STUDENT'S NOTEBOOK

FOR

MAINTENANCE AND REPAIR TRAINING
AN/URT-2, AN/URT-3, AND AN/URT-4

R E S T R I C T E D

Prepared by

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FOREWORD

The material contained in this book has been carefully selected from previous courses given on this subject. It is believed it offers the maximum assistance to the student in understanding the AN/URT-2, AN/URT-3, and AN/URT-4 Radio Transmitting Sets.

In using the course material included in this book it is assumed that the U.S.Navy will provide the student with a copy of the INSTRUCTION BOOK FOR RADIO TRANSMITTING SETS AN/URT-2, AN/URT-3, and AN/URT-4. Wherever supplemental material seems desirable as a training aid, it has been included. This supplemental material includes descriptive material, lists, tables and such other training aids as have been found helpful in previous courses.

The writers of this course feel that additional forms or methods of presentation may be developed by some instructors, and are most interested in receiving comments from each school concerning any material which the instructors or their students feel will materially assist in the presentation of future courses on this subject. All comments should be addressed through proper channels to Code 992, Bureau of Ships, for military personnel; and to Code 724, Bureau of Ships, for civilian personnel of the Department of the Navy.

In pursuing this course, the student is preparing to assist materially the Department of the Navy in their continuing program of maintaining and improving the efficiency of Naval communications. In order that Naval personnel may be fully capable of handling any emergency, extreme care should be exercised in taking notes and in preparing sketches, lists and tables.

Unless it is contrary to current regulations, each student should be permitted to retain this notebook during the time he is engaged in electronics activities for the Bureau of Ships. This notebook is classified as RESTRICTED, and must be handled in conformance with security regulations governing the handling of such classified matter.

FEC

CURRICULUM

LECTURE NUMBER	SHOP EXERCISE	TITLE	HOURS ALLOTTED
		1st Week	
1		Introduction to the AN/URT-2, -3, and -4 Radio Transmitting Sets	2
	1	Demonstration of the AN/URT-2, -3, and -4 Radio Transmitting Sets in Operation	1
2		Functional Description	2
	2	General Familiarization	3
3		Introduction to the Radio Frequency Oscillator	4
	3	Radio Frequency Oscillator and Control Circuits	4
4		Radio Frequency Oscillator Control System Analysis	4
5		Introduction to the Low Level Radio Modulator	4
	4	Low Level Radio Modulator Identification	2
6		Introduction to the High Level Radio Modulator	1
	5	High Level Radio Modulator Identification	1
7		Introduction to the Radio Frequency Amplifier	2
	6	Radio Frequency Amplifier Identification	2
		Review No. 1	4
		Examination No. 1	2
		Review No. 2	2
		2nd Week	
8		Introduction to Power Supplies and Base Mount	1
	7	Control Circuits in Power Supplies and Base Mount	3

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LECTURE NUMBER	SHOP EXERCISE	TITLE	HOURS ALLOTTED
9		Analysis of Transmitter Group Control Circuits	4
	8	Transmitter Group Operation and Control Circuit Check	2
10		Introduction to the Antenna Tuning Equipment	2
11		Analysis of Antenna Tuning Equipment Control Circuits	4
	9	Antenna Tuning Equipment and Control Circuits	4
12		Installation and Checkout Procedures	2
13		Preventive Maintenance -- Procedures	2
	10	Equipment Checkout	4
	11	Preventive Maintenance -- Practice	4
		Review No. 3	4
		Examination No. 2	2
		Review No. 4	2
		3rd Week	
14		Corrective Maintenance -- Procedures	4
	12	Corrective Maintenance -- Practice	12
15		Special Circuits	4
	13	Special Circuit Operation	4
	14	System Control Circuits	8
		Review No. 5	4
		Examination No. 3	2
		Review No. 6	2

Curriculum

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LECTURE NUMBER	SHOP EXERCISE	TITLE	HOURS ALLOTTED
		4th Week	
	15	RFO and RFA Preventive Maintenance, Corrective Maintenance, and Checkout	8
	16	LLRM and HLRM Preventive Maintenance, Corrective Maintenance, and Checkout	8
	17	ATE Preventive Maintenance, Corrective Maintenance, and Checkout	8
		Review No. 7	8
		Examination No. 4	4
		Review No. 8	4

LIST OF WALL CHARTS FOR USE WITH
FOUR-WEEK COURSE
of
MAINTENANCE AND REPAIR TRAINING
AN/URT-2, AN/URT-3, AND AN/URT-4

Chart No.	Title	IB Fig. No.
1	Radio Transmitting Sets AN/URT-2, -3 and -4, Functional Block Diagram	2-1
2	Radio Frequency Oscillator O-153/URT, Functional Block Diagram	2-3
3	Radio Modulator MD-143/URT, Block Diagram	2-64
4	Radio Frequency Amplifier AM-519/URT, Complete Block Diagram	2-100
5	Control Circuits Schematic Diagram, AN/URT-3 Transmitter Bay	7-152
6	Antenna Tuning Equipment, Functional Block Diagram	(ATE)2-1
7	Antenna Tuning Equipment, Schematic Diagram	(ATE)7-27
8	Pictorial System Diagram, Radio Transmitting Set AN/URT-3	3-39
9	Interconnecting Wiring Diagram, AN/URT-3	3-51

TOOLS AND TEST EQUIPMENT
REQUIRED FOR FOUR-WEEK COURSE
of
MAINTENANCE AND REPAIR TRAINING
AN/URT-2, AN/URT-3, AND AN/URT-4

1. Standard Test Equipment Required

(a) ME-25A/U VTVM
(b) ME-48A VOM
(c) OS-8A/U Oscilloscope
(d) LAJ Audio Oscillator
(e) AN/USM-3 U.S. Navy Test Tool Set

2. Special Test Equipment Required

(a) RF Probe Voltmeter
(b) RF Tuner Test Set
(c) Antenna Control Group Test Set
(d) 500-watt, 50-ohm Dummy Load
(e) Jumper Connector Set

3. Standard Tools Required

(a) Set of Socket Wrenches up to 9/16"
(b) Set of Open End Wrenches up to 3/8" with both 30° and 90° heads.
(c) One Thin Jaw 8" Adjustable Wrench
(d) One Stubby Screwdriver with a 1/4" to 3/8" blade 3/4" to 1" long.
(e) 4" x 1/8" Screwdriver
(f) 4" x 1/4" Screwdriver
(g) 8" x 1/8" Screwdriver
(h) 2½" x 3/16" Screwdriver
(i) 10" x 3/8" Screwdriver
(j) 6" Diagonal Pliers
(k) 6" Longnose Pliers
(l) 8" Linesman's Pliers
(m) 10" Waterpump Pliers
(n) 6" Gas Pliers
(o) Pencil Soldering Iron, Assorted Tips
(p) 100-watt to 150-watt Soldering Iron
(q) Stands for (o) and (p)

4. Special Tools Required

It is expected that all special tools will be supplied with the transmitter.

5. Other Items

In certain parts of Sections 6 and 7, requirements are stated for resistors, capacitors, plugs, jacks and other similar items. These items are not listed here and must be requisitioned by the instructor as required.

LESSON SHEET NO. 1

Time Allotted: - 2 Hours

SUBJECT: Introduction to the AN/URT-2, -3, and -4 Radio Transmitting Sets.

OBJECTIVE: To provide an overall picture of the AN/URT-( ) Radio Transmitting Sets.

INTRODUCTION: The AN/URT-2, AN/URT-3 and AN/URT-4 Radio Transmitting Sets are formed from a number of identical interchangeable major components which are used like building blocks to assemble a set with desired features. Though necessary differences exist in the interconnecting wiring of the various chassis groups, the major component units forming each chassis group are identical. The Sets are designed to provide a reliable transmitter series for ship, shore or ground station usage, in which frequency change and tuning adjustments are relatively simple and installation flexibility is provided by unitized construction.

The AN/URT-( ) series of Radio Transmitting Sets are more completely automatic than any other transmitter of similar frequency range ever before manufactured. A new and very precise frequency determining method is incorporated in the AN/URT-( ) Radio Transmitting Sets. Some complication is to be expected in the various Sets since servo-mechanisms are included to perform tuning operations normally manually performed. However, the severe program of Navy tests and inspections, plus the built-in indicator lamps, meters, and oscilloscope, has led to an equipment wherein trouble may be quickly localized and corrected. A particularly important part of the AN/URT-( ) Radio Transmitting Set is the Antenna Tuning Equipment, which achieves a radiation efficiency when used with a recommended antenna greater than that ever previously achieved over such a wide frequency range.

SUBJECT MATERIAL:

1. Display equipment, photograph, or a drawing of the equipment. (Figures 1-1, 1-2, or 1-3 may be projected with an opaque projector).

2. Cover the Basic Features. (Pages 1-1 through 1-5).

3. Refer to Table 1-1 and point out the quantity of major units for the AN/URT-2, -3, and -4. Note that certain items must be ordered separately from Navy depots.

4. Discuss the possibilities of converting from AN/URT-2 to AN/URT-3 and from AN/URT-3 to AN/URT-4.

5. Point out the component units of the Transmitter Group, the Booster, and the Antenna Tuning Equipment. Draw attention to abbreviations used; e.g., HVPS for Power Supply PP-707/URT. (Refer to Table 1-2).

6. Describe the Transmitter Group. (Refer to pages 1-7 and 1-10).

7. Describe Mounting MT-958/URT. (Refer to pages 1-20 and 1-21).

8. Describe the Booster. (Refer to pages 1-21 and 1-22).

9. Describe Transmitter Control C-916/URT. (Refer to pages 1-24 and 1-25).

10. State the requirements for:

    (a) Remote Control Unit
    (b) Antennas
    (c) Standard Test Equipment
    (d) Special Test Equipment
    (e) Test Cables, and
    (f) Special Tools

    (Note:- Refer to pages 1-31 through 1-38).

11. Refer the student to the Reference Data on pages 1-39 through 1-49.

CONCLUSION: The basic information on the physical and electrical characteristics of the AN/URT-2, -3, and -4 is available in condensed form on pages 1-39 through 1-49.

QUESTIONS AND/OR ORAL QUIZ: Time permitting, student questions will be answered by the lecturer, and/or an oral quiz may be given.

SHOP EXERCISE NO. 1

Time Allotted: - 1 Hour

SUBJECT: Demonstration of the AN/URT-( ) Transmitters in Operation

OBJECTIVE: To demonstrate the operation of the AN/URT-2, 3 and/or 4 Radio Transmitting Sets.

EQUIPMENT REQUIRED: One (1) or more completely installed AN/URT-2, 3, and/or 4 Radio Transmitting Sets.

PROCEDURE (INSTRUCTOR):

1. Point out Safety Equipment - Wall Chart on Artificial Respiration Methods, First Aid Kit.
2. Distribute Safety Bulletins.
3. Assemble group or groups near set(s) to be operated.

INSTRUCTIONS (INSTRUCTOR):

1. Give General Information
   - (a) Locate and name each drawer
   - (b) Show makeup of the three sets
   - (c) Point out general installation requirements
2. State and demonstrate:
   - (a) Frequency selection
     - (1) 10-Channel frequency adjustments
     - (2) Knob-set frequency adjustments
   - (b) Other preliminary adjustments
     - (1) Remote or local
     - (2) Auto, semi-auto or manual operation
     - (3) Type of emission (CW, Voice, etc.)
   - (c) "Power On" prerequisites
     - (1) Primary power on
     - (2) Emergency switch on
     - (3) Start-stop switch closed
     - (4) All drawers interlocks closed

CONCLUSION: At this point, the lecturer will answer any questions which may be asked by the students.

LESSON SHEET NO. 2

Time Allotted: - 2 Hours

SUBJECT: Functional Description

OBJECTIVE: To outline the functions of the various component units in the AN/URT-2, -3, and -4 Radio Transmitting Sets.

INTRODUCTION: The complexity of an automatic tuning system may seem to obscure the true simplicity of design in the AN/URT-2, -3, and -4 Radio Transmitting Sets. However, when the set is broken into functional groups, the basic nature of the design is apparent.

SUBJECT MATERIAL:

1. Display Figure 2-1 -- Radio Transmitting Sets AN/URT-2, -3, and -4, Functional Block Diagram.

2. Describe briefly the equipment in each block on Figure 2-1. (Refer to paragraphs 1 through 9 and 14 through 16, pages 2-2 through 2-5).

3. Describe functionally the following units:

   (a) RFO (see para.(3), pages 1-13 through 1-17; also Figure 2-2).
   (b) RFA (see para.(1), pages 1-10 through 1-12; also Figure 2-2).
   (c) LLRM (see para.(2), pages 1-12 and 1-13; also Figure 2-2).
   (d) LVPS (see para.(4), pages 1-17 and 1-18).
   (e) MVPS (see para.(5), pages 1-18 and 1-19).
   (f) Transmitter Control C-916/URT (see para. e, pages 1-24 and 1-25).
   (g) Remote Radiophone Unit (see para. i, page 1-31; also Figure 2-2).
   (h) HLRM (see para.(1), page 1-22).
   (i) HVPS (see para.(2), page 1-23).
   (j) RF Tuner (see para. f, pages 1-25 through 1-27).
   (k) ACG (see para. h, pages 1-28 through 1-30).
   (l) Capacitor Assembly CB-5/URT (see para. g, page 1-27).

4. Return to Figure 2-1 and on the basis of 3, above, state the nature of all signals between connecting units.

CONCLUSION: It is readily seen that, except for differences in packaging, the Set does not materially differ functionally from other transmitters.

QUESTIONS: Student questions will be permitted at the end of the lecture.

SHOP EXERCISE NO. 2

Time Allotted: - 3 Hours

SUBJECT: General Familiarization

OBJECTIVE: To familiarize the student with the equipment, the location of major units and of components parts.

EQUIPMENT REQUIRED: One (1) or more completely installed AN/URT-2, -3, and/or -4 Radio Transmitting Sets.

PROCEDURE (INSTRUCTOR): The students are shown how to remove each drawer from the bay(s).

INSTRUCTIONS:

1. Students will be directed to remove all drawers of transmitter(s).

2. The instructor will point out receptacles in rear of each drawer space and give correct circuit nomenclature.

3. The instructor will explain interconnecting cabling inside bay(s).

4. The instructor will draw attention to the base mount and location of blowers and air filters.

5. Students will label each major unit on Figures 1-1, 1-2, and 1-3 in the Instruction Book. With the assistance of the instructor, all fuses, controls and pilot lights will be located on or in each major unit and properly labeled.

6. With the assistance of the instructor, the student will locate the input power connectors, the interconnection cabling and connectors between transmitter and antenna tuning equipment, the RF output connectors to the antenna, and control line terminals.

CONCLUSION: After all work is completed and sketches have been checked by the instructor, students will replace and secure all drawers, panels and/or covers, turn in all tools and/or test instruments, and clear working space for the next shop exercise.

LESSON SHEET NO. 3

Time Allotted: - 4 Hours

SUBJECT: Introduction to the Radio Frequency Oscillator

OBJECTIVE: To introduce the basic concepts of Radio Frequency Oscillator O-153/URT.

INTRODUCTION: Radio Frequency Oscillator O-153/URT is a complex unit only in that it is made up of many parts and covers a very wide frequency range with exceptional accuracy and stability of frequency. In this lecture the instructor will break the oscillator into component units so as to show the simplicity of design which provides for such accuracy and stability.

SUBJECT MATERIAL:

1. The instructor will sketch that section of Figure 2-2 which refers to the RFO and explain the sketch (see para.(1), pages 2-6 through 2-9).

2. The student will be referred to Figures 1-13 through 1-16 or an RFO will be displayed before the class. The instructor will explain the following with appropriate references to the illustrative material:
   (a) Interchangeability and plug-in of units.
   (b) Controls on front panel (Unit 13).
   (c) Inter-unit RF connections.

3. Display Figure 2-3 and explain (see pages 2-17 through 2-20).

4. The student will be referred to Figures 2-4 through 2-42 as the instructor gives a basic analysis of each unit. (See 2-20 through 2-68).

CONCLUSION: It should now be obvious that no "trick" circuits are incorporated in the RFO. Every circuit is a simple circuit similar to those circuits met previously by the student. Many of the circuits may be compared in principle to those seen in the mixer stage of the ordinary superhetrodyne receiver. Since the IF stages of the receiver act as a filter in the elimination of the original frequencies and any other undesired frequencies, the use of many filters in the RFO is to be expected. The only point which may not be obvious is that of the somewhat odd frequencies obtained from the individual component units. This is easily explained in that the most stable oscillator readily available is a 100 kc crystal controlled unit, the specification calls for a 60 db ratio between the desired frequencies and all undesired harmonics, and it was desirable to use components of reasonable size.

QUESTIONS AND/OR ORAL QUIZ: Student questions directly related to the RFO will be permitted, and/or an oral quiz may be given.

SHOP EXERCISE NO. 3

Time Allotted: - 4 Hours

SUBJECT: Radio Frequency Oscillator and Control Circuits

OBJECTIVE: To familiarize the student with Radio Frequency Oscillator O-153/URT, the location and function of its component sub-unit chassis, the frame, and the location and function of front panel controls.

EQUIPMENT REQUIRED:

1. One, or more, Radio Frequency Oscillator(s) O-153/URT.

2. One, or more, test cables for same.

PROCEDURE:

1. At the request of the instructor, students will remove Radio Frequency Oscillator O-153/URT from the transmitter bay.

2. With the assistance of the instructor, students will determine the location of all component chassis on equipment.

3. The instructor will point out that those units which couple to front panel knobs (Units 3, 6, and 8) must have their knobs retracted before the unit may be removed from the rack. The instructor will demonstrate how this is accomplished, and will further demonstrate that Units 11B and 11C can be plugged in or removed only when both switches are in the zero position.

4. The student will remove all units from the rack (Unit 14) under the supervision of the instructor.

5. The student will observe that all RF cables are part of Unit 14 (the rack), and the student will observe the nomenclature system used for connecting cables.

6. Under the supervision of the instructor, the student will re-assemble all units on Unit 14.

7. After 6 is completed, the instructor will demonstrate and explain the operation of a step motor.

8. The student will sketch the front panel, label all controls with the proper nomenclature and prepare a list showing the function of all controls.

CONCLUSION: After all work is completed and sketches and/or lists have been checked by the instructor, students will replace and secure all drawers, panels and/or covers, turn in all tools and/or test instruments, and clear working space for the next shop exercise.

LESSON SHEET NO. 4

Time Allotted: - 4 Hours

SUBJECT: RFO Control System Analysis

OBJECTIVE: To analyze the control circuitry whereby the basic circuits of Lesson Sheet No. 3 are integrated into a very flexible, wide-range source of radio frequency energy.

SUBJECT MATERIAL: (Note:- The following material has been prepared to supplement that included in the Instruction Book, but in no way is intended to replace the Instruction Book. References to the Instruction Book are made throughout the lesson material).

1. The functions of the RFO Control System are as follows:

(a) Allows dialing any one of ten pre-set frequencies by the use of as many as four channel selector telephone dials (part of Transmitter Control C-916/URT) at local or remote stations. In addition, channel frequencies may be changed while on the air.

(b) Permits setting up of frequencies by use of decade knobs in manual operation.

(c) Sends band information to the Radio Frequency Amplifier (RFA).

(d) Sends information to the RFA that frequency is being changed. After change is accomplished, the RFA is permitted to retune.

(e) Controls a relay at the input of the RFA to change the input impedance of the RFA at frequencies below 6 mc.

(f) Homes step motors to the right position, and provides protection for step motors to prevent them from jamming or burning up.

2. A major part of the RFO Control System consists of the step switches. These operate in the following manner:

(a) Reference Figure 2-12:- A step switch consists of a solenoid and plunger, an inclined plane, a ratchet, a wafer shaft, a homing wafer, an interruptor switch, and a detent mechanism. When current flows through the coil of the solenoid, the plunger is attracted axially; i.e., to the right on Figure 2-12. By means of the inclined plane, the axial motion of the plunger is converted to a combination of short rotary motion and axial motion on the part of the left section of the ratchet. The axial portion of the plunger motion acts to engage the ratchet teeth while 30° of the about 45° of short rotary motion is used in moving the homing and rotor shafts (wafer shaft) to the next position of positive lock with the detent mechanism. The remaining 15° of short rotary motion is lost during the process of engaging the ratchet teeth. When the step switch has completed one step, the 150 VDC used to supply the solenoid coil is interrupted by the operation of the interruptor switch. The interruptor switch is mounted on the homing wafer and its contacts are opened by a bakelite cam mounted on the step motor. The solenoid coil is de-energized when the interruptor switch contacts open, and the plunger is forced back to its original position by a spiral spring. The wafer shaft, however, remains at the position to which it has been driven. If no other control were present under the conditions so far stated, the 150 VDC connection to the solenoid coil would be made and broken in sequence and the wafer shaft would rotate continuously in 30° steps. It will be shown presently that the 150 VDC connection to the solenoid coil may be made or broken by two other elements in the RFO Control System.

(b) Reference Figure 2-13:- In this illustration, it will be observed that only those elements within the boxed area are integral portions of the step switch. The control of the step switch by three different switching operations is shown in schematic form. One switching operation is that of the interruptor switch which was previously explained. The second switching operation is that of the motor actuated switch. In this case the switch is that shown in Figure 2-48, and performs two functions -- to minimize the danger of solenoid coil failure due to a jammed ratchet and to reduce the size of the 150 VDC supply by connecting only seven step switches to its positive terminal at any one time. The third switching operation is the one of most importance in the actual selection of a desired frequency. In this case, a control wafer with a knob to determine its contact position (basically, this could be any type of switch) is connected by wire lines to contacts on the homing wafer of the step motor. It will be observed that the step motor will stop whenever the wire connections between the control and homing wafers no longer provide a positive 150 VDC connection to one side of the solenoid coil -- i.e., the notch on the homing wafer moves opposite the contact connected by a wire line to the engaged contacts of the control wafer. The illustrated Control System that uses one wire for each position is called the 12-wire system. It is possible to obtain 12-position control with four wires between control and homing wafers by the use of specially cut notches on both wafers. In the 12-wire system it is possible to obtain any fixed relationship between the positions of the control and homing wafers by appropriate wiring. With the 4-wire system, however, the number of relationships between the control wafer and homing wafer are limited.

(c) <u>12-wire and 4-wire Control Systems</u>:- (see pages 2-78 through 2-80 and Figures 2-49 through 2-52). The two types of control systems are used in the RFO due to the necessity in the one case -- 12-wire system -- for the homing wafer in certain cases to home to a position not corresponding to the same position on the control wafer, and in the second case -- 4-wire system -- for a reduction in inter-unit wiring. As an example of 12-wire control, if position 9 on the homing wafer were wired to position 3 on the control wafer for the step motor, the step motor would home to position 9 each time the contacts of position 3 were engaged. It follows that a very large number of combinations of positions are possible with the 12-wire system. However, in the case of the 4-wire system, the number of combinations of control and homing wafer positions are strictly limited. Twelve positions are obtained with the 4-wire system through the use of specially cut notches on the control and homing wafers.

3. <u>Motor B-2916</u> (see Figure 2-53):- The operation of motor B-2916 has been referred to in 1(b) above; however, a closer examination is warranted. This motor drives the

commutator switch of Figure 2-48. From experience it has been determined that the teeth on the step switch ratchet may jam under certain circumstances. The operation of the commutator switch on motor B-2916 is to switch the positive 150 VDC lead in and out of the step motor control circuit at a 12 cps rate. The 12 cps rate is maintained constant by the governor on motor B-2916; and it is obvious that 1 cycle is applied for every 30° of wafer shaft rotation. This feature, coupled with the operation of the interruptor switch, insures that in the event of the ratchet teeth becoming jammed, the solenoid coil will not be burned out. In addition, the commutator switch is used to reduce the size of the 150 VDC supply since it connects only 7 of the 14 step motors to the supply at any one time.

4. <u>150 VDC Supply</u>:- The instructor will refer the student to Figure 2-46 and pages 2-74 and 2-75. In explaining this subject, the instructor will stress the operation of relay K-2917, which performs important functions in both CHANNEL and MANUAL operation of the RFO.

5. <u>Other Major Items in the RFO Control System</u>:-

   The instructor will refer the student to paragraphs (2), (3) and (4), pages 2-75 through 2-77, and to Figures 2-47 and 2-53.

6. <u>RFO Control Circuits -- General</u>:- The instructor will explain the material covered on pages 2-71 through 2-73.

7. <u>Automatic Operation of the RFO</u>:- The instructor will explain automatic operation in accordance with paragraph (7), pages 2-80 through 2-86 and Figure 2-53. It will be observed that all the functions that are performed in MANUAL, except for turning decade knobs and opening and closing of transparent door covering them, must also be performed in automatic operation. In addition, it is necessary to be able to dial any one of 10 pre-set channels. The additional components necessary are:

   (a) A set-up panel consisting of 70 miniature, ten position switches. For each of the ten channels there are seven switches; and for each of the seven digits of the output frequency, there is a bank of 10 switches - one switch for each channel. The corresponding points on each switch of the bank of 10 switches are connected together. These leads are then connected to the appropriate contacts on the homing wafer of the step-motor that controls the corresponding digit of the output frequency.

(b) Seven step-motors for controlling the position of each of the knobs on the front panel.

(c) The channel distributor switch S-2986, which consists of a step-motor and seven wafers. This switch connects power to the arms of the seven set-up switches corresponding to the channel dialed. Each wafer is connected to 10 set-up switches. The position of a wafer determines which set-up switch of a group of 10 receives power.

(d) Two control relays, K-2916 and K-2918, which cause channel selector relay K-2995 to come to rest in the position corresponding to the channel dialed.

(e) A DPST CHANNEL-MANUAL switch which applies power to the channel voltage divider and the channel distributor switch wafers when in channel position. In manual position this power is removed and therefore the channel selector relay and the channel distributor switch will not be capable of operating. In addition, the two control relays can not be energized.

8. <u>Operation of Step Switches During Automatic Operation</u>:-

The instructor will cover the material of pages 2-86 through 2-98 and Figures 2-55 through 2-62 in the briefest possible manner conducive to the student understanding how to find the position of each of the 14 step switches for a desired frequency. In this connection, it is suggested that Figure 2-63 be used as an example and that the students work with the instructor in establishing the position of all 14 step switches for this frequency. Tables 2-1 through 2-14, less Table 2-3, will be found helpful in this problem. Table 2-22 should also be studied.

9. Operation of Step Switches During Manual Operation:-

It is intended that the instructor use this subject as a test of the student's comprehension of the RFO Control System. The subject of MANUAL operation is covered in paragraph (b) at the top of page 2-108, and on pages 2-99 through 2-101. To assist the student, it should be pointed out that only certain step switches are electrically controlled in MANUAL operation. These are S-2426, S-2526, S-2651, S-2427, S-2652, and S-2996. In addition it should be observed that S-2801 and S-2802 in Unit 11C are mechanically connected to S-2651 and S-2652, respectively, in Unit 11B. It is suggested that the instructor use any remaining time in this period in having the student write out the switch positions for a test frequency.

CONCLUSION: It should now be apparent that the apparent complexity of the RFO evolves from the multiplicity of control operations. However, when the student reduces the circuitry to its basic groupings, the repeated usage of the same simple circuits is observed.

LESSON SHEET NO. 5

Time Allotted: - 4 Hours

SUBJECT: Introduction to the Low Level Radio Modulator

OBJECTIVE: To introduce the basic concepts of Radio Modulator MD-143/URT.

INTRODUCTION: Basically, the LLRM consists of seven major circuits together with a number of minor circuits wherein a large percentage of the control functions of the AN/URT-2, -3, and -4 Radio Transmitting Sets are initiated or channeled. Most of the circuits are conventional and will be passed over quickly; however, the keying circuits and the 250 VDC regulated power supply are unconventional and should be studied carefully.

SUBJECT MATERIAL:

1. Display Figure 2-64.

2. Refer the student to pages 2-108 through 2-159 for a complete theoretical explanation of the operation of the LLRM.

3. Explain the operation of the LLRM on the basis of the material in pages 2-108 down to the middle of page 2-112 with brief extensions of this material by excerpts from pages 2-112 through 2-159. Figures 2-65 through 2-95 may be referred to as required.

4. The Instruction Book material starting with paragraph f on page 2-124 and continuing to paragraph g on page 2-141 should be explained in detail. In addition, the material starting with paragraph h on page 2-148 and continuing to paragraph i on page 2-151 should be covered extensively.

5. The LLRM control circuits (see para. g, pages 2-141 to the middle of page 2-148) should be explained only to the extent necessary so that the student may localize trouble due to malfunction in these circuits. No particular difficulty may be expected in correcting troubles due to such malfunction since, in most cases, the corrective measure will be obvious.

CONCLUSION: The apparent complexity of the LLRM should by now be reduced to simple circuitry with which the student has had previous experience.

QUESTIONS AND/OR ORAL QUIZ: Time permitting, student questions will be answered, and/or an oral quiz may be given.

SHOP EXERCISE NO. 4

Time Allotted: - 2 Hours

SUBJECT: Low Level Radio Modulator Identification (LLRM)

OBJECTIVE: To identify Radio Modulator MD-143/URT (LLRM), locate components and establish a basic check list of voltages and/or resistances at test points.

EQUIPMENT REQUIRED:

1. One or more LLRM(s) properly installed in AN/URT-( ) Radio Transmitting Set(s).

2. One or more test cables for use with 1, above.

3. One or more ME-25A/U VTVM(s) and/or ME-48A VOM(s), or equivalents.

PROCEDURE:

1. At the request of the instructor, students will remove LLRM from the bay and place on a suitable support.

2. Students will determine the location of all major circuits and of major components within those circuits and will sketch and label both top and bottom views of the chassis by reference to the schematic in the Instruction Book.

3. Reference should be made to the proper Lesson Sheet for an outline of the more important circuits. Should any difficulty be met in determining the location of these circuits, the instructor should be asked to point out the limits of the circuit.

4. Students will connect LLRM to bay by means of a test cable and will check voltages at various test points.

(Note:- DANGER - HIGH VOLTAGE sign must be displayed and all necessary safety precautions taken).

CONCLUSION: After all work is completed and sketches and/or lists have been checked by the instructor, students will replace and secure all drawers, panels and/or covers, turn in all tools and/or test instruments, and clear working space for the next shop exercise.

LESSON SHEET NO. 6

Time Allotted: - 1 Hour

SUBJECT: Introduction to the High Level Radio Modulator

OBJECTIVE: To introduce the basic concepts of Radio Modulator MD-149/URT.

INTRODUCTION: This is the first unit introduced so far in this course which is directly connected with 500-watt operation of the AN/URT-2, -3, and -4 Radio Transmitting Sets. It is a part of the Booster (HVPS and HLRM) and will only be required when it is desired to operate at the 500-watt level.

SUBJECT MATERIAL:

1. Refer the student to pages 2-160 through 2-171 and Figures 2-96 through 2-99.

2. The instructor will explain the circuitry in detail with particular emphasis on the 21 used sections of Switch S-1601. Switch S-1601 plays a very important part in the Transmitter Group Control circuits.

CONCLUSION: The HLRM is a standard audio amplifier operating in class AB_2 with drive supplied from the LLRM.

QUESTIONS AND/OR ORAL QUIZ: Time permitting, student questions will be allowed, and/or an oral quiz may be given.

SHOP EXERCISE NO. 5

Time Allotted: - 1 Hour

SUBJECT: High Level Radio Modulator Identification

OBJECTIVE: To identify Radio Modulator MD-149/URT (HLRM), and locate components.

EQUIPMENT REQUIRED:

1. One or more HLRM(s) properly installed in AN/URT-( ) Radio Transmitting Set.

2. One or more test cables for use with 1, above.

3. One or more ME-25A/U VTVM(s) and/or ME-48A VOM(s), or equivalents.

PROCEDURE:

1. Students will remove HLRM from transmitter bay.

2. Using Figures 2-96 and 2-99, the student will trace the following on the equipment to a plug or jack termination and label the figures in the Instruction Book:-

   (a) Audio from LLRM (both leads).
   (b) -50 Volts Bias
   (c) ≠2400 V (Phone) or ≠3000 V (CW, FSK, FAX) to K-1605(6).
   (Note:- Assume K-1603 energized and K-1605 energized, all other circuits in proper operation and S-1602 in position 1. What are the power levels and possible methods of operation for right and left transmitters in the case of the AN/URT-4?)
   (d) ≠2400 V (Phone) or ≠3000 V (CW, FSK, FAX) from HVPS.

3. Using Figure 2-97, locate E-1603 in the equipment and observe the operation of link modification for 220V to 440V operation. One student will be selected by the instructor to perform this operation.

4. Using Figure 2-98, the student will compile a list of the connections for decks A through X for position 1 of S-1601; e.g., Plug P-1601 (1) to S-1601 (A-1) to V-1601 Control Grid. Two students at a time will be selected by the instructor to check the list being prepared by ohmeter measurements.

5. Find S-1604 and S-1605 and make list similar to 4, above, for all positions of each switch. List the purpose of the two switches.

6. Study the components involved and state the purpose of C-1603, C-1604, and R-1607 through R-1610.

CONCLUSION: After all work is completed and sketches and/or lists have been checked by the instructor, students will replace and secure all drawers, panels and/or covers, turn in all tools and/or test instruments, and clear working space for the next shop exercise.

LESSON SHEET NO. 7

Time Allotted: - 2 Hours

SUBJECT: Introduction to the Radio Frequency Amplifier

OBJECTIVE: To analyze the operation and certain control features of Radio Frequency Amplifier AM-519/URT.

INTRODUCTION: The Radio Frequency Amplifier is a combination of several units which are utilized in providing 100 or 500 watts output and in supplying control signals as required for the proper operation of the AN/URT-( ) Radio Transmitting Set.

SUBJECT MATERIAL:

1. Display Figure 2-100.

2. Refer the student to pages 2-172 to the top of page 2-230 for a complete theoretical explanation. Figures 2-101 through 2-122 are used in conjunction with the written material.

3. The instructor will explain the operation of the RFA on the basis of the material covered in pages 2-172 through 2-176 with such additional material from the remaining theoretical discussion as may be required for the student to understand Figure 2-100.

4. In addition to the explanation of 3, above, the instructor will cover in detail the simplified schematics shown in Figures 2-110, 2-115, and 2-119 through 2-122. An understanding of these circuits is of considerable importance in the understanding of the Transmitter Group Control Circuits.

CONCLUSION: The RFA differs from previous equipments known to the student only in respect to the automatic tuning features.

QUESTIONS: Student questions will be permitted.

SHOP EXERCISE NO. 6

Time Allotted: - 2 Hours

SUBJECT: Radio Frequency Amplifier Identification

OBJECTIVE: To familiarize the student with the operation of Radio Frequency Amplifier AM-519/URT, the location of its five basic sections, the location of certain component parts and their function in the circuit.

EQUIPMENT REQUIRED:

1. One or more Radio Frequency Amplifier(s) AM-519/URT.
2. One or more test cables for same.

PROCEDURE:

1. Students will remove Radio Frequency Amplifier from transmitter bay.

2. Using Figure 7-144 as a guide, the instructor will point out the five major sections:

   (a) RF Amplifier Exciter Assembly
   (b) Keying Unit Assembly
   (c) Servo Amplifier Assembly (IPA and PA)
   (d) PA Sense Rectifier Unit
   (e) Primary IPA and PA circuits

3. Connect Radio Frequency Amplifier to bay by means of test cable and energize equipment. Using Figure 2-100 as a guide, students will set up the RFO for one frequency in each RFA band and observe the following during automatic and semi-automatic operation:

   (a) Operation of Bandswitch Motor (see Figure 2-109)
   (b) Buffer-IPA Tuning (see Figure 2-114).
   (c) PA Tuning (see Figure 2-118).

4. Based upon 3, above, list the relay number and function performed by relay actuated by each of S-1351, S-1353, S-1355, and S-1357. Also state dial reading for IPA and PA Dial when switches close.

5. With equipment operating as an AN/URT-2, list the following indications as observed on Test Meter M-1301:

M-1301 Position	IPA	PA
RFO Out		
E_b		

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Page 2.

M-1301 Position	IPA	PA
E_{c2}		
I_k		
I_{c2}		
I_{c1}		

6. After completion of 5, above, and all power is turned off, each student will sketch the front panel and show by arrows the schematic symbol for each meter, switch, and indicator lamp. The student will then prepare a list of the symbols and the functions of the components designated.

CONCLUSION: After all work is completed and sketches and/or lists have been checked by the instructor, students will replace and secure all drawers, panels and/or covers, turn in all tools and/or test instruments, and clear working space for the next shop exercise.

LESSON SHEET NO. 8

Time Allotted: - 1 Hour

SUBJECT: Introduction to Power Supplies and Base Mount

OBJECTIVE: To indicate the functions and basic controls in the LVPS, MVPS, HVPS, and the Base Mount.

INTRODUCTION: With the exception of the Dumping Circuit in the MVPS, all of the circuits in the four units are conventional. It is desired that the student understand the operation of the respective units as covered by the simplified schematics and that particular emphasis be given to the control circuits.

SUBJECT MATERIAL:

1. Refer the student to Figures 2-124 through 2-142 which will be used in the discussion.

2. On the basis of the material in pages 2-230 through 2-254, the instructor will give a brief description of each circuit shown.

CONCLUSION: Refer the student to pages 2-230 through 2-254 for a complete explanation of any circuit which may be new to him.

SHOP EXERCISE NO. 7

Time Allotted: - 3 Hours

SUBJECT: Control Circuits in Power Supplies and Base Mount

OBJECTIVE: To familiarize the student with the Power Supplies and Base Mount, with particular reference to control circuits.

EQUIPMENT REQUIRED:

1. One operating AN/URT-3 or AN/URT-4 Radio Transmitting Set.
2. One set of test cables.
3. One ME-48A VOM, or equivalent.

PROCEDURE: (Note:- During this exercise the student will be in close proximity to voltages dangerous to life. Extreme caution must be exercised).

1. LVPS, MVPS, and HVPS drawers will be removed from Transmitter Bay by students when directed by the instructor.
2. Terminal board will be unscrewed and raised to enable access to base mount.
3. The location of blowers, heaters, and air filters will be observed.
4. Base mount will be reassembled and MVPS and HVPS replaced in Transmitter Bay.
5. With the LVPS on a test cable, energize the transmitter and complete Table 7-34W-1.
6. Replace LVPS in Transmitter Bay, remove MVPS on test cable as in 5, above, and complete Table 7-34W-2.
7. Replace MVPS in Transmitter, remove HVPS on test cable as in 5, above, and complete Table 7-34W-3.
8. Two students will be assigned by the instructor to demonstrate link changes in the LVPS and HVPS for power sources of different voltage and/or frequency.
9. Using Figure 7-145, list the LVPS operating voltages as measured at the following points:-

Point Measured	Voltage
V-3001, Pins 2 and 8	
V-3001, Pin 4 to ground	

Point Measured	Voltage
V-3001, Pin 6 to ground	
J-3001 to ground	
V-3002, Pins 2 and 8	
V-3002, Pin 4 to ground	
V-3002, Pin 6 to ground	
High side of R-3009 to ground	
V-3003, Pins 2 and 8	
V-3003, Pin 4 to ground	
V-3003, Pin 6 to ground	
J-3002 to ground	
P-3002 (9) to ground	
P-3003 (8) to ground	

10. Using Figure 7-146, list the MVPS operating voltages as measured at the following points:-

	Point Measured	Voltage
	V-501, Cap to ground	
	V-501, Pins 1 and 4	
	V-502, Cap to ground	
	V-502, Pins 1 and 4	
100W only	(V-503, Cap to ground	
	(V-503, Pins 1 and 4	
	(V-504, Cap to ground	
	(V-504, Pins 1 and 4	
	V-505, Pins 1 and 5	
	V-505, Pin 2 to ground	

Point Measured	Voltage
V-505, Pin 3 to ground	
V-505, Pin 4 to ground	
V-505, Cap to ground	
V-506, Pins 1 and 5	
V-506, Pin 2 to ground	
V-506, Pin 3 to ground	
V-506, Pin 4 to ground	
V-506, Cap to ground	

11. List meter type and serial number with which measurements of 9 and 10, above, were made.

Meter Type____________________

Serial No.____________________

CONCLUSION: At end of shop exercise, when all work is completed, students will replace all covers, return and secure all drawers to Transmitter Bay, and turn in all tools and/or test equipment.

RESTRICTED

Table 7-34W-1:- LVPS Relay Controls

LVPS Relay	Operated By	Function
K-3001	S-3004	Power to LVPS rectifiers; blowers in base mount; RFO, RFA, LLRM and MVPS filaments; 150-volt supply in RFO; and +250 and -12 volt supply in LLRM.
K-3002	S-3004	Same as K-3001, except for 400 cps AC or 115/230 VDC operation.
K-3003		
K-3004		
K-3005		Same as K-3006, except for 400 cps AC or 115/230 VDC operation.
K-3006		
K-3007		
K-3008		

RESTRICTED

Table 7-34W-1:- LVPS Relay Controls
cont'd.

LVPS Relay	Operated By	Function
K-3009	______	
K-3010	______	

Table 7-34W-2:- MVPS Relay Controls

MVPS Relay	Operated By	Function
K-501	______	
K-502	______	
K-503	______	

RESTRICTED

RESTRICTED

Table 7-34W-3:- HVPS Relay Controls

HVPS Relay	Operated By	Function
K-1501	______	______
		______
K-1502	______	______
		______
K-1504	______	______
		______

RESTRICTED

LESSON SHEET NO. 9

Time Allotted: - 4 Hours

SUBJECT: Analysis of Transmitter Group Control Circuits

OBJECTIVE: To analyze the control circuits used in the Transmitter Group of the AN/URT-2, -3, and -4 Radio Transmitting Sets.

INTRODUCTION: It is assumed that the student is now aware of the individual drawer circuitry within the Transmitter Bay -- Transmitter Group plus Base Mount. This lesson provides the student with information for tying together the drawer controls into a system of controls.

SUBJECT MATERIAL:

1. The instructor will refer the student to Figure 2-143 and explain the sequence of operation for:

   (a) Condition 1,
   (b) Condition 2, and
   (c) Condition 3.

   (See page 2-258 to top of page 2-260).

2. Referring to Figures 2-144 and 2-145, the instructor will explain 1, above, in greater detail. (See page 2-260 through the middle of page 2-264).

3. The instructor will display "Transmitter Bay Control Circuits, Simplified Schematic," Figure 7-152, and will explain:

   (a) Power for the Control Circuits (see pages 2-264 through 2-267).
   (b) Automatic Operation (see pages 2-273 through 2-284).
   (c) Semi-Automatic Operation (see pages 2-285a through 2-288).
   (d) Manual Operation (see pages 2-289 and 2-290).
   (e) Auxiliary Control Circuits (see pages 2-291 through 2-295).

   (Note:- It may be found that, in the explanation of the power circuits within the Transmitter Bay, Figure 3-54 may be of assistance for an overall grasp of the problem, in addition to Figure 7-152, specified above).

CONCLUSION: The AN/URT-2, -3, and -4 series of transmitters is composed of units which employ mainly conventional circuitry, the operation of which is not difficult to understand. The automatic tuning feature of the IPA, PA and ATE is not normally employed in other transmitting systems. It is, therefore, recommended that the student try to visualize what happens at each step of the tuning cycle in each of these three stages.

QUESTIONS AND/OR ORAL QUIZ: Questions will be allowed if time permits, and an oral quiz may be given.

SHOP EXERCISE NO. 8

Time Allotted: - 2 Hours

SUBJECT: Transmitter Group Operation and Control Circuit Check

OBJECTIVE: To identify the major control circuits within the AN/URT-( ) Radio Transmitting Set.

EQUIPMENT REQUIRED:

1. One or more AN/URT-( ) Radio Transmitting Set(s), completely installed.

2. One copy of "Transmitter Bay Control Circuits, Simplified Schematic," Figure 7-152, for each student or group of students.

PROCEDURE:

1. Students will be assigned to transmitting set(s).

2. With controls set for automatic operation, student will list sequence of operation and front panel indications, starting from "Main Power Switch On."

3. Student will repeat 2 with controls set for semi-automatic operation.

4. Student will repeat 2 with controls set for manual operation.

NOTE: - The student may desire to do steps 2, 3, and 4 in reverse order and to remove various chassis for operation on a test cable. Such deviation from this procedure should be permitted at the discretion of the shop instructor.

INSTRUCTIONS: After completion of 4, above, student will refer to "Transmitter Bay Control Circuits, Simplified Schematic," Figure 7-152, and trace the path of electron flow for each front panel indication. Mark schematic with pencil or colored pencils, if available.

CONCLUSION: After all work is completed and sketches and lists have been checked by the instructor, students will replace and secure all drawers, panels and/or covers, turn in all tools and/or test instruments, and clear working space for the next shop exercise.

LESSON SHEET NO. 10

Time Allotted: - 2 Hours

SUBJECT: Introduction to the Antenna Tuning Equipment

OBJECTIVE: To introduce the Antenna Tuning Equipment.

INTRODUCTION: The Antenna Tuning Equipment is made up of Radio Frequency Tuner TN-197/URT, Antenna Control Group OA-297/URT, and Capacitor Assembly CB-5/URT. The Radio Frequency Tuner TN-197/URT serves as a transmission line which is automatically or manually tuned to a condition of optimum match between the AN/URT-( ) Radio Transmitter and any antenna ranging from a 35-foot whip (Navy type C-66047) to an inverted "L" 100 to 175 feet in length including a 40-foot down-lead. The tuner operates over the entire range of 0.3 to 26 mcs.

The Antenna Control Group consists of a Control Indicator C-915/URT, a Power Supply PP-708/URT, 2 Pre-amplifiers -- Electronic Control Amplifier AM-556/URT, 2 Electronic Control Amplifiers AM-555/URT, and the Cabinet CY-1047/URT. This equipment is required as a connecting link in the automatic tuning sequence for the antenna system. The Capacitor Assembly CB-5/URT provides a series or parallel capacitor for use in the antenna circuit when required.

SUBJECT MATERIAL:

1. Display "Antenna Tuning Equipment, Functional Block Diagram," Figure 2-1. Give a general description of the ATE. (See paragraph 2, pages 2-2 through 2-5 of "Section 2, Theory of Operation for Antenna Tuning Equipment.")

2. The instructor will refer the student to Figure 7-27 in Section 7, "Corrective Maintenance for Antenna Tuning Equipment," and will indicate the location and briefly describe the function of the various circuits shown during the following operations:

   (a) Normal scan
   (b) Antenna too short) Capacitor Assembly
   (c) Antenna too long) Operation
   (d) "Mismatch"
      (1) Normal operation
      (2) Emergency manual operation

   (See paragraph 6, pages 2-44 through 2-51, in "Theory of Operation for Antenna Tuning Equipment," Section 2 of the Instruction Book).

3. Referring to the same illustration, the instructor will discuss briefly the following operations, and will utilize Figure 7-14 in the Antenna Tuning Equipment section of Section 7 to illustrate the functional operation involved:

   (a) Limit switch
   (b) Drive mechanism
      (1) Gear train
      (2) Differential
      (3) Motors
      (4) "Helipot"
      (5) Chain drive
      (6) Guards
      (7) Shielding

CONCLUSION: It should be obvious by now that the Antenna Control Group and the Radio Frequency Tuner, together with the Capacitor Assembly, comprise a system for the matching of the output of the AN/URT-( ) Radio Transmitting Set to various antennas over an extremely wide range of frequencies. Since these items are parts of a system, it is of the utmost importance that the student understand both the individual units and the interrelation of these units in the performance of the overall system functions.

QUESTIONS: Student questions will be permitted provided they are directly related to the Antenna Control Group, the Radio Frequency Tuner, or the Capacitor Assembly.

LESSON SHEET NO. 11

Time Allotted: - 4 Hours

SUBJECT: Analysis of Antenna Tuning Equipment Control Circuits

OBJECTIVE: To analyze the ATE Control Circuits as an extension of Lesson Sheet No. 10.

INTRODUCTION: All of the ATE controls have been designed with a requirement for the exchange of 24 VDC On-Off signals between the Transmitter Group and the ATE so that automatic tuning may proceed in an orderly manner. It is the purpose of this lecture to acquaint the student with the operation of the ATE control circuits following or preceding each signal, and the design features of subsidiary amplifiers, power supplies, and special circuitry involved in such control operation.

SUBJECT MATERIAL: (Note:- Instruction Book explanatory material for this lesson is found on pages 2-5 through the middle of page 2-44. However, the lecture found on the pages of this notebook directly following this lesson sheet has been found to satisfy most course requirements).

1. Display Figure 7-27, "Antenna Tuning Equipment, Schematic Diagram," and explain the following:

   (a) Major Units in ATE (Appendix "A" of lecture).
   (b) ATE Relays and Switches (Appendix "B" of lecture).
   (c) 24 VDC Supply (Paragraph 4 of lecture).
   (d) "Transmitter-On" Signal (Paragraph 5 of lecture).
   (e) "Ready-to-Tune" Signal (Paragraph 6 of lecture).
   (f) "Reset Signal" (Paragraph 7 of lecture).
   (g) "Interrogate" Signal (Paragraph 8 of lecture).
   (h) Servo Amplifiers (Paragraph 9 of lecture).
   (i) Conditions for a Tuning Scan (Paragraph 10 of lecture).
   (j) Conditions for a "Tuned" Signal (Paragraph 11 of lecture).
   (k) Servo Motor and Limit Switch Circuits (Paragraph 12 of lecture).
   (l) "Tuned" Signal (Paragraph 13 of lecture).
   (m) Capacitor Assembly Operation (Paragraph 14 of lecture).
   (n) "Mismatch" Signal (Paragraph 15 of lecture).
   (o) Manual Tuning Process (Paragraph 16 of lecture).

CONCLUSION: It will be observed by the student that, although the Antenna Tuning Equipment Control Circuits appear quite complex at first glance, the individual circuits involved are basically those circuits with which the electronics technician has had considerable previous experience. One difficulty which has been met in previous courses is that more than one operation is being carried on at the same time. However, once the student understands the control operations for each of the individual circuits, the factor of multiple operation at any given instant should introduce no great difficulty in total comprehension of the Antenna Tuning Equipment and its control circuits.

QUESTIONS: Questions by the students will be permitted; however, the lecturer will reserve the right to pass over questions involving long theoretical explanations.

ANALYSIS OF ATE CONTROL CIRCUITS

Suggested Lecture
for use with
Lesson Sheet No. 11

(Note:- The material presented in this suggested lecture is a condensation of certain portions of Section 2, "Theory of Operation for Antenna Tuning Equipment," in the Instruction Book. This material supplements, but in no way is intended to replace any of, the material in the Instruction Book).

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APPENDICES

LIST OF ILLUSTRATIONS

ANTENNA TUNING EQUIPMENT CONTROL CIRCUITS

1. INTRODUCTION

It is the purpose of this paper to present the ATE (Antenna Tuning Equipment, see Appendix "A") control circuits in the simplest possible manner. It is believed that a combination of simplified schematics and explanatory appendices will accomplish this purpose.

2. FIGURE 7-152 OF THE INSTRUCTION BOOK

For the purpose of the presentation to be made, it is assumed that the reader is familiar with "Control Circuits Schematic Diagram, AN/URT-3 Transmitter Bay," Figure 7-152 of the Instruction Book. In connection with this drawing, it will be observed that certain signals -- 24 VDC On-Off -- are exchanged between the transmitter bay and the ATE. The signals exchanged are listed, and the terminal unit wiring is shown in Figure 1. Arrows are used to indicate the direction of electron flow. It will be observed that the six signals are "Transmitter-On", "Mismatch", "Interrogate", "Ready-to-Tune", "Tuned", and "Reset". In addition, the RF power is transmitted over a coaxial cable running between the transmitter bay and J-435 on the RF Tuner.

3. APPENDIX "B"

In this discussion, the primary interest will be in the operation of switches and relays in the various sections of the ATE (see Appendix "A"). For this reason, all the switches and relays located in the ATE have been listed in Appendix "B" according to their physical location and function.

4. 24 VDC SUPPLY

All of the 24 VDC signals, with the exception of the "Transmitter-On" signal, are positive and are obtained through the circuits connecting to the 24 VDC Supply in the Antenna Control Group Control-Indicator

(ACG C-I). The "Transmitter-On" signal is a negative 24 VDC obtained from the relay or control supply in the transmitter bay Low Voltage Power Supply (LVPS). The C-I 24 VDC supply is shown in simplified form in Figure 2.

The independent 110 VAC line to the ACG enters the ACG cabinet through terminals A and B of P-1902. C of P-1902 is grounded. The 110 VAC proceeds through ACG Cabinet wires 2 and 1 to terminals K and F, respectively, on J-1910/P-210. From these terminals, the 110 VAC is switched on through S-202, "Emergency" switch, passes through line fuses F-201 and F-202, and lights lamp I-201 on the front of the ACG Power Supply (ACG PS). From this point, one side of the 110 VAC line proceeds through terminal P of P-201/J-1910, ACG Cabinet wire number 46, ACG Main Terminal Board (ACG MTB) terminal 1, wire 44, terminal L of J-1905/P-302 to terminal 2 of T-301 in the ACG C-I. From the other side of the 110 VAC line, one can similarly follow the path through either the "Local" position of "Local-Remote" switch, S-201, or the contacts of K-202, "Transmitter-On" relay, when energized. From this point, the second side of the 110 VAC line proceeds to terminal J on P-201/J-1910, along wire 49 to ACG MTB terminal 3, then along wire 48 to terminal N of J-1905/P-302, and finally reaches terminal 1 of T-301 in the ACG C-I. It follows that the 24 VDC control source in the ATE is available any time the "Local-Remote" switch, S-201, is in the "Local" position or any time the "Transmitter-On" relay, K-202, is energized, assuming S-202, "Emergency", is closed.

5. "TRANSMITTER-ON" SIGNAL (1st SIGNAL)

The first signal exchanged between the transmitter bay and the ATE is the "Transmitter-On" signal (see Figure 1). This is a negative 24 VDC which enters terminal A of P-1901 on the ACG from line 133. Then, as we follow along wire 4 in the ACG Cabinet wiring, the signal enters the ACG PS through terminal N of J-1910/P-201. The negative 24 VDC goes to ground through the coil of the "Transmitter-On" relay and lamp, K-202 and I-202, respectively. K-202 being energized closes the open side of the line to the C-I 24 VDC supply (see Figure 2).

6. "READY-TO-TUNE" SIGNAL (2nd SIGNAL)

When the 24 VDC supply in the ACG C-I was energized, (see Figure 2), relay K-321, Blower relay, was energized closing contacts 3R-2R. The output of the 24-volt rectifier, CR-301, is connected to terminal 3R of K-321; therefore, the 24 VDC now may be traced through terminal V of P-303/J-1908, wire 18 in the ACG Cabinet, terminal K of J-1901/--/P-435, to one side of S-439, the thermostat in the RF Tuner. Since S-439 is normally closed, the 24 VDC returns to the ACG through terminal F of P-435/--/J-1901, then passes along wire 23 to terminal D on J-1910/P-201, where the 24 VDC goes to one side of K-201, (20-second TD), and through the field coil of K-201 to ground. After 20 seconds, K-201 is energized providing the 24 VDC "Ready-to-Tune" signal to the transmitter bay through terminal C on P-201/J-1910, ACG Cabinet wire 79, ACG MTB terminal 22, ACG Cabinet wire 8, terminal E of P-1901 on the ACG and then through wire 61 to terminal 73 on TB E-606 in the transmitter bay.

When K-201 is energized, 24 VDC is also supplied to one side of S-201, "Local-Remote" switch. In the "Local" position, S-201 supplies the 24 VDC to terminal H on P-201/J-1910, ACG Cabinet terminals 19 and 18 to ACG Cabinet wires 72, 73, and 74. the 24 VDC to terminal N on J-1909/P-151 and then to the "Hi" side o. the coil on K-151, Disable relay in the ACG "T" Servo PA. Wire 73 feeds the 24 VDC to terminal N on J-1911/P-151 and then to the "Hi" side of the coil on K-151, Disable relay in the ACG "C" Servo PA. Wire 74 feeds the 24 VDC to terminal W on J-1907/P-301 and then to the "Hi" side of the coil on K-304, Local relay in the ACG C-I. The coils of K-151 and K-304 have one side grounded and are energized under this condition.

7. <u>"RESET" SIGNAL</u> (3rd SIGNAL)

The "Reset" signal cannot be sent to the ATE until such time as the "Ready-to-Tune" signal has been received in the transmitter bay. Once the "Ready-to-Tune signal is available in the transmitter and on any occasion during which the IPA stage of the RFA is caused to retune, the "Reset" signal will be sent out to the ATE. The 24 VDC from the "Ready-to-Tune" signal is connected to terminal 72 on TB E-606 when contacts 7L-8L close and continues for such period as "Call for IPA Tune" relay K-1360 is energized. The 24 VDC leaves the transmitter bay on wire 136 and enters the ACG (see Figure 1) on terminal H of P-1901. ACG Cabinet wire 10 connects the 24 VDC to ACG MTB terminal 9 from which wires 58 and 38 transmit the signal to terminal C on J-1907/P-301 (ACG C-I) and to terminal B on J-1903 (ACG Cabinet), respectively. From terminal C on P-301, the 24 VDC signal energizes Reset relay, K-301, and is connected to terminal 3R on K-301 and to one side of S-306, the Reset momentary contact switch, in the ACG C-I. When K-301 contacts 3R-2R close, TBLR relay K-308 is energized. Plate Supply relay K-203 is also energized through K-301 contacts 2L-3L which feed a 24 VDC signal through terminal E on P-303/J-1908, ACG Cabinet wire 96, and through terminal S on J-1910/P-201 to the "Hi" side of the coil on K-203. The Reset relay, K-301, has broken all previous circuit connections for any previous status of tuning when K-308 was energized, and through K-308 acts to move "T" to the top of the main coil in the RF Tuner. When relay K-301 is energized, a phase shifted 110 VAC source is connected through contacts 1R-2R to the variable phase of the "T" Servo Motor, B-435. The "T" Servo Clutch, L-435, is now connected directly to the 24 VDC line from terminal J on P-301, TBLR relay K-308 contacts 4L-5L, and TTLR relay K-307 contacts 6L-5L (see Figure 2-10 in the Instruction Book). The 110 VAC is so connected as to drive "T" toward the top, or antenna, end of the RF Tuner main coil, and remains so connected till such time as "T" trips TTLS switch S-436. When S-436 is tripped, TTLR relay K-307 is energized, closing K-307 contacts 5L-4L, 4R-5R, and 1R-2R and TBLR relay K-308 is deenergized through opening TTLR contacts 2L-3L (see Figure 2-10 in the Instruction Book). This constitutes the end of the "Reset" operation in the RF Tuner.

The "Reset" signal also performs a function in the Capacitor Assembly. Entering the ACG Cabinet on terminal H of P-1901 from Cable R-RT5, (see Figure 1), the "Reset" signal proceeds to terminal B of J-1903, which is connected to terminal B of P-451 by Cable R-RT8 (see Figure 5). The 24 VDC signal then energizes the Reset coil of K-453 (called S-451 on some drawings), the Sequence Selector (see Figure 2-17 in the Instruction Book). This operation returns the Sequence Selector to position 1, the "Ready-to-Tune" position.

8. "INTERROGATE" SIGNAL (4th SIGNAL)

The "Interrogate" signal is sent out from the transmitter bay from terminal 74 of TB E-606 along wire 77 of Cable R-RT5 by the closing of contacts 3R-4R on K-1306, Dummy Load--Antenna Transfer Relay. The "Ready-to-Tune" signal provides the energy for operating K-1306 through contacts 9L-10L on K-1362, "Call for Antenna Tuning" relay. The receipt of the "Interrogate" signal in the ACG (see Figure 1) is recognized by the ACG as the start of its tuning cycle. RF energy has been sent to the RF Tuner by the operation of K-1306.

The "Interrogate" signal energizes K-302, Interrogate relay, and I-304, "RF On" lamp in the ACG C-I. When K-302 is energized, the following operations occur:

(a) Contacts 2R-3R close providing 24 VDC from the "Ready-to-Tune" line to terminal E of P-303/J-1908, ACG Cabinet wire 96, terminal S of J-1910/P-201, and to ground through the coil of K-203. Energizing K-203 supplies the two regulated 275 VDC outputs to terminals U and R on P-201.

(b) Contacts 2L-3L close, closing the circuit between contact 3R of K-311, "Tuned (b)" relay, and contact 2L of K-308, TBLR relay.

(c) The 25-second "Auto-Jog" relay, K-313, is energized through contacts 2R-1R of K-304, 2L-1L of K-301, 2R-3R of K-311 and 2L-3L of K-302.

9. SERVO AMPLIFIERS

Before discussing the "Tuned" Signal (5th Signal, in normal operation) it is necessary to consider the operation of the servo amplifiers. Each of the two servo amplifiers is made up of a pre-amplifier, Electronic Control Amplifier AM-556/URT, and a power amplifier, Electronic Control Amplifier AM-555/URT. Both servo amplifiers are identical and may be interchanged.

The purpose of the pre-amplifier is to receive the DC signal from the sensing circuits (see Figure 4), convert it to a 60-cycle square wave by means of K-101 (see Figure 2-12 in the Instruction Book), amplify the 60-cycle square wave and send it to the power amplifier over terminals C and D of P-101/J-1904 or P-101/J-1906. J-1904 is connected to the "T" power amplifier by the ACG Cabinet wiring; and J-1906, to the "C" power amplifier. The full schematic of this circuit is at the top of Figure 2-27 in the Instruction Book.

The power amplifier receives the output of the pre-amplifier over terminals D and F of P-151 from the ACG Cabinet wiring and J-1909 for the "T" servo and J-1911 for the "C" servo. The power amplifier amplifies the sensing signal from the pre-amplifier and delivers its power to terminals J and L of P-151, and then to the "T" or "C" servo motor through the ACG Cabinet wiring and Cable R-RT6 (see Figure 3). The power amplifiers are push-pull, two-stage, low frequency audio amplifiers with feedback provided so as to lower the source impedance of the power fed to the servo motors. The feedback effectively reduces the output impedance of the servo amplifier from 330 ohms at peak input signal to 17 ohms at zero input signal. Thus, a virtual short circuit exists across the servo motor variable phase (control winding) when no signal is supplied, and the motors are brought to a quick stop with no tendency to run single phase.

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(a) Servo Pre-Amplifier (Figure 2-12 in the Instruction Book)

The incoming signal to the pre-amplifiers is filtered by capacitors C-106 and C-107 and choke coil L-101 to remove any stray RF. The signal then passes through the derivative control network of resistor R-111 and capacitor C-105 to K-101, DC to AC Chopper, which converts the DC signal to a 60-cycle square wave. The derivative control network is provided to reduce the hunting of the servo motors during operation of the ATE. With a steady state signal from the sensing circuit, the capacitor acts as an open circuit and all the current passes through R-111, causing a large voltage drop at terminal 3 of K-101. The values of the components of the derivative control network are chosen for the particular natural frequency of hunt for the servo system, which is approximately three cycles per second. At 3 cps, the impedance of the capacitor is approximately equal to that of the resistor, and half the current passes through each branch of the network. For a high rate of change (large derivative) of the error signal from the sensing circuit, indicating that the equipment is approaching the tuned condition, the voltage at the input to the chopper is much larger than when the error is changing slowly. The network then sends a negative pulse back to the motors which acts as an electric brake preventing the motors from overrunning the tuned point they are seeking. K-101 converts the dc signal to two oppositely-phased 60-cycle square waves and feeds them separately to the grids of the first stage amplifier tube V-101 after being filtered by capacitors C-108 and C-109. Resistors R-101 and R-102 are grid bias resistors and R-103 is the cathode bias for V-101. The

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Potentiometers R-110A and R-110B are adjustable gain control potentiometers, and R-104 is the cathode bias for the second stage amplifier V-102. Resistor R-113 is an isolation resistor between the two square wave circuits. The tube filaments and the chopper are fed from the 6.3-volt line of the ACG PS, terminal M on P-201, and the plate supply from the 275-volt line.

(b) Servo Power Amplifier (Figure 2-13 in the Instruction Book)

The input signal from the pre-amplifier enters the power amplifier through relay K-151 contacts 1L and 2L, and 4L and 5L which in automatic tuning are connected to the grids of the driver amplifiers V-151 and V-152. The amplified signal is fed through coupling capacitors C-151 and C-152 to the control grids of the output tubes V-153 and V-154, where it is amplified again and sent to the output coupling transformers T-151; this provides the final phasing and shaping of the signal which originated as a square wave in the pre-amplifiers. The output of the second stage is fed back through the feedback network composed of R-157, R-158, R-159, and R-160 to the grids of the second half of the first stage amplifier tubes. Plate power to all tubes of the power amplifier is supplied from the 275-volt line, terminal C on P-151 (see Figure 3, page 2 for "T" Servo), and is reduced where necessary by means of dropping resistors. Grid bias of the first stage tubes is maintained by resistors R-154 and R-155 and on the output tubes by cathode resistor R-163. Cathode bias is provided by resistors R-168 and R-169 connected to ground from V-151 and V-152. Cathode bias for the output tubes is provided by grid return resistors R-161 and R-162 connected to ground. Resistors R-170 and R-171 are voltage dropping resistors from the 275-volt line to the screen grids of the output tubes of the amplifier.

Relay K-151 is energized during manual tuning because the operator, rather than the amplifiers, tunes the equipment through the "MANUAL TUNING" and the "MANUAL COUPLING" switches on the Control-Indicator panel, and the amplifiers are not required to run the motors. "LOCAL-REMOTE" switch, S-201, in the ACG PS energizes K-151 during manual tuning, when it is set on "LOCAL".

10. CONDITIONS FOR A TUNING SCAN

When the ATE is set to tune automatically and assuming that the "Reset" operation has been completed, TTLR relay, K-307, and Interrogate relay, K-302, are energized before the ATE tuning cycle starts. Relay K-203 is energized (see paragraph 8 (a) on page 6) in order to supply power to the servo and SWR monitor amplifiers and to the "TUNE" and "COUPLE" meter circuits (see Figure 3, page 2). The output of the SWR monitor amplifier is such that SWRC (standing wave ratio control) relay, half of the first stage amplifier tubes. Plate power to all tubes of the power amplifier is supplied from the 275-volt line, terminal C on P-151 (see Figure 3, page 2 for "T" Servo), and is reduced where necessary by means of dropping resistors. Grid bias of the first stage tubes is maintained by resistors R-154 and R-155 and on the output tubes by cathode resistor R-163. Cathode bias is provided by resistors R-168 and R-169 connected to ground from V-151 and V-152. Cathode bias for the output tubes is provided by grid return resistors R-161 and R-162 connected to ground. Resistors R-170 and R-171 are voltage dropping resistors from the 275-volt line to the screen grids of the output tubes of the amplifier.

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11. CONDITIONS FOR A "TUNED" SIGNAL

It is necessary that three conditions be met or nearly so during a tuning scan in order that a "Tuned" signal may be sent to the transmitter bay. These are as follows:

(a) The "T" sensing circuit output voltage must be zero; i.e., the antenna load reactance must be zero.

(b) The "C" sensing circuit output voltage must be zero; i.e., the antenna load impedance must be equal to 180 ohms as seen from the "C" sensing circuit, or,

(c) Since full realization of (a) and/or (b) is impractical, the output from the 2:1 tap on the SWR monitor circuit must be zero or a slightly positive DC error voltage -- 2:1 SWR or less.

12. SERVO MOTOR AND LIMIT SWITCH CIRCUITS

The tuning scan involves the simultaneous operation of both the "T" and the "C" elements in the RF Tuner by their respective servo motors. The "T" servo motor drives the shorting sleeve, "T", seeking a reactive zero, or near zero, point. Simultaneously, the "C" servo motor drives the coupling coil, "C", seeking an impedance match to the 180-ohm line, which in turn means an impedance match of 50 ohms as seen from the transmitter bay. A tuned condition means that both "T" and "C" are close enough to the perfect tune point that the combination error does not cause more than a 2:1 SWR.

(a) <u>"T" Servo Motor and Limit Switch Circuit</u> (Figure 2-10 in the Instruction Book)

At the beginning of the tuning scan, "T" is at the top of the main coil and TTLR relay, K-307, has been energized by S-436. For a very short period of time, "T" is driven down the main coil of the RF Tuner by a phase shifted 110 VAC signal to the control winding -- through contacts 1R-2R of K-307 to terminal 1 of B-435 and through contacts 4R-5R of K-307 and contacts 3R-2R of K-308 to terminal 3. When "T" has moved a sufficient distance down the main coil, S-436 opens and K-307 is deenergized. At this time two things happen, which are as follows:

(1) L-435, the "T" servo motor clutch, is now supplied a 24 VDC signal through contacts 2R-1R of K-303, contacts 3L-2L of K-316-- energized at this time --, contacts 2L-1L of K-304, contacts 6L-5L of K-308, and contacts 6L-5L of K-307.

(2) The "T" servo amplifier takes control of the "T" servo motor, B-435, by a direct connection of its output to terminals 1 and 3 -- the control winding.

Since, under this condition, the "T" sensing circuit will see a reactive antenna load in most cases, and since the "T" servo motor cannot drive upward due to the "T" top limit switch and relay, the "T" servo motor will drive "T" downward; i.e., towards the bottom of the main coil of the RF Tuner. The case could be simplified by considering that the frequency were less than 6 mcs for a 35-foot "Whip" antenna. Under this condition the "T" sensing circuit output would be a negative DC error voltage due to the capacitive reactance of the antenna load. It is obvious that under this condition the zero reactance point on the main coil of the RF Tuner is downward, and the "T" servo motor will drive "T" toward a point which gives a less negative error voltage at the output of the "T" sensing circuit. However, since K-302, the Interrogate relay, remains energized until such time as a "Tuned" or "Mismatch" signal is obtained, and since a maximum of 20 seconds is required to send "T" to the top of the main coil when driven by a phase shifted 110 VAC line to the control winding of the servo motor, "T" will be driven downward for five seconds -- about 5 inches out of the 22 inches on the RF Tuner main coil. It must be understood, of course, that at the same time K-309, CTLR, through S-440, CPTLS, is preventing more than 40 percent of the coupling coil to extend above "T" at the top of the main coil and a progressively larger amount of "C" to be extended as "T" moves downward (see Figure 2-9 in the Instruction Book). During the five-second downward scan, the "T" servo amplifier will reverse the direction of the "T" servo motor if the error voltage output of the "T" sensing circuit passes through the zero point. It will be observed that this does not introduce a large loss factor or degree of inefficiency since the 5 inches of downward travel, if carried to its culmination, would only mean that all frequencies above about 3.94 mcs were tuned to the first or greater odd multiple of a quarter wave-length with a 35-foot "Whip" antenna. However, even this loss will not be apparent since the "T" element will tune the reactive portion of the antenna load impedance to zero or nearly so, except in those cases where the effective length of the antenna plus the RF Tuner main coil is less than a quarter wave-length. Those frequencies near 300 kcs fall in this last case; and, by practical experience, any frequency below 400 kcs may fail to tune due to the fact that the quarter wave-length point falls beyond the bottom end of the main coil.

The case of a failure to tune during the downward scan of the "T" element will not be discussed here, but will be covered in paragraph 14.

(b) <u>"C" Servo Motor and Limit Switch Circuit</u> (Figure 2-9 in the Instruction Book)

When "T" moves to the top of the RF Tuner main coil and starts its downward scan, the CPTLS switch, S-440, will have controlled the position of the coupling coil, "C", through the operation of K-309, so as to prevent more than 40 percent of "C" protruding above "T" at the time "T" is at the top of the RF Tuner main coil. This is of importance in that the efficiency of the coupling coil would be reduced if it protruded to such an extent that its total length were more than a half wave-length at any frequency. It may be shown that the frequency for which the coupling coil extends to such an extent that it approaches a half wave-length in length, when 40 percent of "C" is extended above "T", is greater than 26 mcs.

When K-309 is energized, "C" is driven downward by the "C" servo motor in a manner similar to the operation of the "T" servo motor searching for a point where the "C" sensing circuit output will be zero.

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When K-309 is energized, "C" is driven downward by the "C" servo motor in a manner similar to the operation of the "T" servo motor searching for a point where the "C" sensing circuit output will be zero.

It will be observed that the output of the "C" sensing circuit is a positive DC error voltage for an antenna load impedance more than 180 ohms, and negative for an antenna load impedance less than 180 ohms. The output of the "C" sensing circuit drives "C" with respect to "T" between the limiting cases of no coupling -- "T" at the top of "C" -- and maximum coupling -- that proportion of "C" above "T" permitted by the operation of S-440, CPTLS. However, it should be pointed out here that in the case of "C", as soon as S-437, CBLS, opens due to the upward travel of "C" with respect to "T", the "C" servo amplifier assumes control of the "C" servo motor. It will be observed that "T" will be locked in by the operation of S-435 (see Figure 2-10 in the Instruction Book) until such time as S-436, TTLS, closes. This means that "T" is controlled by a phase shifted 110 VAC during the upward drive in all cases. The "C" servo motor stops operation at the same time as the "T" servo motor, which is at such time as the output of the SWR monitor amplifier is affected by a positive voltage at terminal 7 of V-302 and a greater plate current passes to terminal 8 of K-317, SWRC, through the coil to terminal 1, and back to the 275-volt DC supply through R-319. This greater current closes contacts 6 to 7 on K-317, which indicates that the SWR is equal to or less than 2:1.

13. <u>"TUNED" SIGNAL</u> (5th Signal in Normal Operation)

The closing of contacts 6 to 7 on K-317 initiates the cycle which may or may not result in a "Tuned" signal. At this time SWRL (standing wave ratio low) relay, K-315, is energized by a 24 VDC signal from terminal J on P-301 (see Figure 1) through contacts 5L-4L of Tuned (c) relay, K-305, and contacts 6-7 of K-317. The lock on K-316, SWRH, is broken when contacts 4L-5L of K-315 open, and I-303, Tuned lamp, on the front of the ACG C-I is lighted through contacts 2R-3R of K-315 and contacts 5L-4L of K-303, Mismatch relay. Breaking contacts 2L-3L of K-316, SWRH, breaks the 24 VDC lead to the "T" and "C" servo motor clutches and stops the movement of "T" and "C". K-315, SWRL, is locked in through contacts 1R-2R of K-316 and contacts 5R-6R of K-315. Closing contacts 2L-3L of K-315 starts K-322, Tuned (a) (1-second TD), through its cycle. If, at the end of one second, the tuned condition is still maintained, the Tuned (c) relay, K-305, is energized through the closing of contacts 5L-4L of Tuned (b) relay, K-311.

Relay K-322 consists of a resistor-capacitor time constant network which fires a gas tube to energize Tuned (b) relay, K-311. If the circuit to K-322 is interrupted before the gas tube fires, K-311 is not energized.

14. CAPACITOR ASSEMBLY OPERATION

If "T" and "C" have scanned all the way to the bottom of the RF Tuner main coil looking for a tuned condition and not finding it, S-435, TBLS, will close energizing K-308, TBLR. This provides a phase shifted 110 VAC signal to the control winding of B-435 (see Figure 2-10 in the Instruction Book) which acts to drive "T" to the top of the RF Tuner main coil. Contacts 2L-1L of K-308, TBLR, have closed sending a 24 VDC signal to the step coil of K-453 (see Figure 2-17 in the Instruction Book) through terminal J of P-303 (see Figure 5). When K-453 steps to position 2, a 100 $\mu\mu$d capacitor is added in series with the RF lead to the antenna. The tuning cycle then proceeds again.

In like manner, if a "Tuned" condition does not result on this downward scan of the "T" and "C" elements of the RF Tuner, a second signal will be transmitted to the Capacitor Assembly and two 100 $\mu\mu$d capacitors in parallel are shunted across the RF feed line to ground.

15. "MISMATCH" SIGNAL (5th Signal in Abnormal Operation)

In the event the third scan of "T" and "C" does not result in a "Tuned" signal, terminal A of P-451 is connected to terminal G of P-451 through positions 4 through 10 of K-453. This energizes the Mismatch relay, K-303, through terminal M of P-303 (see Figure 5). When K-303 is energized, contacts 2R-3R close, sending a 24 VDC signal out over terminal D of P-301 to the transmitter bay (see Figure 1). This 24 VDC signal proceeds over wire 79 of Cable R-RT5 to TB E-606, terminal 76, and from there it lights I-1316, "Mismatch" lamp, on the RFA front panel, and energizes K-1365, "Mismatch" relay, in the RFA. Closing contacts 5L-6L of K-1365 lights I-1317, "Alarm" lamp, on the RFA front panel and energizes I-1318, signal buzzer providing an aural alarm. Under this condition, the operator must resort to manual tuning.

16. MANUAL TUNING PROCESS

In manual operation, the operator takes over the functions of the amplifiers and the automatic relay system operation of the control indicator. Instead of sending the outputs of the sensing circuits to the amplifiers which control the servo motors in automatic operation, the operator monitors the antenna tuning equipment by observing the antenna match meter and the position indicators, and adjusts the positions of the shorting sleeve and coupling coil by means of the "MANUAL TUNING" and "MANUAL COUPLING" jog switches, S-304 and S-303, respectively, on the ACG C-I panel. For manual operation, the "LOCAL-REMOTE" switch, S-201, on the ACG PS is set on "LOCAL". This opens all circuits which energize the control relays in the antenna tuning equipment, and it energizes Local relay, K-304, connecting the manual controls, the "RE-SET" and "STEP" push buttons, S-306 and S-305, respectively, and the jog switches, S-304 and S-303, on the ACG C-I panel. The jog switches are momentary single-pole, double-throw, center-off switches that operate the tune and couple limit relays controlling the drive of the servo motors. The antenna match meter indicates the direction in which the movable tuning elements must be driven in order to establish a match of 2:1 or better. The "TUNE" and "COUPLE POSITION" meters also enable the operator to determine the tuned point by indicating the relative positions of "T" and "C" on the main coil. The position meters read zero when the elements are at the bottom of the main coil and read full scale for "T" when "T" is at the top of the main coil and for "C" when "C" is completely extended above "T". If the operator knows the proper positions for the shorting sleeve and the coupling coil for tuning at a particular frequency, he may by means of the jog switches and the information on the position meters quickly arrive at a balanced condition. The magnitude of the error shown on the antenna match meter is dependent on the power level, and actually increases as the tuned point is approached; therefore, it is not an indication of proximity to a balanced condition.

At higher frequencies, the region where the standing wave ratio is less than 2:1 is very small; and the equipment may miss the first point of possible balance and tune at the second or even the third point. The first point has the highest efficiency, but lower points may be required for stable tuning. The reason for this is that at high frequencies, the wave length is relatively short and the Q of the balance points is high. This means that the tuning is critical because the Q curve is very narrow. At low frequencies fewer points of balance exist, and the region is wider so that tuning at the optimum efficiency is not difficult.

As in automatic tuning, it may be necessary to add capacitance in series or parallel with the antenna. This is accomplished manually by pressing the "STEP" switch, S-305, on the control indicator panel. Each time it is pressed, the stepping switch K-453 switches to its next position.

Manual tuning allows the operator under emergency conditions to tune the antenna to a match that is not as efficient as the nominal value reached in automatic tuning. At such a value, only the 100-watt transmitter level may be employed. Manual tuning also provides a means of tuning in case of faulty operation of the automatic process.

APPENDIX "A"

LIST of MAJOR UNITS in ATE

I Antenna Control Group OA-297/URT, comprising:

	Component	AN Type No.	Ref. Symbol
(a)	Electronic Control Amplifier (Electronic Control Pre-Amplifier)	AM-556/URT	101-150
(b)	Electronic Control Amplifier	AM-555/URT	151-199
(c)	Power Supply	PP-708/URT	201-299
(d)	Control Indicator	C-915/URT	301-399
(e)	Cabinet	CY-1047/URT	1901-1999
II	Radio Frequency Tuner	TN-197/URT	401-450
III	Capacitor Assembly	CB-5/URT	451-499

APPENDIX "B"

LIST of ATE RELAYS and SWITCHES

I Antenna Control Group OA-297/URT

(a) Cabinet CY-1047/URT

No relays or switches are contained within this unit.

(b) Electronic Control Amplifier AM-556/URT (Pre-Amplifier)

1. K-101: DC to AC Chopper (Non-Synchro vibrator)

(c) Electronic Control Amplifier AM-555/URT (Power Amplifier)

1. K-151: Disable Relay

(d) Power Supply PP-708/URT

1. K-201: Plate Supply Relay (20 sec. TD)
2. K-202: "Transmitter ON"
3. K-203: Plate Supply Relay
4. S-201: "Local-Remote" Switch
5. S-202: "Emergency" Switch

(e) Control Indicator C-915/URT

1. K-301: Reset Relay
2. K-302: Interrogate Relay
3. K-303: "MISM" (Mismatch) Relay
4. K-304: Local Relay
5. K-305: Tuned (c) Relay
6. K-306: No Relay exists for this number
7. K-307: TTLR Relay
8. K-308: TBLR Relay
9. K-309: CTLR Relay
10. K-310: CBLR Relay
11. K-311: Tuned (b) Relay
12. K-312: No Relay exists for this number
13. K-313: Mismatch Relay (25 sec. TD)
14. K-314: No Relay exists for this number
15. K-315: SWRL Relay
16. K-316: SWRH Relay
17. K-317: SWR Relay (Polar Sensitive Null Type)
18. K-318: DC to AC Chopper (Non-Synchro vibrator)
19. K-319: Synchronous Rectifier (Non-Synchro vibrator)
20. K-320: No relay exists for this number
21. K-321: Protective Relay (Protects B-437 motor)
22. K-322: Time Delay Relay (1.0 Sec.)
23. S-301: No switch exists for this number

APPENDIX "B"

Page 2.

24. S-302: No switch exists for this number
25. S-303: Tune Motor Jog Switch (PP - "MANUAL TUNING")
26. S-304: Couple Motor Jog Switch (RR - "MANUAL COUPLING")
27. S-305: Reset Switch (MM - "RESET")
28. S-306: Step Switch (NN - "LOADING UNIT STEP")
29. S-307: Switching (Used only in preventive-corrective maint.)

II RF Tuner TN-197/URT

1. No relays are contained within this unit.
2. S-401 through S-434: No switches exist for these numbers.
3. S-435: TBLS Switch
4. S-436: TTLS Switch
5. S-437: CBLS Switch
6. S-438: CTLS Switch
7. S-439: Overheat Switch (Thermostat)
8. S-440: CPTLS Switch

III Capacitor Assembly CB-5/URT

1. K-451: Switching Relay (Series Capacitor Relay)
2. K-452: Switching Relay (Shunt Capacitor Relay)
3. K-453 or S-451: Sequence Selector (T_p Stepping Relay)

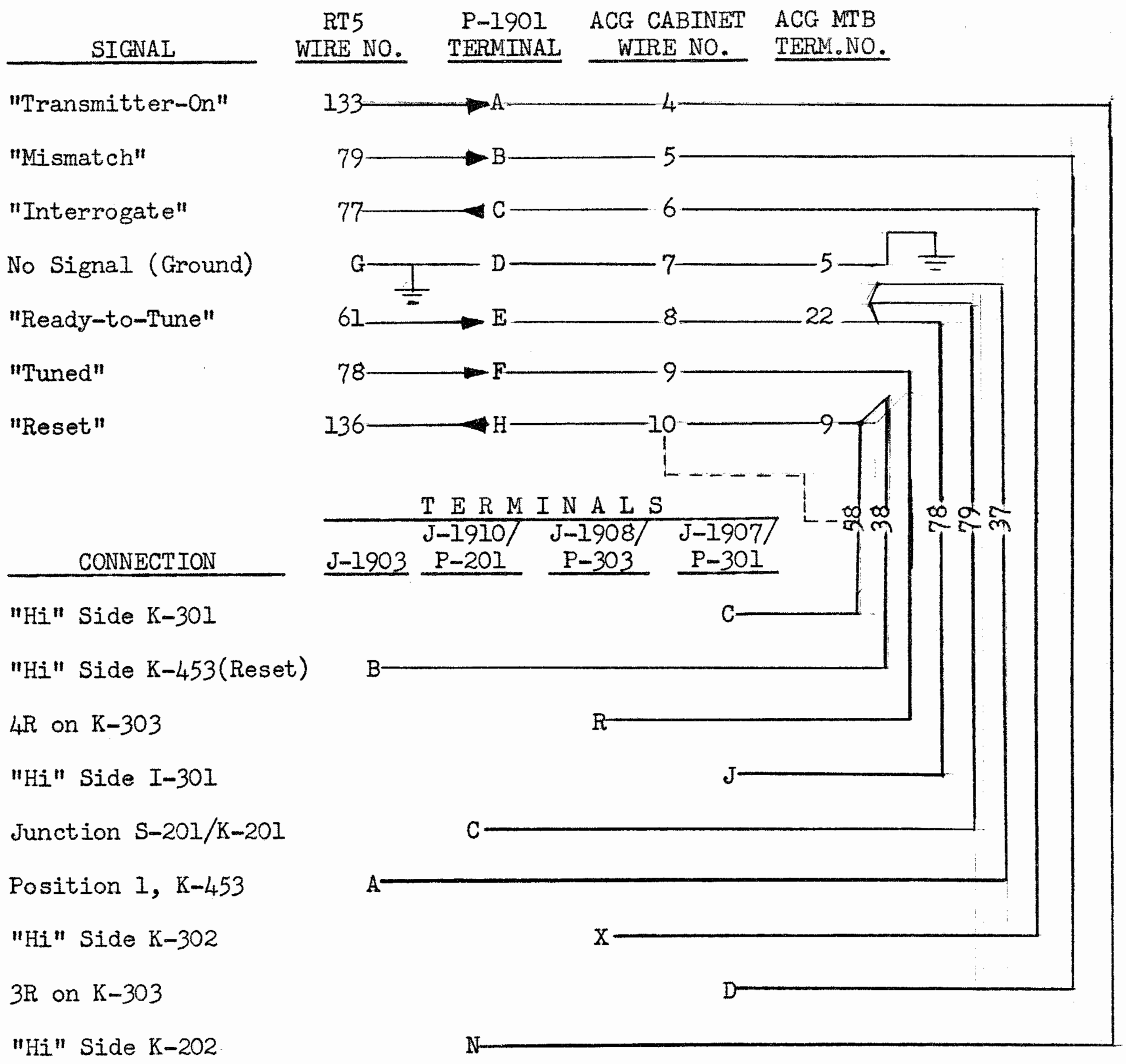

Figure 1:- Terminal Connections for Cable R-RT5.

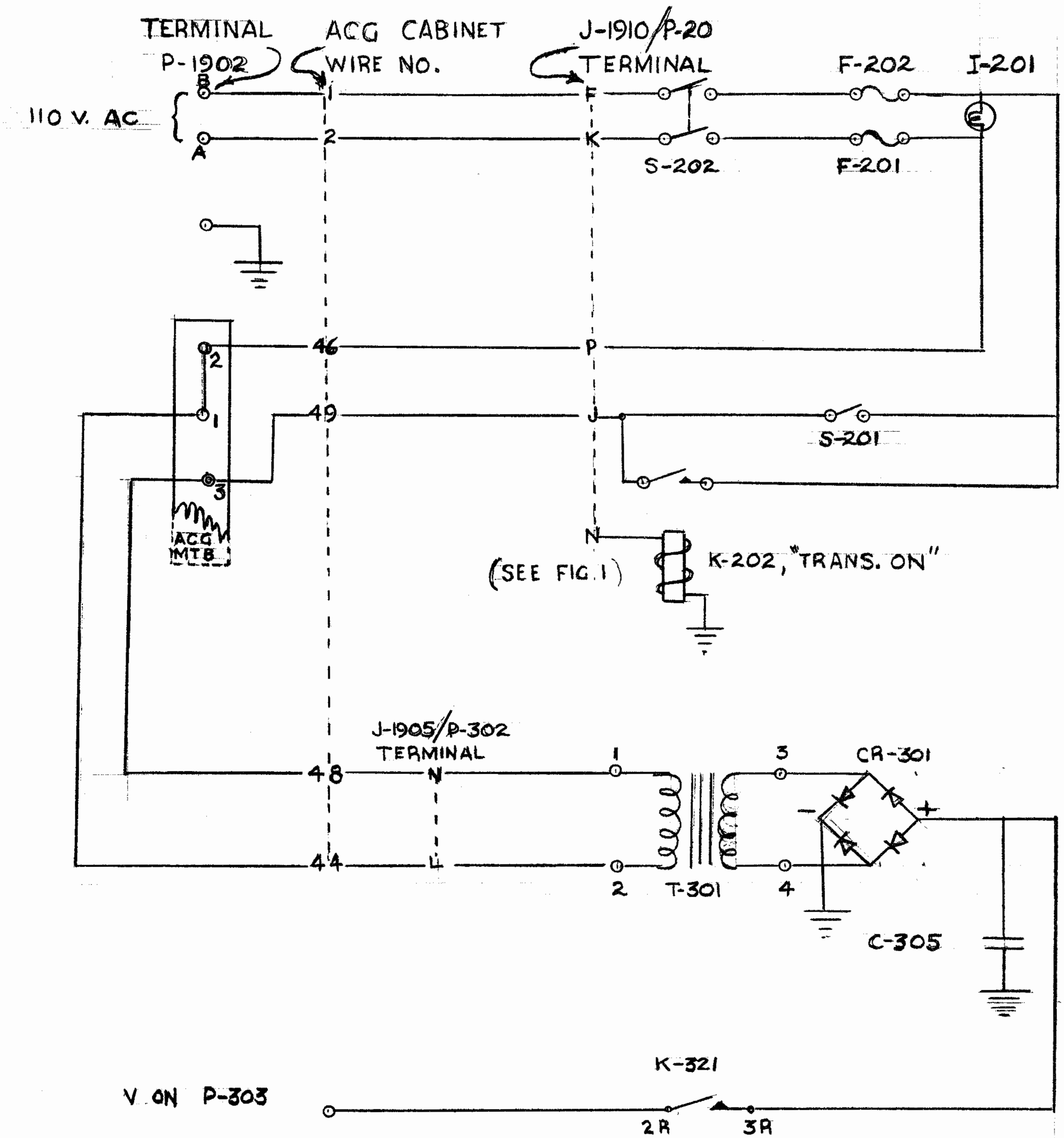

Figure 2:- 24 VDC Supply in ATE

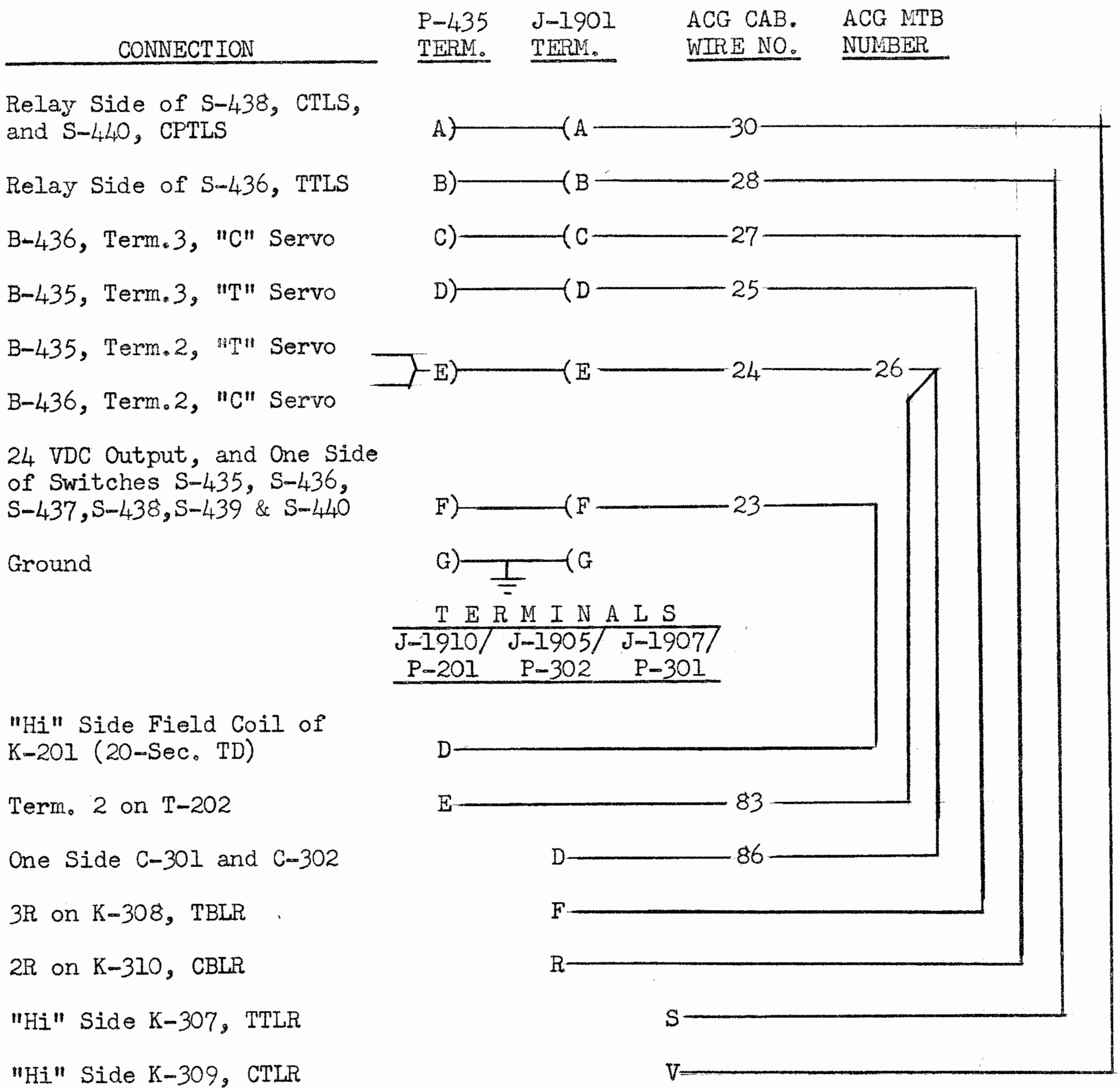

Figure 3 (Page 1 of 3):- Terminal Connections for Cable R-RT6

CONNECTION	P-435 TERM.	J-1901 TERM.	
Reg. 25 VDC Input and "Hi" sides of R-435 and R-436	H)	(H	21 — 23 — R-1901 56 K
B-437, Term's. 2 & 4	J)	(J	20
24 VDC Input	K)	(K	18
B-436, Term.1, "C" Servo	L)	(L	16
B-435, Term.1, "T" Servo	M)	(M	15
R-436, "T" Pot. Output	N)	(N	13
L-437, "T" Clutch	P)	(P	12
Relay Side of S-435, TBLS	R)	(R	11

	TERMINALS J-1907/ P-301	TERMINALS J-1905/ P-302	TERMINALS J-1908/ P-303	
"Hi" side of K-308, TBLR	F			
5L on K-307, TTLR	H			
One side R-307	R			
2R on K-307, TTLR		E		
2R on K-309, CTLR		H		
2R on K-321, Blower			V	
T-301, Term. 1		N		48 — 3

	TERMINALS J-1904/ P-101	TERMINALS J-1909/ P-151	TERMINALS J-1910/ P-201	
T-201, Term. 2			J	49 — 3
275 VDC Input	P			80 — 24
275 VDC from V-204			R	81 — 25
T-151, Term. 2		C		82

Legend: —12— ACG Cabinet Wire No. 12
—3— ACG Main Terminal Board Term. No. 3

Figure 3 (Page 2 of 3):- Terminal Connections for Cable R-RT6

CONNECTION	P-435 TERM.	J-1901 TERM.	ACG CAB. WIRE NO.
L-436, "C" Clutch	S)	(S	31
Relay side S-437, CBLS	T)	(T	29
B-436, Term. 4, "C" Servo	U)	(U	
B-435, Term. 4, "T" Servo	V)	(V	26
No Connection	W)	(W	
B-437, Term. 1, Blower	X)	(X	19
B-437, Term. 3, Blower	Y)	(Y	17
R-435, "C" Pot. Output	Z)	(Z	14

	TERMINALS J-1907/ P-301	TERMINALS J-1905/ P-302
One side R-308	U	
One side C-306		M
One side F-301		J
T-301, Term. 2		P
"Hi" side K-310, CBLR	T	
2L on K-309, CTLR	E	

Figure 3 (Page 3 of 3):- Terminal Connections for Cable R-RT6

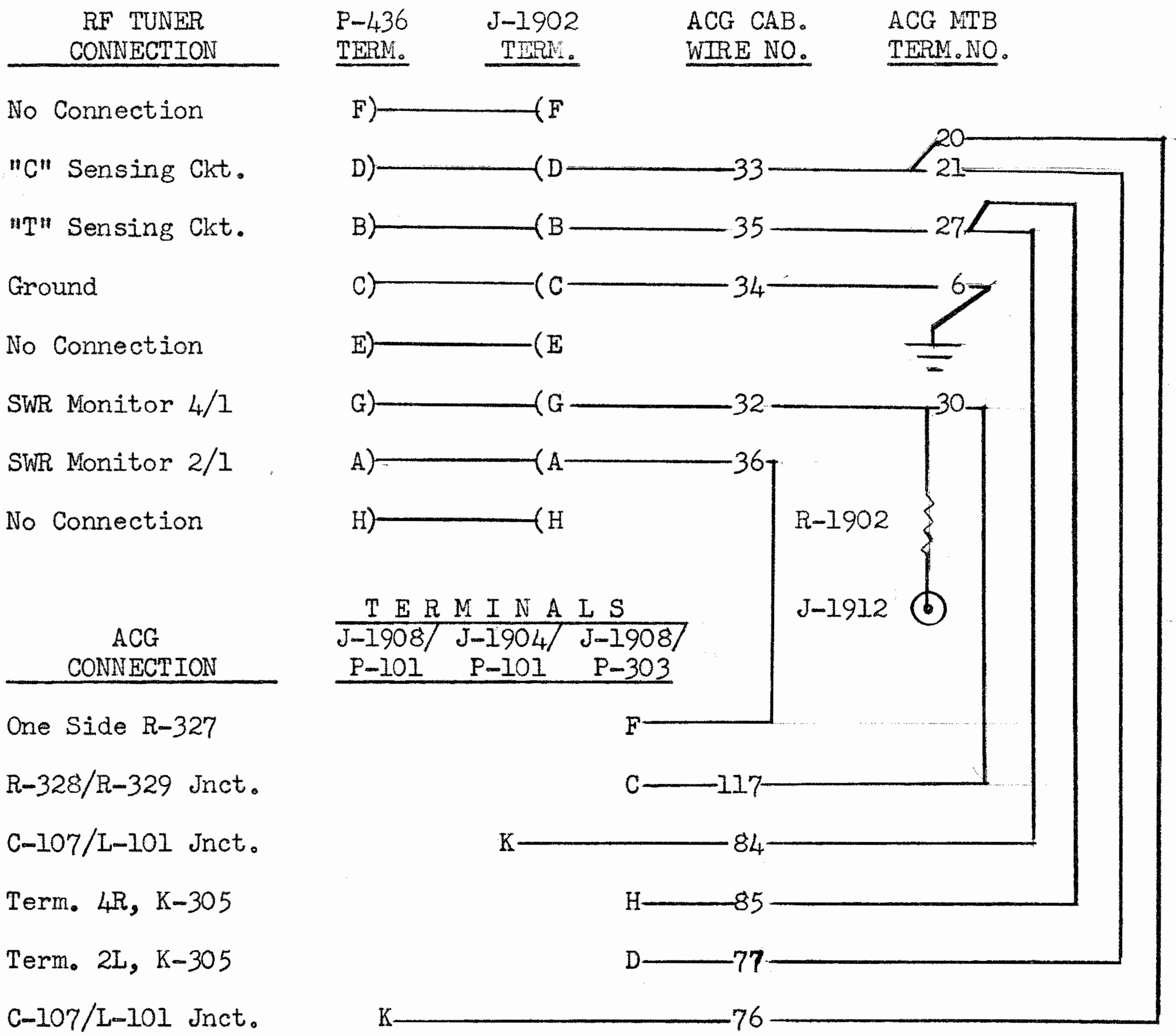

Figure 4:- Terminal Connections for Cable R-RT7.

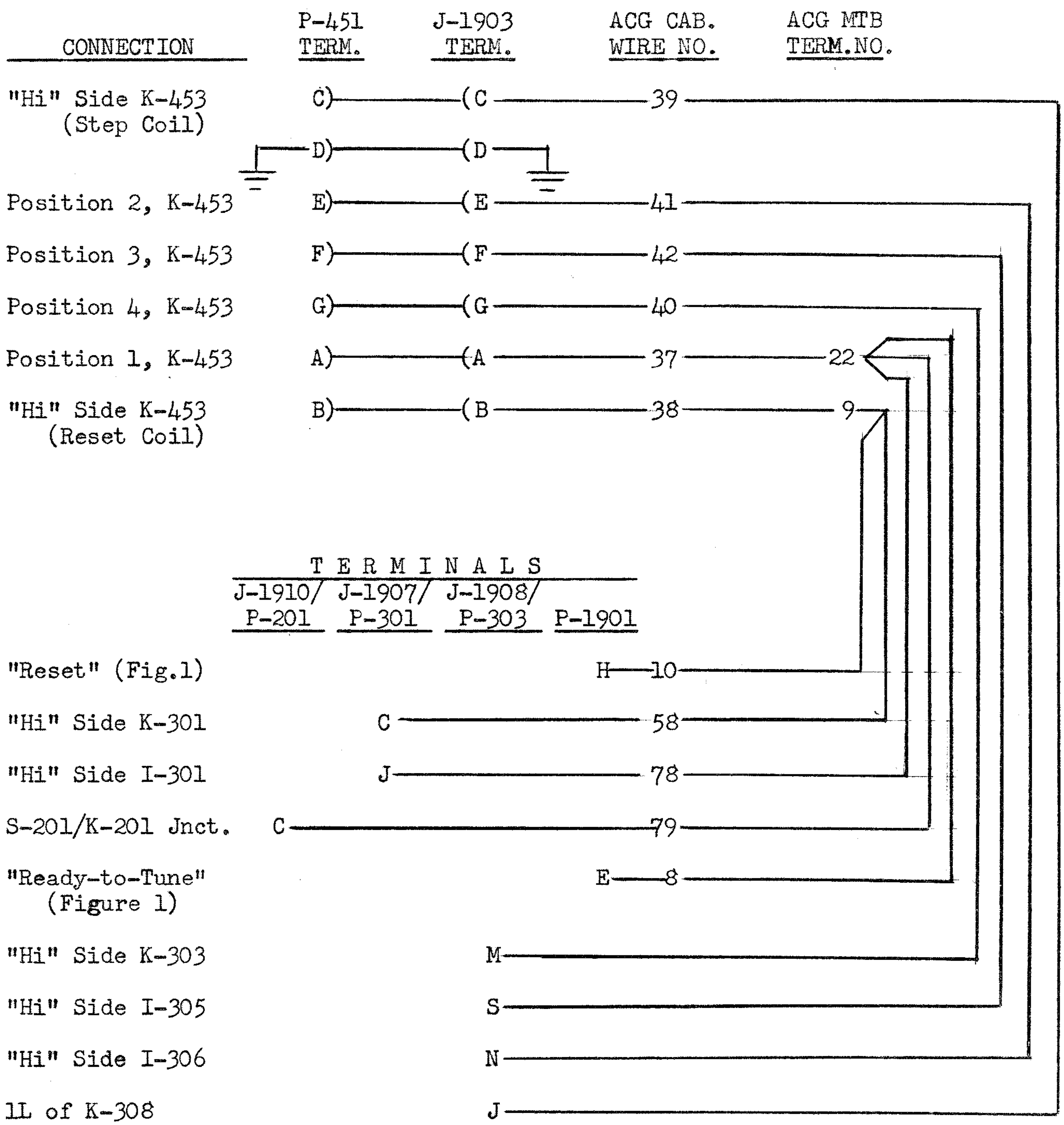

Figure 5:- Terminal Connections for Cable R-RT8.

SHOP EXERCISE NO. 9

Time Allotted: - 4 Hours

SUBJECT: Antenna Tuning Equipment and Control Circuits

OBJECTIVE: To familiarize the student with the Antenna Tuning Equipment and the control circuits in the ATE.

EQUIPMENT REQUIRED:

1. One or more AN/URT-( ) Radio Transmitting Set(s), completely installed.

PROCEDURE:

1. The instructor will:

   (a) Display Antenna Control Group, Radio Frequency Tuner, and Capacitor Assembly with power available to the Antenna Control Group.
   (b) Dismount the various component units of the Antenna Control Group and point out the various external features of the component units.
   (c) Point out on the face of the Control Indicator the various meters, switches, lamps, and calibrating adjustments, and explain circuit functions.
   (d) Demonstrate interchangeability of pre-amplifiers and of amplifiers.
   (e) Demonstrate by manual operation of the Control Indicator the meter indications to be expected during actual operation of the Antenna Control Group.
   (f) Operate the RF Tuner from the Antenna Control Group panel and demonstrate the following:

      (1) Scan operation
      (2) Limit switch operation
      (3) Capacitor assembly operation
      (4) "Mismatch" conditions

2. The student will be permitted to operate the ATE and observe the interrelation of switch and relay operation between the RF Tuner, the ACG and the Capacitor Assembly.

3. The student will be directed to open the Radio Frequency Tuner and the instructor will point out and explain component assemblies and circuits.

4. The student will be directed to open the Capacitor Assembly and the instructor will point out and explain the component assemblies and circuits.

CONCLUSION: Students will return shop to proper status for next class.

LESSON SHEET NO. 12

Time Allotted: - 2 Hours

SUBJECT: Installation and Checkout

OBJECTIVE: To provide general information concerning the installation and checkout of the AN/URT-2, -3, and -4 Radio Transmitting Sets. Emphasis will be placed on those items of major importance to maintenance personnel.

SUBJECT MATERIAL:

1. Refer the student to Section 3 of the Instruction Book.

2. The instructor will cover the material given in pages 3-9 to para. 4 at the top of page 3-15, stressing those points which may lead to maintenance difficulties.

3. The high points of Assembly and Wiring will be discussed by the instructor from the material found on pages 3-15 through 3-64. (Note:- The student should be aware of assembly and wiring methods as they apply to battle and/or storm damage control).

4. The instructor will point out the information on Initial Adjustments (see pages 3-65 through 3-83). (Note:- The instructions on pages 3-68 and beyond will be followed in performing Shop Exercise No. 10. The student will be asked to read this material during the time remaining for this lesson and request clarification from the instructor where necessary).

CONCLUSION: It has been found that numerous difficulties in maintenance may be traced to the manner of installation. A good electronics technician will double check any new installation in order that corrective measures may be taken while still in the yard.

LESSON SHEET NO. 13

Time Allotted: - 2 Hours

SUBJECT: Preventive Maintenance -- Procedures

OBJECTIVE: To provide the student with adequate information concerning the procedures used in preventive maintenance of the AN/URT-2, -3, and -4 Radio Transmitting Sets. The instructor will stress that corrective maintenance will be inversely proportional to the amount of preventive maintenance and the quality of the preventive maintenance.

SUBJECT MATERIAL:

1. Refer the student to Section 6, Text and Illustrations, in the Instruction Book.

2. Introduction and explanation of weekly records (See pages 6-1, 6-2, and Sample Weekly Record Chart 6-3).

3. Proper use of Routine Maintenance Check Chart (See pages 6-7 and Table 6-2 on pages 6-8 through 6-28).

4. Lubrication Procedures.

   (a) General Procedure (see page 6-31).
   (b) RF Tuner Procedure (see pages 6-32 through 6-34).
   (c) Lubricants (see Table 6-3, pages 6-35 through 6-38).

5. Stress all safety precautions to be observed.

CONCLUSION: A step-by-step Routine Maintenance Check Chart is provided and no difficulty should be encountered by the student.

QUESTIONS AND/OR ORAL QUIZ: Time should be allowed for the students to ask questions.

SHOP EXERCISE NO. 10

Time Allotted: - 4 Hours

SUBJECT: Equipment Checkout

OBJECTIVE: To run through a complete checkout of the AN/URT-( ) Radio Transmitting Set. The instructor will stress the importance of an orderly approach to equipment checkout.

EQUIPMENT REQUIRED:

1. One (1) or more completely installed AN/URT-2, -3 and/or -4 Radio Transmitting Set(s).
2. One (1) or more ME-25A/U VTVM(s).
3. One (1) or more ME-48A VOM(s).
4. One (1) or more AN/USM-3 Test Tool Set(s).
5. One (1) or more Adapter Plug(s).
6. One (1) or more 500-watt Dummy Load(s).

PROCEDURE: The student(s) will follow the step-by-step procedure listed in paragraph 6, Section 3, of the Instruction Book.

CONCLUSION: Students will return the shop to the proper status for the next class.

SHOP EXERCISE NO. 11

Time Allotted: - 4 Hours

SUBJECT: Preventive Maintenance -- Practice

OBJECTIVE: To provide practice in performing the periodic checks designed to keep outage time of equipment at a minimum.

EQUIPMENT REQUIRED:

1. One AN/URT-( ) Radio Transmitting Set in proper operating order.
2. One ME-25A/U VTVM, or equivalent.
3. One ME-48A, or equivalent.
4. One AN/USM-3 Test Tool Set, or equivalent.
5. One RF Tuner Test Set.
6. One 50-ohm, 500-watt Dummy Load.
7. One shorting plug.
8. One ACG Test Set.
9. One receiver capable of receiving 10 mcs signals.
10. Dry cloths, oils, greases, brushes, etc., as determined by the instructor.

PROCEDURE:

1. Each student will perform all measurements and record readings in one column of Table 6-1 for standard conditions specified by the instructor.
2. The students will be separated into groups as necessary and will perform the Routine Maintenance Checks as specified in Table 6-2, for Daily, Weekly, and Monthly checks. The measurements of Table 6-1 should not be recorded a second time; however, where readings vary with frequency, the variation should be noted.
3. The instructor will direct the students in the performance of quarterly checks as specified in Table 6-2.
4. Semi-Annual and Annual checks will be performed during Shop Exercises 15, 16, and 17 at the discretion of the instructor.

CONCLUSION: After all work has been checked by the instructor, students will return the shop to proper order for the next class.

LESSON SHEET NO. 14

Time Allotted: - 4 Hours

SUBJECT: Corrective Maintenance — Procedures

OBJECTIVE: To familiarize the student with the methods used in localizing trouble in the AN/URT-2, -3, and -4 Radio Transmitting Sets.

SUBJECT MATERIAL:

1. Part I - Transmitter Bay (2½ Hours):-

   (a) Refer the student to the Transmitter Bay portion of Section 7 of the Instruction Book.
   (b) Stress will be given to finding the source of the trouble causing equipment failure, as well as the repair of a trouble (see page 7-1).
   (c) Localizing trouble to a drawer is simplified by numerous signal lamps and certain aural alarms, together with the step-by-step charts. The students' attention will be drawn to Table 7-1, System Trouble Shooting Chart, and this chart will be explained in detail. The work experience of Shop Exercises 12, 15, 16, and 17 will be augmented in accordance with the students comprehension of Table 7-1 and other tables which follow.
   (d) The instructor will point out the major unit corrective maintenance procedures:-

      (1) RFO (see pages 7-4 through 7-17 and Table 7-2).
      (2) LLRM (see pages 7-18 through top of page 7-26 and Table 7-5).
      (3) HLRM (see pages 7-26 through 7-28).
      (4) RFA (see pages 7-29 through 7-30 and Tables 7-7 through 7-14).
      (5) LVPS (see page 7-31 and Table 7-15).
      (6) MVPS (see page 7-33 and Table 7-16).
      (7) HVPS (see page 7-34 and Table 7-17).
      (8) Other Units (see pages 7-35 through 7-37).

   (e) In some cases it may be necessary to refer to Servicing Block Diagrams in addition to the material of 1.(d), above. The instructor will point out the usefulness of Figures 7-101 through 7-121 in servicing a major unit or units and will indicate the availability of comprehensive schematics and wiring diagrams in Figures 7-122 through 7-199.

(f) The instructor will list the requirements for standard and special test equipment on the blackboard and discuss usage. (See Section 1, pages 1-31 through 1-38).

2. Part II - ATE ($1\frac{1}{2}$ Hours):-

(a) Refer the student to the ATE portion of Section 7 of the Instruction Book.
(b) The instructor will stress the necessity for a clear analysis of the trouble in order that troubles occurring in one unit with indications in a second unit will not lead to loss of time in maintenance.
(c) System Trouble Shooting. At first, the student should be required to start with the procedure of Table 7-1 and follow step-by-step until the trouble is localized. The instructor will explain the reasons for this (see pages 1 through 5).
(d) The instructor will explain trouble shooting with and without RF in localizing a fault (see Table 7-1).
(e) The instructor will point out the major unit corrective maintenance procedures:-

(1) ACG (see pages 6 and 7 and Tables 7-2 and 7-3).

a. PP-708/URT (see pages 9 through 11).
b. AM-556/URT (see pages 12 through top of 14).
c. AM-555/URT (see pages 14 through 16).
d. C-915/URT (see pages 17 through 20 and Table 7-5).
e. CY-1047/URT (see page 25).

(2) RF Tuner (see pages 26 through 64, Tables 7-6 and 7-7).
(Note:- Disassembly, assembly, test and alignment of this unit are tedious operations and the instructor will stress again the use of Tables 7-1 and 7-2 in addition to Table 7-6, in order to avoid haphazard and indiscriminate disassembly).

(3) Capacitor Assembly (see pages 65 through 68).

(f) The instructor will ascertain that all students are familiar with the Failure Reports covered in Figure 7-1. A supply of these forms will be kept on hand and students will be required to fill out these forms for faults found during shop exercises. The instructor will stress the importance of reporting primary cause of failure and of filing Failure Reports for every failure no matter how small.

CONCLUSION: When the above tests, charts, equipment, and procedures have been mastered, locating trouble during shop exercises will not be difficult.

SHOP EXERCISE NO. 12

Time Allotted: - 12 Hours

SUBJECT: Corrective Maintenance -- Practice

OBJECTIVE: To provide the student with practice in the correction of faults in the AN/URT-2, -3, or -4 Radio Transmitting Set.

MATERIAL REQUIRED:

1. One completely installed AN/URT-2, -3, or -4 Radio Transmitting Set.

2. One set of test cables for same.

3. All standard and special test equipment.

4. All standard and special tools.

PROCEDURE:

1. Transmitter Bay Corrective Maintenance (4 Hours). The student will establish the location of the fault using only Table 7-1, "Corrective Maintenance for Transmitter Bay," and Figure 7-152. Faults will be simulated by the instructor. The student will not repair the faulty part or unit until such time as he has called the instructor and explained how the fault was found.

2. ATE Corrective Maintenance (4 Hours). The student will establish the location of the fault using only Table 7-1, "Corrective Maintenance for Antenna Tuning Equipment," and Figure 7-27. Faults will be simulated by the instructor. The student will not repair the faulty part or unit until such time as he has called the instructor and explained how the fault was found.

3. AN/URT-( ) Corrective Maintenance (4 Hours). The student will establish faults to an actual component in any unit of the AN/URT-( ) Radio Transmitting Set using any Table or Figure within the entire Instruction Book. Faults will be simulated by the instructor. The student will not repair the faulty part or unit until such time as he has called the instructor and explained how the fault was found.

CONCLUSION: At the end of the exercise, and after all work has been checked by the instructor, the students will return the shop to proper order for the next class.

LESSON SHEET NO. 15

Time Allotted: - 4 Hours

SUBJECT: Special Circuits

OBJECTIVE: To clarify any circuits which may be causing the student difficulty.

SUBJECT MATERIAL: (Note:- The subject material presented here can only be suggested since different classes will experience difficulty with different circuits. The instructor may change this lesson sheet in whole or in part, as determined by local circumstances).

1. Reactance Control Tube (see Note No. 15-1 on the following pages of this notebook).

2. 10 kc Blocking Oscillator V-2202A (see Note No. 15-2 on the following pages of this notebook).

3. Thyratrons in the RFA and LLRM (see Note No. 15-3 on the following pages of this notebook).

4. The instructor will add such additional circuits as are required using explanations from the Instruction Book with such general theory from "Radar Electronic Fundamentals", NAVSHIPS 900,016, as may be necessary.

CONCLUSION: The major difficulties met by students are usually traceable to a theoretical explanation of a circuit which was designed by "cut-and-try" methods. In some cases, these circuits do not lend themselves to easy theoretical explanation. In other cases the explanation is easy, but the concept being mathematical will be beyond the scope of this course.

QUESTIONS: The student will be permitted to ask questions throughout this lecture; but the instructor may suggest further study in an available text unless the explanation is brief and of general interest to the class.

Note No. 15-1

REACTANCE CONTROL TUBE

GENERAL THEORY

In any conventional oscillator circuit, such as shown in Figure 1, the frequency of oscillation is inversely proportional to the LC product of the tuned circuit; i.e., $F = \frac{1}{2\pi\sqrt{LC}}$. If either L or C is increased in value, the frequency will obviously decrease.

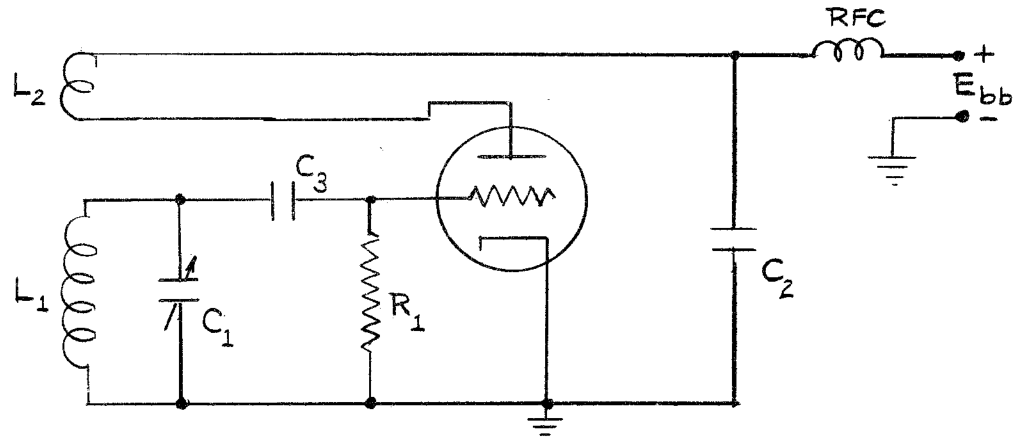

Figure 1.

It is possible to vary the frequency of the above oscillator by mechanically varying the values of either L_1 or C_1. A motor-driven variable capacitor could be used in place of capacitor C_1 as a means of varying the frequency at a rate governed by the shaft speed of the directly coupled motor. Similarly, a variometer type of inductor consisting of a rotatable form carrying one winding and a fixed form carrying the other winding could be substituted for L_1 in the above circuit. The rotatable coil could be driven by a motor and here again the frequency of the oscillator would vary at a rate governed by the speed of the motor shaft. In the above manner, we have accomplished frequency modulation of the oscillator by mechanically varying either the inductance L_1 or capacitance C_1 in the circuit.

Frequency modulation of such an oscillator can also be produced by electronic means by the use of a vacuum tube reactance modulator circuit. Strange as it may seem, it is quite possible to make a vacuum tube behave as an inductance or a capacitance. For the purposes of this explanation we will first explain how a vacuum tube can be made to behave like an apparent inductance. If we can make the plate-cathode circuit of a vacuum tube look like an inductance, such a tube connected across an oscillating tank circuit will affect the frequency of the oscillations due to the fact that connecting two inductances in parallel results in a final value of inductance which is less than the smaller of the two values; hence, the frequency of the oscillator is increased.

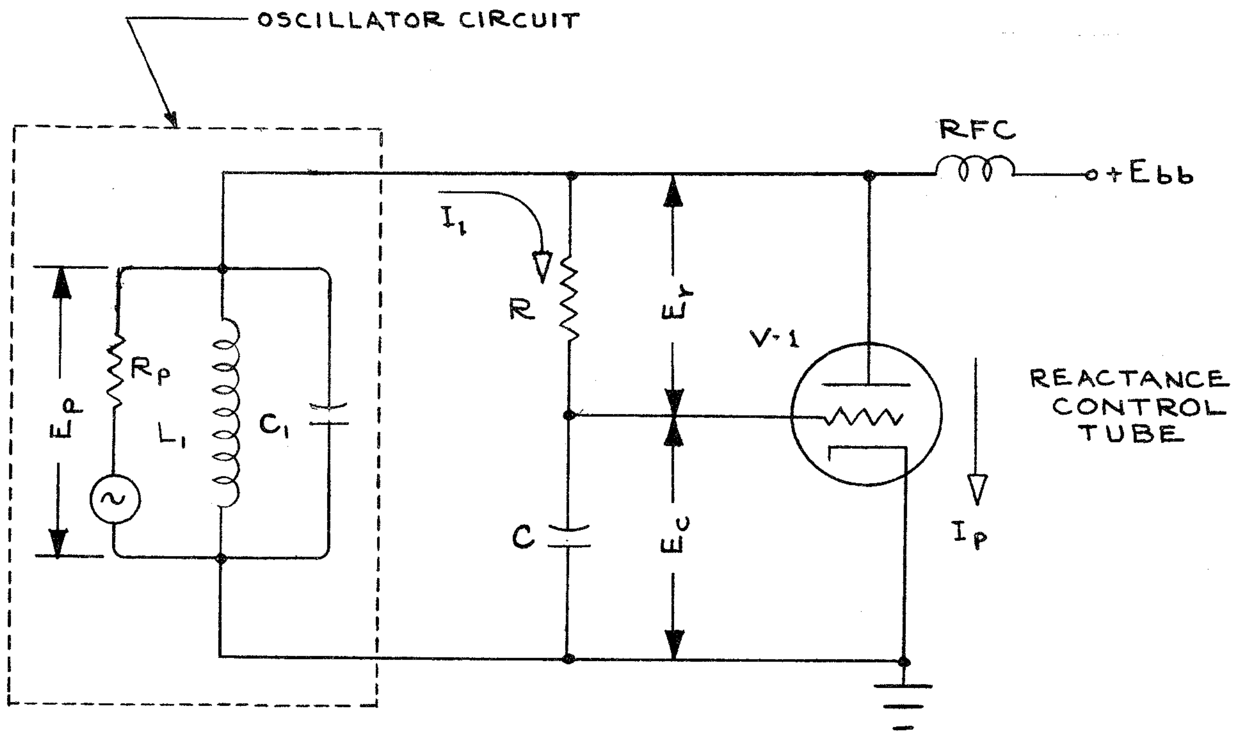

Figure 2a. - Simplified Circuit of Reactance Control Tube
(Inductive Case).

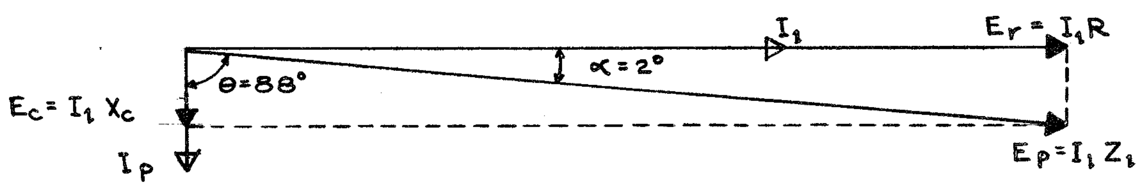

Figure 2b. - Vector Diagram of Figure 2a.

I_1 = RF line current thru RC branch
E_p = $I_1 Z_1$ = RF applied plate voltage applied to RC branch
Z_1 = $R - jX_c$ = RF impedance of RC branch
E_r = $I_1 R$ = RF voltage drop across R
E_c = $I_1 X_c$ = RF reactive voltage drop across C
I_p = RF plate current drawn by V1
R $\geq$ $5X_c$, R is equal to or greater than $5\left(\frac{1}{2\pi f C}\right)$
I_p lags E_p by 90° (Inductive Case)
L_a = $\frac{RC}{G_m}$ Henries = Apparent inductance developed by V1

By means of a simple circuit arrangement as shown in Figure 2a, the plate to cathode impedance of an ordinary pentode can be made to appear as an apparent or virtual inductive reactance. The tube used is one of the extended cut-off or variable mu type so that its transconductance, G_m, can be made to vary as a linear function of grid voltage. The reactance tube, V-1, has its plate and cathode connected across the tuned circuit of the oscillator and is thus excited by the RF output voltage, E_p. An RC phase-splitter network is also connected across the oscillator's tuned tank circuit. The value of R has been purposely selected so that it is at least equal to 5 times the reactance of C. This makes the effects of C negligible in comparison to the effects of R, as far as tank circuit loading is concerned. The impedance of the RC network is thus made to appear as an essentially pure resistive load to the tuned circuit. The vector diagram for this circuit is shown in Figure 2b. The vectors are not drawn to scale. Since the line current, I_1, is the same throughout the series RC circuit, the vector I_1 has been chosen as a common base or reference for the diagram. Due to the fact that the network appears as an almost pure resistive load to E_p, the series current I_1 is almost in phase with the impressed voltage, E_p, and will be displaced by some very slight angle, $\measuredangle$, which has been arbitrarily chosen as being equal to only 2° for this particular case. If it were not for the minor effects of C, the voltage, E_p, would be exactly in phase with the current, I_1, and the small phase angle $\measuredangle$ would be reduced to zero. As can be later seen, however, the minor effects of C are of no consequence and can be considered as being negligible. It is a fundamental characteristic of any reactive element that the current flowing through the reactance will always be 90° out of phase with the voltage across it. In the case of a capacitive reactance, the voltage E_c across the capacitor will always lag the current I_1 through the capacitor by an angle of 90°.

The RF tank circuit voltage E_p, as well as $+B$ voltage, is fed to the plate of the reactance tube V-1; however, the tube will be relatively insensitive to the RF plate voltage E_p and little or no RF plate current will flow as a result. The reactive RF voltage drop across the capacitor, E_c, is applied to the control grid of V-1 and due to the fact that it lags E_p by nearly 90°, the resultant RF plate current, I_p, also lags its applied RF plate voltage by 90°; thus, tube V-1 is made to appear as a virtual or an apparent inductive reactance, $L_a = \frac{RC}{G_m}$ Henries, in parallel with the oscillator tank circuit.

The magnitude of the 90° lagging RF plate current flowing through V-1 depends on the mutual conductance, G_m, of the tube. Reducing the negative control grid bias increases the tube G_m and allows the tube to draw a larger 90° lagging RF plate current, I_p, reducing the inductive reactive effect of V-1; hence, the apparent inductive reactance of the control tube varies inversely with the tube's plate current, I_p. If an audio voltage was impressed on the control grid of V-1 through a suitable RF choke, to prevent losing the RF grid excitation voltage, E_c, the reactance of V-1 could be made to vary at an audio rate producing frequency modulation of the oscillator's output.

By interchanging R and C in the RC phase-splitter network and making the resistance of R small compared with the reactance of C ($R \leqq \frac{X_c}{5}$) at the operating frequency, the reactance tube V-1 can be made to look like an apparent capacity (I_p leads E_p by 90° and $C_a = G_m RC$ Farads).

It is generally preferable that the RF plate current I_p lead or lag the impressed RF plate voltage E_p by an angle of as nearly 90° as possible. If I_p and E_p are displaced by some angle appreciably less than 90°, a resistive component of impedance "R" will result ($Z = "R" \neq jX$) which will appear in shunt with the tuned circuit. The effect of the resistive term "R" across the tuned circuit will be such that it will produce amplitude modulation as well as frequency modulation of the oscillator output.

The residual amount of reactance provided by the tube to the oscillator tuned circuit, in the absence of modulation, is governed by the operating grid bias, which allows the zero center or resting frequency of the oscillator to be adjusted by varying the grid bias on the reactance tube. The reactance tube is usually biased so that its operating point will appear at the center of the tube's transconductance characteristic, so that symmetrical oscillator frequency deviation will be effected for equal positive and negative excursions of the control tube's modulating grid bias voltage.

Note No. 15-2

ISOLATING AMPLIFIER V-2201, SHAPER V-2202B AND
10 KC BLOCKING OSCILLATOR V-2202A

SIMPLIFIED SCHEMATIC AND DETAILED FUNCTIONING OF CIRCUIT

1. ISOLATING AMPLIFIER V-2201, 5654 (6AK5). -- This stage is essentially a Class A RF Buffer Amplifier whose main function is to amplify and isolate the 100 kc sync signal applied to the Blocking Oscillator V-2202A. This stage has a voltage gain of approximately 15X developing 100 rms volts across plate load resistor R-2203. The cathode resistor R-2206 (270 ohms) is left un-bypassed to provide a slight amount of degeneration, limiting the gain, and improving the stability of the amplifier. Test Point TP-2201 is provided for testing input lc (approx. 7.4 rms volts). The 100 kc synchronizing signal is fed to the Blocking Oscillator thru dc blocking capacitor C-2203 and resistor R-2205. Disregarding the negligible reactance afforded by capacitor C-2204, resistor R-2205 in conjunction with resistor R-2207 forms a voltage divider of 10:1 ratio, which compensates for the undesired voltage gain of the buffer and permits a 10 rms volt sync signal to be injected on the control grid of Blocking Oscillator V-2202A. Resistor R-2205 also provides the necessary degree of desired isolation between the two stages.

2. BLOCKING OSCILLATOR V-2202A, 1/2 5814 (12AU7). -- This stage is a synchronized blocking oscillator, which functions as a frequency division (scale of 10) circuit. A sinusoidal RF 100 kc synchronizing carrier of approximately 10 rms volts is injected into the grid circuit of the blocking oscillator at terminal 1 of transformer T-2201. The blocking oscillator circuit is a conventional free running relaxation oscillator whose output consists of RF pulses occurring at a repetition rate of 10 kc per second.

   2.1 Following is a detailed explanation of the single swing type of blocking oscillator V-2202A. This circuit can be likened to a conventional grid-plate tickler feedback type of oscillator of the self-squeging type. Assuming plate voltage is applied to V-2202A, the tube starts to conduct, drawing plate current thru transformer T-2201, inducing a positive going grid voltage across winding 1-2 of T-2201, which causes the plate current to further increase to the point of saturation. At this point the varying plate current suddenly becomes a steady value and no longer induces a positive voltage across 1-2 of T-2201; thus decreasing the plate current thru the primary winding of this transformer and inducing a negative going voltage at the grid of V-2202A. This condition occurs very rapidly, driving the grid far below the cut-off value and completely cutting off the plate current of this tube. The grid voltage wave form is shown in Figure 2b. During the above cycle, it will be noted that the grid of V-2202A is driven positive with respect to the cathode producing grid current thru grid resistor R-2207. The self-rectified grid voltage produced as the result of the IR drop across this resistor charges capacitor C-2204 in the direction shown on Figure 1. As a result of the combined charging effects of the negative going induced voltage across winding 1-2 of T-2201 and the self-rectified negative grid voltage, capacitor C-2204 will hold its charge long after the point where plate current cut-off occurs. The charge on C-2204 will leak off or discharge in the direction shown on Figure 1 thru grid resistor R-2207. This discharge period will be governed by the approximate RC recovery time of R-2207 and C-2204. Tube V-2202A will remain in a plate current cut-off condition until such time as the negative grid voltage decays to the critical value which will again allow the tube to conduct and generate another plate voltage pulse. The blocking oscillator will thus pulsate at a rate (10 kc per second) essentially determined by the LCR recovery time of R-2207, C-2204, the inductance of winding 1-2 of T-2201 and the cut-off point of the tube's plate characteristic determined by cathode bias resistor R-2210. Variable cathode resistor R-2210 (1500 ohms) is of relatively low value and varying this resistor will produce a fine or vernier control of the output pulse rate of V-2202A. This resistor is purposely left un-bypassed to provide a slight amount of current degeneration to improve the stability of the oscillator and also to render the stage impervious to minor circuit changes such as tube aging, variation, etc. To further improve the stability of the amplifier, the tube's plate supply is derived from a voltage regulated source. It should be noted that a blocking oscillator is inherently an unstable oscillator and as such it is quite responsive to external influences such as a trigger or synchronizing voltage.

2.2 Referring to Figures 2a and 2b it can be readily seen that the grid recovery time and the cut-off point are so chosen that only every 10th cycle from the isolating buffer amplifier V-2201 will arrive at the proper instant to trigger the grid of the blocking oscillator. As a result the pulse output of the blocking oscillator occurs at a rate of exactly 1/10th that of the master crystal oscillator frequency of 100 kc. In other words, the output of the blocking oscillator is locked to the master frequency source in order to critically control its output pulse rate. In order to provide good lock-in or synchronization, the free-running output of the blocking oscillator should occur at a frequency slightly lower than 10 kc.

If it is adjusted to a frequency higher than 10 kc (grid recovery time is too short), the individual cycles of the free-running blocking oscillator will occur too close together. Considering one individual cycle of sync voltage with respect to one cycle of the free-running pulse oscillator, it can be seen that the free-running pulse (pulse repetition rate too high; above 10 kc) will precede or occur ahead of the sync cycle; thus, in effect, getting in the way of the sync voltage. This would prevent the sync voltage from accomplishing its intended function.

3. PULSE SHAPER & LIMITER V-2202B, 1/2 5814 (12AU7). — This stage which receives the 10 kc **ac** pulse output of V-2202A serves to clip and shape the pulse wave form into a positive going dc pulse, 4.5V peak voltage approximately 1 microsecond wide.

3.1 The alternating pulse output (100V rms) of V-2202A (Figure 1) is applied to the grid of V-2202B, pulse limiter and shaper. It will be noticed that resistor R-2211 (270 megohms) appears in series with the grid of this tube. The value of this resistor is large compared to the conducting grid-cathode resistance of the tube, thus eliminating the positive half pulses to approximately ground or zero potential. Grid current is drawn throughout the entire positive half cycle thru R-2211 and the conducting grid-cathode resistance R_{gk} of the tube is small compared to the resistance of R-2211. Since the full input voltage must appear as the sum of the drops across R-2211 and R_{gk}, the larger the R is with respect to R_{gk}, the nearer the voltage on the grid is limited to that of the cathode, or ground in this particular case.

3.2 The grid of V-2202B is driven very rapidly to plate current cut-off, producing a sharp negative pulse in the plate circuit, across winding 2-3 of T-2202. Due to the action of transformer T-2202, this pulse appears as an ac wave form pulse across the secondary winding 1-4. Capacitor C-2206-c (.25 mf) provides a low reactance path for the pulse return circuit. A de-coupling network consisting of R-2213 and C-2202B provides a simple de-coupling filter to prevent this pulse from appearing on the +B power supply bus. The ac wave form across the secondary of transformer T-2202 is applied to shunt diode CR-2201 (1N38 crystal diode). This diode having extremely low distributed capacity imposes very low shunt capacitive loading on the output pulse. This diode will conduct on the negative excursions of the ac pulse wave form, thus shorting out the negative half of the wave form. The resultant output at this point is a 1 microsecond positive going pulse, approximately 4.5V rms in amplitude, which occurs at a rate equal to 1/10th the frequency of the 100 kc crystal oscillator or at an accurately controlled rate of 10,000.000 or exactly 10 kc pulses per second.

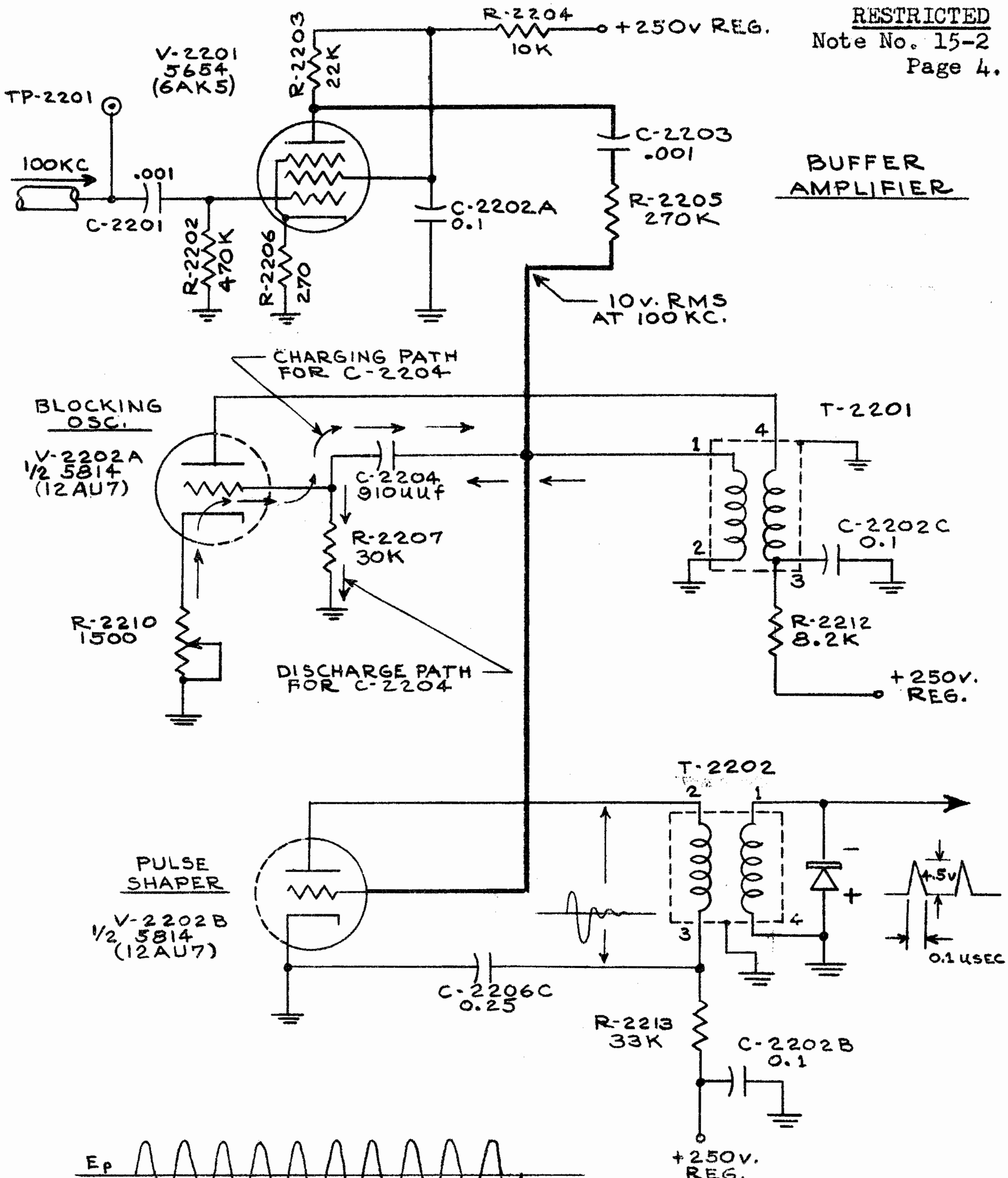

Figure 1
10 Kc Step Generator

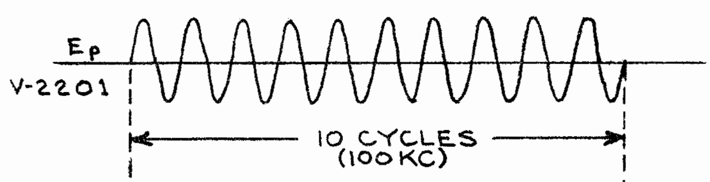

Figure 2a.

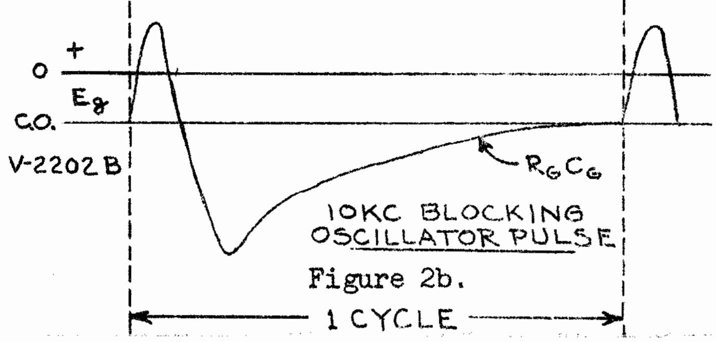

Figure 2b.

THYRATRONS -- GENERAL THEORY

Thyratrons are hot cathode gas discharge tubes containing a grid. If the tube is non-conducting, and the grid sufficiently negative, it will remain non-conducting. As the grid becomes less negative with respect to the cathode, a point is reached at which the tube "fires" and begins to conduct. When the tube is conducting, it will carry a heavy current between plate and cathode with a small voltage between them. While the tube is conducting, the grid has no control. Making the grid negative will not cut off the current. However, if for any reason the voltage between cathode and plate drops below a critical value, the tube becomes non-conducting, and the grid takes control again.

Characteristics of 2D21
(Commercial equivalent of 5727)

Shield Grid 0 Volts Anode Volts	$E_f = 6.3$ Volts Grid voltage at which conduction starts
200	-2.5
400	-3.2
600	-3.7

When the anode voltage is less than 25 volts, a grid voltage of -2 volts will cut off the anode current.

In practical equipments the two common methods of reducing the voltage across the tube are to use an R-C combination in the plate -- or externally disconnect the voltage as by a switch. There are examples of both in the URT.

The saw tooth horizontal sweep circuit in the oscilloscope is an R-C oscillator of the relaxation type. There is a good description of it on pages 2-154 and 2-155 of Section 2, Theory of Operation. The circuit diagram is Figure 2-112 in the Section 2 Illustrations.

In the Intermediate Power Amplifier and the Power Amplifier, there are practically identical Thyratron circuits. The description is to be found in Theory Page 2-175 (6) and (8). The circuit diagrams are to be found in Section 2, Illustrations, Figures 2-112 and 2-117. It should be noted that the 300V plate supply is through the contacts of a relay. Further cathode bias is provided by the drop of the screen bias divider current through the cathode resistor. Thus, while the tube is non-conducting, the cathode is about 10V positive. As the grid return is to ground, this means about a 10-volt negative bias.

A positive pulse from the multivibrator triggers the thyratron which operates the tuning motor control relay. One pair of contacts on this relay opens the thyratron plate supply relay. This, of course, removes plate voltage from the thyratron.

SHOP EXERCISE NO. 13

Time Allotted: - 4 Hours

SUBJECT: Special Circuit Operation

OBJECTIVE: To provide work experience with the circuits covered during the lecture of Lesson Sheet No. 15.

EQUIPMENT REQUIRED: To be determined by the instructor based on material covered in Lesson Sheet No. 15.

PROCEDURE: To be determined by the instructor based on material covered in Lesson Sheet No. 15.

CONCLUSION: At end of shop exercise, students will return shop to proper status for the next class.

SHOP EXERCISE NO. 14

Time Allotted: - 8 Hours

SUBJECT: System Control Circuits

OBJECTIVE: To provide the student with additional work experience in the manipulation of controls and in the recognition and correction of faults in the AN/URT-2, -3, and/or -4 Radio Transmitting Set control circuits.

EQUIPMENT REQUIRED:

1. One completely installed AN/URT-2, -3, or -4 Radio Transmitting Set.

2. One set of test cables for same.

3. All standard and special test equipment.

4. All standard and special tools.

PROCEDURE:

1. The students will be divided into groups by the instructor.

2. One group will be assigned to place faults in the CONTROL CIRCUITS of the transmitter.

3. After 2, above, is completed, the second group of students will be assigned to locate the faults. No corrective maintenance will be performed until such time as the instructor has been satisfied that the fault was located by use of proper methods as stated in the Instruction Book. If only two groups are formed, the faults will be corrected by the second group. If three groups are formed, the third group will correct the faults found by group number 2 and will insert additional faults to be found by group number 1.

4. In 3, above, if only two groups have been formed, the second group will correct the faults inserted by the first group and will insert faults to be found by the first group.

5. The variations of the procedure indicated above will be continued throughout the time allotted with the exception that the instructor may insert faults at any time and assign a student or group of students to find and correct such faults.

CONCLUSION: At the end of the exercise, the students will turn in all tools and test equipment and clear the shop for the next class.

SHOP EXERCISE NO. 15

Time Allotted: - 8 Hours

SUBJECT: RFO and RFA Preventive Maintenance, Corrective Maintenance, and Checkout

OBJECTIVE: To provide work experience in the RF portion of the Transmitter Group, and in the associated power and control circuits.

EQUIPMENT REQUIRED:

1. One operating AN/URT-2, -3, or -4 Radio Transmitting Set.
2. One set of test cables for same.
3. All standard and special test equipment.
4. All standard and special tools.

PROCEDURE:

1. The students will be divided into groups by the instructor should this seem necessary.
2. The class or a group of students will be assigned to perform the following:

   (a) Preventive Maintenance
   (b) Insertion of faults
   (c) Corrective Maintenance
   (d) Preparation of Failure Reports
   (e) Checkout of the equipment

CONCLUSION: At the end of the exercise, the students will turn in all tools and test equipment and clear the shop for the next class.

SHOP EXERCISE NO. 16

Time Allotted: - 8 Hours

SUBJECT: LLRM and HLRM Preventive Maintenance, Corrective Maintenance and Checkout

OBJECTIVE: To provide work experience in the modulator portions of the Transmitter Group, and in the associated power and control circuits.

EQUIPMENT REQUIRED:

1. One operating AN/URT-2, -3, or -4 Radio Transmitting Set.
2. One set of test cables for same.
3. All standard and special test equipment.
4. All standard and special tools.

PROCEDURE:

1. The students will be divided into groups by the instructor should this seem necessary.
2. The class or a group of students will be assigned to perform the following:

   (a) Preventive Maintenance
   (b) Insertion of faults
   (c) Corrective Maintenance
   (d) Preparation of Failure Reports
   (e) Checkout of the equipment

CONCLUSION: At the end of the exercise, the students will turn in all tools and test equipment and clear the shop for the next class.

SHOP EXERCISE NO. 17

Time Allotted: - 8 Hours

SUBJECT: ATE Preventive Maintenance, Corrective Maintenance, and Checkout

OBJECTIVE: To provide work experience in the ATE with and without RF.

EQUIPMENT REQUIRED:

1. One operating AN/URT-2, -3, or -4 Radio Transmitting Set.
2. One set of test cables for same.
3. All standard and special test equipment.
4. All standard and special tools.

PROCEDURE:

1. The students will be divided into groups by the instructor should this seem necessary.
2. The class or a group of students will be assigned to perform the following:

   (a) Preventive Maintenance
   (b) Insertion of faults
   (c) Corrective Maintenance
   (d) Preparation of Failure Reports
   (e) Checkout of the equipment

CONCLUSION: At the end of the exercise, the students will turn in all tools and test equipment and clear the shop for the next class.

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ANALYSIS OF POWER AND CONTROL CIRCUITS

AN/[illegible] RADIO TRANSMITTING SETS

Suggested Lecture
[illegible] with
Lesson Sheet No. 9

POWER CONTROLS

(Ref: Drawing ML-81367-25)

1.

(a) Primary power 110 volts, 60 cps on 115 or 230 volts DC is fed to the transmitting set through leads 17 and 18 of E-602.

(b) Leads 17 and 18 connect to contacts 7, 8, and 5, 6 of plug P-3001 (Input plug of low voltage power supply).

(c) Leads from 7, 8 and 5, 6 of P-3001 connect to emergency switch DD S-3001 in LVPS which must be closed to extend the electrical path.

(d) Switch S-3002 connects cabinet space heaters HR-701, 702, 703 and 704 to power lines through fuses F-3001 and F-3002. Indicator lamp I-3003 lights when switch S-3002 is closed.

(e) Shunt heater elements HR-701, 702 and shunt elements HR-703, and 704 may be connected either in parallel for 110 volt operation or in series for 230 volt operation by links 1,2 and 3,4. (Fig. 2-141).

(f) For 60 cps operation, the line is extended through fuses F-3005 and F-3006 by links 23,24 and 7,6, also links 20,21 and 10,9. For 400 cps operation the line is extended by links 23,22 and links 20,19, and the rectified DC through selenium rectifier CR-3002 is extended by links 5,6 and links 8,9.

(g) Power is extended from link contact 9 through the interlock circuits of all the chassis in series to voltage dropping resistor R-3003. For 230 volt operation, power is extended through link 14,12 or for 110 volt operation through link 13,12 which shorts voltage dropping resistor R-3003.

(h) Power is extended from link contact 12 to current limiting resistor R-3004 and closed contacts L3,T3 of Master Control relay K-3001 to relay coil of K-3001.

(i) Power is extended from coil of K-3001 to main power switch S-3004. The other side of S-3004 connects to other power line extended from contact 6 of links 5,6 or 7,6. Closing main power switch EE S-3004 completes the circuit, and closes master control relay K-3001, lighting Master Control lamp I-3001. Relay K-3001 remains energized through its own contacts L2,T2 which shunt switch S-3004. Resistor R-3005 is in series with I-3001 lamp through link 16 and 18 for 230 volt operation and is shorted by link 16,17 for 110 volt operation.

(j) Failure of any section of the interlock circuit to make properly will prevent the equipment from being energized.

(k) Power is turned off by stop switch EE S-3004, which shorts coil of Master Control relay K-3001, causing relay to open.

(l) When Local-Remote switch S-1109 in LIRM is placed in remote position, power is extended through pin 3 of plug P-3004, line 36, pin 4 of P-1108, across contacts C of S-1109, pin 5 of P-1108, line 1, terminal 1 of E-601, to a remote start switch in remote control box. The other side of remote start switch extends power to terminal 2 of E-601, across contacts B of S-1109, pin 3 of P-1108, line 35 of pin 4 of P-3004 and leads to one side of Master Control relay K-3001. This remote start switch is therefore in parallel with start switch EE S-3004 and either may be used to start transmitter. Conected to terminal 2 of E-601 is also one side of Remote Stop switch, the other side of which connects to terminal 3 of E-601, line 3, pin 1 of P-3003 and leads to other side of Master Control relay K-3001. is remote switch is therefore in parallel with Stop switch EE S-3004 and either may be used to stop transmitter.

(m) When 115 or 230 volts DC is used as a primary source of power, pressing start button energizes relay K-3001 extending power from one side of line through contacts L2,T2 of relay K-3001 to terminal 4 of P-3004 through line 35 to terminal 19 of E-602. An auxiliary converter motor controller is connected between terminals 19 and 20 of E-602. From terminal 20 of E-602 the power is extended through line 4 and contacts T4,L4 of relay K-3001 to the other power line.

(n) The 110 volts AC from Auxiliary Converter is connected to terminal 22 and 21 of E-602, and is extended through contacts 1,2 and 3,4 of plug P-3001 to links 27,26 and links 30,29.

(o) When the primary source of power is 110 AC the power is extended by turning links mentioned in (n) to positions 25,26, and 28,29.

(p) When Master Control relay K-3001 is energized, power is extended through fuses F-3007 and F-3008 contacts L1,T1, and L5,T5 of relay K-3001, through fuse F-3009 to the primary of the Low Voltage Power Supply transformer T-3001.

NOTE:- In the AN/URT-2, a jumper connects terminals 44 and 45 of E-604 since the High Voltage Power Supply and High Level Radio Modulator are not in the rack.

2.

(a) 110 volt AC power supplied to Low Voltage Power Supply energizes:

(1) Two -24 volt supplies (Fig. 2-126)

(2) -220 volts (Fig. 2-129)

(3) /250 volts (Fig. 2-128)

(4) /300 volts (Fig. 2-127)

(b) The -220, /250, and /300 volts are not available until relay K-3010 operates.

(c) Time Delay relay K-3003 starts as soon as -24 volts is available, and after a time delay of 30 seconds closes contacts 1C,1A of K-3003, lighting Time Delay lamp I-3002, which indicates that power from Low Voltage Power Supply is available.

(d) When relay K-3003 operates, closing contacts 2C-2A, 24 volts is extended to coil of relay K-3010 energizing same. Relay K-3010 contacts 2R-3R close, grounding the center tap of the 300 and 250 volts winding on power transformer T-3001, extending /300 and /250 volts to various stages using same, and lighting neon lamps I-3005 and I-3004. Contacts 2L-3L also close, grounding the center tap of -220 volt winding of power transformer T-3001, extending -220 volts to stages using same, and lighting neon lamp I-3006.

3.

(a) The 110 volt AC power is connected through pins 4,5 and pins 2,3 of plug P-3003 to lines 29 and 30, which supply power through pins 6 and 7 of plug P-1109 to:

(1) Oscilloscope through fuse F-1003

(2) The -12 volt power supply through fuse F-1002

(3) The /250 volt regulated supply through fuse F-1001

(4) The Low Level Modulator filament transformer through fuse F-1002

(b) The 110 volts AC is extended through pins 4 and 5 of plug P-2925 to Frequency Generator filament and 150 volt Ledex motor supply.

(c) The 110 volts AC is extended through pins 1 and 2 of plug P-501 to the Medium Voltage Power Supply transformers through fuses F-501, F-502, and F-503.

(d) The 110 volts AC is extended through filter Z-601 to the filament transformer for the Radio Frequency Amplifier and blower motor in RFA throggh fuse F-1301.

4.

(a) When -24 VDC is available from Low Voltage Power Supply (step 2a) it energizes Blower relay K-3009.

(b) Energizing relay K-3009 closes its contacts 3L,2L and contacts 3R-2R, extending 110 volts AC to the blower motors in the base mounting.

Suggested Lecture [illegible]

RADIO FREQUENCY [illegible]

1. The Operation Selector switch [illegible] Amplifier selects the method of tuning [illegible] positions:

(a) Automatic (as shown on print)

(b) Semi-Automatic

(c) Manual

2. Since the transmitter is normally tuned [illegible] selector switch A should be set in automatic position [illegible] such. If a stage-by-stage check of tuning [illegible] it should be placed in position 2 or 3 (semi-automatic [illegible]

3. The 24-volt motor supply from [illegible] is [illegible]

(a) By line 129 to pin [illegible] of plug [illegible] section "D" of switch S-1361. The 24 volts is [illegible] of [illegible] and the motor bus which connects to [illegible] of relays K-1360 and K-1361.

(b) From rotor of section "D" [illegible] switch S-1[illegible]

(c) Contacts 2 and 3 of section "E" [illegible]

(d) Contact [illegible] of [illegible]

4. [illegible] standby switch SS S-3005 [illegible] supply has three positions:

(a) Operate

(b) Standby

(c) Remote

(a) Placing switch S-3005 in Operate [illegible] position [illegible] remote switch in operate position [illegible] from contacts 1B,1A of relay [illegible]-3005 [illegible] to terminal [illegible] of [illegible], terminal 20 of [illegible] rotor section "D" of switch S-1361.

(b) Switch S-3005 operated by [illegible] unit if switch S-1361 is being [illegible]

(c) Switch S-1601 is the "Booster" transfer switch, which selects which of the transmitter stacks will be boosted from 100 watts to 500 watts. Position R, as shown on drawing, is the right stack; position L, the left stack, and the center position is booster off. The booster will be considered as drawn, in the right position (R).

(d) The 24 volts is extended to contact R of S-1601, through normally closed contacts 2L,3L of "Overload" relay K-1602 (HLRM). The 24 volts is extended through normally closed contacts of switch S-1113, which will open the circuit only when switch S-1102 is being turned. The 24 volts is extended through normally closed contacts 2R,#R of "Overload" relay K-1303 (PA), to the time delay bus energizing relay K-1368 and closing contacts 2L,3L of K-1368.

6.

(a) When frequency selection in the RFO is started, 24 volts is extended from J-613 terminal 1 to terminal 9 J-614 (see Fig. 2-53,) relay K-2919 contacts 2,1). The 24 volts is further extended through contacts 3R,4R of "Call for Bandswitch" relay K-1359, through switch S-1361 contact 1 to rotor, to coil of K-1359. From K-1359 coil through contacts 5R-6R of relay K-1360, contacts 3L,4L of relay K-1361, contacts 5R-6R of relay K-1362, contacts 5R-6R of relay K-1363 to ground, energizing K-1359.

(b) When K-1359 closes 24 volts is extended through contacts 9L,10L of relay K-1359, through contact 1 to rotor of switch S-1361 section R to coil of "Interlock Break" relay K-3007, energizing same and opening its contacts 1R-2R.

(c) The 24 volts is extended to K-1359 coil through "AX" contacts 1R-2R of K-1359 and the normally closes contacts 3R-4R open.

7.

(a) When frequency selection (by dial X) is completed, 24 volts is switched from terminal 9 of J-613 to terminal 10 of J-614 (Figure 2-53, contacts 2,3 of relay K-2919). The 24 volts is extended through contacts 7R,8R of relay K-1359 lighting bandswitch start lamp I-1301 and energizing slow operate "Bandswitch Motor Delay" relay K-1308. This 24 volt line is extended to 10 megacycle step switch S-2987, Section M, the 100 kc step switch S-2326, wafer D, the 1 megacycle step switch S-2988, wafer M. After passing through these switches the 24 volts is returned to S-1378 on one of six leads which matches the RF band to which the RFO is tuned.

(b) i.e:
See Fig. 2-62
Fig. 2-110

Band	Lead	Contact Front Switch S-1378
1	1	1
2	2	3
3	3	5
4	4	7
5	5	9
6	6	11

8.

(a) Engrgizing relay K-1308 closes contacts 6R-7R of relay K-1308, so 24 volts is extended from closes contacts 9L,10L of relay K-1359 through wafer M to contact 1 of switch S-1361, contacts 6R-7R of relay K-1308, normally closed contacts 1L,2L of relay K-1307, lighting band switch motor lamp I-1321, and energizing "Handwitch Motor" B-1302. B-1302 is grounded through normally closed contacts 6L,5L of relay K-502, the closed contacts section Y of switch S-1601, and normally closed contacts B2,A2 of relay K-1502.

(b) The Bandswitch motor B-1302 drives bandswitch S-1301 and S-1302, the band dial and switches S-1378, and S-1379 and S-1380.

9.

(a) When the band dial and switch S-1378 of the RFA arrive on the same band as the band dial and switches S-2986, S-2988 and S-2987 set up up in the RFO, the 24 volts is extended to "Bandswitch Completed" relay K-1307.

(b) Energizing K-1307 opens contacts 1L,2L of same, stopping band-switch motor, closes contacts 2L,3L of K-1307 lighting "Bandswitch Completed" lamp I-1302.

(c) If the Bandswitch in the RFA is on the desired band when frequency selection in the RFO is completed, the rotor of switch S-1378 front would be opposite the live contact and bandswitch complete relay K-1307 would be energized and operate before the slow operate Bandswitch motor start relay K-1308 could close its contacts. Thus, unnecessary running of bandswitch system is prevented.

10.

(a) The 24 volts is extended through contacts 9L,10L of relay K-1359, through rotor to 1 of switch S-1361 section L, through contacts 2R,1R of relay K-1308 through high limit switch S-1372 to field of motor B-1301, also through normally closed contacts 7R,6R of relay K-1361, through normally closed contacts [illegible] of relay K-1360, through rotor to contact 1 of switch S-1361 section G, through high limit switch S-1374 to field of motor [illegible].

(b) This energizes the tuning motors and runs the tuning of the IPA and PA stages to the high frequency end of their tuning excursion at which point they are shut off by cam operated limit switches S-1372 and S-1374.

11.

(a) Energizing relay K-1307 also closes contacts [illegible] extending 24 volts from the time delay bus through contacts [illegible] of relay K-1359, contacts 4L,5L of relay K-1307, normally closed contacts 3R,4R of relay K-1360, contact 1 to rotor of section [illegible] of switch S-1361 energizing "Call for IPA Tuning" relay K-1360, which is grounded through contacts 3L,4L of relay K-1361, contacts 5R,6R of relay K-1362, contacts 6R,5R of relay [illegible].

(b) When relay K-1360 operates its normally [illegible] relay K-1359 [illegible] continues to be energized by 24 volts through [illegible] contacts 2L,3L of relay K-1362 (which closed [illegible]) and AX contacts 3R,2R of K-1360.

(c) Contacts 5R,6R of relay K-1360 open [illegible] from relay K-1359 coil causing relay K-1359 [illegible] the [illegible] switch control circuits are restored to the [illegible] they were prior to the start of tandem tuning.

12.

(a) 24 volts is extended from the motor [illegible] relay K-1360, normally closed contacts [illegible] contacts of motor reversing switch [illegible] the tuning motor B-1301, causing it to rotate.

(b) 24 volts is extended from the time [illegible] 9R,8R of relay K-1360 lighting IPA [illegible] further extended through rotor to [illegible] to switch S-1353, contact 1R of [illegible] relay K-1360.

13.

(a) 24 volts is extended through AX [illegible] switch S-1377 rear contacts [illegible] and relay K-1302 which supply BF [illegible] (This circuit will be followed [illegible] analysis).

(b) When the tuning motor B-1301 reaches [illegible] run, a cam closes switch S-1353 [illegible] normally closed contacts 3R,4R of [illegible]

Relay K-1356 remains energized through [illegible] K-1354.

Relay K-1356 [illegible] capacitor C-1358.

When the tuning motor B-1301 [illegible] run, it is [illegible] by switch S-1 [illegible] S-1351 closes [illegible] through normally closed contacts [illegible] contacts 1R,2R of relay K-1356.

When relay K-1356 [illegible] continues to be energized [illegible]

(b) Contacts 5R,6R of relay K-1350 close connecting the rotor of switch S-1379 front to the field winding of motor B-1301, which is unused during comparator scan. On band 4 resistor R-1395 and on band 5 and 6 resistor R-1399 are connected by contacts 7, 9 and 11 of switch S-1379 front. Current flows in the unused field winding slowing down the tuning motor, thus preventing overshoot during the second scan, on bands 4, 5 and 6, which are more critical then bands 1, 2 and 3. (Fig. 2-112) (Text 2-203).

(c) Relay K-1350 contacts 3L-4L connect ≠300 volts to plate of thyratron tube V-1308.

(d) When the IPA sense circuit indicates that IPA is tuned, it fires thyratron tube V-1308, drawing current through coil of "IPA Tuning Motor Control" relay K-1351, energizing it.

15.

(a) Relay K-1351 contacts 5R-4R open, stopping motor B-1301.

(b) Relay K-1351 contacts 5R,6R close, lighting "IPA Tuning Complete" lamp I-1304.

(c) Relay K-1351 contacts 2R,3R close, extending 24 volts through normally closed contacts 3R,4R of relay K-1361 and contact 1 to rotor of section B, switch S-1361, energizing "Call for PA Tuning" relay K-1361, which is grounded through contacts 5R,6R of relay K-1362 and contacts 5R,6R of relay K-1363.

16.

(a) When relay K-1361 operates, it opens contacts 3R,4R of K-1361, but continues to be energized by 24 volts extended through contacts 2L,3L of relay K-1368 (which closed when time delay ran out) and AX contacts 1R,2R of K-1361.

(b) Contacts 3L,4L of K-1361 open and remove grd. return from relay K-1360 coil, causing relay K-1360 to drop out. The "Call for IPA Tuning" circuits are restored to the condition they were in prior to the "Call for IPA Tuning."

17.

(a) 24 volts is extended from the motor bus through contacts 9L,10L of relay K-1361, normally closed contacts 5R,4R of relay K-1353, contacts of motor reversing switch S-1356 to one field of PA tuning motor B-1303, causing it to rotate.

(b) 24 volts is extended from the time delay bus through contacts 7L,8L of relay K-1361, lighting "PA Start" lamp I-1305. It is further extended from rotor to contact 1 of section F of switch S-1361, to contact 1R of relay K-1355 and contact 1R of relay K-1352.

18.

(a) 24 volts is extended through AX contacts [illegible] of relay K-1361 to switch S-1378 rear contacts 2 & 4. This energizes relay K-1305 and relay [illegible], which supply [illegible] voltages to [illegible] during tuning. (This circuit will be [illegible] from switch S-1378 later in the analysis).

(b) When the tuning motor [illegible] reaches the high frequency end of its run, it is [illegible] by cam operated switch [illegible] and a cam closes switch [illegible], energizing relay K-1352 through normally closed contacts [illegible] of relay [illegible].

(c) Relay [illegible] is [illegible] through closed contacts 1R,2R of K-1352.

(d) Relay [illegible] contacts [illegible] open, removing short from memory capacitor [illegible].

(e) When the tuning motor [illegible] reaches the low frequency end of its run, it is [illegible] by switch [illegible]-1356, and the cam operated switch [illegible], connecting the coil of relay K-1352 to 24 volt source [illegible] contacts 4R, 3R of K-1352 and the closed contacts [illegible] of relay [illegible].

19.

(a) When relay K-1352 [illegible] it opens contacts [illegible] of relay K-1352, but continues to be energized through its own contacts 1R-2R.

(b) Contacts [illegible] of relay K-1352 close, connecting the rotor of switch S-1379 rear to the field winding of motor B-1303, which is unused during [illegible] scan. On bands 3 and 4, resistor [illegible]-1397 and on bands 5 and 6, resistor R-1340 are connected by contacts 6, 8, 10 and 12 of switch S-1379 rear. Current flows in the unused field winding, slowing down the tuning motor, thus preventing overshoot during the second scan on bands 3, 4, 5, and 6 which are more critical than bands 1 and 2 (Fig. 2-[illegible]) (Text [illegible]).

(c) Relay K-[illegible] contacts [illegible] connect +300 volts to plate of thyratron tube V-1311.

(d) When the [illegible] circuit indicates that [illegible], it fires thyratron V-[illegible], drawing current through coil of "[illegible] Tuning Motor Control" relay K-[illegible], energizing it.

20.

(a) Relay K-[illegible] contacts [illegible] open, stopping motor B-1303.

(b) Relay K-[illegible] contacts [illegible] close, lighting [illegible] tuning complete lamp I-[illegible].

(c) Relay K-[illegible] contacts 2R-3R close, extending 24 volts through normally closed contacts 3R,4R of relay K-1363 and contact 1 to rotor of section B switch S-1362, energizing "Call for Antenna Tuning" relay K-1362, which is grounded through contacts [illegible] of relay K-[illegible]

18.

(a) 24 volts is extended through AX contacts [illegible] of relay K-1361 to switch S-1378 rear contacts 2 & 4. This energizes relay K-1305 and relay K-[illegible], which supply [illegible] voltages to [illegible] during tuning. (This circuit will be [illegible] from switch S-1378 later in the analysis).

(b) When the tuning motor [illegible] reaches the high frequency end of its run, it is [illegible] by the operated switch [illegible] and a cam closes switch S-[illegible], energizing relay K-1355 through normally closed contacts [illegible] of relay [illegible].

(c) Relay [illegible] through closed contacts 1R,2R of K-[illegible].

(d) Relay [illegible] open, removing short from memory capacitor [illegible].

(e) When the tuning motor [illegible] reaches the low frequency end of its run, it [illegible] S-1356, and the [illegible] operated switch [illegible] the coil of relay K-[illegible] to 24 volt source through normally closed contacts 4R,5R of K-1352 and the closed contacts [illegible] of relay K-[illegible].

19.

(a) When relay K-[illegible] operates it opens contacts [illegible] of relay K-1352, but continues to be energized through its own contacts 1R-2R.

(b) Contacts [illegible] of relay K-[illegible] close, connecting the motor of switch S-1379 rear to the field winding of motor B-1303, which is unused during [illegible]. On bands 3 and 4, resistor R-1397 and on bands 5 and 6, resistor R-[illegible] are connected by contacts 6, 8, 10 and 12 of switch S-1379 rear. Current flows in the unused field winding, slowing down the tuning motor, thus preventing overshoot during the [illegible] on bands 3, 4, 5, and 6 which are more critical than bands 1 and 2 (Fig. 2-[illegible]) (Text [illegible]).

(c) Relay K-[illegible] contacts [illegible] connect [illegible] volts to plate of thyratron tube [illegible].

(d) When the [illegible] circuit indicates that [illegible] is tuned, it fires thyratron [illegible], drawing current through coil of [illegible] Tuning Motor Control relay K-[illegible], energizing it.

20.

(a) Relay K-[illegible] contacts [illegible] open, stopping motor B-1303.

(b) Relay K-[illegible] contacts [illegible] close, lighting [illegible] tuning complete lamp [illegible].

(c) Relay K-1363 contacts 2R-3R close, extending 24 volts through normally closed contacts 3R,4R of relay K-1362 and contact 1 to rotor of section D switch S-1361, energizing "Call for Antenna Tuning" relay K-1362, which is grounded through contacts [illegible] of relay [illegible]

21.

(a) When relay K-1362 operates, it opens contacts 3R,4R of relay K-1362, but continues to be energized by 24 volts extended through contacts 2L,3L of relay K-1368, and AX contacts 1R-2R of relay K-1362.

(b) Contacts 5R,6R of K-1362 open and remove ground return from relay K-1361 coil causing K-1361 to drop out. The "Call for PA Tuning" circuits are restored to the condition they were in prior to the "Call for PA Tuning".

(c) 24 volts is extended through AX contacts 2L,1L of relay K-1362, through contacts 1R,2R of relay K-1306 to switch S-1378 rear, contacts 2 and 4. This energizes relay K-1305 and relay K-302 which supply B+ voltages to RFA during tuning. (This circuit will be followed from S-1378 later in the analysis).

22.

(a) If the Radio Frequency Tuner is ready for the RF output of the RFA, 24 volts from the Antenna Control Group is extended over line 61, lighting "Antenna Ready" lamp I-1315. It is further extended through contacts 9L,10L of relay K-1362 to coil of "Antenna Transfer" relay K-1306, energizing same.

23.

(a) The RF output is transferred by a set of contacts on relay K-1306, from the 50-ohm dummy load R-1334 to the Radio Frequency Tuner.

(b) 24 volts is extended through contacts 3R,4R of K-1306 over ATU Interrogate line to Antenna Control Group, as a "Call for Antenna Tunigg" signal. 24 volts is also extended through closed contacts 9R,10R of relay K-1362, lighting "Antenna Tuning Start" lamp I-1307.

(c) When the antenna is tuned, 24 volts is extended from Antenna Control Group to coil of "Antenna Tuned" relay K-1364, energizing K-1364. This 24 volts is further extended through closed contacts 7R-8R of relay K-1362 lighting "Antenna Tuning Complete" lamp I-1308.

(d) 24 volts is extended through switch S-1301 rotor to contact 1 of section C, through closed contacts 6R-7R of relay K-1364 to coil of "Carrier Ready For Modulation" relay K-1363, energizing relay K-1363.

(e) When relay K-1363 operates, opening its contacts 5R-6R which removes ground return from relay K-1362 coil, causing K-1362 to drop out, the "Call for Antenna Tuning" circuits are restored to the condition they were in prior to "Call for Antenna Tuning".

24.

(a) 24 volts is extended through contacts 7L,8L of relay K-1363, lighting "Ready for Carrier" lamp I-1309. It is further extended by lead 62 to the coil of "Interlock Auxiliary" relay K-3044, energizing K-3044.

(b) 24 volts is also extended through plug P-1105 terminal 10 to coil of "Modulator Unblocking" relay K-1107. (Fig. 7-7?)(Text 2-126).

25.

(a) When "Interlock Auxiliary" relay K-3004 is energized, 110 volts is extended from interlock circuit through link 31-32 (or 220 volts through dropping resistor R-3002 and link 32-34) through normally closed contacts 1R,2R of "Interlock Break" relay K-3007, through contacts 4R,5R of relay K-3004, through normally closed contacts 3R,4R of relay K-3006, to coil of relay K-3006, energizing same. The other sidel of relay K-3006 coil is connected to other side of 110 or 220-volt line.

(b) Relay K-3006 remains energized through AX contacts 1R,2R when contacts 3R,4R open.

(c) Relay K-3006 will remain energized through its own contacts 1R,2R after transmitter is shut off provided:

(1) The main power has not been removed.

(2) Emergency switch # DD S-3001 has not been opened.

(3) No interlock has been broken.

(4) Dial X switch S-1107 has not been operated, energizing interlock break relay K-3007. (Step 5b)

26.

(a) Energizing relay K-3006 closes contacts 8R,9R of relay K-3006 and they remain in that position as long as conditions listed (25c) are met.

27.

(a) When transmitter is again turned on and time delay has run out, with switch S-3005 in "operate" position, 24 volts is extended from S-3005 to coil of "Tune By-pass" relay K-3008, energizing same.

(b) Relay K-3008 is a slow operate relay and before its contacts 1R, 2R open, current will flow in the following circuit charging condenser C-3012. From contacts 1R, 2R of K-3008 through contacts 8R, 9R of relay K-3006 through contact 1 to rotor of switch S-1041 section E, through contact 3R, 4R of relay K-1362, through coil of relay K-1362 to ground, energizing relay K-1362.

(c) Relay K-1362 remains energized through its own AX contacts 1R,2R.

(d) Slow operate relay K-3008 contacts 1R,2R open.

(e) This starts tuning process of the transmitter at this point, with a call for antenna tuning, by-passing call for bandswitching. IIA

28.

(a) If conditions 1, 2, 3 or 4 of 24(c) are not met, and relay K-3006 has been de-energized, when the transmitter is again turned on, and time delay has run out with switch S-3005 in operate position, 24 volts is extended from S-3005 to coil of "Tune By-pass" relay K-3008, energizing same.

b) Current will flow in the following circuit charging condenser C-3012. From contacts 1R,2R of relay K-3008 through 3R-4R of relay K-3006 through contacts 3R-4R of relay K-1359 through coil of relay K-1359 to ground, energizing relay K-1359.

(c) Slow operate relay contacts 1L,2R open.

(d) This starts tuning with a call for bandswitching to the channel in use before the interruption occurred.

29.

(a) Following operation of carrier ready relay K-1363, 24 volts is extended through contacts 9L,10L of relay K-1363 to bandswitch S-1378 rear rotor contact 1. (Switch S-1378 is rotated by band switch motor B-1302).

(b) This section of S-1378 limits operational power on bands 1 and 2 to 100 watts, but allows 500 watts operation on other bands.

30.

(a) On bands 1 and 2, the 24 volts is extended through contacts 2 or 4 respectively of switch S-1378.

(b) From contacts 2 and 4 of switch S-1378, 24 volts is extended to coil of relay K-1305, energizing same.

(c) Energizing K-1305 closes contacts 2R,3R extending [illegible] volts to screens of power amp tubes for 100-watt operation.

(d) 24 volts is also extended to 100-watt control indicator lamp I-13[illegible] lighting same.

(e) 24 volts is also extended by line 97 through "Transmitter Transfer" switch S-1601 section J, through normally closed contacts 3L-4L of "High Voltage Plate" relay K-1502, through normally closed contacts 1R-2R of relay K-1607 to coil of relay K-1502, energizing same.

(f) When relay K-502 is energized, closing contacts 3R, 4R and contacts 2L, 3L of same, 110 volts is extended through fuse F-501 to primary of T-501, which is the ∮500 volt supply transformer, lighting lamp I-501. The ∮500 volt line to RFA and Radio Modulator is energized, lighting neon lamp I-503.

(g) Closing contacts 4L, 3L and contacts 2R, 1R of relay K-502 extends 110 volts to lamp I-502, lighting same. It is further extended through contacts 2L, 1L or 2L, 3L of relay K-503 to primary of T-503, the 1300/1050 volt supply transformer. The 1300/1050 volt supply line to RFA is energised, lighting neon lamp I-504.

(h) Relay K-502 contacts 5L, 6L open ground return of bandswitch motor B-1302 preventing bandswitching with the ∮500 and 1300 volt supplies running.

31.

(a) On bands 3, 4, 5 or 6, the 24 volts is extended through contacts 6, 8, 10 or 12, respectively, of switch S-1378 through normally closed contacts 2L, 1L of "Mismatch" relay K-1365, contacts 1R, 2R of relay K-1364 (which closed step 22c), lighting 500-watt control indicator lamp I-1323. 24 volts is further extended through normally closed contacts 6R, 5R of relay K-502, through contacts of section P of switch S-1601, to coil of relay K-1604, energizing same.

(b) 24 volts is extended from LVPS through section O of switch S-1601, through contacts 3R-2R of relay K-1604 to coil of relay K-1607 and relay K-1605, energizing both.

(c) The 24 volts is also extended from 5R of relay K-502 over line 90 energizing relay K-1304, K-1102, and K-1104.

(d) Relays K-1607, K-1605, K-1304, K-1102 and K-1104 change output of transmitter to 500 watts and will be discussed later.

32.

(a) If excessive mismatch occurs at antenna, 28 volts is extended from Antenna Control Group over line 79 to coil of "Mismatch" relay K-1365, energizing same, and lighting mismatch indicator lamp I-1316.

(b) 24 volts is extended from time delay bus through contacts 5L, 6L of relay K-1365, lighting alarm lamp I-1317, and it is further extended through normally closed contacts 6R, 5R of relay K-1367, energizing buzzer and sounding alarm.

(c) Energizing K-1365 also opens contacts 2L, 1L and closes contacts 3L, 4L. This change of contacts transfers the normal circuit path extending from contacts 6, 8, 10 and 12 of switch S-1378 rear, to the normal circuit path extending from contacts 2 and 4 of switch S-1378 rear, (or from 500-watt to 100-watt operation).

(d) Since no "Antenna Tuned" signal is received from the Antenna Control Group when a mismatch occurs, relay K-1364 will not operate and energize relay K-1363, (step 23(d)). However, by turning switch S-1361 to the semi-automatic position, it is possible to press carrier ready button S-1370, which closes ready for carrier relay K-1303. (Operation to be analyzed later). In this way, it is possible to bypass K-1364 and force the carrier on at the 100-watt level.

(e) If operation under this condition is continued, pushing "Buzzer Disconnect" switch S-1371 extends 24 volts through contacts 3R-4R of relay K-1367, to coil of relay K-1367, energizing same.

(f) This opens contacts 5R-6R of relay K-1367, disconnecting the buzzer.

(g) Relay K-1367 remains energized after switch S-1371 is released through contacts 1R-2R of K-1367.

(h) K-1367 is de-energized only when mismatch is corrected or 24 volts is removed from time delay bus.

33. High Power (500-watt operation) Ref: Page 16 for IVTS.

(a) When time delay relay K-1504 closes, 24 volts is extended from contacts 4R,5R of relay K-1307 (operation 31c) through contacts 2 and 8 of relay K-1504 to coil of relay K-1502, energizing same. It is further extended through section 7 of switch S-1501 to coil of relay K-501, energizing same.

(b) Contacts 1R-2R of relay K-1507 and contacts 1L,2L of relay K-1502 open, de-energizing relay K-502 (which receives its 24 volts through these contacts).

(c) Relay K-502 contacts 1L,2R and 3L,4L [illegible] 450/1050 volt supply. Contacts [illegible] 4500 volt supply continues to receive 117 volts [illegible] contacts [illegible] and 11-21 of relay K-501. [illegible]

(d) Normally closed contacts 1R-2R of relay K-1502 open, removing ground from motor B-1302. This prevents [illegible] while high voltage is applied to RF circuits.

(e) Relay K-1304 is energized [illegible] contacts 1L,2R,3R,4R, and 5R,6R change the grid bias of the [illegible] tubes. The contacts 3L,4L close, extending 4500 volts to the [illegible] of the Power Amplifier tube, through the normally closed contacts 1R,2R of relay K-1305. (Fig. 2-195) (Text 2-183).

(f) Relay K-1102 is energized (in step 31c). Its contacts 3R-4R change cathode bias resistor of Audio Amplifier tube 1106B while contacts 2L,3L are used to hold signal level to side tone amplifier constant (Fig. 2-68).

(g) Relay K-1104 is energized (in step 31c). Its contacts 5L,6L and 5R,6R transfer the 6 watts output of the LLRM to the grids of the HLRM. (Fig. 2-74).

(h) The coil of Overload relay K-1602 is in series with the ≠350 volt screen grid supply of Audio Amplifier tubes V-1601 and V-1602. It is energized if excessive sdreen current is drawn by these HLRM tubes. Its normally closed contacts 2L,3L open, de-energizing the time delay bus, returning the transmitter to a standby condition. Contacts 1L,2L close, extending 24 volts through section E of switch S-1601 to buzzer alarm and lighting alarm indicator lamp I-1317.

(i) Relay K-1602 remains locked in the energized position until the relay resdt coil is energized by pressing switch S-1603, extending 24 volts from supply line through the reset coil.

BOOSTER UNIT POWER SUPPLY

1.

(a) Primary power of 220 or 440 volt 60 cycle 3 phase is extended from power supply lines by closing "Booster Emergency" switch S-1501 FF.

(b) One phase is extended through fuses F-1509 and F-1510 for 220 volt input. It extends to primary of HVPS filament transformer T-1501 and HLRM filament transformer T-1602.

(c) For 440 volt operation, a link is placed between 2 and 3 of E-1504, connecting two primary windings of T-1501 in series. For 220 volt operation, links are connected between terminal 1 and 3 and between terminal 2 and 4, placing the two windings in parallel. 220 volts is extended to "Time Delay" relay K-1504, which closes 30 seconds after switch FF S-1501 is closed. When relay K-1504 closes contacts 5 and 7 of K-1504 extend 220 volts to and lights lamp I-1504.

(d) 24 volts is extended from contacts 4R-5R of K-1607 through contacts 2 and 8 of relay K-1504 to coil of relay K-1502, energizing K-1502. (K-1607 was energized step 31b).

2.

(a) Relay K-1502 closes its contacts L1,T1, also contacts L2,T2 and L3,T3, connecting the three phase power through fuses F-1501, F-1502, and F-1503 for 440 volt operation, or through F-1506, F-1507 and F-1508 for 220 volt operation.

(b) This line voltage is further extended to the primary winding of high voltage transformer T-1502. High voltage primary indicator lamps I-1501, I-1502, and I-1503 light. Links are connected across terminals 1 and 2, 3 and 4, 5 and 6 of E-1503, shorting resistors R-1505, R-1506, and R-1507 when primary voltage is 220 volts.

(c) Links on plate transformer T-1502 arrange the six primary windings with two windings in series for each phase on 440 volt operation, or 2 windings in parallel for each phase on 220 volt operation.

3.

(a) 24 volts is extended from contact 6 of switch S-1102 section B (phone operate position) through switch S-1602 section Q to coil of relay K-1501, energizing same. Contacts 11,4 10,2 and 9,6 close, increasing the number of primary turns and lowering the high voltage output to ≠2400 volts for phone operation. For all other positions of switch S-1102b, the relay K-1501 is de-energized and high voltage transformer primary is connected through normally closed contacts 11,3, 10,5 and 9,7, and the high voltage output is ≠3000 volts. The 2400/3000 volt output of the High Voltage Power Supply lights "High Voltage" indicator neon lamp I-1601.

SEMI-AUTOMATIC BANDSWITCHING AND TUNING

1.

(a) Operation selector switch A S-1361 is placed in semi-automatic position 2.

(b) Bandswitch Section selector switch C S-1362 is placed in the "On" position and extends 24 volts direct from 24 volt supply through its own contacts and contact 2 to rotor of S-1362 section N to the "Call for Bandswitch" relay K-1359, energizing same.

(c) The 24 volts which was extended from ~~mmmk~~ rotor to terminal 1 of S-1362 section L is interrupted at this point with S-1361 in position 2, so the IPA tuning motor B-1301 and PA tuning motor B-1303 are not run up to the high frequency end of the band before tuning starts.

(d) The 24 volts which is extended from contacts 4L-5L of relay K-1307 when bandswitching is completed, is interrupted at S-1661 section K, which is in position 2 so "Call for IPA Tune" relay K-1360 will not be energized.

(e) Switch C S-1362 is returned to "Off" position, causing relay K-1359 to drop out. 24 volts is now extended through contacts 5R-6R of K-1359 to "IPA Tuning Selector" switch E S-1363.

(f) When switch E S-1363 is placed in "On" position, 24 volts is extended through its own contacts and contacts 2 to rotor of switch S-1361 section K to "Call for IPA Tune" relay K-1360, energizing same.

Tuning will take a little longer because motor must run to high frequency end before automatic tuning begins.

(g) (Turn off switch E within 1 minute after IPA tuning complete lamp I-1304 lights).

2.

(a) The 24 volts which extends from contacts 5R-6R of relay K-1351 when "IPA Tuning" is completed, is interrupted at S-1361 section H, which is in position 2, so "Call for PA Tuning" relay K-1361 will not be energized.

(b) Switch E is returned to "Off" position, causing relay K-1360 to drop out. 24 volts is now extended through contacts 5L-6L of K-1360 to "PA Tune Selector" switch G S-1364.

(c) When Switch G S-1364 is placed in "On" position, 24 volts is extended through its own contacts and contacts 2 to rotor of switch S-1361 section H to "Call for PA Tune" relay K-1361, energizing same.

(d) (Turn off switch G within 1 minute after PA tuning complete lamp I-1306 lights).

3.

(a) The 24 volts which is extended from contacts 3R-2R of relay K-1353 when PA tuning is completed, is interrupted at S-1361 section D, which is in position 2, so "Call for Antenna Tune" relay K-1362 will not be energized.

(b) Switch G S-1364 is returned to "Off" position, causing relay K-1361 to drop out. 24 volts is now extended through contacts 5L-6L of K-1361 to "Antenna Tuning Selector" switch L S-1365.

(d) When switch L S-1365 is placed in "On" position, 24 volts is extended through its own contacts and contact 2 to rotor of switch S-1361 section D, to "Call for Antenna Tune" relay K-1362, energizing same.

4.

(a) The 24 volts which is extended to "Carrier Ready for Modulation" relay K-1363 when "Antenna Tuned" relay K-1364 closes its contacts 8R-7R, is interrupted at switch S-1361 section C, which is in position 2.

(b) 24 volts is now extended from switch S-1361 contact 2 of section C to "Carrier on" pushbutton switch H S-1370.

(c) Closing switch S-1370 extends 24 volts through contacts 3R-4R of K-1363, which remains energized through its own A1 contacts 1R-2R after switch S-1370 is released.

MANUAL BANDSWITCHING AND TUNING

1.

(a) Operation selector switch A S-1361 is placed in manual position 3.

(b) Bandswitch section selector switch C S-1362 is placed in "On" position as in semi-automatic to energize K-1359.

(c) The 24 volts which is extended through contacts 9L-10L of K-1359 is transferred to contact 3 of S-1361 section N, bypassing bandswitch start and stop relays K-1308 and K-1307, and instead, extends 24 volts to "Bandswitch Increase" switch B S-1358. Bandswitch motor B-1302 will be energized when S-1358 is jogged to the increase or closed position.

(d) Bandswitch complete light I-1302 will not light so correct bandswitch position or channel must be noted on dial.

2.

(a) "IPA Tuning Section" selector switch E S-1363 is placed in "On" position as in semi-automatic to energize K-1360.

(b) The IPA Tuning motor B-1301 will not run or be controlled by the IPA sense circuit because 24 volts to motor bus is interrupted by switch A S-1361 section O, which is in position 3, and 24 volts to sense circuit relays K-1350 and K-1354 is interrupted by switch A S-1361 section J, which is in position 3.

(c) 24 volts is extended from rotor to contact 3 of switch A- S-1361 section P to IPA tuning increase-decrease switch D S-1359. 24 volts is extended to either of the two fields of IPA tuning motor B-1301 by closing switch D S-1359. Cam-operated switch S-1372 removes power from motor B-1301 at high frequency limit of tuning excursion, and S-1373 removes power at low frequency limit of tuning excursion. (Turn off E- S-1363).

3.

(a) PA tuning section selector switch G S-1364 is placed in "On" position as in semi-automatic to energize K-1360.

(b) The PA tuning motor B-1303 will not run or be controlled by PA sense circuit because 24 volts to motor bus is interrupted by switch A S-1361 section Q, which is in position 3, and 24 volts to sense circuit relays K-1352 and K-1356 is interrupted by switch A S-1361 section F, which is in position 3.

(e) 24 volts is extended from rotor to contact 3 of switch (A) S-1361 section P to PA tuning increase-decrease switch (F) S-1360. 24 volts is extended to either of the two fields of PA tuning motor B-1303 by closing switch (F) S-1360. Cam-operated switch S-1374 removes power from motor B-1303 at high frequency limit of tuning excursion, and S-1375 removes power at low frequency limit of tuning excursion. (Turn off switch (G) S-1364.)

4. (a) Antenna tuning selector switch (L) S-1365 is placed in "On" position, as in semi-automatic, to energize K-1362.

(For manual tuning controls in antenna control group, see section 4 paragraph 6a(6).

When antenna is tuned, "Carrier-On" push button switch (H) S-1370 is operated as in semi-automatic.

FOLLOWING CARRIER READY CONDITION

1.

(a) Following the operation of energizing the ≠500 volt supply by relays K-502 or K-501, the plate current drawn by the IPA amplifier tube energizes relay K-1108, (a condition that exists when the carrier is actually on).

(b) ≠500 volts is extended through resistors R-1044, R-1045, R-1046, and R-1243 to coil of relay K-1109 (≠500 volt plate supply voltage for LLRM power amplifier tube) energizing relay K-1109 and closing its contacts 5R-6R, extending ≠300 volts from the ≠300 volt power supply (line 27) to the screen grids of the LLRM power amplifier tubes, and dumping circuit in MVPS. (Fig. 2-74).

2.

(a) When K-1108 is energized, -12 volts is extended through contacts 2R-3R of relay K-1108 and contacts 8R-9R of relay K-[illegible], lighting "Carrier On" lamp I-1310.

(b) Contacts 2L-3L disable the receiver.

(c) Contacts 4R-5R turn on the "Carrier On" lamp in remote radiophone unit. (Fig. 2-88).

3.

(a) 24 volts is extended from rotor of service selector switch S-1102B to coil of Modulator Blocking relay K-1107, energizing same.

(b) Contacts 6R-7R of relay K-1107 extend -12 volts to coil of "Press-to-Talk" relay K-1101. K-1101 will be energized when press to talk button on handset is depressed. (Fig. 2-87)

(c) Contacts 3L-4L-5L of relay K-1107 change input of Keying Control tube from test key to CW key or FSK keying. (Fig. 2-77) (Text 2-126).

(d) Contacts 4R-5R close and prevent carrier from going on air until press to talk or CW key is operated. (Fig. 2-80) (Test 2-125).

4.

(a) Slow operate relay K-1303 whose coil is in series with the screen supply of Power amplifier tube V-1304, is energized when excessive screen current is drawn. Its normally closed contacts 2R-3R open, de-energizing the time delay bus returning the transmitter to a standby condition.

(b) Relay K-1303 contacts 2R-1R close, extending 24 volts to buzzer alarm and lighting indicator lamp I-1317.

(c) Relay S-1303 remains locked in the energized position until the relay reset coil is energized by pressing switch S-1304, extending 24 volts from supply line through the reset coil.

(d) Thermostat switch S-1381 will close if the temperature of the air exhaust from the [illegible] becomes excessive. When S-1381 closes, 24 volts is extended from the time delay bus to the alarm buzzer and alarm light I-1317.

MODES OF OPERATION

1.

(a) The mode of operation is selected by Service Selector switch Q S-1102

(b) Switch S-1102 section B (Shown on print in position 6) extends 24 volts through its rotor and contact 6 to coils of "Audio Unshort" relay K-1103 (Fig. 2-68), and "Low Level Modulator Transformer Unshort" relay K-1106, (Fig. 2-74). These coils are grounded through contact 5R-4R of relay K-1101 and will be energized when these contacts close. (Fig. 2-87).

(c) The 24 volts is further extended to coil of relay K-503, energizing same. Relay K-503 contacts 2L,3L close and decrease the output of the Medium Voltage Power Supply from ≠1300 volts to ≠1050 volts.

(d) The 24 volts is further extended through section Q of switch S-1601, (for 500 watt operation), to coils of "Screen Short" relay K-1601 (in high level modulator) and "Transformer Short" relay K-1603 (in high level modulator). These coils are grounded through section T of S-1601 and contacts 5R-4R of relay K-1101 and will be energized when these contacts are closed. It is further extended to coil of relay K-1501, energizing K-1501.

(e) Relay K-1501 contacts 9,6 10,2 11,4 close and decrease the output of the High Voltage Power Supply from ≠3000 volts to ≠2400 volts (Fig. 2-134).

(f) The 24 volts is extended through contacts 2L,3L of relay K-1101 to coil of relay K-1111. Contacts 3R-4R of K-1111 open, and allow the carrier to go on the air when relay K-1101 is energized by push to talk button in handset. (Fig. 2-80) (Test 2-135). Relay K-1111 is a slow release type and its contacts 4R-3R remain open for 0.2 seconds after push to talk button is released, keeping the carrier on the air for that length of time.

(g) Relay K-1601 (energized in step d) contacts 1L,2L open, removing ground from screens of high level radio modulator tubes. Contacts 2L,3L close, extending ≠350 volts to screens to high level radio modulator tubes through coil of "Overload" relay K-1602, lighting ≠350 volt screen lamp I-1602.

TRANSMITTER TRANSFER CONTROL

1.

(a) Switches S-1601, S-1602, S-1604, and S-1605 are ganged together to form 500-watt selector switch GG.

(b) The AN/URT-4 has three positions for this switch:-

(1) 500-watt left transmitter

(2) 100-watt both transmitters

(3) 500-watt right transmitter

(c) The AN/URT-3 has only positions (1) and (2).

2. Switch S-1601 (Fig. 2-98).

(a) Sections A, B and C shift the 6-watt audio input and bias supply for HLRM tube from left to right LLRM as required, or in position 2, disconnects audio input from the HLRM tube grids.

(b) Section R and S (See Text 2-166, par. h).

(c) Section T and Q (See Text 2-169, par. r).

(d) Section P (See Text 2-168, par. q).

(e) Section J (See Text 2-167, par. j).

(f) Section K (See Text 2-167, par. 1).

(g) Section L and M are similar to section J and K, except that the connections are made to the left transmitter group.

(h) Section H (See Text 2-168, par. n).

(i) Section N same as H, but in left transmitter group.

(j) Section V (See Text 2-170, par. t).

(k) Section D (See Text 2-165, par. d).

(l) Section C (See Text 2-166, par. f).

(m) Section E (See Text 2-166, par. e).

(n) Section F same as section E, except for left transmitter group.

(o) Section X (See Text 2-120, par. u).

3.

(a) Switch S-1602 (Fig. 2-99) (Text 2-170)