 (S-101 ON)	0
(69) T-102 Ter. 14 to T-102 Ter. 15	2.6 ohms
(70) T-102 Ter. 4 to T-102 Ter. 6	1 K
(71) T-102 Ter. 5 to T-102 Ter. 6	400 ohms
(72) T-102 Ter. 6 to T-102 Ter. 7	400 ohms
(73) T-102 Ter. 8 to ground	0-250 ohms

b. TECHNICAL CHARACTERISTICS.

Power Supply	50-1200 cps; 105-125 volts; 125 watts
Frequency swing of analyzer r-f oscillator (sawtooth FM)	40 to 50 mc/s.
First Intermediate Frequency	22.5 mc/s.
Second Intermediate Frequency	3.0 mc/s.
Overall I-F band-width at half power points	50 kc/s.
Receiver gain (2 I-F stages, 1 Video Stage)	100 db
Sensitivity to CW	90 db below 1 watt (10^{-9} watts or .001 microwatt)
Tuning Range	Limited to frequency range of local oscillator tube 2K25. Characteristics vary with different tubes.
Frequency Meter Range	Calibrated directly from 8470 mc/s. to 9630 mc/s. Tolerance ± 5 mc/s.
Sweep Frequencies	10 to 20 cps.
Indicator	Cathode Ray Tube
Information Displayed	Each frequency component in an r-f signal displayed as power plotted against frequency.
Attenuation	Uncalibrated, variable between 3 and 70 db
Maximum Dispersion of Spectra	1.5 mc/s per inch
Power Output	Approximately 1 milliwatt
Operating Temperature Range	−40° to +55° C.

2. ADJUSTMENT OF R-F SENSITIVITY.

a. GENERAL.

(1) Beginning with Serial No. 496 a potentiometer, R-197, was added in series with resistor R-195 to adjust the screen voltage of V-101 when the SELECTOR SWITCH is in the SPECTRUM position. Resistor R-195 was reduced from 3300 ohms to 1000 ohms. This permits the r-f sensitivity to be adjusted so that it is 25 db below the sensitivity obtained when the SELECTOR SWITCH is in the SPECTRUM AMPLIFIED position.

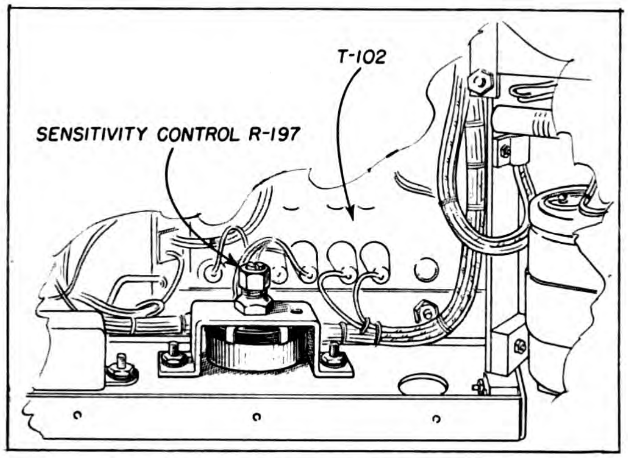


Figure 5-0A. Location of SENSITIVITY Control.

b. LOCATION.

(1) The SENSITIVITY CONTROL R-197 is placed in series with resistor R-195 and SELECTOR SWITCH S-103. It is mounted on a U-shaped bracket located on the inside of the rear of the chassis, directly over transformer T-102. See Fig. 5-0A.

c. WIRING INFORMATION.

(1) Wire #88, shown in Figs. 7-9, and 5-0B, which formerly connected from resistor R-102 to switch S-103 (R-195) now connects between resistor R-102 and terminal A on potentiometer R-197 through cable C3-D3-D. Jumper wire #43 connects between terminals A and B on potentiometer R-197. Wire #53 connects between terminal C on potentiometer R-197 and terminal B4 on switch S-103 (R-195) through cable D-D3-C8-C7. The wire cable and terminal numbers to which reference is made are shown in the wiring diagram in Fig. 7-9, which should be corrected to show the changes made. See Fig. 5-0B.

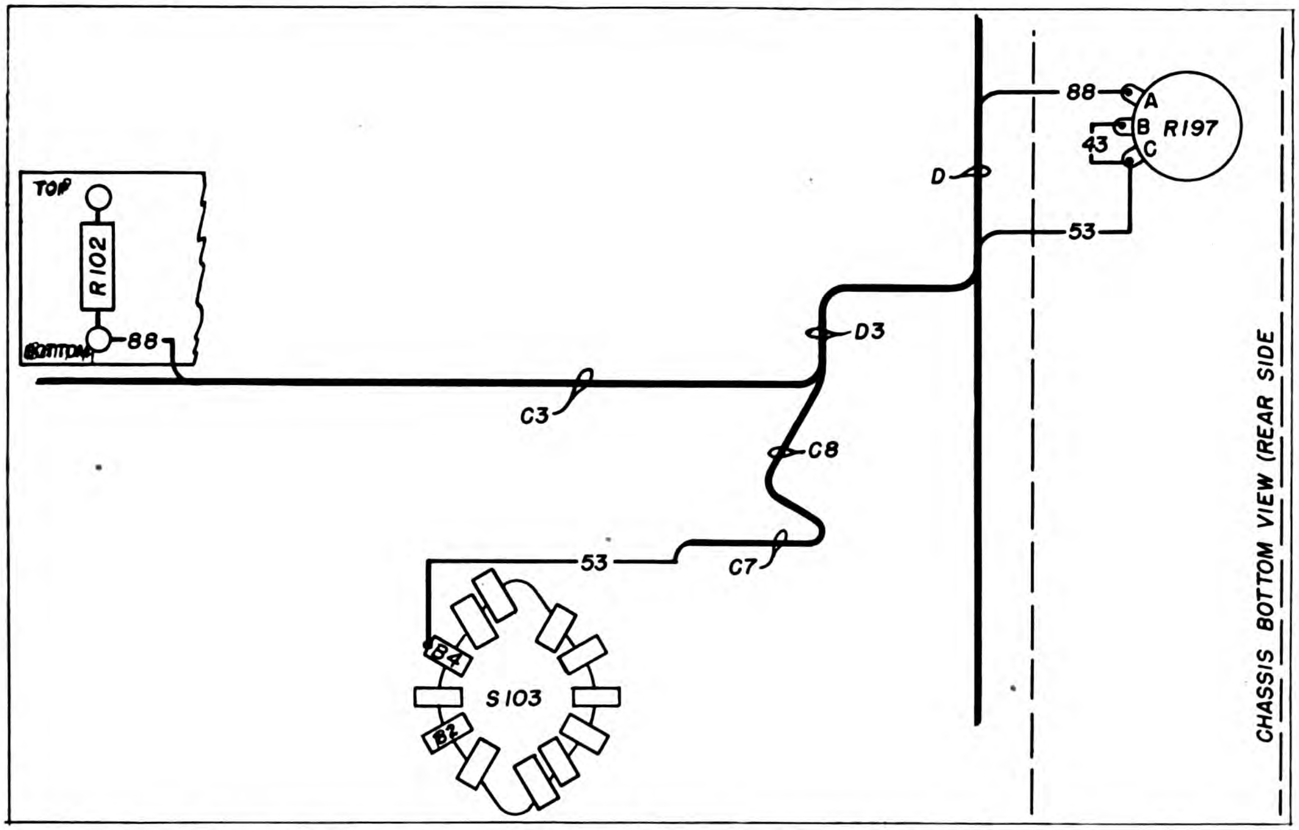


Figure 5-0B. Corrected Section of Fig. 7-9 Showing Addition of SENSITIVITY Control.

d. SCHEMATIC CHANGES.

(1) Fig. 5-0C shows the changes in the schematic diagrams shown in Figs. 7-6 and 7-7. These figures should be corrected to agree with the sketch in Fig. 5-0C.

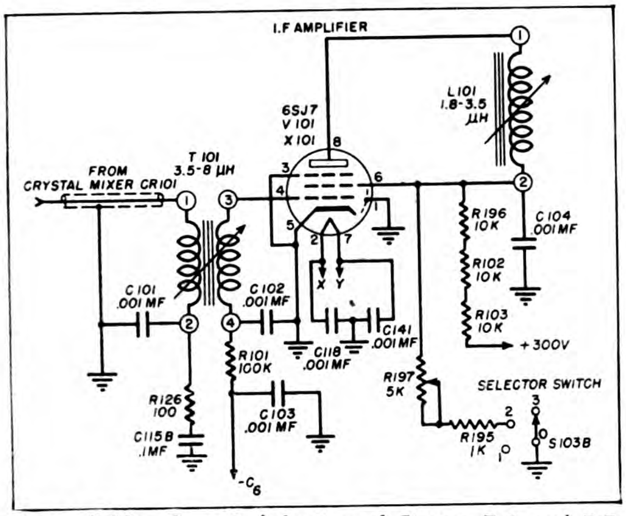


Figure 5-0C. Corrected Section of Figures 7-6 and 7-7 Showing Addition of SENSITIVITY Control.

3. ERRATA.

a. PAGE 2-0 SECTION II.

(1) References to Figs. 7-4, 7-5 and 7-6 in Paragraph 1c should be to Figs. 5-4, 5-5 and 5-6.

b. PAGE 3-13 SECTION III.

(1) Reference to SYNC switch S-101 in paragraph 3h(2) should read SYNC switch S-102.

4. CORRECTIONS FOR TABLE OF REPLACEABLE PARTS.

a. Make the following corrections in the Table of Replaceable Parts.

(1) C-119A, change Function to "Blanking Tube Bias Filter."

(2) C-126, change Function to "Sweep Coupling to Blanking Tube."

(3) E-202, under Name of Part and Description change UG-79/U to UG-183/U.

(4) E-203, under Name of Part and Description change CG-182/U to CG-182/APM-40-15.

(5) O-106, under Name of Part and Description change #110 to #260.

(6) P-205, under Manufacturer and Designation change UG-24/U to UG-21/U.

(7) R-195, under Name of Part and Description change 3,300 ohms ± 5% to 1,000 ohms ± 10%.

(8) R-197, under Reference Symbol add R-197 after R-196, under Name of Part and Description add, "RESISTOR, VARIABLE – 5,000 ohms, ± 10%, linear taper, 2 watts. Case 1.227" diam. x 9/16" thick, maximum dimensions. Three terminals. Shaft .250" diam. x 9/16" long from 3/8" bushing with screwdriver slot. Under Function, add, "Sensitivity Control." The Manufacturer and Designation is #11 7713389-p-28. The Drawing or Specification Number is 7613284-p-190.

(9) V-115, under Function change to read "Micro-Wave Oscillator Tube".

(10) X-111, under Name of Part and Description change to read "SOCKET—Octal, mica-filled, etc."

Date 24 Feb. 1945

ADDENDA NO. 1

FOR

INSTRUCTION BOOK CO-AN'08-TS148-2-M

TS-148/UP TEST EQUIPMENT

SPECTRUM ANALYZER

1. ELIMINATION OF LEAKAGE INTERFERENCE

a. The high-gain i-f amplifier of the TS-148/UP Spectrum Analyzer is very sensitive and picks up interference when the Analyzer is operated in the radiation field of other equipments. Since the noise voltage is picked up by leakage into the waveguide assembly, its amplitude cannot be controlled by the variable attenuator. To attenuate the noise voltage in the i-f amplifier the following changes have been made:

(1) The intensifier action has been detached from switch S-103 and functions continuously.

(2) Position 3 of SELECTOR switch S-103 now gives the same type of operation as position 2 did previously. The nameplate for position 3 is changed to read SPECTRUM AMPLIFIED.

(3) Position 2 of S-103 now connects a 3.3K, 1 watt, ± 5% resistor from the screen of V-101 to ground. This reduces the screen and plate voltage from 110 to 40 volts, reducing the gain of the i-f amplifier approximately 25 db. The nameplate for position 2 is changed to read SPECTRUM. Due to the additional current drain through R-102 and R-103, these resistors have been changed to 10K, 1 watt, ± 5% resistors and a new resistor, R-196 has been added in series. R-196 is similar to the new R-102 and R-103.

(4) On position 1.of S-103, grid 4 of V-109 is grounded to prevent i-f signals and the frequency meter pip from being intensified.

b. These changes necessitate the following corrections:

(1) Page 2-1, paragraph 2c(7), line 4. Change "If the SELECTOR switch is in either the SPECTRUM-INTENSIFIED or SPECTRUM positions - -" to read, "If the SELECTOR switch is in either the SPECTRUM or SPECTRUM AMPLIFIED positions."

(2) Page 2-2, paragraph 2c(14), line 1. Change "Set the SELECTOR switch to either the SPECTRUM-INTENSIFIED or the SPECTRUM position. The Analyzer is normally operated in the SPECTRUM-INTENSIFIED position." to read, "Set the SELECTOR switch in either the SPECTRUM or the SPECTRUM AMPLIFIED position."

(3) Page 2-2, Fig. 2-6. Change title to read, "Frequency Meter Pip, SELECTOR Switch in SPECTRUM or SPECTRUM AMPLIFIED position."

(4) Page 2-3, Fig. 2-7. Change sub-titles of parts b and d to read, "SPECTRUM or SPECTRUM AMPLIFIED."

(5) Page 2-4, paragraph 3a(3)(b). Change paragraph to read: "The second position is the SPECTRUM position. When the switch is set to this position, the signal input to the i-f amplifier is attenuated about 25 db."

(6) Page 2-4, paragraph 3a(3)(c). Change paragraph to read: "The third position is the SPECTRUM AMPLIFIED position. This position is similar to the second position except that the signal input to the i-f amplifier is not attenuated."

(7) Page 2-4, paragraph 3a(15), lines 3 and 4. Change, "-- the SELECTOR switch is in the SPECTRUM-INTENSIFIED or SPECTRUM positions." to read, "-- the SELECTOR switch is in the SPECTRUM or SPECTRUM AMPLIFIED positions."

(8) Page 2-6, paragraph 5a(4). Change to read, "Place the SELECTOR switch in its SPECTRUM position."

(9) Page 2-17, Fig. 2-25. Change sub-title of part b to read, "SPECTRUM or SPECTRUM AMPLIFIED position."

(10) Page 2-18, Fig. 2-26. Change sub-title of part b to read, "SPECTRUM or SPECTRUM AMPLIFIED position."

(11) Page 2-19, Fig. 2-27. Change sub-title of part b to read, "SPECTRUM or SPECTRUM AMPLIFIED position."

(12) Page 2-20, Fig. 2-28. Change sub-title of part b to read, "SPECTRUM or SPECTRUM AMPLIFIED position."

(13) Page 3-7, paragraph 2b(13)(b). Delete first sentence.

(14) Page 3-12, paragraph 3f(2), add sub-paragraph at bottom of column as follows:

(e) The SPECTRUM position of the SELECTOR switch inserts resistor R-195 between the screen of V-101 and ground. This reduces the screen and plate voltages from 110 to 40 volts and reduces the gain of the i-f amplifier approximately 25 db.

(15) Page 3-13, paragraph 3g(2), lines 1 and 2. Change to read, "When the SELECTOR switch is in the SPECTRUM or SPECTRUM AMPLIFIED positions."

(16) Page 3-13, paragraph 3g(6), line 4. Change the word INTENSIFIED to AMPLIFIED.

(17) Page 3-13, paragraph 3g(6), lines 7 and 8. Change to read, "--voltage to the control grid of the cathode ray tube."

(18) Page 3-16, paragraph 3k(3). After (3) add new paragraph as follows:
(4) When the SELECTOR switch is in the MIXER position, the grid of V-109B is grounded to prevent i-f signals and the frequency meter pip from being intensified.

(19) Page 4-3, under Symptom (3), line 4. Change word INTENSIFIED to AMPLIFIED.

(20) Page 4-3, under Symptom (6), lines 3 and 4. Change word INTENSIFIED to AMPLIFIED.

(21) Page 4-5, check point (34). Delete "--Or 3".

(22) Page 6-18, Reference Symbol R-102. Change first line of Description to read, "10,000 ohms ± 5%, 1 watt." Change manufacturer's number to RC30BF103J.

(23) Page 6-23, Reference Symbol R-154. Under Description change 2,200 to 1,000. Under Manufacturer's Number change to read: RC20BF102K.

(24) Page 6-26, After R-193 add R-194 in Symbols column. Under Description add: Resistor, Fixed ---Same as R-154. Under function add: Video amplifier decoupling.

(25) Page 6-26. After R-194 add R-195 in Symbols column. Under Description add: "Resistor, Fixed -- 3,300 ohms ± 5%, 1 watt.

Under Function add: "1st i-f screen." Under Manufacturer's Number add: "RC20BF333J". Under Drawing No. add: "7613284 P-188."

(26) Page 6-26. After R-195 add "R-196" in Symbols column. Under Description add: "Resistor Fixed--Same as R-102." Under function add: "1st i-f screen supply divider."

(27) Page 7-11, Fig. 7-6. Make the following changes:

(a) Disconnect C-129 from terminal 2, section B of S-103. Connect R-195 (3.3K) between grid 6 of V-101 and terminal 2, section B, of S-103.

(b) Disconnect junction of R-161, R-162, and R-192 from terminal 1, section B, of S-103.

(c) Disconnect R-115 from C-129 and terminal 3, section B on S-103.

(d) Connect junction of R-161, R-162, and R-192 to free end of C-129.

(e) Disconnect arm of Section B, S-103 from grid 4 of V-109, and connect arm of switch to ground.

(f) Connect grid 4 of V-109 to terminal 1, section B of S-103.

(g) Disconnect terminal 3 from terminal 1 on section B of S-103.

(h) Change the value of R-102 and R-103 to 10K.

(i) Add R-196 (10K) in series with R-102 and R-103.

(j) Change SPEC-INT to SPEC on S-103.

(k) Change SPEC to SPEC AMP on S-103.

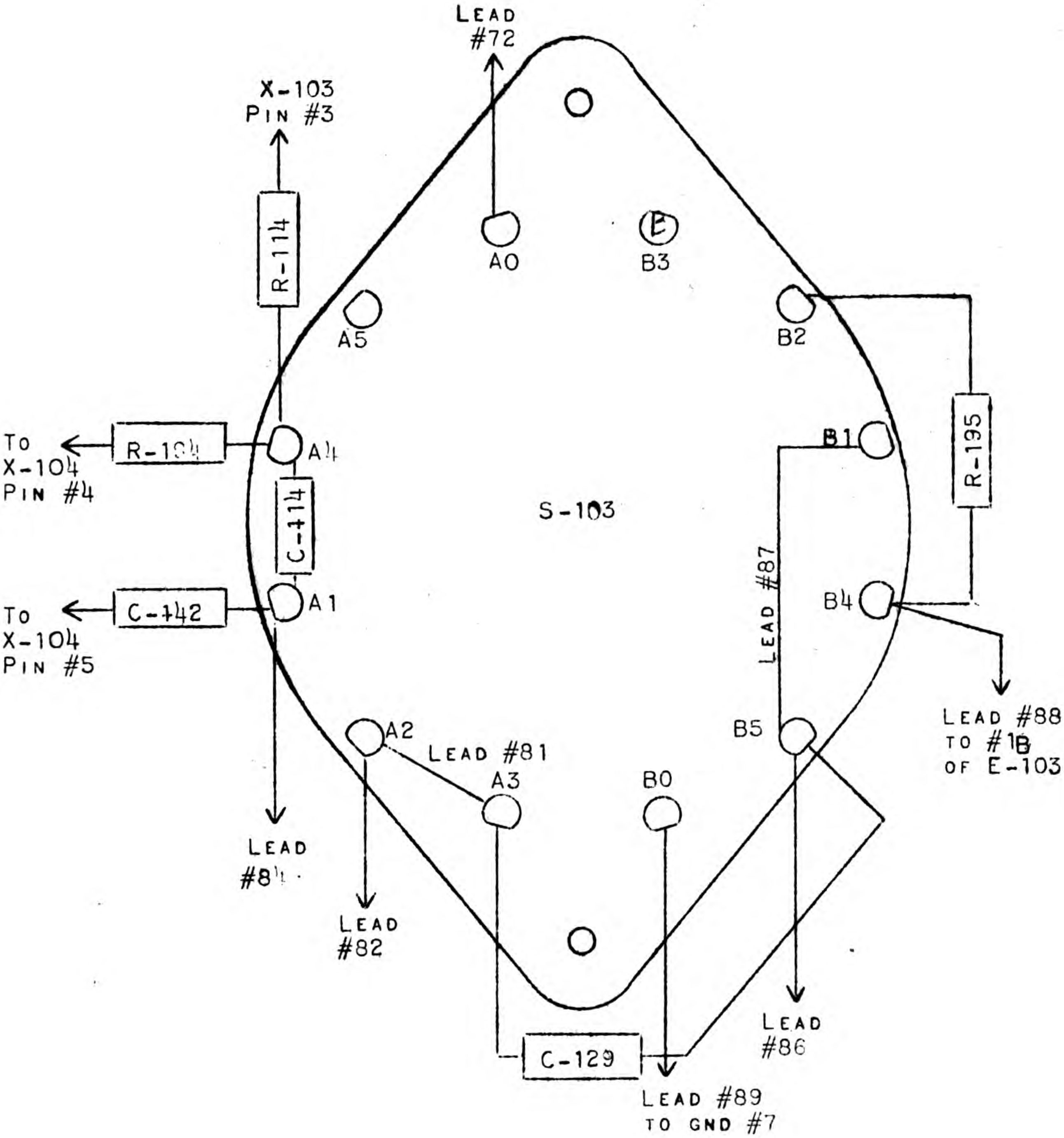
(l) Add R-194 (1K) in series with grid 4 of V-104.

(m) Change value of R-154 to 1K.

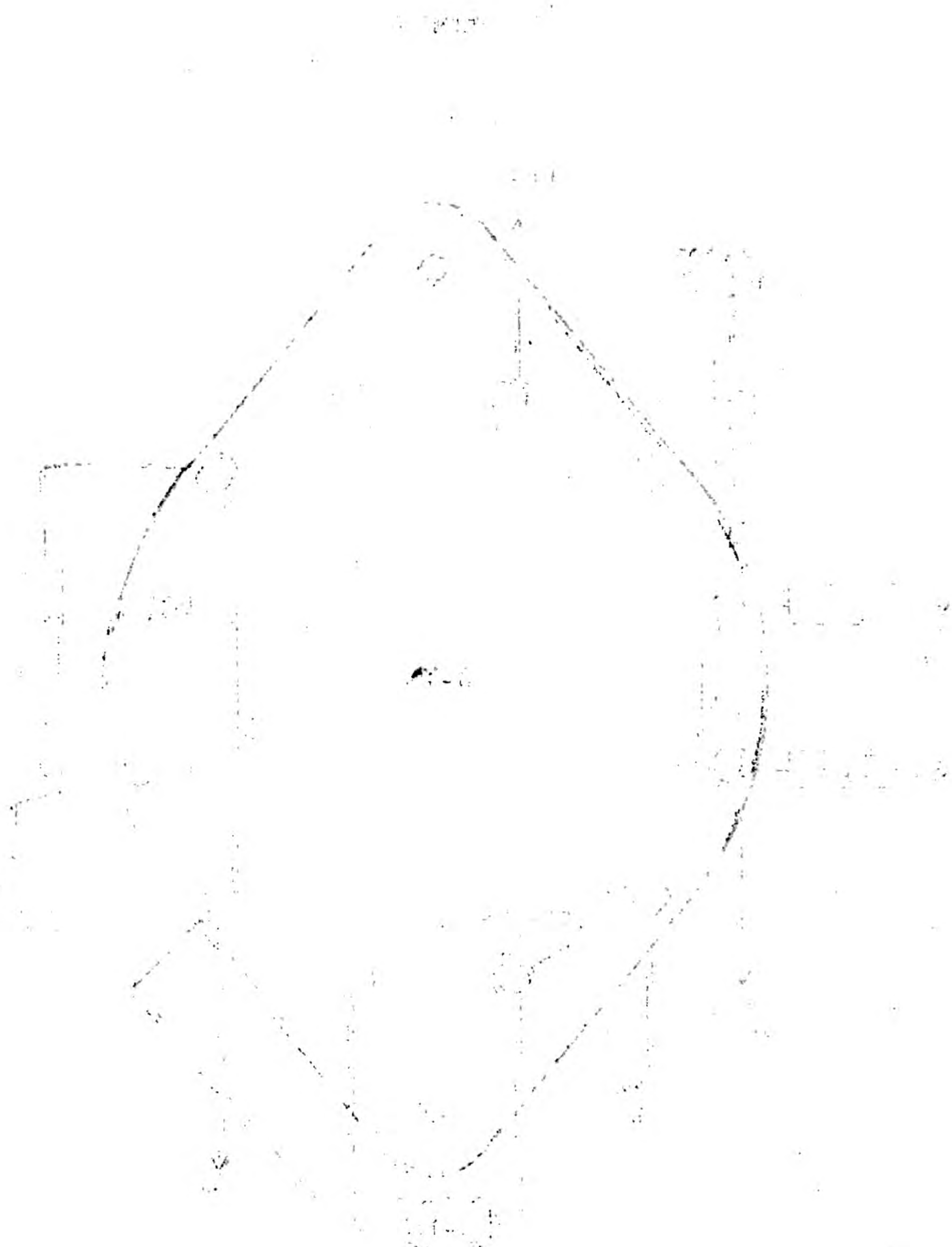
(n) Remove C-142 from plate 8 of V-106 and connect it between ground and terminal 1, section A of S-103.

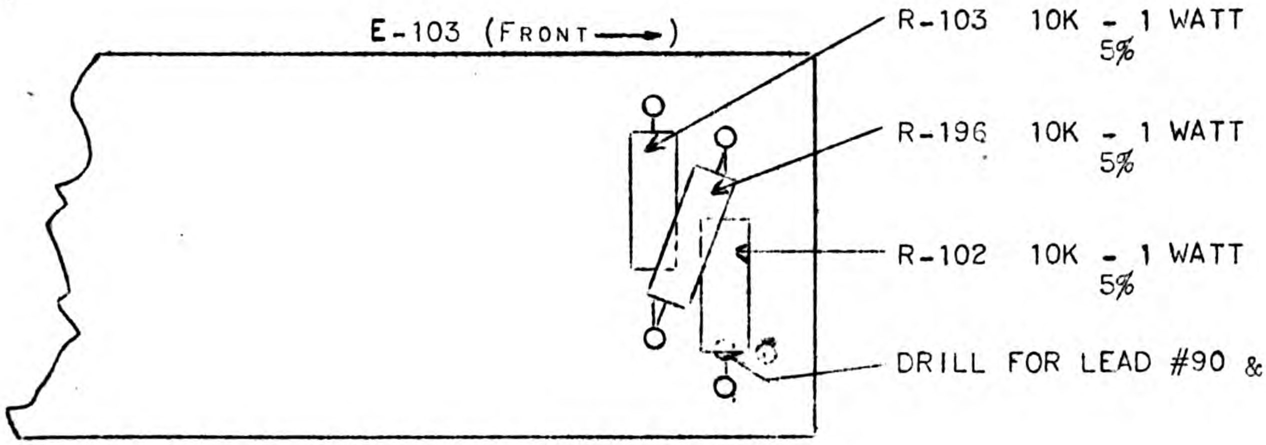
(28) Page 7-13, Fig. 7-7. Refer to Change (27) and make the same changes on Fig. 7-7.

(29) Page 7-17. Fig. 7-9. Change connections to SELECTOR switch on wiring diagram as indicated on attached sketches A and B.

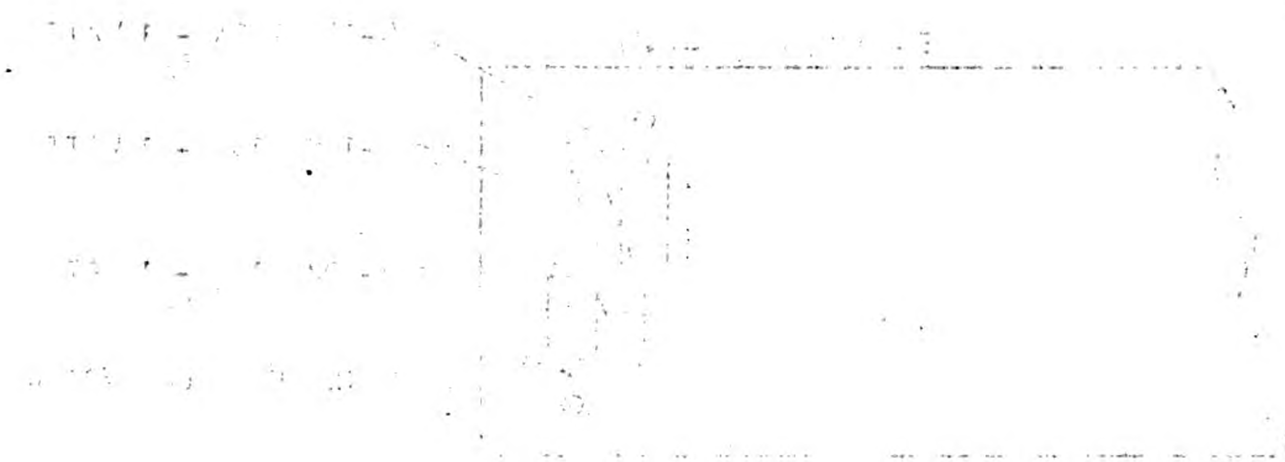

LEAD
#72
X-103
PIN #3
R-114
A0
B3
A5
B2
R-135
TO
X-104
PIN #4
R-104
A4
B1
C-114
S-103
LEAD #87
TO
X-104
PIN #5
C-142
A1
B4
LEAD #88
TO #1B
OF E-103
A2
LEAD #81
A3
B0
B5
LEAD
#84
LEAD
#82
LEAD
#86
C-129
LEAD #89
TO GND #7

SKETCH A




E-103 (FRONT →)
R-103 10K - 1 WATT 5%
R-196 10K - 1 WATT 5%
R-102 10K - 1 WATT 5%
DRILL FOR LEAD #90 &

SKETCH B



Date: 14 April 1945

ADDENDUM NO.2
FOR
HANDBOOK OF OPERATING AND MAINTENANCE INSTRUCTIONS
CO-AN 08-TS-148-2-M

1. GENERAL

a. Due to recent modifications of the TS-148/UP Spectrum Analyzer, it is necessary to revise the Instruction Book as follows:

(1) PAGE 1-3, TABLE III. -- Sensitivity to CW should be changed to read as follows:

SPECTRUM AMPLIFIED position -- 80 db below 1 watt, for one inch of deflection on the oscilloscope screen.

SPECTRUM position -- 55 db below 1 watt, for one inch of deflection on the oscilloscope screen.

(2) PAGE 2-0, FIG. 2-1. -- Change J-101 on access door to E-101.

(3) PAGE 2-5, PARAGRAPH 4. -- Insert a reference to the following note:

NOTE

Due to backlash, parallax, and tuning errors due to the human element, the accuracy of the frequency meter may be reduced in extreme cases, to ± 2.0 mc/s at the zero check point. The error may be as much as ∓ 5 mc/s at other points on the dial. However, the average reading will be much more accurate. The frequency meter cavity is zero set for 9310 mc/s in an approximate ambient temperature of 21°C. and an approximate relative atmospheric humidity of 60 per cent. If the Analyzer is operated under temperature and humidity conditions that vary appreciably from the values given, the error in calibration will increase proportionately.

(4) PAGE 2-14 PARAGRAPH 7c. -- Insert reference to the note given in Paragraph 1a(3) of this addenda.

(5) PAGE 3-13 PARAGRAPH 3f(5). -- Insert reference to the following note:

NOTE

The i-f amplifiers must be aligned with the SELECTOR switch in its SPECTRUM AMPLIFIED position. Do not attempt to realign the i-f amplifiers with the SELECTOR switch in the SPECTRUM position.

(6) PAGE 4-1, PARAGRAPH 3.--Insert reference to the note in Paragraph 1a(5) of this addenda.

(7) PAGE 5-2, PARAGRAPH 1b.-- Change Sensitivity to CW as directed in Paragraph 1a(1) of this addenda.

2. CIRCUIT CHANGES

a. PAGE 7-11, FIG. 7-6 and PAGE 7-13, FIG. 7-7.-- Change the following parts values:

(1) Potentiometer R-135 will be changed to 1.2 megohms beginning approximately with serial No. 350. This change is necessary to obtain sufficient sweep frequency range.

NOTE

The sweep frequency range was increased on Analyzers beginning with serial no. 191 and continuing through about serial no. 350 by making the value of resistor R-134, 470K instead of 330K. At the time potentiometer R-135 is changed, 1.2 megohm potentiometers for R-135 will be included in Bulk Spares. Either the original value of 1 megohm or the new value of 1.2 megohm may be used in Analyzers where R-134 is 470K although slightly better performance will be obtained if R-134 is returned to its original value of 330K and R-135 is made 1.2 megohms.

(2) After serial no. 190, potentiometer R-174 was changed from 100K to 250K. A 250K potentiometer will be supplied in Bulk Spares for R-174. This change was made to increase the adjustment range of the SPOT FOCUS Control.

3. WIRING CHANGES

a. The following change was made beginning with serial no. 250:

(1) Terminal Board E-105 was replaced with Terminal Board E-109 which necessitated changes in the wiring. Both E-105 and E-109 are supplied in Bulk Spare Parts since they are not interchangeable. The wiring changes are shown in the attached wiring diagram.

b. PAGE 7-15, FIG. 7-8; PAGE 7-17, FIG. 7-9, PAGE 7-19, FIG. 7-10.

(1) The wiring diagram contained in these figures has been changed to conform with the changes described in Addendum No. 1 and Addendum No. 2. A page size copy of each revised figure is attached to this addendum. The revised figures should be inserted adjacent to the original figures.

4. TABLE OF REPLACEABLE PARTS

a. The Table of Replaceable Parts should be corrected to conform with the changes listed in Addenda No. 1 and Addenda No. 2. These changes are listed as follows:

(1) E-101B-- Manufacturer and designation should be #31, A2849 and A2852.

(2) E-101C-- Manufacturer and designation should be, #31, A2838.

(3) E-101D-- Manufacturer and designation should be, #31-2864.

(4) E-101E-- Manufacturer and designation should be, #31-2865.

(5) E-102-- Part of description referring to "48 terminals" should be changed to read "39 terminals."

(6) E-104-- Part of description referring to "24 terminals" should be marked "18 terminals".

(7) E-109-- Delete "Not used.", and insert the following description:

BOARD TERMINAL--Varnish impregnated micarta board, 2" x 3/4" overall x 3/32" thick, mounting 3 terminals.

Under Function insert the following:

Local oscillator board.

Under Manufacturer and Designation insert the following:

#1-7410891 G-1.

Under Drawing and Specification No., insert the following:

7614131, Pt. 21.

(8) H-108-- Change 2-9/16" to 3-9/16".

(9) L-103-- Change 17 microhenries to 0.07 millihenries.

(10) O-102-- Manufacturer and designation should be #31-2863.

(11) O-103-- Manufacturer and designation should be, #31-A663.

(12) O-104-- Delete. No longer used.

(13) O-105-- Manufacturer and designation should be, #31-2847.

(14) O-115, O-116, and O-117-- Manufacturer should be #1 instead of #48 or #54.

(15) R-127-- Change 3 watts to 2 watts in the description.

(16) R-133-- Change 3 watts to 2 watts in the description.

(17) R-135-- Change 1.0 megohm to 1.2 megohm, and change 3 watts to 2 watts in the description. Change Drawing and Specification number to 7713389-Part 23.

(18) R-140-- Change 3 watts to 2 watts in the description.

(19) R-144-- Change 3 watts to 2 watts in the description.

(20) R-153-- Change 3 watts to 2 watts in the description.

(21) R-174-- Under description, change 100,000 ohms to 250,000 ohms, and change 3 watts to 2 watts. Change Drawing and Specification No. to 7713389, Part #24.

(22) X-115-- Manufacturer and designation should be #31-2860.

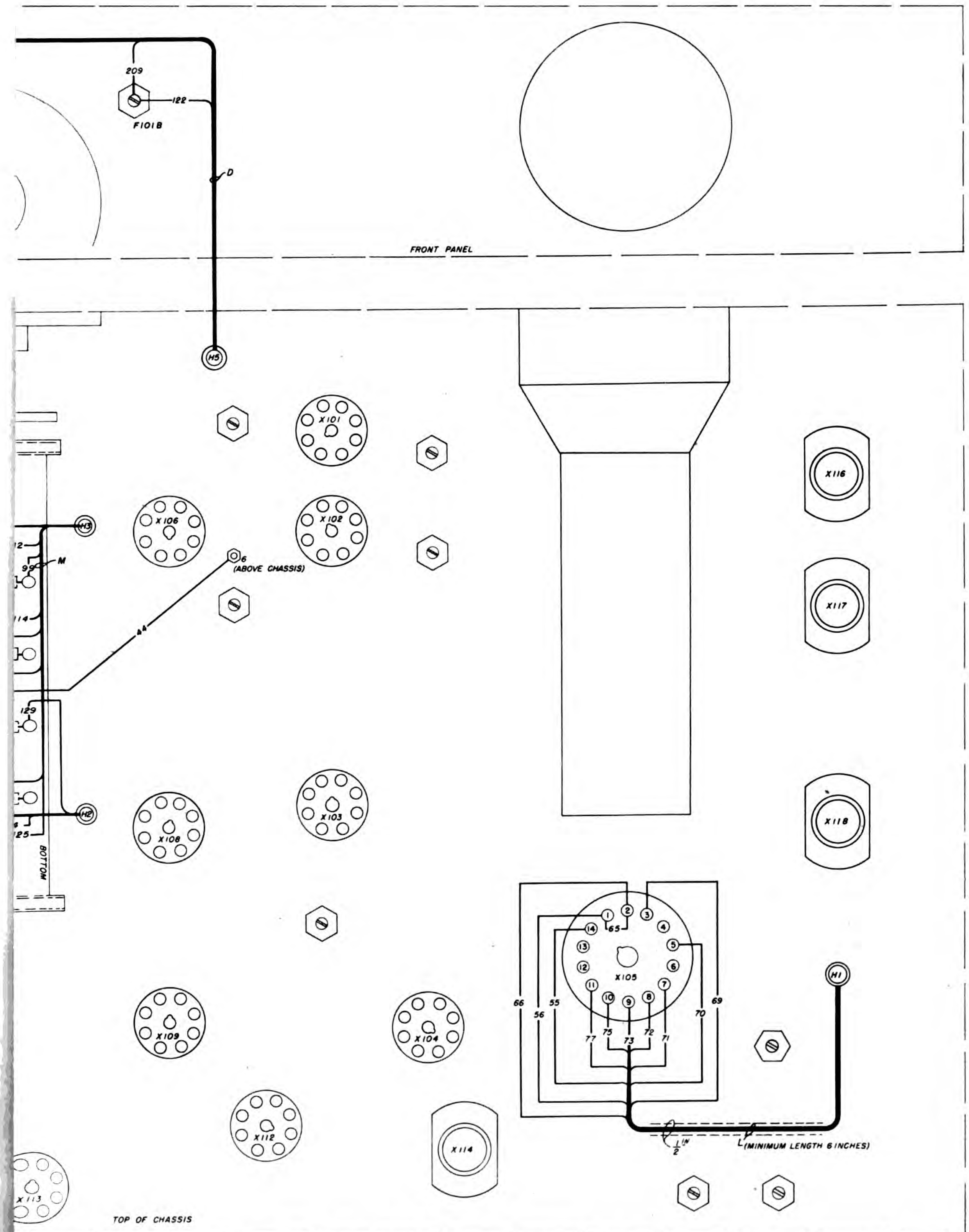


Figure 7-8. Spectrum Analyzer, Wiring Diagram. For Top of Chassis. **Fig. 7-8**
See Fig. 7-10 for wiring legend.

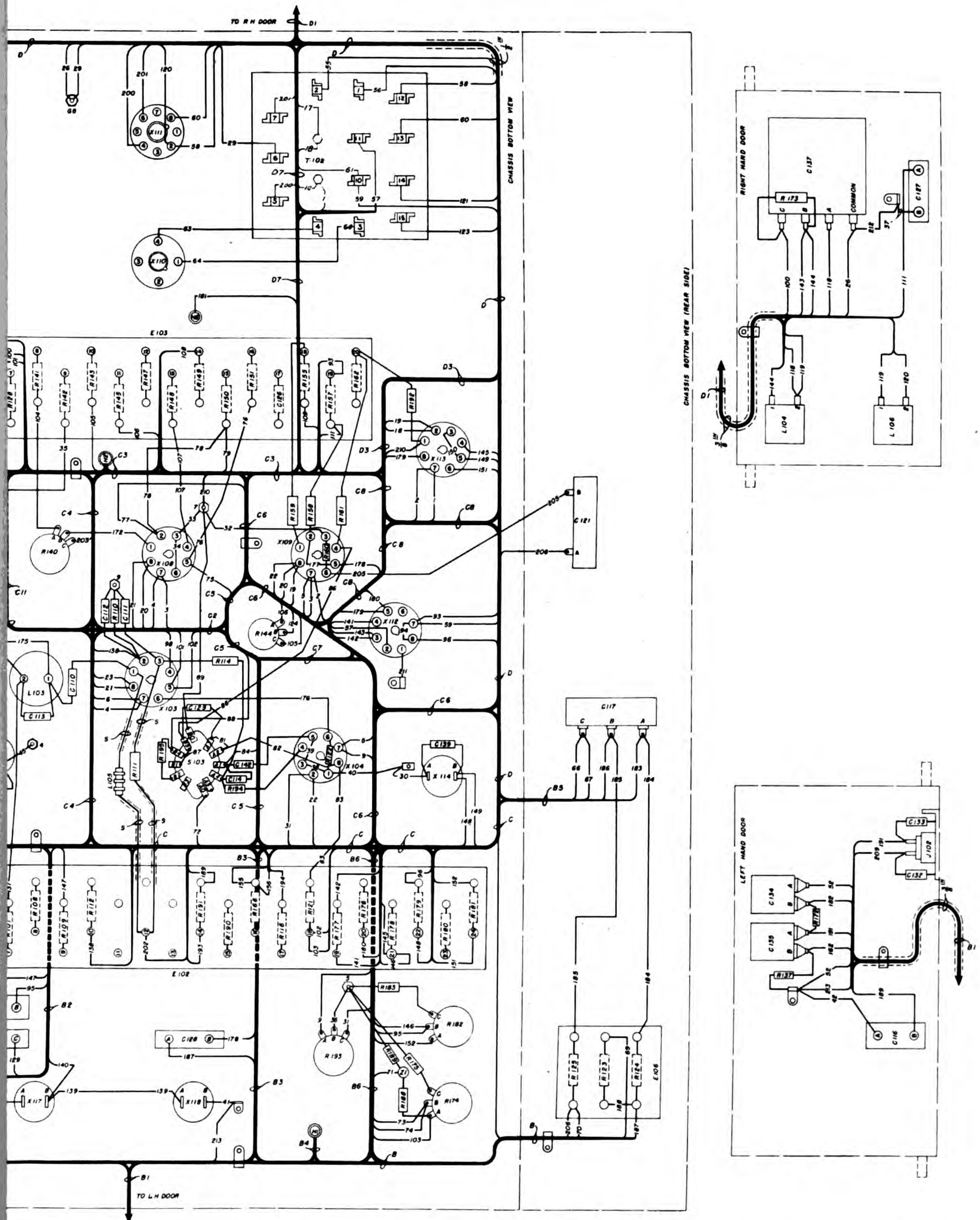


Figure 7-9. Spectrum Analyzer, Wiring Diagram. For Bottom of Chassis. Fig. 7-9
See Fig. 7-10 for wiring legend.

Figure 7-10. Spectrum Analyzer, Wiring Legend.

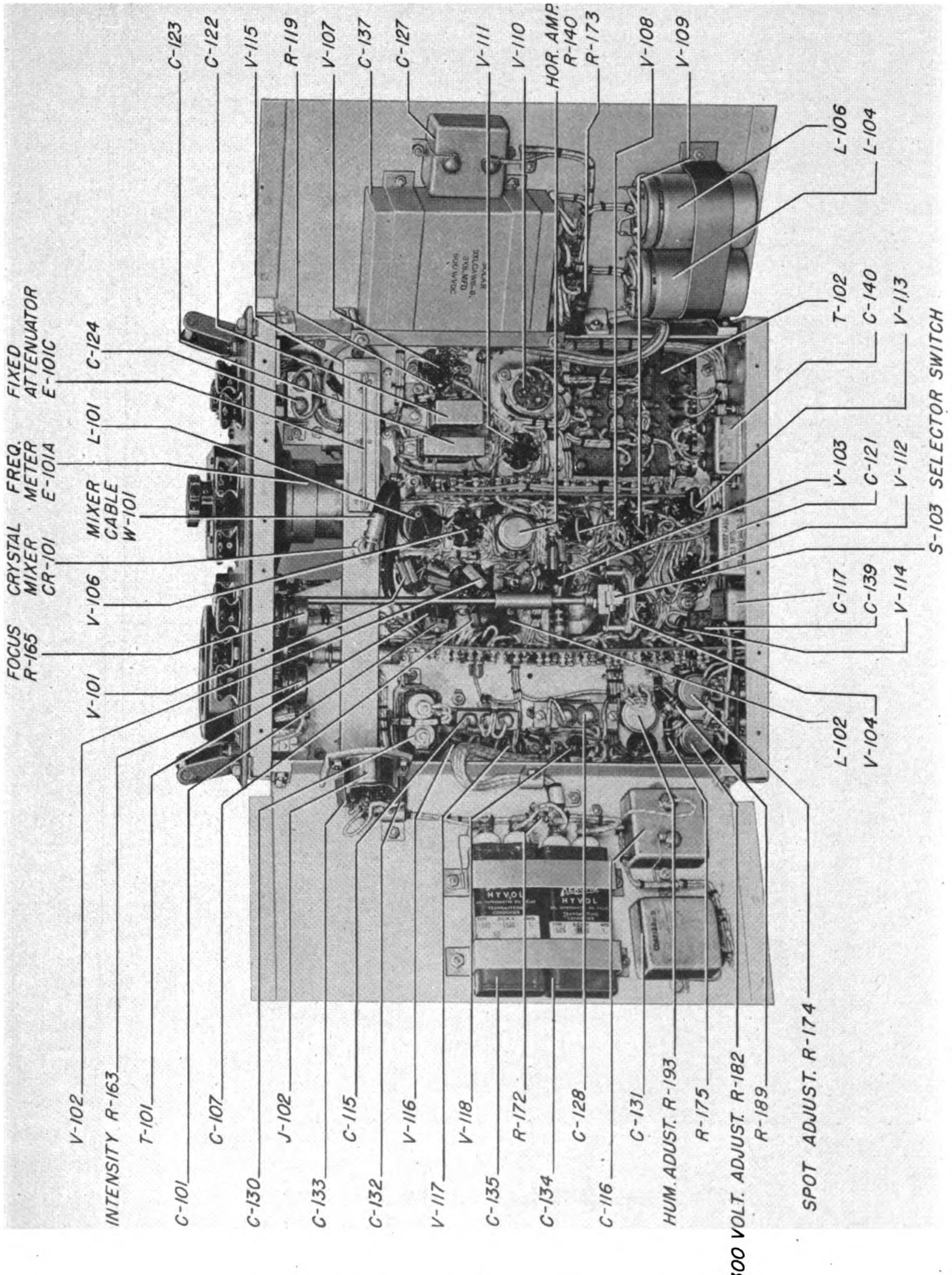


Figure 5-1. Spectrum Analyzer, Bottom View

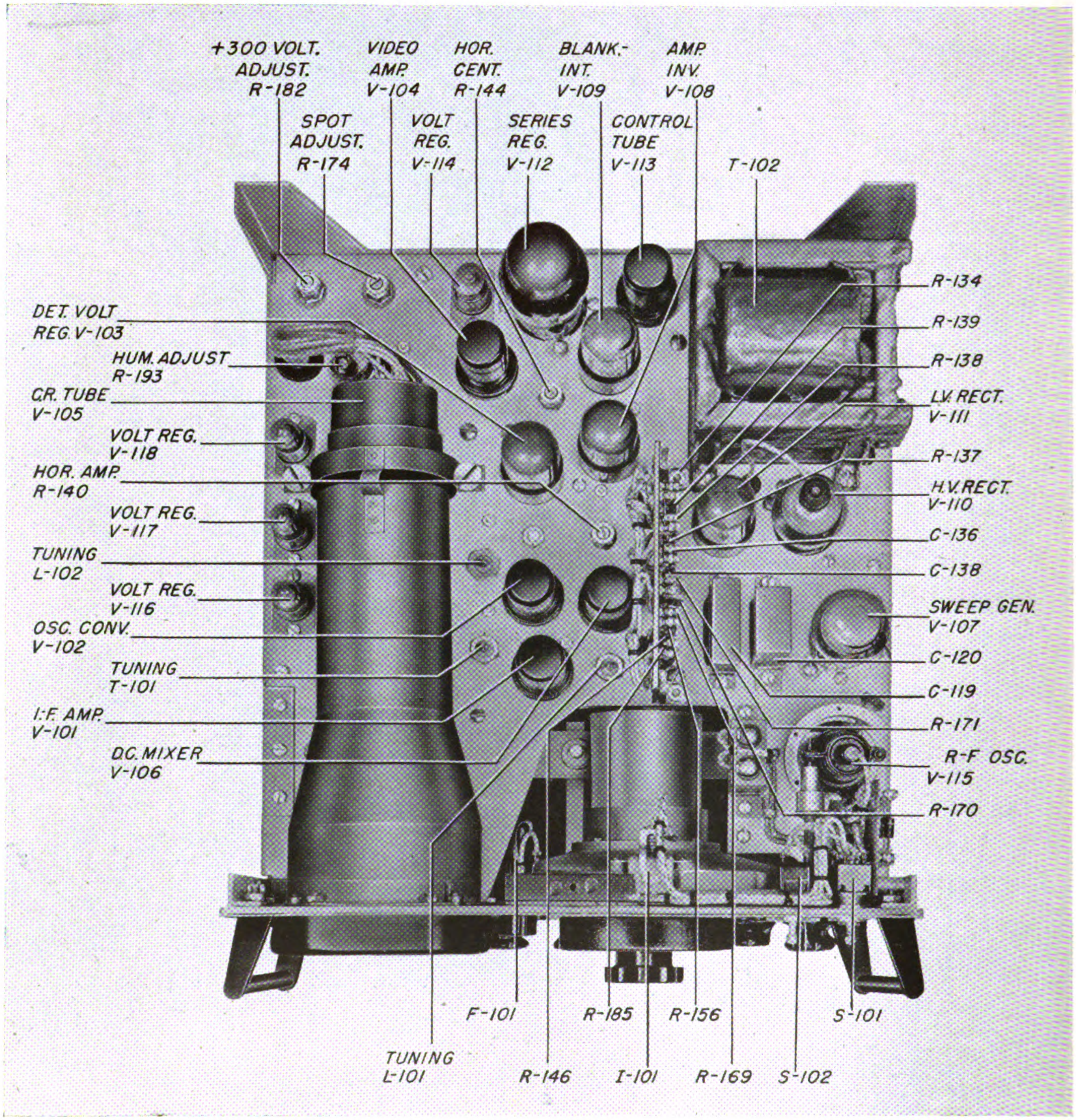
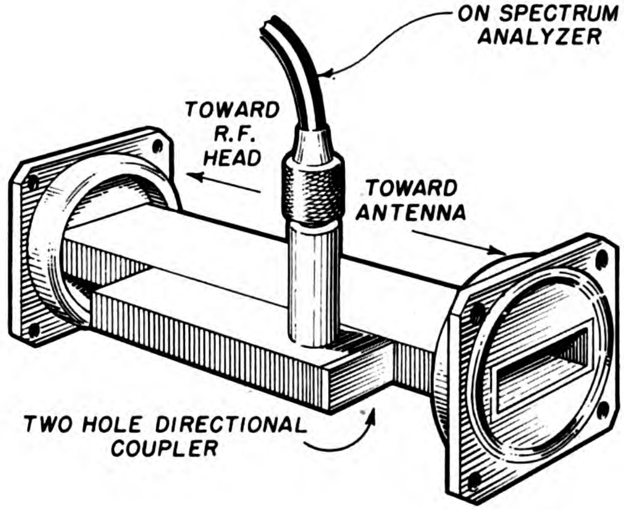


Figure 5-2. Spectrum Analyzer, Top View



NAVY TYPE CG-176/AP

Figure 5-3. Directional Coupler CG-176/AP

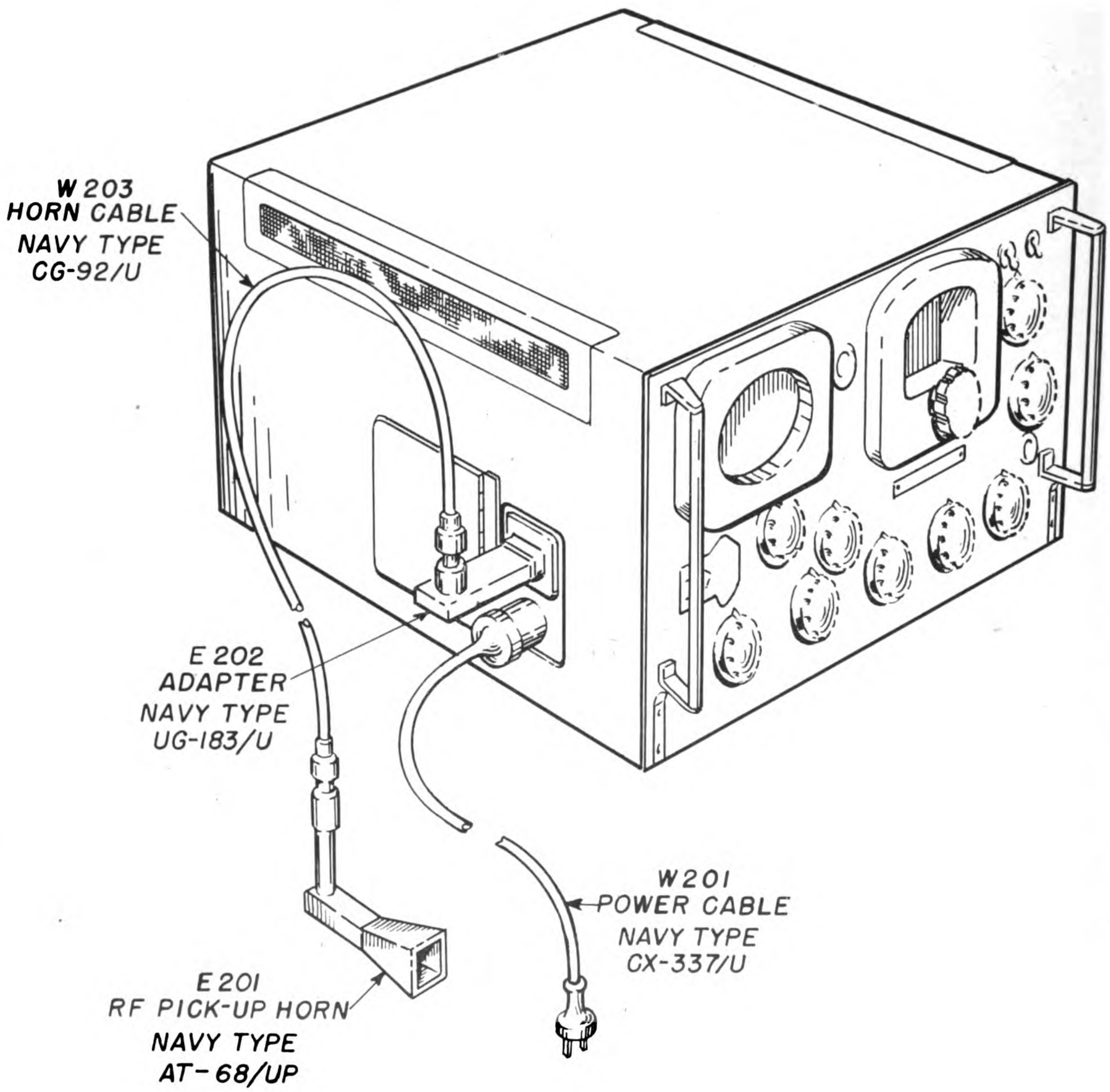


Figure 5-4. Spectrum Analyzer With Antenna Horn

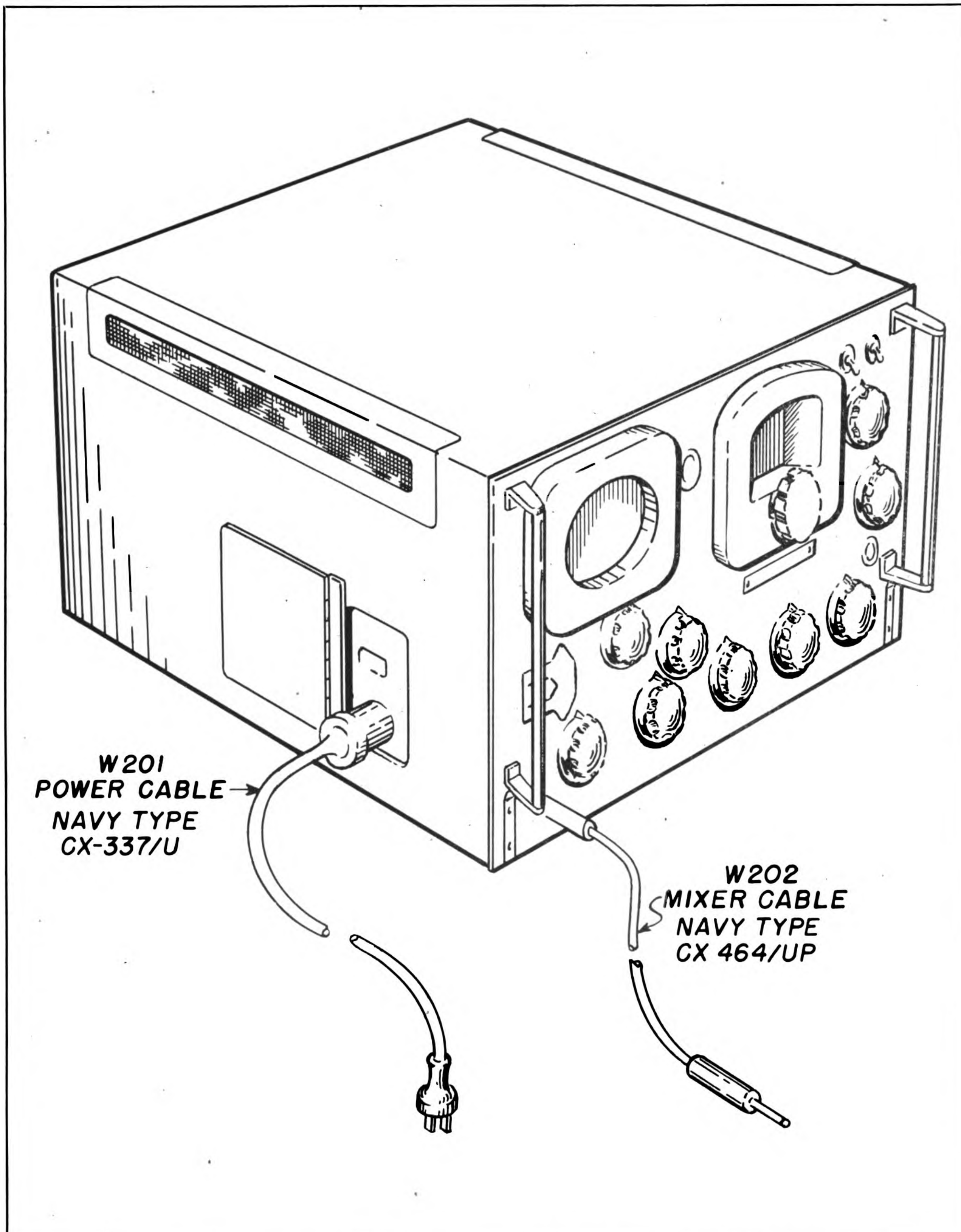


Figure 5-5. Spectrum Analyzer Set Up for Viewing Output of Radar Crystal Mixer

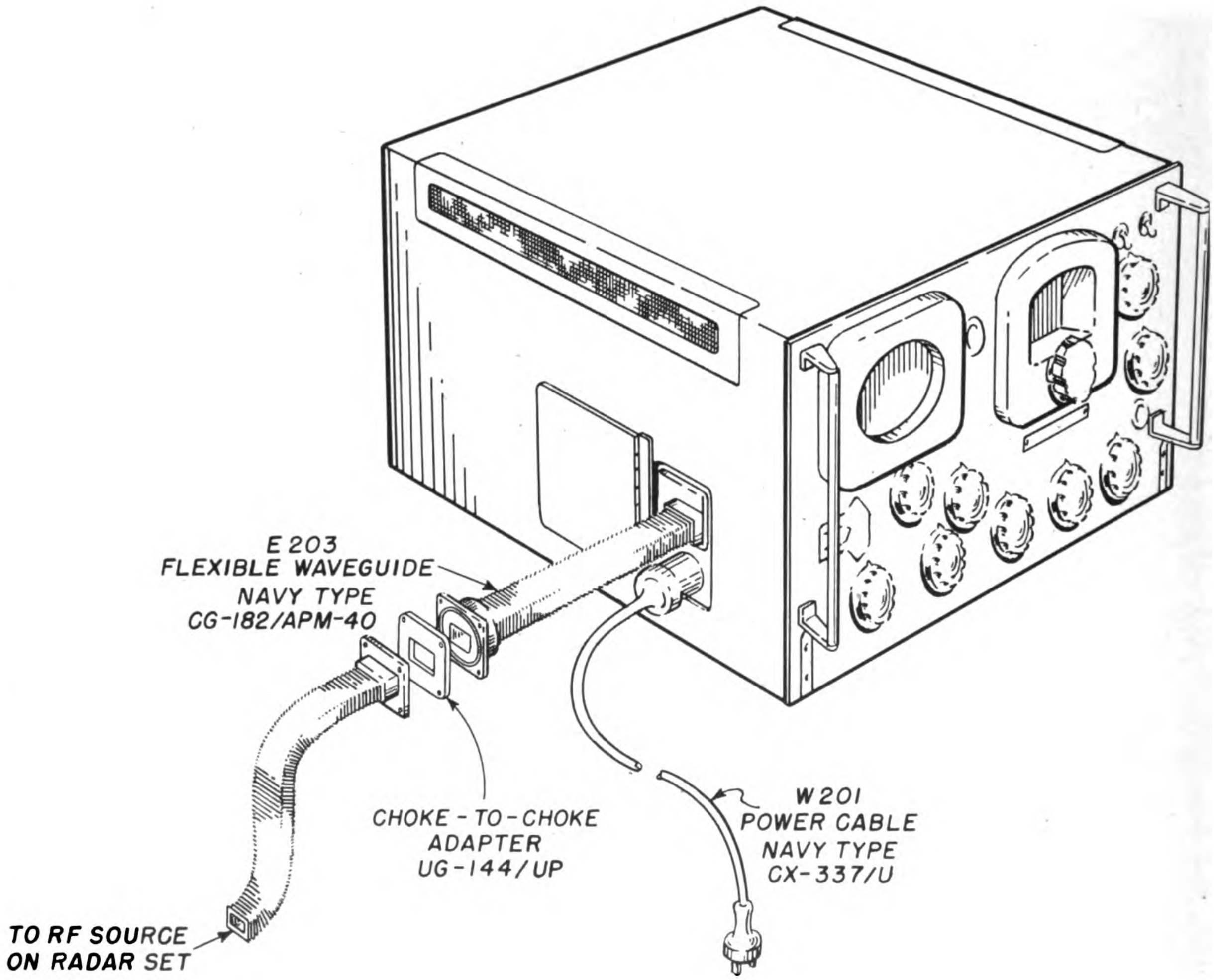


Figure 5-6. Spectrum Analyzer Set Up for Use With Flexible Wave Guide

SECTION VI
TABLE OF REPLACEABLE PARTS

TS-148/UP EQUIPMENT
SPECTRUM ANALYZER

CONTRACT NO. NXSA-59108

TS-148/UP SPECTRUM ANALYZER

a. This catalog contains a list of the replaceable components used on the Model TS-148/UP equipment, which includes approved items of electrical, mechanical and auxiliary parts that may require replacement during the service life of the equipment.

b. All electrical parts and such mechanical parts which need referencing in drawings or instruction books on which replacements may be required during the service life of the equipment are designated, where applicable, by one or two capital letters followed by one or more significant figures, the combination being subsequently referred to as the "symbol designation."

(1) The alphabetical portions of "symbol designation" were selected from the following list:

(*a*) Structural parts, panels, frames, castings.

(*b*) Motors and other prime movers.

(*c*) Capacitors of all types.

(*d*) Dynamotors, rotary converters.

(*e*) Miscellaneous electrical parts: insulators, knobs, brushes.

(*f*) Fuses.

(*g*) Generators and exciters.

(*h*) Hardware, screws, bolts, studs, pins.

(*i*) Indicating devices (except meters and thermometers) pilot lamps.

(*j*) Jacks and receptacles (stationary).

(*k*) Contactors, relays and circuit breakers.

(*l*) Inductors, R.F. and A.F.

(*m*) Meters of all types, gauges and thermometers.

(*n*) Nameplates, dials, charts.

(*o*) Mechanical parts, bearings, shafts, couplings, gears.

(*p*) Plugs.

(*q*) Diaphragms (microphone, telephone, projectors).

(*r*) Resistors, fixed and variable, potentiometers.

(*s*) Switches, interlocks, thermostats, thermoregulators.

(*t*) Transformers, R.F., A.F. and power.

(*u*) Hydraulic parts.

(*v*) Vacuum and gaseous, discharge tubes.

(*w*) Wires, Interconnecting cables.

(*x*) Sockets.

(*y*) Mechanical oscillators, crystals, magnetostriction tubes.

(*z*) Filter, I.F. transformers, compound tuned circuit assemblies, etc., in a common container.

(*cr*) Copper oxide rectifiers.

(*hs*) Handset (telephone and microphone combination).

(*ht*) Hand telephones.

(*hx*) Heat exchangers.

(*ls*) Loud speakers.

(*mg*) Motor generators.

(*mi*) Microphone (hand or chest type).

(*ty*) Surge eliminators (special discharge resistors).

(*yr*) Voltage regulators (except vacuum or gaseous tubes).

(2) The numerical portion of the symbol designations starts with 101 for the first item or each class and runs in consecutive order for the remaining items in that class. Since the equipment consists of one principle unit, carrying (transit) case, an auxiliary box, shockmounted carriage and auxiliary equipment, approved replaceable parts which may be required in the maintenance of units other than the major assembly are included in the list.

(3) Only one symbol designation was assigned to cover items of multiple electrical or mechanical characteristics, such as multiple capacitor units. Since it was desirable to identify certain mechanical or electrical parts of these items, suffix letters were added.

Example: C-101A.
C-101B identifies each part of a triple section capacitor.
C-101C.

c. The name of the manufacturer (not necessarily the prime contractor) or group of manufacturers of each item is represented by a code letter or letters. The key to the code can be found on page 2, titled "Numerical List of Manufacturers." Directly beneath the manufacturer's code symbol appears the designation by which the item is procured by the prime contractor.

d. ORDERING OF SPARE PARTS.—Each service using this list has established certain depots and service groups for the storage and issue of spare parts to its organizations requiring them. The regulations of each service should be studied to determine the method and source for requisitioning spare parts. The information in this list as to manufacturer's or contractor's name, type, model or drawing number is not to be interpreted as authorization to field agencies to attempt to purchase identical or comparable spare parts direct from the manufacturer or a wholesale or retail store except under emergency conditions as covered by existing regulations of the service concerned.

TABLE OF REPLACEABLE PARTS

MODEL TS-148/UP

NUMERICAL LIST OF MANUFACTURERS

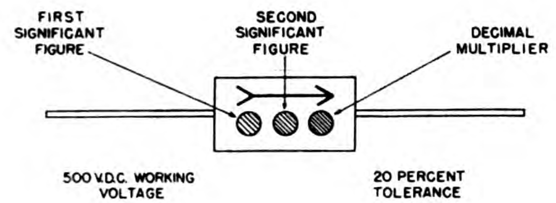
Mfr. No.	Prefix	Manufacturer	Address
1	CAY	Westinghouse Electric & Mfg. Co.	2519 Wilkens Ave., Baltimore, Md.
2	CER	Erie Resistor Company	644 12th St., Erie, Pa.
3	CIR	International Resistance Co.	401 N. Broad St., Philadelphia, Pa.
4	CPQ	Speer Resistor Company	Theresia St., St. Mary's, Pa.
5	CSA	Stackpole Carbon Company	1942 Tannery St., St. Mary's, Pa.
6	CC	Continental Carbon Company	13908 Lorain Ave., Cleveland, Ohio
7	CAE	Cutler-Hammer, Inc.	1333 W. St. Paul Ave., Milwaukee, Wisc.
8	CPH	American Phenolic Corporation	1250 W. Van Buren St., Chicago, Illinois
9		Anaconda Wire & Cable Co.	New York, N. Y.
10	CFT	Fed. Tel. & Radio Corp.	200 Mt. Pleasant Ave., Newark, New Jersey
11	CBZ	Allen-Bradley Company	118 W. Greenfield Ave., Milwaukee, Wisc.
12	CAW	Aerovox Corporation	742 Belleville Ave., New Bedford, Mass.
13	CSL	Solar Mfg. Corp.	586 Avenue "A," Bayonne, N. J.
14	CTD	Tobe-Deutschman Corp.	Canton, Mass.
15	CLF	Littlefuse Laboratories, Inc.	4765 Ravenswood Ave., Chicago, Ill.
16	CMA	P. R. Mallory Co.	1941 Thomas St., Indianapolis, Ind.
17	CRC	RCA Mfg. Co.	Harrison, New Jersey
18	CMG	Cinch Mfg. Co.	2339 W. Van Buren St., Chicago, Ill.
19	CG	General Electric Co.	Schenectady, New York
20	CJA	James Millen Mfg. Co.	150 Exchange St., Malden, Mass.
21	CBN	Centralab	900 E. Keefe Ave., Milwaukee, Wisc.
22	CD	Cornell-Dubilier Elec. Corp.	1000 Hamilton Blvd., South Plainfield, N. J.
23		Titeflex Metal Hose Co.	500 Frelinghuysen Ave., Newark, New Jersey
24	CHS	Sylvania Electric Products, Inc.	Emporium, Pennsylvania
25	CYA	Alden Products Co.	715 Center Street, Brockton, Mass.
26	CMH	American Radio Hardware Co., Inc.	476 Broadway, New York City, New York
27	CS	Sperry Gyrocompass Co., Inc., Aeronautical Radio Div.	40 Flatbush Ave. Ext., Brooklyn, N. Y.
28	CYD	Bryant Electric Co.	1421 State St., Bridgeport, Conn.
29	CSF	Sprague Specialties Co.	189 Beaver St., North Adams, Mass.
30	CNA	National Company, Inc.	61 Sherman St., Malden, Mass.
31	CUO	General Electronic Industries, Division of Maguire Industries	Greenwich, Conn.
32	CFA	Bussman Manufacturing Co.	2538 W. University Ave., St. Louis, Missouri
33	CBU	Isolantite, Inc.	233 Broadway, New York City, New York
34		Pierce-Roberts Co.	Trenton, New Jersey
35	CAEK	Hanovia Chem. & Mfg. Co.	Newark, New Jersey
36	CW	Western Electric	300 Central Ave., Kearny, New Jersey
37	CMF	Electro-Motive	Williamantic, Conn.
38	CMR	Micamold Radio Corp.	1087 Flushing Ave., Brooklyn, New York
39	CNB	Noma Electric Corp.	55 W. 13th St., New York, New York
40	CAN	Sangamo Electric Co.	1935 Funk St., Springfield, Illinois
41	CFW	Sickles Co., F. W.	Springfield, Mass.
42		Electrical Reactance Corporation	Franklinville, New York
43	CAKD	Muter Co.	1255 S. Michigan Ave., Chicago, Illinois
44		Atlantic India Rubber Co.	1453 W. Van Buren St., Chicago, Illinois
45		Parker-Kalon	200 Varick St., New York, N. Y.
46		Zierick Mfg. Co.	385 Gerard Ave., New York, New York
47		Kurz-Kasch	220 E. 23rd St., New York, New York
48		Rubber Miller	709 S. Canton Ave., Baltimore, Md.
49		Allen Mfg. Co.	Hartford, Conn.
50		Westinghouse Supply Co.	
51	CQG	Belden Mfg. Co.	Post Office Box 5070A, Chicago, Illinois
52	CTE	Telephonics Corp.	350 W. 31st St., New York, N. Y.
53	CIU	Mendelsohn Speed Gun Co.	457-461 Bloomfield Ave., Bloomfield, N. J.
54		Continental Rubber Works	Erie, Pennsylvania

DECIMAL EQUIVALENTS OF AWG & SWG

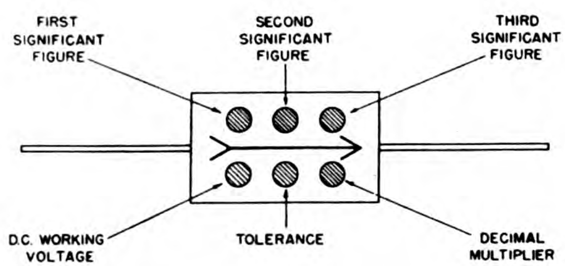
Gauge No.	Diameter in Inches AWG	Diameter in Inches SWG	Gauge No.	Diameter in Inches AWG	Diameter in Inches SWG
0000000		.500	18	.04030	.048
000000		.464	19	.03589	.040
00000		.432			
0000	.4600	.400	20	.03196	.036
000	.4096	.372	21	.02846	.032
00	.3648	.348	22	.02535	.028
			23	.02257	.024
0	.3249	.324	24	.02010	.022
1	.2893	.300			
2	.2576	.276	25	.01790	.020
3	.2294	.252	26	.01594	.018
4	.2043	.232	27	.01419	.0164
			28	.01264	.0149
5	.1819	.212	29	.01126	.0136
6	.1620	.192			
7	.1443	.176	30	.01003	.0124
8	.1285	.160	31	.008928	.0116
9	.1144	.144	32	.007950	.0108
			33	.007080	.0100
10	.1019	.128	34	.006304	.0092
11	.09074	.116			
12	.08081	.104	35	.005614	.0084
13	.07196	.092	36	.005000	.0076
14	.06408	.080	37	.004453	.0068
			38	.003965	.0060
15	.05707	.072	39	.003531	.0052
16	.05082	.064			
17	.04526	.056	40	.003145	.0048

RMA COLOR CODE

CAPACITORS (MMFD)



COLOR	NUMERAL	VOLTS	MULTIPLIER	TOLERANCE
BLACK	0		1	
BROWN	1	100	10	1%
RED	2	200	100	2%
ORANGE	3	300	1,000	3%
YELLOW	4	400	10,000	4%
GREEN	5	500	100,000	5%
BLUE	6	600	1,000,000	6%
VIOLET	7	700	10,000,000	7%
GREY	8	800	100,000,000	8%
WHITE	9	900	1,000,000,000	9%
GOLD		1000	0.1	5%
SILVER		2000	0.01	10%
NO COLOR		500		20%

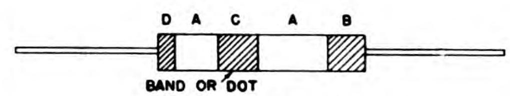


RESISTORS (OHMS)

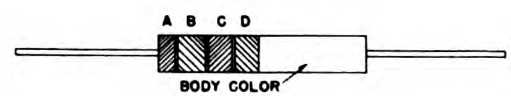
COLOR	A 1 ST DIGIT	B 2ND DIGIT	C MULTIPLIER
SILVER			0.01
GOLD			0.1
BLACK		0	1.0
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
PURPLE	7	7	10,000,000
GREY	8	8	100,000,000
WHITE	9	9	

D - TOLERANCE CODE

GOLD = 5% SILVER = 10% NO COLOR = 20%



OLD COLOR ARRANGEMENT

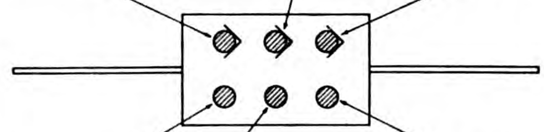


NEW COLOR ARRANGEMENT

BODY COLOR (NEW COLOR ARRANGEMENT ONLY) INDICATES TYPE OF RESISTORS, AS FOLLOWS:-
- BLACK - COMPOSITION, NON-INSULATED
- TAN, OLIVE OR WHITE - COMPOSITION, INSULATED
- DARK BROWN - WIRE WOUND, INSULATED

AMERICAN WAR STANDARD COLOR CODES

A - CAPACITORS



CODE

COLOR	CAPACITANCE (MMFD)		TOLERANCE	CHARACTERISTIC
	SIGNIFICANT FIGURE	DECIMAL MULTIPLIER		
BLACK	0	1	20 M	A
BROWN	1	10		B
RED	2	100	2 (G)	C
ORANGE	3	1000		D
YELLOW	4			E
GREEN	5			F
BLUE	6			G
VIOLET	7			
GRAY	8			
WHITE	9			
GOLD		0.1	5 (J)	
SILVER		0.01	10 (K)	

B - RESISTORS – SAME AS RMA STANDARDS; SEE PAGE 7-3

TABLE OF REPLACEABLE PARTS

MODEL TS-148/UP — **MAJOR ASSEMBLY: SPECTRUM ANALYZER**

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
TS-148/UP Symbol Series 101-299		SPECTRUM ANALYZER TS-148/UP, Complete with carrying case, CY-246/U; containing an auxiliary box, CY-245/U; and a shock-mounted carriage for set, MT-325/U; with the addition thereto of 1 complete set of tubes. Analyzer proper is a self-contained set in a box approximately 9⅛ by 13 by 14 inches, with indicator tube (scope), wavemeter dial and other adjustment controls on the front panel.		DL-7502890 G-1	
C-101		CAPACITOR—Fixed, mica, 1000 MMFD. ±10%, 500 V.D.C. Working, phenolic case 45/64″ x 29/64″ x 3/16″, with tinned wire leads 1¼″ long.	I.F. input transf. R.F. by-pass	CM20A102K	7613282 P-1
C-102		CAPACITOR—Same as C-101	I.F. input transf. by-pass		
C-103		CAPACITOR—Same as C-101	I.F. bias filter		
C-104		CAPACITOR—Same as C-101	1st I.F. screen by-pass		
C-105		CAPACITOR—Fixed, silvered mica, 100 MMFD. ±5%, 500 V.D.C. working, phenolic case 45/64″ x 29/64″ x 3/16″, with tinned wire leads 1¼″ long.	Grid coupling 1st detector	CM20C101J	7613282 P-5
C-106		CAPACITOR—Fixed, ceramic, 10 MMFD. ±5%, 500 V.D.C. working, ceramic case 7/16″ long x 7/32″ diam., with tinned wire leads 1½″ long.	Converter osc.	CC21HH100D	7613282 P-6
C-107		CAPACITOR—Same as C-105.	Converter osc.		
C-108		CAPACITOR—Fixed, mica, 10,000 MMFD. ±10%, 300 V.D.C. working, phenolic case 25/32″ x 25/32″ x 9/32″, with tinned wire leads 1¼″ long.	Converter screen by-pass	CM30A103K	7613282 P-8

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP — MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
C-109		CAPACITOR—Same as C-108.	Converter plate by-pass		
C-110		CAPACITOR—Same as C-105	Detector grid coupling		
C-111		CAPACITOR—Same as C-105	Detector cathode by-pass		
C-112		CAPACITOR—Same as C-101.	Detector plate by-pass		
C-113		CAPACITOR—Same as C-106.	Converter plate tuning		
C-114		CAPACITOR—Fixed, silvered mica, 15 MMFD. ±5%, 500 V.D.C. working, phenolic case 45/64" x 29/64" x 3/16", with tinned wire leads 1¼" long.	Video pip coupling	CM20C150J	7613282 P-14
C-115		CAPACITOR—Fixed, paper dielectric, oil filled, 3 sections, each 100,000 MMFD. +20% −10%, 400 V.D.C. working; metal case 1 1/16" x 1¾" x 9/16" with two mounting feet; three terminals on top; case is common for all 3 sections.		CP67B5EE104MK	7613282 P-15
C-115A		CAPACITOR—Part of C-115.	Spot adjust. by-pass		
C-115B		CAPACITOR—Part of C-115.	R.F. by-pass		
C-115C		CAPACITOR—Part of C-115.	Sweep by-pass filter		
C-116		CAPACITOR—Fixed, paper dielectric, oil filled, 2 MMFD. +20% −10%, 400 V.D.C. working; metal case 2" x 2" x 1 3/16", with two mounting feet; 2 terminals on top.	Detector bias by-pass	CP51B1EE205MK	7613282 P-18

C-117		CAPACITOR—Fixed, paper dielectric, oil filled, 2 sections, each 100,000 MMFD., +20% −10%, 1000 V.D.C. working; metal case 1$\frac{13}{16}$″ x 1″ x $\frac{3}{4}$″, with two mounting feet; three terminals. Terminal at left common to both sections.		CP50B4AG104KK	7613282 P-19
C-117A		CAPACITOR—Part of C-117.	Cathode ray grid by-pass		
C-117B		CAPACITOR—Part of C-117.	Cathode ray grid by-pass		
C-118		CAPACITOR—Same as C-101.	I.F. filament by-pass		
C-119		CAPACITOR—Fixed, paper dielectric, oil filled, 3 sections, each 100,000 MMFD. +20% −10%, 400 V.D.C. working; metal case 1$\frac{1}{16}$″ x 1$\frac{3}{4}$″ x $\frac{9}{16}$″, with two mounting feet; three terminals on bottom, case is common for all 3 sections.		CP69B5EE104MK	7613282 P-22
C-119A		CAPACITOR—Part of C-119.	D.C. amp. input by-pass		
C-119B		CAPACITOR—Part of C-119.	Sweep generator bias filter		
C-119C		CAPACITOR—Part of C-119.	Sweep amp.—inv. bias filter		
C-120		CAPACITOR—Fixed, paper dielectric, oil filled, 500,000 MMFD. +10%, 600 V.D.C. working; metal case 2$\frac{1}{16}$″ x 1$\frac{5}{16}$″ x $\frac{11}{16}$″, with two mounting feet; two terminals on bottom.	Sweep generator	CP65B1EF504KK	7613282 P-25
C-121		CAPACITOR—Fixed, paper dielectric, oil filled, 100,000 MMFD. +20% −10%, 1000 V.D.C. working; metal case 1$\frac{13}{16}$″ x 1″ x $\frac{3}{4}$″, with two mounting feet; two terminals on side.	Focus Pip Coupling	CP50B1AG104MK	7613282 P-27
C-122		CAPACITOR—Fixed, paper dielectric, oil filled, 100,000 MMFD. +20% −10%, 600 V.D.C. working; metal case 2$\frac{1}{16}$″ x 1$\frac{5}{16}$″ x $\frac{11}{16}$″ with two mounting feet; two terminals on bottom.	Sweep Coupling	CP65B1AF104MK	7613282 P-30

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP — MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
C-123		CAPACITOR—Fixed, paper dielectric, oil filled, 100,000 MMFD. +20% −10%, 600 V.D.C. working; metal case 1 1/16" x 1 3/4" x 9/16", with two mounting feet; two terminals on bottom.	Sweep amp.—inv. coupling	CP69B1EF104MK	7613282 P-31
C-124		CAPACITOR—Fixed, paper dielectric, oil filled, 500,000 MMFD. +20% −10%, 400 V.D.C. working; metal case 2 1/16" x 1 5/16" x 11/16", with two mounting feet; two terminals on top.	Sweep coupling to R.F. oscillator	CP63B1AE504MK	7613282 P-32
C-125		CAPACITOR—Same as C-124	Sweep coupling to R-F oscillator		
C-126		CAPACITOR—Fixed, mica, 500 MMFD. ±10%, 500 V.D.C. working, phenolic case 45/64" x 29/64" x 3/16", with tinned wire leads 1 1/4" long.	Sweep coupling to intensifier	CM20A501K	7613282 P-34
C-127		CAPACITOR—Same as C-116.	Intensifier plate filter		
C-128		CAPACITOR—Fixed, paper dielectric, oil filled, 100,000 MMFD. +20% −10%, 2500 V.D.C. working; metal case 1 1/4" x 2 1/4" x 9/16", with two mounting feet, two terminals on bottom.	Cathode ray coupling	#12 applicable parts of AWS C75, 16 Aerovox #2516	7613282 P-36
C-129		CAPACITOR—Same as C-108.	Intensifier coupling		
C-130		CAPACITOR—Fixed, paper dielectric, oil filled, 250,000 MMFD. +20% −10%, 2000 V.D.C. working; metal case 2 1/8" x 1 13/16" x 1 1/16", with two mounting feet, two terminals at top.	Cathode ray bias filter	CP70E1AJ254MK	7613282 P-38
C-131		Not used.			

C-132		CAPACITOR—Same as C-108.	Primary by-pass		
C-133		CAPACITOR—Same as C-108.	Primary by-pass		
C-134		CAPACITOR—Fixed, oil filled, 1 MFD. ±10%, 1500 V.D.C. working; metal case 4" x 13/16" x 11/16"; 2 terminals	Negative supply filter	CP71D1EH105MK	7613282 P-43
C-135		CAPACITOR—Same as C-134.	Negative supply filter		
C-136		Not used.			
C-137		CAPACITOR—Fixed, paper dielectric, oil filled, 3 sections, each 8 MFD. +20% −10%, 600 V.D.C. working; metal case 4 3/4" x 3 3/4" x 2", with mounting flange; 4 terminals on side, one terminal common to all three sections.		#13 7415448 PT-1	7613282 P-46
C-137A		CAPACITOR—Part of C-137	Positive supply filter		
C-137B		CAPACITOR—Part of C-137	Positive supply filter		
C-137C		CAPACITOR—Part of C-137.	400 V. supply filter		
C-138		Not used.			
C-139		CAPACITOR—Same as C-108.	Reg. filter		
C-140		CAPACITOR—Fixed, oil filled, 100,000 MMFD. +20% −10%, 600 V.D.C. working; metal case 1 13/16" x 15/16" x 13/16", with two mounting feet; two terminals on top.	Reg. filter	CP51B1AF104MK	7613282 P-51
C-141		CAPACITOR—Same as C-101.	I.F. filament by-pass		
C-142		CAPACITOR—Same as C-105.	D.C. amp. plate by-pass		
CR-101		CRYSTAL—1N23A.	Rectifier	#1 S#867893	7613282 P-56

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP — MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
E-101		R.F. ASSEMBLY—Includes frequency meter, dial, waveguide and attenuators.	R.F. mixer and frequency indicator	#31 1561 and 3005	7613282 P-57
E-101A		FREQUENCY METER—Part of E-101.	Frequency indicator		
E-101B		ATTENUATOR, VARIABLE—Micarta strip 4¾" x .375" x .031", with a brass, nickel-plated bushing at center.	R.F. attenuator	#1 7415337 G-1 and G-2	7613282 P-59
E-101C		ATTENUATOR, FIXED—"X" coated resistor card, 500 ohms/square, mounted in a brass, silver-plated holder 13⅞" long.	R.F. attenuator	#1 7415393 G-1	7613282 P-60
E-101D		ATTENUATOR, POLYIRON—.375" long x .235" diam. with shoulder .125" long x .295" diam.	Crystal holder	#1 7817813 P-1	7613282 P-61
E-101E		ATTENUATOR, POLYIRON—.281" long x .293" diam. with a shoulder .156" long x .343" diam. and .159" diam. hole through center.	R-F oscillator coupling	#1 7817733 P-1	7613282 P-62
E-102		BOARD, TERMINAL—Varnish impregnated micarta board, 9" x 2¼" x 3/32", mounting 48 terminals.	Resistor mounting	#1 7416265 G-1	7614131 P-1
E-103		BOARD, TERMINAL—Varnish impregnated micarta board, 7 7/16" x 2¼" x 3/32", mounting 40 terminals.	Capacitor and resistor mounting	#1 7416324 G-1	7614131 P-2
E-104		BOARD, TERMINAL—Varnish impregnated micarta board, 4 15/16" x 2¼" x 3/32", mounting 24 terminals.	Capacitor and resistor mounting	#1 7416269 G-1	7614131 P-3
E-105		BOARD, TERMINAL—Varnish impregnated micarta board, 2⅞" x 2¼" x 3/32", mounting 9 terminals.	Resistor mounting	#1 7416300 G-1	7614131 P-4

E-106		BOARD, TERMINAL—Varnish impregnated micarta board, 2¾" x 1¾" x 3/32", mounting 6 terminals.	Resistor mounting	#1 7713440 G-2	7614131 P-5
E-107		SHIELD, TUBE.	Cathode ray shield	#1 7713337 G-1	7614131 P-6
E-108		HOLDER, CRYSTAL—Consisting of the following: Body (7816603 P-1) Plug (7816606 P-1) Contact (7816709 P-1) Washer (7816588 P-1) Spacer (7816604 P-1) Connector (7414341 P-1)	Crystal holder	#1 7818639 G-1	7614131 P-7
E-109		NOT USED.			
E-110		NOT USED.			
E-111		NOT USED.			
E-112		NOT USED.			
E-113		NOT USED.			
E-114		BRACKET—3⅛" x 1¼" x ⅞", black moldarta.	Mounting for R-163 and R-165	#1 7415333 P-1	7614131 P-13
E-115		KNOB—Molded plastic, ⅝" diam. x ⅝" high, to fit ¼" shaft, furnished with two #8-32 set screws.	Control	#1 7708220 P-2	7614131 P-14
E-116		GROMMET—1" O.D. x ½" I.D. x ¼" thick, soft rubber.	Wire protection	#1 S#282498	7614131 P-15
E-117		INSULATOR—½" long x ⅜" diam., ceramic, with #6-32 tapped hole at each end. Furnish with lead washer.	Insulator	#1 7818639 G-2	7614131 P-16
E-118		GROMMET—½" O.D. x ⅛" I.D. x 5/16" thick, soft rubber.	Wire protection	#1 S#660828	7614131 P-17
E-119		GROMMET—21/32" O.D. x ⅜" I.D. x ¼" thick, soft rubber.	Wire protection	#34 Type #100	7614131 P-18
E-120		KNOB—Molded plastic, 1⅝" diam. x ¾" high, to fit ¼" shaft, furnished with #8-32 set screw.	Control	#47 Type #S-309-1	7614131 P-19

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP

MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
E-121		KNOB—Molded plastic, 1½" diam. x ⅞" high, to fit ¼" shaft, furnished with two #8-32 set screws.	Control	#1 7415805 P-1	7614131 P-20
E-201		ANTENNA—Horn AT-68/U.	Antenna pick-up	#27 5660159	7613392 P-1
E-202		ADAPTER ASSEMBLY UG-79/U.	Coax. to wave guide	#1 7415323 G-1	7613392 P-2
E-203		FLEXIBLE WAVE GUIDE ASSEMBLY CG-182/U.	Antenna pick-up	#23 7415324 G-1	7613392 P-3
E-204		ADAPTER UG-144/AP.	Choke-to-choke adapter	#1 7818651 P-1	7613392 P-4
F-101A		FUSE—Extractor type, 2 amps., 250V., 1¼" long x ¼" diam., with nickel-plated caps.	Power input	#15 Benny 1042	7613282 P-63
F-101B		FUSE HOLDER—Extractor type, bayonet type knob, black phenolic, for 1¼" x ¼" diam. fuse, mounts in ½" diam. hole, 2⅜" over-all length, furnished with mounting nut and rubber gasket.	Holder for F-101A	#32 Type HKM-H	7613282 P-64
F-102A		FUSE—Same as F-101A.	Mounted spare		
F-102B		FUSE HOLDER—Same as F-101B.	Holder for F-102A		
H-101		THUMB SCREW—1$\frac{1}{64}$" over-all length, ½" diam. knurled head with screwdriver slot, #10-32 x $\frac{5}{16}$" threads, stainless steel.	C-R tube shield	#1 7813730 P-1	7614131 P-28
H-102		THUMB SCREW—$\frac{13}{16}$" over-all length, ½" diam. knurled head, #10-32 x $\frac{9}{16}$" threads, micarta.	Insulating screw	#1 7817840 P-1	7614131 P-29

H-103		LOCK-NUT—Furnished as part of R-140, R-144, R-174 and R-182.	Variable resistor	#20 Cat. #10061	7614131 P-30
H-104		NOT USED.			
H-105		NOT USED.			
H-106		SCREW—Self-tapping, type "Z," slotted round head, #2 x 1/8" long, stainless steel, black enamel finish on head.	Hardware	#1 7614131 P-33	7614131 P-33
H-107		NOT USED.			
H-108		WRENCH, TUNING—Brass bar 1/8" diam. with sleeve at one end and 90° bend at other end, 2 9/16" long; black nickel finish.	Tool	#1 7416520 G-1	7614131 P-35
H-109		PIN—2 1/4" long x 3/8" diam. with #10-32 x 7/16" threads, stainless steel.	Hold dust cover to carriage	#1 7814217 P-1	7614131 P-36
H-110		WRENCH—Hex. for #4 set screw.	Tool	#49	7614131 P-37
H-111		WRENCH—Hex. for #6 set screw.	Tool	#49	7614131 P-38
H-112		WRENCH—Hex. for #8 set screw.	Tool	#49	7614131 P-39
I-101A		LAMP—6.3 V.A.C., bayonet base.	Dial illumination	#1 Mazda #44	7613282 P-68
I-101B		HOLDER, LAMP—Miniature bayonet.	Holder for I-101A	#26 Type 1539	7613282 P-69
I-102A		LAMP—Same as I-101A.	Dial illumination		
I-102B		HOLDER, LAMP—Same as I-101B.	Holder for I-102B		
J-101		JACK, PHONE—Midget, shorting insert type, 2 circuit.	D.C. amp. input	#16 Type A-2A	7613282 P-73
J-102		CONNECTOR—Two blade with 1 1/2" diam. mounting cup.	110 V. input socket	#28 Type UR	7613282 P-74
J-103		CLIP, TUBE CONTACT—29/32" diam. x 25/32" high with phosphor bronze clip.	Clip for V-110	#25 Type 915	7613282 P-75

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP — MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
J-104		CLIP, TUBE CONTACT—7/16" diam. x 19/32" high with beryllium copper clip.	Clip for V-115	#25 Type 90BC	7613282 P-76
L-101		COIL, R.F.—Variable 1.8-3.5 microhenries.	1st I.F. coil	#1 7713258 G-1	7613283 P-83
L-102		COIL, R.F.—Variable 2.7-5.7 microhenries.	Converter oscillator	#1 7713258 G-2	7613283 P-84
L-103		COIL, R.F.—Fixed 17 microhenries.	2nd I.F. coil	#1 7713280 G-1	7613283 P-85
L-104		COIL, A.F.—Fixed, 6.5 H., 65 MA.	Power supply filter	#1 L-423178	7613283 P-86
L-105		COIL, R.F.—Fixed, Pi wound, 2.1 MH.	R.F. choke	#35 Type HCH-1	7613283 P-87
L-106		COIL, A.F.—Same as L-104.	Power supply filter		
O-101		GASKET—10 13/32" x 1" x 3/8" adhesive coated, sponge rubber.	C. R. tube gasket	#44	7614131 P-47
O-102		SHAFT—3 7/32" long x .248 diam. at one end; at other end .139 diam. for 1 5/32" then 1/4"-28 L.H. threads for 25/32".	Shaft for E-101B	#1 7817729 P-1	7614131 P-48
O-103		STOP WASHER—1/2" O.D. x .250" I.D. x .042" thick with .062" wide x .037" long tab; stainless steel.	Rotation limiter	#1 7817688 P-1	7614131 P-49
O-104		STOP WASHER—1/2" O.D. x .250" I.D. x .042" thick with .062" wide x .093" long tab; stainless steel.	Rotation limiter	#1 7817689 P-1	7614131 P-50

O-105		SLEEVE—$1\frac{1}{8}$" long, $\frac{1}{4}$"-28 R.H. threads, with shoulder at one end $\frac{1}{8}$" x $\frac{1}{2}$" diam., micarta.	Sleeve for E-101B	#1 7817730 P-1	7614131 P-51
O-106		WINDOW—3.125" diam. x $\frac{1}{8}$" thick, green plexiglas #110.	C.R. filter	#1 7415185 P-1	7614131 P-52
O-107		SHAFT—$3\frac{5}{32}$" long x .248" diam. with two flats, $\frac{1}{32}$" deep located 120° apart, at each end, micarta.	Tuning shaft	#1 7817811 P-1	7614131 P-53
O-108		CLAMP—$1\frac{5}{32}$" I.D. ring, with lever & mounting foot; nickel silver.	Tube clamp	#1 7611463 G-17	7614131 P-54
O-109		CLAMP—$1\frac{23}{64}$" I.D. ring, with lever & mounting foot; nickel silver.	Tube clamp	#1 7611463 G-20	7614131 P-55
O-110		WINDOW—Clear plastic, $2\frac{3}{8}$" x $1\frac{15}{16}$" x $\frac{1}{16}$" with 4 mounting holes.	Frequency meter window	#1 7416392 P-1	7614131 P-56
O-111		WASHER, STOP—.500" O.D. x .296" I.D. x .031" thick, with .067" wide notch on outside edge & .109 wide tab 180° from notch; stainless steel.	Rotation limiter	#31 A-2875-C	7614131 P-57
O-112		WASHER, STOP—.500" O.D. x .203" I.D. x .031" thick, with 12—.060" long flutes on inside & .109" wide tab on outside; stainless steel.	Stop washer drive	#31 A-2587-C	7614131 P-58
O-113		WASHER, SPRING—$\frac{13}{16}$" O.D. x $\frac{19}{64}$" I.D. x .014" thick; 6 slots $\frac{1}{16}$" wide, equally spaced radially; phosphor bronze.	Stop washer tension plate	#31 A-2585-C	7614131 P-59
O-114		SPRING—1" long x .204" I.D., 9 turns of .041 steel wire.	Spring for H-109	#1 7814216 P-1	7614131 P-60
O-115		ABSORBER, SHOCK—Buna "S", 30-35 durometer hardness, 3" x 1" x 1" mounted on a steel flange $4\frac{1}{4}$" x $1\frac{1}{4}$" x .063".	Shock absorber	#48 7415678 G-1	7614131 P-61
O-116		ABSORBER, SHOCK—Buna "S", 30-35 durometer hardness, 5" x 1" x $\frac{3}{4}$" mounted on a steel flange $6\frac{1}{4}$" x $1\frac{1}{4}$" x .063".	Shock absorber	#48 7416687 G-1	7614131 P-62
O-117		GASKET—Buna "N" or neoprene, 25-35 durometer hardness, $23\frac{13}{16}$" x $11\frac{7}{16}$", cross section $\frac{7}{8}$" x $\frac{3}{8}$".	Moisture seal	#54 7714401 P-1	7614131 P-63

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP — MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
P-101		CONNECTOR—Type SKL, right hand cable end, part of W-101.	Crystal cable	#27 S-3011	7613283 P-88
P-201		Not used.			
P-202		Not used.			
P-203		PLUG—Single circuit, phone plug.	Mixer cable	#52 PL-55	7613392 P-11
P-204		PLUG—Same as P-203.	Mixer cable.		
P-205		PLUG—Type "N" connector, submersion proof.	Antenna-horn cable	UG-24/U	7613392 P-13
P-206		PLUG—Same as P-205.	Antenna-horn		
R-101		RESISTOR, FIXED—100,000 ohms ±10%, 1/2 watt, composition, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	I.F. grid filter	RC20BF104K	7613283 P-89
R-102		RESISTOR, FIXED—15,000 ohms ±10%, 1 watt, composition, phenolic insulation, 11/16" long x 1/4" diam., with wire leads 1 1/2" long.	1st I.F. screen	RC30BF153K	7613283 P-90
R-103		RESISTOR—Same as R-102.	1st I.F. screen		
R-104		RESISTOR, FIXED—220,000 ohms ±10%, 1/2 watt, composition, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	1st detector grid	RC20BF224K	7613283 P-92
R-105		RESISTOR, FIXED—22,000 ohms ±10%, 1/2 watt, composition, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Converter oscillator	RC20BF223K	7613283 P-93

R-106		RESISTOR, FIXED—7500 ohms ±10%, 1 watt, composition, phenolic insulation, 11/16″ long x 1/4″ diam., with wire leads 1 1/2″ long.	Converter screen	RC30BF752K	7613283 P-94
R-107		RESISTOR, FIXED—Same as R-106.	Converter screen		
R-108		RESISTOR, FIXED—1100 ohms ±10%, 1 watt, composition, phenolic insulation, 11/16″ long x 1/4″ diam., with wire leads 1 1/2″ long.	Converter plate filter	RC30BF112K	7613283 P-96
R-109		RESISTOR, FIXED—Same as R-108.	Converter plate filter		
R-110		RESISTOR, FIXED—Same as R-105.	Detector plate		
R-111		RESISTOR, FIXED—150,000 ohms ±10%, 1/2 watt, composition, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Detector cathode	RC20BF154K	7613283 P-99
R-112		RESISTOR, FIXED—330,000 ohms ±10%, 1/2 watt, composition, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Detector plate	RC20BF334K	7613283 P-100
R-113		NOT USED.			
R-114		RESISTOR, FIXED—47,000 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Video coupling	RC20BF473K	7613283 P-102
R-115		RESISTOR, FIXED—4.7 megohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Intensifier grid coupling	RC20BF475K	7613283 P-103
R-116		RESISTOR, FIXED—Same as R-114.	Negative bias divider		
R-117		RESISTOR, VARIABLE—50,000 ohms ±10%, linear taper, 2 watts, case 1.227″ diam. x 9/16″ thick; 3 terminals; shaft .250″ diam. x 1/4″ long from 3/8″ bushing, with screwdriver slot.	Vertical centering	#5 7713389 P-9	7613283 P-105
R-118		RESISTOR, FIXED—68,000 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Detector bias	RC20BF683K	7613283 P-106

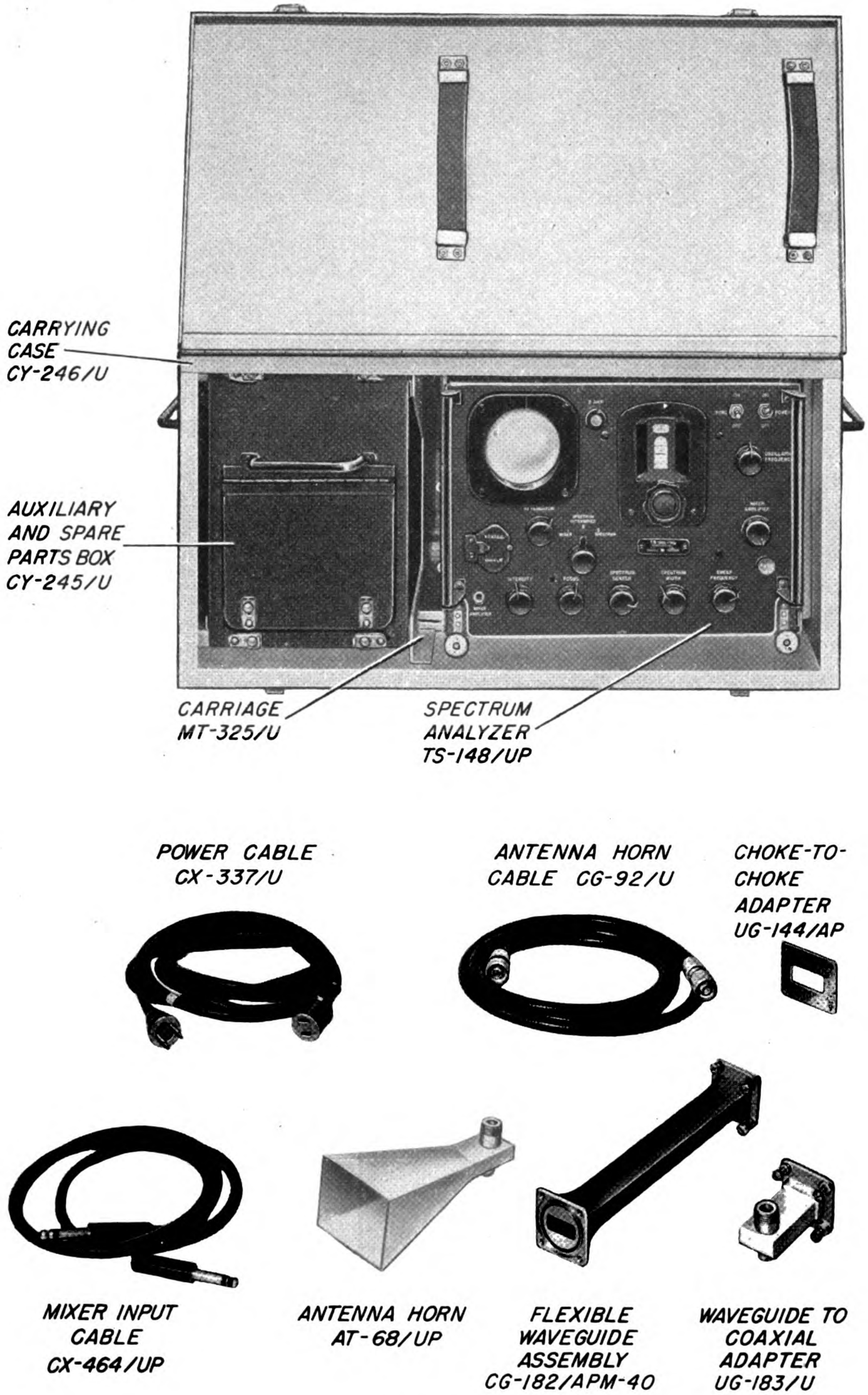


Figure 1-1. Spectrum Analyzer, Cables and Auxiliary Parts

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP

MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
R-119		RESISTOR, FIXED—1 megohm ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Horiz. amp. grid coupling	RC20BF105K	7613283 P-107
R-120		NOT USED.			
R-121		RESISTOR, FIXED—56,000 ohms ±5%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Video plate	RC20BF563J	7613283 P-109
R-122		RESISTOR, FIXED—Same as R-101.	Video screen		
R-123		RESISTOR, FIXED—33,000 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Oscilloscope grid	RC20BF333K	7613283 P-111
R-124		RESISTOR, FIXED—Same as R-104.	Oscilloscope grid		
R-125		RESISTOR, FIXED—Same as R-101.	Oscilloscope grid		
R-126		RESISTOR, FIXED—100 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	D.C. amp. input	RC20BF101K	7613283 P-114
R-127		RESISTOR, VARIABLE—5,000 ohms ±10%, linear taper, 3 watts; case 1 1/16" diam. x 9/16" thick; 3 terminals; shaft .250" diam. x 3/8" long from 3/8" bushing.	D.C. amp. input	#11 7713389 P-14	7613283 P-115
R-128		RESISTOR, FIXED—Same as R-119.	D.C. amp. plate		
R-129		RESISTOR, FIXED—Same as R-105.	D.C. amp. screen		
R-130		RESISTOR, FIXED—Same as R-105.	D.C. amp. screen		

R-131		RESISTOR, FIXED—3,300 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	D.C. amp. screen to cathode	RC20BF332K	7613283 P-119
R-132		RESISTOR, FIXED—51 ohms ±5%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	D.C. amp. bias	RC20BF510J	7613283 P-120
R-133		RESISTOR, VARIABLE—250 ohms ±10%, linear taper, 3 watts; case 1 1/16" diam. x 9/16" thick; 3 terminals; shaft .250" diam. x 1/4" long from 3/8" bushing, with screwdriver slot.	D.C. amp. vert. centering	#11 7713389 P-20	7613283 P-121
R-134		RESISTOR, FIXED—330,000 ohms ±5%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Sweep plate	RC20BF334J	7613283 P-122
R-135		RESISTOR, VARIABLE—1 megohm ±10%, linear taper, 3 watts; case 1 1/16" diam. x 9/16" thick; 3 terminals; shaft .250" diam. x 3/8" long from 3/8" bushing.	Sweep frequency adjust.	#11 7713389 P-15	7613283 P-123
R-136		RESISTOR, FIXED—Same as R-126.	Sweep plate limiting.		
R-137		RESISTOR, FIXED—22 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Sweep voltage generator	RC20BF220K	7613283 P-125
R-138		RESISTOR, FIXED—Same as R-123.	Sweep gen. bias filter		
R-139		RESISTOR, FIXED—Same as R-101.	Sweep gen. bias filter		
R-140		RESISTOR, VARIABLE—1 megohm ±10%, linear taper, 3 watts; case 1 1/16" diam. x 9/16" thick; 3 terminals; shaft .250" diam. x 9/16" long from 3/8" bushing, with screwdriver slot. Furnished with lock-nut (H-103).	Horiz. sweep amplitude	#11 7713389 P-11	7613283 P-128
R-141		RESISTOR, FIXED—Same as R-101.	Sweep amp.-inv. grid		

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP

MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
R-142		RESISTOR, FIXED—Same as R-114.	Horiz. cent. network		
R-143		RESISTOR, FIXED—Same as R-105.	Horiz. cent. network		
R-144		RESISTOR, VARIABLE—50,000 ohms ±10%, linear taper, 3 watts; case 1 1/16″ diam. x 9/16″ thick; 3 terminals; shaft .250″ diam. x 9/16″ long from 3/8″ bushing with screwdriver slot. Furnished with lock-nut (H-103).	Horiz. cent. control	#11 7713389 P-12	7613283 P-132
R-145		RESISTOR, FIXED—Same as R-105.	Horiz. cent. network		
R-146		RESISTOR, FIXED—Same as R-101.	Sweep amp.-inv. bias filter		
R-147		RESISTOR, FIXED—Same as R-114.	Horiz. cent. network		
R-148		RESISTOR, FIXED—Same as R-101.	Sweep amp.-inv. grid		
R-149		RESISTOR, FIXED—2.2 megohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Sweep amp.-inv. grid	RC20BF225K	7613283 P-137
R-150		RESISTOR, FIXED—100,000 ohms ±10%, 1 watt, compound, phenolic insulation, 11/16″ long x 1/4″ diam., with wire leads 1 1/2″ long.	Sweep amp.-inv. plate	RC30BF104K	7613283 P-138
R-151		RESISTOR, FIXED—Same as R-150.	Sweep amp.-inv. plate		

R-152		RESISTOR, FIXED—Same as R-111.	Sweep voltage div.		
R-153		RESISTOR, VARIABLE—100,000 ohms ±10%, linear taper, 3 watts; base 1 1/16" diam. x 9/16" thick; 3 terminals; shaft .250" diam. x 3/8" long from 3/8" bushing.	Sweep control	#11 7713389 P-16	7613284 P-146
R-154		RESISTOR, FIXED—2,200 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Sweep voltage div.	RC20BF222K	7613284 P-147
R-155		RESISTOR, FIXED—470,000 ohms ±5%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Blanking (back-trace) suppressor grid	RC20BF474J	7613284 P-148
R-156		RESISTOR, FIXED—Same as R-101.	Blanking (back-trace) suppressor grid		
R-157		RESISTOR, FIXED—Same as R-150.	Blanking (back-trace) suppressor plate		
R-158		RESISTOR, FIXED—15,000 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Blanking (back-trace) suppressor plate	RC20BF153K	7613284 P-151
R-159		RESISTOR, FIXED—Same as R-114.	Blanking (back-trace) suppressor grid		
R-160		RESISTOR, FIXED—Same as R-123.	Intensifier grid		
R-161		RESISTOR, FIXED—Same as R-155.	Intensifier grid filter		
R-162		RESISTOR, FIXED—Same as R-114.	Intensifier grid filter		
R-163		RESISTOR, VARIABLE—25,000 ohms ±10%, linear taper, 2 watts; case 1.227" diam. x 9/16" thick; 3 terminals; shaft .250" diam. x 1 3/16" long from 3/8" bushing.	Oscilloscope intensity control	#5 7713389 P-7	7613284 P-156

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP — MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
R-164		RESISTOR, FIXED—Same as R-101.	Neg. supply div.		
R-165		RESISTOR, VARIABLE—250,000 ohms ±10%, linear taper, 2 watts; case 1.227″ diam. x 9/16″ thick; 3 terminals; shaft .250″ diam. x 1 3/16″ long from 3/8″ bushing.	Oscill. focus control	#5 7713389 P-8	7613284 P-158
R-166		RESISTOR, FIXED—Same as R-114.	Neg. supply div.		
R-167		RESISTOR, VARIABLE—Same as R-153.	Spectrum center control		
R-168		RESISTOR, FIXED—Same as R-114.	Neg. supply div.		
R-169		RESISTOR, FIXED—430,000 ohms ±5%, 1/2 watt, compound, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Neg. supply div.	RC20BF434J	7613284 P-162
R-170		RESISTOR, FIXED—51,000 ohms ±5%, 1/2 watt, compound, phenolic insulation, 3/8″ long x 5/32″ diam., with wire leads 1 1/2″ long.	Intensifier bias div.	RC20BF513J	7613284 P-163
R-171		RESISTOR, FIXED—Same as R-158.	Neg. supply div.		
R-172		RESISTOR, FIXED—Same as R-114.	Neg. supply filter		
R-173		RESISTOR, FIXED—10,000 ohms ±10%, 2 watts, compound, phenolic insulation, 1 3/8″ long x 3/8″ diam., with wire leads 1 1/2″ long.	Pos. supply filter	RC40BF103K	7613284 P-166
R-174		RESISTOR, VARIABLE—100,000 ohms ±10%, linear taper, 3 watts; case 1 1/16″ diam. x 9/16″ thick; 3 terminals; shaft .250″ diam. x 9/16″ long from 3/8″ bushing, with screwdriver slot. Furnished with lock-nut (H-103).	Spot adjust.	#11 7713389 P-13	7613284 P-167

R-175		RESISTOR, FIXED—68,000 ohms ±10%, 1 watt, compound, phenolic insulation, 11/16" long x 1/4" diam., with wire leads 1 1/2" long.	Voltage div. oscill. plate	RC30BF683K	7613284 P-168
R-176		RESISTOR, FIXED—Same as R-112.	Voltage reg. plate		
R-177		RESISTOR, FIXED—1,000 ohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Voltage reg. screen	RC20BF102K	7613284 P-170
R-178		RESISTOR, FIXED—Same as R-119.	Voltage reg. div.		
R-179		RESISTOR, FIXED—Same as R-119.	Voltage reg. div.		
R-180		RESISTOR, FIXED—Same as R-111.	Voltage reg. div.		
R-181		RESISTOR, FIXED—Same as R-123.	Voltage reg. div.		
R-182		RESISTOR, FIXED—Same as R-144.	Pos. supply volt. adjust.		
R-183		RESISTOR, FIXED—Same as R-105.	Pos. supply div.		
R-184		RESISTOR, FIXED—Same as R-119.	R.F. osc. plate		
R-185		RESISTOR, FIXED—Same as R-105.	D.C. amp. plate		
R-186		Not used.			
R-187		Not used.			
R-188		RESISTOR, FIXED—150,000 ohms ±10%, 1 watt, compound, phenolic insulation, 11/16" long x 1/4" diam., with wire leads 1 1/2" long.	Voltage div. osc. plate	RC30BF154K	7613284 P-181
R-189		RESISTOR, FIXED—Same as R-188.	Voltage div. osc. plate		
R-190		RESISTOR, FIXED—1.5 megohms ±10%, 1/2 watt, compound, phenolic insulation, 3/8" long x 5/32" diam., with wire leads 1 1/2" long.	Detector bias filter	RC20BF155K	7613284 P-183
R-191		RESISTOR, FIXED—Same as R-190.	Detector bias filter		

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP

MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
R-192		RESISTOR, FIXED—Same as R-123.	Intensifier plate filter		
R-193		RESISTOR, VARIABLE—Same as R-133.	Fil. center tap adjust.		
S-101		SWITCH—Toggle, D.P.S.T., 1 13/32″ x 11/16″ x 21/32″, with 15/32″—32 bushing 15/32″ long, 4 lugs.	Power on-off	#7 8370K2	7613284 P-193
S-102		SWITCH—Toggle, S.P.S.T., 1 3/32″ x 43/64″ x 11/16, with 15/32″—32 bushing 15/32″ long, 2 lugs.	Synch.	#7 8381K3	7613284 P-194
S-103		SWITCH—D.P. 3 positions, non-shortening; 3/8″—32 bushing 3/8″ long, shaft .250 diam. x 1 7/8″ long, from bushing, with 2 flats 5/8″ long x 1/32″ deep located 120° apart.	D.C. amp. video switch.	#21 7713876 P-1	7613284 P-195
T-101		TRANSFORMER—Iron core, variable 3.5-8.0 μh. (or micro-henries).	R.F. input	#1 7713258 G-3	7613284 P-199
T-102		TRANSFORMER—Power, 50/1200 cycles, 115 volts primary; secondary voltages: 6.3 volts at 0.6 amps., 2.5 volts at 1.75 amps., 6.3 volts at 4.83 amps., 6.3 volts at 1.25 amps., 5.0 volts at 2.0 amps. 1045 volts at .005 amps., 650-0-650 volts at .075 amps.; 15 terminals and 4 mounting feet.	Power supply +300 V.D.C. −1000 V.D.C.	#1 L-423172	7613284 P-200
V-101		TUBE—Pentode.	1st I.F.	#17 6SJ7	7613284 P-203
V-102		TUBE—Converter.	Converter, 22.5 to 3 MC.	#17 6SA7	7613284 P-204
V-103		TUBE—Twin triode.	Detector.	#17 6SN7	7613284 P-205

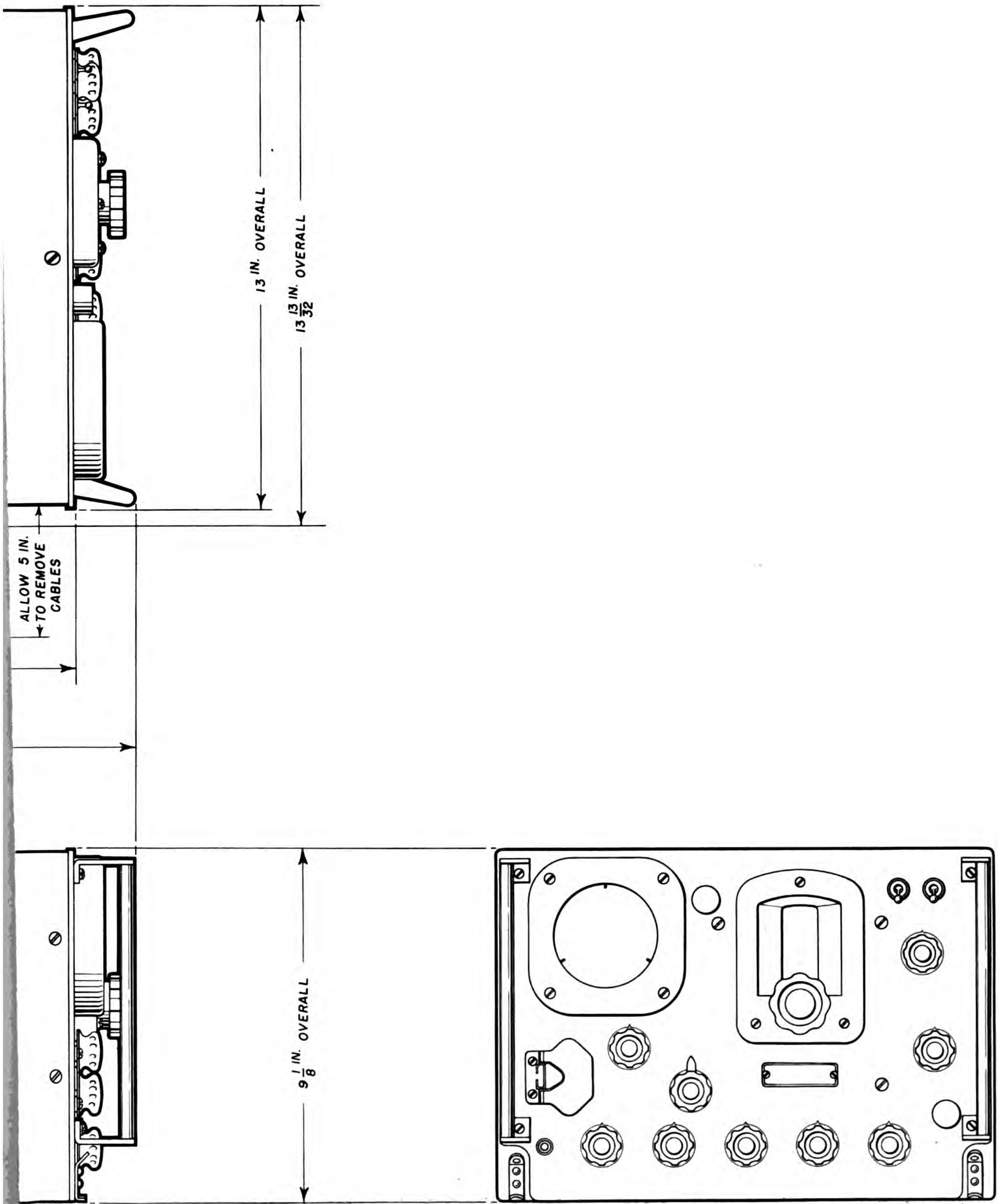
V-104		TUBE—Pentode.	Video amplifier	#17 6AC7	7613284 P-206
V-105		TUBE—Cathode ray.	Indicator	#17 3BP1	7613285 P-217
V-106		TUBE—Same as V-101	D.C. amp.		
V-107		TUBE—Grid controlled, gas rectifier.	Sweep generator	#17 #884	7613285 P-219
V-108		TUBE—Same as V-103.	Sweep amp.—inv.		
V-109		TUBE—Same as V-103.	Blanking (back-trace) suppress & intensifier		
V-110		TUBE—Vacuum rectifier.	Neg. supply rectifier	#17 2X2	7613285 P-222
V-111		TUBE—Vacuum rectifier.	Pos. supply rectifier	#17 5R4GY	7613285 P-223
V-112		TUBE—Power.	+300 volt. reg.	#17 6Y6G	7613285 P-224
V-113		TUBE—Same as V-101.	+300 volt. reg.		
V-114		TUBE—Neon filled.	+300 volt. reg.	#17 991	7613285 P-226
V-115		TUBE—3 CM. oscillator.	R-f osc.	#36 2K25	7613285 P-227
V-116		TUBE—Same as V-114.	Volt. reg., ng. supply		
V-117		TUBE—Same as V-114.	Volt. reg., neg. supply		
V-118		TUBE—Same as V-114.	Volt. reg., neg. supply		

TABLE OF REPLACEABLE PARTS (Continued)

MODEL TS-148/UP — MAJOR ASSEMBLY: SPECTRUM ANALYZER

Reference Symbol	Army Stock Number Navy Stock Number British Reference No.	Name of Part and Description	Function	Manufacturer and Designation or AWS Type	Contractor or Government Drawing or Specification No.
W-101		CABLE—Single conductor, double shielded, polyethylene insulation and vinylite jacket, with 90° connector (P-101) at one end.	Crystal mixer to input transf.	#1 7415327 G-1	7613285 P-236
W-201		CABLE—Type "SJ" cable, #18 wire, with 2 blade receptacle at one end and 2 socket receptacle at other end, approx. 10 feet total length. CX-337/U.	Power cable	#1 7415325 G-1	7613392 P-21
W-202		CABLE ASSEMBLY—Consisting of cable (W-202A) and phone plugs (P-203 and P-204). CX-464/UP.	Mixer cable	#1 741536 G-1	7613392 P-23
W-202A		CABLE—Type "SJ," #18 wire, one conductor covered with white vinylite, the other with black vinylite, then both covered with black vinylite.	Conductor for W-202	#8, 9, 10 Type SJ	7613392 P-24
W-203		CABLE ASSEMBLY—Consisting of cable (W-203A) and connectors (P-205 and P-206). CG-92/U.	Antenna-horn cable	#1 7415328 G-1	7613392 P-25
W-203A		CABLE—Single conductor, double shielded, polyethylene insulation and vinylite jacket.	Coaxial cable for W-203	#8, 9, 10 RG-9/U	7613392 P-26
X-101		SOCKET—Octal, mica filled phenolic, for 3/32" thick panel, complete with mounting ring.	Socket for V-101	#8 78-S8-T	7613285 P-240
X-102		SOCKET—Same as X-101.	Socket for V-102		
X-103		SOCKET—Same as X-101.	Socket for V-103		
X-104		SOCKET—Same as X-101.	Socket for V-104		
X-105		SOCKET—14 contacts, mica-filled phenolic.	Socket for V-105	#18 9453	7613285 P-244
X-106		SOCKET—Same as X-101.	Socket for V-106		

X-107		SOCKET—Octal, mica-filled phenolic, with mounting plate.	Socket for V-107	#8 77-MIP-8TM	7613285 P-246
X-108		SOCKET—Same as X-101.	Socket for V-108		
X-109		SOCKET—Same as X-101.	Socket for V-109		
X-110		SOCKET—4 contact, mica-filled phenolic.	Socket for V-110	#8 78-RS-4TM	7613285 P-249
X-111		SOCKET—Octal-filled phenolic, with mounting plate.	Socket for V-111	#8 78-RS-8TM	7613285 P-250
X-112		SOCKET—Same as X-111.	Socket for V-112		
X-113		SOCKET—Same as X-101.	Socket for V-113		
X-114		SOCKET—Two-contact, phenolic, with mounting plate.	Socket for V-114	#20 7411241 P-1	7613285 P-253
X-115		SOCKET—Octal, mica-filled phenolic, with pins 3, 4, 5, 6 removed. At position of #4 pin is to be a hole .169″ diam. and counter-bored .375″ diam. x 7/32″ deep in bottom of socket.	Socket for V-115	#1 7415381 P-1	7613285 P-254
X-116		SOCKET—Same as X-114.	Socket for V-116		
X-117		SOCKET—Same as X-114.	Socket for V-117		
X-118		SOCKET—Same as X-114.	Socket for V-118		



FRONT VIEW

Figure 7-1. Spectrum Analyzer, Outline Drawing ***Fig. 7-1***

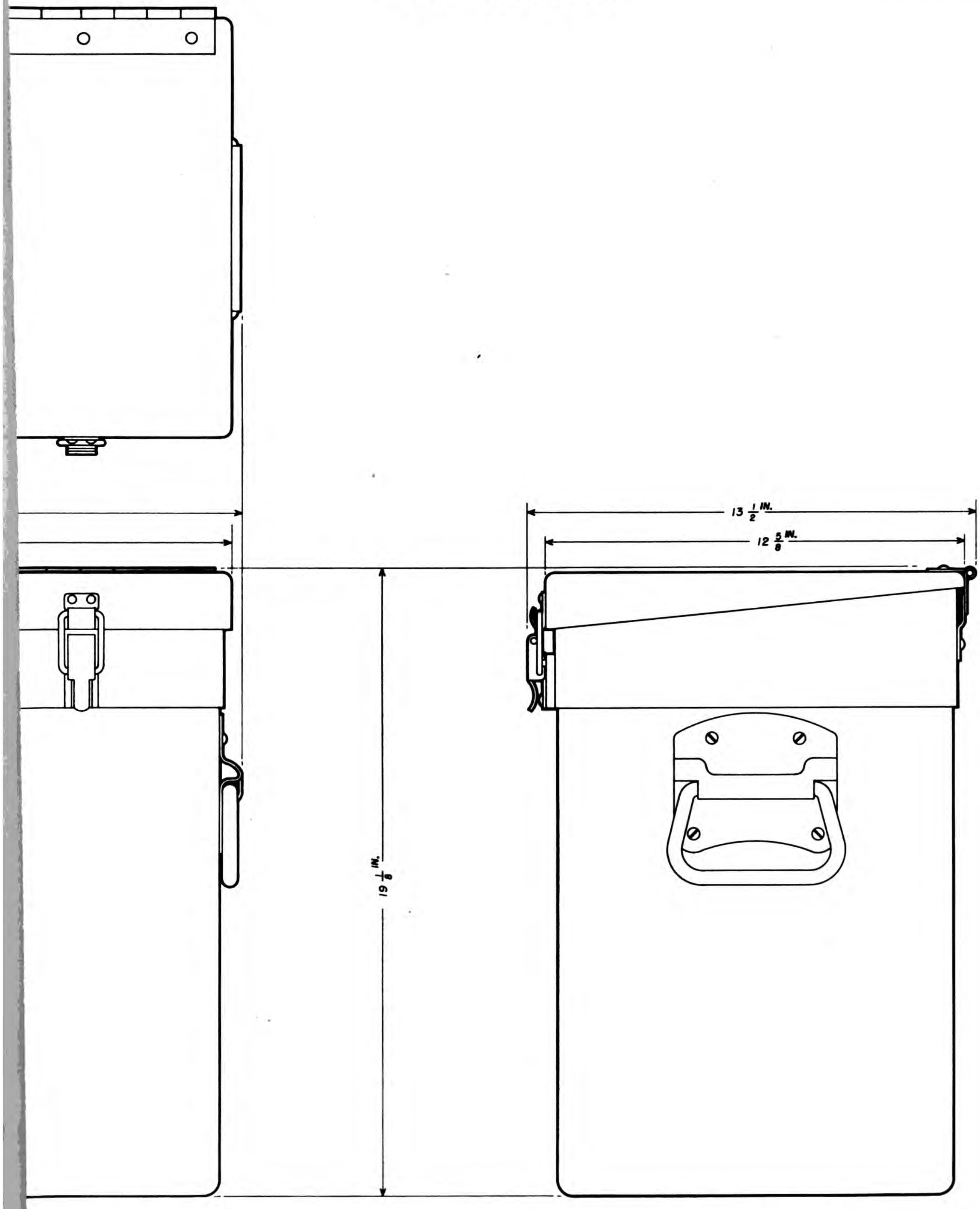
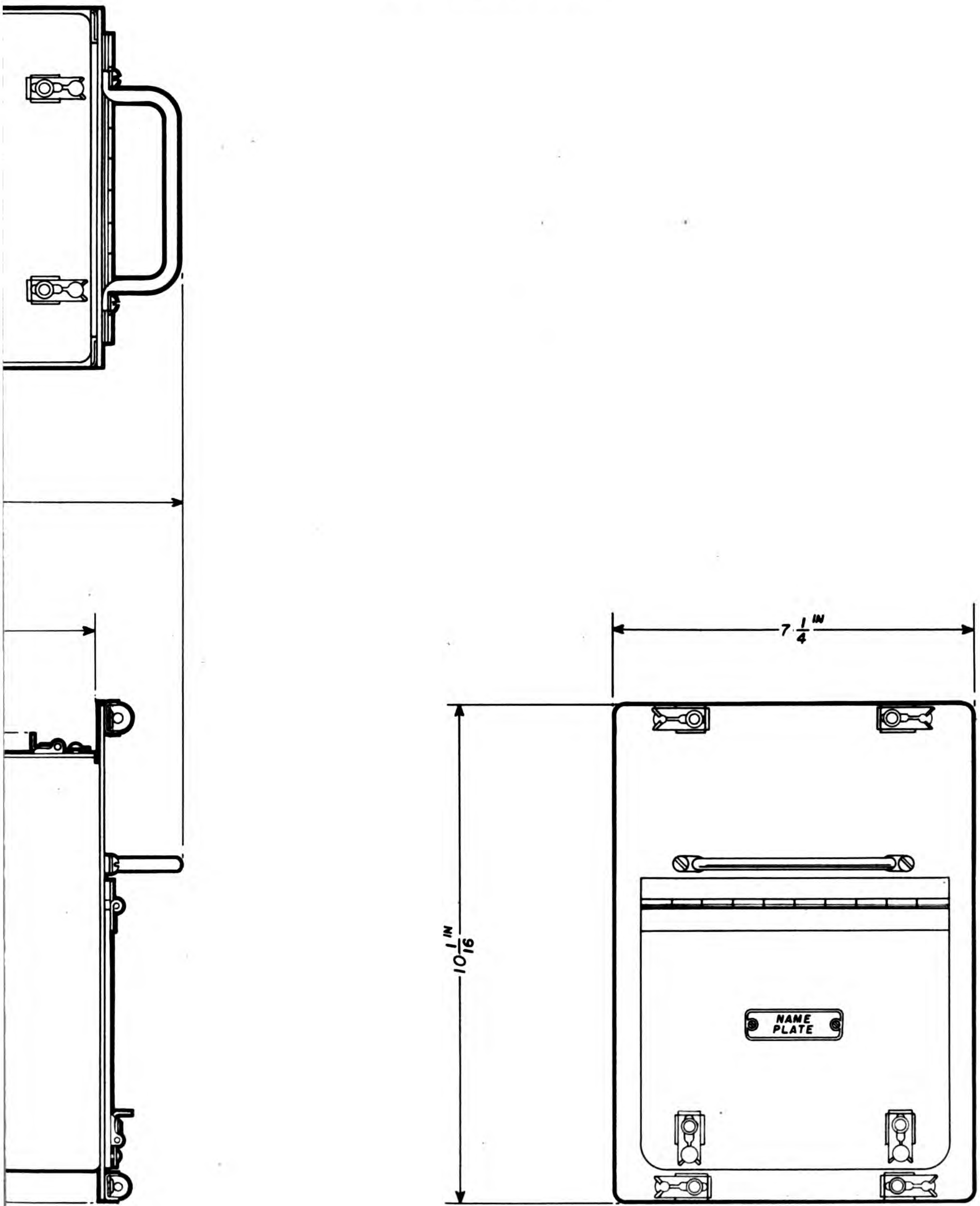


Figure 7-2. Carrying Case, Outline Drawing

Fig. 7-2

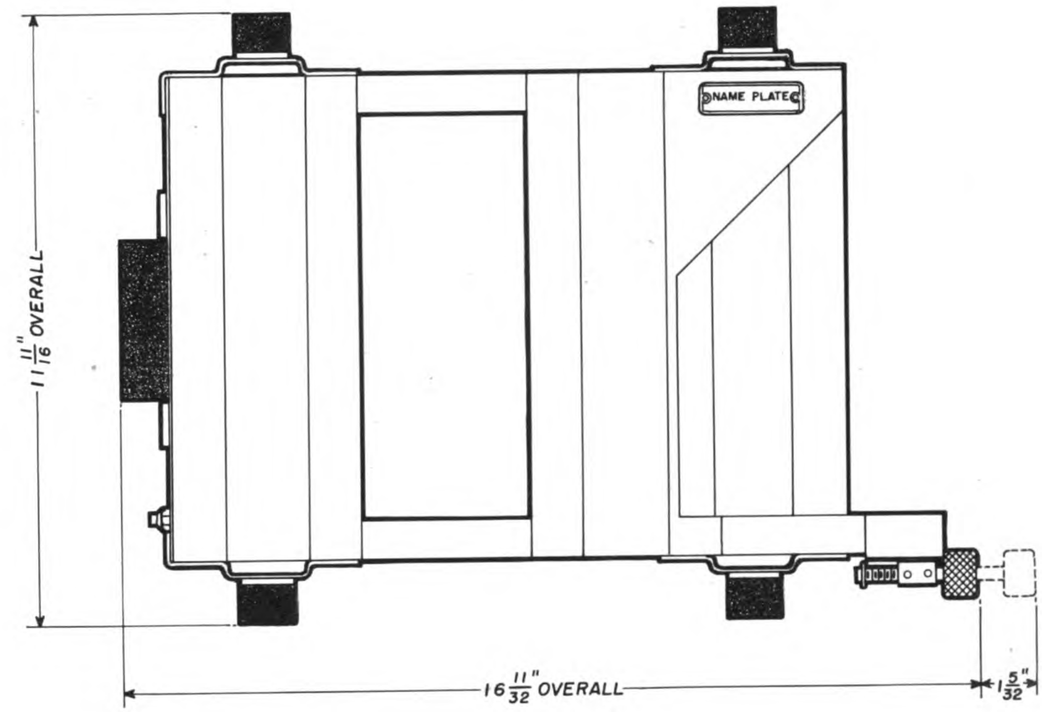


NAVY TYPE NO. CY-245/U OF TS-148/UP

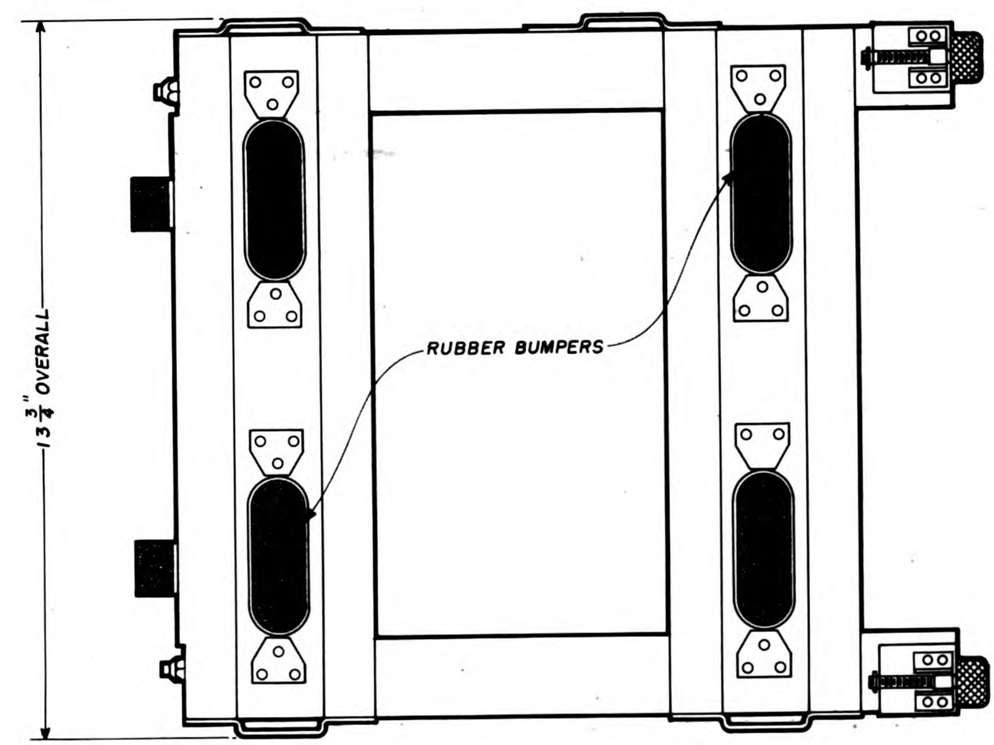
FRONT VIEW

Figure 7-3. Auxiliary and Spare Parts Box, Outline Drawing

Fig. 7-3



SIDE VIEW



BOTTOM VIEW

Figure 7-4. Carriage, Outline Drawing

Fig. 7-4

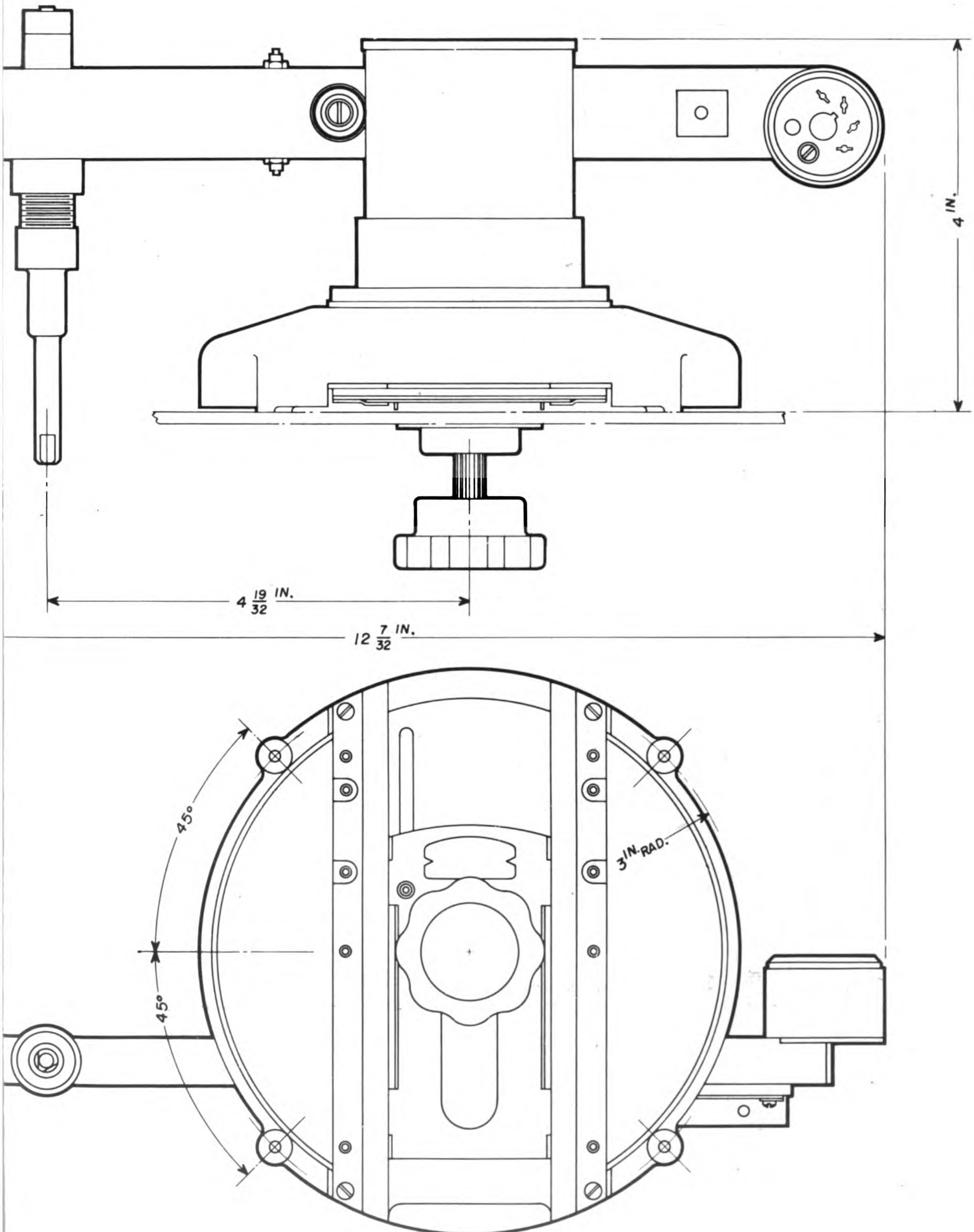


Figure 7-5. R-F Assembly, Outline Drawing

Fig. 7-5

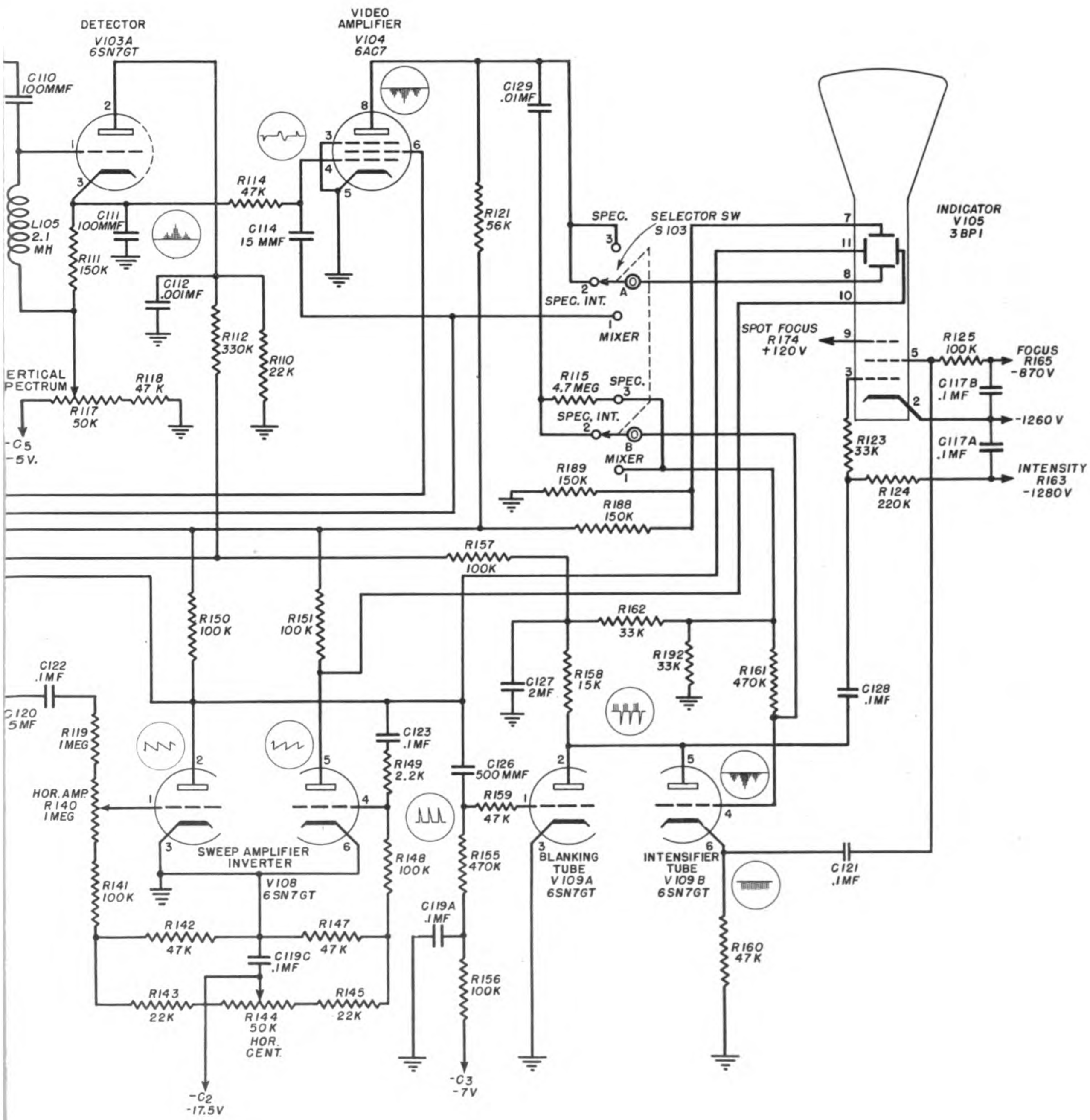


Figure 7-6. Spectrum Analyzer, Simplified Schematic

Fig. 7-6

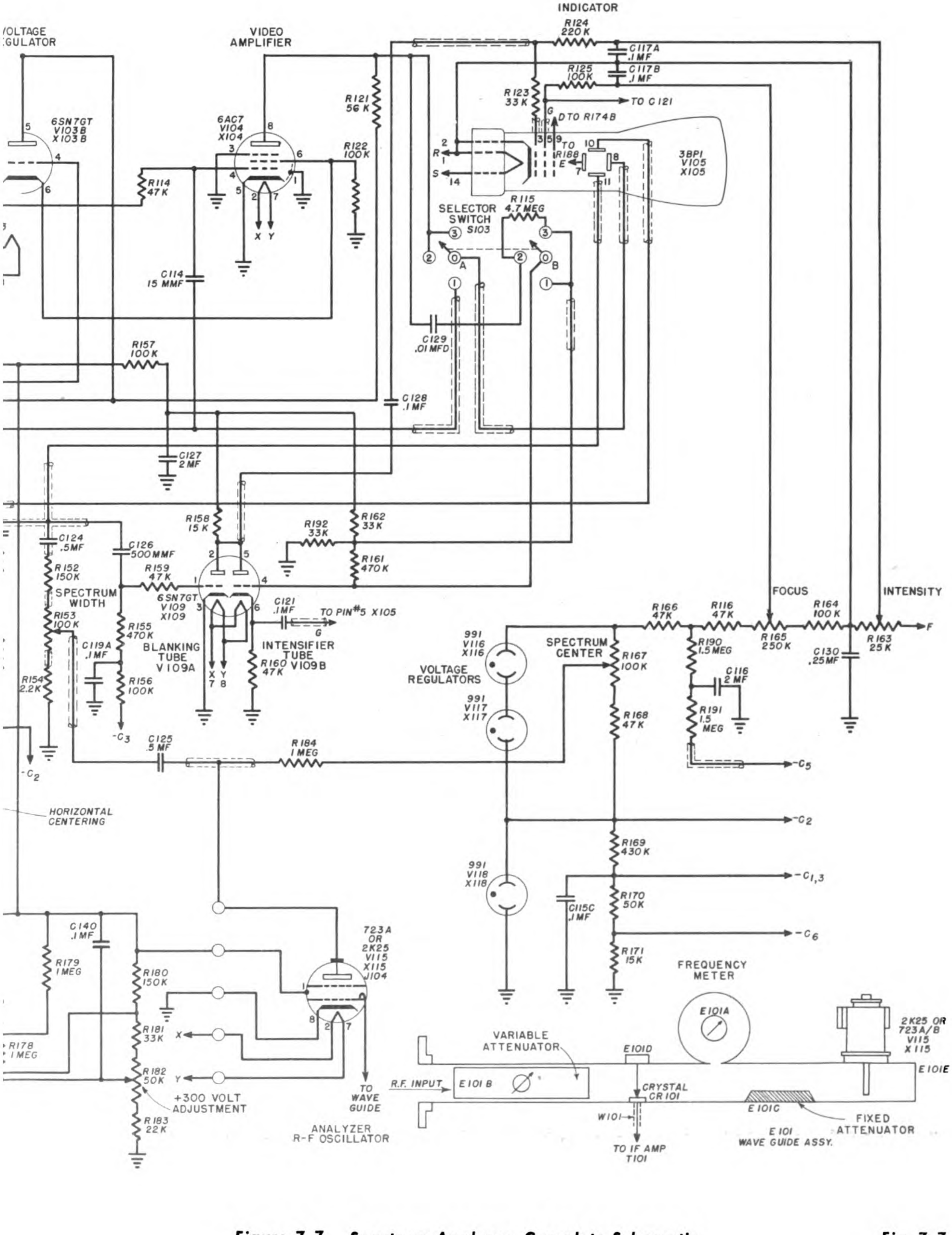


Figure 7-7. Spectrum Analyzer, Complete Schematic *Fig. 7-7*

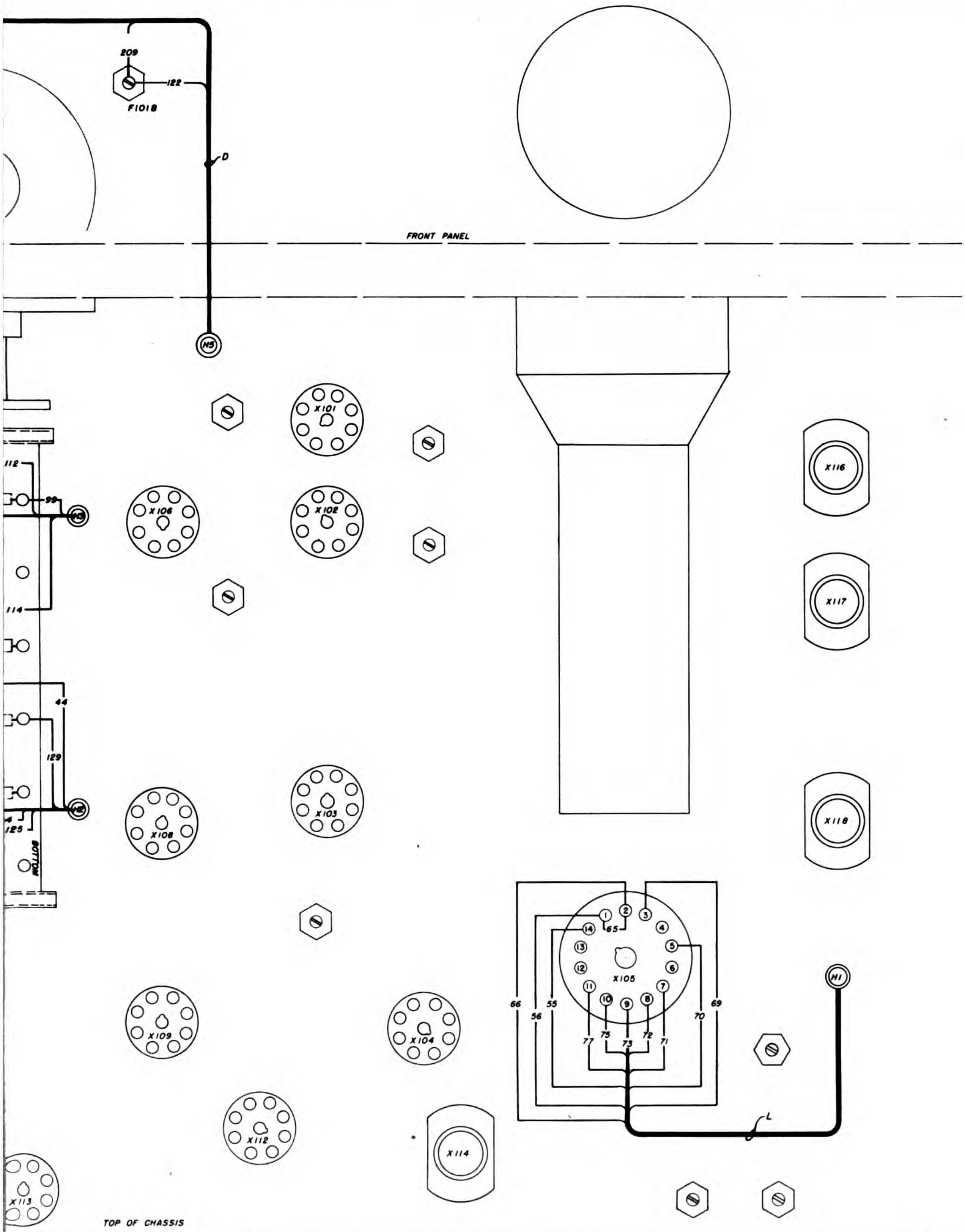


Figure 7-8. Spectrum Analyzer, Wiring Diagram. For Top of Chassis. See Fig. 7-10 for wiring legend.

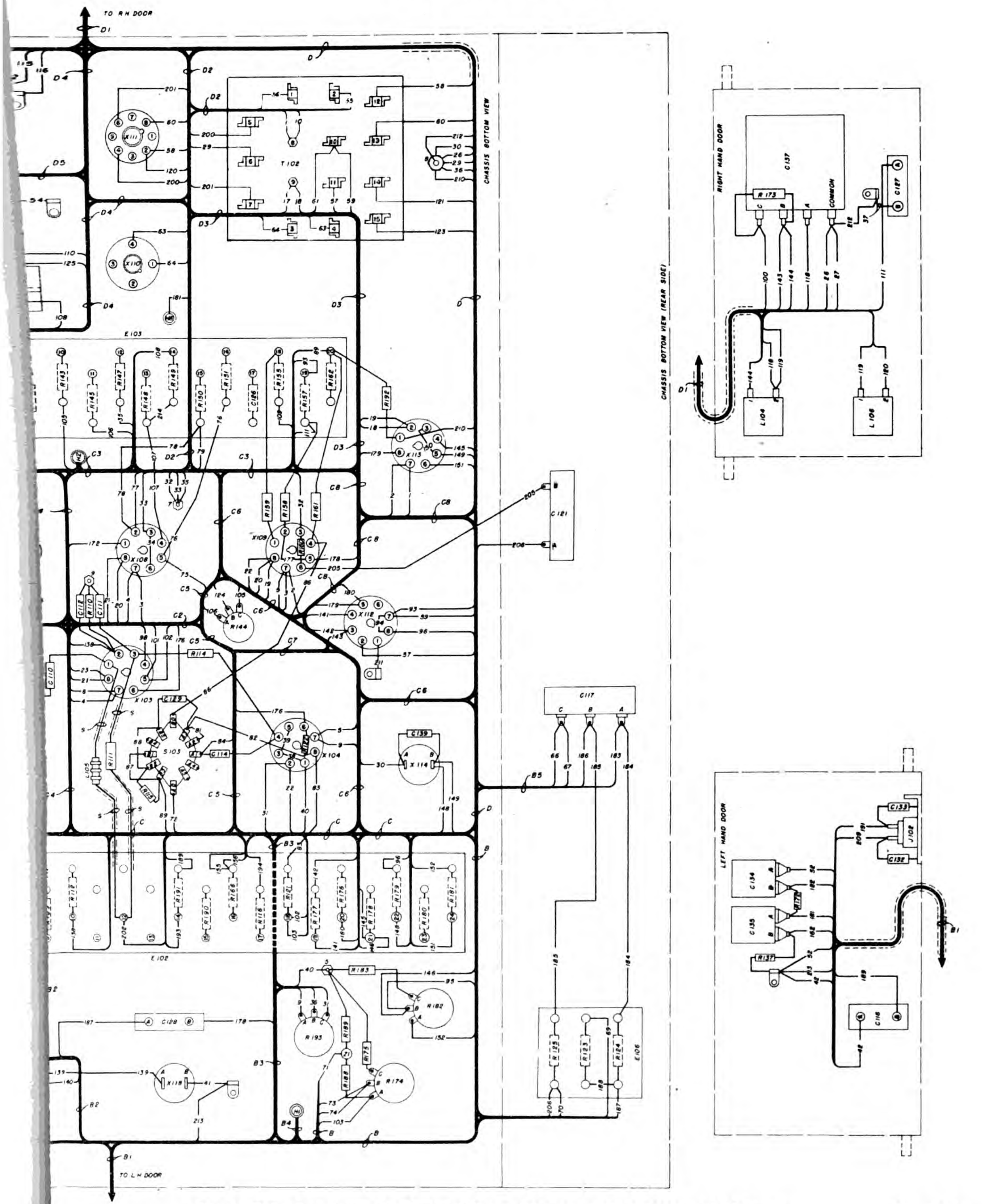


Figure 7-9. Spectrum Analyzer, Wiring Diagram. For Bottom of Chassis.
See Fig. 7-10 for wiring legend.

Fig. 7-9

Figure 7-10. Spectrum Analyzer, Wiring Legend.

Figure 7-11. Cable Assemblies

SECTION VIII—INDEX

INDEX—Continued

INDEX—Continued

INDEX—Continued

INDEX—Concluded

SECTION V
SUPPLEMENTARY DATA

1. TECHNICAL SUMMARY, SPECTRUM ANALYZER TS-148/UP

a. TUBE COMPLEMENT.

QUANTITY	*TYPE*	*CIRCUIT DESIGNATION*	*FUNCTION*
1	6SJ7	V-101	I-F Amplifier
1	6SA7	V-102	Oscillator-Converter
1	6SN7GT	V-103	Infinite-Input-Impedance Detector and Voltage Regulator
1	6AC7	V-104	Video Amplifier
1	3BP1	V-105	Cathode-Ray Tube
1	6SJ7	V-106	D-C Mixer Amplifier
1	884	V-107	Sweep Oscillator
1	6SN7GT	V-108	Horizontal Sweep-Amplifier Inverter
1	6SN7GT	V-109	Back Trace Remover and Intensifier
1	2X2	V-110	H-V Rectifier
1	5R4GY	V-111	L-V Rectifier
1	6Y6G	V-112	Voltage Regulator
1	6SJ7	V-113	Regulator Control
4	991	V-114	Neon Voltage Regulators
..	..	V-116	....
..	..	V-117	....
..	..	V-118	....
1	2K25 (or 723/A)	V-115	Analyzer R-F Oscillator