TM 11-2141

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

MULTIPLEXER SET AN/TCC-13
MULTIPLEXER GROUP AN/TCA-1
AND
PULSE FORM RESTORER
GROUP AN/TRA-10



DEPARTMENT OF THE ARMY • MARCH 1956

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the +250-volt plate and power supply circuits, or on the 115-volt ac and dc connections.

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNIT:

Oscilloscope OS-25/G	1,800-volt circuits

DON'T TAKE CHANCES!

MULTIPLEXER SET AN/TCC–13, MULTIPLEXER GROUP AN/TCA–1, AND PULSE FORM RESTORER GROUP AN/TRA–10

TM 11–2141
CHANGES No. 2

DEPARTMENTS OF THE ARMY AND THE AIR FORCE
WASHINGTON 25, D. C., *9 November 1956*

TM 11–2141, 14 March 1956, is changed as follows:

Page 44, paragraph 40.1 (C 1). In the first column of the chart change the nomenclature of the first two cables listed from "CG–530E/U" to **"CG–409E/U".**

Paragraph 40.2 (C 1). Make the following changes to:

b. In the first column of the chart lines 2 and 4 change "CG–530E/U" to read: **CG–409E/U.**

c. In the first column of the chart lines 1 and 3 change "CG 530E/U" to read: **CG–409E/U.**

Page 77, figure 53.1 (C 1). Change "FUSES 4 AMP" to read: **FUSES 2 AMP.**

Page 161, figure 164. Make the following changes:

Change the word "NOTE" to read: **NOTES.**

Designate the existing note "1" and add the following:

2. IN MULTIPLEXER TD–60A/TCC–13, RESISTOR R170, 10K OHMS HAS BEEN ADDED FROM THE + 250-VOLT SOURCE TO THE JUNCTION OF R61 AND THE CATHODE OF V10A, PIN 3.

Page 162, paragraph 167.

Note. (Added) In Multiplexer TD–60A/TCC–13, resistor R170 has been added to the circuit to increase the bias on the tube. The increased bias reduces the amplification of the negative pulses and thereby reduces the noise coupled to the following stage.

Page 218, figure 224. Make the following changes:

Change the value of "C4" to read **"8UF"** and the value of "R9" to read **"470K".**

Delete the connection from pin 2 of V6 to the junction of C4 and R9. Connect the junction of C4 and R9 to ground.

Delete Note 3 (C 1) and substitute.

3. IN OSCILLOSCOPE OS–25A/G RESISTOR R17 IS 200K OHMS AND FUSES F1 AND F2 ARE 2 AMPS.

Page 219, figure 227 (C1). Delete notes 2 and 3. Correct the figure as follows:

Change the value of "C4" to read **"8UF"** and the value of "R9" to read **"470K".**

Delete "TO +22V D–C RECTIFIER V6" and arrowhead, connect this line to ground.

Add the following note:

2. IN OSCILLOSCOPE OS–25A/G THE VALUE OF RESISTOR R17 IS 200K.

Page 227, figure 238. Make the following changes:

Change the word "NOTE" to read **"NOTES".**

Designate the existing note as "1" and add the following:

2. IN OSCILLOSCOPE OS–25A/G RESISTOR R123 IS 470K OHMS.

Page 248, figure 253. Add the following note to figure 253:

5. IN MULTIPLEXER TD–60A/TCC–13, THE VOLTAGE READING FOR PIN 3, V10 IS APPROXIMATELY 5 VOLTS.

Page 265, par. 309. Add the following to the chart.

Fig. No.	Description
371. 1	Telephone Modem MD–179/TC, schematic diagram, showing waveforms.

Figure 389. Add the following note:

5. IN MULTIPLEXER TD–60A/TCC–13, RESISTOR R170, HAS BEEN ADDED BETWEEN E21, STATIONS AND PIN 3 STATION 11.

[AG 413.44 (6 Nov. 56)]

By order of the Secretaries of the Army and the Air Force:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

Official:

JOHN A. KLEIN,
Major General, United States Army,
The Adjutant General.

N. F. TWINING,
Chief of Staff, United States Air Force.

Official:

E. E. TORO,
Colonel, United States Air Force,
Air Adjutant General.

Distribution:

Active Army:

CNGB (1)
ASA (3)
Tec Svc, DA (1) except CSIGO (30)
Tec Svc Bd (1)
Hq CONARC (5)
CONARC Bd (incl ea Test Sec) (1)
Army AA Comd (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
MDW (1)
Armies (5)
Corps (2)
Ft & Cp (2)
Sp Wpn Comd (2)
Army Cml Cen (4)
Gen & Br Svc Sch (5) except Sig Sch (25)
Gen Depots (2) except Atlanta Gen Depot (None)
Sig Sec, Gen Depots (10)
Sig Depots (17)
US Army Tng Cen (2)
POE (OS) (2)
Trans Terminal Comd (2)
Army Terminals (2)
OS Sup Agencies (2)
Sig Fld Maint Shops (3)
Sig Lab (5)
ACS (3)
Mil Dist (1)
Units organized under following TOE's:
11–7C, Sig Co, Inf Div (2)
11–16C, Hq & Hq Co, Sig Bn, Corps or Abn Corps (2)
11–57C, Armd Sig Co (2)
11–127R, Sig Rep Co (2)
11–128C, Sig Depot Co (2)
11–500R, Sig Svc Org (2)
11–557C, Abn Sig Co (2)
11–587R, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2)
11–597R, Sig Base Depot Co (2)

NG: State AG (6); units—same as Active Army except allowance is one copy to each unit.
USAR: None.
For explanation of abbreviations used, see SR 320–50–1.

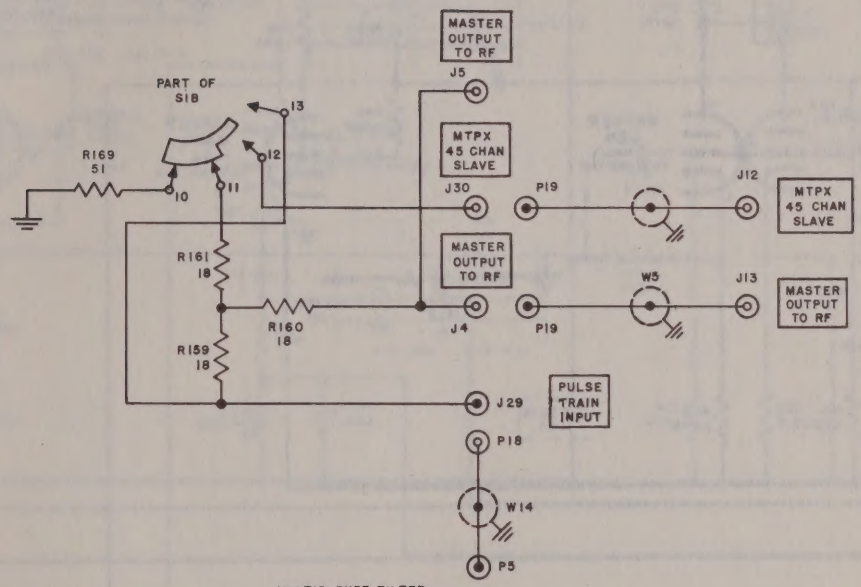
U. S. GOVERNMENT PRINTING OFFICE: 1956 O—408731

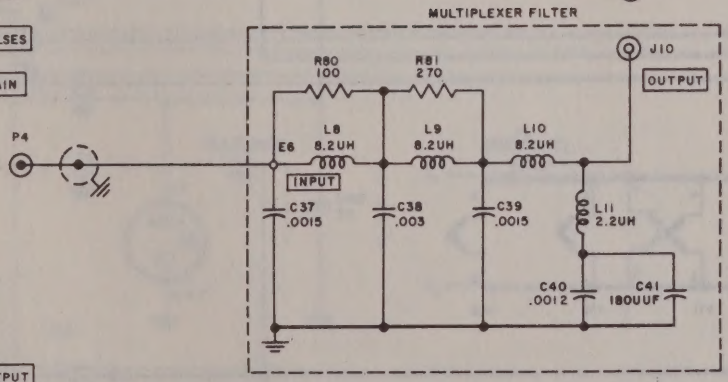
NOTES:

1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS AND ONE HALF WATT. CAPACITORS ARE IN UF.
2. SWITCH S1 SHOWN IN 23-CHANNEL POSITION AND VIEWED FROM END OPPOSITE CONTROL KNOB.

FUNCTION	INTERCONNECTED POSITIONS	
	SECTION A	SECTION B
23 CHANNELS	1-2, 4-5, 9-10, 15-16	1-18, 6-7, 10-11, 15-16
45 CHN MASTER	2-3, 4-5-6, 9-10, 12-13, 16-17	1-18, 7-8, 11-12, 15-16
45 CHN SLAVE	3-4, 6-7, 10-12	1-3, 8-9, 12-13, 16-18

3. V NUMBERS LOCATED BELOW WAVE SHAPES INDICATE POINTS AT WHICH WAVE SHAPES ARE TAKEN. FOR EXAMPLE V13, P-5 INDICATES THAT THE WAVE SHAPE WAS TAKEN AT PIN 5 OF TUBE V13.





5US/CM

TM2141-C2-1

By order of the Secretaries of the Army and the Air Force:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

Official:

JOHN A. KLEIN,
Major General, United States Army,
The Adjutant General.

N. F. TWINING,
Chief of Staff, United States Air Force.

Official:

E. E. TORO,
Colonel, United States Air Force,
Air Adjutant General.

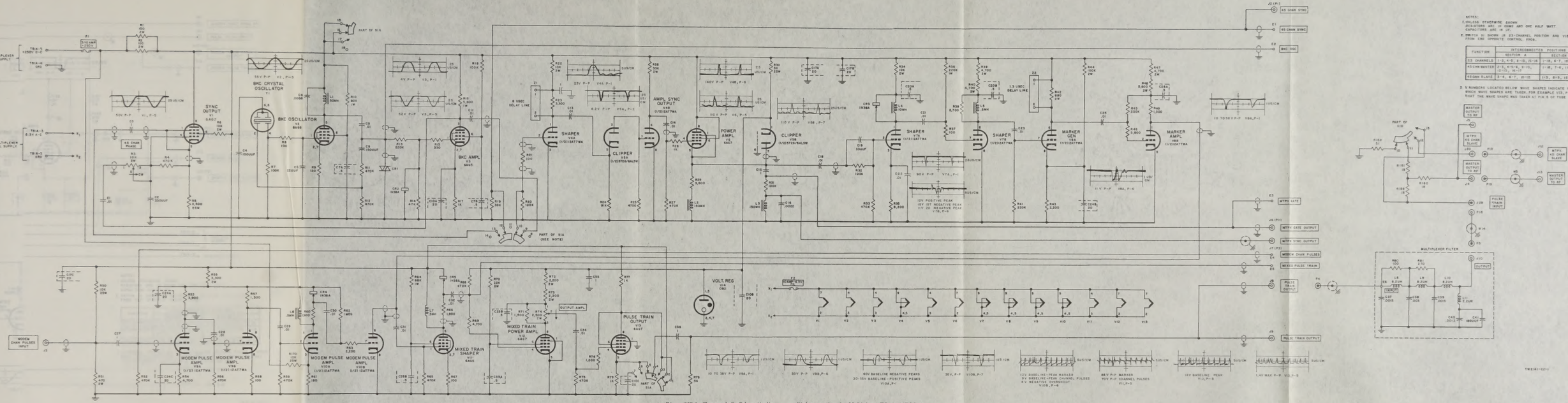
Distribution:

Active Army:

CNGB (1)
ASA (3)
Tec Svc, DA (1) except CSIGO (30)
Tec Svc Bd (1)
Hq CONARC (5)
CONARC Bd (incl ea Test Sec) (1)
Army AA Comd (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
MDW (1)
Armies (5)
Corps (2)
Ft & Cp (2)
Sp Wpn Comd (2)
Army Cml Cen (4)
Gen & Br Svc Sch (5) except Sig Sch (25)
Gen Depots (2) except Atlanta Gen Depot (None)
Sig Sec, Gen Depots (10)
Sig Depots (17)
US Army Tng Cen (2)
POE (OS) (2)
Trans Terminal Comd (2)
Army Terminals (2)
OS Sup Agencies (2)
Sig Fld Maint Shops (3)
Sig Lab (5)
ACS (3)
Mil Dist (1)
Units organized under following TOE's:
11–7C, Sig Co, Inf Div (2)
11–16C, Hq & Hq Co, Sig Bn, Corps or Abn Corps (2)
11–57C, Armd Sig Co (2)
11–127R, Sig Rep Co (2)
11–128C, Sig Depot Co (2)
11–500R, Sig Svc Org (2)
11–557C, Abn Sig Co (2)
11–587R, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2)
11–597R, Sig Base Depot Co (2)

NG: State AG (6); units—same as Active Army except allowance is one copy to each unit.
USAR: None.
For explanation of abbreviations used, see SR 320–50–1.

U. S. GOVERNMENT PRINTING OFFICE: 1956 O—408731

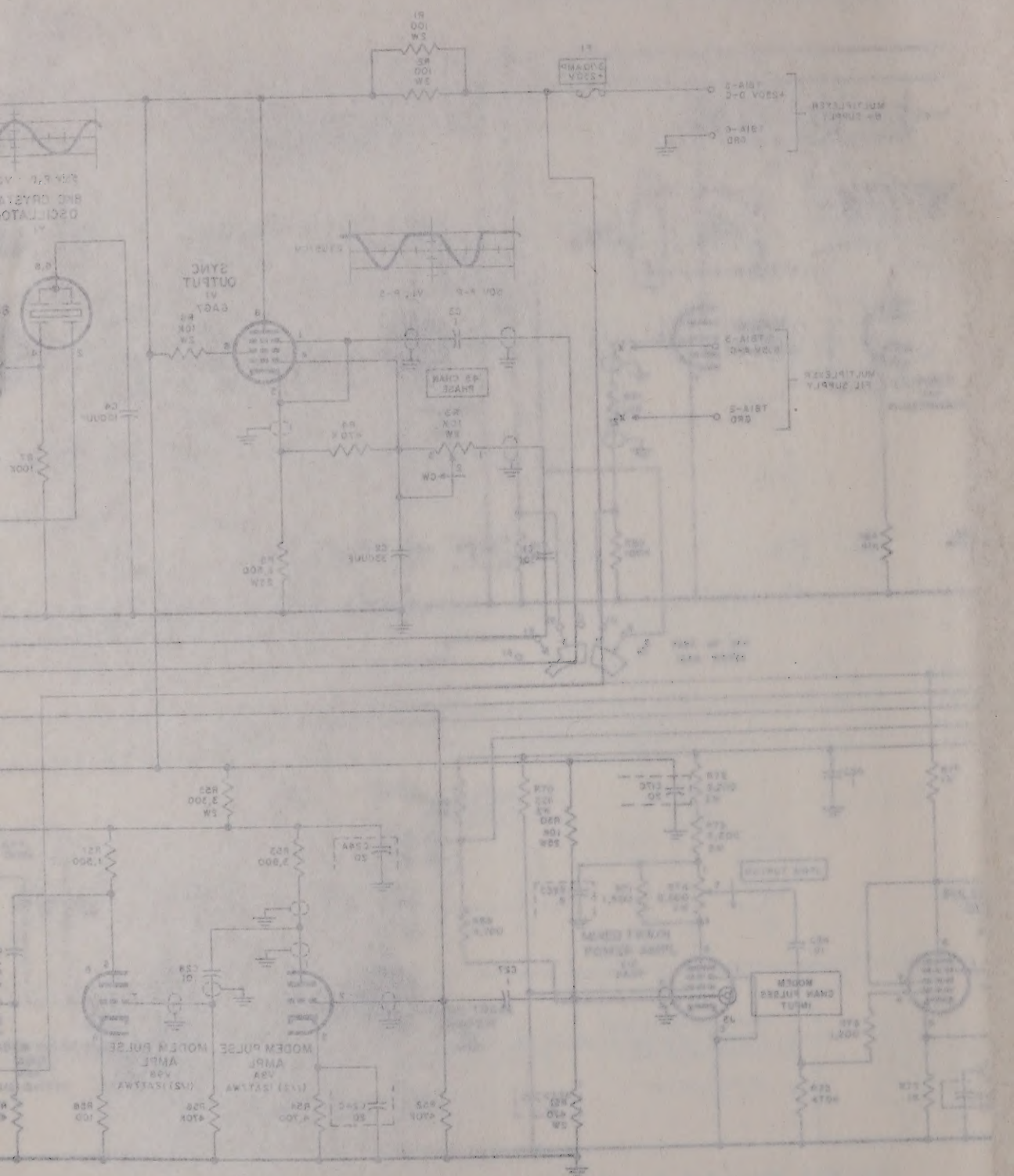


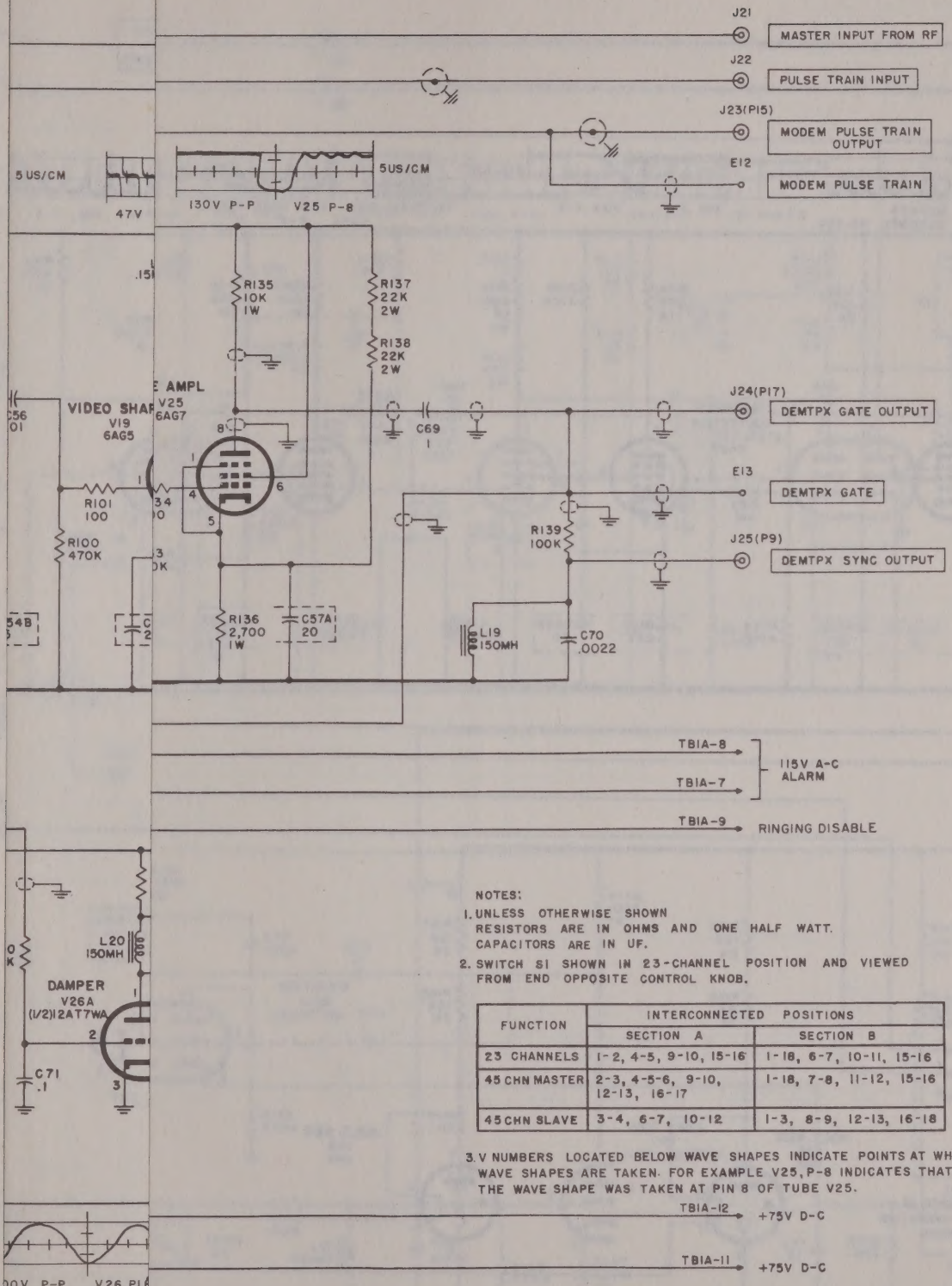
NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS AND ONE HALF WATT CAPACITORS ARE IN μF.
2. SWITCH S1 SHOWN IN 23-CHANNEL POSITION AND VIEWED FROM END OPPOSITE CONTROL KNOB.

FUNCTION	INTERCONNECTED POSITIONS	
	SECTION A	SECTION B
23 CHANNELS	1-2, 4-5, 8-13, 15-16	1-18, 4-7, 10-11, 15-18
45 CHN MASTER	2-3, 4-5-6, 8-10, 12-13, 16-17	1-18, 7-8, 11-12, 15-18
45 CHN SLAVE	3-4, 6-7, 10-13	1-3, 8-9, 12-13, 16-18

3. V NUMBERS LOCATED BELOW WAVE SHAPES INDICATE POINTS AT WHICH WAVE SHAPES ARE TAKEN. FOR EXAMPLE V1A, P-8 INDICATES THAT THE WAVE SHAPE WAS TAKEN AT PIN 8 OF TUBE V1A.

Figure 367.1. (Superseded) *Schematic diagram, multiplexer section, for Multiplexer TD-60A/TCC-18.*





NOTES:

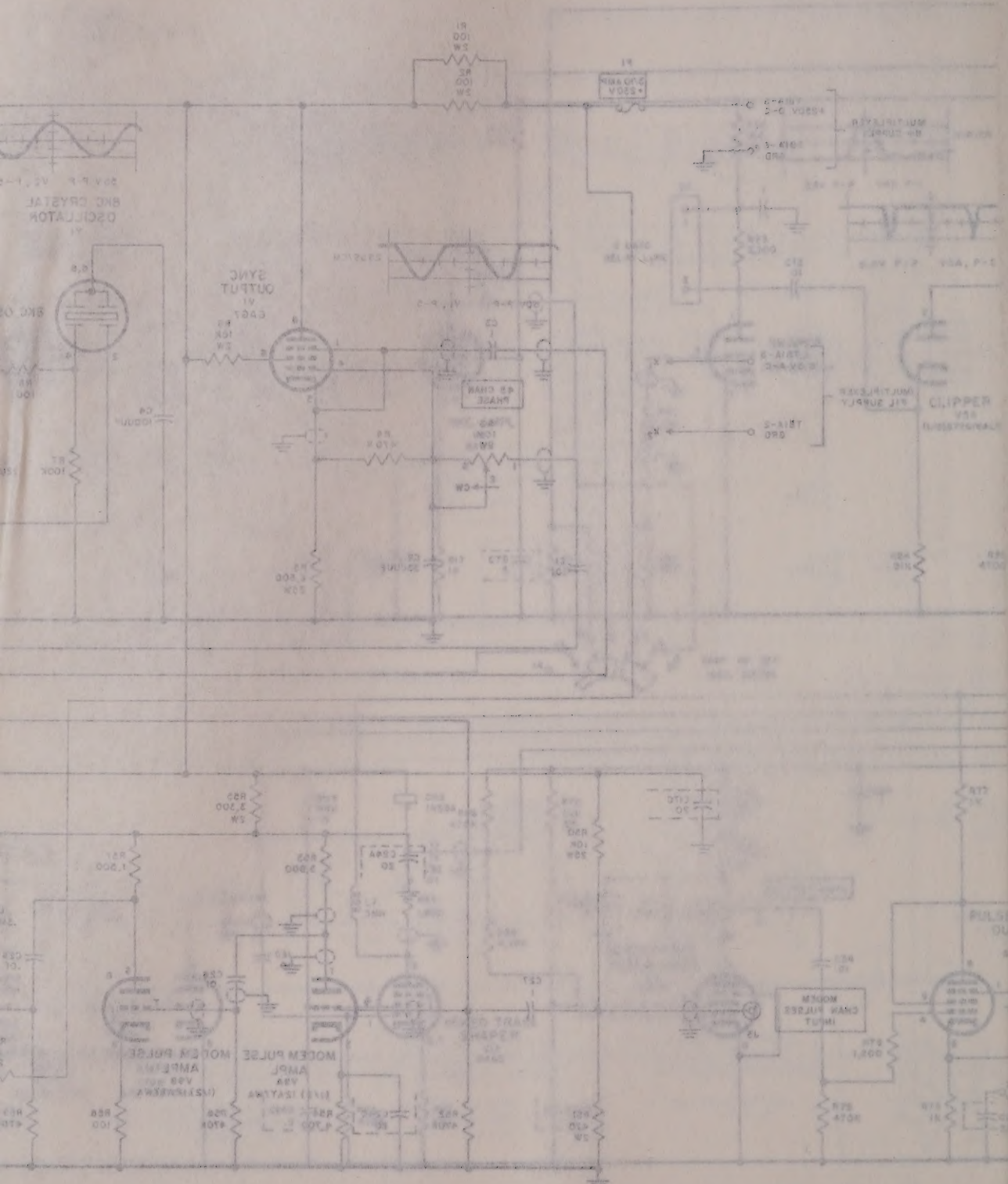
1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS AND ONE HALF WATT. CAPACITORS ARE IN UF.
2. SWITCH S1 SHOWN IN 23-CHANNEL POSITION AND VIEWED FROM END OPPOSITE CONTROL KNOB.

FUNCTION	INTERCONNECTED POSITIONS	
	SECTION A	SECTION B
23 CHANNELS	1-2, 4-5, 9-10, 15-16	1-18, 6-7, 10-11, 15-16
45 CHN MASTER	2-3, 4-5-6, 9-10, 12-13, 16-17	1-18, 7-8, 11-12, 15-16
45 CHN SLAVE	3-4, 6-7, 10-12	1-3, 8-9, 12-13, 16-18

3. V NUMBERS LOCATED BELOW WAVE SHAPES INDICATE POINTS AT WHICH WAVE SHAPES ARE TAKEN. FOR EXAMPLE V25, P-8 INDICATES THAT THE WAVE SHAPE WAS TAKEN AT PIN 8 OF TUBE V25.

TM 2141-C2-2

(Superseded) S


SYNC OUTPUT
CLIPPER
MODEM PULSE AMPL
MODEM PULSE AMPL

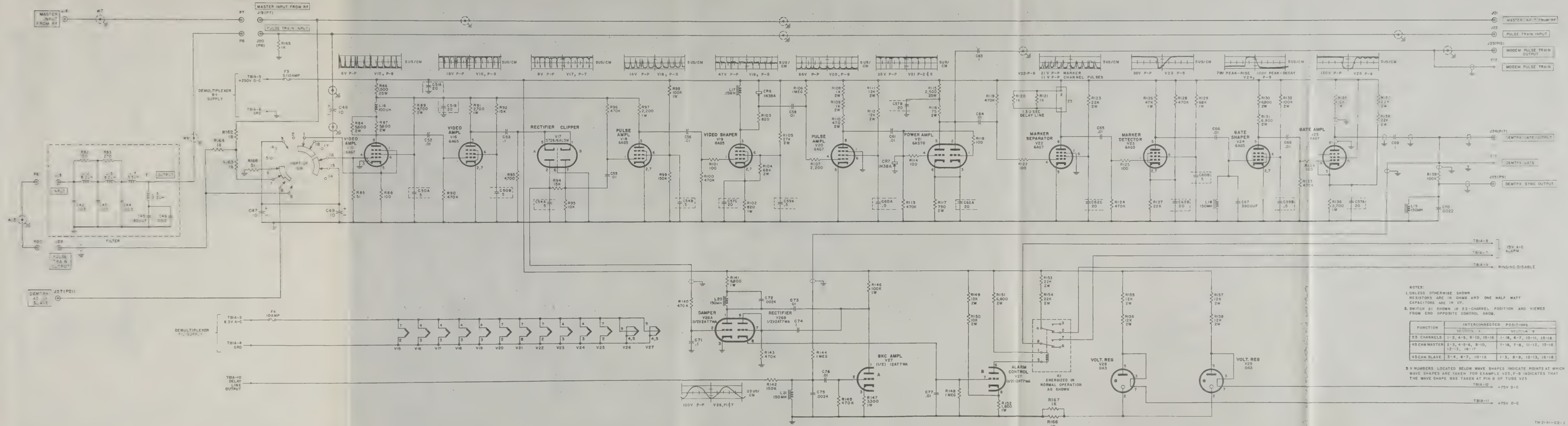


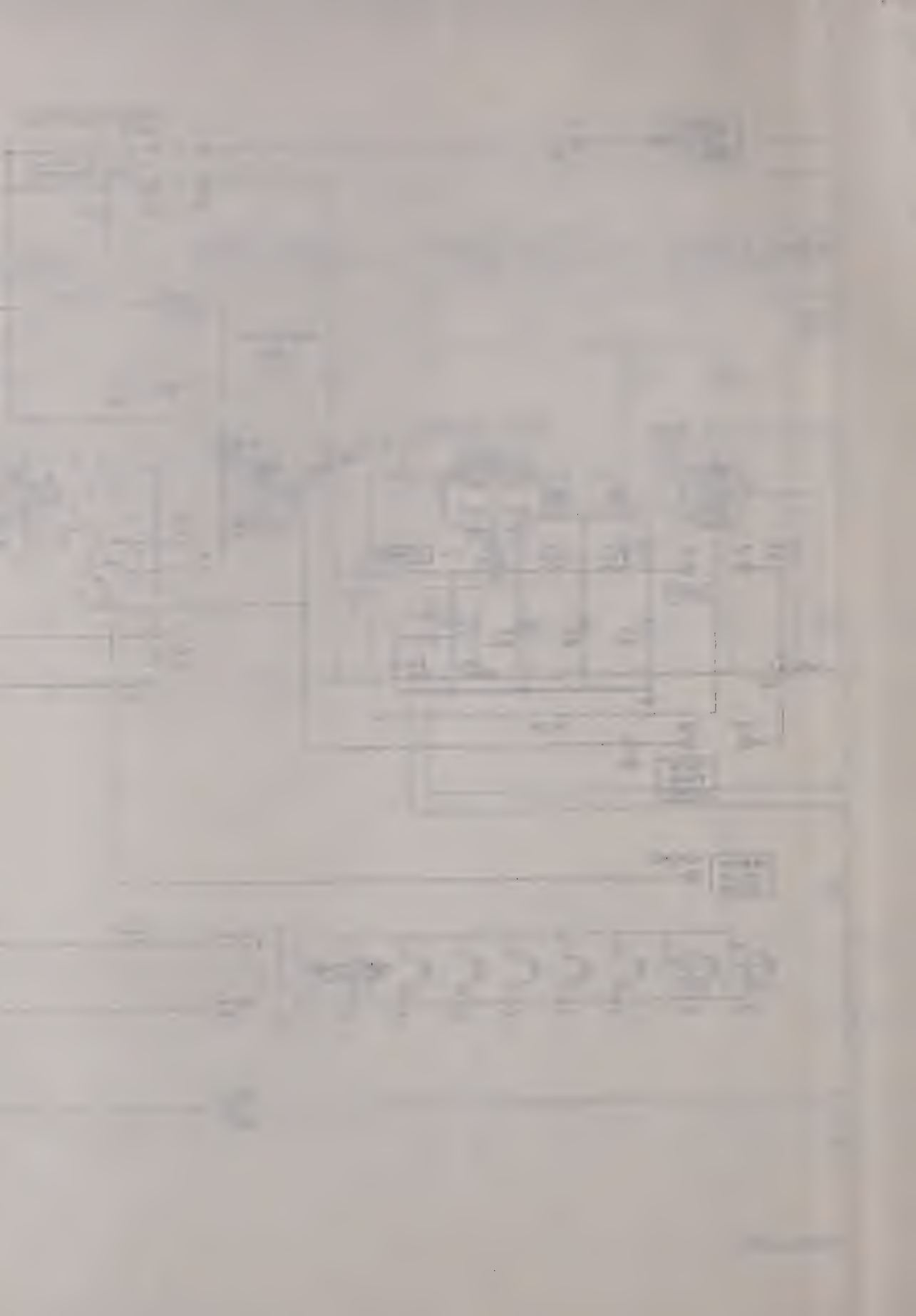
Figure 368.1. (Superseded) *Schematic diagram, demultiplexer section, for Multiplexer TD-60A/TCC-13.*

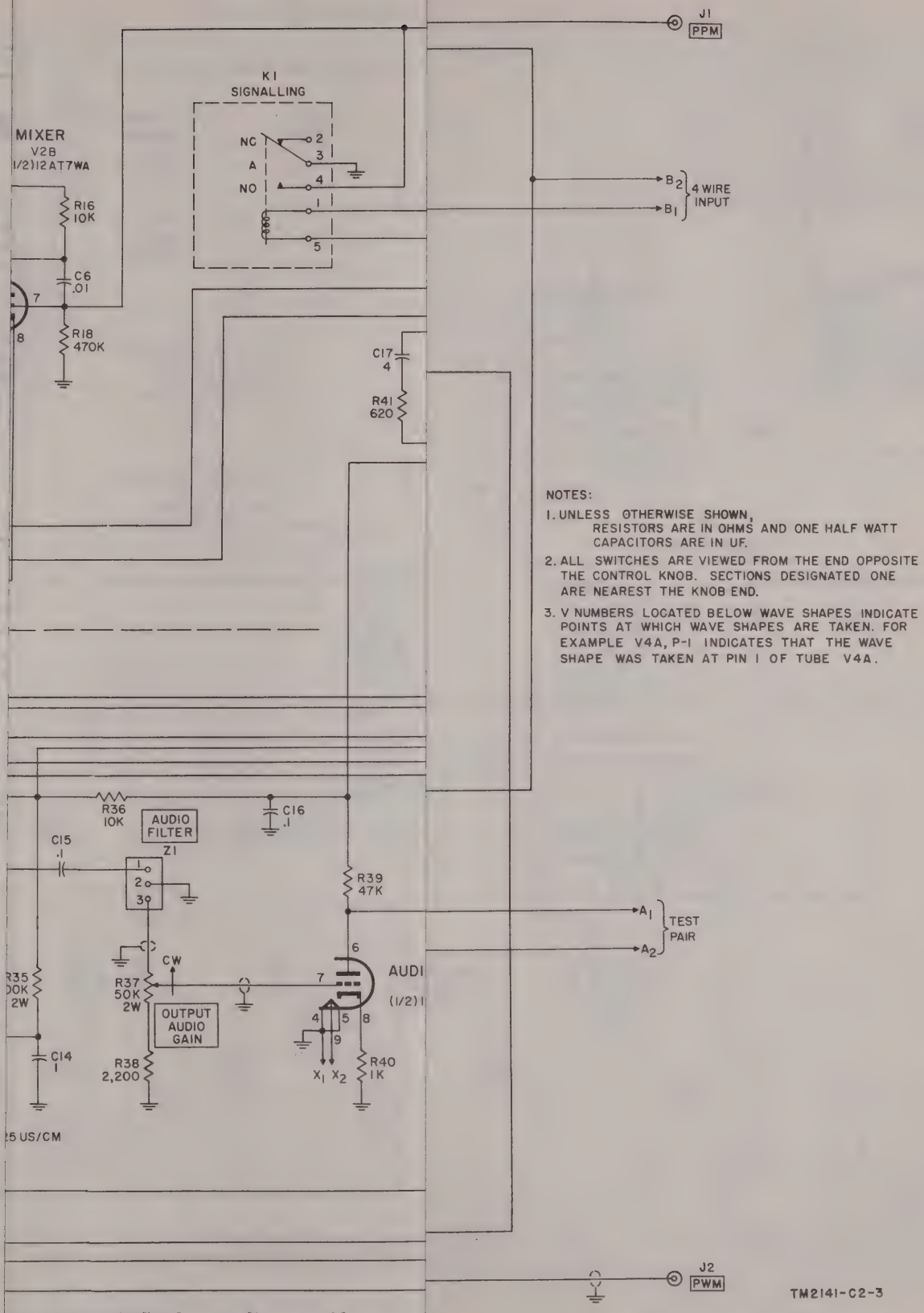
NOTES:
1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS AND ONE HALF WATT CAPACITORS ARE IN UF.
2. SWITCH S1 SHOWN IN 23-CHANNEL POSITION AND VIEWED FROM END OPPOSITE CONTROL KNOB.

FUNCTION	INTERCONNECTED POSITIONS (SECTION I)	(SECTION II)
23 CHANNELS	1-2, 4-5, 9-10, 11-12	1-18, 4-7, 10-11, 15-16
45 CHN MASTER	2-3, 4-5-6, 9-10, 12-13, 16-17	1-18, 7-8, 11-12, 15-16
45 CHN SLAVE	3-4, 6-7, 10-12	1-3, 8-9, 12-13, 16-18

3. V NUMBERS LOCATED BELOW WAVE SHAPES INDICATE POINTS AT WHICH WAVE SHAPES ARE TAKEN FOR EXAMPLE V25, P-8 INDICATES THAT THE WAVE SHAPE WAS TAKEN AT PIN 8 OF TUBE V25

TM 2141-C2-2





dem MD–179/TC, schematic diagram with waveforn



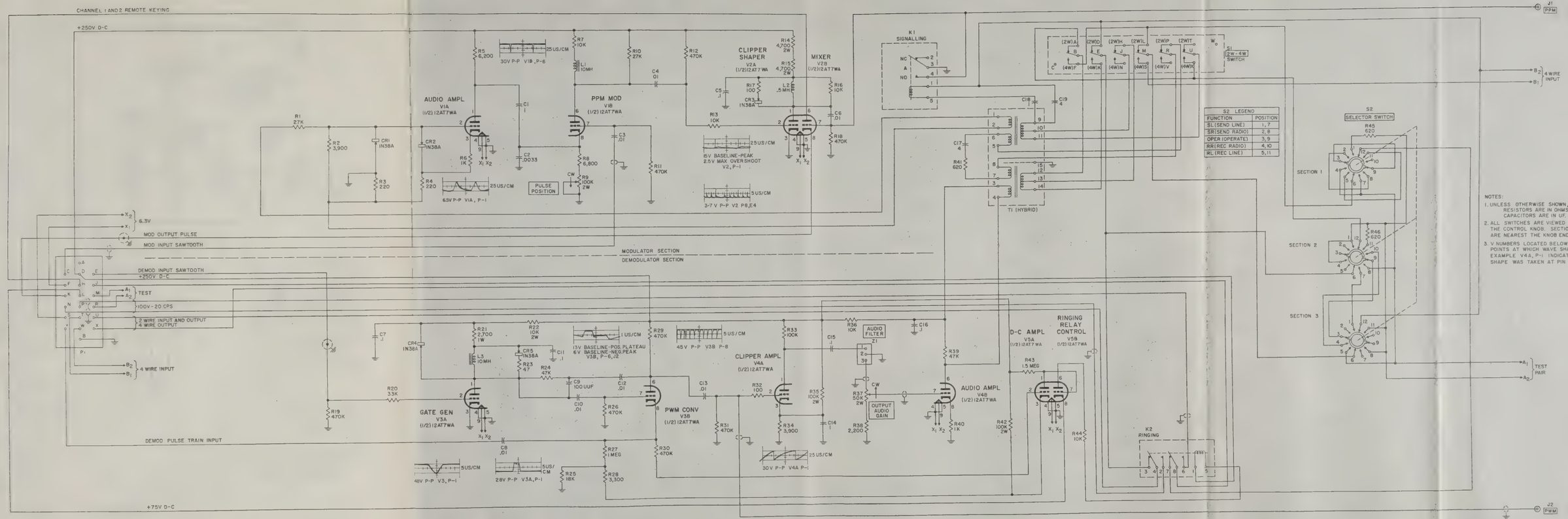
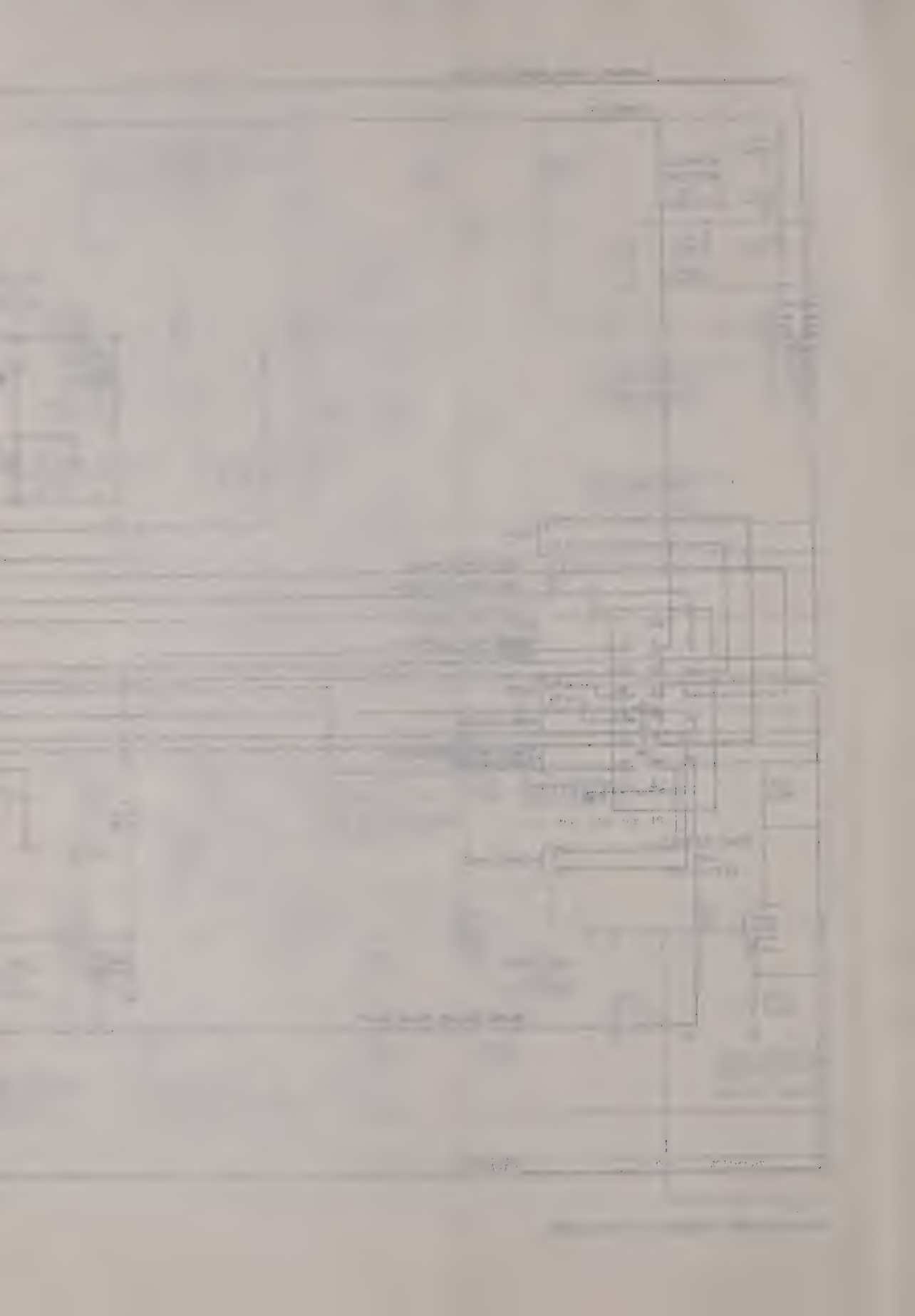
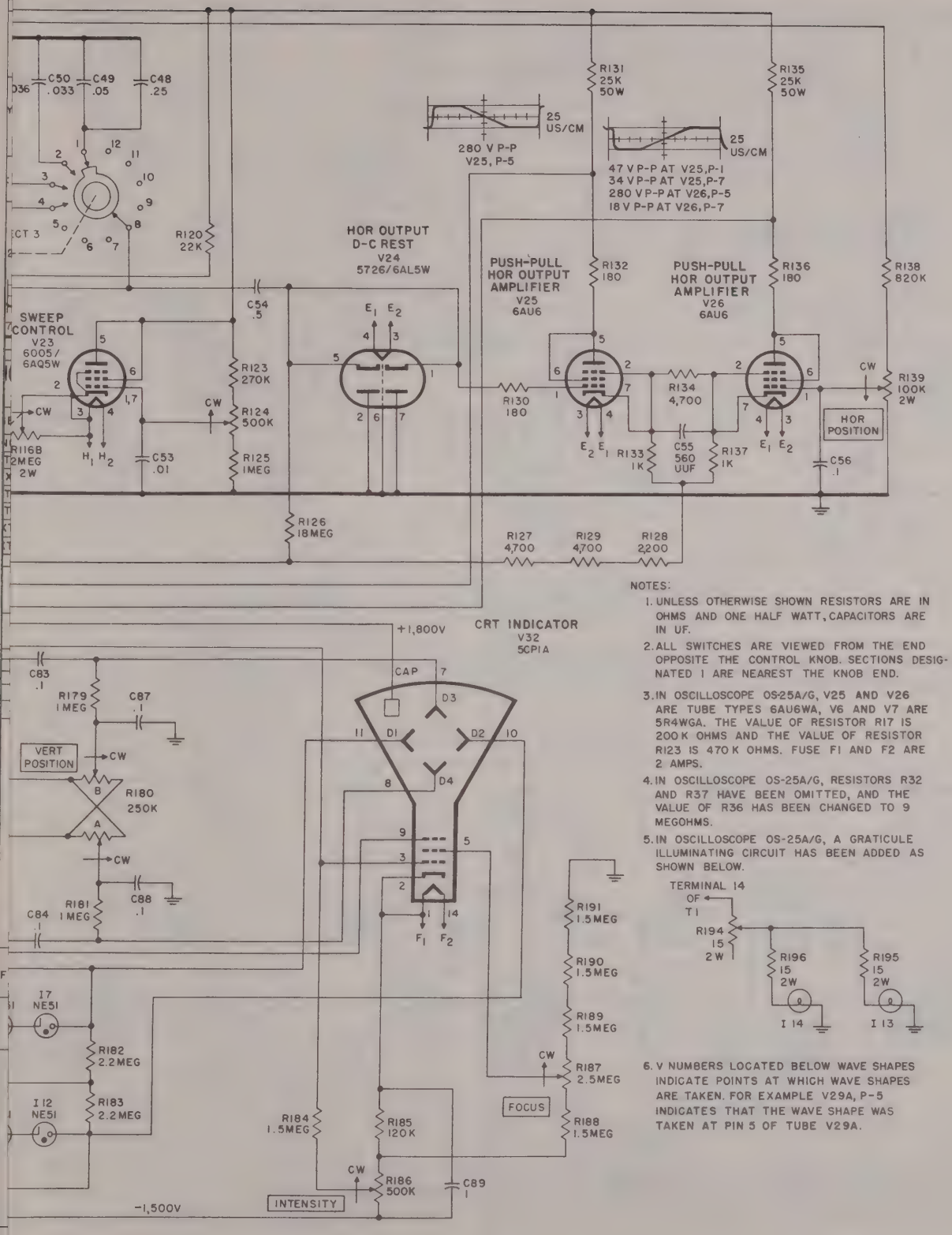


Figure 871.1. (Added) *Telephone Modem MD-179/TC, schematic diagram with waveforms.*





NOTES:

1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS AND ONE HALF WATT, CAPACITORS ARE IN UF.
2. ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB. SECTIONS DESIGNATED 1 ARE NEAREST THE KNOB END.
3. IN OSCILLOSCOPE OS-25A/G, V25 AND V26 ARE TUBE TYPES 6AU6WA, V6 AND V7 ARE 5R4WGA. THE VALUE OF RESISTOR R17 IS 200 K OHMS AND THE VALUE OF RESISTOR R123 IS 470 K OHMS. FUSE F1 AND F2 ARE 2 AMPS.
4. IN OSCILLOSCOPE OS-25A/G, RESISTORS R32 AND R37 HAVE BEEN OMITTED, AND THE VALUE OF R36 HAS BEEN CHANGED TO 9 MEGOHMS.
5. IN OSCILLOSCOPE OS-25A/G, A GRATICULE ILLUMINATING CIRCUIT HAS BEEN ADDED AS SHOWN BELOW.

6. V NUMBERS LOCATED BELOW WAVE SHAPES INDICATE POINTS AT WHICH WAVE SHAPES ARE TAKEN. FOR EXAMPLE V29A, P-5 INDICATES THAT THE WAVE SHAPE WAS TAKEN AT PIN 5 OF TUBE V29A.

TM2141-C2-4



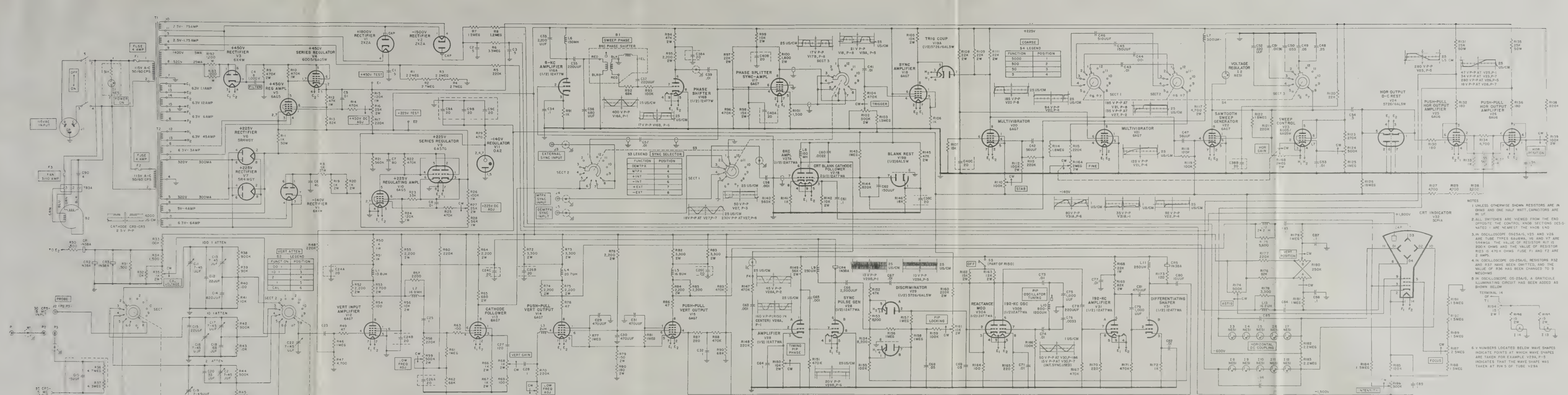
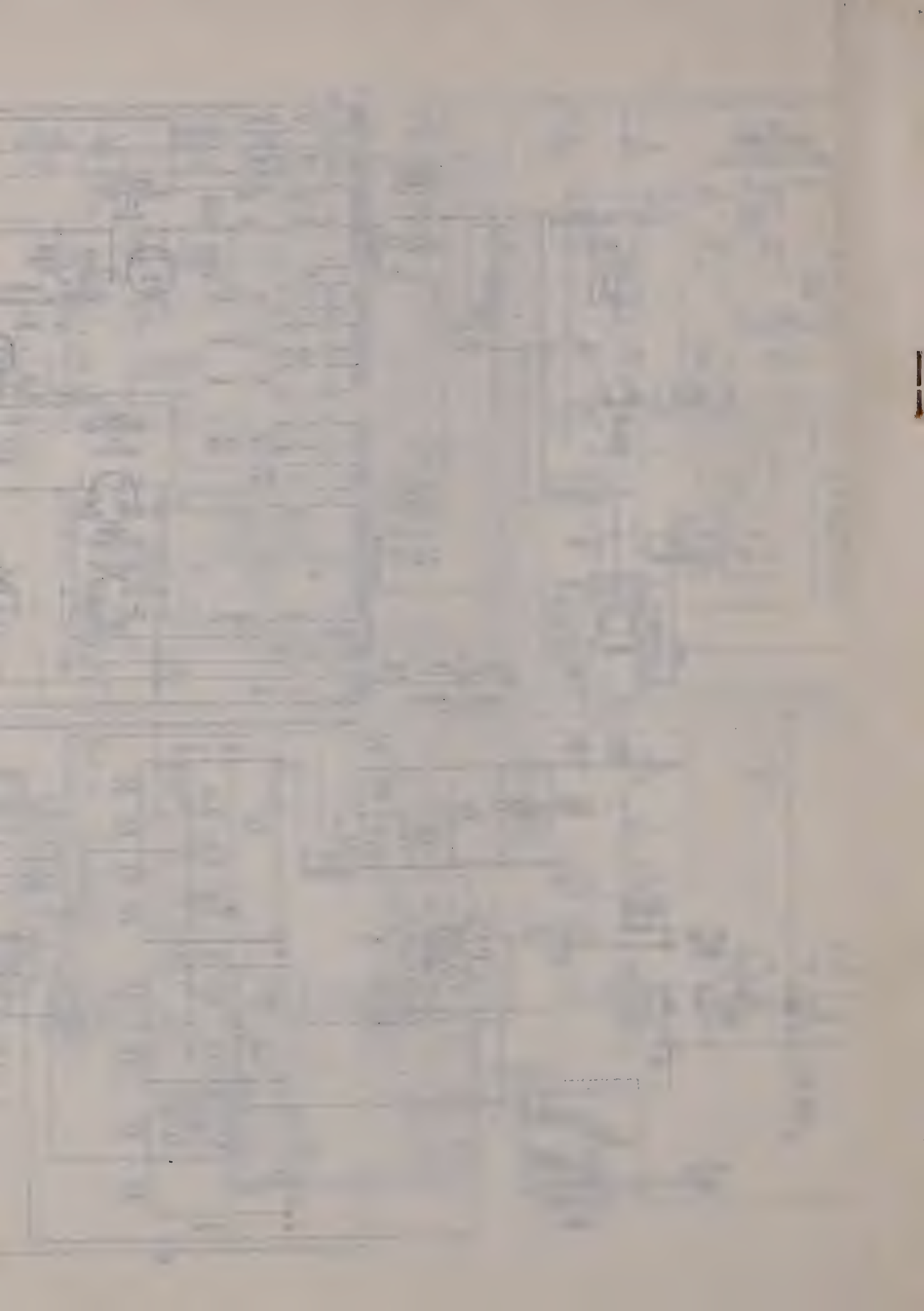


Figure 580. (Superseded) *Oscilloscope, schematic diagram.*



DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., 14 MARCH 1956

MULTIPLEXER SET AN/TCC-13
MULTIPLEXER GROUP AN/TCA-1
AND
PULSE FORM RESTORER GROUP AN/TRA-10

	Paragraph	Page
CHAPTER 1. INTRODUCTION		
Section I. General	1-2	1
II. Description and data	3-33	1-33
CHAPTER 2. INSTALLATION OF MULTIPLEXER SET AN/TCC-13		
Section I. Service upon receipt of equipment	34-41	35-44
II. Installation and adjustment procedures, four-wire operation	42-51	44-51
III. Installation and adjustment procedures, two-wire operation and remote keying operation	52, 53	51
IV. Installation and adjustment procedures, 45-channel operation	54-59	52-54
CHAPTER 3. INSTALLATION OF MULTIPLEXER GROUP AN/TCA-1 AND PULSE FORM RESTORER GROUP AN/TRA-10		
Section I. Service upon receipt of equipment	60-64	55-62
II. Installation and adjustment procedures	65-78	62-72
CHAPTER 4. OPERATION		
Section I. Controls and instruments	79-91	73-81
II. Operation under usual conditions	92-98	82-86
III. Operation under unusual conditions	99-102	86-87
CHAPTER 5. ORGANIZATIONAL MAINTENANCE		
Section I. Tools and equipment	103-105	88
II. Preventive maintenance services	106-110	89-90
III. Lubrication and weatherproofing	111, 112	93
IV. Trouble shooting Multiplexer Set AN/TCC-13 at organizational maintenance level	113-128	93-118
V. Trouble shooting Multiplexer Group AN/TCA-1 and Pulse Form Restorer Group AN/TRA-10 at organizational maintenance level	129-136	124-138
CHAPTER 6. AUXILIARY EQUIPMENT	137-147	139-145
CHAPTER 7. MULTIPLEXER SET AN/TCC-13 THEORY OF OPERATION		
Section I. Basic principles	148-153	146-150
II. Multiplexer Set AN/TCC-13 set theory	154-158	151-154
III. 23-channel modulating and multiplexing theory	159-178	154-168
IV. 23-channel demodulating and demultiplexing theory	179-191	168-178
V. 45-channel operation	192-194	179-181
VI. Remote keying circuits	195-197	182-185

		Paragraph	Page
CHAPTER 8.	**MULTIPLEXER GROUP AN/TCA-1 AND PULSE FORM RESTORER GROUP AN/TRA-10 THEORY OF OPERATION**		
Section I.	Application theory	198-204	186-192
II.	Theory of video restorer	205-212	192-197
III.	Demultiplexing and demodulating circuit	213-217	197-200
IV.	Modulating and multiplexing circuit	218-222	200-203
V.	Blanking and insert circuits	223-225	203-204
VI.	Audio terminations and alarm circuits	226-232	205-208
CHAPTER 9.	**POWER SUPPLIES AND TEST EQUIPMENT THEORY OF OPERATION**		
Section I.	Power supplies	233-236	209-214
II.	Oscilloscope OS-25/G	237-262	214-233
III.	Audio Test Set TS-762/TC	263-267	233-238
IV.	Control Monitor C-1151/TC	268-272	238-239
V.	Pulse Form Restorer Group AN/TRA-10 twenty-cycle ringing supply	273-276	239-240
CHAPTER 10.	**FIELD MAINTENANCE**		
Section I.	General trouble-shooting procedure	277-290	241-244
II.	Trouble shooting common unit multiplexer circuits	291-296	244-249
III.	Trouble shooting common unit demultiplexer circuits	297-301	251-256
IV.	Trouble shooting and testing Video Restorer TD-68/G	302-308	257-265
V.	Trouble shooting Telephone Modem MD-179/TC	309-317	265-273
VI.	Trouble shooting delay lines	318-322	273-276
VII.	Trouble shooting Electrical Equipment Rack MT-1665/TCC-13	323, 324	277
VIII.	Trouble shooting Electrical Equipment Rack MT-1433/TCA-1	325, 326	279
IX.	Trouble shooting Electrical Equipment Rack MT-1434/TRA-10	327-333	283-288
X.	Trouble shooting Multiplexer Subassembly MX-1442/TC	334-339	289-293
XI.	Trouble shooting Power Supply PP-691/G	340-344	294-297
XII.	Trouble shooting Voltage Regulator CN-236/G	345-350	298-299
XIII.	Trouble shooting Oscilloscope OS-25/G	351-356	302-312
XIV.	Trouble shooting Control Monitor C-1151/TC	357-361	321-322
XV.	Trouble shooting Audio Test Set TS-762/TC	362-366	323-331
XVI.	Trouble shooting switch box	367-369	332
XVII.	Repairs	370, 371	333
CHAPTER 11.	**ALIGNMENT, ADJUSTMENT AND FINAL TESTING**		
Section I.	Alignment, adjustment, and final testing of Multiplexer Set AN/TCC-13	372-382	334-336
II.	Alignment, adjustment, and final testing of Multiplexer Group AN/TCA-1 and Pulse Form Restorer Group AN/TRA-10	383-404	337-347
CHAPTER 12.	**SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE**	405-409	348-349
APPENDIX	**TABLE OF COMPONENTS**	1-3	350-355
INDEX		....	365-371

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

a. This manual contains instructions for the installation, operation, maintenance, and repair of Multiplexer Set AN/TCC–13 (fig. 1), Multiplexer Group AN/TCA–1 (fig. 2), and Pulse Form Restorer Group AN/TRA–10 (fig. 3). A list of components is given in the appendix.

b. Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 are used as terminals, drop-and-insert terminals, and pulse form restorers, respectively, in a 23- or 45-channel microwave radio-relay system.

c. Forward comments on this publication directly to: Commanding Officer, The Signal Corps Publications Agency, Fort Monmouth, New Jersey.

2. Forms and Records

a. Unsatisfactory Equipment Reports.

(1) DA Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in SR 700–45–5.

(2) DD Form 535, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700–45–5 and AF TO 00–35D–54.

b. Damaged or Improper Shipment. DD Form 6, Report of Damaged or Improper Shipment will be filled out and forwarded as prescribed in SR 74–45–5 (Army); Navy Shipping Guide, Article 1850–4 (Navy); and AFR 71–4 (Air Force).

c. Preventive Maintenance Forms.

(1) DA Form 11–238, (fig. 60) Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar) will be prepared in accordance with the instructions on the back of the form.

(2) DA Form 11–239, (fig. 61) Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form.

Section II. DESCRIPTION AND DATA

3. Purpose and Use

a. Multiplexer Set AN/TCC–13 (fig. 1).

(1) Multiplexer Set AN/TCC–13 is used as a terminal in a multichannel microwave radio-relay communication network. Multiplexer Sets AN/TCC–13 are used in pairs, one at each end of the system.

(2) Multiplexer Set AN/TCC–13 combines 23 independent voice-frequency (vf) channels into a common video signal for transmission over a single radio-

frequency (rf) carrier. Conversely, it separates an incoming common video signal into 23 individual vf channels. Thus, two Multiplexer Sets AN/TCC–13 (one at each terminal) provide two-way communications for up to 23 telephone channels; four (two at each terminal) can be used for 45 simultaneous telephone channels. Multiplexer Set AN/TCC–13 can be used only with a manual switchboard, and can be operated on either a 2-wire or 4-wire basis for each of the 23 standard telephone channels.

(3) Multiplexer Set AN/TCC–13 has the following features:

(*a*) Complete vf facilities are provided on each of the 23 channels

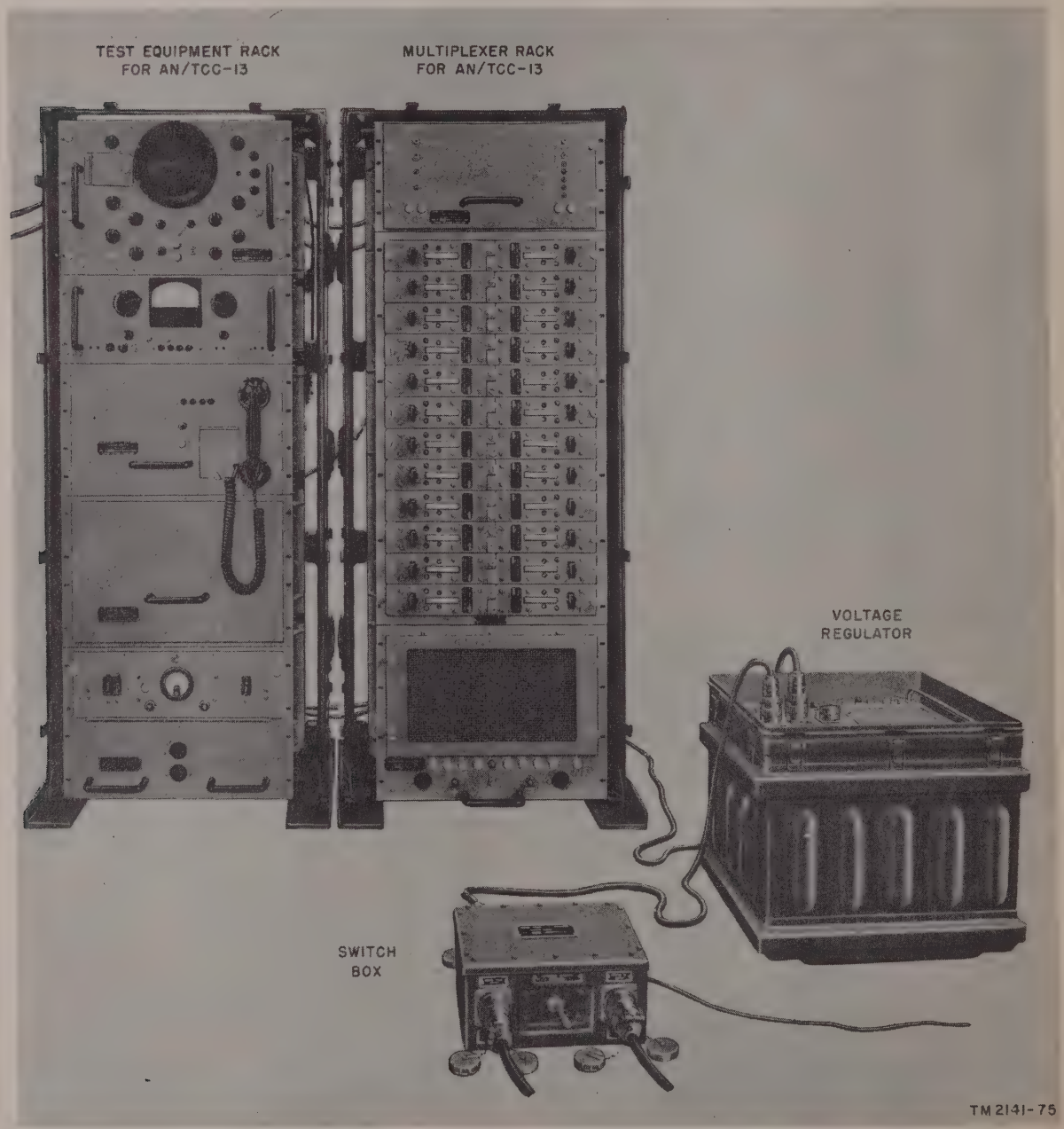


Figure 1. Multiplexer Set AN/TCC–13, in operation.

(voice, telemetering, facsimile, or vf telegraph).

(*b*) Order-wire operation on channel 1 enables the operator to communicate with other operators for testing, alignment, and maintenance.

(*c*) Very-high-frequency (vhf) remote keying facilities are provided on channels 1 and 2. This extends the range of vhf mobile units over the full length of the radio-relay network of which the multiplexer group is a part (par. 195*b*)

Note. The remote keying facilities on each channel is provided only on a party-line basis. This party-line operation furnishes the audio signal on a two-wire connection. A hybrid coil arrangement is required in the vhf equipment to keep the receiver and transmitter signals separated.

(*d*) Each channel is monitored by the local telephone.

(*e*) Ringing circuits on each channel permit the transmission of a 20-cycle-per-second (cps) signal to call the operator at the other site.

(*f*) An alarm circuit indicates failure of the incoming pulse train.

(*g*) Test equipment necessary for testing, alignment, and maintenance is provided.

(4) The use of the Multiplexer Set AN/TCC–13 as a terminal in a microwave radio-relay system is shown in figure 4. Two terminals are shown: the *east* terminal and the *west* terminal. One

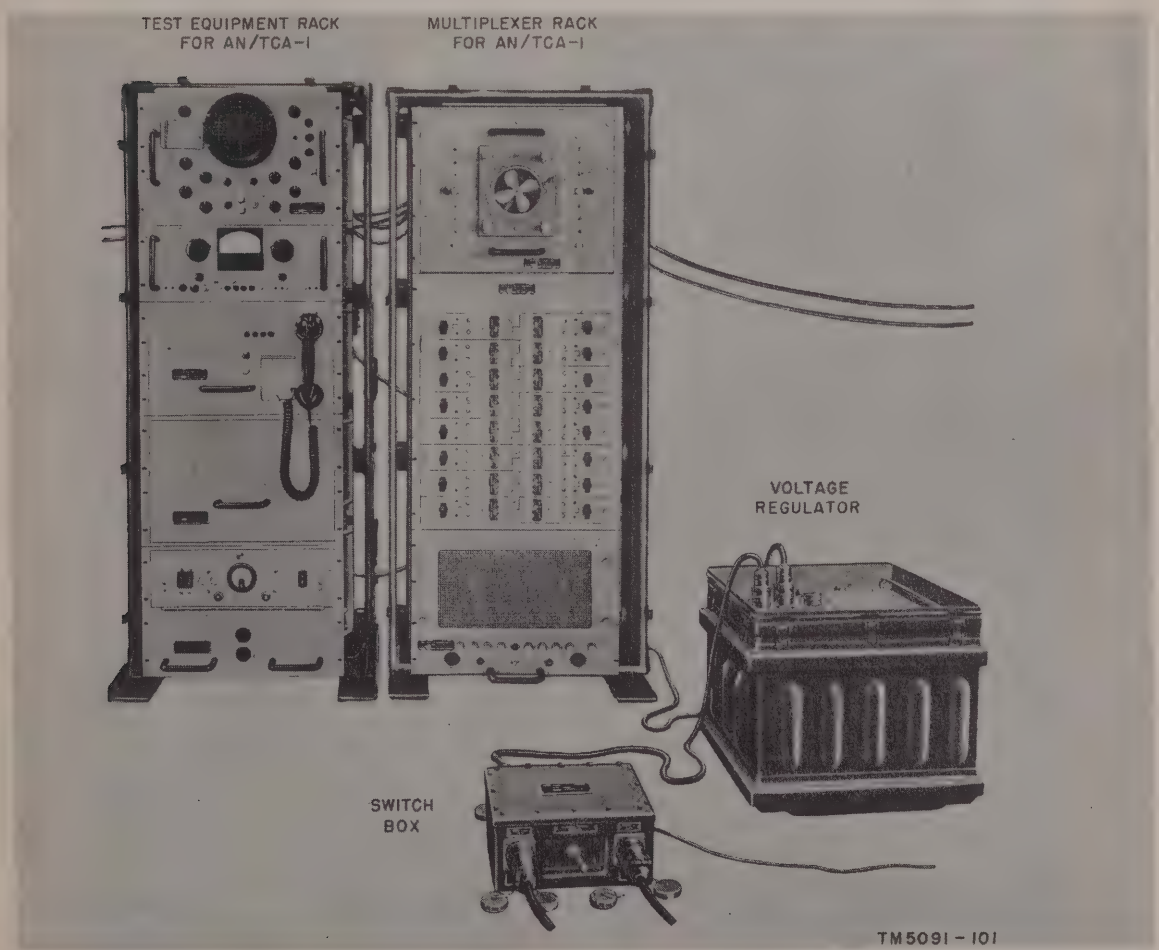


Figure 2. Multiplexer Group AN/TCA–1, in operation.

Radio Set AN/TRC–29 is normally used at each terminal.

b. Multiplexer Group AN/TCA–1 (fig. 2)

(1) Multiplexer Group AN/TCA–1 is designed primarily for use as a drop-and-insert terminal at a radio-relay link in a multichannel microwave radio-relay communication network. It can provide eight independent vf communication channels at a repeater station. Its use is limited to a system using Multiplexer Sets AN/TCC–13 as terminals.

(2) Multiplexer Group AN/TCA–1 is also used to restore the 23- or 45-channel video pulse train (from the radio receiver) into a standard wave shape (before it is fed into the transmitter). The use of Multiplexer Group AN/TCA–1 as part of a microwave radio-relay communication link is shown in figure 5. Multiplexer Group

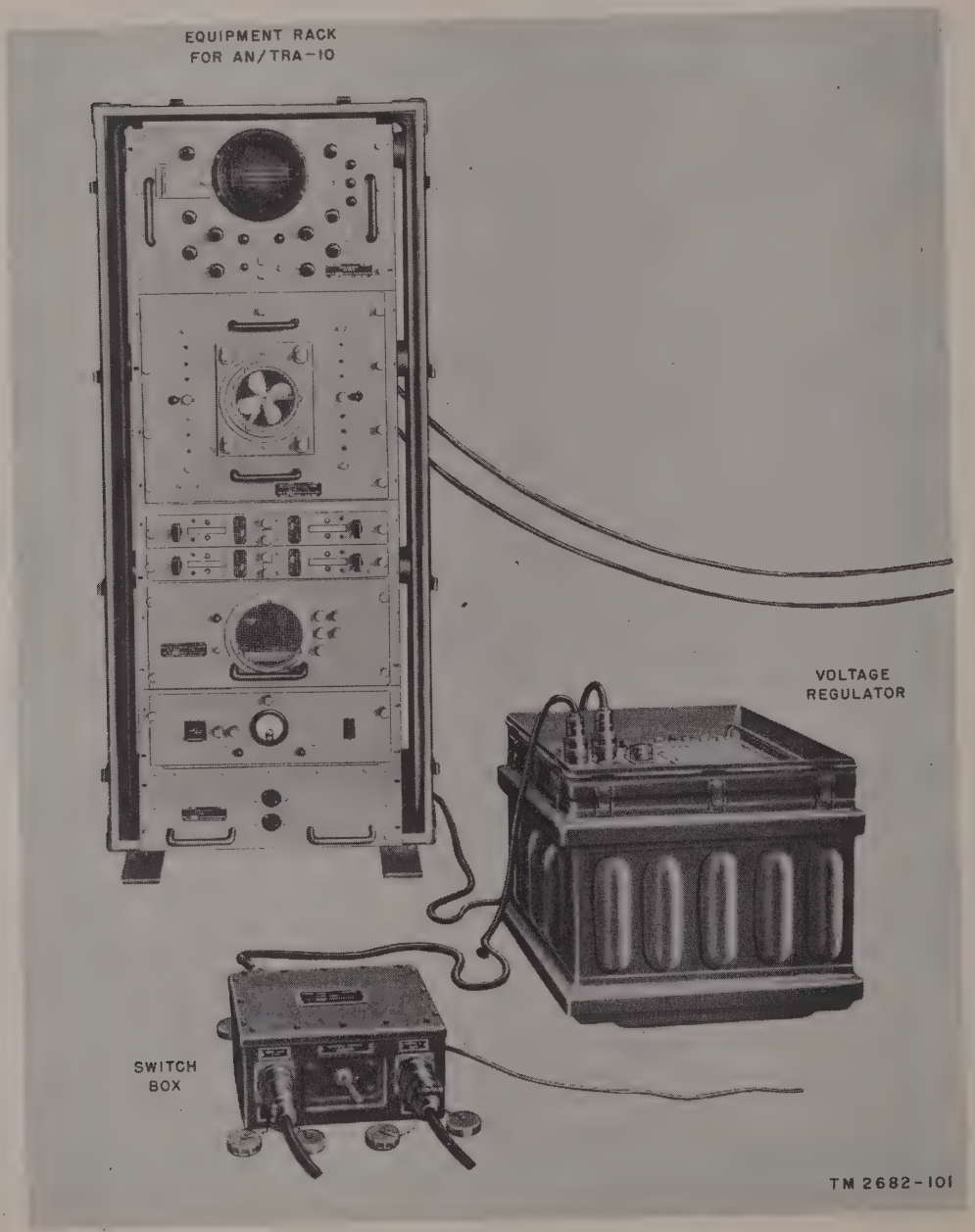


Figure 3. Pulse Form Restorer Group AN/TRA–10, in operation.

AN/TCA–1 is usually placed between two Radio Sets AN/TRC–29 at a drop-and-insert repeater station.

(3) Multiplexer Group AN/TCA–1 has the following features:

(*a*) Eight vf communication channels can be used for vf telemetering, facsimile, or vf telegraph. Each of the eight channels can be dropped for local use or passed on a *through* basis.

(*b*) All 23 or 45 receive channels are reshaped.

(*c*) Channels 1 (the order-wire channel) and 2 can be used for either private- or party-line operation; channels 3 through 8 can be used *only* for private-line operation. Each channel can be terminated into a two-wire or four-wire line.

(*d*) Channels 1 and/or 2 can be used for order-wire operation and/or normal communications. Order-wire operation enables the operators of the communication link to communicate with each other for maintenance, alignment, and testing.

(*e*) Channels 1 and/or 2 can be used for remote keying between vhf mobile equipments to extend the range of the vhf units over the full length of the radio-relay communication system of which the multiplexer group is a part (par. 195*b*).

Note. The remote keying facilities on each channel furnish the audio signal on a two-wire line (party-line) so that a hybrid is required in the vhf equipment to keep the receiver and transmitter signals separate.

(*f*) Ringing circuits permit the transmission of a 20-cps signal to call the operator at the other end of the channel.

(*g*) An alarm circuit is included to indicate the failure of inputs, outputs, and high noise levels. The alarm circuit also disables local ringing on the channels and thereby eliminates false ringing.

Note. Should the equipment become disabled, the alarm circuit will automatically bypass the multiplexer group and cause no interruption of terminal-to-terminal traffic. If this happens, drop-and-insert facilities are not available at the drop-and-insert repeater.

(*h*) Test equipment necessary for the complete alignment testing, and maintenance of Multiplexer Group AN/TCA–1 is provided.

c. Pulse Form Restorer Group AN/TRA–10 (fig. 3)

(1) The primary purpose of the Pulse Form Restorer Group AN/TRA–10 is to reshape the 23- or 45-channel pulse train received from the radio receiver into a standard wave shape before it is fed to the transmitter at a repeater station in a microwave radio-relay system. The use of Pulse Form Restorer Group AN/TRA–10 solely for wave-form restoration is not necessary at every hop in the relay system. It is necessary to insert Pulse Form Restorer Group AN/TRA–10 at a repeater solely for restoration of the pulse train wave shapes every several hops. A secondary purpose of the equipment is to provide communications at the repeater station by two drop-and-insert channels.

(2) The use of Pulse Form Restorer Group AN/TRA–10 as part of a communication system is illustrated in figure 5. Two Radio Sets AN/TRC–29 are used: one coupled to the eastgoing, and one coupled to the westgoing sections of the Pulse Form Restorer Group AN/TRA–10. A repeater in which Pulse Form Restorer Group AN/TRA–10 is used is called a *pulse-forming repeater station.*

(3) Pulse Form Restorer Group AN/TRA–10 has the following features:

(*a*) All 23 or 45 receive channels are reshaped.

(*b*) Each of the two drop-and-insert channels (channels 1 and 2) provides complete voice-channel facilities. Each channel can be used for the transmission and reception of such signals as voice, signaling, telemetering, facsimile, and vf telegraph.

(*c*) Channels 1 and/or 2 can be dropped for local use or passed on a *through* basis. When dropped for local use, they can be used for party-line or private-line operation. The local connection can be either two-wire or four-wire.

(*d*) The two channels can be used for remote keying between very-high-frequency mobile equipments to extend the range of mobile communications over the entire length of the radio-relay communication system of which the restorer is a part. The remote keying facility on each channel is provided only on a party-line basis. The party-line operation furnishes the audio signal on a two-wire connection to the vhf equipment which is operated on a push-to-talk basis (*a*(3)(*c*) above).

(*e*) Personnel at a drop-and-insert repeater (restorer location) can utilize a field telephone, such as Telephone EE–8–B, on the channel 1 PARTY LINE binding posts to provide order-wire facilities in conjunction with the multiplexer sets, multiplexer groups, and other pulse form restorer groups.

(*f*) Ringing circuits in each channel permit transmission of a 20-cps ringing signal for calling the operator at the other end of the channel.

(*g*) An alarm circuit is included to indicate failure of inputs and outputs, and to indicate high noise levels. The alarm circuit also disables local ringing to eliminate false ringing on the channels. Should the equipment become disabled for any of the reasons mentioned, the restorer group will be bypassed and cause no interruption in terminal-to-terminal traffic. However, there will be no drop-and-insert facilities at the repeater.

(*h*) An oscilloscope is provided for maintenance, testing, and alignment.

4. System Applications

(fig. 4 and 5)

a. General. The applications of Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 are described in *a* through *c* below. The equipments are part of a transportable multichannel radio communication system. Multiplexer Set AN/TCC–13 converts up to 23 channels of audio information into a single pulse position modulated-time division multiplexed (ppm-tdm) pulse train. The train is then fed to a radio-frequency link which transmits the signal to the desired terminal, often by a series of repeaters. At the distant terminal the pulse train is fed to another Multiplexer Set AN/TCC–13 which demultiplexes and demodulates the pulse train into the original number of audio information channels. One or more channels may be dropped from the transmitted pulse train by drop-channel equipment at the various repeaters.

(1) *Multiplexer Set AN TCC–13.* Multiplexer Set AN/TCC–13, in conjunction with two Radio Sets AN/TRC–29 (one used as a spare) and auxiliary components, comprises Radio Telephone Terminal Set AN/TRA–38. Each Radio Telephone Terminal Set AN/TRC–38 is a terminal station in a radio-relay system. Two Radio Telephone Terminal Sets AN/TRC–38 (with repeater stations as required) comprise a time-division multiplex radio-relay system.

(2) *Pulse Form Restorer Group AN/TRA–10.* Pulse Form Restorer Group AN/TRA–10, inserted between two Radio Sets AN/TRC–29 at a drop-

channel repeater station, can be used to extract one or both of the first two audio channels included in the time-division multiplexed (tdm) pulse train, and to insert locally generated pulses back into the pulse train. In this way, it is possible to provide branching use of two telephone channels at the repeater station. Two channels are inserted or dropped from each of the two pulse trains, providing a maximum of four one-way channels, two for each direction of transmission. A two-channel, drop-and-insert repeater station consisting of three Radio Sets AN/TRC–29 (one spare), one Pulse Form Restorer Group AN/TRA–10 and auxiliary components comprises Radio Repeater Set AN/TRC–40.

(3) *Multiplexer Group AN/TCA–1.* Multiplexer Group AN/TCA–1, inserted between two Radio Sets AN/TRC–29 at a drop-channel repeater station, can be used to extract the first eight audio channels of the tdm pulse train and to insert these audio channels back into the tdm signal. It is possible, therefore, to provide branching use of up to eight telephone channels at the repeater station. Eight channels are inserted or dropped from each of the two pulse trains; therefore, the multiplexer group can provide 16 channels (eight for each direction of transmission). An eight-channel, drop-and-insert repeater station consisting of three Radio Sets AN/TRC–29 (one spare) and one Multiplexer Group AN/TCA–1 comprises Radio Repeater Set AN/TRC–41.

(4) *System equipments.* The chart below lists the equipment and components used in a ppm-tdm microwave radio-relay system employing the equipment described in this manual.

Radio Telephone Terminal AN/TRC–38	Radio Repeater SET AN/TRC–39	Radio Repeater Set AN/TRC–40	Radio Repeater Set AN/TRC–41
2 Radio Sets AN/TRC–29.	3 Radio Sets AN/TRC–29.	3 Radio Sets AN/TRC–29.	3 Radio Sets AN/TRC–29.
1 Multiplexer Set AN/TCC–13.	1 Tower AB–216/U.	1 Pulse Form Restorer Group AN/TRA–10.	1 Multiplexer Group AN/TCA–1.
1 Tower AB–216/U.	2 groups of special procurement components. Field Wire WD–1/TT.	1 Tower AB–216/U	1 Tower AB–216/U.
1 Group of special procurement components. Field Wire WD–1/TT.		2 groups of special procurements components. Field Wire WD–1/TT.	1 Group of special procurement components. Field Wire WD–1/TT.

b. Single Hop, Terminal to Terminal.

(1) Figure 4 is a block diagram of a 23-channel ppm-tdm system using two Radio Telephone Terminals Sets AN/TRC–38. This system provides multichannel telephone trunk service between the two terminals. For convenience the radio telephone terminal sets are called *east* terminal and *west* terminal throughout the manual.

(2) At the *west* terminal, incoming vf telephone signals from a manual switchboard (which may be located some distance away from the multiplexer set) are fed into the modulator and multiplexer circuits of Multiplexer Set AN/TCC–13. In the modulator and multiplexer, the vf signals are converted into a series of ppm-tdm pulses. These pulses are fed to Radio Set AN/TRC–29 to frequency modulate the transmitter. The modulated microwave carrier is then fed through a duplexer to an antenna and transmitted to the *east* terminal. With the duplexer, one antenna can be used for both transmitter and receiver.

(3) At the *east* terminal the antenna picks up the signal and feeds it through a duplexer to the radio receiver. The output of the receiver is a pulse train consisting of a series of ppm-tdm pulses. The pulse train is fed to the demultiplexer and demodulator section of Multiplexer Set AN/TCC–13. Here the channel pulses are separated and demodulated and the proper vf channels are distributed to the telephone lines and to the manual switchboard. Communications from *west* to *east* take a similar path. Duplicate facilities are made available to each station: one for *east* to *west* traffic and one for *west* to *east* traffic. Each of the incoming or outgoing vf channels can be connected on a two-wire or four-wire basis.

c. Multiple-hop Radio-relay System. A block diagram of a microwave radio-relay system utilizing Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 is shown in figure 5. Note that Multiplexer Set AN/TCC–13 is used only at terminal stations. At *through* repeaters (AN/TRC–39), where no multiplexing or demultiplexing equipment is used, the video output of the radio receiver is fed directly into the input of the radio transmitter. To drop channels, to an audio basis, or to insert them at a repeater station (called a *drop-channel repeater*), Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 is used. If the prime function of the repeater is to restore the video signal to the required level, Pulse Form Restorer Group AN/TRA–10 is used. If the repeater is one in which the prime function is to drop branching audio channels, Multiplexer Group AN/TCA–1 is used. Pulse Form Restorer Group AN/TRA–10 provides facilities for two drop-and-insert channels, and Multiplexer Group AN/TCA–1 provides facilities for eight drop-and-insert channels.

Note. Use of the equipment is not limited to that shown in figure 5.

5. Technical Characteristics

The following characteristics apply to the Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 unless otherwise noted.

a. General.

Type of modulation	Pulse position.
Type of multiplexing	Time division.
Number of channels	AN/TCC–13: 23; AN/TCA–1: 8; AN/TRA–10; 2.

b. Audio Channel.

Input level for full modulation (private operation) ...	0 dbm, 2-wire; —4 dbm, 4-wire.
Output level for full modulation (private operation) ...	—3 dbm, 2-wire; 0 dbm, 4-wire.
Termination	600 ohms, 2-wire or 4-wire.

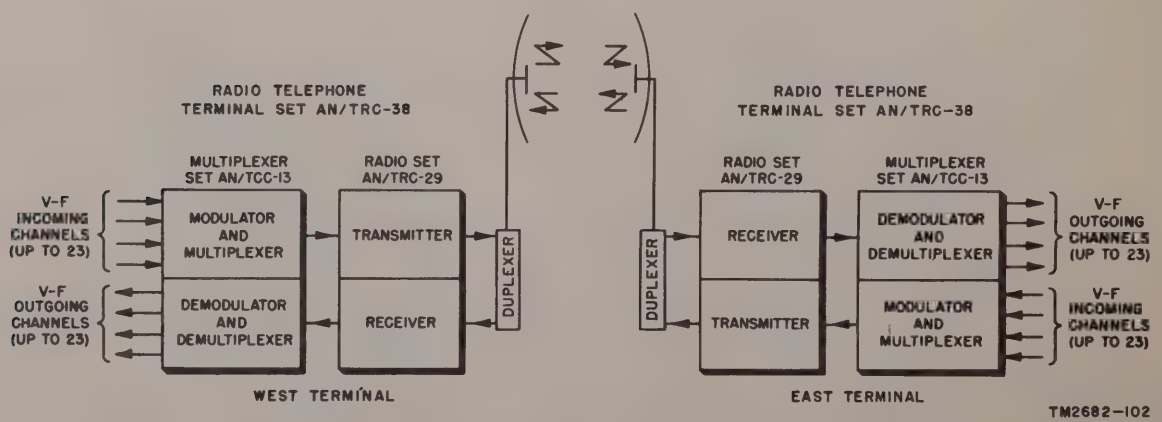
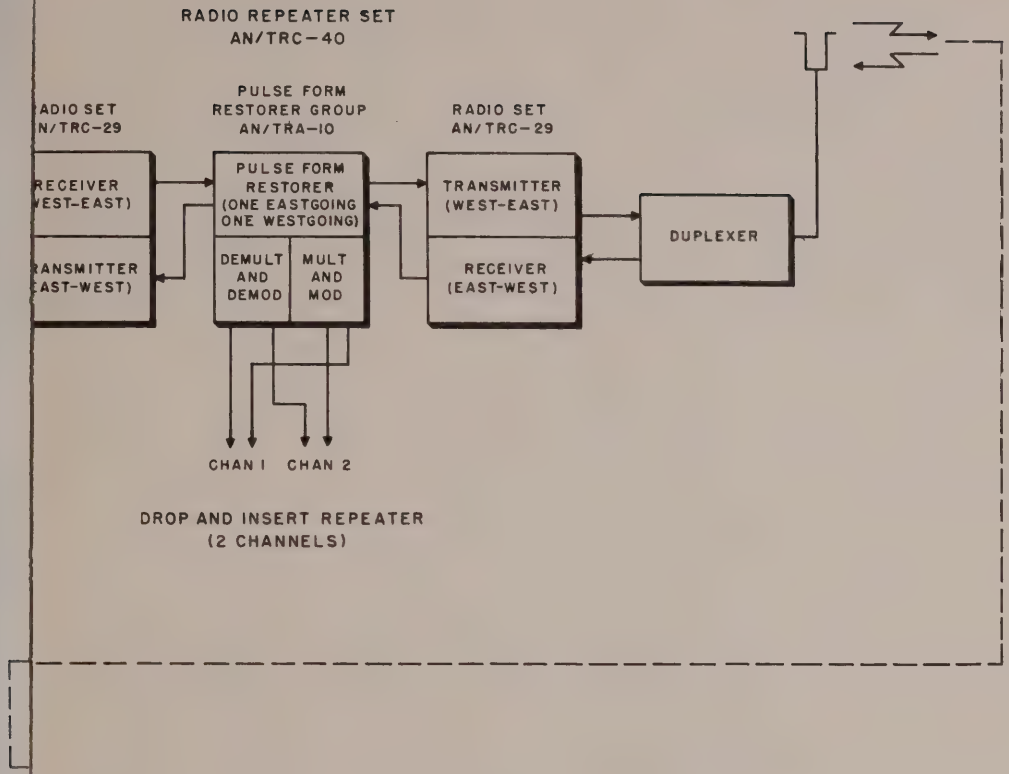


Figure 4. Single-hop, ppm-tdm radio-relay system, block diagram.


RADIO REPEATER SET
AN/TRC-40
ADIO SET
N/TRC-29
PULSE FORM
RESTORER GROUP
AN/TRA-10
RADIO SET
AN/TRC-29
RECEIVER
WEST-EAST)
RANSMITTER
EAST-WEST)
PULSE FORM
RESTORER
(ONE EASTGOING
ONE WESTGOING)
DEMULT
AND
DEMOD
MULT
AND
MOD
TRANSMITTER
(WEST-EAST)
RECEIVER
(EAST-WEST)
DUPLEXER
CHAN 1
CHAN 2
DROP AND INSERT REPEATER
(2 CHANNELS)

TM2141-400

(3) At the *east* terminal the antenna picks up the signal and feeds it through a duplexer to the radio receiver. The output of the receiver is a pulse train consisting of a series of ppm-tdm pulses. The pulse train is fed to the demultiplexer and demodulator section of Multiplexer Set AN/TCC–13. Here the channel pulses are separated and demodulated and the proper vf channels are distributed to the telephone lines and to the manual switchboard. Communications from *west* to *east* take a similar path. Duplicate facilities are made available to each station: one for *east* to *west* traffic and one for *west* to *east* traffic. Each of the incoming or outgoing vf channels can be connected on a two-wire or four-wire basis.

c. Multiple-hop Radio-relay System. A block diagram of a microwave radio-relay system utilizing Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 is shown in figure 5. Note that Multiplexer Set AN/TCC–13 is used only at terminal stations. At *through* repeaters (AN/TRC–39), where no multiplexing or demultiplexing equipment is used, the video output of the radio receiver is fed directly into the input of the radio transmitter. To drop channels, to an audio basis, or to insert them at a repeater station (called a *drop-channel repeater*), Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 is used. If the prime function of the repeater is to restore the video signal to the required level, Pulse Form Restorer Group AN/TRA–10 is used. If the repeater is one in which the prime function is to drop branching audio channels, Multiplexer Group AN/TCA–1 is used. Pulse Form Restorer Group AN/TRA–10 provides facilities for two drop-and-insert channels, and Multiplexer Group AN/TCA–1 provides facilities for eight drop-and-insert channels.

Note. Use of the equipment is not limited to that shown in figure 5.

5. Technical Characteristics

The following characteristics apply to the Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 unless otherwise noted.

a. General.

Type of modulation	Pulse position.
Type of multiplexing	Time division.
Number of channels	AN/TCC–13: 23; AN/TCA–1: 8; AN/TRA–10; 2.

b. Audio Channel.

Input level for full modulation (private operation) ...	0 dbm, 2-wire; —4 dbm, 4-wire.
Output level for full modulation (private operation) ...	—3 dbm, 2-wire; 0 dbm, 4-wire.
Termination	600 ohms, 2-wire or 4-wire.

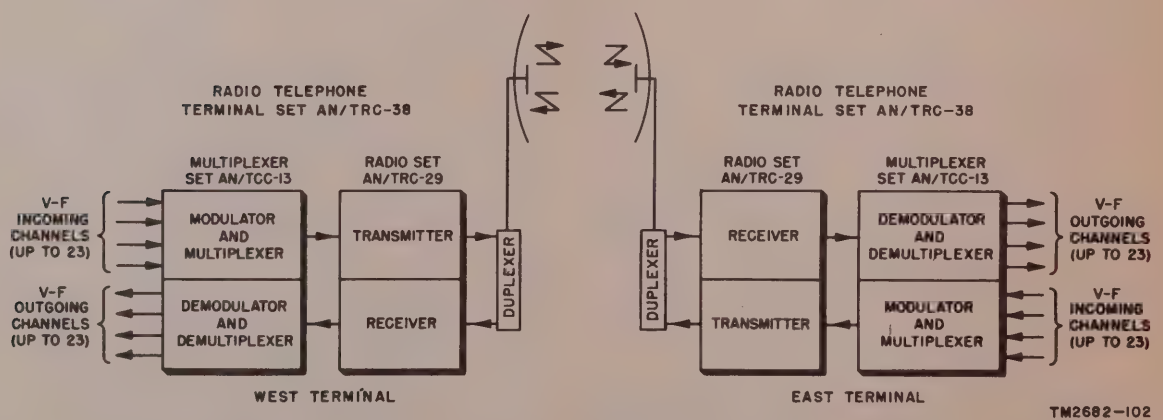


Figure 4. Single-hop, ppm-tdm radio-relay system, block diagram.

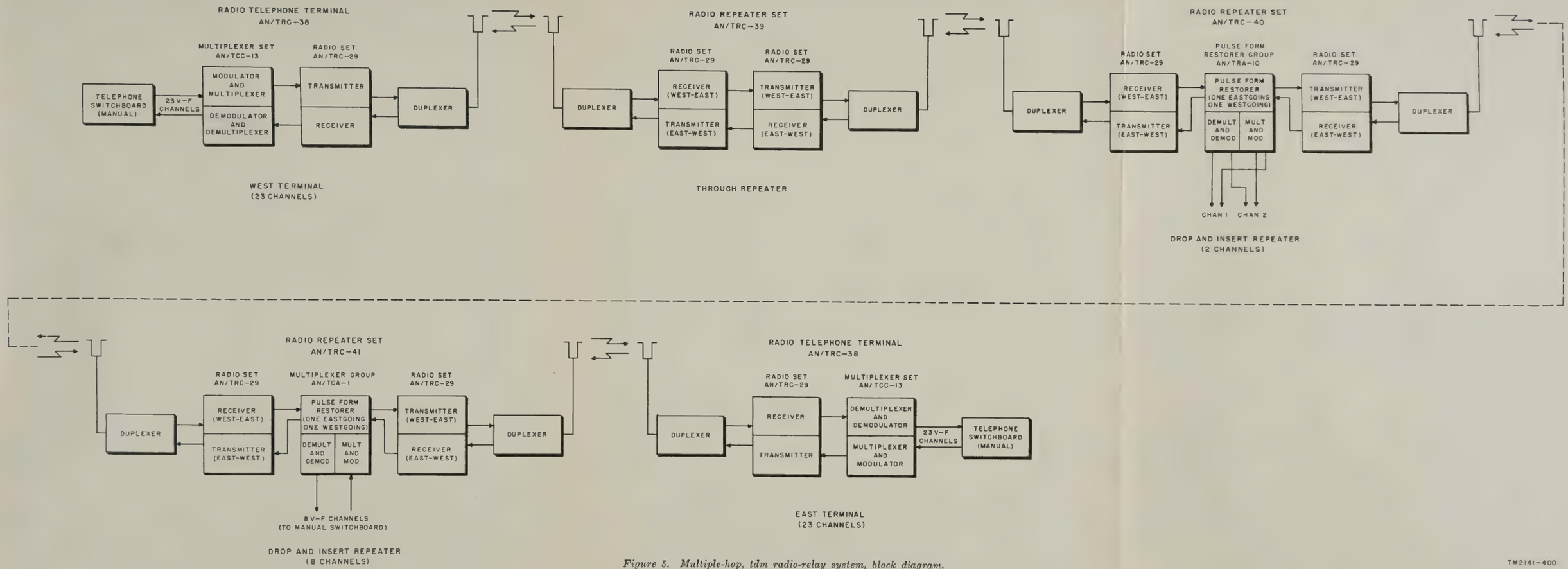


Figure 5. Multiple-hop, tdm radio-relay system, block diagram.

Signaling ..... 20 cps.
Modulating bandwidth... 300 cps to 3,500 cps.
Signal-to-noise ratio (F1A) 60 db minimum (23 or 45 channel).
Signal to cross-talk ratio 55 db minimum (one loop).
Distortion ..... 4 per cent maximum.

c. Video Characteristics.

Pulse deviation ..... ±½ microsecond at 100 per cent modulation.
Pulse rate ..... 192 kc.
Pulse width ..... 0.6 microsecond.
Pulse rise time ..... 0.3 microsecond.
Impedance ..... 50 ohms.
Amplitude ..... AN/TCC–13: .5 volts; AN/TRA–1 and AN/TRA–10: .22 to .66 volt (23 channel); .45 to .9 volt (45 channel).
Bandwidth ..... 1 mc.

d. Party-line Operation (2-wire only, 600 Ohms).

Input level ..... 0 dbm.
Output level (terminal to terminal) ..... —3 dbm.
Output level (terminal to repeater) ..... 7 dbm.
Output level (repeater to repeater) ..... —10 dbm.

e. Oscilloscope OS–25/G.

Bandwidth ..... 6 mc.
Vertical sensitivity ..... 2.5 volts per cm max with 10 to 1 probe; .25 to .3 volts per cm max without probe.
Time base ..... .5 to 5,000 microsecond per cm.
Presentation ..... 5 in. crt.

f. Audio Test Set TS–762/TC.

Note. Not supplied as part of Pulse Form Restorer Group AN/TRA–10.

Test frequency ..... 1,000 cps.
Test level ..... —35 to +10 dbm.
Level measurements .... —70 to +10 dbm.
Audio filters ..... F1A for noise weighting; 1,000-cps rejection for distortion.

g. Power.

Supply voltage ..... 115 ±10% or 230 v ±10%, 47.5 to 63 cps.
Power consumption ..... AN/TCC–13; 1.1 kw; AN/TCA–1: 1.1 kw; AN/TRA–10: 785 W.

6. Packaging Data

a. Export Shipment. When packaged for shipment, the components of the multiplexer set, the multiplexer group, and the pulse form restorer group are placed in moisture-vaporproof containers. Figures 26 and 27 are cutaway views of typical crates packed for export shipment.

b. Crating. The equipment covered in this manual is never used alone, but it is always shipped as part of the microwave radio-relay system described in paragraph 4. The chart below describes the crates that contain the equipment.

c. Packaging Data Chart.

(1) *Multiplexer Set AN/TCA–13.*

Crate No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Weight (lb)	Contents
1 of 6	74¾	39½	35⅝	60.8	900	Multiplexer rack
2 of 6	74¾	39½	35⅝	60.8	900	Test rack
3 of 6	29⅛	24	30⅛	12.2	290	Voltage regulator
4 of 6	23½	29¾	24⅛	9.8	176	Accessories case 1
5 of 6	23½	29¾	24⅛	9.8	200	Accessories case 2
6 of 6	12	29½	29½	6.1	130	Cable and reel
Total				159.5	2,596	

(2) *Multiplexer Group AN/TCA–1.*

Crate No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Weight (lb)	Contents
1 of 6	74¾	39½	35⅝	60.8	880	Multiplexer rack
2 of 6	74¾	39½	35⅝	60.8	900	Test rack
3 of 6	29⅛	24	30⅛	12.2	290	Voltage regulator
4 of 6	23½	29¾	24⅛	9.8	176	Accessories case 1
5 of 6	23½	29¾	24⅛	9.8	200	Accessories case 2
6 of 6	12	29½	29½	6.1	130	Cable and reel
Total				159.5	2,576	

(3) *Pulse Form Restorer Group AN/TRA–10.*

Crate No.	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Weight (lb)	Volume
1 of 5	74¾	39½	30⅝	60.8	960	Equipment rack
2 of 5	29⅛	24	30⅛	12.2	290	Accessories case 1
3 of 5	23½	29¾	24⅛	9.8	176	Accessories case 2
4 of 5	23½	29¾	24⅛	9.8	190	Voltage regulator
5 of 5	12	29½	29½	6.1	130	Cable and reel
				98.7	1,746	

7. Common Names and Nomenclature

A list of the nomenclature assignments for the components of Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 are given below. A common usage name is indicated after each component. Common names for the major equipment are also given.

Nomenclature	Common name
Multiplexer Set AN/TCC–13	Multiplexer set, terminal
Multiplexer Group AN/TCA–1	Multiplexer group, drop-and-insert terminal
Pulse Form Resistor Group AN/TRA–10	Pulse form restorer group, pulse form repeater
Accessories Case CY–1334/G	Accessories case
Electrical Standardized Components Cases CY–1719/G and CY–1280/U	Standardized components case, transit case, or equipment mounting rack
Chest CY–250	Chest
Remote Switching Control C–1509/TC	Remote keying unit
Control Monitor C–1151/TC	Control monitor
Telephone Modem MD–179/TC	Modem
Multiplexer TD–60/TCC–13	Multiplexer, common unit
Electrical Connector Assembly J–535/G	Modem test extension
Multiplexer Subassembly MX–1442/TC	Filament supply
Oscilloscope OS–25/G	Oscilloscope
Power Supply PP–691/G	Power supply
Voltage Regulator CN–236/G	Voltage regulator
Switch Box SA–357/G	Switch box
Audio Test Set TS–762/TC	Audio test set
Pulse Form Restorer TD–68/G	Pulse form restorer
Electrical Equipment Rack MT–1165/TCC–13	Multiplexer mounting rack or mounting rack
Electrical Equipment Rack MT–1434/TRA–10	Restorer mounting rack or mounting rack
Electrical Equipment Rack MT–1433/TCA–1	Drop-and-insert mounting rack, or mounting rack

8. Components

a. Components Supplied. Lists of components supplied as part of the Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 are listed in Appendix I.

b. Table of Components. The table below lists the equipment assigned to the multiplexer set, multiplexer group, and pulse form restorer group and indicates the quantity assigned to each unit. Note that some of the units are used in two or more of the equipments.

NOMENCLATURE	AN/TCC–13	AN/TCA–1	AN/TRA–10
Electrical Standardized Components Case CY–1280/U	2	2	
Multiplexer TD–60/TCC–13	1		
Electrical Equipment Rack MT–1165/TCC–13	1		
Delay line	1	1	1
Telephone Modem MD–179/TC	24	16	4
Multiplexer Subassembly MX–1442/TC	1	1	
Remote Switching Control C–1509/TC	2	2	2
Oscilloscope OS–25/G	1	1	
Audio Test Set TS–762/TC	1	1	
Control Monitor C–1151/TC	1	1	1

NOMENCLATURE	AN/TCC–13	AN/TCA–1	AN/TRA–10
Accessories Case CY–1334/G	1	1	
Power Supply PP–691/G	1	1	1
Voltage Regulator CN–236/G	1	1	1
Pulse Form Restorer TD–68/G		1	1
Electrical Equipment Rack MT–1434/TRA–10			1
Electrical Connector Assembly J–535/G	1	1	1
Switch Box SA–357/G	1	1	1
Electrical Equipment Rack MT–1433/TCA–1		1	
Electrical Standardized Components Case CY–1719/G			1
Cable Reel RC–405/TR with Electrical Power Cable Assembly CX–2440/U (150 ft 0 in.).	1	1	1

Note. This list does not contain the cables supplied with each of the equipments. Refer to the appendix for a complete list of cables supplied.

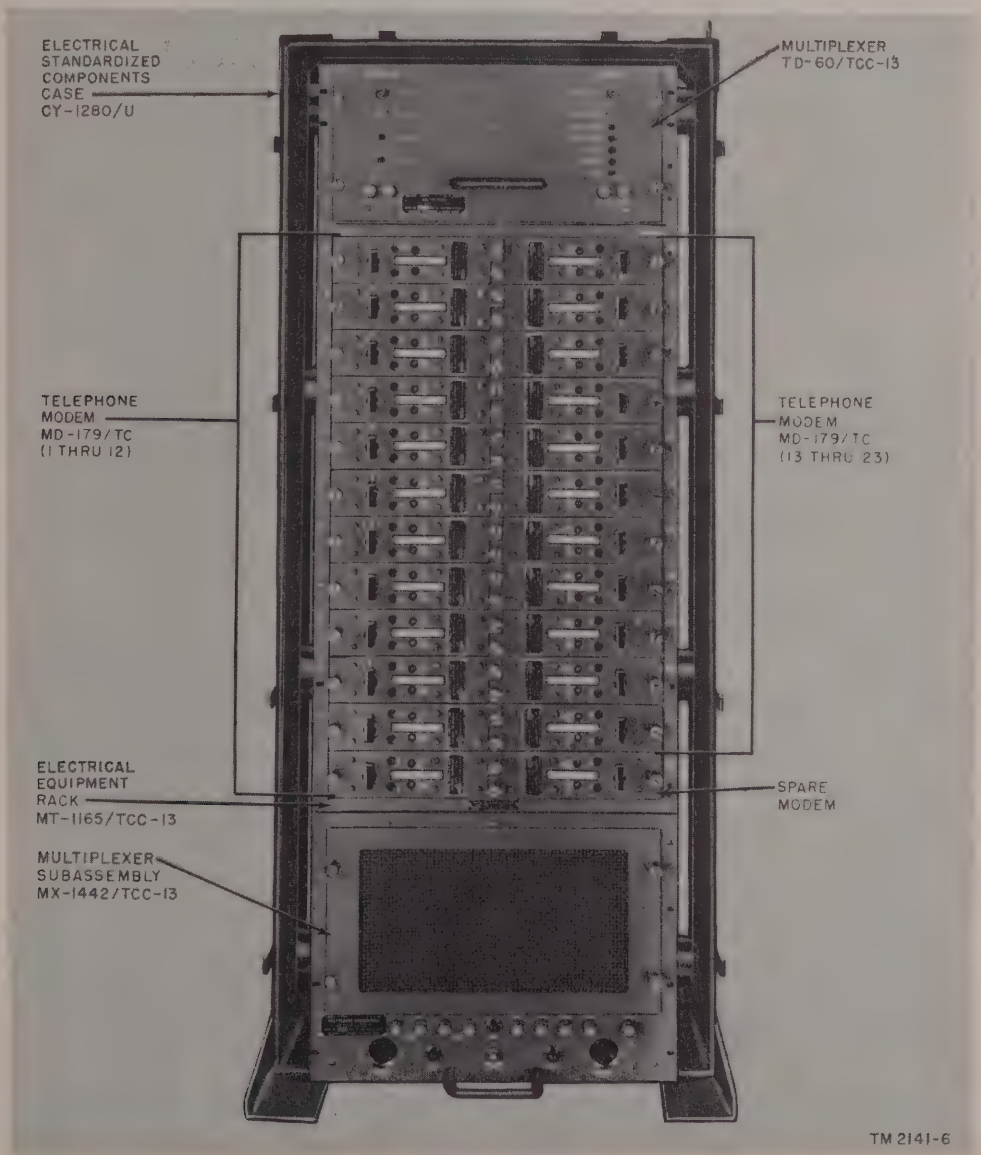


Figure 6. Multiplexer Set AN/TCC–13, multiplexer rack, front view.

9. Component Arrangement

a. All the major components of Multiplexer Set AN/TCC–13 and Multiplexer Group AN/TCA–1, except Voltage Regulator CN–236/G and Switch Box SA–357/G are mounted in two transit cases. One transit case together with its components is called the *multiplexer rack* and the other is referred to as the *test equipment rack*. All the major components of Pulse Form Restorer Group AN/TRA–10, except the voltage regulator and the switch box, are mounted in one transit case.

b. Voltage Regulator CN–236/G is housed in its own cabinet and is located within 15 feet of the multiplexer or pulse form restorer rack. A description of the voltage regulator is given in paragraph 26. Switch Box SA–357/G is normally stored in one of the accessories and spare parts cases. When in use, the switch box may be located up to 150 feet from the voltage

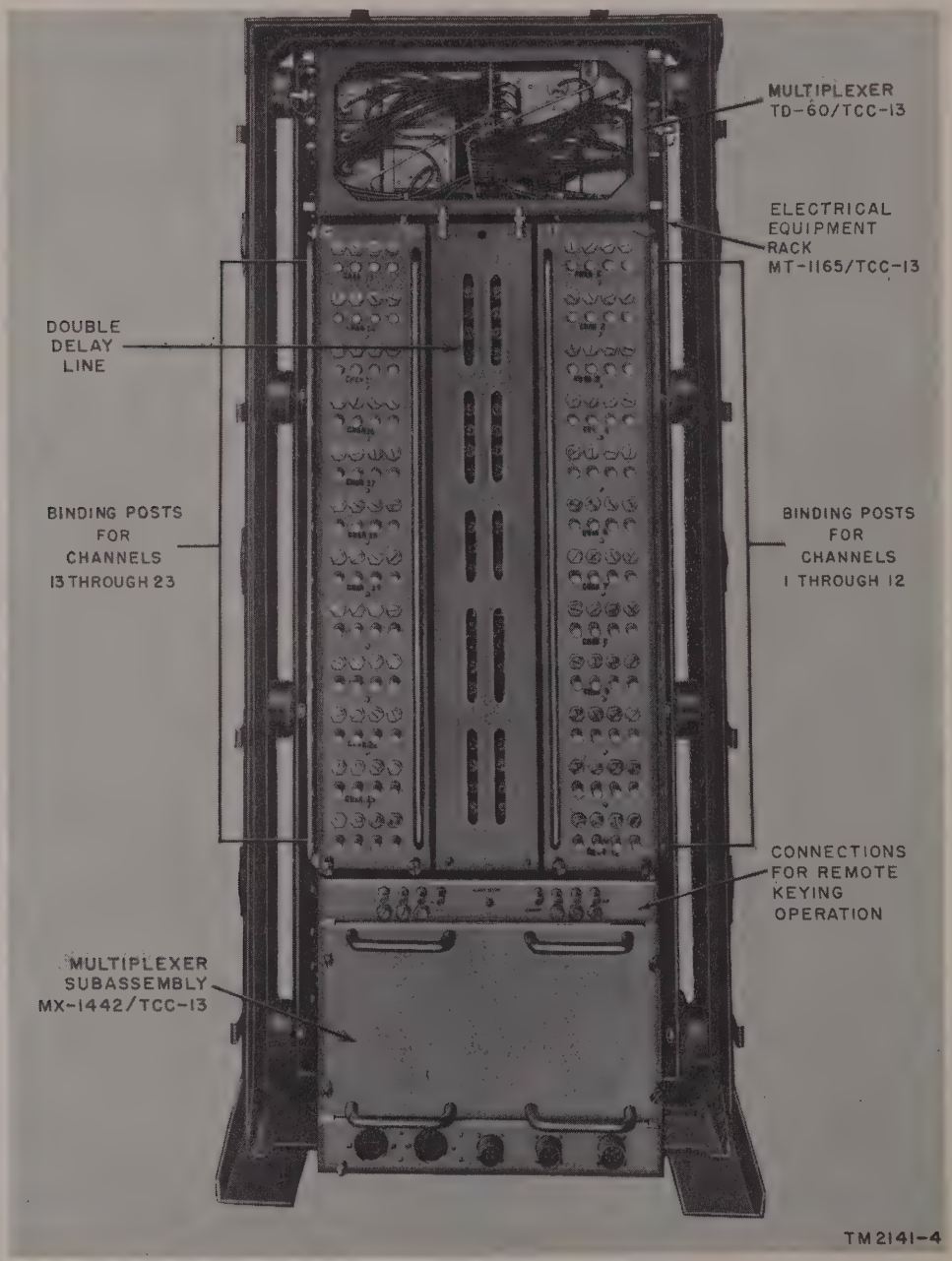


Figure 7. Multiplexer Rack AN/TCC–13, multiplexer rack, rear view.

regulator. A description of the switch box is given in paragraph 27.

10. Description of Mounting Racks

a. Multiplexer Set.

(1) *Multiplexer rack (AN/TCC–13).* The multiplexer rack (fig. 6, 7, and 16) consists of Electrical Standardized Components Case CY/1280–U (par. 11) and the components listed below.

(*a*) Multiplexer TD/60–TCC–13 (par. 15).

(*b*) Electrical Equipment Rack MT–1165/TCC–13 (par. 12).

(*c*) Twenty-four Telephone Modems MD–179/TC (par. 17).

(*d*) Multiplexer Subassembly MX–1442/TC (par. 19).

(*e*) Two Remote Switching Controls C–1509/TC (par. 20).

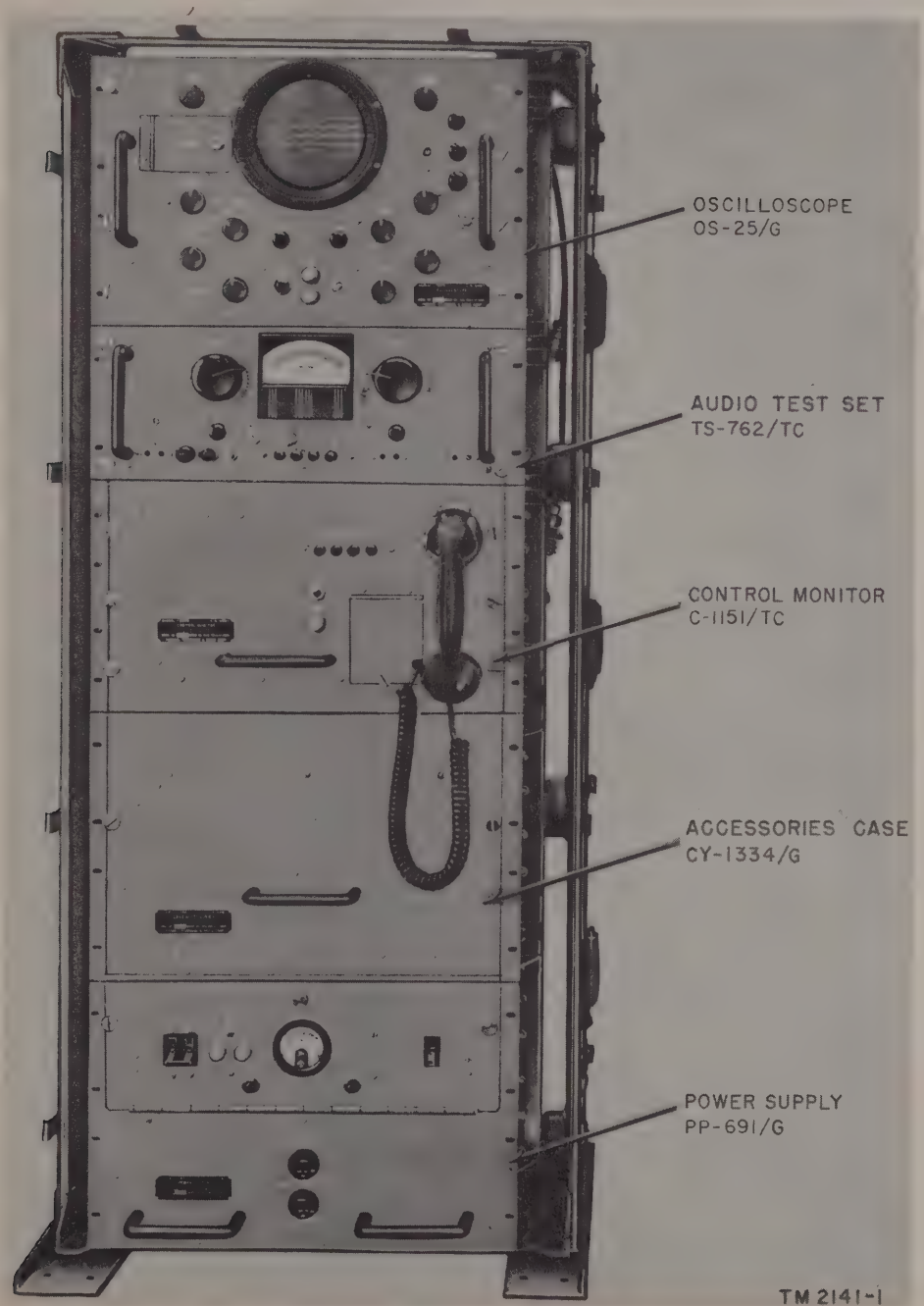


Figure 8. Test rack, front view.

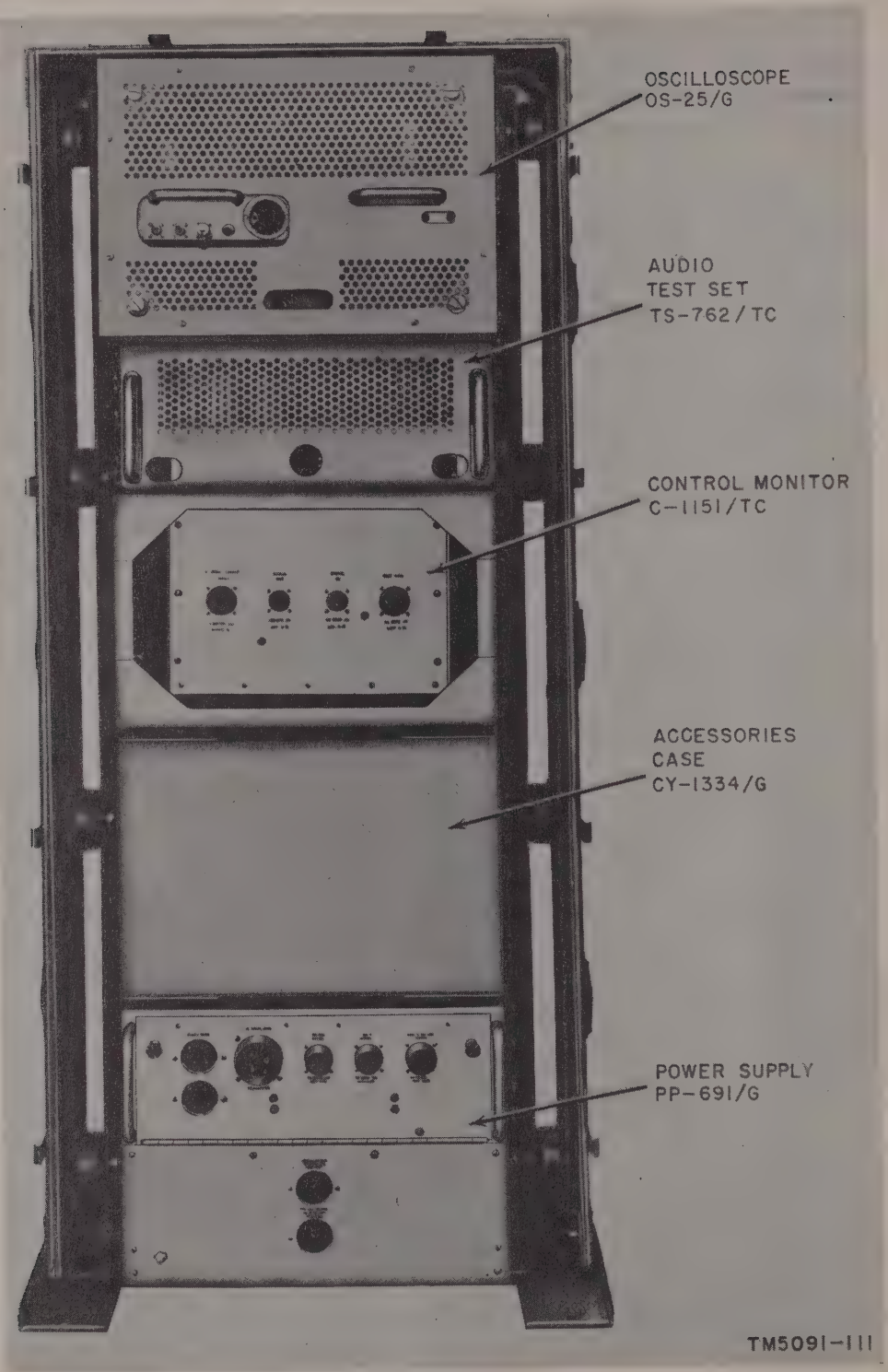


Figure 9. Test rack, rear view.

(*f*) Delay lines (par. 18).

(2) *Test rack.* The test rack (fig. 8 and 9) consists of Electrical Standardized Components Case CY–1280/U (par. 11) and the components listed below.

(*a*) Oscilloscope OS–25/G (par. 23).

(*b*) Audio Test Set TS–762/TC (par. 24).

(*c*) Control Monitor C–1151/TC (par. 25).

(*d*) Accessories Case CY–1334/G (par. 21).

(*e*) Power Supply PP–691/G (par. 22).

b. Multiplexer Group.

(1) *Multiplexer rack (AN/TCA–1).* The multiplexer rack (fig. 10 and 11) consists of Electrical Standardized Components Case CY–1280/U (par. 11) and the components listed below.

(*a*) Pulse Form Restorer TD–68/G (par. 16).

(*b*) Electrical Equipment Rack MT–1433/TCA–1 (par. 13).

(*c*) Sixteen Telephone Modems MD–179/TC (par. 17).

(*d*) Multiplexer Subassembly MX–1442/TC (par. 19).

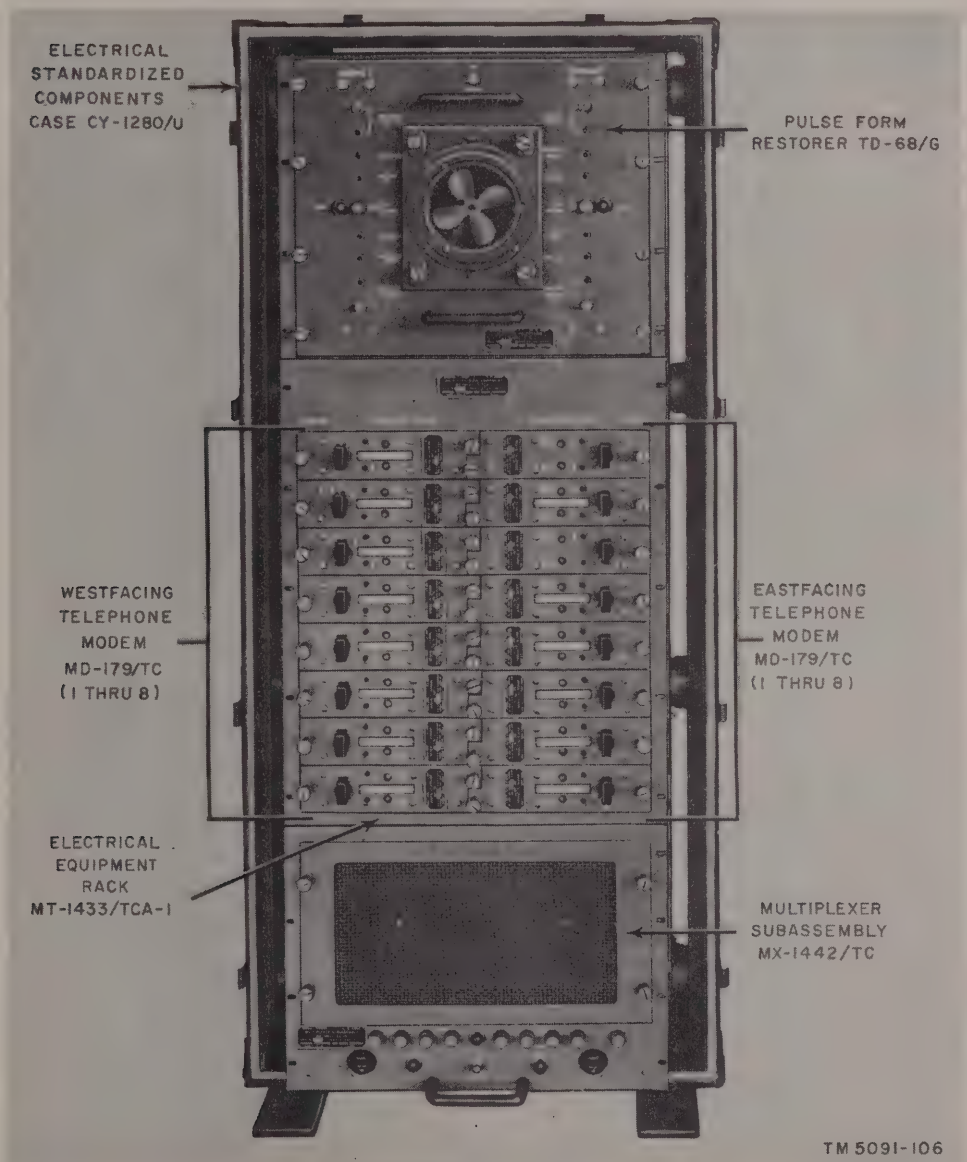


Figure 10. Multiplexer Group AN/TCA–1, multiplexer rack, front view.

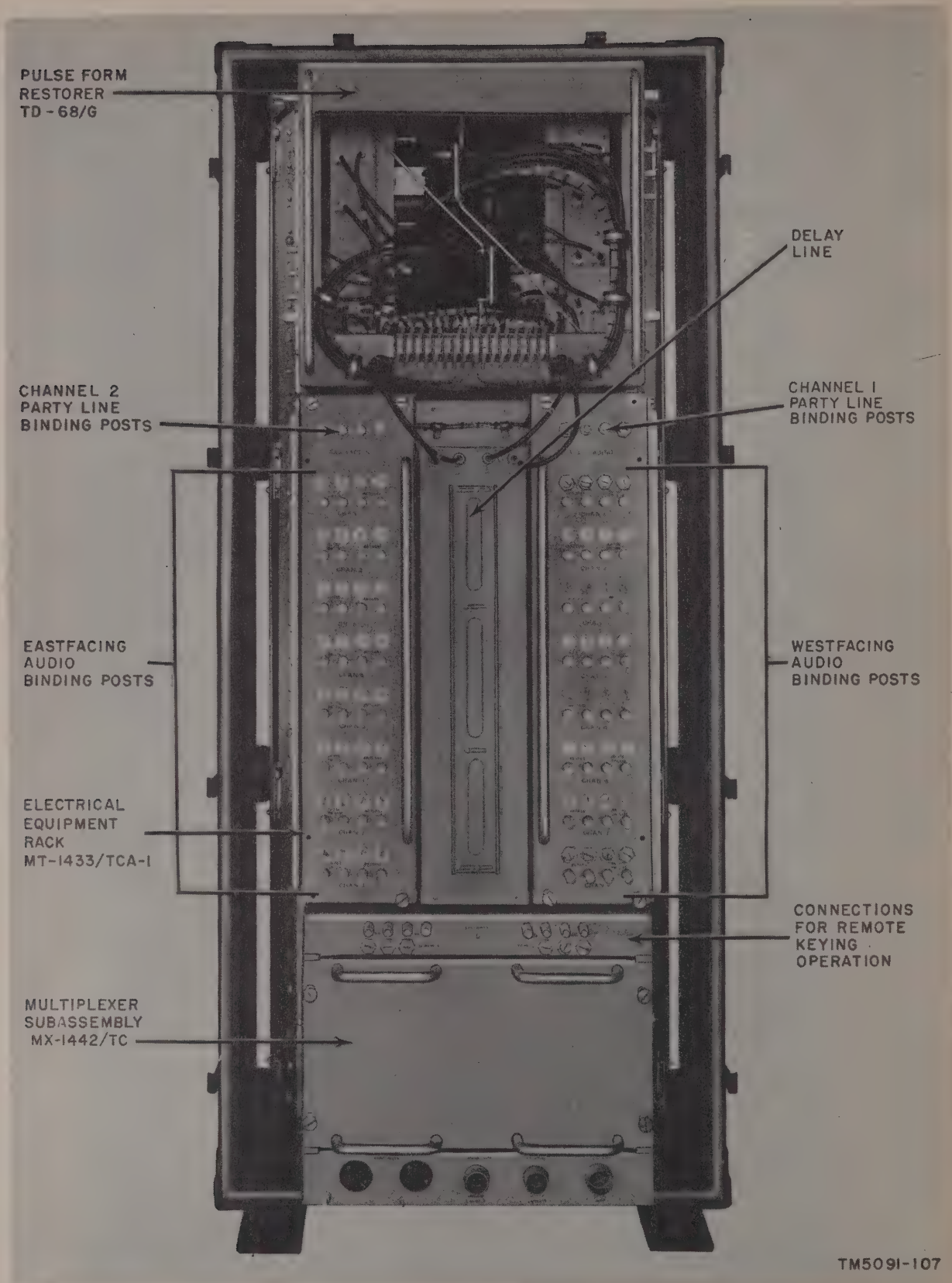


Figure 11. Multiplexer Group AN/TCA–1, multiplexer rack, rear view.

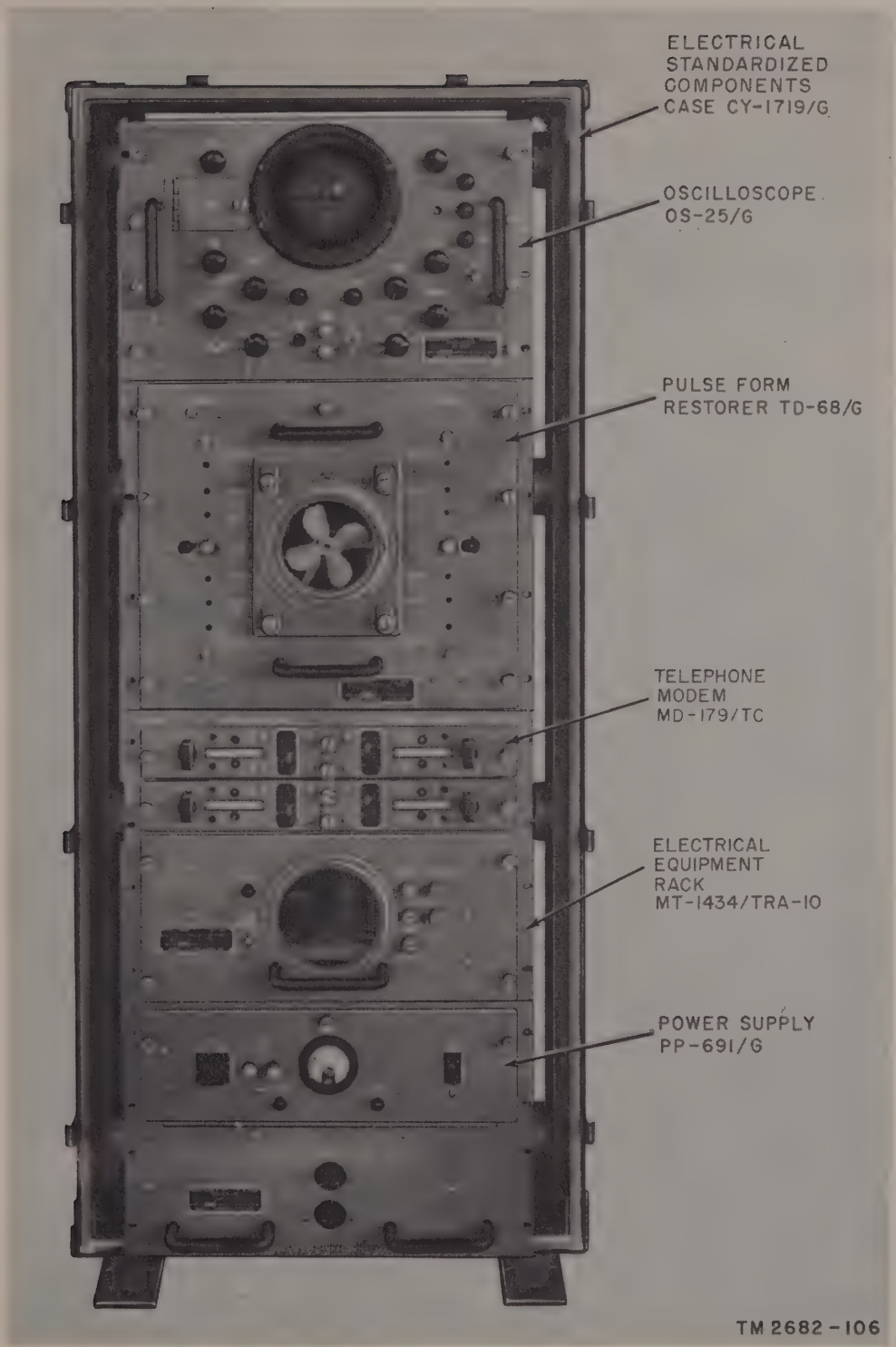


Figure 12. Pulse Form Restorer Group AN/TRA–10, equipment rack, front view.

(*e*) Two Remote Switching Controls C–1509/TC (par. 20).

(*f*) Delay lines (par. 18).

(2) *Test rack.* The test rack used in the multiplexer group is identical with that used in the multiplexer set. Refer to subparagraph *a*(2) above.

c. Pulse Form Restorer Group AN/TRA–10. The equipment rack (fig. 12 and 13) consists of Electrical Standardized Components Case CY–1719/G (par. 11) and the components listed below.

(*a*) Oscilloscope OS–25/G (par. 23).

(*b*) Pulse Form Restorer TD–68/G (par. 16).

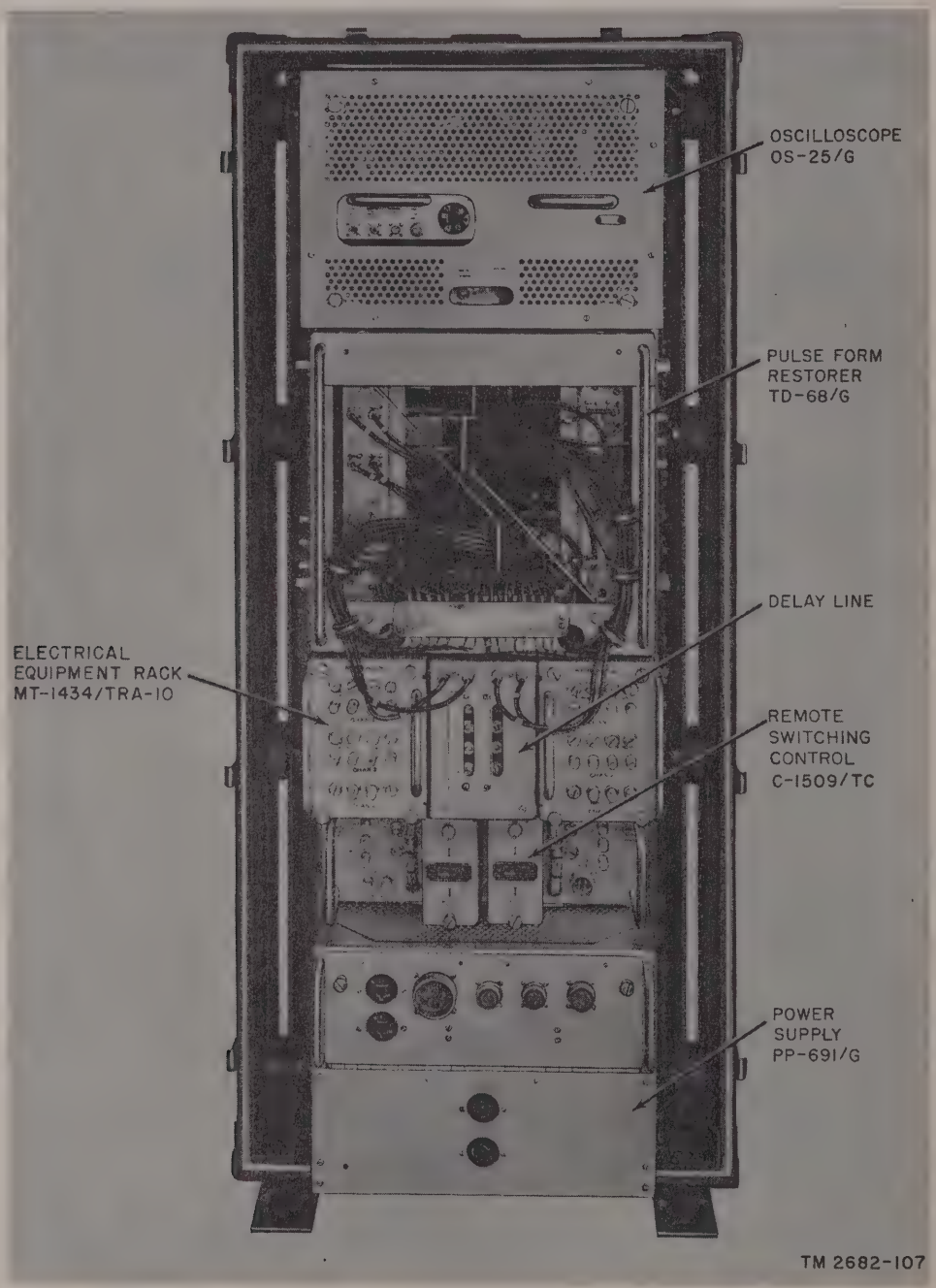


Figure 13. Pulse Form Restorer Group AN/TRA–10, equipment rack, rear view.

(*c*) Four Telephone Modems MD–179/TC (par. 17).

(*d*) Electrical Equipment Rack MT–1434/TRA–10 (par. 14).

(*e*) Delay line (par. 18).

(*f*) Two Remote Switching Controls C–1509/TC (par. 20).

(*g*) Power Supply PP–691/G (par. 22).

11. Description of Electrical Standardized Components Cases CY–1280/U and CY–1719/G

(fig. 14 and 15)

a. Electrical Standardized Components Cases CY–1280/U and CY–1719/G each consists of an equipment mounting rack and two covers. The two covers are identical and interchangeable and can be completely removed from the equipment mounting rack. Three carrying handles and a rope hook are bolted to each side of the equipment mounting rack. One carrying handle is on top of the case. An air-escape valve is located on the right side of the rack. When the equipment is transported by air, the valve is opened to insure equal air pressure inside and outside the transit case; otherwise, the valve is closed.

b. The equipment mounting rack consists of an outer shell, shock-mounted to a metal mounting frame with drilled and tapped mounting holes. The components are mounted on this inner frame with screws. Two metal feet are

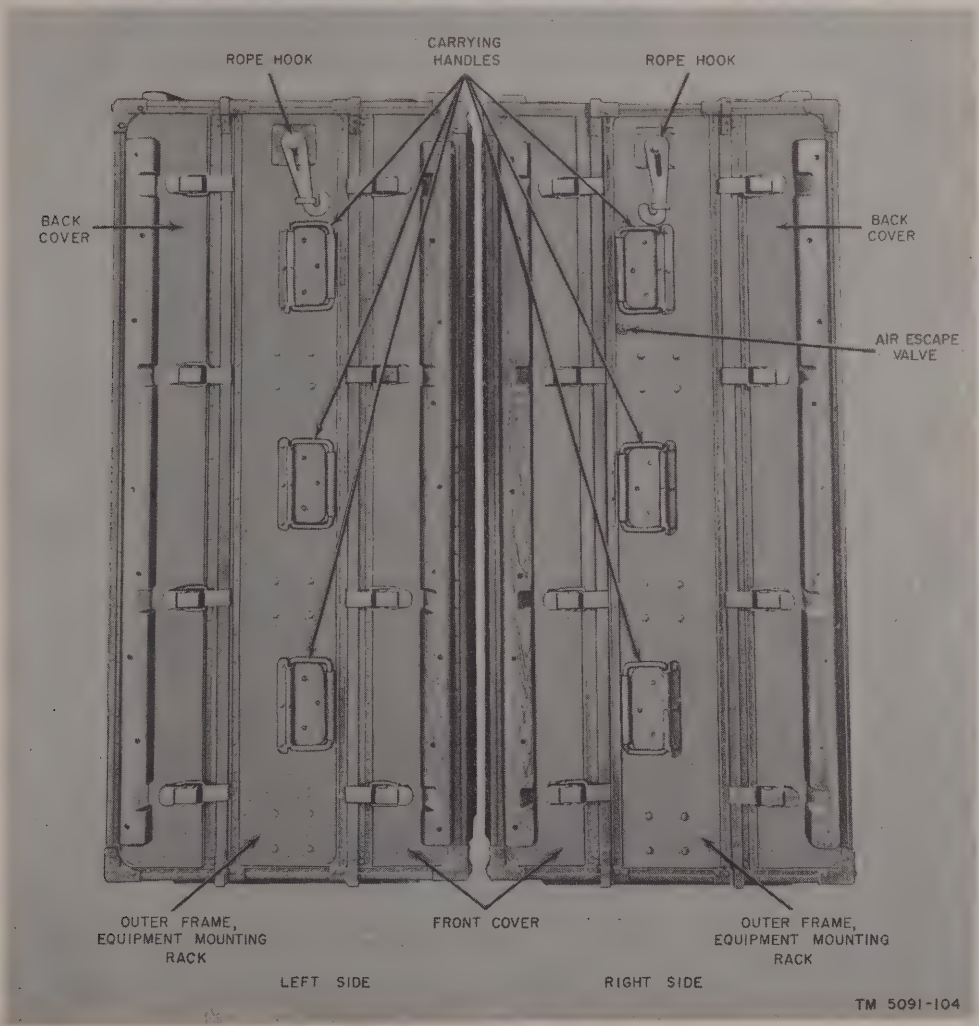


Figure 14. Standardized components case.

bolted to the bottom of the outer case. These feet project to the front and rear to balance the rack when the covers are removed and the equipment is installed.

12. Description of Electrical Equipment Rack MT–1165/TCC–13

(fig. 6, 7, and 16)

The multiplexer mounting rack is attached to Electrical Standardized Components Case CY–1280/U to provide mounting facilities for the 24 modems, audio binding posts and the delay line.

a. Twenty-three operating modems and one spare are mounted on the front of the multiplexer mounting rack, in two vertical rows of 12 each. Each modem is secured to the multiplexer mounting rack by two knurled thumbscrews, one on each side of the modem front panel. The modem slides in or out on angle bracket channel strips. The multiplexer mounting rack contains a mating receptacle for each modem. When the modem is slid into place, the plug on the modem mates with the receptacle on the multiplexer mounting rack, connecting the modem to the multiplexer mounting rack.

b. The double delay line (one section for the multiplexer operation and the other for demultiplexer operation) is mounted at the rear of the multiplexer mounting rack in a vertical position. At each side of the delay line (on the multiplexer mounting rack) are two sets of audio binding posts (four for each channel). Above each audio binding post is a surge protection block.

13. Description of Electrical Equipment Rack MT–1433/TCA–1

(fig. 10 and 17)

Electrical Equipment Mounting Rack MT–1433/TCA–1 is attached to Electrical Standardized Components Case CY–1280/U to pro-

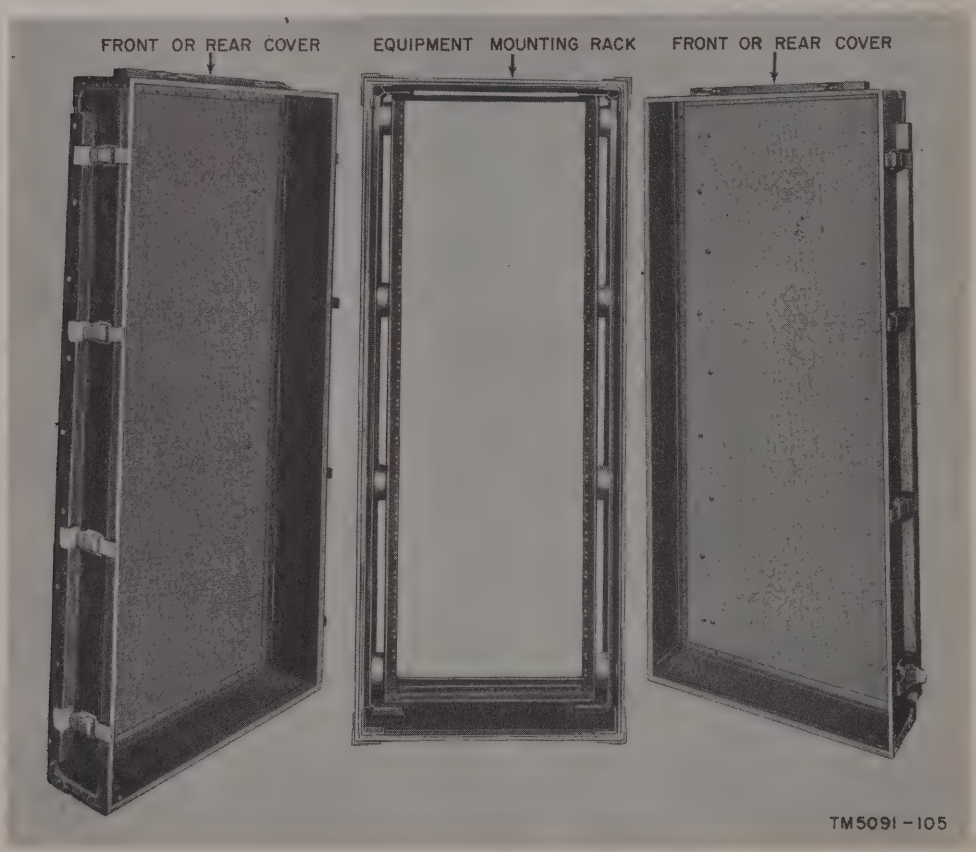


Figure 15. Standardized components case, covers removed.

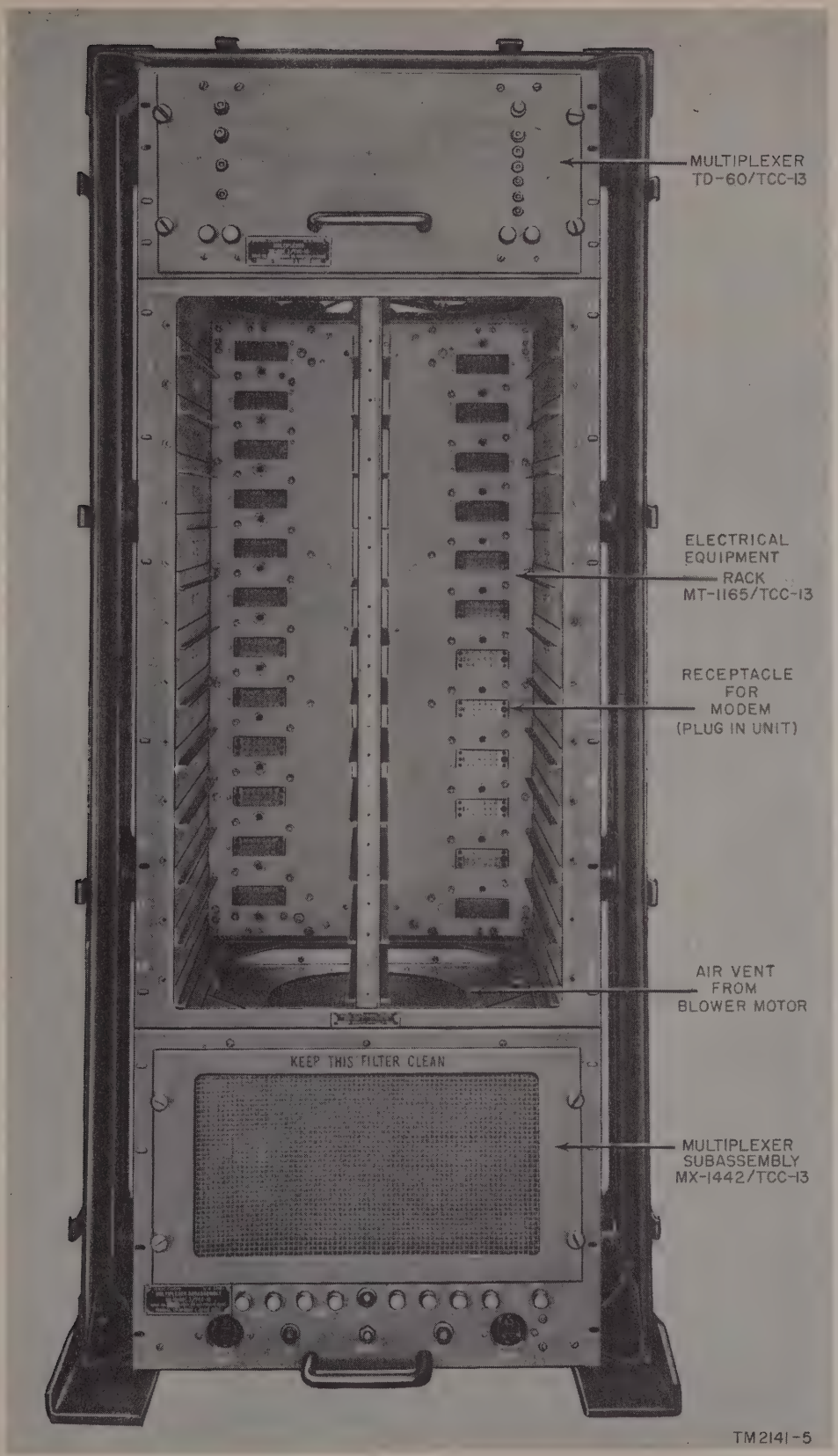


Figure 16. Multiplexer rack (AN/TCC–13), front view, modems removed.

vide mounting facilities for the 16 modems, delay line, and audio terminations.

a. Sixteen modems (one for each direction, two for each of the eight channels) are mounted on the front of the mounting rack in two vertical rows of eight each. Each modem is secured to the mounting rack by two knurled thumbscrews, one on each side of the modem front panel. The modem slides in or out on angle-bracket channel strips. The mounting rack contains a mating receptacle for each modem to connect the modem to the mounting rack.

b. The double delay line mounts to the rear of the mounting rack in a vertical position. All the eastfacing and westfacing channel audio binding posts (four binding posts for each channel) as well as the channels 1 and 2 party-line binding posts are located at each side of the delay line. Above each audio binding post is a surge protection block.

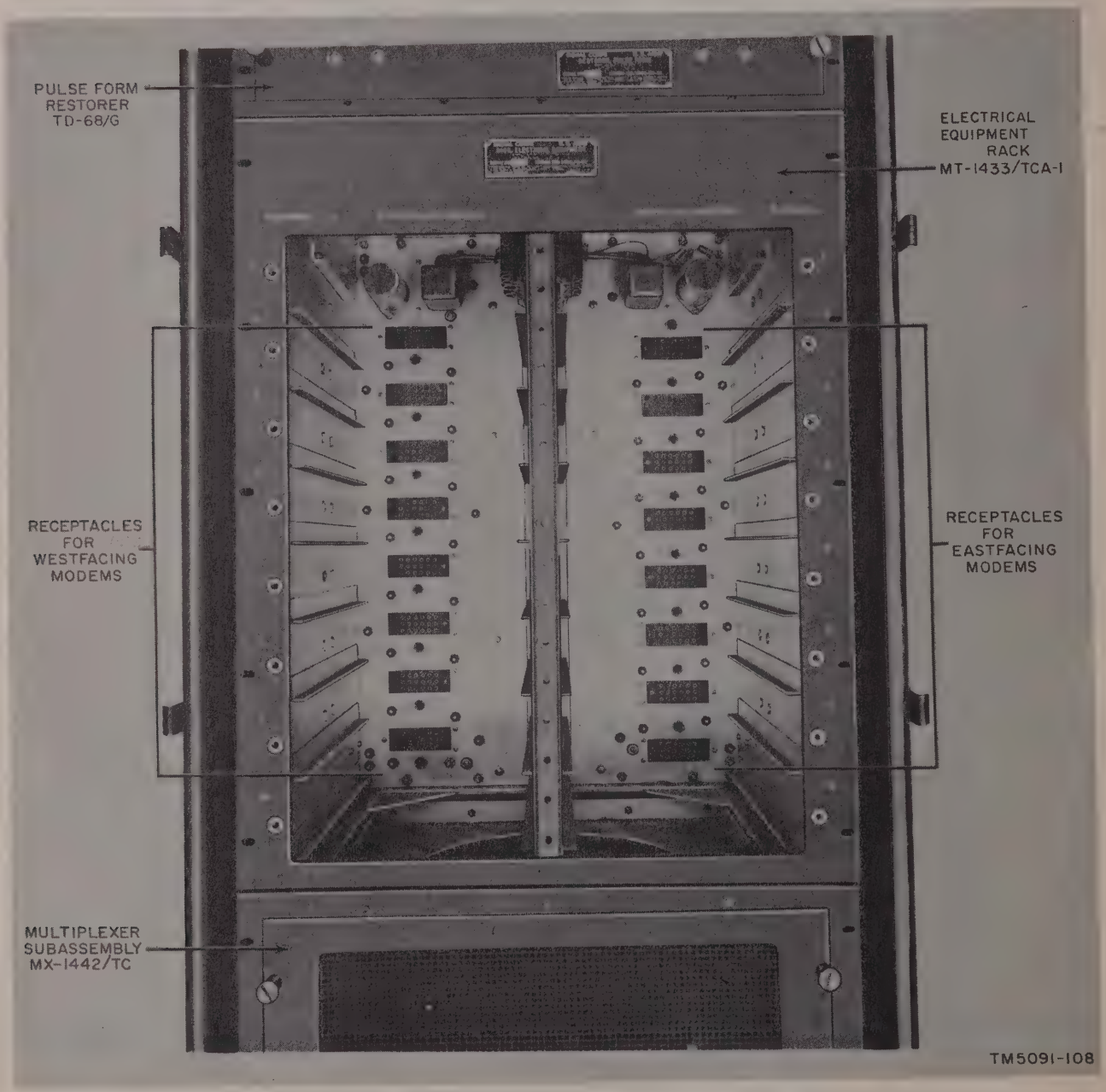


Figure 17. Multiplexer rack (AN/TCA–1), front view, 16 modems removed.

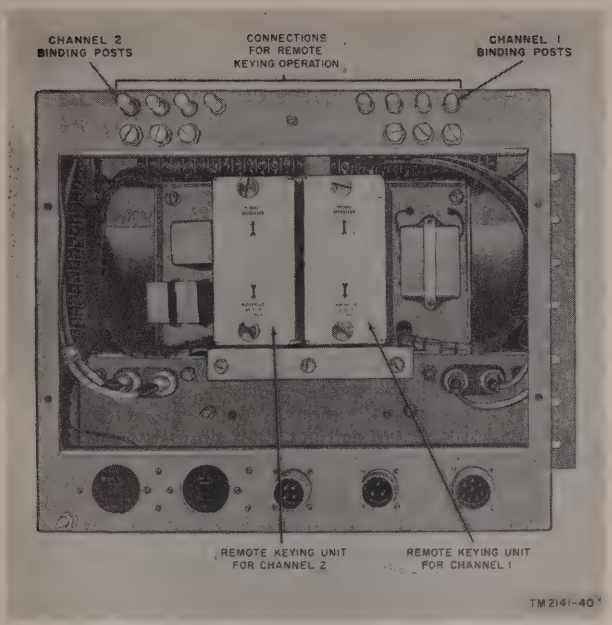


Figure 18. Multiplexer subassembly, rear view, cover removed, showing remote keying units.

14. Description of Electrical Equipment Rack MT–1434/TRA–10

(fig. 12 and 13)

The restorer mounting rack, which is attached to Electrical Standardized Components Case CY–1719/G, provides mounting facilities for the four modems, delay line, filament supply, ringing supply, remote keying units, and audio terminations.

a. Four modems (two for each direction, one for each channel) are mounted on the front of the restorer mounting rack. Each modem is mounted to the rack by two knurled thumbscrews and slides in or out on angle bracket channel strips. The mounting rack contains a mating receptacle for each modem to connect the modem to the restorer mounting rack.

b. The filament supply, which consists solely of a filament transformer, is mounted on the slide drawer chassis below the four modems. This chassis also contains the 20-cycle ringing supply.

c. The double delay line is mounted on the rear of the restorer mounting rack in a vertical position. At each side of the delay line are the channels 1 and 2 eastfacing and westfacing audio binding posts as well as the channels 1 and 2 party-line binding posts. Above each binding post is a surge protection block.

d. Two Remote Switching Controls C–1509/TC are mounted on the mounting rack beneath the delay line. Binding post connections for these units are directly alongside the switching control on the restorer mounting rack. Refer to paragraph 20 for a description of the remote keying unit.

e. On the bottom left rear of the restorer mounting rack are two TEST PAIR binding posts. The TEST PAIR is a pair of wires common to each modem and permits connection of the test pair to any modem for test purposes.

f. On the bottom right rear of the mounting rack is a receptacle for applying alternating-current (ac) power to the mounting rack.

15. Description of Multiplexer TD–60/TCC–13

a. The common unit, mounted at the top of the AN/TCC–13 multiplexer rack (fig. 6 and 7), contains the multiplexer and demultiplexer circuits that are common to every channel. As noted on the front panel of the common unit, the demultiplexer section is located on the left side and the multiplexer section is located on the right side.

b. The front panel contains test pin jacks and fuses for both the demultiplexer and multiplexer circuits. In addition, each section has its own B+ and filament fuses at the bottom of the front panel.

c. At the rear of the common unit are all the connectors used for interconnecting cables. Viewed from the rear of the common unit, the multiplexer section is on the left side and the demultiplexer section on the right side. The connectors are mounted on the rear and side panels of the chassis.

16. Description of Pulse Form Restorer TD–68/G

(fig. 10 and 12)

a. Pulse Form Restorer TD–68/G, mounted in Pulse Form Restorer Group AN/TRA–10 rack and the top of the multiplexer rack of Multiplexer Group AN/TCA–1, consists of two identical chassis (each called a video restorer, mounted side by side). One of these video restorers is used in each direction of communication. The pulse form restorer contains the reshaping, multiplexing, and demultiplexing

circuits common to every channel. The eastgoing video restorer is located on the left side and the westgoing video restorer is located on the right side.

b. The front panel contains test pins, jacks, and fuses for both the eastgoing and westgoing video restorers. The two rear sides of the pulse form restorer have all the connectors for the interconnecting cables. Viewed from the rear of the common unit, the eastgoing video restorer is on the right side, and the westgoing video restorer is on the left side. The oscilloscope, receiver and transmitter connectors are on the right and left sides of the chassis.

17. Description of Telephone Modem MD–179/TC

a. Telephone Modem MD–179/TC is common to all units; Multiplexer Set AN/TCC–13 uses 24 modems, Multiplexer Group AN/TCA–1 uses 8 modems, and Pulse Form Restorer Group AN/TRA–10 uses 4 modems.

b. Each modem consists of three sections: the modulator, demodulator, and the 20-cycle ringing sections. Each modem is secured to the mounting rack by two knurled captive screws and is connected through a male plug at the rear of the modem, to a female receptacle on the mounting rack when it is slid into place. Located on the front panel of each modem are a five-position selector switch, two test jacks, and two recessed screw-driver-adjustment potentiometers.

18. Description of Delay Lines

A delay line assembly is mounted vertically on the rear of each mounting rack (fig. 7, 11, and 13). There are two electrically independent delay line sections associated with each direction of transmission. One is for the multiplexing section of each unit the other for the demultiplexing section of each unit. Four electrically independent delay line sections are contained in one delay line assembly.

a. Multiplexer Set AN/TCC–13. Each delay line section provides 23 separate outputs; each output is delayed approximately 5.2 microseconds from the previous one, and established the time position of the 23 channel pulses. Each of these outputs is applied to one of the 23 modems, where it generates the channel pulses. Two connectors at the top provide appropriate input gate signal connections.

b. Multiplexer Group AN/TCA–1. Each delay line section provides eight separate outputs; each output is delayed 5.2 microseconds from the previous one and thereby maintains the time position of channels 1 through 8. These outputs are applied to the 16 modems. Four connectors at the top provide appropriate input gate connectors.

c. Pulse Form Restorer Group AN/TRA–10. Each delay line section provides two separate outputs; the second output is delayed 5.2 microseconds from the first one and thereby maintains the time position of channels 1 and 2. These outputs are applied to the four modems to generate the channel pulse gates for demodulation. Four connectors at the top provide appropriate input gate connections.

19. Description of Multiplexer Subassembly MX–1442/TC

a. Multiplexer Subassembly MX–1442/TC is the filament supply for the multiplexer set and multiplexer group. It is the bottom unit in the multiplexer rack (fig. 6 and 10).

b. Located on the front panel of the filament supply (fig. 51) are the following: filament fuses for the modems, B+ fuses, a fan fuse, a +250V ON indicator lamp, an alarm indicator lamp, an ac power on indicator lamp, an audible alarm disconnect push button, and two utility power outlets.

c. The top rear of the filament supply contains binding post connections for the two remote keying units (channels 1 and 2 only). These are located beneath the dust cover of the subassembly. Refer to paragraph 20 for a description of these units.

d. The bottom rear of the filament supply contains two convenience outlets, two connectors for applying 115-volt ac power and B+ power for the entire multiplexer rack, and a jack for connecting the audio test set to the TEST PAIR. The TEST PAIR is a pair of wires that are common to each modem and permit connection of the audio test set to any modem for testing purposes.

20. Description of Remote Switching Control C–1509/TC

(fig. 13 and 18)

Two Remote Switching Controls C–1509/TC are supplied with each of the equipments to permit remote keying operation on channel 1 and/or 2. The remote keying unit is a plug-in type unit $5\frac{5}{16}$ inches long by $2\frac{5}{8}$ inches wide by $3\frac{17}{32}$ inches deep and is mounted on the rear of the units. The remote keying unit operates only with the subassemblies. During normal operation, the remote keying unit is plugged in so that the arrow marked NORMAL OPERATION points upward. To permit remote operation of a vhf radio station, the unit is pulled out, inverted, and replaced so that the arrow marked REMOTE KEYING OPERATION is pointing upward.

21. Description of Accessories Case CY–1334/G

(fig. 19)

Accessories Case CY–1334/G is a drawer compartment in the test rack. The case provides storage space for the following miscellaneous tools:

a. One tube puller for the seven-pin miniature tubes.

b. One tube puller for the nine-pin miniature tubes.

c. One pin straightener for the seven-pin miniature tubes.

d. One pin straightener for the nine-pin miniature tubes.

e. One No. 6 Allen-head (socket head), L-type screw wrench.

f. One No. 8 Allen-head (socket head), L-type screw wrench.

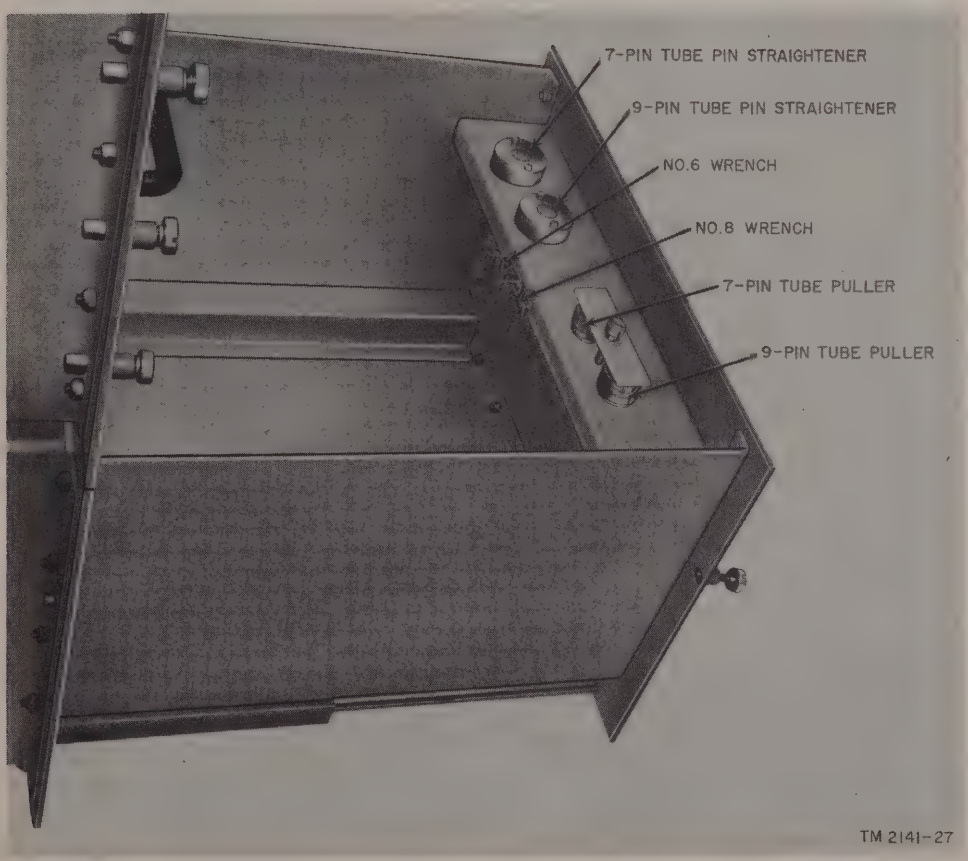


Figure 19. Accessories Case CY–1334/G.

22. Description of Power Supply PP–691/G (fig. 8 and 12)

a. A Power Supply PP–691/G is mounted at the bottom of both the AN/TCC–13 and AN/TCA–1 test rack and at the bottom of the AN/TRA–10 equipment rack. It is the main B+ power supply for the equipments and provides +250 volts direct current (dc) with a total capacity of 1.6 amperes. The power supply acts as the main ac power input chassis and contains the main and B+ circuit breakers.

b. The following components are located on the power supply front panel:

(1) A double circuit breaker for the filament supply.
(2) Two 5-ampere fuses.
(3) A filament power indicator lamp.
(4) A voltmeter for measuring the 115-volt ac input voltage from the voltage regulator.
(5) A B+ power indicator lamp.
(6) A circuit breaker for the B+ supply.
(7) Two utility power outlets.

c. The following components are located on the rear of the unit:

(1) Two utility power outlets.
(2) An ac power input connector.
(3) A B+ output connector.
(4) A B+ and 115-volt ac connector.
(5) Three 115-volt ac output connectors.

23. Description of Oscilloscope OS–25/G (fig. 8 and 12)

The oscilloscope is mounted at the top of the AN/TCC–13 and AN/TCA–1 test rack and the AN/TRA–10 equipment rack by eight captive screws (four on each side). The unit is self-contained and includes its own power supply, fan, controls, fuses, and indicator lamp. It also contains special timing-pip circuits and controls to facilitate testing and trouble shooting the equipment, as well as performing video adjustments. In the upper left corner of the front panel is a small compartment that contains a probe and RF Cable Assembly CG–530A/U. The cathode-ray tube is protected by a green lucite screen that is calibrated in centimeters along the horizontal and vertical axes. The rear of the oscilloscope contains jacks that connect the synchronizing signals to the oscilloscope, and the power input connector, screwdriver adjustments, test jacks for B+ voltages, and a fuse for the fan.

24. Description of Audio Test Set TS–762/TC (fig. 8 and 9)

a. Audio Test Set TS–762/TC is part of the *test rack* supplied with the AN/TCC–13 and AN/TCA–1. The audio test set contains a 1,000-cycle oscillator, metering circuits, and precision attenuators to provide the load for an accurately calibrated test tone over any channel and to measure accurately the received amplitude, signal-to-noise ratio, and distortion on any channel. The audio test set also includes the circuits and controls necessary to calibrate accurately the instrument itself.

b. A decibel meter, calibrated from —20 to +3 decibels (db), is mounted at the top center of the front panel. At the left of this meter is the precision step attenuator used for establishing the transmission level. At the right of this meter is the RECEIVED DBM step attenuator.

c. On the front panel bottom row are two jacks used for sending out the test signal, a fuse, and indicator lamp, a power toggle switch, a potentiometer control for calibrating the 1,000-cycle test signal, two push buttons for calibrating the output signal and the receiving amplifier, two push buttons to permit measurement of the incoming test signal (one noise weighted by the FIA curve and one to check distortion at 1,000 cps), two jacks for monitoring the received signal, a potentiometer control for calibrating the receiving amplifier, and two jacks for receiving the test signal. The rear of the unit contains connectors for the input and output signals and for the input power.

25. Description of Control Monitor C–1151/TC

Control Monitor C–1151/TC (fig. 8 and 9) is mounted below the audio test set on the test rack and includes the telephone handset and four push-button switches. The telephone handset is stored in a small compartment at the lower right of the panel when it is not in use. A cradle is provided alongside this compartment to mount the handset when it is in constant use. A fuse for the microphone current

supply is mounted on the front panel. At the rear of the unit is an input power connector, a signal output connector, a signal input connector, and a test pair connector.

26. Description of Voltage Regulator CN–236/G

(fig. 20)

Voltage Regulator CN–236/G is a separately housed component that is located within 15 feet of the equipment mounting rack. It is an electromechanically controlled voltage regulator that delivers a constant output independent of line voltage or load current. All controls, indicators, and connectors are on the front panel. They include two circuit breakers for 115- or 230-volt input, a power indicator lamp, three fuses, two screw driver potentiometer adjustments, and three power connectors. The ac input power is provided from Switch Box SA–357/G; the 115-volt ac output power is fed to Power Supply PP–691/G.

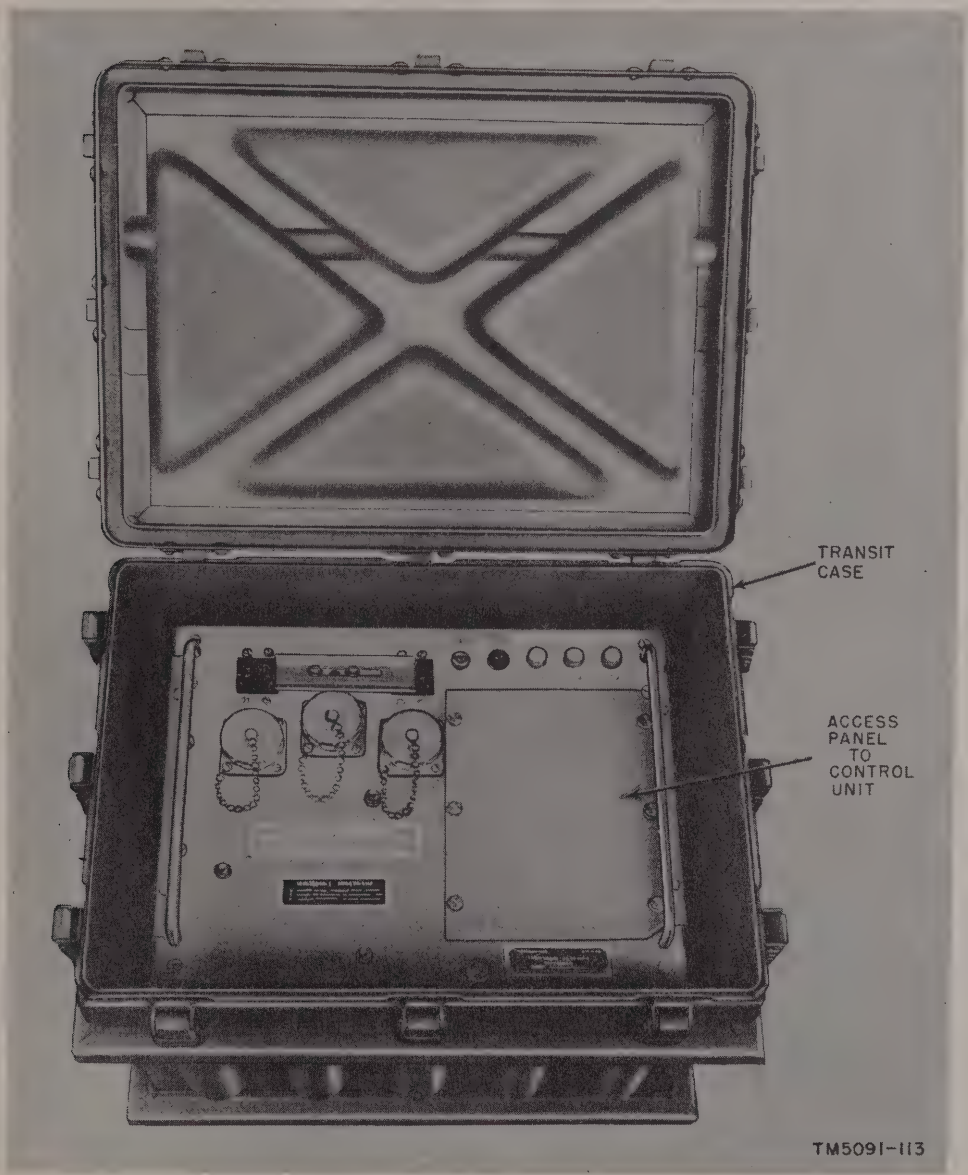


Figure 20. Voltage Regulator CN–236/G.

27. Description of Switch Box SA-357/G
(fig. 21)

The switch box is individually housed and connects either a 115- or 230-volt ac power source to the voltage regulator. On the front of the box are two male connectors; each of these can be connected to a source of power, such as a gasoline-driven generator or a commercial power source. A toggle switch between these connectors selects one of the two power sources that is used by the multiplexer set, multiplexer group, and pulse form restorer group. Two output connectors are on the rear of the box. At one end of the switch box is a terminal screw and wing nut ground connector that must be connected to a good earth ground (through a ground rod). The switch box should not be located more than 150 feet from the voltage regulator.

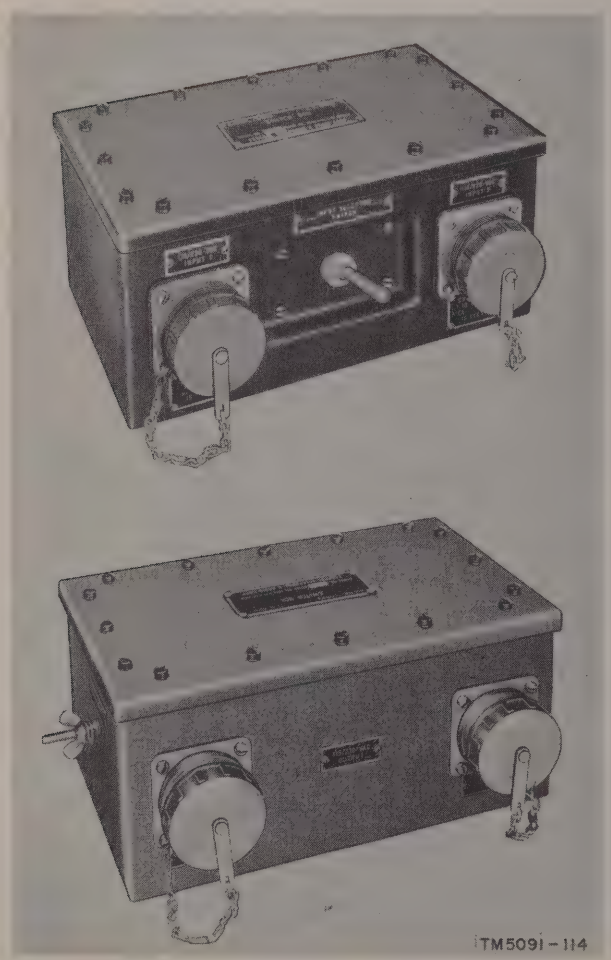


Figure 21. Switch Box SA-357/G, front and rear views

28. Description of Electrical Connector Assembly J-535/G
(fig. 22)

The modem test extension is a convenient accessory for making electrical connections between the plug at the rear of the modem and the mating plug in the mounting rack. It applies the necessary power to the modem when the modem has been removed from the rack for servicing.

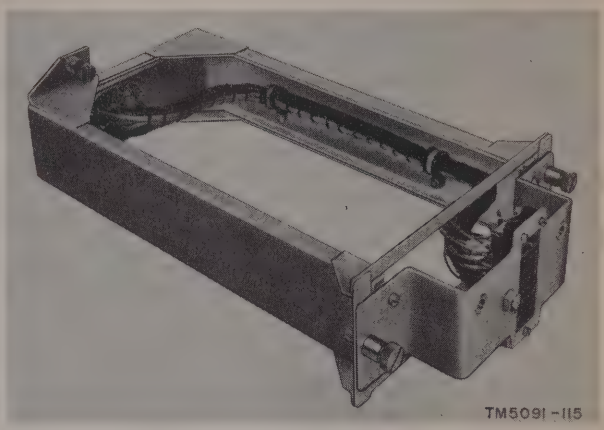


Figure 22. Electrical Connector Assembly J-535/G.

29. Description of Chest CY-250/U
(fig. 23)

Chest CY-250/U is an olive-drab, wooden transit case used for shipping and storing the running spare parts, accessories, and cables of the equipment. It is 27 inches long, 21¼ inches wide, and 20 inches high over-all, and has an adjustable-height tray. Two chests are provided for each equipment. Refer to the appendix for the contents of each case.

30. Description of Cables
(fig. 24 and 25)

The power and interconnecting cables used with the equipment and the number supplied with each equipment are listed below. The description of these cables is given in subparagraphs *b* through *m* below. Refer to the tables in paragraphs 39 and 40 for the multiplexer set cable connections and paragraph 63 for the multiplexer group and pulse form restorer group cable connection.

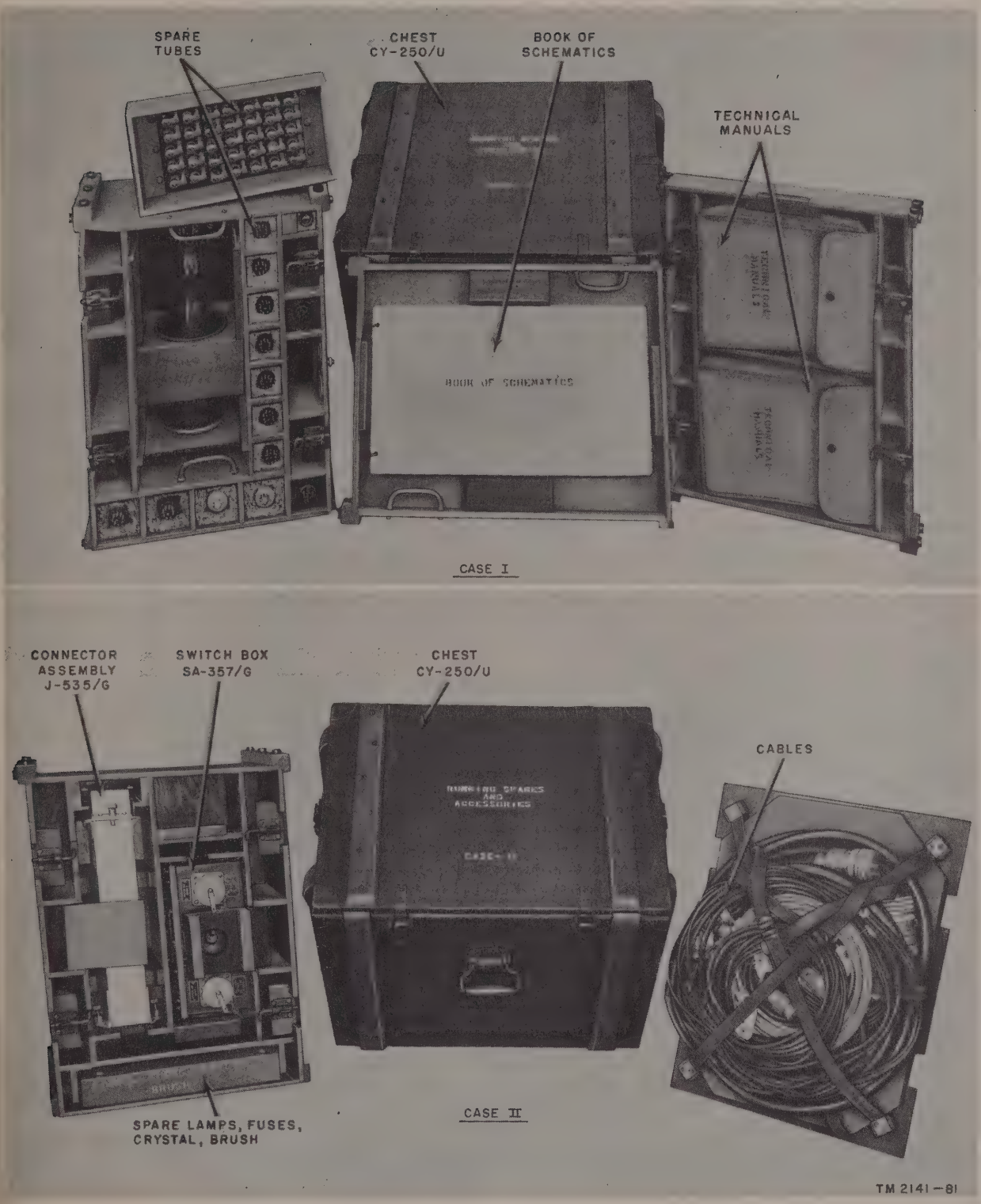


Figure 23. Running spares and accessories cases 1 and 2.

Cable nomenclature	AN/TCC–13	AN/TCA–1	AN/TRA–10
Cord CG–409C/U (25 ft 0 in.)	2	4	4
Radio Frequency Cable Assembly CG–1040A/U (15 ft 3 in.)	2	2	2
Radio Frequency Cable Assembly CG–1040A/U (25 ft 3 in.)	1		
Electrical Power Cable Assembly CX–2272/U (3 ft 5 in.)	1	1	
Electrical Power Cable Assembly CX–2272/U (10 ft 4 in.)	1	1	
Electrical Power Cable Assembly CX–2275/U (8 ft 4 in.)	1	1	
Electrical Power Cable Assembly CX–2276/U (2 ft 0 in.)			1
Electrical Power Cable Assembly CX–2276/U (6 ft 4 in.)	1	1	
Electrical Power Cable Assembly CX–2277/U (8 ft 4 in.)	1	1	
Electrical Power Cable Assembly CX–2440/U (15 ft 0 in.)	1	1	1
Electrical Power Cable Assembly CX–2440/U (150 ft 0 in.)	1	1	1
Electrical Power Cable Assembly CX–2441/U (8 ft 4 in.)	2	2	1
Electrical Power Cable Assembly CX–2442/U (10 ft 0 in.)	2	2	2
Electrical Power Cable Assembly CX–2682/U (3 ft 3 in.)	1	1	
Electrical Lead CX–2683/U (20 ft 0 in.)	1	1	1

a. Reel RC–405/TR and Electrical Power Cable Assembly CX–2440/U (150 ft 0 in.). Electrical Power Cable Assembly CX–2440/U (150 ft 0 in.) connects the output of the switch box to the voltage regulator. Reel RC–405/TR is used to store the 150 feet of the cable assembly. The power cable assembly is a three-conductor (No. 16) cable, with a type AN 3106A–32–2P conector at one end and a type AN 3106A–32–2S conector at the other end.

b. Cord CG–409C/U (25 ft 0 in.). Cord CG–409C/U (25 ft 0 in.) is composed of Radio Frequency Cable RG–58C/U with a Radio Frequency Plug UG–88/U at each end.

c. Radio Frequency Cable Assemblies CG–1040A/U (15 ft 3 in.) and CG–1040A/U (25 ft 0 in.). Radio Frequency Cable Assemblies CG–1040A/U (15 ft 3 in.) and CG–1040A/U (25 ft 3 in.) are composed of Radio Frequency Cable RG–62A/U with a Plug UG–260/U at each end.

d. Electrical Power Cable Assembly CX–2272/U (3 ft 5 in.). Electrical Power Cable Assembly CX–2272/U (3 ft 5 in.) is a two-conductor (No. 16) cable assembly with a type AN 3106B–14S–9S connector at one end and a type AN 3106B–14S–9P connector at the other end.

e. Electrical Power Cable Assembly CX–2273/U (10 ft 4 in.). Electrical Power Cable Assembly CX–2273/U (10 ft 4 in.) is a six-conductor (No. 16) cable assembly with a type AN 3106B–20–7P connector at one end and a type AN 3106B–20–7S connector at the other end.

f. Electrical Power Cable Assembly CX–2275/U (8 ft 4 in.). Electrical Power Cable Assembly CX–2275/U (8 ft 4 in.) is a three-conductor (No. 16) cable assembly with a type AN 3106B–18–5P connector at one end and a type AN 3106B–18–5S connector at the other end.

g. Electrical Power Cable Assembly CX–2276/U (6 ft 4 in.) and CX–2276/U (2 ft 0 in.). Electrical Power Cable Assemblies CX–2276/U (6 ft 4 in.) and CX–2276/U (2 ft 0 in.) are four-conductor (No. 16) cable assemblies. Each has a type AN 3106B–20–4P connector at one end and a type AN 3106B–20–4S connector at the other end.

h. Electrical Power Cable Assembly CX–2277/U (8 ft 4 in.). Cable Assembly CX–2277/U (8 ft 4 in.) is a four-conductor (No. 12) cable assembly with a type AN 3106B–18–10P connector at one end and a type AN 3106B–18–10S connector at the other end.

i. Electrical Power Cable Assembly CX–2440/U (15 ft 0 in.). Electrical Power Cable Assembly CX–2440/U (15 ft 0 in.) is a three-conductor (No. 6) cable assembly with a type AN 3106A–32–2S at one end and a type AN 3106A–32–2P connector at the other end.

j. Electrical Power Cable Assembly CX–2441/U (8 ft 5 in.). Electrical Power Cable Assembly CX–2441/U (8 ft 5 in.) is a three-conductor (No. 14) cable assembly. It has a Hubbell type No. 7572 connector at one end and a Hubbell type No. 7555 connector on the other end.

k. Electrical Power Cable Assembly CX–2442/U (10 ft 0 in.). Two Electrical Power Cable Assemblies CX–2442/U (10 ft 0 in.) are supplied to connect Switch Box SA–357/G with a prime and auxiliary power source. Each has a type AN 3106A–32–2S connector at one end and three terminal leads at the other end.

l. Electrical Power Cable Assembly CX–2682/U (3 ft 3 in.). Electrical Power Cable Assembly CX–2682/U (3 ft 3 in.) is a two-conductor (No. 16) cable assembly with a type AN 3106B–14S–7S connector at one end and a type AN 3106B–14S–7S connector at the other end.

m. Electrical Lead CX–2683/U (20 ft 0 in.). Electrical Lead CX–2683/U (20 ft 0 in.) is a one-conductor (No. 6) cable assembly that grounds Switch Box SA–357/G to Ground Rod MX–148/G (not supplied). One terminal lead (with eyelet) is connected to the terminal stud (and wing nut) on the GROUND side of the switch box and the other terminal lead connects to the ground rod clamp.

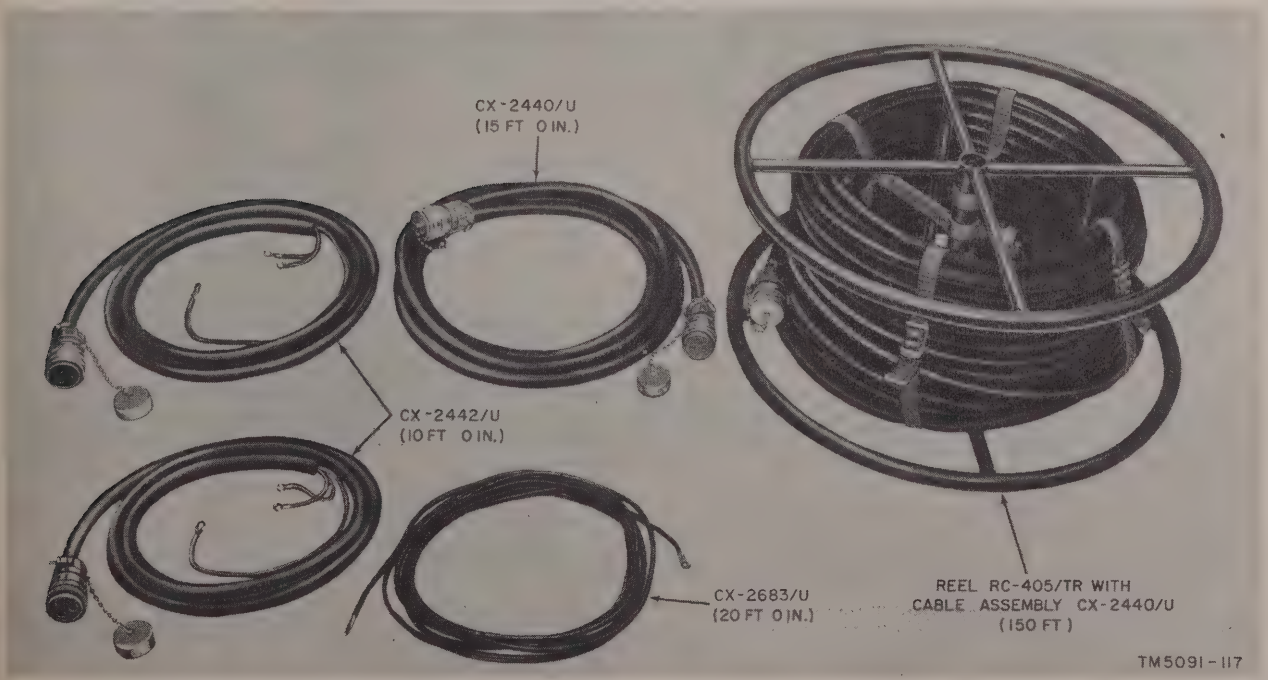


Figure 24. Main power cables.

31. Running Spares

Note. A spare modem and 4 spare lightning arrestors are supplied with Multiplexer Set AN/TCC–13. These are mounted on the multiplexer rack.

A list of the running spares supplied with the equipment is given below. These running spares are stored in the chests.

Quantity			Name	Type
AN/TCC–13	AN/TCA–1	AN/TRA–10		
1	1	1	Electrical contact brush assembly	Powerstat, S373P
1	1	1	Crystal rectifier	IN34A
14	12	5	Crystal rectifier	IN38A
2	2	2	Electron tube	OA2
1	1	1	Electron tube	OA3
1	1	1	Electron tube	OB2
1	1	1	Electron tube	2X2A
1	1	1	Electron tube	5CP1A
2	2	1	Electron tube	5R4WGY
5	7	6	Electron tube	6AG5
7	9	9	Electron tube	6AG7
2	1	2	Electron tube	6AS7G
1	1	1	Electron tube	6AU6
1	1	1	Electron tube	6X4
2	2		Electron tube	12AT7
17	12	9	Electron tube	12AT7WA
3	5	5	Electron tube	5726/6AL5W
1	1	1	Electron tube	5727/2D21W
1	1	1	Electron tube	6005/6AQ5W
		6	Fuse, cartridge	15/100 amp, 250v
6	6		Fuse, cartridge	1/10 amp, 125 v
	6	18	Fuse, cartridge	1/10 amp, 250 v
	6	6	Fuse, cartridge	3/10 amp, 125 v
36	24		Fuse, cartridge	3/10 amp, 250 v
	12	12	Fuse, cartridge	6/10 amp, 250 v
6	6		Fuse, cartridge	1 amp, 125 v
6	6		Fuse, cartridge	1.5 amp, 125 v
30	30	12	Fuse, cartridge	2 amp, 125 v
12	12		Fuse, cartridge	3 amp, 125 v
		12	Fuse, cartridge	3 amp, 250 v
12	12		Fuse, cartridge	4 amp, 125 v
		12	Fuse, cartridge	4 amp, 250 v
12	12		Fuse, cartridge	5 amp, 125 v
		12	Fuse, cartridge	5 amp, 250 v
6	6		Fuse, cartridge	8 amp, 125 v
		6	Fuse, cartridge	8 amp, 250 v
12			Fuse, cartridge	10 amp, 32 v
8	8	7	Glow lamps	NE–51
1	1		Incandescent lamps	GE type 3S6–125
1	1		Thermal resistor	WECo type 13D
	4	2	lightning arrestor assembly	

Note. This list is for general information only. See appropriate supply publications for information pertaining to allowable spare parts.

32. Electrical Power Requirements

a. Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 each require a single-phase ac input. This can be obtained from any source of power within the following limits.

(1) 115 or 230 volts ac ±10 per cent.

(2) 47.5 to 63 cps.

b. The multiplexer set and the multiplexer group consumes 1,100 watts. The restorer group consumes 785 watts.

33. Additional Equipment Required

No additional equipment is necessary to install the equipment other than ordinary small hand tools and a vacuum-tube voltmeter (vtvm). Because the multiplexer set, multiplexer group, and restorer group are always operated as part of a communication system, a radio set capable of being modulated over the required bandwidth (such as Radio Set AN/TRC–29) is necessary, in addition to the individual telephone handsets or manual telephone switchboard.

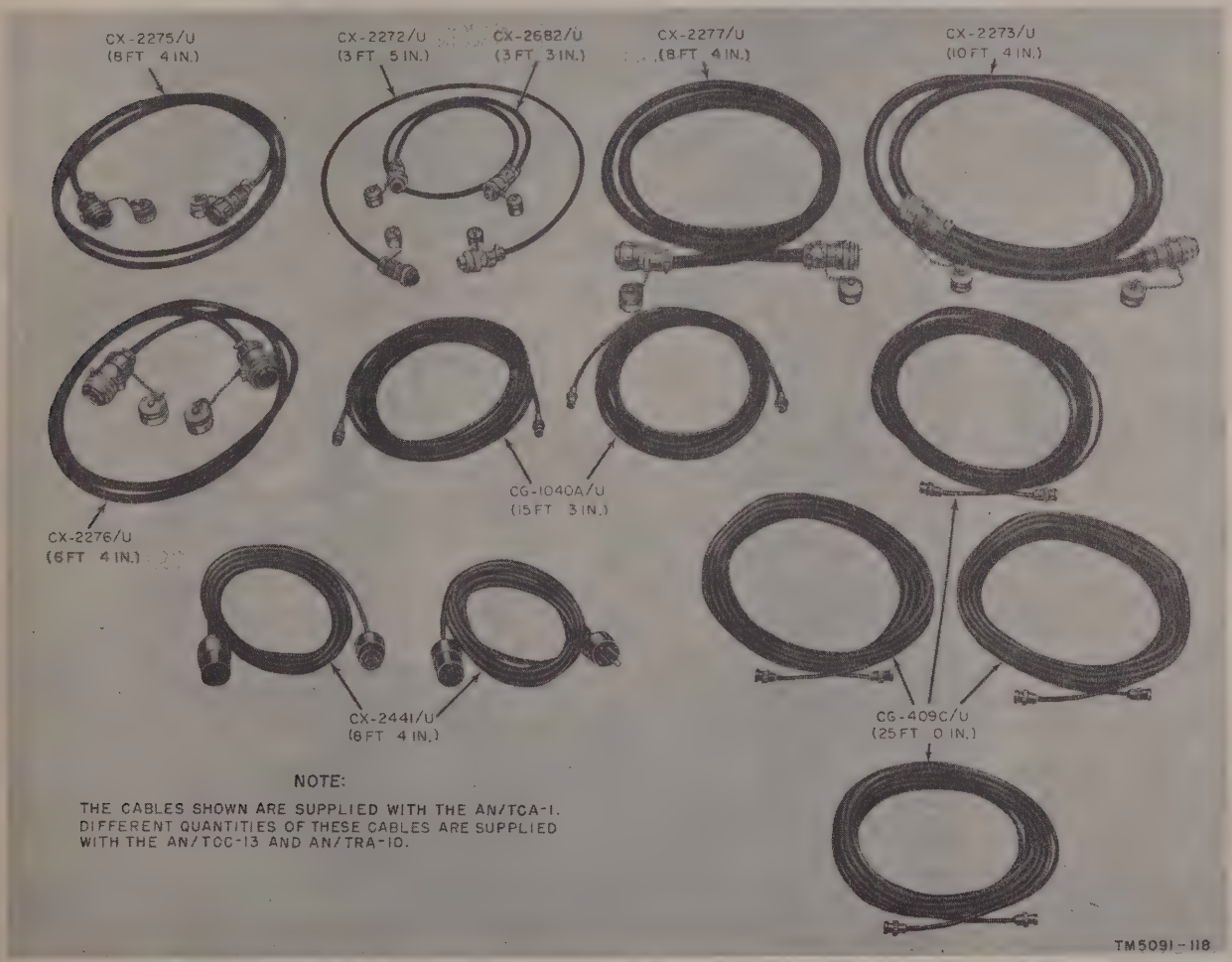


Figure 25. Interconnecting power and signal cables.

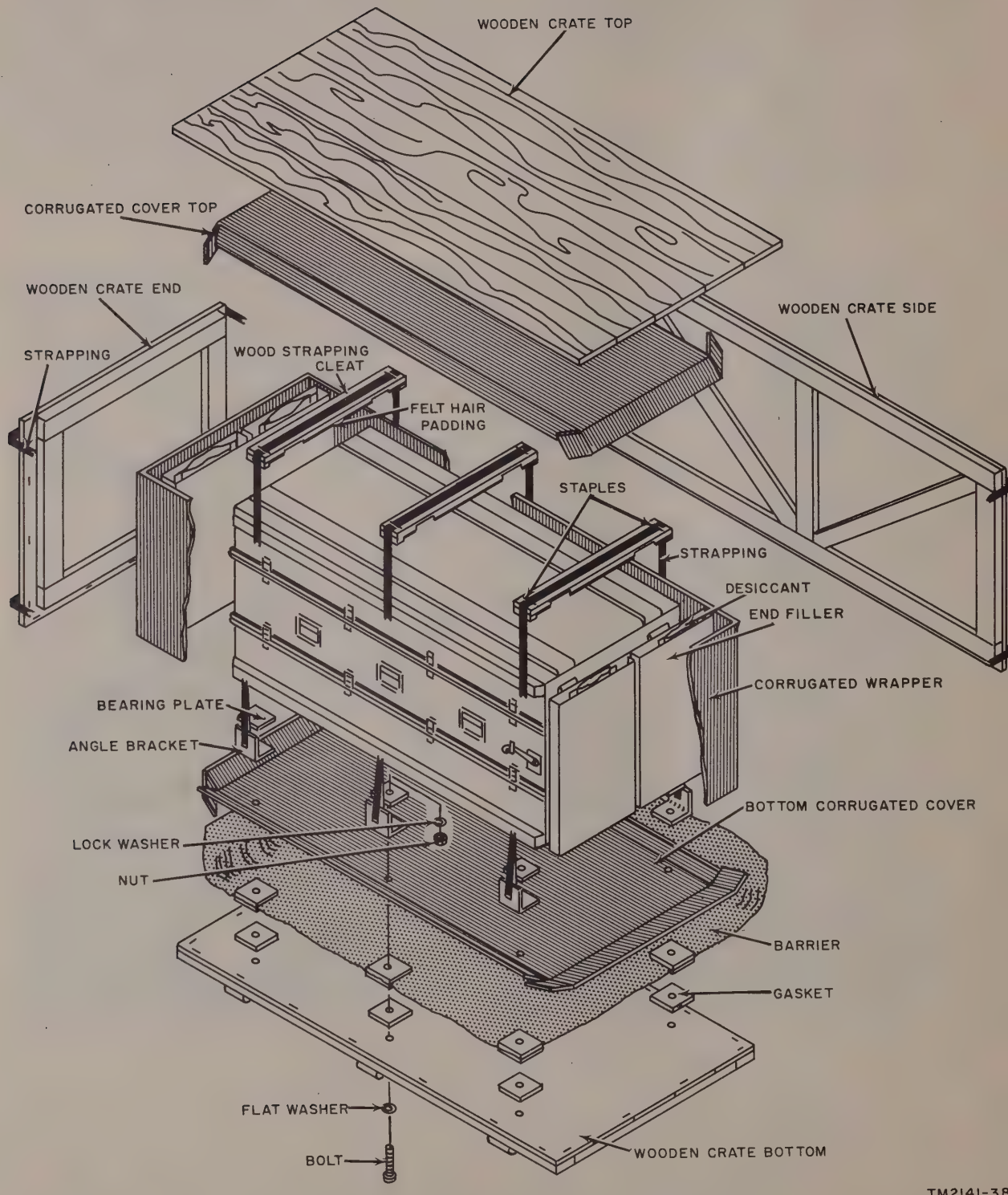


Figure 26. Large case packaging diagram.

CHAPTER 2

INSTALLATION OF MULTIPLEXER SET AN/TCC–13

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

34. Siting

a. Multiplexer Set AN/TCC–13 is never used alone but always as a part of a radio-relay system. When used as part of Radio Telephone Terminal Set AN/TRC–38 (fig. 5), the siting problems applicable to Radio Set AN/TRC–29 are the prime transmission considerations. (Refer to the manual on Radio Set AN/TRC–29 for siting considerations when the multiplexer set is used as part of Radio Telephone Terminal Set AN/TRC–38.)

b. The multiplexer set may be located in any place that is convenient to the supplied radio set, the audio input lines, and the power source. The length of input cables is not important if the audio input level is adequate.

35. Uncrating, Unpacking, and Checking New Equipment

Note. For service upon receipt of used or reconditioned equipment, refer to paragraph 41.

a. General. The components of Multiplexer Set AN/TCC–13 may be packed for oversea or domestic shipment. Check the number of crates against the table of components (par. 8) to be sure that all the components have been received.

b. Step-by-step Instructions for Unpacking Crates 1 and 2 (Multiplexer and Test Equipment Racks) (fig. 26).

(1) Place packing crates 1 and 2 (par. 6) as near the operating position as convenient.

(2) Cut and fold back the steel straps.

(3) Remove the nails from the top and one end of the wooden crate with a nail puller. Remove the top and end. Prying off the top and end may cause damage to the equipment.

(4) Remove the nails from the remaining sides of the crate with a nail puller.

(5) Cut the barrier and remove the corrugated cover.

(6) Remove the end fillers and desiccant.

(7) Cut each of the three strappings.

(8) Use the carrying handles to remove the cases. Because these cases weigh as much as 535 pounds, seven men may be required to remove them.

(9) Place the cases at the desired locations.

(10) Inspect the equipment for possible damage incurred during shipment.

(11) Check the contents of each packing case against the master packing list.

c. Step-by-step Instructions for Unpacking Small Crates (fig. 27).

(1) Place packing crates 3, 4, and 5 (par. 6) as near the operating position as convenient.

(2) Cut and fold back the steel straps.

(3) Remove the nails from the top and one side of the crate with a nail puller. Remove the top and side. Prying off the top or side may cause damage to the equipment.

(4) Remove the nails from the remaining sides of the crate with a nail puller.

(5) Open the outer moistureproof barrier.

(6) Remove the outer corrugated carton.

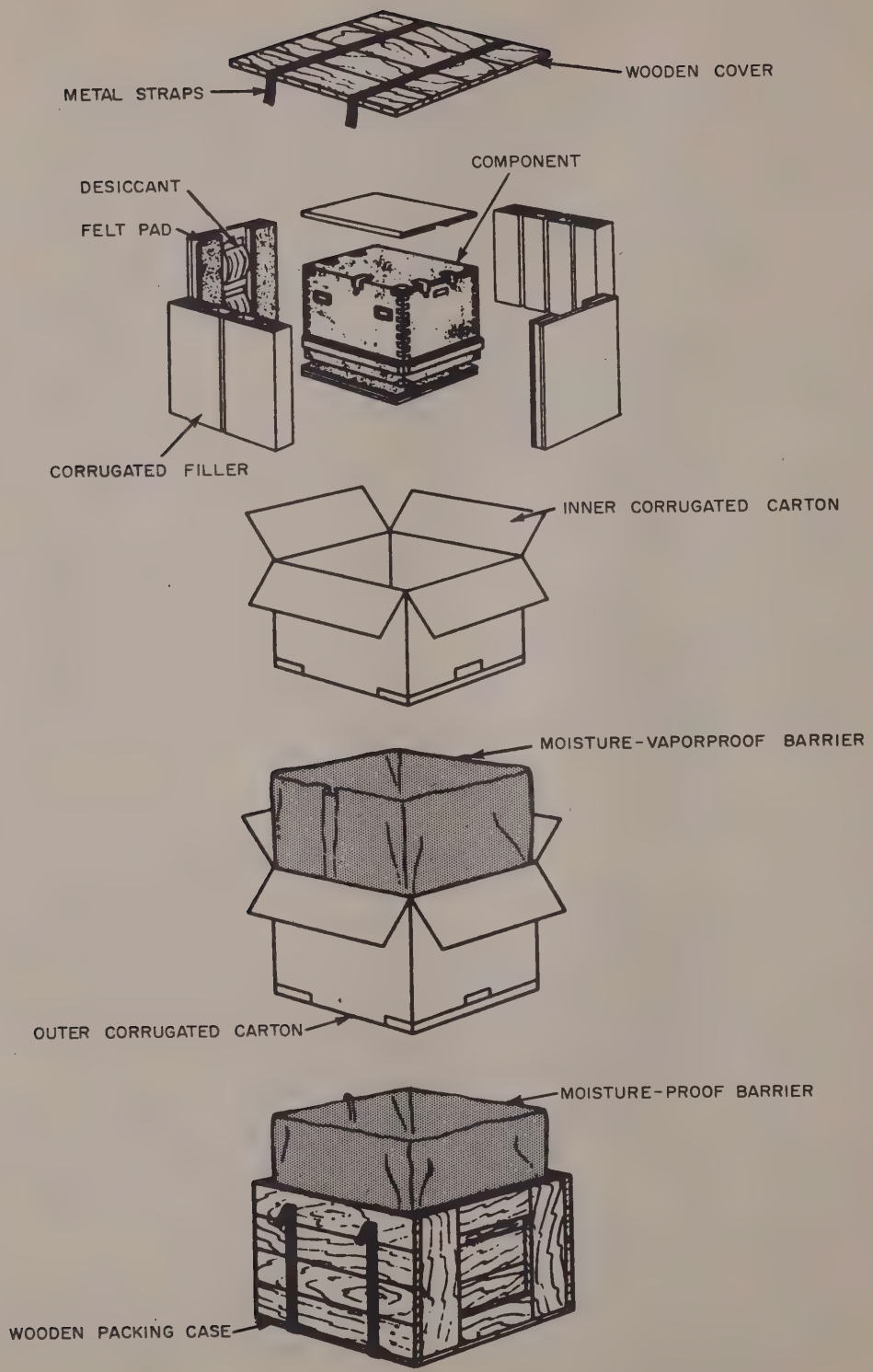


Figure 27. Typical small case packaging diagram.

(7) Open the inner moisture-vaporproof barrier.
(8) Remove the inner corrugated carton.
(9) Remove the corrugated filler, felt pads, and desiccant.
(10) Use the carrying handles to remove the cases from the crates.
(11) Place the cases at the desired location.
(12) Inspect the equipment for possible damage incurred during shipment.
(13) Check the contents of each packing case against the master packing slip.

d. Unpacking Domestic Shipment. When packed for domestic shipment, the multiplexer set is packed exactly as for oversea shipment except for the lack of the outer moistureproof barrier liner. To unpack equipment packed for domestic shipment, proceed as directed in *b* and *c* above.

Note. Save the original packing cases and containers for both oversea and domestic shipments. They can be used again when the equipment is repacked for storage or shipment.

36. General Installation

a. Except for the initial uncrating, which requires seven men to lift the transit cases from the packing crates, one man who is familiar with the installation procedures can assemble Multiplexer Set AN/TCC–13 in approximately 30 minutes. An additional 30 minutes is required to connect the 23 telephone input lines. In 45-channel operation, these time requirements are doubled.

b. The components of Multiplexer Set AN/TCC–13 are packed in five crates (par. 6). All the individual subchassis are mounted in the multiplexer and test equipment racks. No assembly other than connecting the cables and telephone lines is required.

c. When the transit cases are opened for the first time, each of the subchassis should be inspected for proper seating of tubes, tightness of front panel controls, and free motion on the runner tracks. Loosen the captive screws of each subchassis with a screw driver and pull the subchassis forward as far as it will go.

d. The following table lists the fuses used in the AN/TCC–13 and AN/TCA–1 and indicates their functions. Check these fuses to be sure that the proper fuse is installed in the proper clip.

Equipment	Panel Marking	Values in Amperes
Common unit (fig. 16)	10 AMP —6.3V FIL	10
	3/10 AMP +250V	3/10
	10 AMP —6.3V FIL	10
	3/10 AMP +250V	3/10
Filament supply (fig. 51)	FIL LEFT SIDE	2
	FIL RIGHT SIDE	2
	B+ GROUP 1	3/10
	B+ GROUP 2	3/10
	B+ GROUP 3	3/10
	B+ GROUP 4	3/10
	FAN	2
Voltage regulator (fig. 57)	BRUSH FUSE	8
	CONTROL FUSE	3
	MOTOR FUSE	3
Power supply (fig. 56)	UTILITY POWER FUSES	5
Audio test set (fig. 54)	FUSE	4
Oscilloscope (fig. 53 and 31)	FUSE	4
	FAN	3/10

Caution: There is no locking mechanism to hold the individual modems and the audio test set in place; these chassis may be withdrawn completely from the mounting rack. The multiplexer subassembly (filament supply) and the power supply *do not slide forward.* Unscrew the captive screws and the multiplexer subassembly chassis to remove the filter panel. Unscrew the captive screws on the power supply so that the panel can swing down on its hinges.

37. Installation Procedures for 23-channel Operation

a. Unpack the interior of the transit cases by removing the transit case doors and removing the packing around the racks and subunits.

b. Check the individual subchassis (par. 36).

c. Connect all the cables as indicated in paragraph 39.

d. Do not connect the telephone lines to the binding posts at the rear of the mounting rack until all the adjustments are completed.

e. Refer to figures 28 through 31 for the location of all receptacles, and to figure 32 for the 23-channel interconnection diagram.

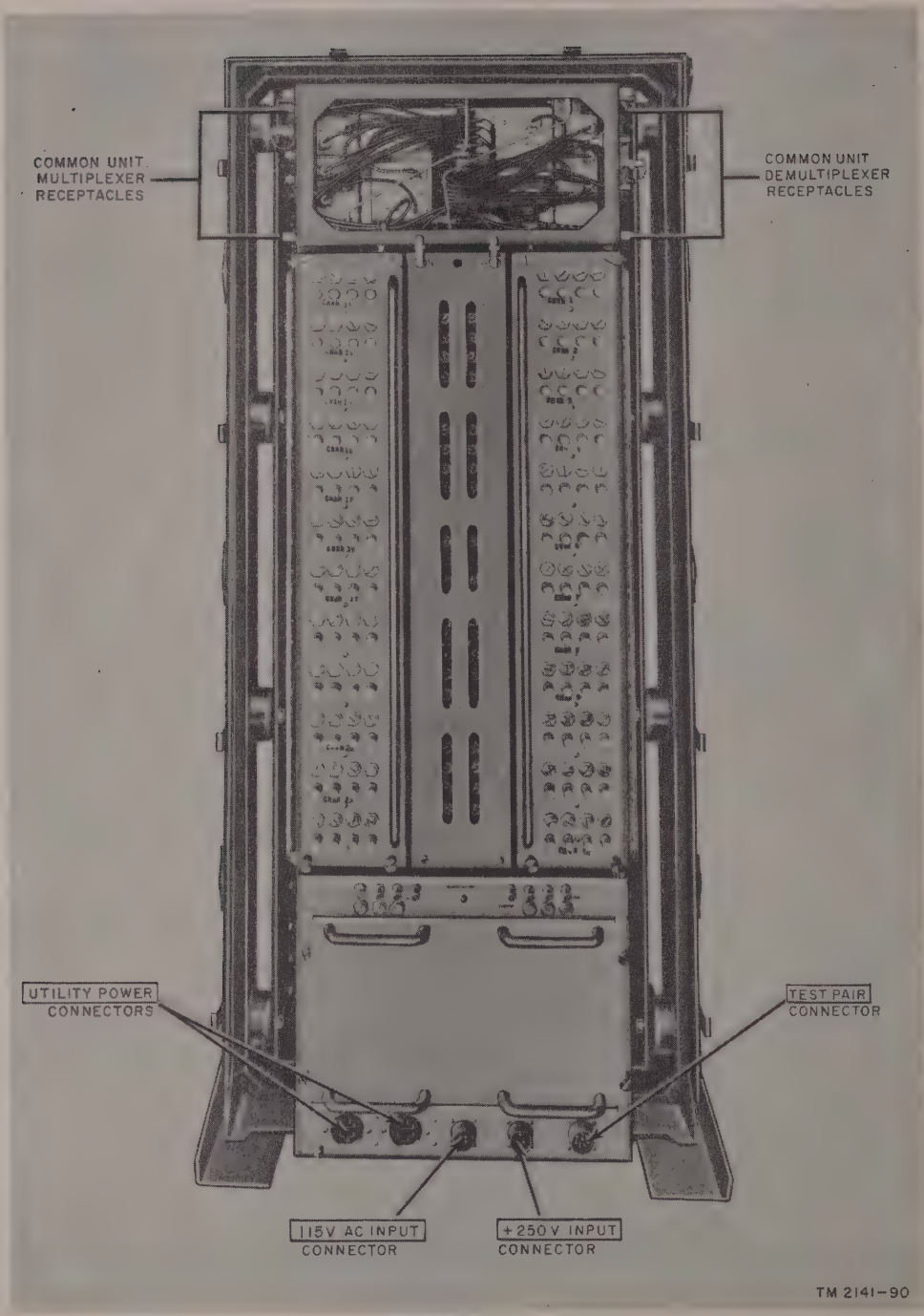


Figure 28. Multiplexer Set AN/TCC–13, multiplexer rack, showing receptacles, rear view.

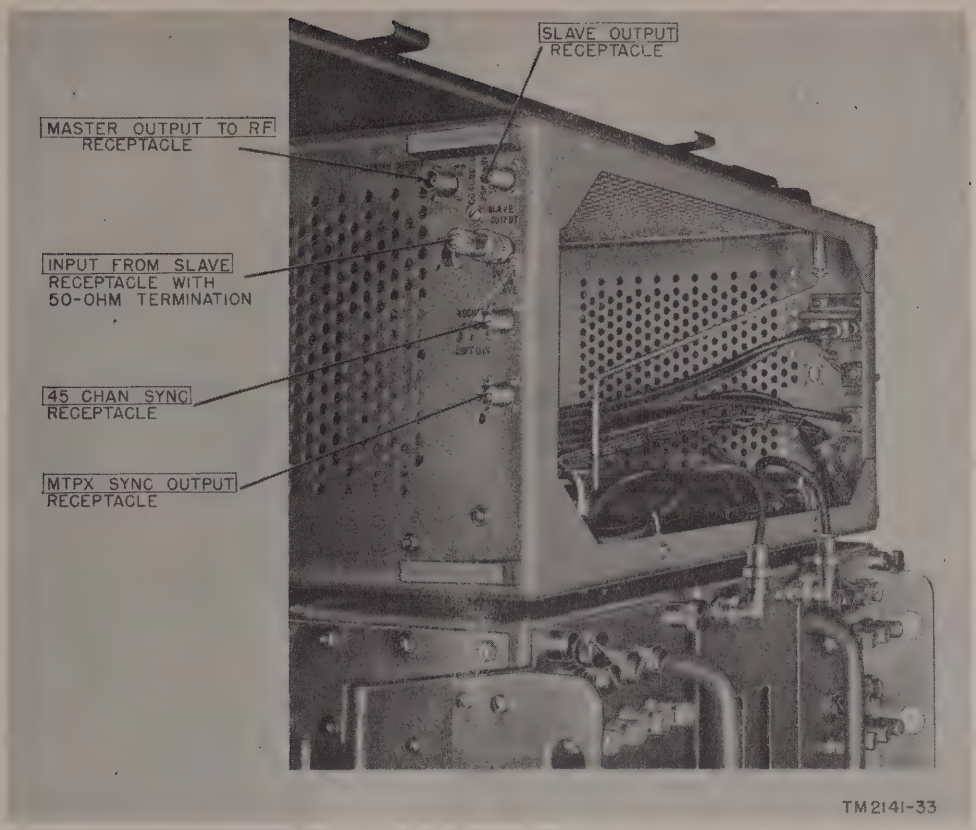


Figure 29. Common unit multiplexer receptacles.

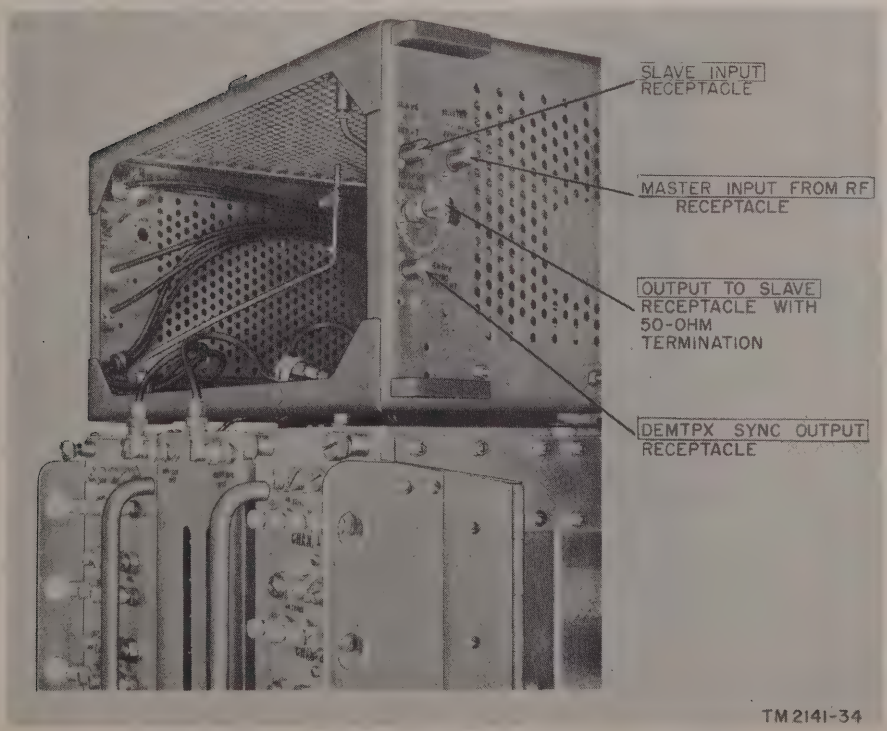


Figure 30. Common unit demultiplexer receptacles.

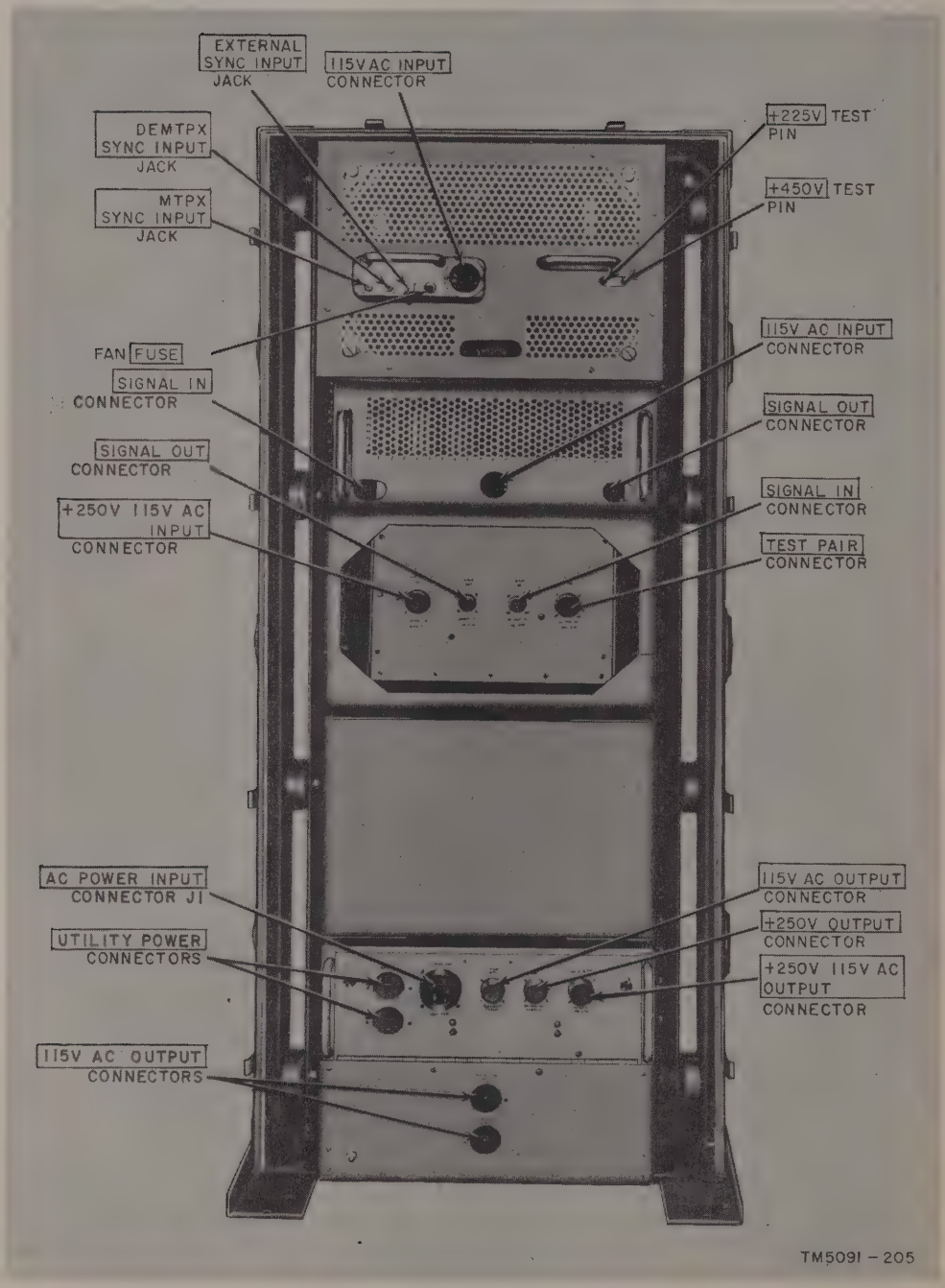


Figure 31. Test rack, showing receptacles, rear view.

38. Installation Procedures for 45-channel Operation

a. Unpack the transit cases of two individual Multiplexer Sets AN/TCC–13. Unpack each transit case by removing the doors and removing all packing from around the racks and subunits.

b. Check the individual subchassis (par. 36).

c. Connect all the cables as indicated in paragraph 40.

d. Do not connect the telephone lines to the binding posts at the rear of the mounting rack.

e. Refer to figures 28 through 31 for the location of all receptacles, and to figure 33 for the 45-channel interconnection diagram.

39. Cable Connections for 23-channel Operation (fig. 32)

Cord or cable assembly	Length	From		To	
		Subchassis	Connector	Subchassis	Connector
CG–409C/U	25 ft	Common unit	MASTER OUTPUT TO RF	Suitable transmission system	VIDEO FILTER INPUT
CG–409C/U	25 ft	Common unit	MASTER INPUT FROM RF	Suitable receiver system	VIDEO OUTPUT
CG–1040A/U	15 ft, 3 in.	Common unit	MTPX SYNC OUTPUT	Oscilloscope	MTPX SYNC INPUT
CG–1040A/U	15 ft, 3 in.	Common unit	DEMPTX SYNC OUTPUT	Oscilloscope	DEMPTX SYNC OUTPUT
CX–2441/U	8 ft, 5 in.	Power supply	115V AC OUTPUT	Audio test set	115V AC INPUT
CX–2441/U	8 ft, 5 in.	Power supply	115V AC OUTPUT	Oscilloscope	115V AC INPUT
CX–2272/U	3 ft, 5 in.	Test set	SIGNAL IN	Control monitor	SIGNAL OUT
CX–2273/U	10 ft, 4 in.	Control monitor	TEST PAIR	Filament supply	TEST PAIR
CX–2275/U	8 ft, 4 in.	Power supply	+250V OUTPUT	Filament supply	+250V INPUT
CX–2276/U	6 ft, 4 in.	Power supply	+250V 115V AC OUTPUT	Control monitor	+250 115V AC INPUT
CX–2277/U	8 ft, 4 in.	Power supply	115V AC OUTPUT	Filament supply	115V AC INPUT
CX–2440/U	15 ft	Power supply	AC POWER INPUT	Voltage regulator	AC POWER OUTPUT
CX–2440/U	150 ft	Switch box	115/230 VAC OUTPUT	Voltage regulator	AC POWER INPUT
CX–2442/U	10 ft	Switch box	115/230 VAC INPUT 1	Prime power source	
CX–2442/U	10 ft	Switch box	115/230 VAC INPUT 2	Auxiliary power source	
CX–2683/U	3 ft, 3 in.	Test set	SIGNAL OUT	Control monitor	SIGNAL IN
CX–2683/U	20 ft	Switch box	GROUND	Ground rod	

Note. Attach 50-ohm terminating plugs that hang alongside the INPUT FROM SLAVE and OUTPUT TO SLAVE connectors.

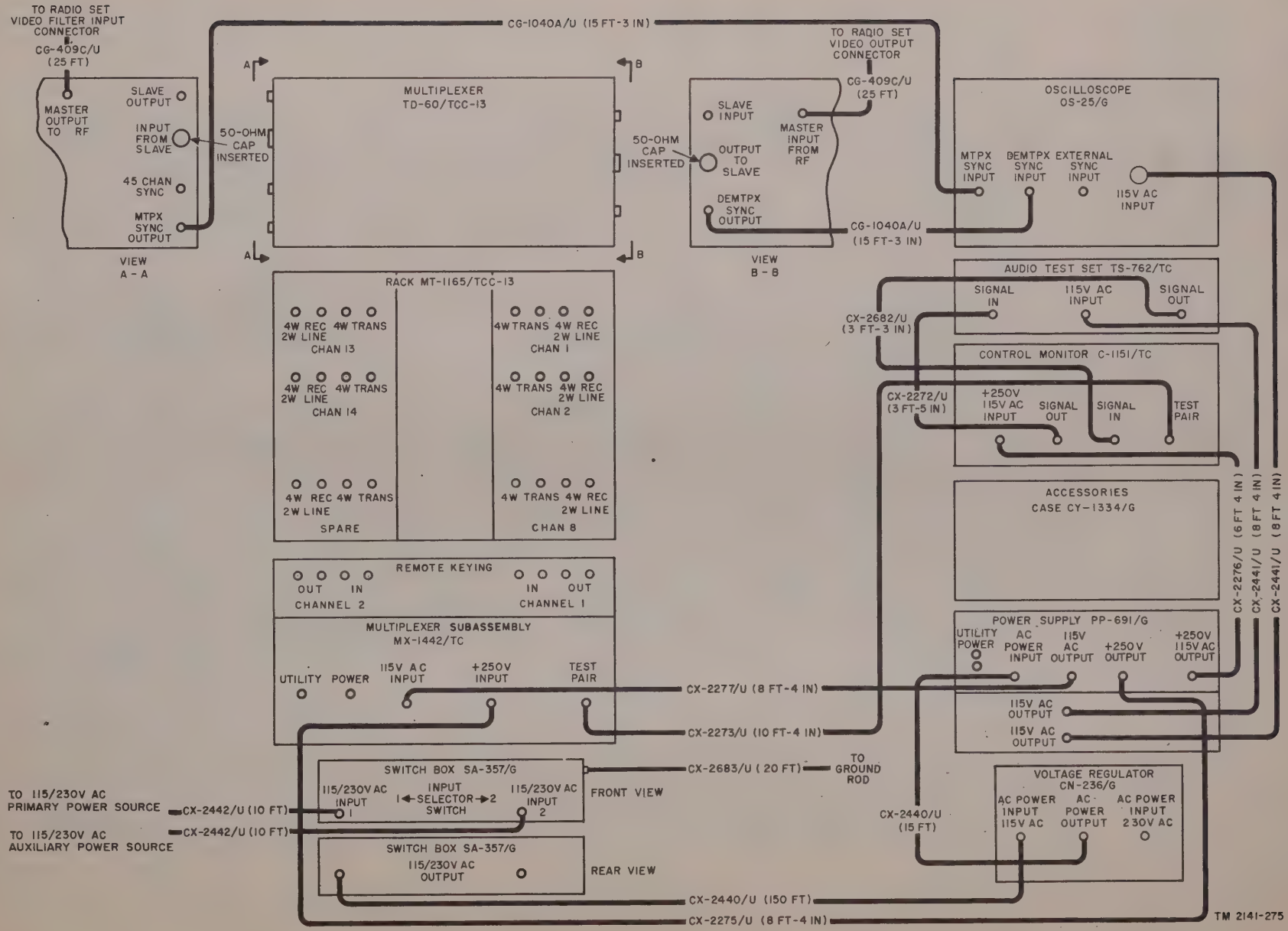


Figure 32. Interconnection diagram for 23-channel operation.

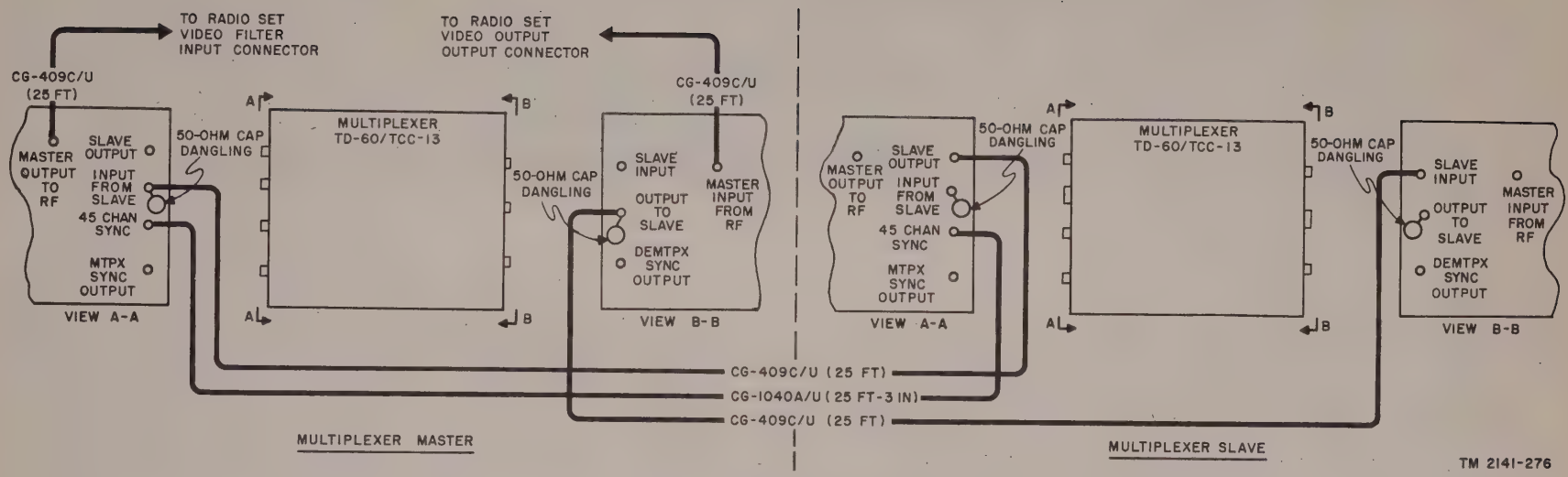


Figure 33. Interconnection diagram for 45-channel operation.

40. Additional Cable Connections for 45-channel Operation (fig. 33)

Note. For 45-channel operation, connect all the cables that are required for 23-channel operation (par. 39) and those listed below.

Cord or cable assembly	Length	From		To	
		Unit	Connector	Unit	Connector
CG–409C/U	25 ft	*Master* Multiplexer of common unit	INPUT FROM SLAVE[a]	*Slave* multiplexer of common unit	SLAVE OUTPUT
CG–409C/U	25 ft	*Master* demultiplexer of common unit	OUTPUT TO SLAVE	*Slave* demultiplexer of common unit	SLAVE INPUT
CG–1040A/U	25 ft, 3 in.	*Master* Multiplexer of common unit	45 CHAN SYNC	*Slave* multiplexer of common unit	45 CHAN SYNC

[a]Remove the 50-ohm terminating plugs before inserting the cable assembly connectors.

41. Service upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 35 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for changes made by Modification Work Orders. If any changes in wiring have been made, note the change on the schematic and wiring diagrams in this manual and the book of schematic diagrams.

c. Perform all installation and connection procedures given in paragraphs 36 through 39.

Section II. INSTALLATION AND ADJUSTMENT PROCEDURES, FOUR-WIRE OPERATION

Note. Personnel performing the procedures described in this section should be familiar with the use of controls and instruments described in paragraphs 79 through 91.

42. General

a. Multiplexer Set AN/TCC–13 is factory-aligned. Only the oscilloscope, the audio test set, the initial setting of levels on the modems, and the pulse position alignment require adjustment upon installation.

b. This section covers the initial checks and adjustment procedures that must be performed on Multiplexer Set AN/TCC–13 after installation and before operation. The simplest method of performing these checks is to operate the equipment on a four-wire basis, *back-to-back.* This procedure (par. 44) is only used during testing and alignment. In back-to-back operation, the output of the modulating and multiplexing system is connected to the input of the demultiplexing and demodulating system. There is no external transmission system during back-to-back operation. To prepare the equipment for two-wire operation, check it on a four-wire basis and then change the modem switches to the two-wire position.

c. The adjustment procedure outlined in this section may be performed by one man (on a back-to-back basis). The procedure occasionally may require making an adjustment and then observing the resultant wave shape on the oscilloscope; it is convenient to turn the test equipment rack so that the oscilloscope can be viewed from the point where the adjustments are made.

d. Failure to meet the operational requirements called for in the following paragraph indicates trouble in the equipment. If this occurs, perform the complete realignment procedures described in paragraphs 372 through 382.

43. Initial Checks and Adjustments

a. Mechanical Checks.

(1) Check all the cables for tightness of connections by turning the cable connector plug collars by hand.

(2) Check all the power connections at the switch box, the voltage regulator, the

rear of the power and filament supplies, the oscilloscope, the audio test set, and the control monitor.

(3) Be sure that the tube shields are secure and that the interchassis cables and terminal board connections are tight.

(4) Be sure that the MASTER-SLAVE switches, located on each of the common unit subchassis, are in the MASTER positions. Unscrew the four panel screws that mount the common unit to the multiplexer and pull out the common unit; use the handles.

(5) Unscrew the four screws that hold the filament supply filter and turn the blower motor (fig. 34) over by hand to be sure that it is free.

Caution: Be sure that both the outside and inside of the filter on the filament supply are clean.

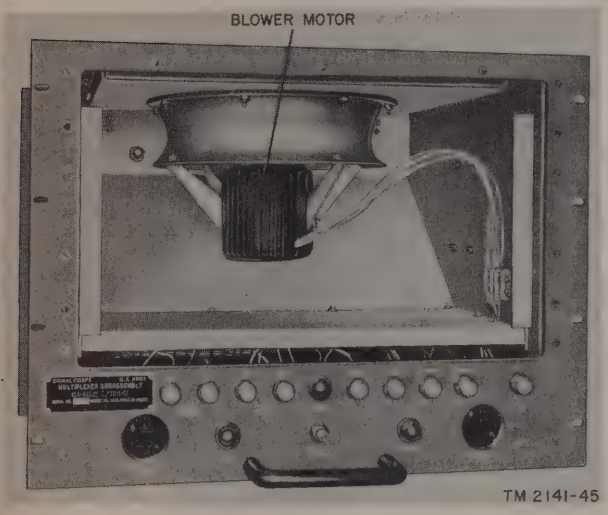


Figure 34. Filament supply blower fan.

(6) Disconnect all the auxiliary equipment that may be plugged into the utility power sockets.

b. Electrical Power Application. Connect the ac input power to the equipment as follows:

(1) Throw the INPUT SELECTOR SWITCH on the switch box to either the 115/230 VAC INPUT 1 or 115/230 VAC INPUT 2 position, depending on the connection of the primary power source.

(2) The voltage regulator (fig. 57) is normally supplied ready for use with a 115-volt ac power source. To reset the voltage regulator for operation on a 230-volt power source from operation on a 115-volt power source (or vice versa), proceed as follows:

(*a*) Disconnect the power cord connected to the AC POWER INPUT connector of the voltage regulator.

Note. Both the power switches should be in the OFF positions.

(*b*) Loosen the screws that hold the protective bar on the voltage regulator circuit breakers.

(*c*) For 230-volt operation, slide the bar to the extreme left; for 115-volt operation, slide the bar to the extreme right; tighten the screws that hold the protective bar to lock the bar in place.

(*d*) Connect the power cord to the appropriate connector.

(*e*) Place the protective cap on the unused receptacle.

Caution: Always cap the unused receptacle on the voltage regulator.

(3) Throw either the 230V AC INPUT ON or 115V AC INPUT ON power circuit breaker on the voltage regulator (fig. 57) to the ON position, depending on the primary power source. The 115 VAC OUTPUT pilot lamp, at the right of the circuit breakers, should light.

(4) Throw the power supply FILAMENT circuit breaker (fig. 56) to the ON position. The FILAMENT ON pilot lamps on the power supply and filament supply should light. Check the line voltage on the LINE VOLTS meter. The line voltage should be 115 volts ± 1 per cent. If the line voltage is not within these limits, adjust the OUTPUT VOLTAGE potentiometer on the voltage regulator (fig. 57) so that the meter indicates 115 volts. Throwing the filament switch to ON applies filament voltage to the entire set, except the oscilloscope and audio test set.

Caution: Be sure that the blower fan, mounted in the bottom of the multiplexer subassembly (filament supply), is operating.

(5) Turn the voltage regulator SENSITIVITY control (fig. 57) clockwise until the voltage regulator starts hunting (gear chatter will be heard from the voltage regulator when the unit is hunting); then turn the control counterclockwise until the hunting just stops. Turn the control counterclockwise another 10° to be sure it has stopped.

(6) Wait 30 seconds and throw the power supply +250V circuit breaker to the ON position. The +250 V ON pilot lamps on the power supply and filament supply should light. This applies plate voltage to all components of the set except the oscilloscope and audio

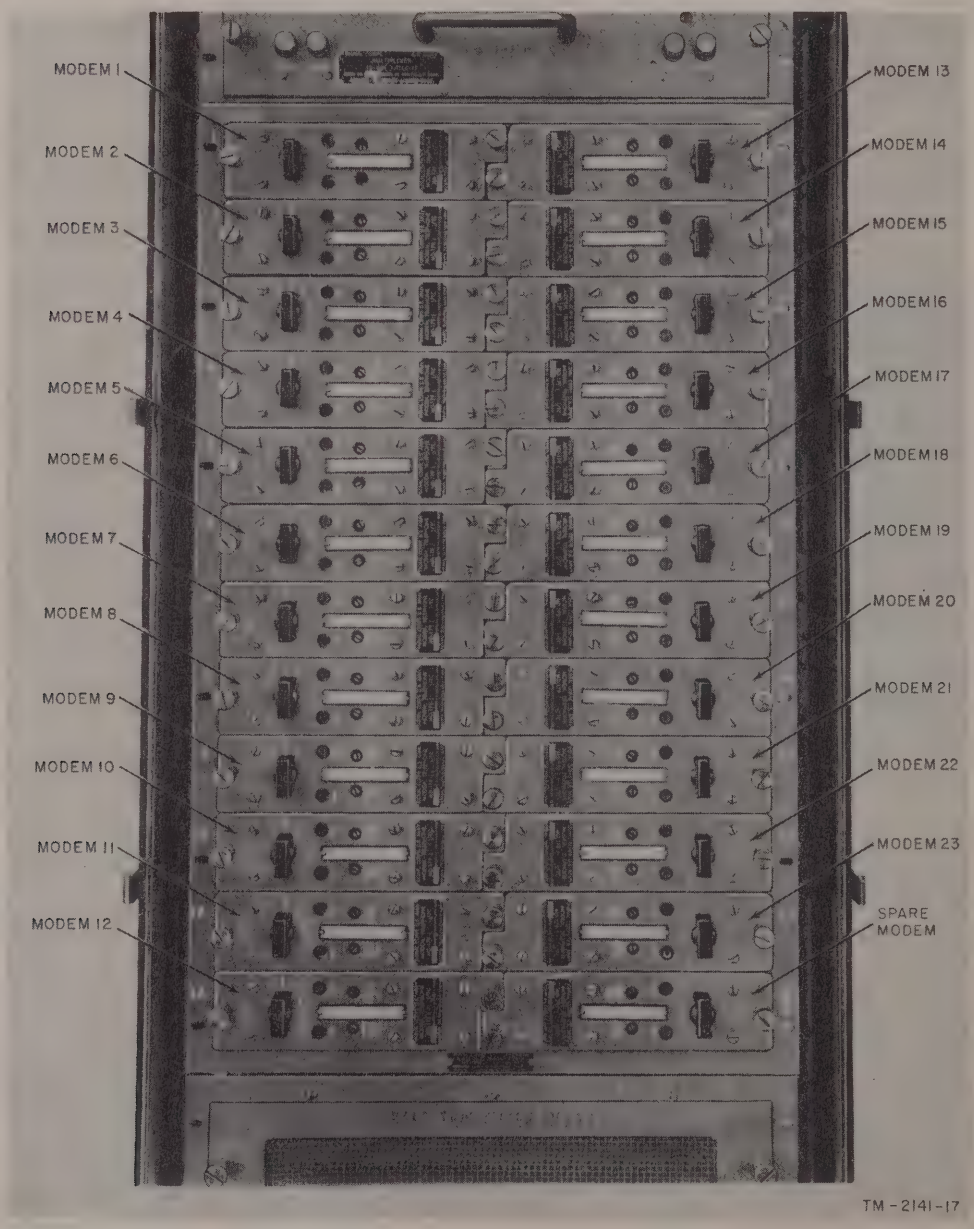


Figure 35. Multiplexer Set AN/TCC–13, location of modems.

test set. These have their own plate supply.

(7) Throw the oscilloscope ON-OFF switch (fig. 53) and the audio test set ON-OFF switch (fig. 54) to the ON position. The POWER ON pilot lamps on each unit should light. Operating the toggle power switches on the oscilloscope and audio test set places the respective units completely in operation, because they have self-contained filament and plate supply sources.

44. Connections for Back-to-back Operation

Connect the multiplexer set for back-to-back operation as follows:

a. Remove two Cords CG–409C/U (25 ft) from the rf transmission system and the common unit.

b. Connect one of the removed cable assemblies between the MASTER INPUT FROM RF and MASTER OUTPUT TO RF connectors on the common unit.

c. Connect 50-ohm terminating plugs to the INPUT FROM SLAVE and OUTPUT TO SLAVE connectors.

d. Place the filament supply remote keying units in the NORMAL OPERATION position.

e. Place all modems on a four-wire basis as follows:

(1) Unscrew the two front panel screws that mount each modem to the mounting rack and pull forward.

Caution: Be careful when pulling the unit out; there is no stop.

(2) Pull out the 2W-4W switch (fig. 36) and plug it in with the 4W position pointing toward the arrow.

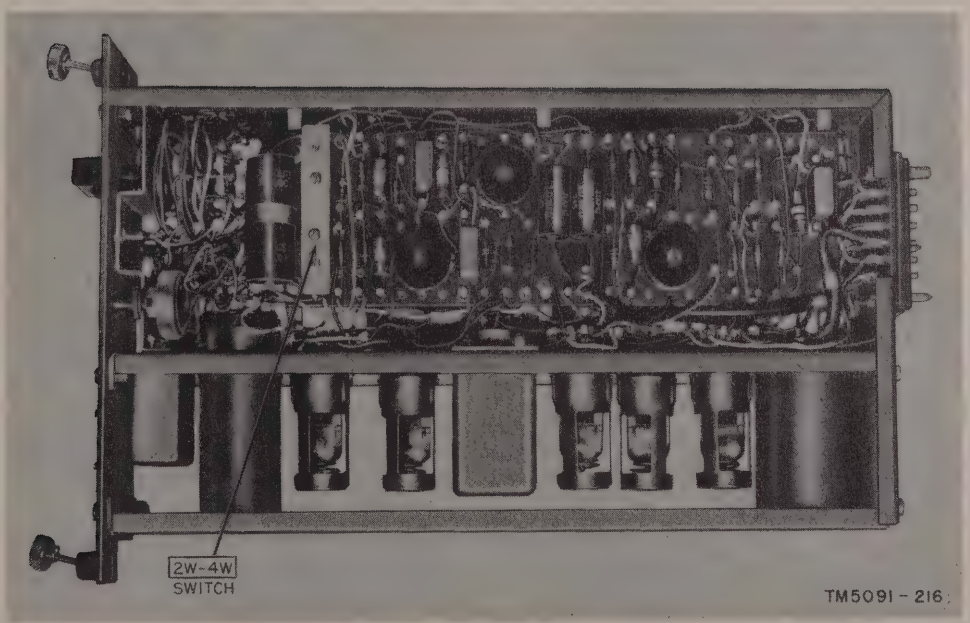


Figure 36. Location of modem 2W–4W switch.

45. Checking Oscilloscope 60-cycle Voltage Calibrator Wave Form

a. Set the oscilloscope controls (fig. 53) as follows:

Control	Position
SYNC SELECTOR	+INT
COARSE	5000
FINE	10
INTENSITY	Fully counterclockwise
HOR POSITION	Fully clockwise
VERT POSITION	Middle of range
TIMING PIP PHASE	OFF
CAL VOLTAGE	5
VERT ATTEN	CAL
VERT GAIN	Fully clockwise
TRIGGER	Fully counterclockwise
STAB	Fully counterclockwise
ON-OFF switch	ON
PIP LOCKING	Fully counterclockwise

b. Wait 30 seconds, then advance the intensity control clockwise until a vertical line appears on the scope.

c. Adjust the ASTIG and FOCUS controls until a sharply focused vertical line is seen at the left side of the screen.

d. Rotate the HOR POSITION control to its midposition.

e. Advance the STAB control until a sweep appears; then turn it in the opposite direction until the sweep just disappears.

f. Advance the TRIGGER control until a stable image of a clipped sine wave appears (fig. 37). The pattern on the screen is the 60-cycle clipped sine wave-voltage calibrator wave form that is used for direct-reading voltage calibration of input signals.

g. The check in *a* through *f* above gives a good indication that the oscilloscope is operating properly.



Figure 37. Oscilloscope voltage calibrating wave form (60-cycle clipped sine wave).

46. Calibrating Audio Test Set

Calibrate the audio test set as follows:

a. Push in the SEND-CALIBRATE push switch (fig. 54). The DECIBELS meter pointer should read at the red line. If it does not, slowly rotate the ADJ SEND control until the pointer rests on the red line. Release the SEND-CALIBRATE switch.

b. Push in the REC-CALIBRATE push switch. The DECIBELS meter should again read at the red line. If it does not, slowly rotate the ADJ REC control until the pointer rests on the red line.

Note. Always perform the SEND calibration before the REC calibration because the REC reading depends on prior ADJ SEND calibrations.

47. Alignment of Output Pulse Train

a. Press the control monitor NORMAL push button switch in and turn the power supply FILAMENT ON power switch (fig. 56) to ON.

b. Set +250V circuit breaker on the power supply to the ON position.

c. Allow the equipment to warm up 15 minutes for stable operation.

d. While the equipment is warming up, proceed as follows:

(1) Check to see if the TW-4W switch (fig. 36) in each modem is in the 4W position.

(2) Place all modem selector switches (fig. 50) in the OPER position.

e. After the 15-minute warm-up, connect the oscilloscope test probe to the PULSE TRAIN OUTPUT TO RF test point on the common unit (fig. 62). A special cable is provided for this purpose in the oscilloscope probe compartment.

f. Check the output train as follows:

(1) Turn the oscilloscope SYNC SELECTOR switch to the MULTIPLEXER position.

(2) Turn the COARSE control to the 50 position, and the FINE control to approximately the 5 position.

(3) Adjust the VERT ATTEN and VERT GAIN controls so that the pattern is two boxes high (2 centimeters (cm)). The pattern now appearing on the

scope screen should be similar to that shown in figure 63.

(4) Check to see that all the individual channel pulses are present. The top left-hand modem unit (fig. 35) generates the pulse immediately to the right of the double marker pulse. This pulse is called the channel 1 pulse. The channel 2 pulse is generated by the second modem down from the top left and is the second pulse to the right of the double marker pulse. The remainder of the modems on the left side generate pulses 3 through 12. Starting at the top right-hand side of the rack, the modems are numbered 13 through 23. The bottom unit on the right side is a spare modem and is interchangeable with any other modem.

g. Align the pulse train as follows:

(1) Adjust the oscilloscope COARSE and FINE controls so that two successive markers occupy approximately nine boxes (9 cm) across the oscilloscope screen.

(2) Turn on the oscilloscope timing pips by turning the TIMING PIP PHASE control clockwise. If the timing pips are not locked, set the TIMING PIP PHASE control to the center of its range and adjust the PIP LOCKING control until the pips are locked. Adjust the phase of the pips with the TIMING PIP PHASE control so that a timing pip begins to ride into the leading edge of the second marker pulse. This will show a slight amplitude increase of the second marker pulse.

(3) Vary the PULSE POSITION control of the channel 1 modem until the leading edge of the channel 1 pulse rides into the timing pip immediately to the right of the second marker pulse. Adjust the PULSE POSITION control so that the channel 1 pulse approaches the timing pip from the right.

(4) Channel 1 is aligned when its amplitude just begins to increase as the second marker pulse did under its alignment ((2) above).

(5) Repeat the steps in (3) and (4) above for channels 2 through 23.

(6) Check the complete pulse train alignment as follows:

(*a*) Change the TIMING PIP PHASE control very slightly.

(*b*) All pulses (including the second marker pulse) should increase and decrease in amplitude simultaneously. If any channel pulse does not do this, repeat the alignment procedure for this channel, and then check the alignment of the entire train again.

48. Checking Amplitude of Output Pulse Train

Check the amplitude of the output pulse train as follows:

a. Perform all the procedures described in paragraphs 45 and 47.

b. Connect the 10:1 oscilloscope probe to the MASTER OUTPUT TO RF test jack on the common unit.

c. Adjust the oscilloscope VERT ATTEN and VERT GAIN controls so that the output pulse train is two boxes high. Note the setting of the VERT ATTEN control.

d. Rotate the VERT ATTEN control to the CAL position. This will supply the 60-cycle voltage calibrator wave form.

e. Adjust the CAL VOLTAGE control until the voltage calibrator wave form is also two boxes high. Note the control setting.

f. The amplitude of the output pulse train is the product of the VERT ATTEN control setting (*c* above) and the CAL VOLTAGE control setting (*e* above) read directly in volts.

Note. When using the direct cable probe, multiply this value by 10.

g. The pulse train level on the oscilloscope should be .5 volt from base level to peak. If this value is not obtained, pull out the common unit and adjust the OUTPUT AMPL control (R74) of the multiplexer section (fig. 111).

49. Checking Modulation of Channels

Check the modulation of the channels as follows:

a. Calibrate the audio test set as described in paragraph 46.

b. Depress the control monitor SEND switch,

set the test set SEND-DBM controls to the —4 position, and depress the audio test set MEASURE F1A push switch.

c. Place the channel 1 modem selector switch in the SR position.

d. Turn on the oscilloscope timing markers by rotating the TIMING PIP PHASE clockwise from the OFF position.

e. Set the oscilloscope COARSE control to the 5-microsecond position, and the FINE control to the 1-microsecond position.

f. Rotate the FINE control until two consecutive timing pips are 10.4 boxes (10.4 cm) apart on the oscilloscope cathode-ray tube. The sweep speed is now .5 microsecond per centimeter.

g. Place the oscilloscope probe in the PULSE TRAIN OUTPUT jack on the common unit. The channel 1 pulse should move one box (±.5 microsecond) from leading edge to leading edge.

h. Return the selector switch on modem 1 to the OPER position, and repeat the steps in *d* through *f* above for all other modems.

50. Checking Modem Audio Output Level

Check the modem audio output level as follows:

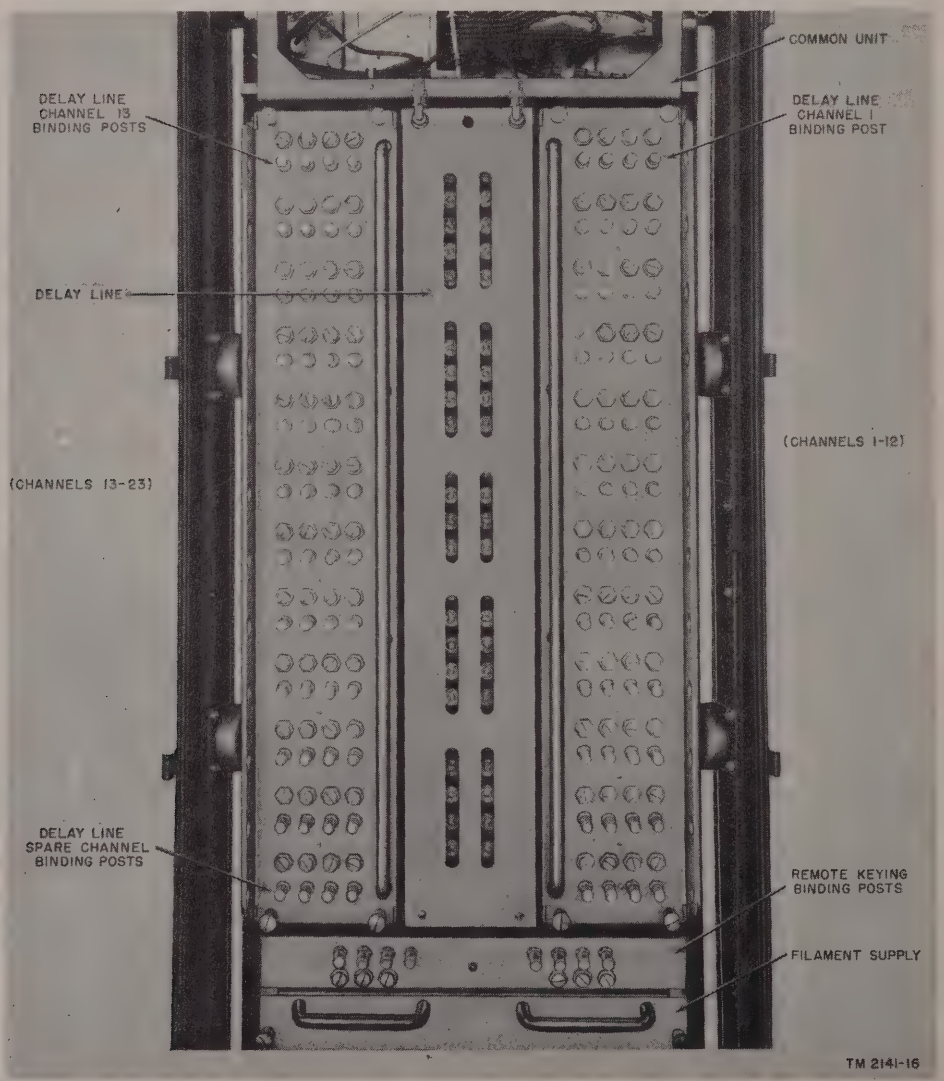


Figure 38. Delay line and channel binding posts.

a. Push the SEND switch on the control monitor panel. Place the modem 1 selector switch in the SR position. Apply a signal of —4 decibels referred to 1 milliwatt in 600 ohms (dbm) to channel 1 from the audio test set. The signal that is received on this modem should be 0 dbm in amplitude. To measure this, connect a separate two-conductor cable from the 4W REC channel 1 binding posts (fig. 38) to the 600-ohm RECEIVE IN pair of jacks on the lower right front panel of the audio test set.

b. If this level is not obtained, adjust the OUTPUT AUDIO GAIN control on the channel 1 modem (fig. 50) until this value is read on the audio test set.

c. Return the modem selector switch to OPER position.

d. Repeat the procedures described in *a* through *c* above for channels 2 through 23.

51. Final Connections

When all checks, adjustments, and alignments (par. 45 through 50) have been completed, remove the back-to-back operational connections by reversing the procedures described in paragraph 44. Prepare for normal multiplexer operation as follows:

a. Connect the four-wire telephone lines to the binding posts alongside the delay line (fig. 38).

b. With the oscilloscope probe connected to the common unit PULSE TRAIN OUTPUT jack, have the switchboard operator at the other end of the telephone line talk into channel 1 in a normal conversational tone and give a test count. Pulse modulation should be seen on the oscilloscope.

c. Repeat the procedure in *b* above for channels 2 through 23.

d. The multiplexer set is now ready for operation.

Section III. INSTALLATION AND ADJUSTMENT PROCEDURES, TWO-WIRE OPERATION AND REMOTE KEYING OPERATION

52. Two-wire Operation

Perform all the installation adjustment procedures described in paragraphs 44 through 51; then proceed as follows:

a. Place the 2W-4W switch in each modem (fig. 36) in the 2W position.

b. Connect the two-wire telephone lines to the binding posts alongside the delay line (fig. 38).

c. The multiplexer set is now ready for use.

53. Remote Keying Operation

a. Perform all the installation adjustment procedures described in paragraphs 44 through 51.

b. In addition to the usual audio connections (either two- or four-wire operation), connect the remote vhf stations to the channel 1 and channel 2 remote keying binding posts, above the rear of the filament supply as follows:

(1) Connect the *keying-in* pair (pair used to operate the remote vhf station) to the appropriate channel REMOTE KEYING IN binding posts (fig. 18).

(2) Connect the *keying-out* pair to the appropriate channel (one or two) REMOTE KEYING OUT binding posts.

c. Unscrew the four captive screws (fig. 39) that hold the rear panel to the filament supply and remove the panel by handles.

d. Remove each of the remote keying units, invert, and replace them so that REMOTE KEYING OPERATION arrows point upward (fig. 18).

e. Replace the rear panel by reversing the procedure described in *c* above.

54. General

Follow the procedures described in paragraphs 42 through 51 for each of the multiplexer sets to be used for 45-channel operation. Designate one the *master* station and the other the *slave* station.

Note. For 45-channel operation, channel 23 of the *slave* station is not used.

55. Initial Checks and Adjustments

a. Cable Connections. Connect the cables as indicated in paragraphs 39 and 40. Refer to figure 33 for the interconnecting diagram.

b. Master Multiplexer. Set the controls of the *master* multiplexer as indicated below. All controls are located on the common unit subchassis.

(1) To gain access to the controls, loosen the four screws that hold the common unit to the multiplexer rack. Pull out the common unit by the handles (fig. 40).

(2) Set the MASTER-SLAVE switch located on the common unit multiplexer section chassis (fig. 111) to the MASTER position.

(3) Set the MASTER-SLAVE switch located on the common unit demultiplexer section chassis (fig. 112) to the MASTER position.

c. Slave Multiplexer. Set the controls of the *slave* multiplexer as indicated below. All controls are located on the common unit subchassis.

(1) To gain access to the controls, loosen the four screws that hold the common unit to the multiplexer rack. Pull out the common unit by the handles.

(2) Set the MASTER-SLAVE switch located on the common unit multiplexer section chassis (fig. 111) to the SLAVE position.

(3) Set the MASTER-SLAVE switch located on the common unit demultiplexer section chassis (fig. 112) to the SLAVE position.

d. Electrical Power Applications. Connect the ac power to the *master* and *slave* units as indicated in paragraph 43*b*.

56. Alignment of 45-channel Output Pulse Train

Note. Align the output pulse train of the *master* and *slave* stations as described in paragraph 47 before proceeding.

a. Connect the oscilloscope probe to the MASTER OUTPUT TO RF test point of the MASTER station.

b. Turn on the oscilloscope timing pips. If the timing pips are not locked, set the TIMING

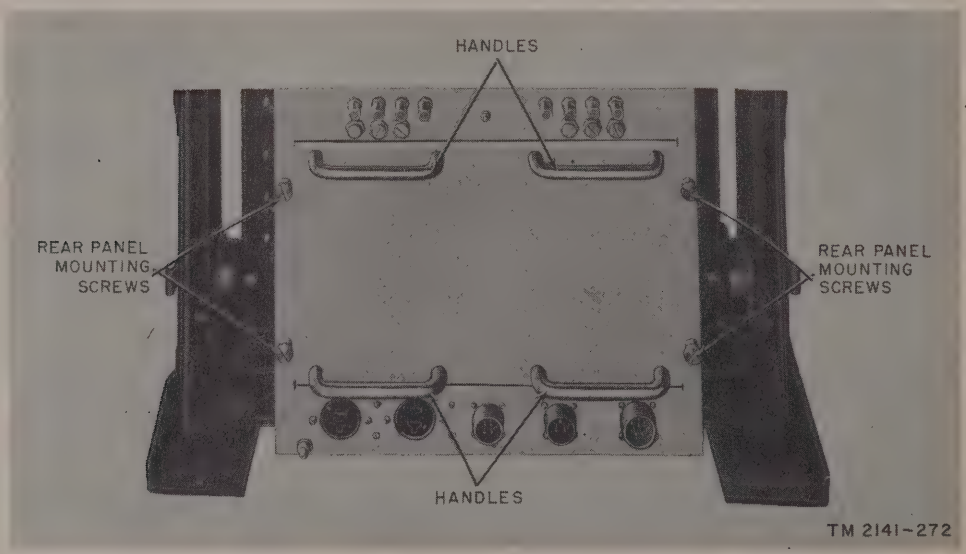


Figure 39. Filament supply, rear view, showing handles and mounting screws.

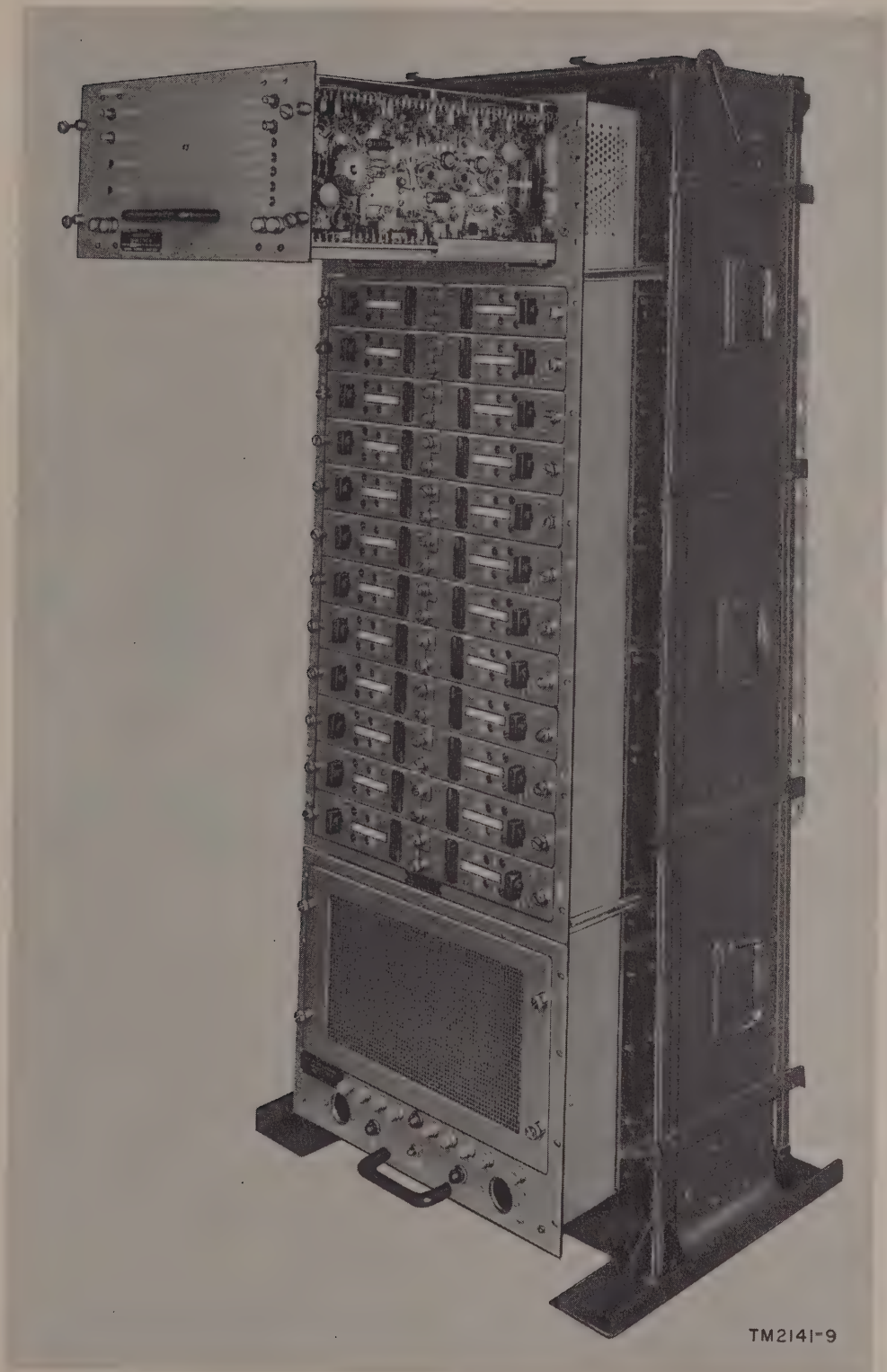


Figure 40. Multiplexer rack, common unit pulled out.

PIP PHASE control to the center of its range and adjust the PIP LOCKING CONTROL until the pips are locked. Adjust the phase of the pips with the TIMING PIP PHASE control so that the timing pip begins to ride into the leading edge of the second marker pulse. This will show a slight amplitude increase of the second marker pulse.

c. Adjust the oscilloscope COARSE and FINE controls so that any two timing pips are 10.4 boxes apart.

d. Shut off the timing pips by turning the TIMING PIP PHASE control counterclockwise.

e. Vary the SWEEP PHASE control until both positive and negative marker pulses appear on the face of the crt screen.

f. Vary the 45 CHAN SYNC control (R3) of the *master* station until the leading edge of the first *negative* marker pulse is exactly 5.2 boxes to the right of the leading edge of the first *positive* marker pulse.

57. Checking Amplitude of Channels

Check the amplitude of the 45-channel output pulse train as follows:

a. Connect the special oscilloscope probe to the MASTER OUTPUT TO RF test jack of the *master* multiplexer common unit.

b. The pulse train level *amplitude* on the oscilloscope should be .5 volt from base level to peak, or 1 volt from peak to peak. If this value is not obtained, adjust the OUTPUT AMPL control on the multiplexer portion of the common unit, both *master* and *slave* units. The final adjustment should be made so that the negative pulse train is equal in amplitude to the positive pulse train and equal to .5 volt (base to peak).

Note. The output of the *master* multiplexer is the positive pulse train, the output of the *slave* multiplexer is the negative pulse train.

58. Installation Procedure, Four-wire or Two-wire Operation

a. Four-wire Operation.

(1) Connect the four-wire telephone lines to the binding posts alongside the delay lines of both *master* and *slave* station.

Note. Be sure that the modem 2W-4W switch is in the 4W position.

(2) Perform the test as indicated in paragraph 51*b*.

(3) The 45-channel multiplexer (*Master* and *Slave*) are now ready for operation.

b. Two-wire Operation. Connections for two-wire operation are identical to those for 23-channel operation. Perform the procedures described in paragraph 52*a* through *c*.

59. Installation Procedure, Remote Keying Operation

The remote keying procedures for 45-channel operation are identical to those for 23-channel operation. Perform the procedures described in paragraph 53*b*.

CHAPTER 3

INSTALLATION OF MULTIPLEXER GROUP AN/TCA-1 AND PULSE FORM RESTORER GROUP AN/TRA–10

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

60. Siting

a. Multiplexer Group AN/TCA–1 or Pulse Form Restorer Group AN/TRA–10 is never used alone, but always as a part of a microwave radio-relay system. The siting problems that are applicable to the associated radio sets are always the prime consideration when installing the equipment. When the equipment is used as part of a microwave radio relay using the AN/TRC–29, refer to the manual covering the Radio Set AN/TRC–29 for siting consideration.

b. The multiplexer or pulse form restorer group may be located in any place that is convenient to the supplied radio sets, the audio input lines, and the power source. The length of input cable is unimportant if the level of the audio input is adequate.

61. Uncrating, Unpacking, and Checking New Equipment

Note. For used or reconditioned equipment, refer to paragraph 64.

a. General. The components of Multiplexer Group AN/TCA–1 or Pulse Form Restorer Group AN/TRA–10 may be packed for oversea or domestic shipment. Check the number of crates against the table of components in the appendix to be sure that all the components have been received.

b. Step-by-step Instructions for Uncrating Equipment Rack Crates. Refer to paragraph 35*b* for step-by-step instructions for uncrating equipment rack crates.

c. Step-by-step Instructions for Unpacking Small Crates. Refer to paragraph 35*c* for step-by-step instructions for unpacking small crates.

d. Unpacking Domestic Shipment. When packaged for domestic shipment, the multiplexer and pulse form restorer groups are exactly as for oversea shipment, except for the lack of the moistureproof barrier. To unpack equipment packed for domestic shipment, proceed as directed in *b* and *c* above.

62. General Installation

a. Other than the initial uncrating which requires seven men to lift the transit cases from the packing crates, one man who is familiar with the installation procedures can assemble the multiplexer or pulse form restorer group in approximately 30 minutes.

b. The components of the multiplexer group are packed in six crates. The components of the pulse form restorer group are packed in five cartons. All the individual subchassis are mounted in the transit case and all accessories and cables are packed in the accessories cases. Other than connecting the cables and telephone lines, no other assembly is required.

c. When the transit cases are opened for the first time, each of the components should be inspected for proper seating of tubes, tightness of front panel control, and free motion on the runner tracks. Loosen the captive screws of each subchassis with a screw driver, and pull the subchassis forward as far as it will go. Unscrewing the captive screws on the video restorer front panel permits the restorer blower

to be inspected. Unscrewing the captive screws on the power supply permits the panel to swing down on its hinges.

Caution: There is no locking mechanism to hold the individual modems and the audio test set in place; these chassis may be withdrawn completely from the mounting rack. The multiplexer subassembly and power supply *do not slide forward.*

d. The following table lists the fuses used in Multiplexer Group AN/TCA–1 and indicates their functions. Check these fuses to be sure that the proper fuse is installed in the power clip.

Equipment	Panel marking	Value in amperes
Video restorer (fig. 45)	EASTGOING +250V FUSE	6/10
	WESTGOING +250V FUSE	6/10
	FAN	1/10
Filament supply (fig. 51)	FIL LEFT SIDE	2
	FIL RIGHT SIDE	2
	B+ GROUP 1	3/10
	B+ GROUP 2	3/10
	B+ GROUP 3	3/10
	B+ GROUP 4	3/10
	FAN	2
Voltage regulator (fig. 57)	BRUSH FUSE	8
	CONTROL FUSE	3
	MOTOR FUSE	3
Power supply (fig. 56)	UTILITY POWER FUSES	5
Audio test set (fig. 54)	FUSE	4
Oscilloscope (fig. 53 and 31)	FUSE	4
	FAN	3/10

e. The following table lists the fuses used in the AN/TRA–10 and indicates their functions. Check these fuses to be sure that the proper fuse is installed in the proper clip.

Equipment	Panel marking	Value in amperes
Mounting rack (fig. 52)	B+ EF MODEMS	1/10
	B+ WF MODEMS	1/10
	FILAMENTS	2
	20⁓RINGING SUPPLY	15/100
Power supply (fig. 56)	UTILITY POWER	5
Oscilloscope (fig. 53)	FUSES	5
	FAN	2
Voltage regulator (fig. 57)	BRUSH	8
	CONTROL	3
	MOTOR	3
Video restorer (fig. 45)	EASTGOING +250V FUSE	6/10
	WESTGOING +250V FUSE	6/10
	FAN	1/10

63. Cable Connections

The following charts lists the cables supplied with the multiplexer and pulse form restorer groups and the components that the cables connect. Refer to figures 31 and 41 for location of all receptacles of the multiplexer group and to figure 43 for location of all receptacles of the pulse form restorer group.

Note. Do not connect the telephone lines to the binding posts at the rear of the mounting rack until audio levels are adjusted.

a. Multiplexer Group AN/TCA–1, Cable Connections. Connect the cables as listed below. Refer to figure 42 for the interconnecting diagram.

Cord or cable assembly	Length	From		To	
		Component	Connector	Component	Connector
CG–409C/U	25 ft	Pulse form restorer	INPUT FROM EAST-FACING REC	Eastfacing radio set	VIDEO OUTPUT
CG–409C/U	25 ft	Pulse form restorer	OUTPUT TO EAST-FACING XMTR	Eastfacing radio set	VIDEO FILTER INPUT
CG–409C/U	25 ft	Pulse form restorer	INPUT FROM WEST-FACING REC	Westfacing radio set	VIDEO OUTPUT
CG–409C/U	25 ft	Pulse form restorer	OUTPUT TO WEST-FACING XMTR	Westfacing radio set	VIDEO FILTER INPUT
CG–1040A/U	15 ft, 3 in.	Pulse form restorer	EASTGOING SCOPE SYNC	Oscilloscope	MTPX SYNC INPUT
CG–1040A/U	15 ft, 3 in.	Pulse form restorer	WESTGOING SCOPE SYNC	Oscilloscope	DEMPTX SYNC INPUT
CX–2277/U	8 ft, 4 in.	Multiplexer subassembly	115V AC INPUT	Power supply	115V AC OUTPUT

Cord or cable assembly	Length	From		To	
		Component	Connector	Component	Connector
CX–2275/U	8 ft, 4 in.	Multiplexer subassembly	+250V INPUT	Power supply	+250V OUTPUT
CX–2273/U	10 ft, 4 in.	Multiplexer subassembly	TEST PAIR	Control monitor	TEST PAIR
CX–2442/U	10 ft, 0 in.	Switch box	115/230 VAC INPUT 1	115/230 volt ac primary power source	
CX–2442/U	10 ft, 0 in.	Switch box	115/230 VAC INPUT 2	115/230 volt ac auxiliary power source	
CX–2683/U	20 ft, 0 in.	Switch box	GND CONN	Ground Rod MX–148/G[a]	
CX–2441/U	8 ft, 4 in.	Oscilloscope	115V AC INPUT	Power supply	115V AC OUT
CX–2272/U	3 ft, 5 in.	Audio test set	SIGNAL IN	Control monitor	SIGNAL OUT
CX–2441/U	8 ft, 4 in.	Audio test set	115V AC INPUT	Power supply	115V AC OUT
CX–2682/U	3 ft, 3 in.	Audio test set	SIGNAL OUT	Control monitor	SIGNAL IN
CX–2276/U	6 ft, 4 in.	Control monitor	+250V 115V AC INPUT	Power supply	+250V 115V AC OUTPUT
CX–2440/U	15 ft, 0 in.	Voltage regulator	AC POWER OUTPUT	Power supply	AC POWER INPUT
CX–2440/U	150 ft, 0 in.	Voltage regulator	AC POWER INPUT 115V (230V)[b]	Switch box	115/230 VAC OUTPUT

[a]Not supplied with Multiplexer Group AN/TCA–1.
[b]Depending on primary power source.

b. Pulse Form Restorer Group AN/TRA–10, Cable Connections. Make the cable connections as outlined below. Refer to figure 44 for the pulse form restorer group interconnecting diagram.

Cord or cable assembly	Length	From		To	
		Component	Connector	Component	Connector
CG–409C/U	25 ft	Video restorer	INPUT FROM EAST-FACING REC	Eastfacing radio set	VIDEO OUTPUT
CG–409C/U	25 ft	Video restorer	OUTPUT TO EAST-FACING XMTR	Eastfacing radio set	VIDEO FILTER INPUT
CG–409C/U	25 ft	Video restorer	INPUT FROM WEST-FACING REC	Westfacing radio set	VIDEO OUTPUT
CG–409C/U	25 ft	Video restorer	OUTPUT TO WEST-FACING XMTR	Westfacing radio set	VIDEO FILTER INPUT
CG–1040A/U	183 in.	Video restorer	EASTGOING SCOPE SYNC	Oscilloscope	MTPX SYNC INPUT
CG–1040A/U	183 in.	Video restorer	WESTGOING SCOPE SYNC	Oscilloscope	DEMPTX SYNC INPUT
CX–2276/U	24 in.	Power supply	+250V 115V AC OUTPUT	Mounting rack	+250V 115V AC INPUT
CX–2440/U	150 ft.	Voltage regulator	115V or 230V AC POWER INPUT[a]	Switch box	115/230V AC OUTPUT
CX–2440/U	15 ft	Voltage regulator	AC POWER OUTPUT	Power supply	AC POWER INPUT
CX–2441/U	8 ft, 4 in.	Power supply	115V AC OUTPUT	Oscilloscope	115V AC INPUT
CX–2442/U	10 ft	Switch box	115/230V AC INPUT 1	115/230V AC primary power source	
CX–2442/U	10 ft	Switch box	115/230V AC INPUT 2	115/230 Volt ac auxiliary power source	
CX–2683/U	20 ft	Switch box	GND CONN	Ground Rod MX–148/G[b]	

[a]Depending on input of primary power source.
[b]Not supplied as part of Pulse Form Restorer Group AN/TRA–10.

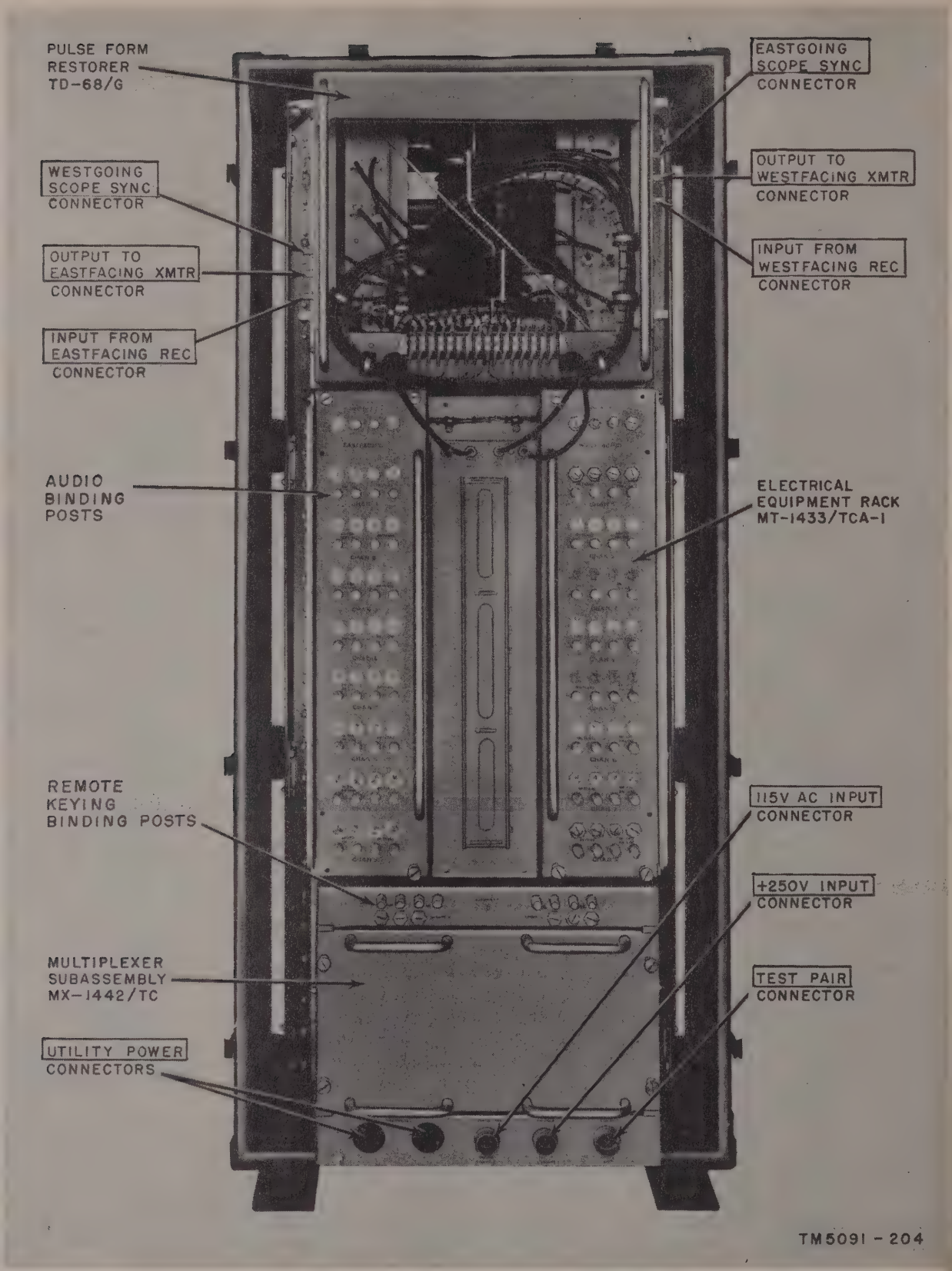


Figure 41. Multiplexer Group AN/TCA–1, multiplexer rack, rear view, showing receptacles.

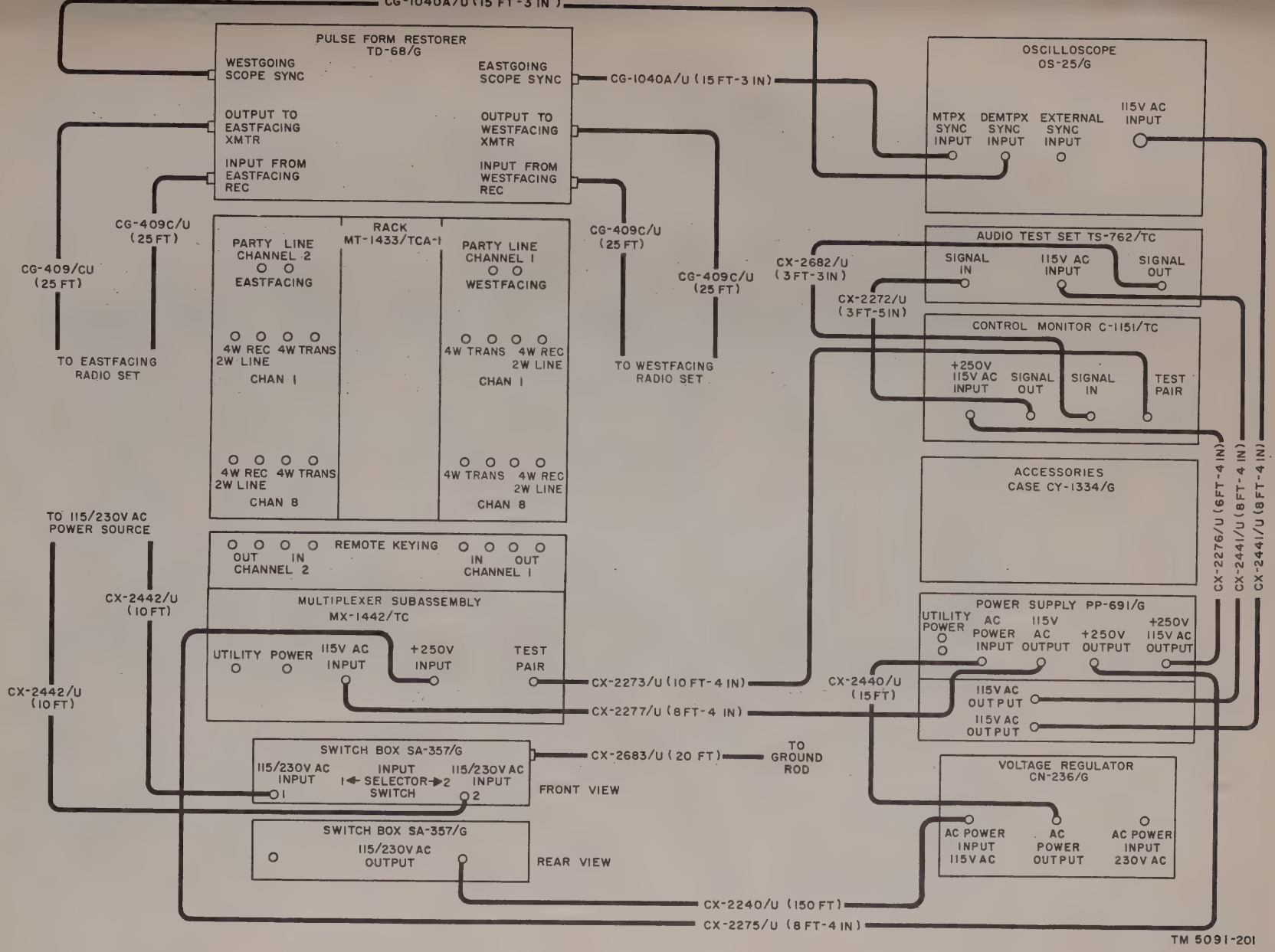


Figure 42. Multiplexer Group AN/TCA–1, interconnecting diagram.

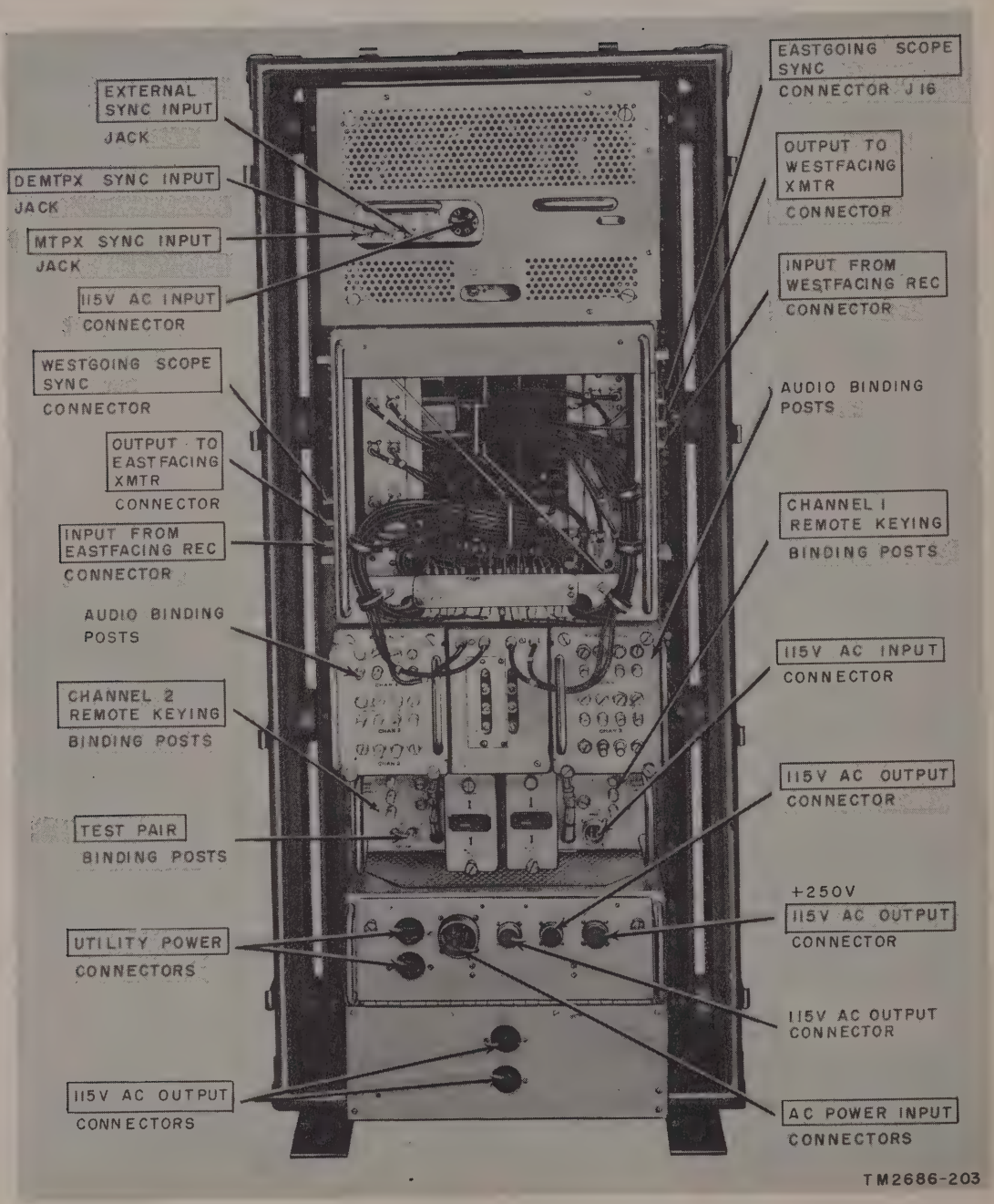


Figure 43. Pulse Form Restorer Group AN/TRA–10, equipment rack, showing receptacles.

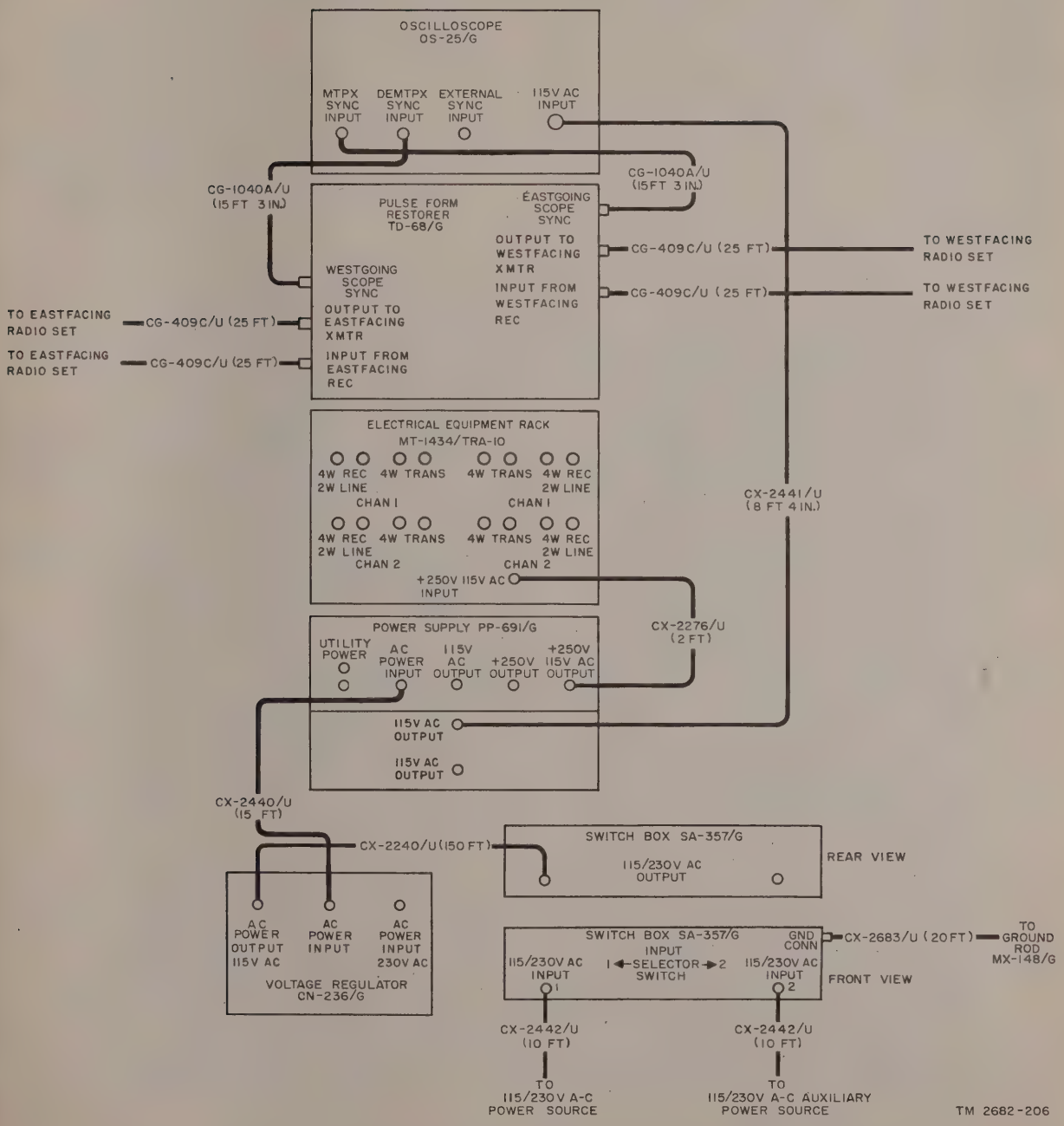


Figure 44. Pulse Form Restorer Group AN/TRA–10, interconnection diagram.

64. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraphs 61 and 62 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for changes made by Modification Work Orders. If any changes in wiring have been made, note the change on the schematic and wiring diagrams in this manual and the book of schematic diagram.

c. Perform all installation and connection procedures given in paragraphs 62 and 63.

Section II. INSTALLATION AND ADJUSTMENT PROCEDURES

Note. Personnel performing the procedures described in this section should be familiar with the use of controls and instruments described in paragraphs 79 through 91.

65. General

a. Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10 are factory-aligned. Only the test equipment, initial setting of levels on the modems, and pulse alignment and amplitude require adjustment.

b. This section covers the initial checks and adjustment procedures that must be performed after installation and before operation. These procedures are based on interconnection of the multiplexer group into a radio-relay system such as Radio Repeater Set AN/TRC–41 and that a signal is being received from the east and west terminal.

c. Failure to meet the operation requirements called for in the following paragraphs indicates trouble in the equipment. If this occurs, refer to paragraphs 103 through 105 and 129 through 136, and perform the complete checks as required.

66. Initial Checks and Adjustments

a. Mechanical Checks.

(1) Check all the cable connections for tightness by turning the cable connector plug collars by hand.

(2) Check all the power connections at the switch box, the voltage regulator, the rear of the power and filament supplies, the oscilloscope, the audio test set, and the control monitor.

(3) Be sure that the tube shields are secure and that the interchassis cables and terminal board connections are tight.

(4) Be sure that the D&I-THRU and PARTY LINE-PRIV (fig. 47 and 49) switches are properly seated.

(5) Unscrew the four captive screws that hold the video restorer fan (fig. 45), pull the fan assembly out, and turn the blower motor (fig. 46) over by hand to be sure that it is free.

(6) Unscrew the four screws that hold the filament supply filter. Remove the filter and turn the blower motor (fig. 34) over by hand to be sure that it is free.

Caution: Be sure that the filter on the filament supply is clean. Refer to paragraph 110*a*(12) for cleaning instructions.

(7) Disconnect all auxiliary equipment that may have been plugged into the utility power sockets.

b. Electrical Power Connections. Connect the ac input power to the equipment as follows:

(1) Operate the INPUT SELECTOR SWITCH on the switch box (fig. 58) to either the INPUT 1 or INPUT 2 position, depending on which connector is connected to the primary power source.

(2) Operate the circuit breaker FOR 115V AC INPUT or FOR 230V AC INPUT on the voltage regulator (fig. 57) to the ON position, depending on the voltage of the input power source. The 115 VAC OUTPUT pilot lamp on the voltage regulator should light. If the voltage regulator is set for 230-volt operation and it is desired to operate at 115-volts (or vice versa) see (3) below.

(3) To reset the voltage regulator for operation on a 230-volt power source from operation on a 115-volt power source (or vice versa), proceed as follows:

(*a*) Disconect the power cord connected to the voltage regulator.

(*b*) Loosen the screws that hold the protective bar on the voltage regulator switches.

Note. Both the 230-volt and 115-volt ac power input switches should be in the OFF position.

(*c*) For 230-volt operation, slide the bar to the extreme left; for 115-volt operation, slide the bar to the extreme right.

(*d*) Tighten the screws that hold the protective bar to lock the bar in place.

(*e*) Connect the power cord to the appropriate receptacle.

(*f*) Place a protective cap on the unused receptacle.

Caution: Always cap the unused receptacle on the voltage regulator.

(4) Operate the power supply FILAMENT circuit breaker to the ON position. The FILAMENT ON indicator lamps on the power supply and filament supply should light, and the LINE VOLTS meter should indicate 115 volts ± 1 per cent (1.1 volts). If the line voltage is not within these limits, adjust the OUTPUT VOLTAGE potentiometer on the voltage regulator (fig. 57) so that the meter indicates 115 volts. Throwing the FILAMENT switch to ON applies

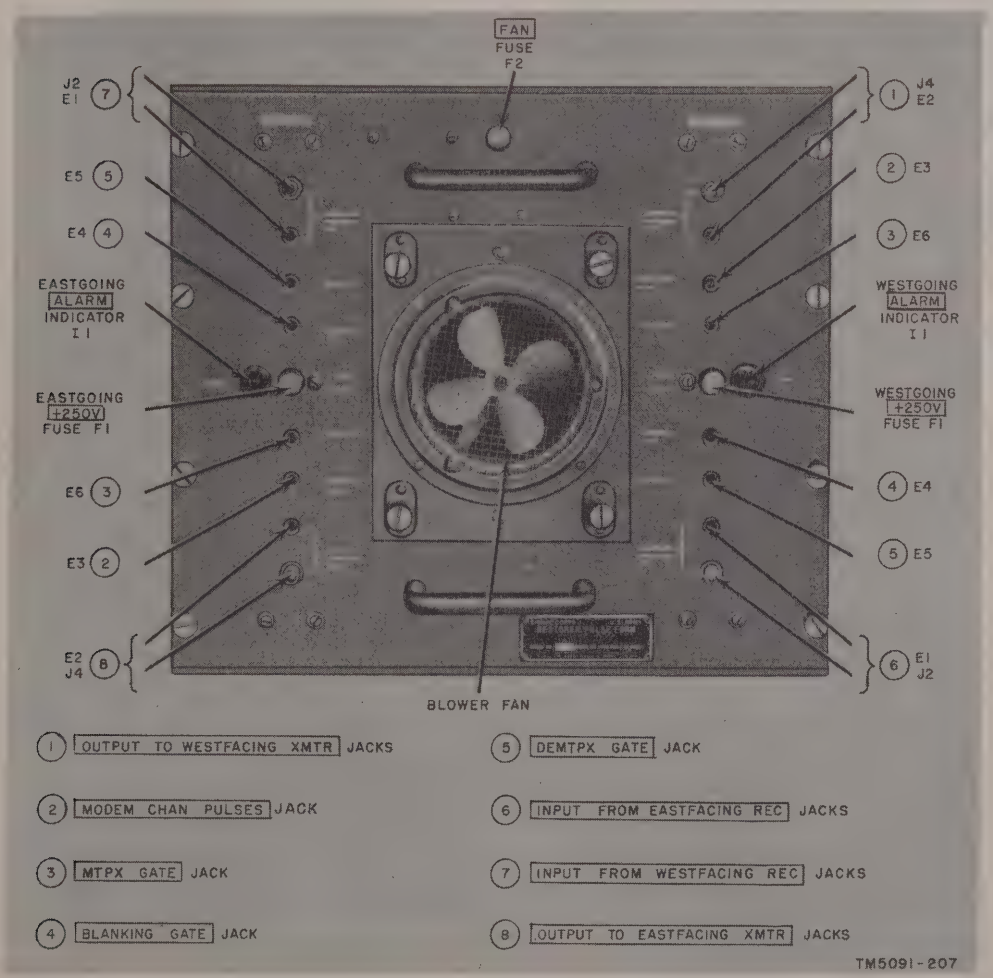


Figure 45. Video restorer, front view.

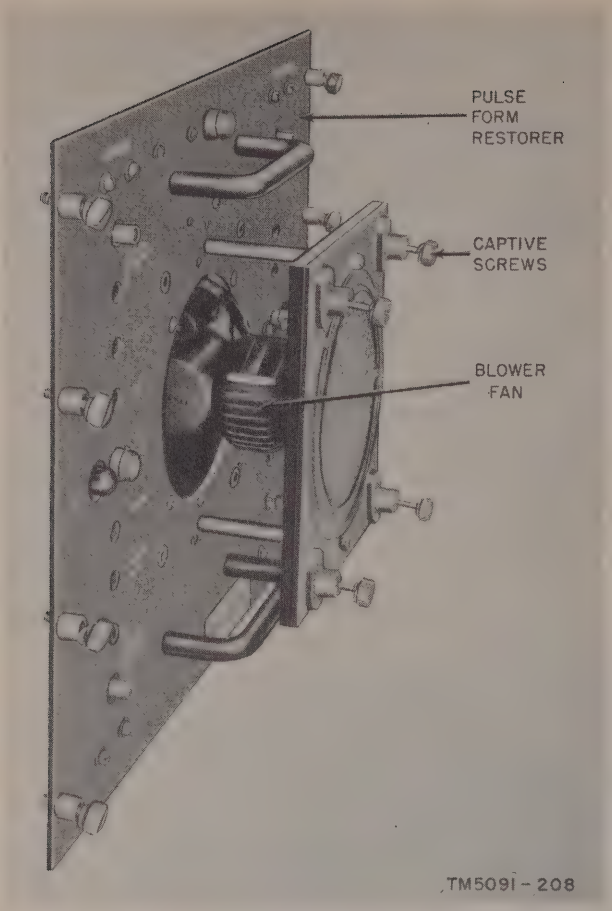


Figure 46. Video restorer blower fan.

filament voltage to the drop-and-insert circuits. The test equipments have their own power supply.

Caution: Be sure that all blower fans are operating.

(5) Turn the voltage regulator SENSITIVITY control (fig. 57) clockwise until the voltage regulator starts hunting (gear chatter will be heard from the voltage regulator when the unit is hunting); then turn the control counterclockwise until the hunting just stops. Turn the control counterclockwise another 10° to be sure it has stopped.

(6) Wait 30 seconds and operate the power supply +250V circuit breaker to the ON position. The +250V ON lamps on the power supply and filament supply pilot should light. This applies plate voltage to the video restorer and modems. Check for +250 volts between terminal 1 and ground and between terminal 16 and ground on terminal TB1A of the video restorer (fig. 273) with Electronic Multimeter TS–505/U. If this voltage is not read, refer to paragraph 123.

(7) Set the oscilloscope and audio test set ON-OFF switches (fig. 53 and 54) to the ON positions. The POWER ON pilot lamps on each unit should light, and the units should be in operation.

67. Preliminary Positioning of Switches

The following switches must be set as indicated before proceedings:

a. Modem 2W–4W Switch. Place all modems on a four-wire basis as follows:

(1) Unscrew the two front panel captive screws that mount each modem to the mounting rack and pull forward; be careful not to pull the unit out entirely. *There is no stop.*

(2) Pull out the 2W–4W switch (fig. 36) and plug it in with the 4W position pointing toward the arrow on the terminal board.

Note. If the equipment is to be operated on a two-wire basis perform all procedures for 4-wire, then place the 2W–4W switch in each modem in the 2W position.

b. Remote Keying Units (fig. 18 and 49). Unscrew the two captive screws on each remote keying unit, invert and insert so that NORMAL OPERATION is at the top.

c. PARTY LINE-PRIV (fig. 47 and 49). Loosen *all four* captive screws on each binding post door alongside the delay line, open the two doors, pull out the two PARTY LINE-PRIV switches (one on each side), invert and insert them so that PARTY LINE is at the top.

d. D&I-THRU. Open the doors as described in *c* above, pull out the D&I-THRU switches (two on each side), invert and insert them so that the D&I marking is on top.

68. Checking Test Equipment

a. Oscilloscope.

(1) Perform the procedures described in paragraph 45*a* through *f* to check the

oscilloscope voltage calibrator. If the oscilloscope can be calibrated as indicated, it is operating satisfactorily.

(2) When using the direct cable probe, multiply any value obtained in paragraph 45*f* by 10.

b. Audio Test Set. The audio test set is not supplied with Pulse Form Restorer Group AN/TRA–10. Calibrate the audio test set as indicated in paragraph 46.

Note. Always calibrate the audio test set before performing the adjustment or alignment procedures.

69. Checking Wave Forms

With the oscilloscope probe, compare wave forms at the pin jacks of the video restorer and modems against the referenced figures as follows:

a. Eastgoing Video Restorer.

(1) INPUT FROM WESTFACING REC (fig. 119).

(2) DEMTPX GATE (fig. 120).

(3) BLANKING GATE (fig. 121).

(4) MTPX GATE (fig. 122).

(5) MODEM CHAN PULSES (fig. 123).

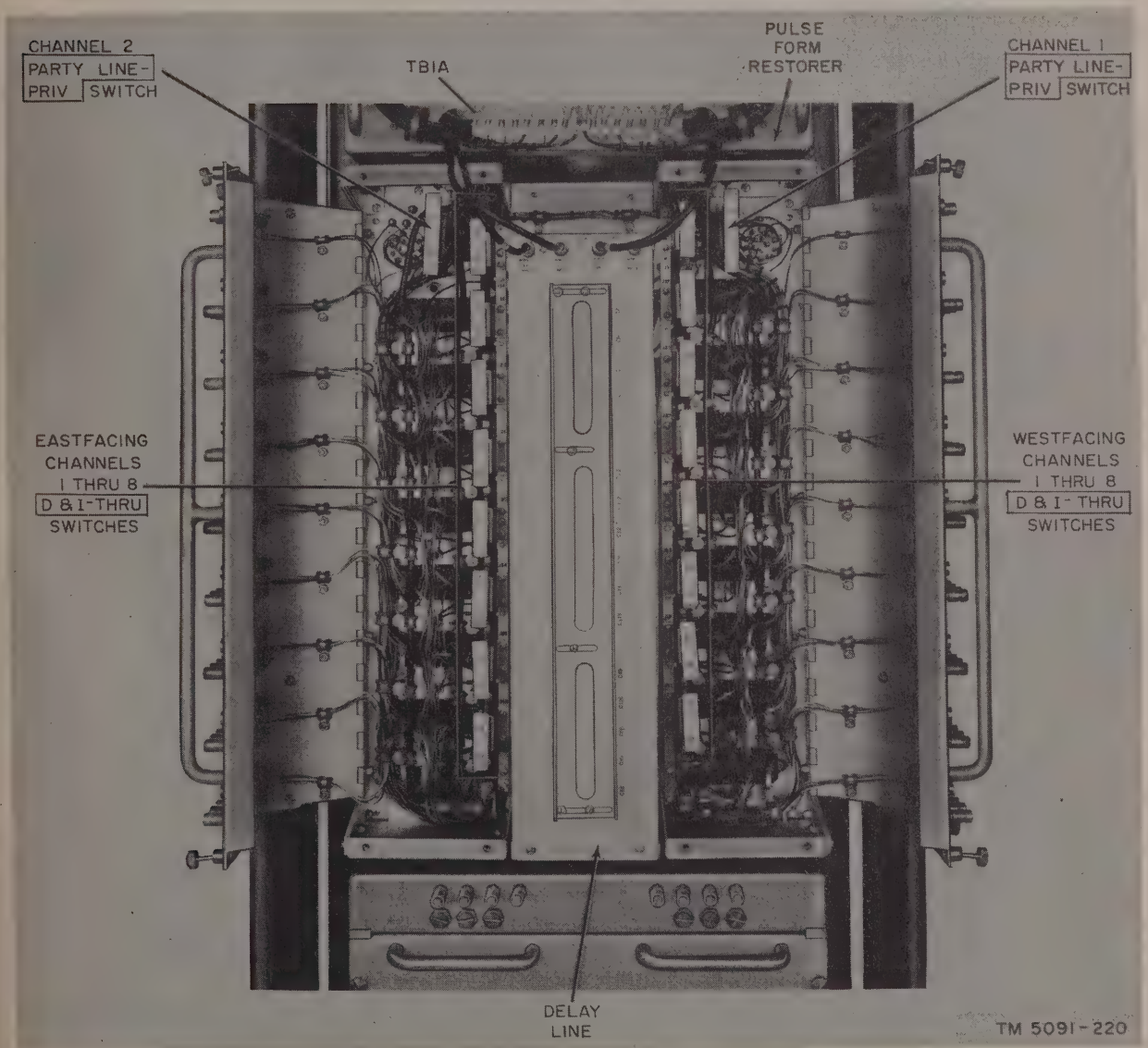


Figure 47. Multiplexer set mounting rack, rear view, binding post doors open.

(6) OUTPUT TO EASTFACING XMTR (fig. 119).

Note. Peak voltage depends on setting of P.T. OUT AMPL switch.

b. Westgoing Video Restorer.

(1) INPUT FROM EASTFACING REC (fig. 119).
(2) DEMTPX GATE (fig. 120).
(3) BLANKING GATE (fig. 121).
(4) MTPX GATE (fig. 122).
(5) MODEM CHAN PULSES (fig. 123).
(6) OUTPUT TO WESTFACING XMTR (fig. 119).

Note. Peak voltage depends on setting of P.T. OUT AMPL switch.

c. Modems.

(1) PPM (fig. 87).
(2) PWM (fig. 104).

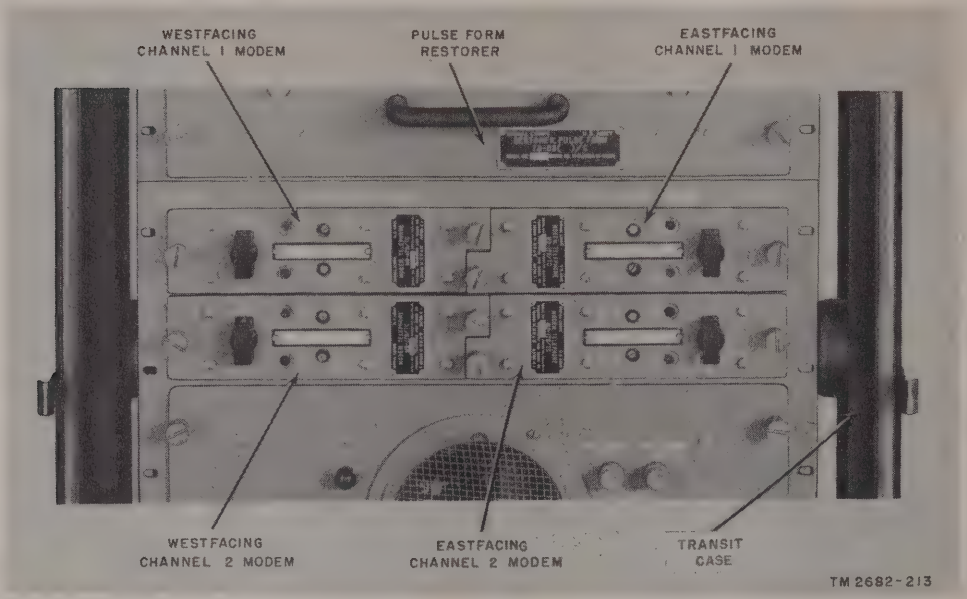


Figure 48. Location of Pulse Form Restorer Group AN/TRA-10 modems.

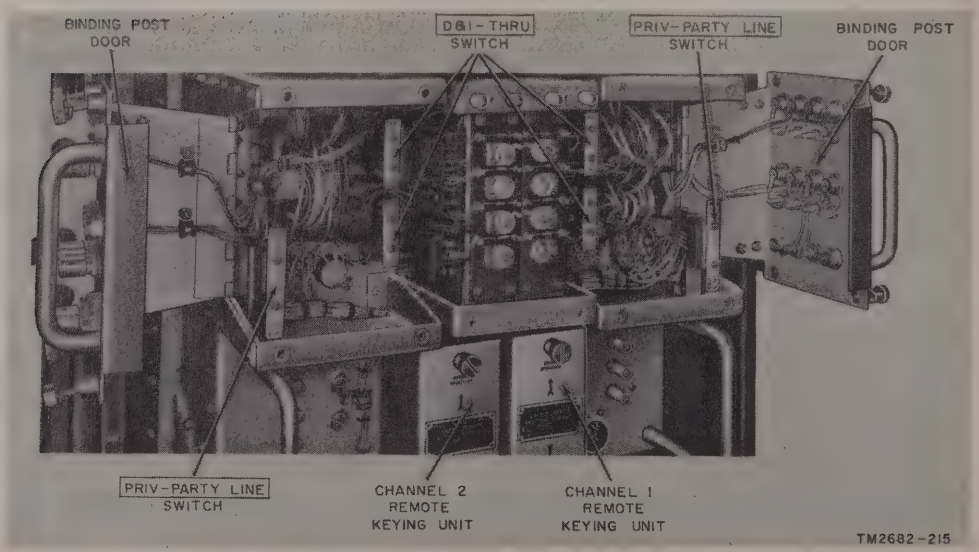


Figure 49. Pulse form restorer mounting rack, rear view, binding post doors open.

70. Checking Alignment of Eastgoing Output Pulse Train

a. Throw the power supply FILAMENT power switch (fig. 56) to ON.

b. Wait 30 seconds then turn the power supply +250V switch to ON.

c. Allow the equipment to warm up 15 minutes for stable operation.

d. While the equipment is warming up, proceed as follows:

(1) Check to see that the 2W–4W switch (fig. 36) in each modem is the 4W position.

(2) Check to see that all modem selector switches (fig. 50) are in the OPER position.

e. After the 15-minute warm up, connect the oscilloscope test probe to the video restorer OUTPUT TO EASTFACING XMTR test point (fig. 43) with the special cable provided for this purpose. The cable is located in the probe compartment of the oscilloscope.

Note. The switch on the control monitor (supplied only with the multiplexer group) should be in the NORMAL position.

f. Check the output train as follows:

(1) Turn the oscilloscope SYNC SELECTOR switch to the MULTIPLEXER position.

(2) Turn the COARSE control to the 50 position, and the FINE control to approximately the 5 position.

(3) Adjust the VERT ATTEN and VERT GAIN controls to obtain a pattern about 2 lines (2 cm) high. The pattern now appearing on the scope screen should be similar to that shown in figure 37.

(4) At the video restorer MODEM CHAN PULSES test jack E3 (fig. 45) check to see that all the individual channel pulses are in the wave form. The top right-hand modem unit in the EASTFACING column generates the pulse immediately to the right of the double marker pulse. This pulse is the new inserted channel 1 pulse. The channel 2 pulse is generated by the modem below the channel 1 modem. It is the second pulse to the right of the double marker pulse. The remainder of the modems on the right of the multiplexer group generate pulses 3 through 8 and are located in that order to the right of the double marker pulse.

g. Align the pulse train as follows:

(1) Adjust the oscilloscope COARSE and FINE controls so that two successive markers (double pulse) occupy approximately 9 lines (9 cm) across the oscilloscope screen.

(2) Turn on the oscilloscope timing pips by turning the TIMING PIP PHASE control clockwise. If the timing pips are not locked, set the TIMING PIP PHASE control to the center of its range and adjust the PIP LOCKING control until the pips are locked. Adjust the phase of the pips with the TIMING PIP PHASE control so that a timing pip begins to ride into the leading edge of the second marker pulse. This will show a slight amplitude increase of the second marker pulse.

(3) Vary the PULSE POSITION control (fig. 50) of the channel 1 eastfacing modem until the leading edge of the channel 1 eastfacing pulse rides into the timing pip immediately to the right of the second marker pulse. Adjust the PULSE POSITION control so that the channel 1 pulse approaches the timing pip from the right.

(4) Channel 1 is aligned when its amplitude just begins to increase as the second marker pulse did under its alignment ((2) above).

(5) Repeat the steps in (3) and (4) above for remaining channels of the drop-and-insert terminal.

(6) Check the complete pulse train alignment as follows:

(*a*) Change the TIMING PIP PHASE control very slightly.

(*b*) All pulses (including the second marker pulse) should increase and decrease in amplitude simultaneously. If any channel pulse for channels 1 through 8 does not act simultaneously, repeat the

alignment procedure for this channel, and then check the alignment of the entire train again.

71. Checking Alignment of Westgoing Output Pulse Train

To check the alignment of the westgoing output pulse train, repeat the procedures described in paragraph 70 with the following exceptions:

a. Connect the oscilloscope to the OUTPUT TO WESTFACING XMTR, with the oscilloscope SYNC SELECTOR switch in the DEMULTIPLEXER position.

b. The top left-hand modem unit in the westfacing column generates the pulse immediately to the right of the double marker (channel 1). The channel 2 pulse is generated by the modem adjacent to and below the channel 1 modem. The remainder of the modems on the left side generates pulses 3 through 8 in that order. Refer to figures 10 and 48 for location of modems.

72. Checking Amplitude of Eastgoing Output Pulse Train

a. Perform all the procedures described in paragraphs 70 and 71.

b. Connect the oscilloscope 10:1 probe to the OUTPUT TO EASTFACING XMTR test jack on the video restorer.

c. Adjust the VERT ATTEN and VERT GAIN controls so that the output pulse train is two boxes high on the oscilloscope screen. Note the setting of the VERT ATTEN control.

d. Rotate the VERT ATTEN control to the CAL position. This will supply the 60-cycle voltage calibrator wave form.

e. Adjust the CAL VOLTAGE control until the voltage calibrator wave form also is two boxes high. Note the control setting.

f. The amplitude of the output pulse train is the product of the VERT ATTEN control setting (*c* above) and the CAL VOLTAGE control setting (*e* above), directing in volts.

g. With a 23-channel input, and the video restorer P.T. OUT AMPL switch in LOW, the pulse train level on the oscilloscope should be .25 volt from base level to peak. If this value is not obtained adjust the video restorer slotted screw-driver SYM ADJ control until the .25-volt level is obtained. If an output greater than .25 volt is required from the video restorer, throw the P.T. OUT AMPL switch to HIGH. An increase of 6 db and an output of .5 volt can be obtained.

h. With a 45-channel input, the output to the eastfacing transmitter should be adjusted with the SYM ADJ control so that the positive and negative pulse train amplitudes are equal. With the P.T. OUT AMPL switch in the LOW position, the level should be greater than .4 volt peak to peak. With the P.T. OUT AMPL switch in the HIGH position, the level should be greater than .8 volt.

73. Checking Amplitude of Westgoing Output Pulse Train

Check the amplitude of the westgoing output pulse train exactly as described in paragraph 72, except that the probe of the oscilloscope is connected to the video restorer OUTPUT TO WESTFACING XMTR test jack (fig. 45).

74. Alignment of Video Levels

a. General. When Radio Set AN/TRC–29 and Multiplexer Group AN/TCA–1 or Pulse Form Restorer Group AN/TCA–1 are set up as part of a multihop radio-relay link, the following video level requirements will result in optimum operation of the system.

(1) All transmitters modulating 100 per cent.

(2) The output video level of each multiplexer or pulse form restorer group to be one-half of its input video level.

Note. Only under conditions of exceedingly long lengths of cable between equipments and under certain conditions of 45-channel operation will it be difficult to maintain the above requirements.

b. 23-channel Operation.

(1) *Normal operating conditions.* Set the video levels as follows:

(*a*) At the repeater station, observe the wave form at the video restorer INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing radio receiver for a baseline-to-peak pulse amplitude of .5 volt.

(*b*) At the repeater station video restorer, westgoing side, set P.T. OUT AMPL switch S2 (fig. 144) in the LOW position, and adjust SYM ADJ control (fig. 144) for a baseline-to-peak pulse train amplitude of .25 volt at the front panel OUTPUT TO WESTFACING XMTR test jack.

(*c*) At the repeater station radio set, adjust the video input level on westfacing transmitter for 100 per cent modulation.

(*d*) Repeat the procedures given in (*b*) and (*c*) above for the other direction of transmission.

(2) *Nonoptimum operating conditions.* The nonoptimum operating conditions of the repeater terminal (AN/TCA–1 or AN/TRA–10) are caused by an input lower than .5-volt pulse amplitude. This may be caused by exceedingly long cable lengths between the AN/TCA–1 or AN/TRA–10 and/or insufficient output from the radio receiver. Under this condition, set the video level of drop-and-insert repeater terminal as follows:

(*a*) At the repeater, observe the wave form at the video restorer front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing radio receiver for a maximum input level.

(*b*) At the repeater station video restorer, set the westgoing P.T. OUT AMPL switch S2 in the HIGH position.

(*c*) With a field telephone, contact personnel at the westfacing transmitter and adjust the video restorer westgoing SYM ADJ control for as low a level as possible to modulate the transmitter 100 per cent.

(*d*) Repeat the instructions in (*a*) through (*c*) above for the other direction of transmission.

c. 45-channel Operation.

(1) *Normal operation conditions.* Set the video levels as follows:

(*a*) At the repeater station, observe the wave form at the video restorer front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing receiver for a peak-to-peak pulse train amplitude of 1 volt.

(*b*) At the drop-and-insert repeater station westgoing side, place the video restorer 23 CHAN-45 CHAN switch in the 45 CHAN position, set P.T OUT AMPL switch S2 in the LOW position, and adjust the SYM ADJ control for a symmetrical pulse train (positive and negative pulse train of equal amplitude) at the OUTPUT TO WESTFACING XMTR test jack.

(*c*) At the repeater station radio set, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

(*d*) Repeat the procedures given in (*a*) through (*c*) above for the other direction of transmission.

(2) *Nonoptimum conditions.* The nonoptimum operating conditions of the AN/TCA–1 or AN/TRA–10 are those that cause an input lower than 1-volt peak-to-peak pulse amplitude. This may be caused by exceedingly long cable lengths between the repeater terminal and the radio set or insufficient output of the radio receiver. Under this condition, set the video level of the AN/TCA–1 or AN/TRA–10 as follows:

(*a*) At the repeater station, observe the wave form at the video restorer front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing radio receiver for a maximum input peak-to-peak level.

(*b*) At the drop-and-insert repeater station westgoing side, place the video restorer 23 CHAN-45 CHAN switch in the 45 CHAN position, the P.T. OUT AMPL switch in the HIGH position, and adjust the SYM ADJ control for a symmetrical pulse train at the front panel OUTPUT TO WEST-FACING XMTR test jack.

(*c*) At the repeater station radio set, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

(*d*) Repeat the procedures given in (*a*) through (*c*) above for the other direction of transmission.

75. Alignment of Audio Levels

a. General. This system alignment procedure precludes a talking circuit in operation independent of the equipment until the channel 1 order-wire circuit is aligned. After the order-wire channel is available, connect field Telephone EE-8-B to the PARTY LINE CHANNEL 1 binding posts at all repeaters and use the order-wire circuit as directed in paragraph 95.

b. Alignment of Channels 1 and 2 at Terminal and Repeater. Channels 1 and 2 of both Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1 are aligned identically in the following manner:

(1) *At east terminal AN/TCC–13.*

(*a*) Press the control monitor SEND button.

(b) Turn the channel 1 modem selector switch to the SR position.

(*c*) Place the remote keying unit in the NORMAL OPERATION position.

(2) *At repeater AN/TRA–10 or AN/TCA–1.*

(*a*) Set the modem channel 1 eastfacing and eastfacing 2W–4W switch in the 4W position.

(*b*) Place the remote keying unit in the NORMAL OPERATION position.

(*c*) Place the channel 1 PARTY LINE - PRIV switch in the PARTY LINE position.

(*d*) Place the channel 1 D&I-THRU switch in the D&I position.

(*e*) At the AN/TCA–1 only, set the control monitor test switch in the NORMAL position.

(3) *At east terminal AN/TCC–13.* At the east terminal AN/TCC–13, modulate channel 1 with full modulation (—4 dbm for four-wire operation and 0 dbm for two-wire operation).

(4) *At repeater AN/TRA–10 or AN/TCA–1.*

(*a*) Conenct the oscilloscope and direct probe to the front panel OUTPUT TO WESTFACING XMTR test jack.

(*b*) Adjust channel 1 modem OUTPUT AUDIO GAIN control until a deviation of ±.5 microsecond (usec) is obtained on the oscilloscope.

(5) *At west terminal AN/TCC–13.*

(*a*) Place the remote keying unit in the NORMAL OPERATION position.

(*b*) Press the control monitor REC button.

(*c*) Turn the channel 1 modem selector switch to the RR position.

(6) *At west terminal AN/TCC–13.* At the west terminal AN/TCC–13, adjust the channel 1 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire or a reading of —3 dbm for two-wire is obtained on the audio test set.

(7) *Channel 2 eastfacing.* Repeat the procedures given in (1) through (6) above for channel 2.

(8) *Westfacing alignment.* Repeat the procedures given in (1) through (7) above for the other direction of transmission.

Note. The above procedures insure zero through loss to prevent cumulative gain or loss through a number

of repeaters. Local sending and receiving levels are fixed and will be correct when the through loss adjustment has been made correctly.

c. Alignment of Channels 3 Through 8 from Terminal to Repeater AN/TCA–1.

(1) *At east terminal AN/TCC–13.*
   (*a*) Press the control monitor SEND button.
   (*b*) Turn the channel 3 modem selector switch to the SR position.

(2) *At repeater AN/TCA–1.*
   (*a*) Press the control monitor REC button.
   (*b*) Turn the eastfacing channel 3 modem selector switch to the RR position.
   (*c*) Place the eastfacing channel 3 D&I-THRU switch in the D&I position.

(3) *At east terminal AN/TCC–13.* At east terminal AN/TCC-13, modulate channel 3 with full modulation (—4 dbm for four-wire operation or 0 dbm for two-wire operation).

(4) *At repeater AN/TCA–1.* At repeater AN/TCA–1, adjust the eastfacing channel 3 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire operation or a reading of —3 dbm for two-wire operation is obtained on the audio test set.

(5) *Alignment, channels 4 through 8.* Repeat the procedures given in (1) through (4) above for channels 4 through 8.

(6) *Westfacing alignment.* Repeat the procedures given in *c*(1) through (5) above for the other direction of transmission (west).

d. Alignment of Channels 3 Through 8 from Repeater AN/TCA–1 to Terminal.

(1) *At repeater AN/TCA–1.*
   (*a*) Press the control monitor SEND button.
   (*b*) Place the channel 3 eastfacing D&I-THRU switch in the D&I position.
   (*c*) Turn the eastfacing channel 3 modem selector switch to the SR position.

(2) *At east terminal AN/TCC–13.*
   (*a*) Press the control monitor REC button.
   (*b*) Turn the channel 3 modem selector switch to the RR position.

(3) *At repeater AN/TCA–1.* At repeater AN/TCA–1, modulate the eastfacing channel 3 with full modulation (—4 dbm for four-wire operation or 0 dbm for two-wire operation).

(4) *At east terminal AN/TCC–13.* At east terminal AN/TCC–13, adjust the channel 3 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire operation or a reading of —3 dbm for two-wire operation is obtained on the audio test set.

(5) *Alignment, channels 4 through 8.* Repeat the procedures in (1) through (4) above for channels 4 through 8.

(6) *Westfacing alignment.* Repeat the procedures given in (1) through (5) above for the other direction of transmission (west).

Note. As a final check of circuit operation, talk and ring from the repeater to the east and then to the west terminals on all channels with a Telephone EE–8–B connected to the 2W LINE binding posts (alongside of delay line).

76. Checking Modulation of Channels 3 through 8 of Multiplexer Group

Check the modulation of the multiplexer group channels as follows:

a. Calibrate the audio test set as described in paragraph 46.

b. Depress the control monitor SEND switch, set the audio test set SEND-DBM control to the 0 position, and depress the audio test set MEASURE F1A push button.

c. Place the selector switch on eastfacing modem 1 in the SR position.

d. Turn on the oscilloscope timing markers by rotating the TIMING PIP PHASE clockwise from the OFF position.

e. Set the oscilloscope COARSE control to the 5-microsecond position and the FINE control to the 1-microsecond position.

f. Rotate the FINE control until two consecutive timing pips are 10.4 lines (10.4 cm) apart on the oscilloscope cathode-ray tube. The sweep speed is now .5 microsecond per centimeter.

g. Place the oscilloscope probe in the OUTPUT TO EASTFACING XMTR test jack on the video restorer. The channel 1 pulse should move 1 line ($\pm$.5 microsecond) from leading edge to leading edge.

h. Return the eastfacing modem 1 selector switch to the OPER position, and repeat the procedures given in *d* through *g* above for all other eastfacing modems.

i. Place the oscilloscope in the OUTPUT TO WESTFACING XMTR test jack and repeat the procedures given in *a* through *h* above for the westfacing channels.

77. Installation Adjustment Procedure for Remote Keying Operation

a. Perform all the installation adjustment procedures described in paragraphs 68 through 76.

b. In addition to the usual audio connections (modem connected in four-wire operation, external audio connections in two-wire operation), connect the remote vhf stations to the channel 1 and channel 2 remote keying binding posts above the rear of the filament supply (fig. 18), as follows:

(1) Connect the *keying-in* pair (pair used to operate the remote vhf station) to the appropriate channel REMOTE KEYING IN binding posts.

(2) Connect the *keying-out* pair to the appropriate channel (one or two) REMOTE KEYING OUT binding posts.

c. Unscrew the four captive screws (fig. 18) that hold the rear cover to the filament supply and remove the cover by the four handles.

d. Remove each of the remote keying units, invert and replace them so that REMOTE KEYING OPERATION points upward.

e. Replace the rear cover by reversing the procedure described in *c* above.

78. Final Connections and Stopping Procedure

a. Final Connections. When all the checks and adjustments described in paragraphs 68 through 77 have been completed, the equipment is ready for operation. Prepare for normal operation as follows:

(1) Connect the four-wire telephone lines to the binding posts alongside the delay line.

Note. If the equipment is to be used on a two-wire basis, be sure that the 2W-4W switch in each modem is in the 2W position and connect the telephone lines to the 2W LINE binding posts.

(2) With the oscilloscope probe connected to the common unit PULSE TRAIN OUTPUT jack, have the switchboard operator at the other end of the telephone line talk into each channel in a normal conversational tone and give a test count. Modulation of the channel pulses should be observed on the oscilloscope.

(3) The equipment is now ready for use.

b. Stopping.

(1) Throw the power supply +250V circuit breaker to the OFF position. The +250V ON pilot lights on the power supply and filament supply should go out.

(2) Throw the power supply FILAMENT circuit breaker to the OFF position. The FILAMENT ON pilot lights on the power supply and filament supply should go out.

(3) Throw the voltage regulator FROM 115VAC INPUT or FROM 230VAC INPUT circuit breaker to the OFF position.

CHAPTER 4

OPERATION

Section I. CONTROLS AND INSTRUMENTS

Note. This section locates, illustrates, and furnishes the operator enough information pertaining to the various controls and instruments that are provided for the proper operation of the equipment.

79. General

Multiplexer Set AN/TCC-13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 contain certain units that are identical and interchangeable. Refer to paragraph 8*b*. This section lists the controls and instruments and their functions for the subunits that make up the equipments.

80. Multiplexer TD–60/TCC–13, Controls (fig. 111 and 112)

The table below lists the controls of the common unit. Two chassis (multiplexer section and demultiplexer section) make up one common unit; therefore, the MASTER-SLAVE switch in each section performs similar functions and both switches must always be in the same position.

Control	Function
MASTER-SLAVE switch (multiplexer section).	Determines whether the operation of the multiplexer section is to be *master* or *slave* during 45-channel operation.
MASTER-SLAVE switch (demultiplexer section).	Determines whether the operation of the demultiplexer section is to be *master* or *slave* during 45-channel operation.
45-CHAN PHASE.	Shifts the positive and negative pulse trains with relation to each other.
OUTPUT AMPL.	Controls the output amplitude of the pulse train.

81. Pulse Form Restorer TD–68/G, Controls (fig. 144)

The table below lists the switches of the video restorer and gives their functions. The 23 CHAN-45 CHAN switch is located at the top of the eastgoing video restorer chassis and, therefore, at the bottom of the westgoing video restorer chassis. The P.T. OUT AMPL switch is located in the center of the video restorer chassis and the SYM ADJ potentiometer is located at the upper left-hand corner of the eastgoing video restorer and the lower right-hand corner of the westgoing video restorer.

Control	Function
23 CHAN-45 CHAN switch.	Controls filament power to negative pulse train reshaping stages. Set to the 23 CHAN position for 23-channel operation, and to the 45 CHAN position for 45-channel operation.
P.T. OUT AMPL switch.	Controls the output of the outgoing pulse train. In the HIGH position, the output is twice that of the LOW position.
SYM ADJ potentiometer.	With the 23 CHAN-45 CHAN switch in the 23 CHAN position, it controls the amplitude of the outgoing positive pulse train. When the 23 CHAN-45 CHAN switch is in the 45 CHAN position, it controls the amplitude of the negative and positive pulses.
WESTGOING ALARM indicator.	When lighted, indicates malfunction of westgoing video restorer.
EASTGOING ALARM indicator.	When lighted, indicates malfunction of eastgoing video restorer.

82. Telephone Modem MD–179/TC, Controls
(fig. 50)

The table below lists the modem controls and their functions. There are 24 modems (1 spare) used with Multiplexer Set AN/TCC–13, 16 modems used with Multiplexer Group AN/TCA–1, and 4 modems used with Pulse Form Restorer Group AN/TRA–10.

Control	Function
SELECTOR switch.	Enables any modem to be connected to the test pair. To maintain correct impedance, only one modem should be switched to the test pair at a time (switched away from the OPER position). The four positions permit connection of the test pair to both the send and receive circuits of the radio side (SR and RR), as well as the send and receive circuits on the line side of the modem (SL and RL). The selector switch is arranged so that the correct connections are made whether or not the circuits are in two- or four-wire operation. In the SL position, connects the TEST PAIR to permit sending a test signal to the line (for example, a switchboard). In the SR position, connects the TEST PAIR to permit sending a test signal to the radio (for example, Radio Set AN/TRC–29). In the OPER position, disconnects the TEST PAIR. In the RR position, connects the TEST PAIR to permit receiving a signal from the radio side (for example, Radio Set AN/TRC–29). In the RL position, connects the TEST PAIR to permit receiving a signal from the line (for example, a switchboard).
OUTPUT AUDIO GAIN control.	Sets the audio output level of the modem.
PULSE POSITION control.	Sets the position of the generated channel pulse, with respect to the marker.
2W-4W switch.	Selects two-or four-wire operation in each modem. It is mounted internally in each modem (fig. 36).

Note. Because the control monitor handset circuit of the AN/TCC–13 and AN/TCA–1 and the field telephone circuit of the AN/TRA–10 is on a two-wire basis, it can be used with the test pair only when the desired channel is connected for two-wire operation. To talk to the radio side, the selector switch must be in the RR or SR position, and to talk to the line side, the selector switch must be in the SL or RL position.

83. Multiplexer Subassembly MX–1442/TC, Controls
(fig. 51)

The following table lists the controls of the Multiplexer Subassembly MX–1442/TC (filament supply) and indicates their functions.

Control	Function
FILAMENT ON indicator lamp.	Glows red when filament voltage is applied to the mounting rack and video restorer.
+250V ON indicator lamp.	Glows red when B+ is applied to the mounting rack and video restorer.
ALARM indicator lamp.	Glows red when an alarm condition exists.
AUDIBLE ALARM DISCONNECT push button.	When pushed momentarily, this button disconnects the alarm buzzer. The alarm circuit restores itself to operation automatically when the alarm condition has been corrected.

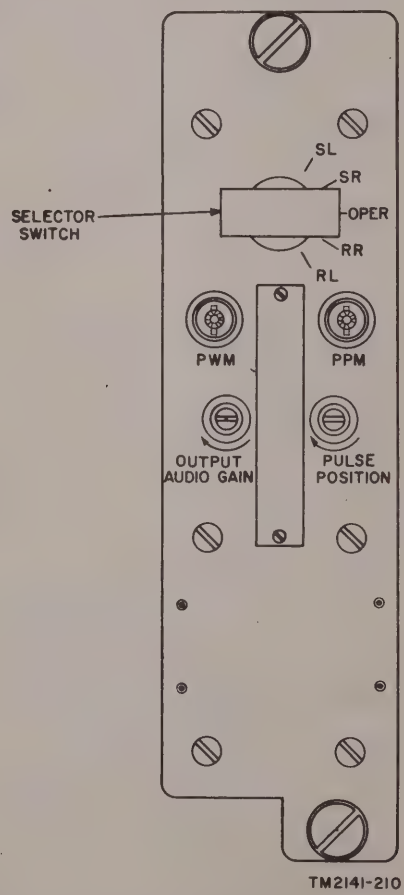
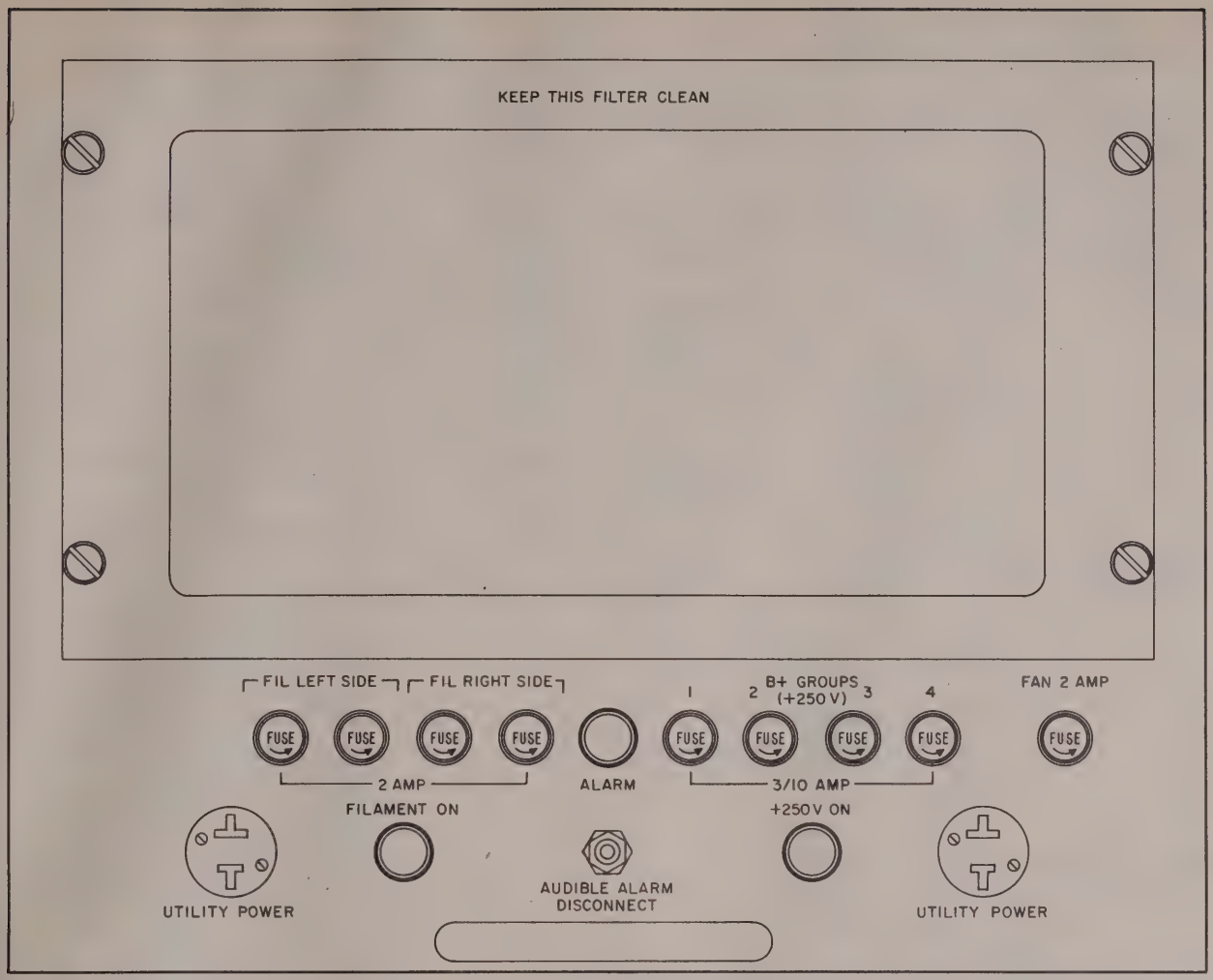
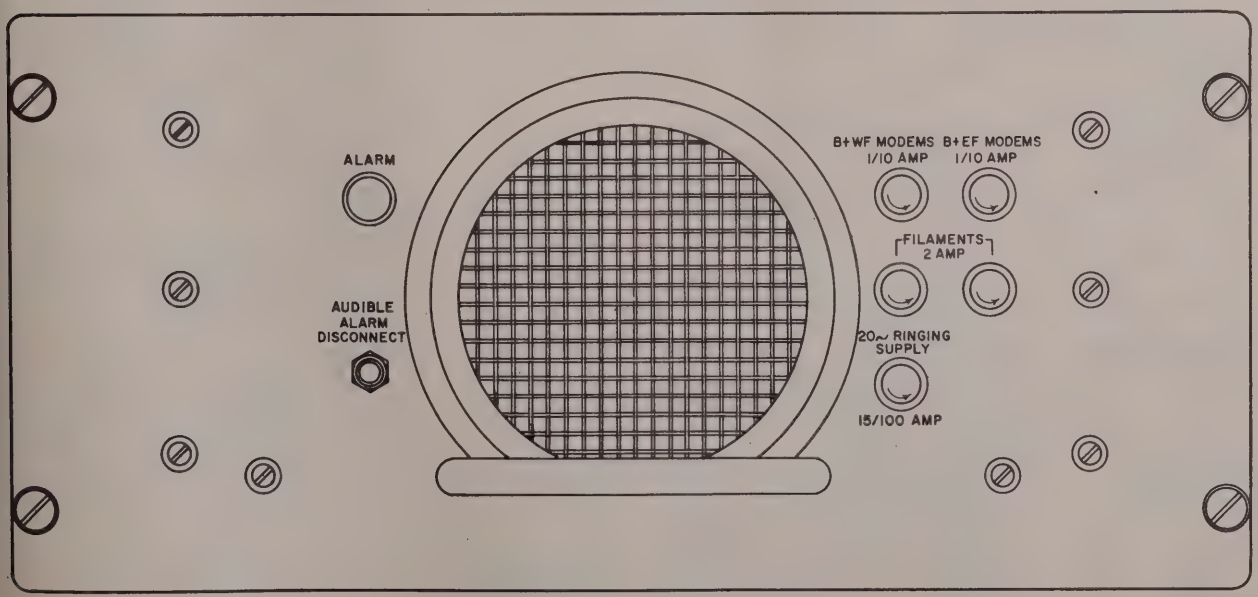


Figure 50. Telephone Modem MD–179/TC controls.



TM2141-208

Figure 51. Multiplexer Subassembly MX–1442/TC, controls.



TM 2682-302

Figure 52. Electrical Equipment Rack MT–1434/TRA–10, controls.

84. Electrical Equipment Rack MT-1433/TCA-1, Controls

(fig. 47)

The tables below lists the switches of the mounting rack and gives their functions.

Control	Function
PARTY LINE-PRIV switches.	Determine mode of operation (party line or private) for channels 1 and 2. In the PARTY LINE position, provides a telephone circuit at the repeater. This circuit is bridged into the channel so that personnel can converse with both terminals and/or other repeaters. In the PRIV position, permits personnel at the repeater to converse with a terminal or repeater in one direction only.
D&I-THRU switches.	Determine whether the channel is to be operated on a drop-and-insert basis or whether it will pass through the repeater. In the D&I position, channel operates on a drop-and-insert basis. In the THRU position, channel passes through the repeater. Each channel pulse, however, is reshaped.

85. Electrical Equipment Rack MT-1434/TRA-10, Controls

(fig. 49, 52, and 295)

The table below lists the controls of the mounting rack and the function of each control.

Control	Function
ALARM indicator lamp.	Glows red when the alarm condition exists.
AUDIBLE ALARM DISCONNECT push switch.	When pushed momentarily, disconnects the alarm bell. The ALARM light remains lighted and the alarm circuit restores itself to operation automatically when the alarm condition has been rectified.
FREQ ADJUST.	Varies the frequency of the 20-cycle multivibrator.
PARTY LINE-PRIV switches.	Determines mode of operation for channels 1 and 2 (see PARTY LINE-PRIV switches (par. 84)).
D&I-THRU switches.	Determines whether the channel is to be operated on a drop-and-insert basis or whether it will pass through the repeater (see D&I-THRU switches (par. 84)).

86. Oscilloscope OS-25/G Controls

(fig. 53)

The table below lists the controls of the oscilloscope and gives their functions.

Control	Function
ON-OFF switch.	When switched to the ON position, ac power is applied to the oscilloscope.
POWER ON indicator lamp.	Glows when ac power is applied to the oscilloscope.
HOR POSITION control.	When this control is turned clockwise or counterclockwise, the image on the screen moves to the right or left.
SWEEP PHASE control.	Adjusts the phase of the 8-kc synchronizing signal.
SYNC SELECTOR switch.	Permits the selection of any one of the following synchronizing signals: In the DEMULTIPLEXER position for AN/TCC-13, synchronizes the oscilloscope with the incoming pulse train. For AN/TCA-1 and AN/TRA-10 synchronizes the eastgoing video restorer with the westgoing pulse train. In the MULTIPLEXER position for AN/TCC-13, synchronizes the oscilloscope with the output pulse train. For AN/TCA-1 and AN/TRA-10 synchronizes the westgoing video restorer with the westgoing pulse train. In the +INT position, synchronizes on the rising edge of the signal into the vertical amplifier. In the —INT position, synchronizes on the trailing edge of the signal into the vertical amplifier. In the +EXT position, synchronizes on the rising edge of the signal into the oscilloscope EXTERNAL SYNC INPUT rear panel connector. In the —EXT position, synchronizes on the trailing edge of the signal into the EXTERNAL SYNC INPUT rear panel connector.
COARSE switch.	Determines the approximate time for a total sweep. Four steps of 5-, 50-, 500-, and 5,000-microseconds are provided. It is used with the FINE control.
FINE control.	Provides fine control of sweep duration in each range of the COARSE switch.
INTENSITY control.	Controls the brightness of the image on the screen.

Control	Function
FOCUS control.	Controls the sharpness of the image on screen.
TIMING PIP PHASE control.	Moves the markers on the screen over a range of about 6 microseconds (6 boxes).
CAL VOLTAGE control.	Used with the VERT ATTEN control, it determines the amplitude of the observed wave form. When the VERT ATTEN control is in the CAL position, the CAL VOLTAGE control setting is the voltage (in volts) that is applied to the input of the vertical amplifier. Refer to paragraph 45 for the use of these controls in determining the value of the calibrated wave form.
VERT ATTEN control.	Attenuates the input signals to the vertical amplifier by the ratios of 100:1, 10:1, 2:1, and 1:1. In the 100:1 position, 100 to 1 attenuation. In the 10:1 position, 10 to 1 attenuation. In the 2:1 position, 2 to 1 attenuation.

Control	Function
VERT ATTEN control.	In the 1:1 position, no attenuation. In the CAL position, removes the signal applied to the probe from the vertical amplifier input and applies the calibrating voltage to the vertical amplifier input.
VERT GAIN control.	Increases the vertical amplitude of the scope presentation over a range of about 8 to 1.
PIP LOCKING control.	Locks the pips with the pulse train.
ASTIG control.	A screw-driver adjustment that sharpens the scope presentation along the horizontal and vertical axes.
TRIGGER control.	Determines the amplitude of the signal that is used to synchronize the sweep multivibrator.
STAB control.	A voltage adjustment which selects either triggered or free-running operation of the sweep multivibrator.
VERT POSITION control.	When turned, it moves the image on the screen up or down.

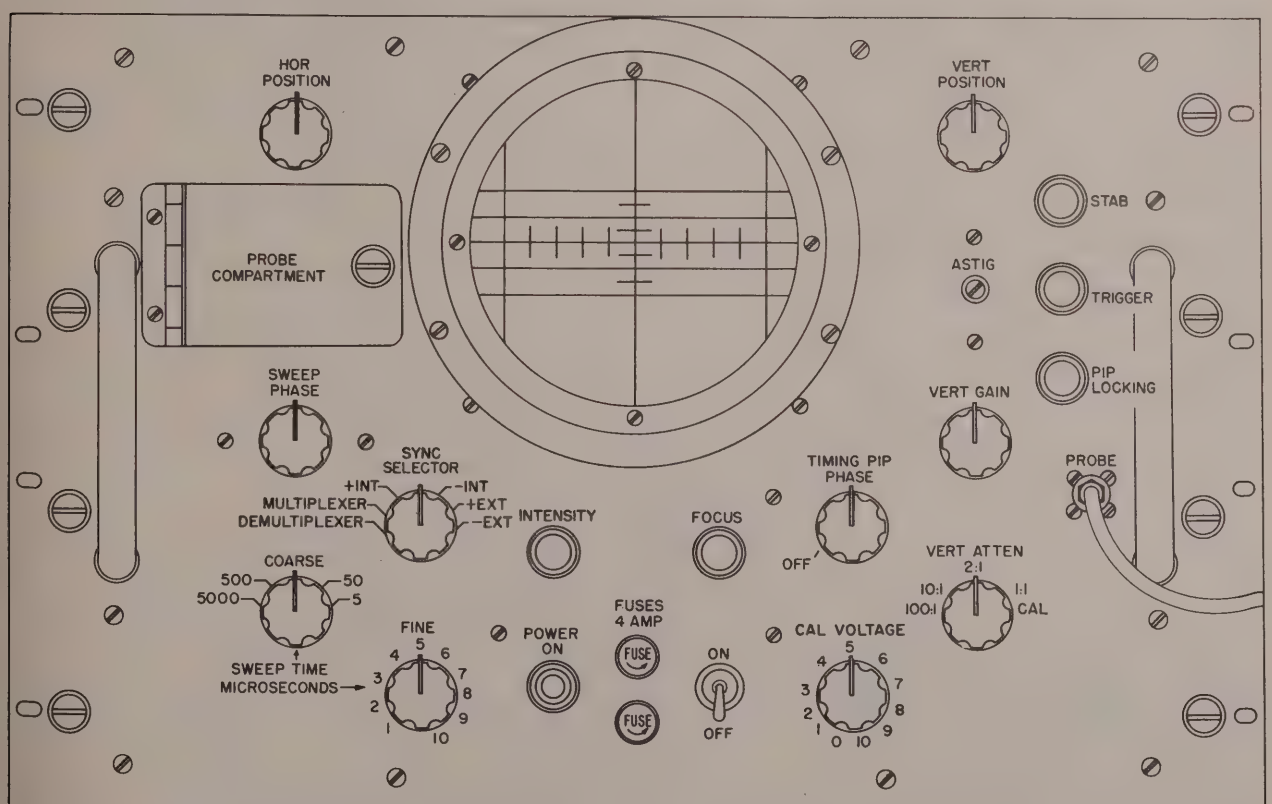


Figure 53. Oscilloscope OS–25/G, controls.

87. Audio Test Set TS-762/TC, Controls

(fig. 54)

The table below lists the controls of the audio test set and gives their functions.

Controls	Function
SEND-DBM control.	Sets the sending level in steps of 1 dbm from —35 to +10 dbm.
ON-OFF switch.	When in the ON position, it applies power to the audio test set.
POWER ON indicator lamp.	Glows when power is applied to the audio test set.
RECEIVE-DBM control.	Attenuates the signal that is applied to the dbm meter. The actual received dbm level is the algebraic sum of the setting of this control and the dbm reading on the meter.
DECIBEIS meter.	Gives a fine reading of the received levels.
ADJ SEND control.	Varies the sending level for calibration.
ADJ REC control.	Varies the receiving level for calibration.
CALIBRATE-MEASURE control buttons.	The four control buttons are depressed to calibrate the audio test set and to measure the levels or distortion. For measuring, the audio test set is used in conjunction with the modem selector switches (par. 82). *Position* — *Function* SEND — Applies send section calibrating voltage to the meter. REC — Applies receive section calibrating voltages to the meter. F1A — Allows meter to measure the levels with F1A line weighting. DIST AT 1000~ — Allows meter to measure the distortion with 1,000-cps rejection.
SEND OUT	A calibrated audio signal is available at these posts.
RECEIVE IN	Voice frequencies to be measured are applied to these binding posts.
REC MONITOR	Permits monitoring of the received signal.

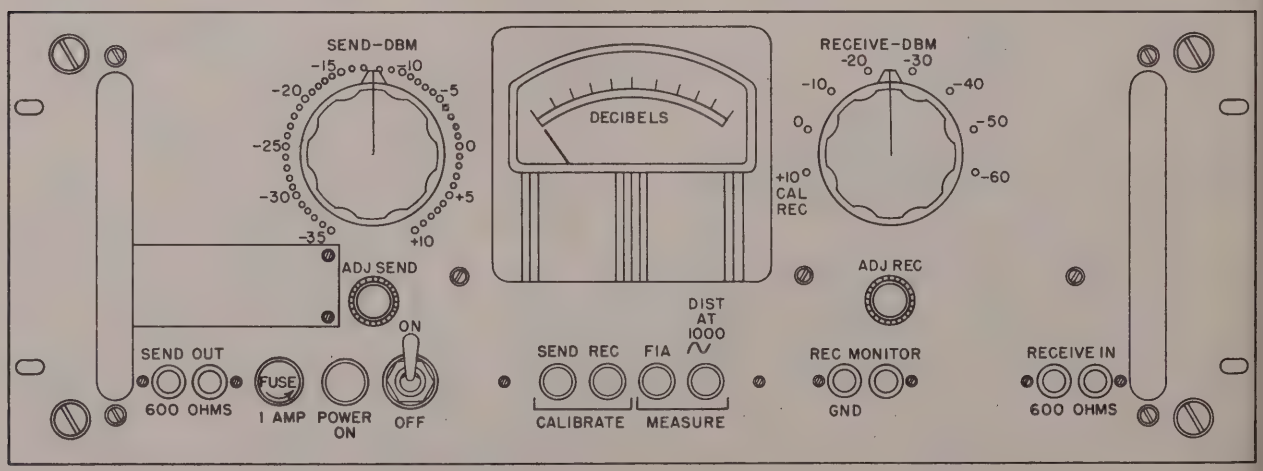


Figure 54. Audio Test Set TS-762/TC, controls.

88. Control Monitor C–1151/TC, Controls (fig. 55)

The table below lists the controls of the control monitor test panel and gives their functions.

Note. Control Monitor C–1151/TC is supplied with the AN/TCC–13 and AN/TCA–1.

Controls	Function
TEST PAIR control buttons.	Control the connections of the TEST PAIR control buttons between the modems and the audio test set. *Position* — *Function* REC — For receiving signals, connect the test pair leads that are common to all modems to the radio test set. SEND — For sending signals, connect the modem test pair to the audio test set. TEL SET — Connect the handset to the test pair. NORMAL — Disconnect all testing functions from the modems.
RING switch.	Applies a ringing tone to the order-wire channel (channel 1) or to the channel to which the telephone handset is connected (V2 selector switch).

89. Power Supply PP–691/G, Controls (fig. 56)

The table below lists the controls of the power supply and gives their functions.

Controls	Function
FILAMENT circuit breakers.	When switched to the ON position, filament power is applied to the equipment and test racks, and ac voltage is applied to the utility outlets and to the test equipment.
+250V circuit breaker.	In the ON position, it applies power to the B+ voltage supply circuits, which generate the B+ voltage for the equipment.
LINE VOLTS meter.	Indicates the line voltage that is applied to the power supply from the voltage regulator.
FILAMENT ON indicator lamp.	Indicates when filament power is applied.
+250V ON indicator lamp.	Indicates when ac voltage is applied.

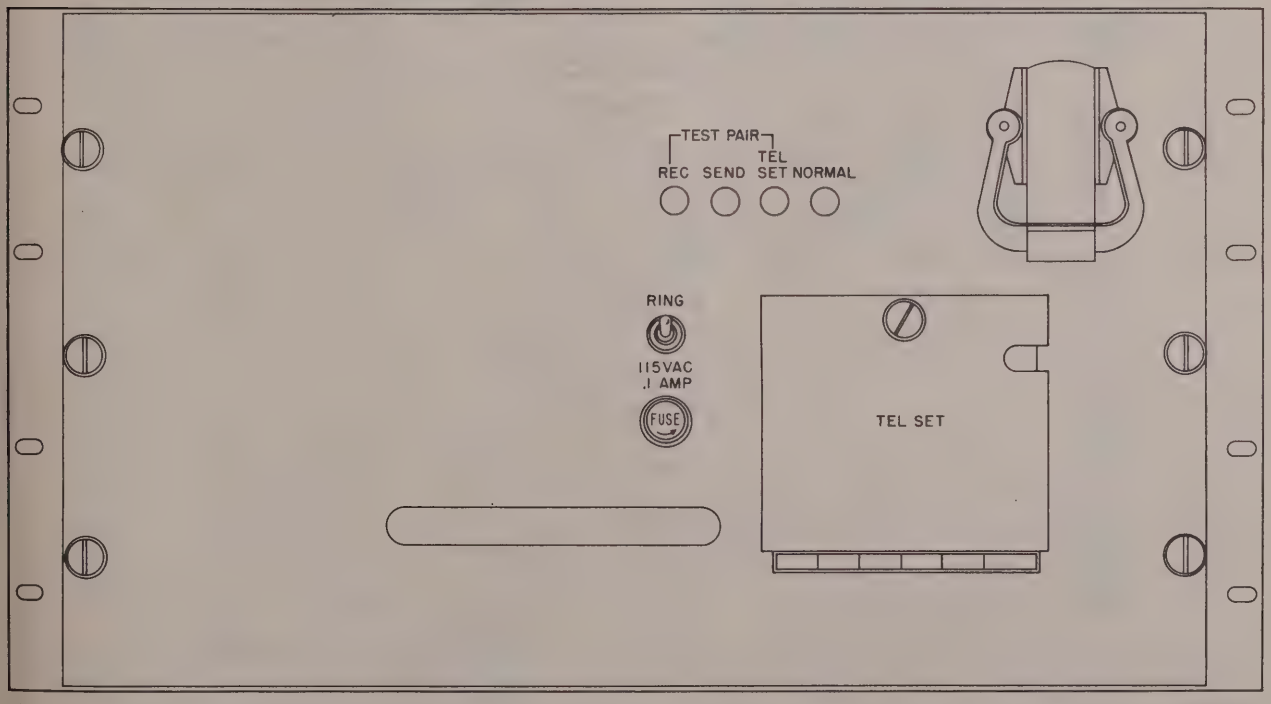


Figure 55. Control Monitor C–1151/TC, controls.

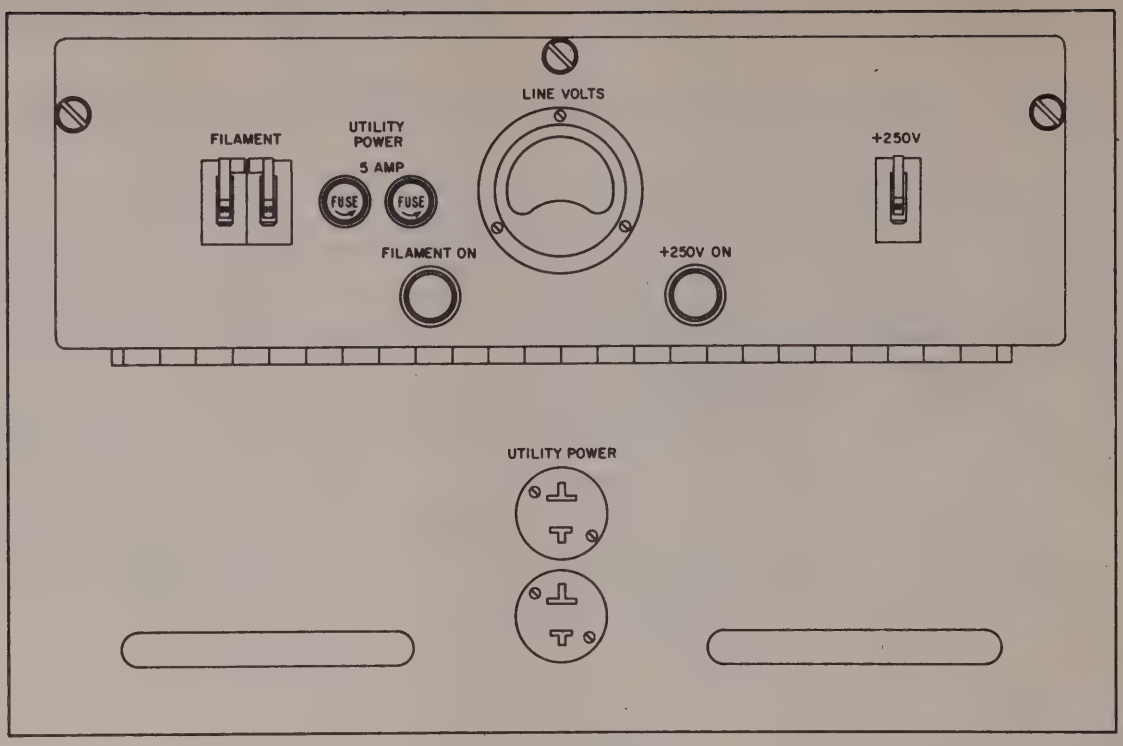


Figure 56. Power Supply PP–691/G, controls.

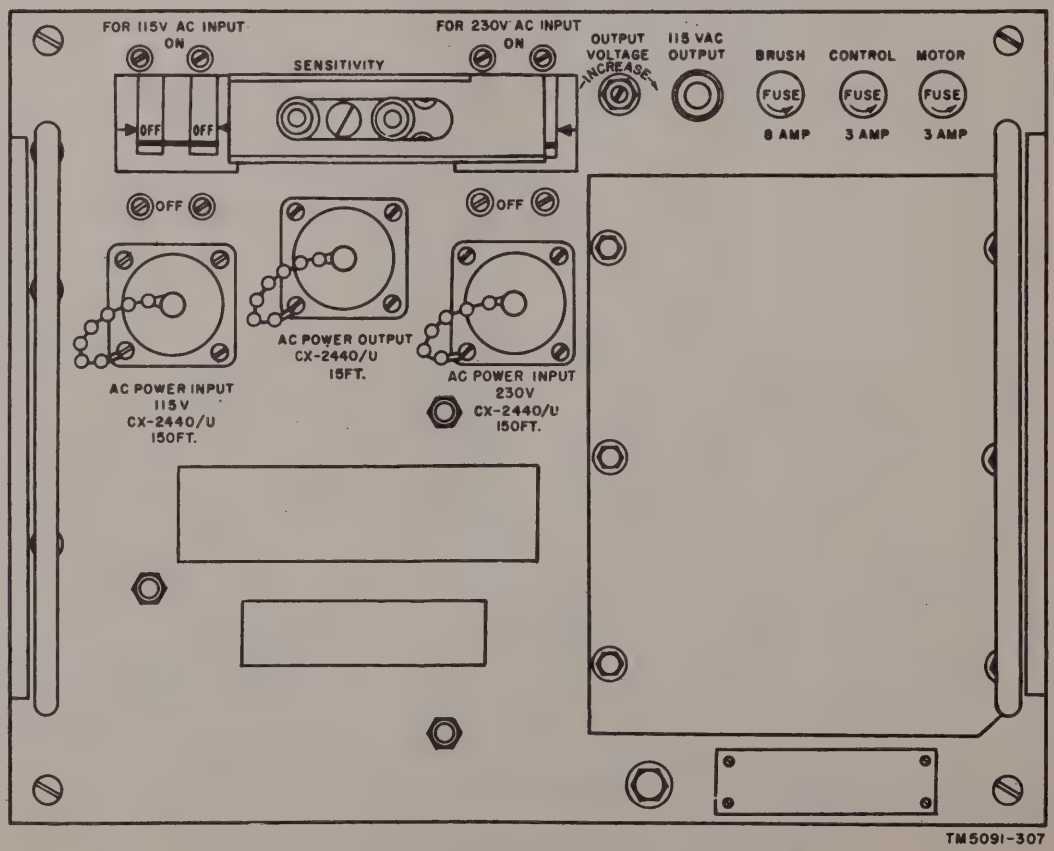


Figure 57. Voltage Regulator CN–236/G, controls.

90. Voltage Regulator CN-236/G, Controls
(fig. 57)

The table below lists the controls of the voltage regulator and gives their functions.

Controls	Function
115 AC INPUT ON circuit breakers.	When switched to ON position, apply 115 volts to the voltage regulator from the output of the switch box.
230V AC INPUT ON circuit breakers.	When switched to ON position, apply 230 volts to the voltage regulator from the output of the switch box.
115 VAC OUTPUT ON indicator lamp.	Glows to indicate that a 115-volt ac output voltage is being supplied to the power supply.
OUTPUT VOLTAGE control.	Adjusts the output voltage from the voltage regulator to the power supply.
SENSITIVITY control.	Determines the output voltage at which the voltage regulator will correct the input voltage.

Note. To operate at 115 volts ac, move the positioning arm to the extreme right and lock. To operate at 230 volts ac, move the positioning arm to the extreme left and lock.

91. Switch Box SA-357/G, Control
(fig. 58)

The table below lists the switch box control and gives its function.

Controls	Function
INPUT SELECTOR SWITCH	Selects 115/230 VAC INPUT 1 or 115/230 VAC INPUT 2. Either of two primary power sources is available to the voltage regulator by the position of the switch.

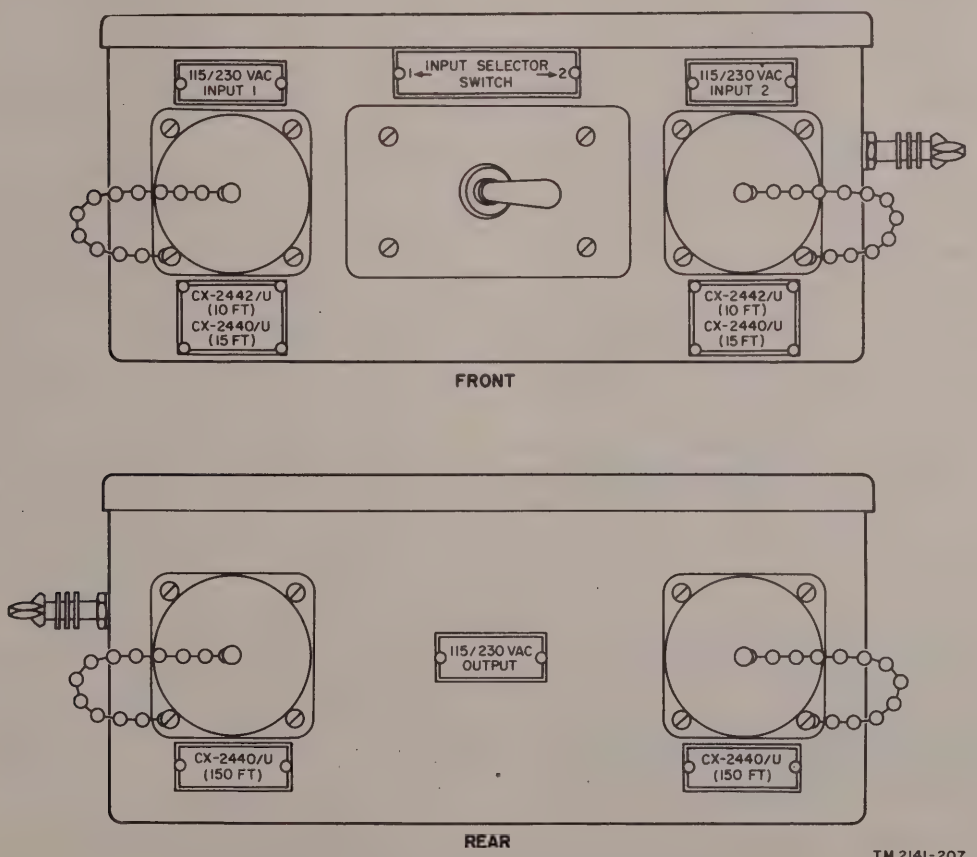


Figure 58. Switch Box SA-357G, controls.

Section II. OPERATION UNDER USUAL CONDITIONS

92. General

This equipment is connected and adjusted for continuous 24-hour-a-day operation by installation and maintenance personnel. No adjustment of controls is required by operating personnel. Paragraphs 93 and 94 describe the preliminary adjustments and starting procedures required for operation. Paragraph 95 describes the operation of the order-wire channel. Paragraph 96 describes the various modes of operation.

93. Preliminary Adjustments

Before power is applied to the equipment, set the following controls to the position shown:

Component	Control	Fig. ref	Position
Power supply	FILAMENT circuit breaker +250V circuit breaker	56 56	Down (OFF). Down (OFF).
Audio test set[a]	ON-OFF switch	54	OFF.
Modem	SELECTOR switch 2W–4W switch	50 36	OPER. Plug in with desired 2W (two-wire) or 4W (four-wire) mark toward arrow on terminal board.
Control monitor[a]	Test switch	55	NORMAL.
Voltage regulator	115V AC INPUT ON circuit breaker 230V AC INPUT ON circuit breaker	57 57	Down to OFF. Down to OFF.
Switch box	INPUT SELECTOR SWITCH	58	Throw to either position 1 or position 2, depending on the source desired.
Multiplexer subassembly,[a] electrical equipment rack[bc]	Remote keying units	18 13	Plug in with either NORMAL OPERATION or REMOVE KEYING OPERATION pointing upward on either or both units, depending on the desired mode of operation for channels 1 and 2.
Oscilloscope	All controls except ON-OFF switch ON-OFF switch	53	Set all controls as shown in paragraph 45*a*. OFF.
Common unit[bc]	Multiplexer and demultiplexer sections, MASTER-SLAVE switches	111 112	Set to MASTER position for 45-channel operation when the particular multiplexer set is the *master;* set to SLAVE position for 45-channel operation when the particular multiplexer set is the *slave.*
Video restorer[b]	23 CHAN-45 CHAN switch	144	Throw to the 45 CHAN or 23 CHAN position.

[a]Not part of Pulse Form Restorer Group AN/TRA–10.
[b]Not part of Multiplexer Set AN/TCC–13.
[c]Not part of Multiplexer Group AN/TCA–1.

94. Starting Procedure

Note. If, during the starting procedure, an abnormal result is obtained, refer to the equipment performance check list (par. 117 or 132).

a. Throw the voltage regulator 115V AC INPUT ON circuit breaker or the 230V AC INPUT ON circuit breaker (depending on the input voltage) to the ON position. The 115V AC OUTPUT indicator lamp on the voltage regulator should light.

b. Place the power supply FILAMENT circuit breaker in the ON position. The indicator lamps marked FILAMENT ON should light. The alarm will sound but can be quieted by pushing the AUDIBLE ALARM DISCONNECT button. The blower fans should operate. The LINE VOLTS meter in the power supply should indicate approximately 115 volts.

c. Wait 30 seconds for the filaments to warm up, then move the power supply +250 circuit breaker to the ON position. The +250V ON indicator lamps in both the power supply and multiplexer subassembly should light.

d. Turn on the audio test set (AN/TCC–13 and AN/TCA–1 only) and oscilloscope by placing their power ON-OFF switches in the ON position. The POWER ON indicator lamps in both units should light.

e. The equipment is now operating.

(1) An alarm buzzer and an ALARM indicator lamp are located on the multiplexer subassembly (mounting rack of the AN/TRA–10). When there is an improper input or improper operation of the demultiplexer section, or delay lines, the buzzer sounds and the ALARM lamp lights. Therefore, *maintenance personnel should be informed immediately* whenever the buzzer sounds and the lamp lights.

(2) To disconnect the alarm buzzer, press the AUDIBLE ALARM DISCONNECT push button on the multiplexer subassembly front panel (mounting rack front panel of the AN/TRA–10). The ALARM indicator lamp will continue to glow until the trouble has been corrected.

95. Operation of Order-wire Channel

The order-wire system provides a channel (channel 1) especially for communication between the operators of the various stations, for instructions, testing, trouble shooting, and other official business.

a. At the East or West Terminal.

(1) Press the control monitor NORMAL button. This connects the telephone handset to channel 1 on a two-wire basis.

(2) To initiate a call, press the RING button on the control monitor. The button should be pressed and released until the desired *party line* ring has been transmitted. The series of ring bursts should be transmitted several times until the desired party responds.

(3) To talk, push the switch on the telephone handset and talk into the transmitting end. The handset may be used for talking and listening when the switch is depressed. If only reception is desired, release the switch.

Note. If the order-wire channel fails, any other preselected channel may be used for this purpose. With the preselected channel set on a two-wire basis, turn the appropriate channel modem selector switch to either SR or RR and depress the control monitor TEL SET button.

b. At Drop-and-insert Repeater.

(1) The channel 1 D&I-THRU switch must be in D&I; the modem 2W–4W switch must be in the 2W position; and the PARTY LINE-PRIV switch must be in the PARTY LINE position.

(2) To initiate a call at an AN/TCA–1 terminal, press the RING button on the control monitor. The button should be pressed and released until the desired *party line* ring has been transmitted. The series of ring bursts should be transmitted several times until the called party responds.

(3) To initiate a call at a pulse form restorer group, connect a field telephone to the channel 1 PARTY LINE binding posts on the back of the equipment rack. Crank the generator in short bursts until the called party responds.

(4) To talk, depress the switch on the telephone handset and talk into the

transmitting end of the handset. The handset may be used for both talking and listening when the switch is depressed. If only reception is desired, release the switch.

(5) If order-wire channel 1 fails, use channel 2 as the order-wire channel. To do this, proceed as follows at the repeater:

(*a*) Place the control monitor switch (at the multiplexer group) in the NORMAL position.

(*b*) Place the channel 2 PARTY LINE-PRIV switch (fig. 47 and 49) in the PARTY LINE position.

(*c*) Place both the eastfacing and westfacing channel 2 D&I-THRU switches (fig. 47 and 49) in the D&I position.

(*d*) Place both the eastfacing and westfacing channel 2 2W–4W switches (fig. 36) in the 4W position.

(*e*) Connect Telephone EE–8–B to the channel 2 PARTY LINE binding posts on the back of the equipment rack.

(6) To ring out, crank the generator in field Telephone EE–8–B. This will apply a 20-cycle ringing voltage to the PARTY LINE binding posts, which, through a sequence of events, causes the channel 2 pulse in both directions to be blanked out. The repeater channel 2 field Telephone EE–8–B rings when the incoming channel 2 pulse is blanked out because the 20-cycle ringing voltage is transferred to the PARTY LINE channel 2 terminals.

(7) At the AN/TCA–1 repeater, if neither channel 1 nor 2 is available, use any of the other channels (channels 3 through 8) for the order-wire channel. To do this, proceed as follows at the repeater (depending on the direction the operator at the repeater wants to talk):

(*a*) Place the control monitor switch (fig. 55) in the NORMAL position.

(*b*) Place the appropriate modem 2W–4W switch (fig. 36) in the 2W position.

(*c*) Place the D&I-THRU switch (fig. 47) in the D&I position.

(*d*) Connect field Telephone EE–8–B to the 2W LINE binding posts of the desired channel (and also desired direction) at the rear of the equipment rack.

(*e*) Place the modem selector switch (fig. 50) in the SR or RR position.

(*f*) It is now possible to talk on the desired channel and in the direction selected.

96. Drop-and-insert Operation of Channels 1 and 2

a. General. The operation of the multiplexer group or pulse form restorer group is first determined by the position of the 23 CHAN-45 CHAN selector switch, and then by the positions of the four pull-out reversible-type switches (two PARTY LINE-PRIV switches and two D&I-THRU switches).

(1) The 23 CHAN-45 CHAN selector switch (fig. 144) on each video restorer chassis should be set to its correct position (for 23– or 45–channel operation).

(2) The four pull-out reversible-type switches determine the various modes of operation of the multiplexer group or pulse form restorer group, as shown in figures 47 and 49. The THRU-D&I and PARTY LINE-PRIV switches are located behind the binding post doors (fig. 47 and 49); the NORMAL OPERATION - REMOTE KEYING OPERATION remote keying unit is located on the rear of the mounting rack (fig. 13 and 18); and the 2W–4W switch is located inside the modem (fig. 36).

b. Through Operation. With the two applicable channel 1 and/or 2 D&I-THRU switches (two for each channel, one for each direction) in the THRU position (THRU on top), the multiplexer group or pulse form restorer group will simply receive, reshape, and retransmit the received pulse train. No drop-and-insert facility is available.

c. Drop-and-insert Operation. With the applicable channel 1 and/or 2 D&I-THRU switch in the D&I position, the drop-and-insert facility of the multiplexer or pulse form restorer is available, using either normal or remote keying operation.

(1) *Normal operation.* With the applicable channel 1 and/or 2 remote keying unit in the NORMAL OPERATION position, the normal drop-and-insert operation is available to permit local access to the vf channels. Under this condition, it is possible to operate either party line or private.

(*a*) *Party-line operation.* With the PARTY LINE-PRIV switch in the PARTY LINE position and the modem 2W–4W switch in the 4W position, party-line operation is possible. Note that although each modem of the given channel is connected for 4-wire output, the party-line circuit is always two-wire. Party-line operation provides a telephone circuit at the repeater station, which is bridged into the given channel so that personnel on the telephone circuit can communicate with both terminals and/or other repeaters (when also connected for party-line operation).

(*b*) *Private operation.* With the PARTY LINE-PRIV switch in the PRIV position, private operation is possible. In private operation, a telephone circuit at a repeater station permits personnel on the circuit to communicate with a terminal or repeater in one direction only. When operating under private operation (in normal operation), it is possible to use the input telephone circuit on either a two- or four-wire basis, provided the modem 2W–4W switch is properly positioned.

Note. Since, in private opera-

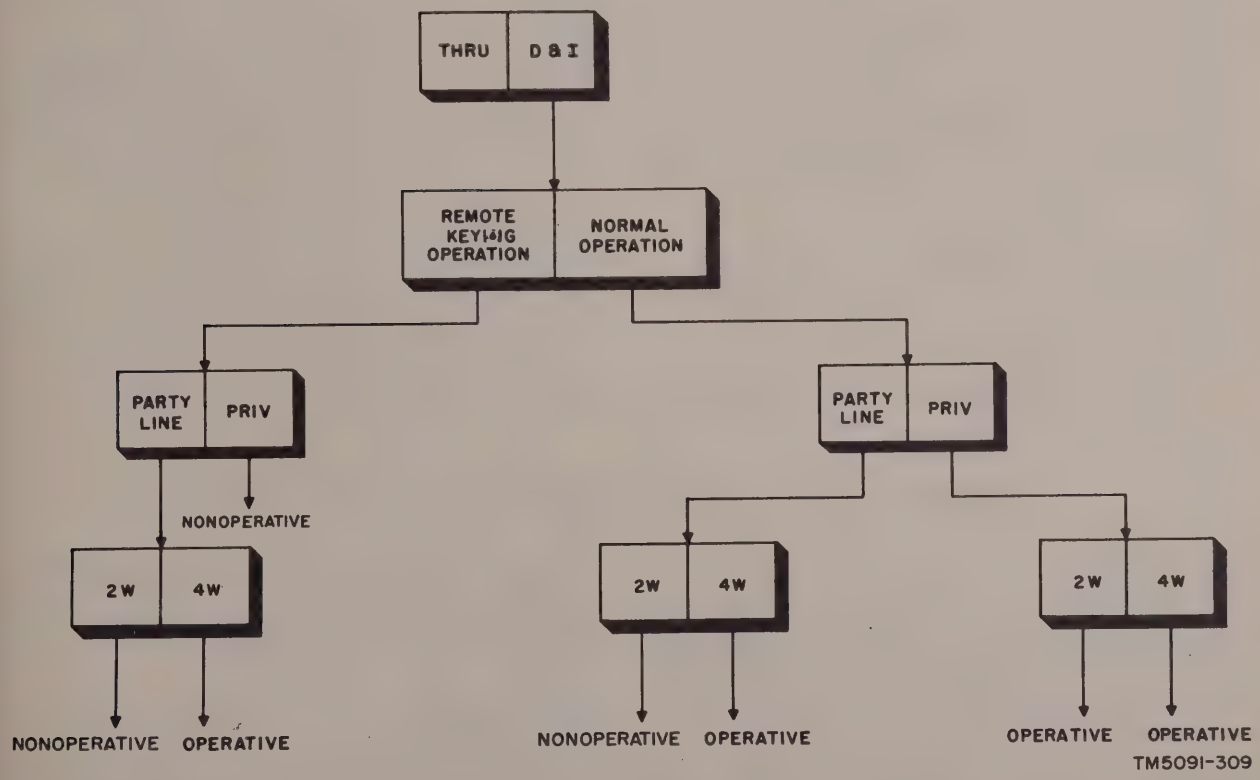


Figure 59. Operational switches (channels 1 and 2), block diagram.

tion, the eastfacing and westfacing circuits are independent, separate circuits to the east and west terminals are available on each channel simply by connecting two field telephones to the proper eastfacing and westfacing binding posts on the rear of the mounting rack.

(2) *Remote-keying operation.* With the applicable channel 1 and/or 2 remote-keying unit in the REMOTE KEYING OPERATION position, the complete remote-keying facility is provided. However, under this condition, the PARTY LINE-PRIV switch must be in the PARTY LINE position, and the modem 2W–4W switch must be in the 4W position. Audio connections are made to party-line terminals on a two-wire basis.

97. Operation of Channels 3 through 8 (Multiplexer Group AN/TCA–1)

Since there are no remote-keying switches or PARTY LINE-PRIV switches for channels 3 through 8, operation on these channels can only be on either a THRU or D&I (PRIV) basis (channels 3 through 8 are automatically wired for private operation). Operation of these channels for either THRU or D&I (private) is exactly as described in paragraph 96*b* and *c*.

98. Stopping Procedure

Note. Do not shut down the equipment without permission.

a. Normal Shut-down Procedure.

(1) Before shutting down the equipment, notify the telephone control operator and the operators at the other stations that the equipment is being shut down. Use the order-wire channel for communication.

(2) Turn the oscilloscope INTENSITY control to the extreme counterclockwise position.

(3) Set the oscilloscope and audio test set power switches to the OFF position.

(4) Set the 250V circuit breaker on the power supply to the OFF position.

(5) Set the FILAMENT circuit breaker on the power supply to the OFF position.

(6) Place the voltage regulator 115V AC INPUT ON circuit breaker or 230V AC INPUT ON circuit breaker (whichever is in use) in the OFF position.

(7) Remove any auxiliary equipment plugs from the utility outlets.

b. Emergency Shutdown Procedure. To shut down the equipment in an emergency, throw the power supply FILAMENT circuit breaker to OFF. Remove any auxiliary equipment plugs from the utility outlets.

c. Bypassing Effects on System Operation. Since the alarm circuit contains a bypassing feature and is of the normally energized type, both video restorers will be bypassed and system operation will be maintained. If a shutdown of several hours or days is contemplated, the multiplexer group or pulse form restorer group should be bypassed manually by connecting the eastfacing radio-frequency receiver directly to the westfacing transmitter, etc, to provide a pure repeater arrangement.

SECTION III. OPERATION UNDER UNUSUAL CONDITIONS

99. General

The operation of the equipments may be difficult in regions where extreme cold, heat, humidity, moisture, and similar conditions prevail. While every precaution is taken in the equipment design to maintain its technical characteristics over a wide temperature and humidity range, adverse conditions may cause equipment failure unless additional precautions are taken. Paragraphs 100 through 102 outline procedures that minimize the effects of these unusual climatic conditions.

100. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather affect the efficient

operation of the equipment. Instructions and precautions for operations under such adverse conditions follow:

a. Handle the equipment carefully.

b. Keep the equipment warm and dry. If the set is not in a heated inclosure, partially cover it during operation with the transit case covers.

c. Heavy coatings of frost will gather on the mouthpiece of the telephone handset in extreme cold weather when the telephone is used outdoors or in a cold room. Frost from the breath will form in the small holes of the cap and effect the output of the telephone. Plastic covers have been designed to protect some types of telephones; use them if available.

d. If water or moisture gets into the telephone receiver, it may freeze and impede the action of the diaphragm. If this happens, unscrew the bakelite cap and remove the ice and moisture.

e. In cold weather, the values of the filter capacitors in the power supply may drop and the output voltage may drop. If this condition occurs, change the taps on power transformer T1 in the power supply from tap 5 to tap 6, and from tap 4 to tap 3. This will raise the output voltage to compensate for the drop caused by cold weather.

101. Operation in Tropical Climates

When operated in tropical climates, the equipment may be installed in tents or huts. In swampy areas, it is subjected to acute moisture conditions. Ventilation is usually very poor, and the high relative humidity causes moisture to condense on the equipment whenever its temperature becomes lower than the surrounding air. When this happens dry the equipment thoroughly. Make frequent preventive maintenance checks (par. 110).

102. Operation in Desert Climates

a. The main problem that arises with equipment operation in desert areas is the large amount of sand, dust, or dirt that enters the blower motors and filter. Check and clean the air filter frequently. The ideal preventive precaution is to house the equipment in a dustproof shelter. The next best precaution is to make the building in which the equipment is located as dustproof as possible with available materials.

b. Never tie power cords, signal cords, or other wiring connection to either the inside or the outside of tents. Desert areas are subject to sudden wind squalls, which may jerk the connections loose or break the lines.

c. Try to keep the equipment as free from dust as possible. Make frequent prevtive maintenance checks (par. 110).

CHAPTER 5

ORGANIZATIONAL MAINTENANCE

Note. In this manual, organizational maintenance consists of 1st and 2nd echelon maintenance.

Section I. TOOLS AND EQUIPMENT

103. General

The tools, materials, or tool equipment kits that are furnished with the equipment are described in paragraph 105. Additional tools and test equipment are supplied with the radio set with which the equipment is used.

104. Tools, Materials, and Test Equipment Required

The following tool, materials, and test equipment are not furnished as part of the equipment. They are required for organizational maintenance.

a. Tool.

Tool Equipment TE–113

b. Materials.

Cheesecloth, bleached, lint-free[1]

Orange stick

Sandpaper, flint #000[1]

Cleaning Compound (Federal stock No. 6G 236.6)

c. Test Equipment

Test equipment	Technical manual
Electron Tube Test Set TV–7/U	11–5083
Electronic Multimeter TS–505/U	11–5511
Multimeter TS–352/U	11–5527

105. Special Tools Supplied

Special tools supplied with Multiplexer Set AN/TCC–13 and Multiplexer Group AN/TCA–1 are located in Accessories Case CY–1334/G (fig. 19). To gain access to the tools, loosen the two thumbscrews and pull out the drawer. Special tools supplied with Pulse Form Restorer Group AN/TRA–10 are stored in accessories and spare parts case[1].

a. Tube Pin Straighteners. Two tube pin straighteners are supplied with the equipment. One is used with 7-pin miniature tubes and the other is used with 9-pin miniature tubes.

b. Tube Pullers. Two tube pullers are supplied with the equipment, one for extracting the 7-pin miniature tubes and the other for extracting the 9-pin miniature tubes.

c. Wrenches. A No. 6 and No. 8 Allen wrench are supplied for use with the equipment.

[1]Part of Tool Equipment TE–113.

Section II. PREVENTIVE MAINTENANCE SERVICES

106. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from trouble shooting and repair since its object is to prevent certain troubles from occurring.

107. General Preventive Maintenance Techniques

Note. The techniques described apply to all units of the multiplexer set, multiplexer group, and pulse form restorer group.

a. Use #000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning. If necessary, moisten the cloth or brush with Cleaning Compound; then wipe the parts dry with the cloth. Use Cleaning Compound on all parts, including electrical contacts.

Caution: Prolonged breathing of Cleaning Compound fumes is dangerous. Be sure adequate ventilation is provided. Cleaning Compound is flammable; do not use it near a flame.

108. Use of First Echelon Preventive Maintenance Forms

(fig. 60)

a. DA Form 11–238 is the preventive maintenance check list to be used by the operator.

b. Items not applicable to Multiplexer Set AN/2CC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 are lined out in figure 60. References in the ITEM block in the figure are to paragraphs in this manual which contain additional information pertinent to the particular item.

109. Use of Second Echelon Preventive Maintenance Forms

(fig. 61)

a. DA Form 11–239 is a preventive maintenance check list to be used by second echelon repairman.

b. Items not applicable to Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, or Pulse Form Restorer Group AN/TRA–10 are lined out in figure 61. Reference in the ITEM block in this figure are to paragraphs in this manual which contain additional information pertinent to the particular item.

c. Items No. 19, 21, 22, 24, 25, 26, 27 and 31 on the check list require that power be removed. Before removing power, obtain permission. The equipment is designed for continuous operation and removal of power will cause the interruption of telephone traffic.

110. Performing Preventive Maintenance

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

a. Exterior Items.

(1) Check for completeness and general condition of the equipment. The components supplied with each equipment are listed in the appendix.

(2) Check suitability of location and installation for normal operation (par. 34 and 60). Be sure that the air intake openings are free from obstructions, thus permitting free circulation of air.

(3) Remove dirt and moisture from the multiplexer subassembly filter, handset, jacks, plugs, and panels of the component parts.

(4) Inspect all plugs and connectors. Inspect the seating of fuses, switches, and circuit breakers. Inspect the captive screws of individual units for tightness.

(5) Inspect the dials and controls of the audio test set and oscilloscope for binding, scraping, and excessive looseness.

(6) Check for normal operation of the oscilloscope and audio test set.

Note. The equipment racks are designed for continuous operation. If the alarm buzzer does not sound or the ALARM light does not light, no operational checks are necessary. If the buzzer sounds and the ALARM light

glows, press the AUDIBLE ALARM DISCONNECT button. If the situation that caused the alarm to sound does not remedy itself the ALARM light will continue to glow. Inform maintenance personnel immediately.

(7) Clean and tighten the exterior panel mounting screws of all components and cases, the equipment rack shock mounts, and cable connections.

(8) Inspect the transit cases, mounting racks, voltage regulator cases, switch box, and other exposed metal surfaces for rust, corrosion, and moisture.

(9) Inspect all cords, cables, wires, and shock mounts for cuts, breaks, fraying, deterioration, kinks, and strain. Under no condition are the cables to be removed without first informing maintenance personnel or the communication chief.

(10) Inspect all canvas items in the accessories and spare parts cases, for mildew, tears, and fraying.

(11) Inspect for looseness of accessible items: switches, knobs, jacks, connectors, voltage regulator, relays, blower motors, capacitors, 20-cycle generator, and pilot light assemblies. Do not loosen, shake, or pull out any items when checking; this may interrupt traffic.

(12) Clean the name plates, meter windows, jewel assemblies, common unit, video restorer, and filament supply air filters. Clean the filament supply air filter of the AN/TCC–13 and AN/TCA–1 as follows:

(*a*) Remove the filament supply cover by unscrewing the four filament panel mounting screws, mounting it to the electrical equipment rack (fig. 6 and 10).

(*b*) Remove the filter from its mounting cover and clean with Cleaning Compound.

(c) Replace the air filter in its mounting cover with the arrow next to the words *AIR FLOW* pointing toward the rack.

(*d*) Remount the air filter mounting cover to the rack with the four filament panel mounting screws.

Note. This air filter must be *cleaned every week.* Failure to do this will result in improper operation of the multiplexer set and multiplexer group.

(13) Inspect the meter of the power supply and audio test set for damaged glass and cases.

(14) Check the switch box and voltage regulator for cracks, leaks, dirt, and grease.

b. Interior Items.

Caution: Disconnect all power before performing the following operations. Upon completion, reconnect power and check for satisfactory operation of the equipment. Be sure to obtain permission before removing power. Telephone traffic being handled by the equipment will be interrupted.

(1) Inspect fixed capacitors for leaks, bulges, and discoloration.

(2) Inspect relays and circuit breakers for loose mountings; burned, pitted, and corroded contacts; misalignment of contacts, insufficient spring tension and binding of hinge parts.

(3) Inspect resistors, bushings, and insulators for cracks, chipping, blistering, discoloration, and moisture.

(4) Inspect terminals of large fixed capacitors and resistors for corrosion, dirt, and loose contacts.

(5) Clean and tighten switches, terminal blocks, blowers, relay cases, and interiors of chassis and cabinets not readily accessible. Clean, inspect for corrosion, and tighten rack slides.

(6) Inspect terminal blocks for loose connections, cracks, and breaks.

(7) Clean and tighten connections and mountings for transformers, chokes, and potentiometers.

(8) Inspect transformers, chokes, and potentiometers for overheating and oil leakage.

(9) Inspect the oscilloscope cathode-ray tube (crt) for burned screen spots.

(10) Inspect all components for adequacy of moistureproofing and fungiproofing.

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE: AN/TCC-13, AN/TCA-1, OR AN/TRA-10 | EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (~~receiver, transmitter~~, carrying cases, wire and cable, ~~microphones~~, tubes, spare parts, technical manuals and accessories). PAR. 110 a (1)							
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 110 a (2)							
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 110 a (3)							
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 110 a (4)							
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION. PAR. 110 a (5)							
6	CHECK FOR NORMAL OPERATION. PAR. 110 a (6)							

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ~~ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES,~~ AND CABLE CONNECTIONS. PAR. 110 a (7)		13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~	
8	INSPECT CASES, MOUNTINGS, ~~ANTENNAS, TOWERS,~~ AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 110 a (8)		14	CLEAN AIR FILTERS, ~~BRASS NAME PLATES,~~ DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR. 110 a (12)	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 110 a (9)		15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 110 a (13)	
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		16	~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING.~~	
11	INSPECT CANVAS ITEMS, ~~LEATHER,~~ AND CABLING FOR MILDEW, TEARS, AND FRAYING. PAR. 110 a (10)		17	~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~	
12	INSPECT FOR LOOSENESS OF ~~A~~ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, ~~SELSYNS,~~ MOTORS, BLOWERS, CAPACITORS, ~~GENERATORS,~~ AND PILOT LIGHT ASSEMBLIES. PAR. 110 a (11)		18	CHECK TERMINAL BOX ~~COVERS~~ FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE. PAR. 110 a (14)	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM5091-402

Figure 60. DA Form 11-238.

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE: AN/TCC-13, AN/TCA-1, OR AN/TRA-10

EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; ⓧ Defect corrected.
NOTE: Strike out items not applicable.

NO.	ITEM	CONDITION NOTE	NO.	ITEM	CONDITION NOTE
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (~~receiver, transmitter~~, carrying cases, wire and cable, ~~microphones~~, tubes, spare parts, technical manuals and accessories). PAR.110a(1)		19	~~ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS; INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES.~~	
2	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR.110a(2)		20	~~INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.~~	
3	CLEAN DIRT AND MOISTURE FROM ~~ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS,~~ JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR.110a(3)		21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION. PAR.110b(1)	
4	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, ~~CRYSTALS,~~ FUSES, CONNECTORS, ~~VIBRATORS, PLUG-IN COILS~~ AND RESISTORS. PAR.110a(4)		22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS. PAR.110b(2)	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, ~~WORN OR CHIPPED GEARS,~~ MISALIGNMENT, POSITIVE ACTION. PAR.110a(5)		23	~~INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.~~	
6	CHECK FOR NORMAL OPERATION. PAR.110a(6)		24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE. PAR.110b(3)	
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ~~ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES,~~ AND CABLE CONNECTIONS. PAR.110a(7)		25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS. PAR.110b(4)	
8	INSPECT CASES, MOUNTINGS, ~~ANTENNAS, TOWERS,~~ AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR.110a(8)		26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR.110b(5)	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR.110a(9)		27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS. PAR.110b(6)	
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		28	~~CHECK SETTINGS OF ADJUSTABLE RELAYS.~~	
11	INSPECT CANVAS ITEMS, ~~LEATHER,~~ AND CABLING FOR MILDEW, TEARS, AND FRAYING. PAR.110a(10)		29	~~LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.~~	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, ~~GELDING,~~ MOTORS, BLOWERS, CAPACITORS, ~~GENERATORS,~~ AND PILOT LIGHT ASSEMBLIES. PAR.110a(11)		30	~~INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.~~	
13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~		31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS. PAR.110b(7)	
14	CLEAN AIR FILTERS, ~~GRASS NAME PLATES,~~ DIAL AND METER WINDOWS, JEWEL ASSEMBLIES. PAR.110a(12)		32	INSPECT TRANSFORMERS, CHOKES, ~~POTENTIOMETERS,~~ AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE. PAR.110b(8)	
15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR.110a(13)		33	~~BEFORE SHIPPING OR STORING - REMOVE BATTERIES.~~	
16	~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.~~		34	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS. PAR.110b(9)	
17	~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~		35	~~INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.~~	
18	CHECK TERMINAL BOX ~~COVERS~~ FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE. PAR.110a(14)		36	~~INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.~~	
			37	MOISTURE AND FUNGIPROOF. PAR.110b(10)	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE. 16—64382-1

TM5091-403

Figure 61. DA Form 11-239.

Section III. LUBRICATION AND WEATHERPROOFING

111. Lubrication

Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 require no lubrication.

112. Weatherproofing Procedures and Precautions

Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

a. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, and TB SIG 72, Tropical Maintenance of Ground Signal Equipment. Use this treatment only when parts are replaced or repaired.

b. Arctic Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66, Winter Maintenance of Signal Corps Equipment, and TB SIG 219, Operation of Signal Equipment at Low Temperatures.

c. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremly high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75, Desert Maintenance of Ground Signal Equipment.

Section IV. TROUBLE SHOOTING MULTIPLEXER SET AN/TCC–13 AT ORGANIZATIONAL MAINTENANCE LEVEL

113. General

a. Trouble shooting by the radio relay operator is limited to the localizing of defective parts that are readily replaceable at an organizational level (tubes, fuses, cables, etc), or to the sectionalizing of defective units that must be replaced as a unit (common unit, modems, power supplies, voltage regulator, etc). The procedures outlined are designed to determine first the defective unit and then the nature of the fault within the unit.

b. The techniques that are utilized for organizational trouble shooting include visual inspection, operational tests, tube tests, and simple continuity checks. The material is presented in the order which the repairman would normally employ in servicing a defective set. When the procedures indicated are not sufficient to determine the source of trouble, trouble shooting by a field radio or carrier repairman, as appropriate, is required.

c. If trouble is encountered in the oscilloscope or audio test set, it is not necessary to trouble shoot the multiplexer racks. Refer to paragraph 124 for oscilloscope organizational maintenance and to paragraph 125 and 126 for audio test set organizational maintenance.

114. Sectionalization of Trouble to Multiplexer Terminal

a. The first step in system trouble shooting is to localize the fault to the multiplexer set rather than to some other part of the radio-relay system in which it is operating. This can be done by inspecting the input and output wave shapes. Set up the oscilloscope as described in paragraph 45, and insert the oscilloscope probe into the common unit MASTER OUTPUT TO RF test point and then to the MASTER INPUT FROM RF test point (fig. 62). Both wave forms should be similar to that shown in figure 63.

b. The absence of one of these signals indicates that either the equipment or the system is faulty. If the wave form at the MASTER INPUT FROM RF is not shown, the system is at fault. If the wave form at the MASTER INPUT FROM RF test point is correct and the wave form at MASTER OUTPUT TO RF is not, the fault lies in the multiplexer set. In

that case, proceed as indicated in paragraphs 115 through 123.

115. Visual Inspection

a. When failure is encountered and the cause is not immediately apparent, check the items listed in *b* below before starting a systematic operational check of the equipment. Do not, however, disassemble the set for a complete inspection without some knowledge of the operational symptoms. If possible, obtain information from the operator of the equipment regarding performance at the time trouble occurred.

b. Complete failure of the multiplexer set often may be caused by one or more of the following faults:

(1) Improperly connected power cables.
(2) Worn, broken, loose, or disconnected cords or plugs.
(3) Blown fuses.
(4) Broken or defective tubes.

116. Trouble Shooting by Using Equipment Performance Check List

a. Purpose and Use. The equipment performance check list is the beginning of a systematic trouble-shooting technique designed to isolate trouble with a minimum of waste effort. Operate the equipment as directed in the check list, check for the normal indications listed, and, if an abnormal indication is obtained, follow the corrective measure outlined in the last column of the check list.

b. Corrective Measures. In a few cases, the nature of the abnormal indication permits immediate localization of trouble to a particular part, so that the corrective measure indicates the specific part to be checked, repaired, or replaced. In most cases, however, the abnormal indication provides only for sectionalization of the trouble to a particular unit or group of parts. In these latter cases, the corrective measures call for the performance of additional testing procedures to localize the trouble. When the procedure referred to is beyond the scope of the radio relay operator, reference is made to specific paragraphs in this manual and trouble shooting by a field radio or carrier equipment repairman, as appropriate, is required.

c. Checking Wave Forms.

(1) Checking wave forms is the best

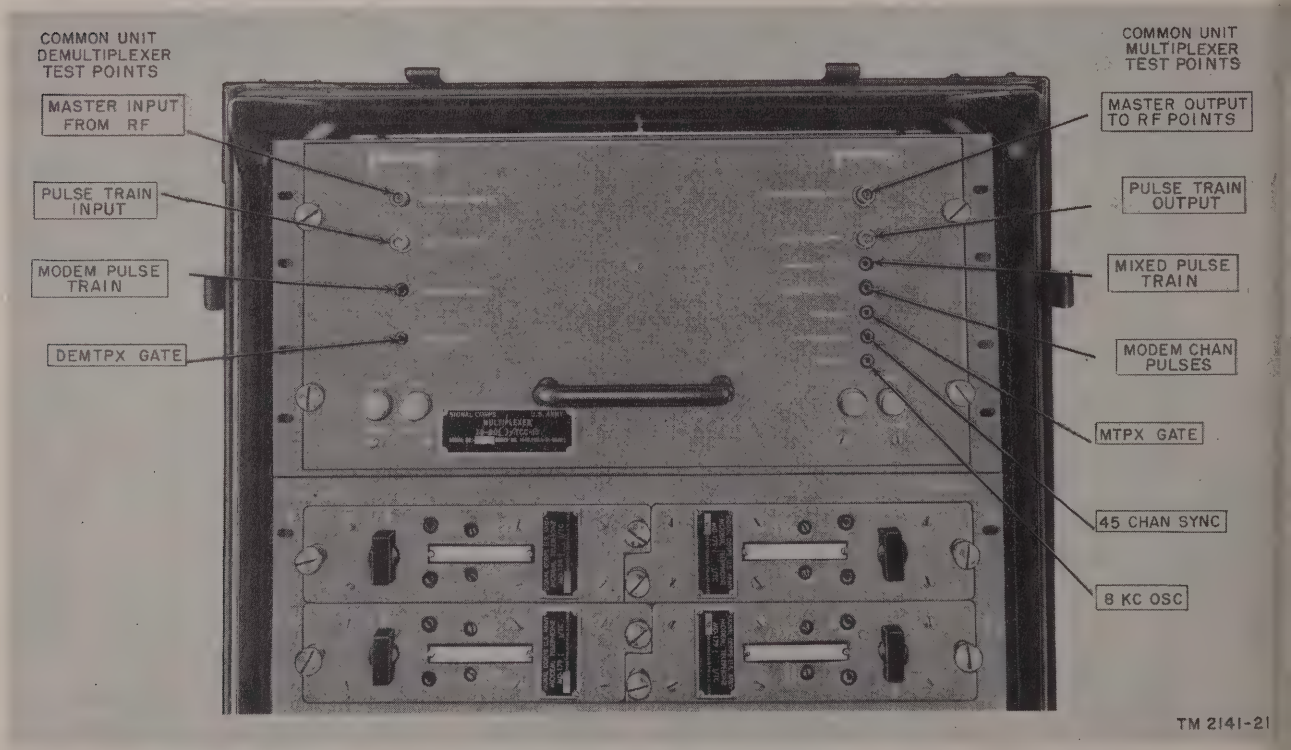


Figure 62. Common unit test points.

method for locating troubles. By the use of the oscilloscope supplied, wave forms at various points in the equipment may be obtained. Faults can be localized rapidly by comparing the observed wave form with the actual reference wave form shown in the trouble-shooting sections.

(2) The various controls in the equipment may not be in the same positions as they were when the reference wave forms were taken. Note the conditions specified for the reference wave forms. Wave form figure references indicate sweep speed and voltage amplitude at specified points. Sweep time is controlled by the COARSE and FINE controls. The voltage amplitude should be checked against the internal oscilloscope calibration voltage. These controls and the amplitude calibration procedure are described in paragraph 45.

(3) The same number of cycles should be displayed.

(4) The vertical or horizontal amplitudes of the reference and test patterns may not be proportional. This will produce apparent differences between the shapes of the two wave forms when there is no real difference.

(5) Whether or not the wave form is regarded as abnormal will depend on the symptom accompanying the fault which is being traced. The error will be considered significant if the fault can be caused by a minor difference in wave form at the point under test. Otherwise, time should not be spent in hunting the cause of relatively minor differences between the shapes of the reference wave forms and the test wave forms.

d. Comparison of Wave Forms. If there is no fault in the circuit or the equipment, an actual wave form taken at a point in the equipment should closely resemble the reference wave form. Differences in shape, however, may occur for the following reasons:

(1) The test leads to the oscilloscope may not be placed as they were when the reference wave forms were taken.

(2) An abnormal wave form indicates a fault between the last point where the wave form is normal and the first point where it is observed to be abnormal. For example, if a wave form is observed to be normal at the grid of a stage and abnormal at the plate of the stage, the trouble lies in that stage. When the wave form of a circuit is found to be abnormal, replace the tube before making any further tests. If replacing the tube does not correct the wave form, place the original tube back in the socket. When a component does not give the expected wave form, the fault is not necessarily in the component. The abnormal wave form may be caused by the absence of a proper signal from another component. The point to start signal tracing a component is at the input receptable.

Note. Wave forms should not vary more than 20 per cent in width and amplitude from the referenced figures.

e. Test Points. When operating the multiplexer set, wave forms at the front panel test points may be observed on the oscilloscope; they should not vary more than 20 per cent in width and amplitude from the figures referred to in the *Normal indication* column of the check list. If all the wave forms are present and correct, no further multiplexer section investigation is necessary.

f. Stage-by-stage Wave Forms. If the wave forms mentioned in *e* above are not correct, check the stage-by-stage wave forms as indicated in the *Corrective measure* column of the check list. These checks should be made in the order given. An absent or distorted wave form at any check indicates that the stage between the last normal indication and the absent or distorted indication is at fault. When such a stage is located, change the tube of that stage. If a tube change does not correct the situation, refer to the chapter on field maintenance. If a modem is defective, replace it with the spare modem.

117. Multiplexer Set AN/TCC-13, Performance Check List

	Item No.	Unit	Item	Action or condition	Normal indication	Corrective measures
PREPARATORY	1		Cables.	Check connections.		
	2	Common unit.	SLAVE-MASTER switch.	Set to MASTER position.		
	3	All modems.	2W–4W switches.	Set in 2W or 4W position (fig. 36).		
	4	All modems.	Modem selector switch.	Set in OPER position.		
	5	Filament supply.	Remote keying units.	Set in NORMAL OPERATION or REMOTE KEYING OPERATION position.		
	6	Control monitor.	Control monitor switch.	Depress NORMAL button.		
	7	Switch box.	Switch box.	Set to desired input source.		
START	8	Switch box.	INPUT SELECTOR switch.	Set to 115/230 VAC INPUT 1 or 115/230 VAC INPUT 2, depending on the primary power source.		
	9	Voltage regulator.	115V AC INPUT ON or 230V AC INPUT ON circuit breaker.	Set to ON position.	115 VAC OUTPUT pilot lamp lights.	Check lamp and circuit breaker.
	10	Power supply.	FILAMENT circuit breaker.	Set to ON position.	1. LINE VOLTS meter indicates 115 volts ±1 per cent; FILAMENT ON indicator lamps glow.	1. Adjust OUTPUT VOLTAGE potentiometer on voltage regulator (par. 43*b*). Check fuses (fig. 56). Check V1 and V2 IN voltage regulator. Refer to paragraph 123.
					2. Filament supply blower fan should operate.	2. Check FAN FUSE.
	11	Power supply.	+250V circuit breaker.	*Wait 30 seconds;* throw +250V circuit breaker to ON.	±250V ON pilot lamps glow; ALARM indicator light does not light; alarm buzzer is silent.	Check B+ GROUPS fuses on filament supply. Refer to paragraph 123*a*.
	12	Oscilloscope.	ON-OFF switch.	Set to ON.	POWER ON indicator light glows.	Check fuses 4 AMP. Refer to paragraph 124.
	13	Audio test set.	ON-OFF switch.	Set to ON.	POWER ON indicator light glows.	Check fuse. Refer to paragraphs 125 and 126.

EQUIPMENT PERFORMANCE	14	Common unit.	Multiplexer section.	Check wave form at 8 KC OSC test point.	As shown in figure 64.	Check wave form at pin 5 of V2 (fig. 71).
	15	Common unit.	Multiplexer section.	Check wave form at 45 CHAN SYNC test point.	As shown in figure 65.	Check wave form at pin 8 of V1 (fig. 70) and pin 5 of V3 (fig. 72).
	16	Common unit.	Multiplexer section.	Check wave form at MTPX GATE test point.	As shown in figure 66.	Check wave form at pin 2 of V5A (fig. 74), pin 6 of V4B (fig. 73), pin 5 of V6 (fig. 75), check tube V5.
	17	Common unit.	Multiplexer section.	Check wave form at MODEM CHAN PULSES test point E4.	As shown in figure 67.	Check modems as in item 20.
	18	Common unit.	Multiplexer section.	Check wave form at MIXED PULSE TRAIN test point E5.	As shown in figure 68.	1. If there are no marker and channel pulses, check wave form at pin 5 of V11 (fig. 84). 2. If there are no marker pulses, check pin 1 of V7A (fig. 76), pin 6 of V7B (fig. 77), pin 6 of V8A (fig. 78), and pin 1 of V8B (fig. 79). 3. If there are no channel pulses, check pin 1 of V9A (fig. 80), pin 6 of V9B (fig. 81), pin 1 of V10A (fig. 82), and pin 6 of V10B (fig. 83).
	19	Common unit.	Multiplexer section.	Check wave form at PULSE TRAIN OUTPUT test point J8 or J9.	As shown in figure 69.	Adjust OUTPUT AMPL control (par. 48). Check wave form at pin 8 of V12 (fig. 85) and at pin 5 of V13 (fig. 86).
	20	All modems.	1. Modulator circuit.	1. Check wave form at PPM test point J1.	1. Wave form as shown in figure 87.	1. Check wave form at pin 1 of V1A (fig. 88), pin 6 of V1B (fig. 89), and pin 1 of V2 (fig. 90).
			2. Demodulator circuit.	2. Check wave form at PWM test point.	2. Wave form as shown in figure 104.	2. Check wave form at pin 1 of V3A (fig. 105), pin 6 of V3B (fig. 104), pin 1 of V4A (fig. 106), and pin 6 of V4B (fig. 107).
	21	Common unit.	Demultiplexer section.	Check wave form at PULSE TRAIN INPUT test point J22.	Wave form as shown in figure 91.	Check 1-mc filter (par. 299).

	Item No.	Unit	Item	Action or condition	Normal indication	Corrective measure
EQUIPMENT PERFORMANCE	22	Common unit.	Demultiplexer section.	Check wave form at MODEM PULSE TRAIN test point E12.	Wave form as shown in figure 92.	Check wave form at pin 8 of V15 (fig. 94)), pin 5 of V16 (fig. 95), pin 7 of V17 (fig. 96), pin 5 of V18 (fig. 97), pin 5 of V19 (fig. 98), pin 8 of V20 (fig. 99), and pin 2 or 5 of V21 (fig. 92).
	23	Common unit.	Demultiplexer section.	Check wave form at DEMTPX GATE test point E13.	Wave form as shown in figure 93.	Check wave form at pin 8 of V22 (fig. 100), pin 5 of V23 (fig. 101), pin 5 of V24 (fig. 102), and pin 8 of V25 or J24 (fig. 93).
	24	Common unit.	Demultiplexer circuits.		Alarm quiet, alarm light out.	Check wave form at pins 1 and 6 of V26 and pin 1 of V27 (fig. 103).
	25	Control monitor.	Control circuit.	Perform control monitor checks as indicated in paragraph 118.	See paragraph 118.	Refer to paragraph 357 through 358.
	26	Multiplexer set.	Modem ringing circuits.	Perform ringing circuit checks as indicated in paragraph 119.	See paragraph 119.	1. Check V28 and V29. Replace defective tube. 2. If the test cannot be performed on channels 1 and 2, check position of the remote keying unit.
	27	Multiplexer set.	Alarm circuits.	1. Remove the pulse train input cable from the demultiplexer. 2. Press the available AUDIBLE ALARM DISCONNECT button.	1. Alarm sounds and the ALARM indicator on the multiplexer subassembly should light. 2. Alarm no longer sounds, ALARM light stays on.	1. Check V26 and V27. Replace if defective. 2. If horn continues to blow, check switch S1 and alarm disconnect relay K3.
	28	Multiplexer set.	Remote keying units.	Perform remote keying tests as indicated in paragraph 120.	See paragraph 120.	Trouble shooting at a field maintenance level is required (par. 338).
	29	Multiplexer set.		Perform signal - to - noise measurement tests as indicated in paragraph 121*a*.	See paragraph 121*a*.	Refer to the manual on the radio set.
	30	Multiplexer set.		Perform cross talk measurements as indicated in paragraph 121*b*.		

	31	Multiplexer set (45-channel operation).	Common unit.	Check wave form at MASTER OUTPUT TO RF test point.	As shown in figure 109.	Vary 45 CHANNEL PHASE CONTROL.
	32	Multiplexer set (45-channel operation).		Perform operational checks as indicated in paragraph 122.		
	33	Power supply.	+250V circuit breaker.	Set to OFF.	Associated indicator lamps go off.	Check circuit breaker.
STOP	34	Power supply.	FILAMENT circuit breaker.	Set to OFF.	Associated indicator lamps go off; blower motor stops.	Check circuit breaker.
	35	Oscilloscope.	ON-OFF switch.	Set to OFF.	POWER ON indicator light goes off.	Check switch.
	36	Audio test set.	ON-OFF switch.	Set to OFF.	POWER ON indicator lamp goes off.	Check switch.
	37	Voltage regulator.	Power input circuit breaker.	Set to OFF.	115 VAC OUTPUT pilot lamp goes off.	Check circuit breaker.

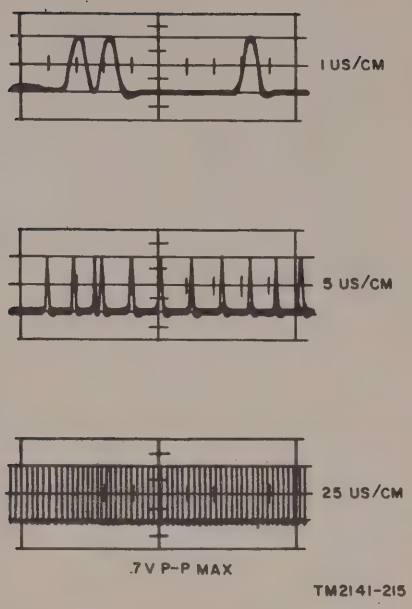


Figure 63. Common unit input and output wave form.

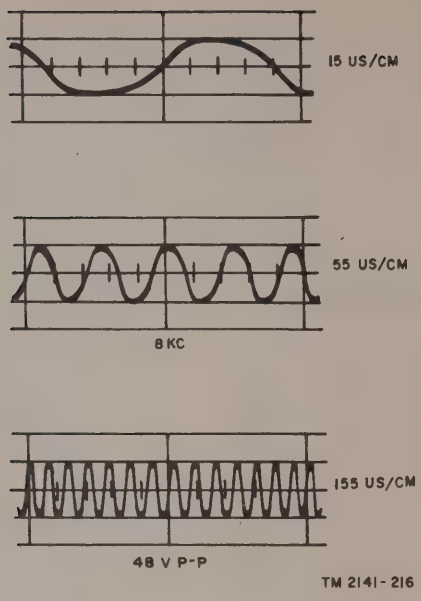


Figure 64. Wave form at multiplexer 8KC OSC test point.

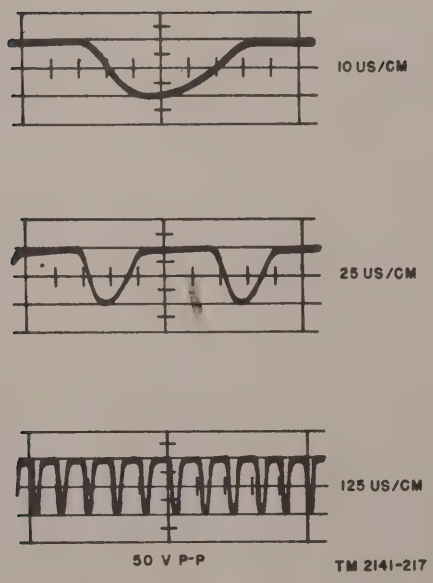


Figure 65. Wave form at multiplexer 45 CHAN SYNC test point.

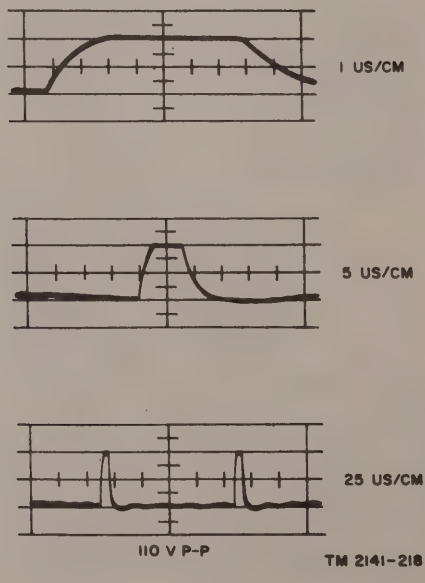


Figure 66. Wave form at multiplexer MTPX GATE OUTPUT test point.

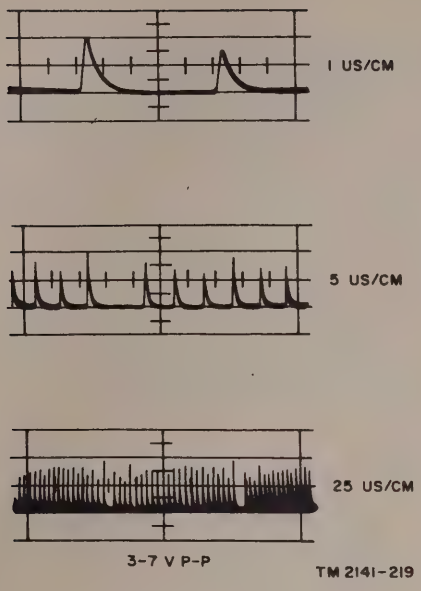


Figure 67. Wave form at multiplexer MODEM CHAN PULSES test point.

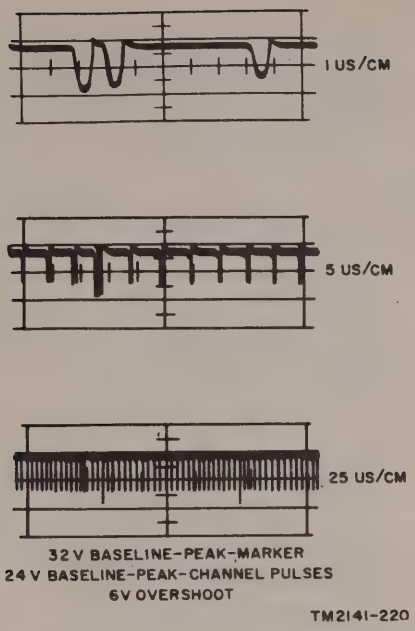


Figure 68. Wave form at MIXED PULSE TRAIN test point.

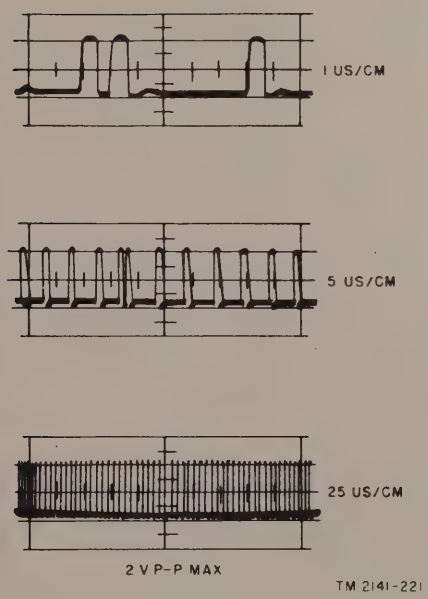


Figure 69. Wave form at multiplexer PULSE TRAIN OUTPUT test point.

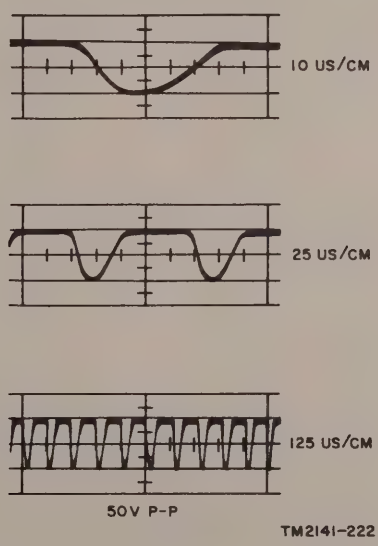


Figure 70. Wave form at pin 8 (plate) of V1 (multiplexer).

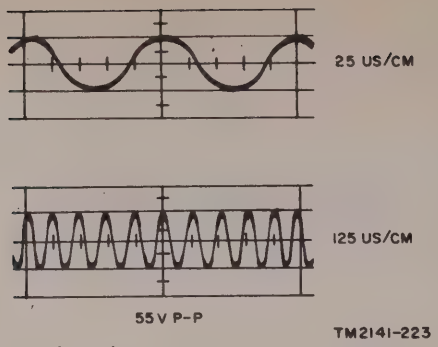


Figure 71. Wave form at pin 5 (plate) of V2 (multiplexer).

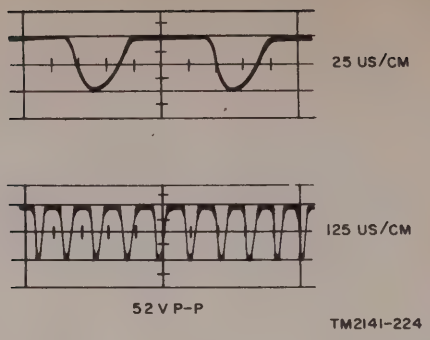


Figure 72. Wave form at pin 5 (plate) of V3 (multiplexer).

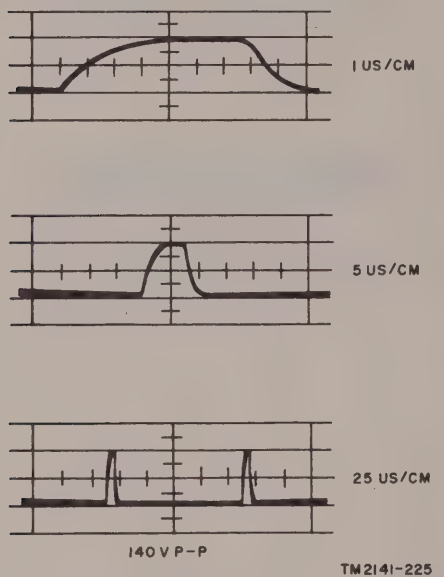


Figure 73. Wave form at pin 6 (plate) of V4B (multiplexer).

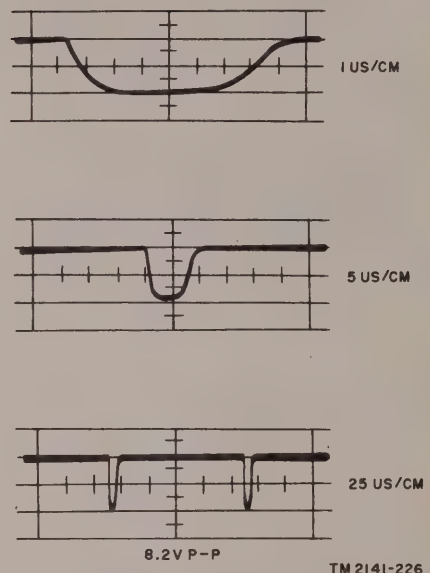


Figure 74. Wave form at pin 2 (plate) of V5A (multiplexer).

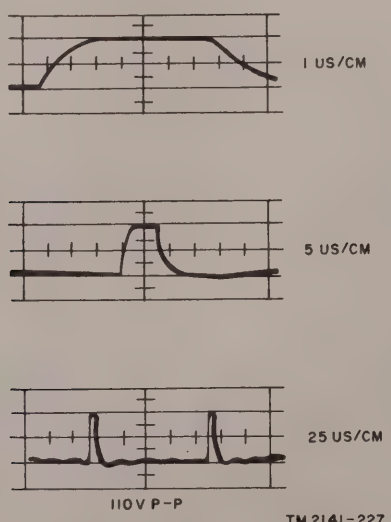


Figure 75. Wave form at pin 7 (plate) of V5B and pin 5 (cathode) of V6 (multiplexer).

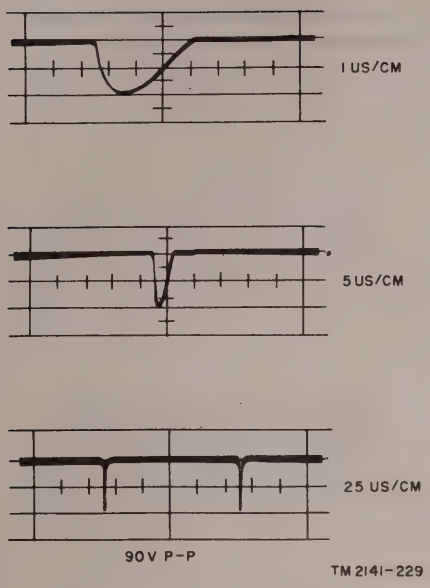


Figure 76. Wave form at pin 1 (plate) of V7A (multiplexer).

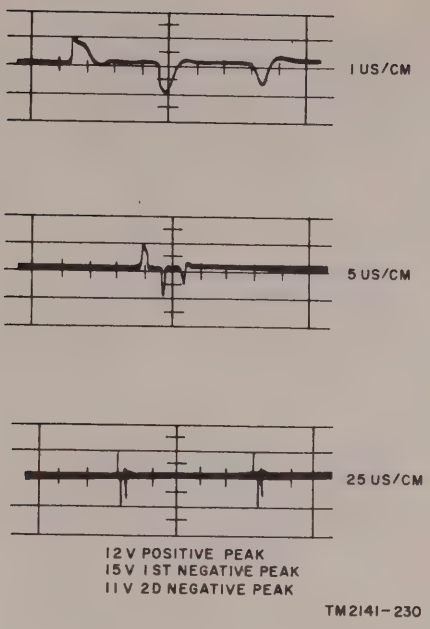


Figure 77. Wave form at pin 6 (plate) of V7B (multiplexer).

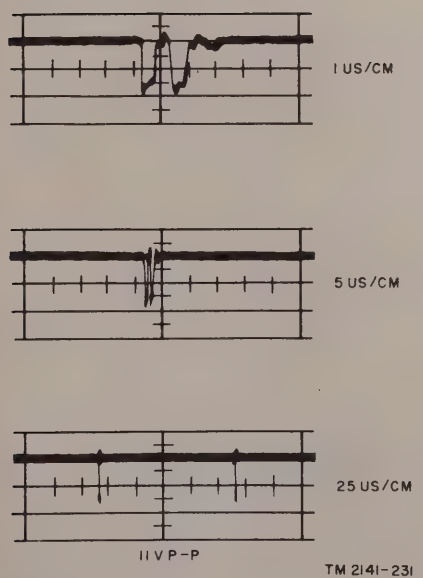


Figure 78. Wave form at pin 6 (plate) of V8A (multiplexer).

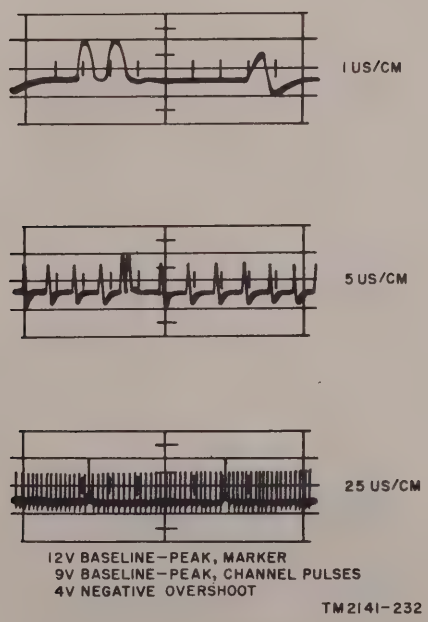


Figure 79, Wave form at pin 1 (plate) of V8B (multiplexer).

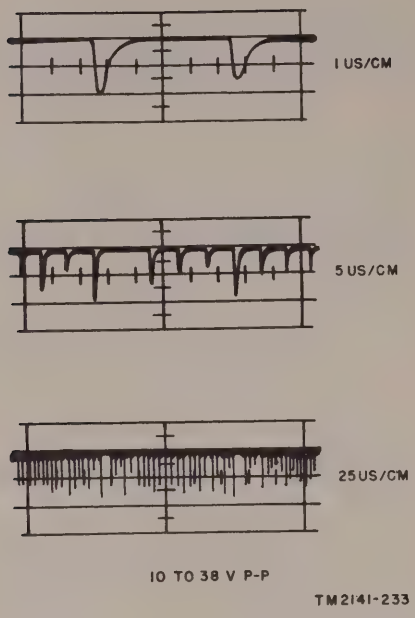


Figure 80. Wave form at pin 1 (plate) of V9A (multiplexer).

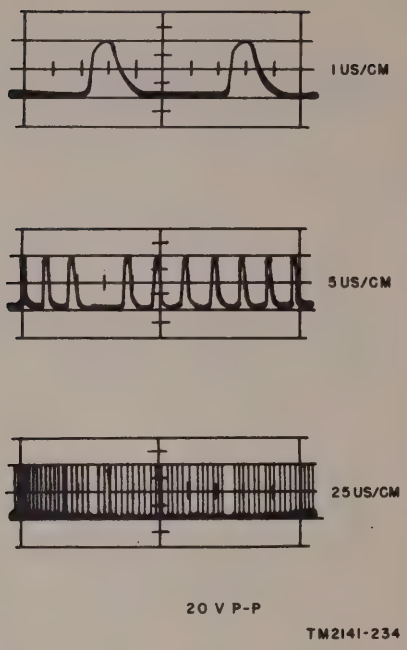


Figure 81. Wave form at pin 6 (plate) of V9B (multiplexer).

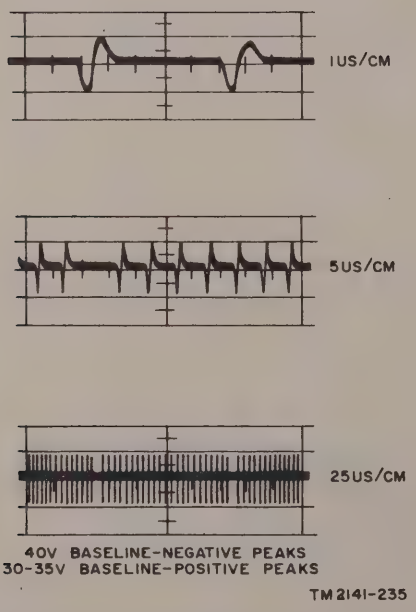


Figure 82. Wave form at pin 1 (plate) of V10A (multiplexer).

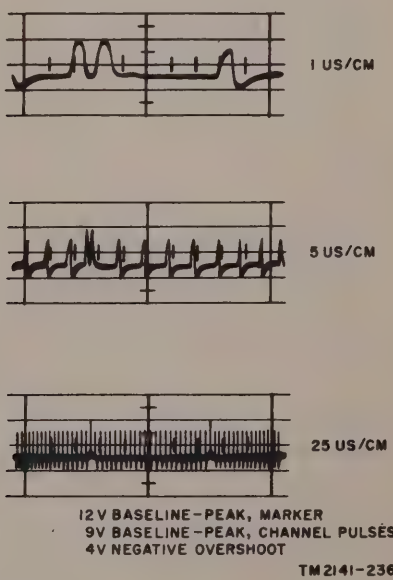


Figure 83. Wave form at pin 6 (plate) of V10B (multiplexer).

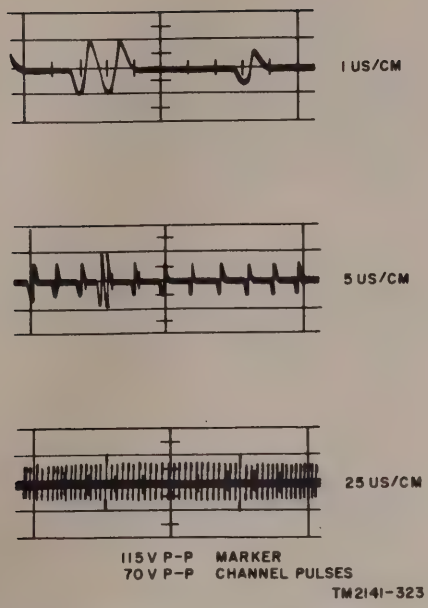


Figure 84. Wave form at pin 5 (plate) of V11 (multiplexer).

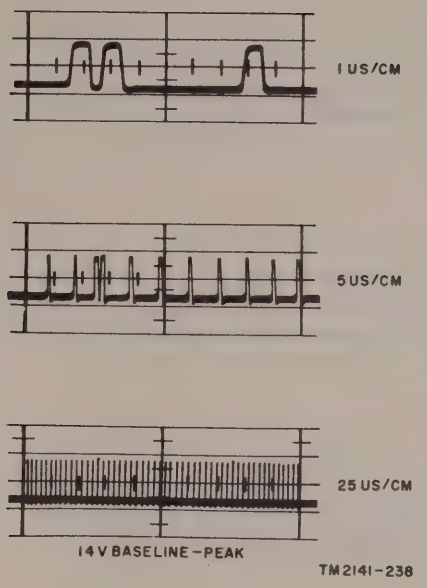


Figure 85. Wave form at pin 8 (plate) of V12 (multiplexer).

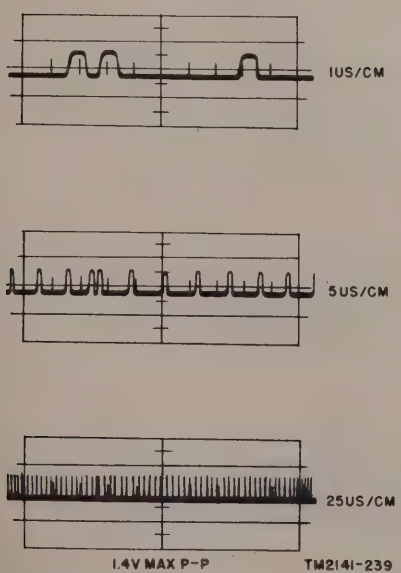


Figure 86. Wave form at pin 5 (cathode) of V13 (multiplexer).

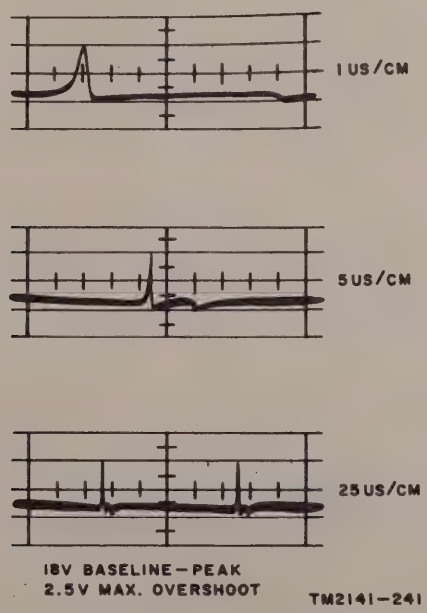


Figure 87. Wave form at modem PPM test point.

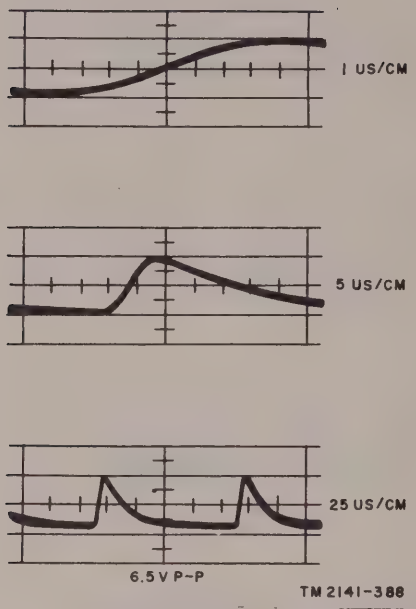


Figure 88. Wave form at pin 1 (plate) of V1A (modem).

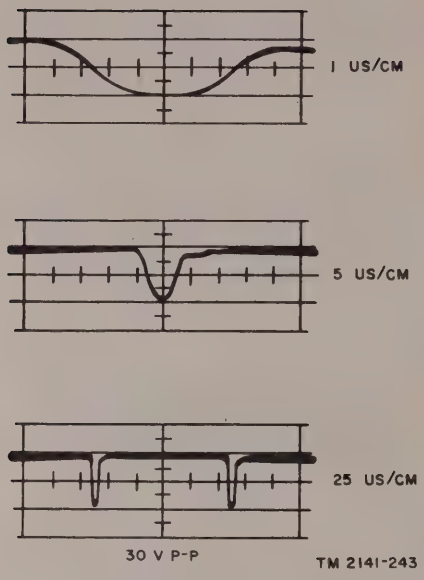


Figure 89. Wave form at pin 6 (plate) of V1B (modem).

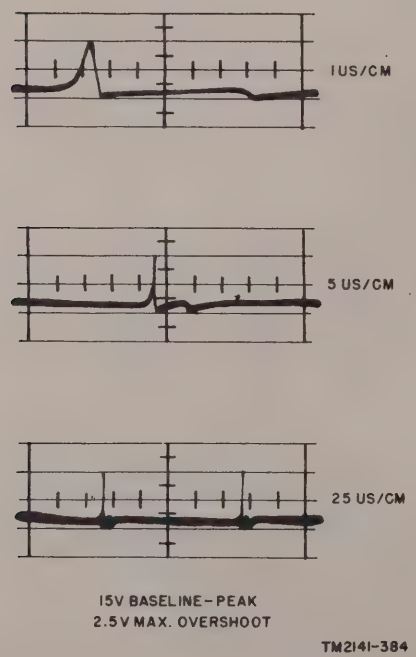


Figure 90. Wave form at pin 1 (plate) of V2 (modem).

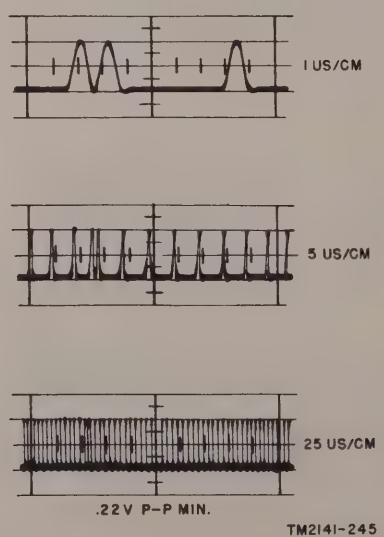


Figure 91. Wave form at demultiplexer PULSE TRAIN INPUT test point.

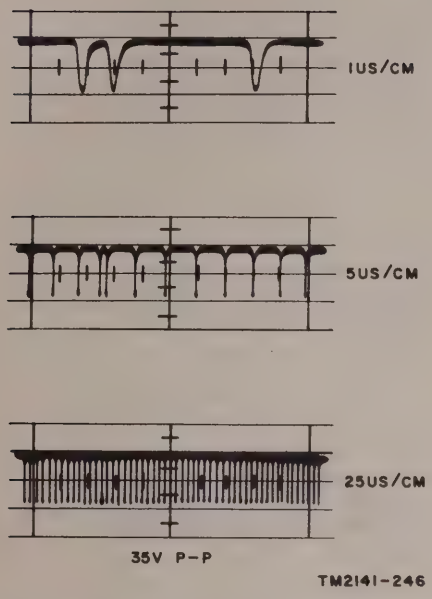


Figure 92. Wave form at demultiplexer MODEM PULSE TRAIN test point, and pins 2 and 5 of V21.

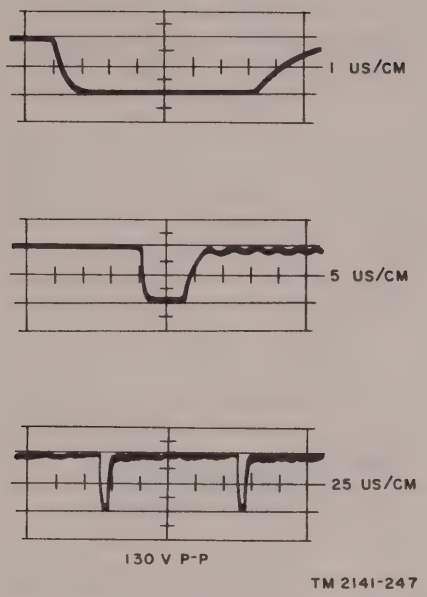


Figure 93. Wave form at pin 8 (plate) of V25 and demultiplexer DEMTPX GATE test point.

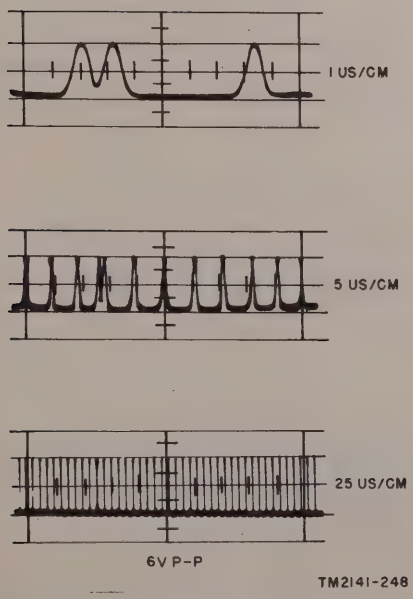


Figure 94. Wave form at pin 8 (plate) of V15 (demultiplexer).

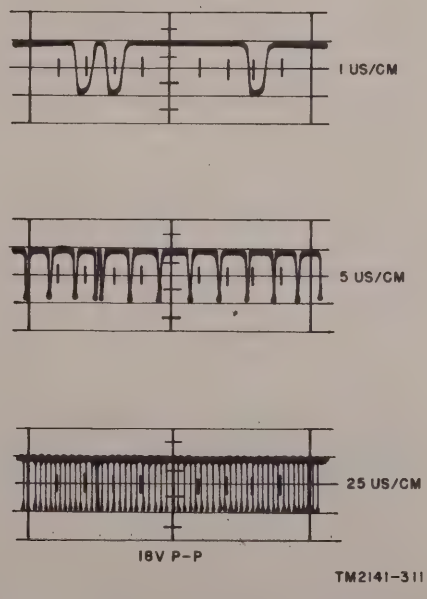


Figure 95. Wave form at pin 5 (plate) of V16 (demultiplexer).

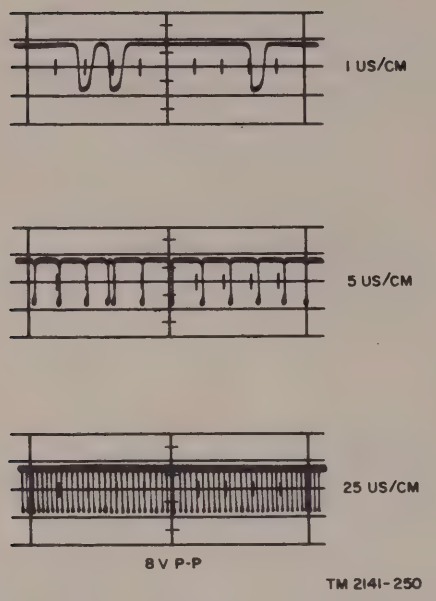


Figure 96. Wave form at pin 7 (plate) of V17 (demultiplexer).

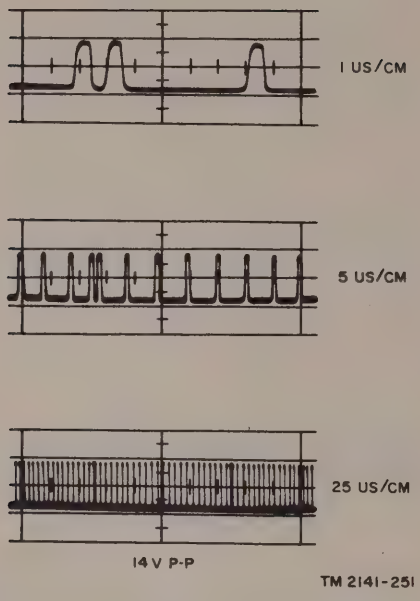


Figure 97. Wave form at pin 5 (plate) of V18 (demultiplexer).

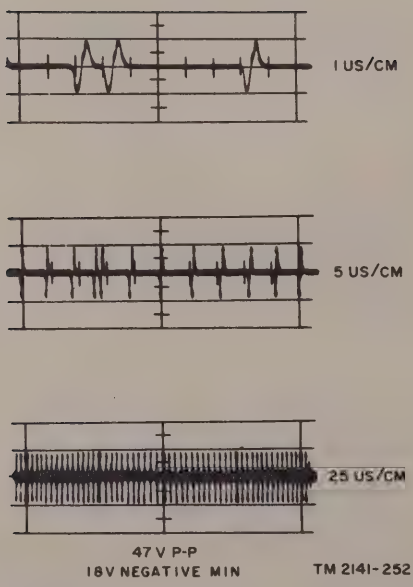


Figure 98. Wave form at pin 5 (plate) of V19 (demultiplexer).

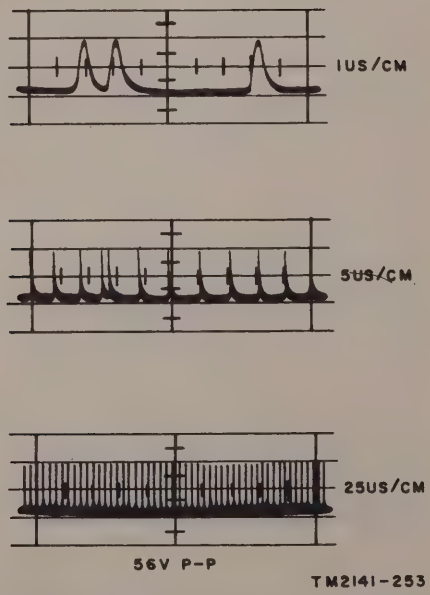


Figure 99. Wave form at pin 8 (plate) of V20 (demultiplexer).

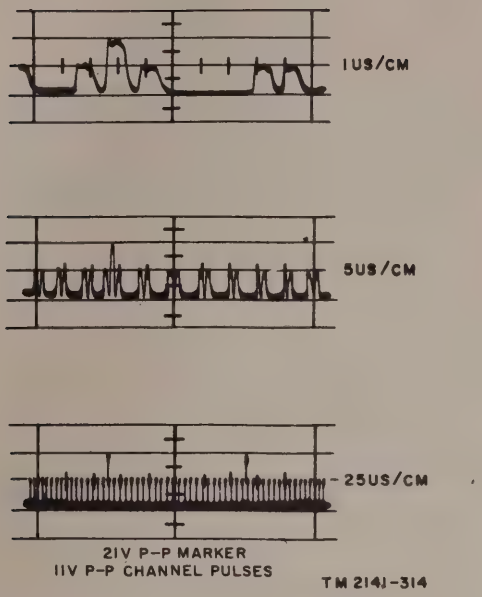


Figure 100. Wave form at pin 8 (plate) of V22 (demultiplexer).

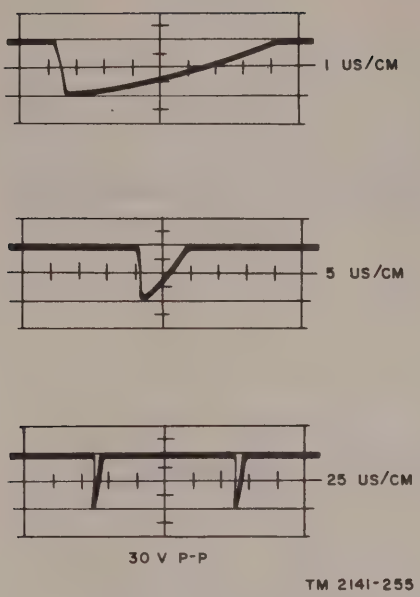


Figure 101. Wave form at pin 5 (plate) of V23 (demultiplexer).

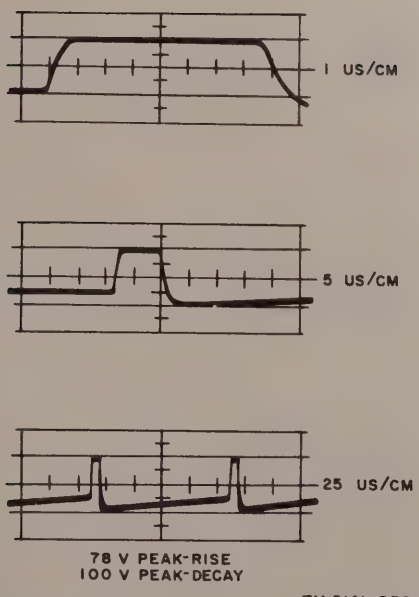


Figure 102. Wave form at pin 5 (plate) of V24 (demultiplexer).

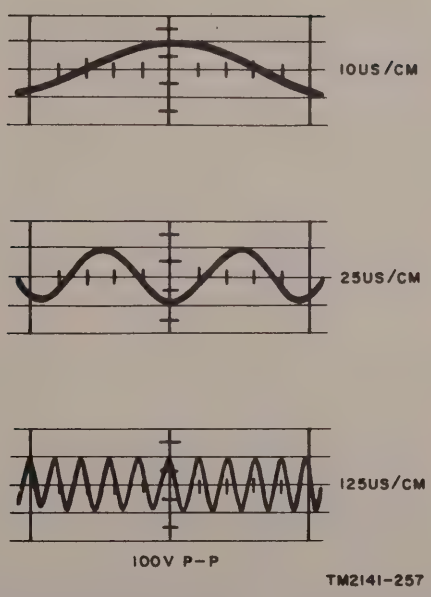


Figure 103. Wave form at pin 1 (plate) of V26 and V27A (demultiplexer).

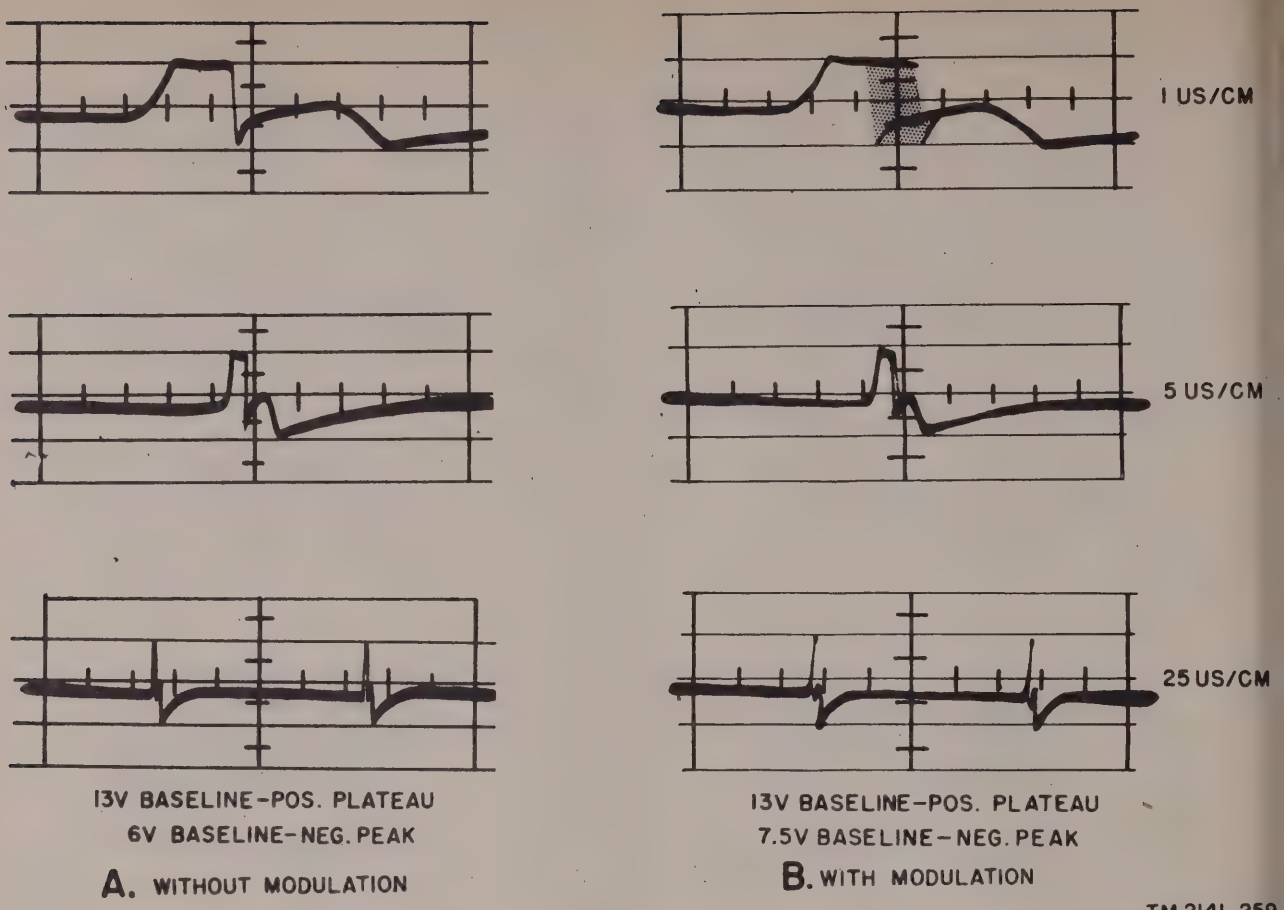


Figure 104. Wave form at modem PWM test point.

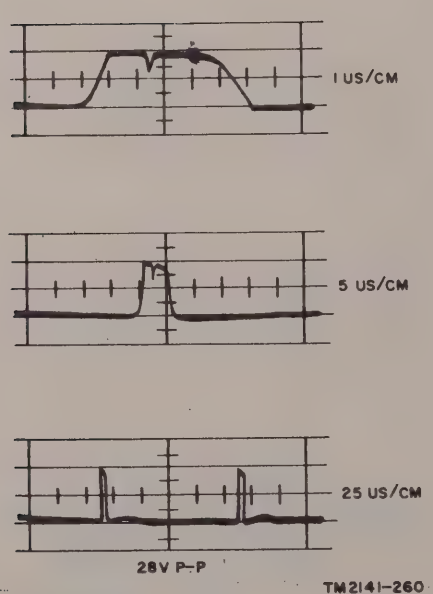


Figure 105. Wave form at pin 1 (plate) of V3A (modem).

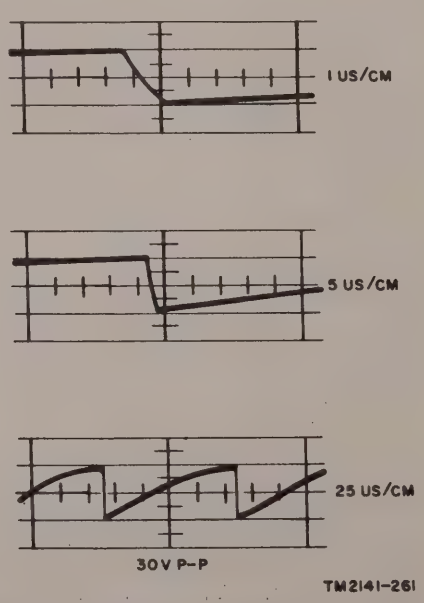


Figure 106. Wave form at pin 1 (plate) of V4A (modem).

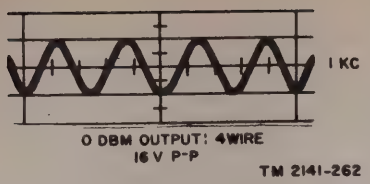


Figure 107. Wave form at pin 6 (plate) of V4B (modem).

118. Control Monitor Checks

Note. The following tests can be performed only when the equipment is connected into a system or when two multiplexers are connected back to back.

a. Switching Functions. Check the switching functions as follows:

(1) Turn on the audio test set and set the SEND-DBM control for a —4-dbm output for four-wire, or at a —3-dbm output for two-wire connection.

(2) Press the SEND button on the control monitor.

(3) Turn the channel 1 modem switch to the SR position, channel 1 should be modulated ±.5 microsecond. Check this with the oscilloscope (par. 49).

(4) Place the modem selector switch in the SL position. The channel pulse should not be modulated and a level of —4 dbm should be present on the REC line terminals (when terminated in 600 ohms).

(5) Perform the procedure described in (3) and (4) above for the remaining modems.

(6) Press the REC button on the control monitor.

(7) Have the other terminal modulate each channel *one at a time.* Turn the modem switch of each respective channel in the terminal being tested to the RR position, and adjust the OUTPUT AUDIO GAIN control on the modem until the audio test set indicated 0-dbm output for four-wire operation, or —3 dbm for two-wire operation.

(8) Connect a level of —4 dbm on the line to each 4W SEND terminal, with the modem switch in the RL position. The audio test set should indicate —4 dbm and the channel pulse should not be modulated.

b. Telephone Circuit.

(1) Depress the control monitor NORMAL button at the east and west terminals.

(2) Place channel 1 of both terminals in two-wire operation.

(3) Press the RING switch on the control monitor panel of the east terminal. The RING bell and the bell at the west terminal should ring.

(4) Press the RING switch on the control monitor panel of the west terminal. The RING bell and the bell at the east terminal should ring.

(5) It should be possible to talk between the two handsets over channel 1.

(6) At both terminals, press the TEL SET control monitor panel switch.

(7) At both terminals, place channel 2 in two-wire operation. It should be possible to talk between the handsets over channel 2 by placing channel 2 of each unit in either the RR or SR position.

(8) At both terminals, return channels 1 and 2 to four-wire operation and depress the NORMAL button on the control monitor.

119. Ringing Circuit Checks

Check each circuit for ringing as follows:

a. Connect Telephone EE–8–B to the 4W REC terminal of the local terminal under test. Have the operator at the distant terminal connect a field telephone to the 4W SEND terminals.

b. Have the terminal operator at the distant terminal crank the field telephone connected to the 4W SEND terminals.

c. The field telephone connected to the 4W REC terminals at the local terminal should ring.

d. Alternately, the switchboards at the two terminals should ring each other, on each channel in turn.

120. Remote Keying Circuit Tests

a. Normal Operation. The tests described in paragraphs 118 and 119 are a good indication of the satisfactory operation of the remote keying units in NORMAL OPERATION. If channels 1 and 2 have passed the tests, the

remote keying units should be working properly in the NORMAL OPERATION position.

b. Remote Keying Operation.

(1) Have the operator at the distant terminal place the two remote keying units in the REMOTE KEYING OPERATION position.

(2) Place the two remote keying units at the local terminal in the REMOTE KEYING OPERATION position.

(3) Channels 1 and 2 should be blanked out at both units. There should be an open circuit between E11 and E12 (remote keying unit out) and also between E1 and E2 (remote keying unit out) of the multiplexer subassembly. Use Multimeter TS–352/U, check continuity to be sure that this open exists.

(4) Place a short circuit across E13 and E14 (remote keying unit in) of the terminal being tested. This should put channel 1 pulse back into the pulse train of the terminal being tested. Place Multimeter TS–352/U across terminals E11 and E12 of the local terminals. The meter should indicate an open circuit.

(5) Place a short circuit across E3 and E4 (remote keying unit in) of the terminal being tested. This should put channel 2 back into the pulse train. There should still be an open circuit across E1 and E2.

(6) Have the operator at the distant terminal put a short circuit across E3 and E4. Place Multimeter TS–352/U across E1 and E2 on the terminal being tested. The multimeter should indicate continuity.

Note. If the conditions described above do not exist, trouble shooting at a field maintenance level is necessary (par. 324, 326, or 332).

121. Signal-to-noise and Cross-talk Measurements

Note. It is assumed that the demodulator gain controls have all been set for 0-dbm output with —4-dbm modulated input on a four-wire connection. Be sure that none of the far terminals are being modulated.

a. Signal-to-noise. The signal-to-noise ratio should be checked as follows:

(1) Depress the REC button on the control monitor.

(2) Turn each modem switch to the RR position, one at a time, and read the meter on the audio test set. This is a noise reading that should be not greater than —55 dbm over a normally operating single hop rf system.

b. Cross-talk Measurements. The following cross-talk measurements should be made: all forward adjacent channels (for example, 1 into 2, 2 into 3, etc), channel 1 into all other channels, and channel 23 into all other channels. The cross-talk measurements are as follows:

(1) At the distant terminal, set the audio test set for —4-dbm output; place the control monitor panel switch in the SEND position and the modem switch of the channel to be modulated in the SR position.

(2) On the terminal being tested, place the control monitor switch in the REC position and the modem switch of the channel on which cross talk is to be measured in the RR position. The cross-talk reading on the audio test set meter should be not greater than —50 dbm.

(3) After all the cross-talk readings have been taken, reverse the steps given in *a* and *b* above with respect to the terminals (for example, modulate the channels of the terminal to be tested and read the cross talk on the far terminals).

122. Operational Checks, 45-channel

The tests and procedures described in paragraphs 114 through 121 also apply to multiplexer sets being used for 45-channel operation. When a multiplexer is being used for 45-channel operation, complete the test of the unit by the tests outlined below.

a. Connect the two terminals for 45-channel operation (par. 38) with the test terminal in *master* operation.

b. Place the oscilloscope probe in the MASTER OUTPUT TO RF test point of the test terminal.

c. The wave form on the oscilloscope should be a 45-channel pulse train as shown in figure 108.

d. Place the oscilloscope probe in the PULSE TRAIN OUTPUT test point of the common unit being tested.

e. The wave form displayed on the oscilloscope should be a positive pulse train as shown in figure 109.

f. Reconnect the two terminals with the terminal to be tested in *master* operation.

g. Check to see that there is a 45-channel pulse train wave form of the common unit MASTER OUTPUT TO RF test point of the terminal being tested similar to that shown in figure 108.

h. Vary the 45 CHANNEL PHASE CONTROL, R3, to be sure that the negative and positive pulse trains can be shifted with relation to each other.

123. Power Supplies

a. B+ Power Supply, Power Supply PP–691/G. There are no tubes in the power supply. If the input voltage is normal, lack of output voltage indicates a need for servicing. Servicing of this unit should be done by field maintenance personnel only (par. 340 through 344).

Caution: The failure of selenium rectifiers in Power Supply PP–691/G can result in liberation of poisonous fumes and deposits of poisonous selenium compounds. If a rectifier arcs over, the odor is strong. Provide adequate ventilation immediately.

b. Filament Supply, Multiplexer Subassembly MX–1442/TC. There are no tubes in the filament supply. Servicing instructions are described in paragraphs 334 through 339.

c. Voltage Regulator CN–236/G. If the input voltage is normal, lack of output voltage or fluctuation of the output voltage indicates a need for servicing. Adjust the SENSITIVITY control as indicated in paragraph 43*b*. If the voltage still fluctuates, check tubes V1 and V2. If the trouble cannot be corrected, refer to paragraphs 390 through 395.

124. Oscilloscope OS–25/G, Performance Check List

Note. Oscilloscope trouble is completely independent of the remainder of the equipment and usually cannot effect the operation of the rest of the equipment.

Voltage test points +450V and +225V (fig. 110) at the rear of the chassis should be

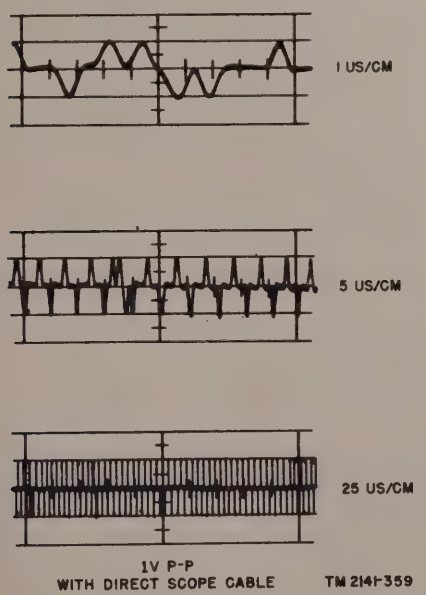


Figure 108. Wave form at MASTER OUTPUT TO RF test points.

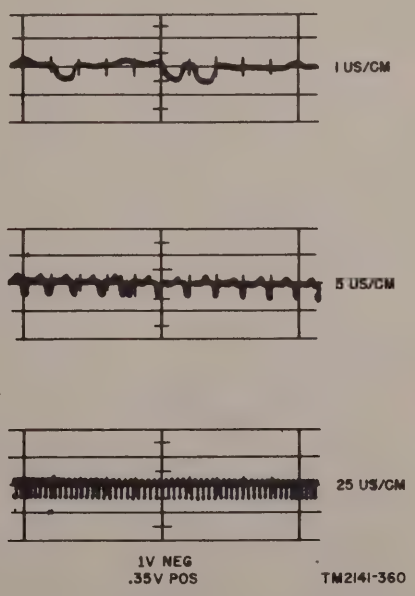


Figure 109. Wave form at PULSE TRAIN OUTPUT test point 45-channel operation, slave terminal.

checked with a vtvm. Use Electronic Multimeter TS–505/U or equivalent. If these voltages are not correct, vary +225V ADJ control R27 and +450V ADJ control R16 at the rear of the oscilloscope chassis. If the voltages are present and correct, trouble shooting by use of the equipment performance check list is indicated. If the corrective measures indicated in the equipment performance check list do not yield results, refer to paragraph 127*c*(5) and if replacing tubes as indicated from the symptoms do not yield results, trouble shooting at a field maintenance level (par. 351 through 356) is required.

Note. The controls should turn smoothly, and the image on the screen should move slowly without jumping.

	Item No.	Item or control	Action, condition, or position	Normal indication	Corrective measure
PREPARATORY	1	ON-OFF switch.	OFF.		
	2	COARSE.	5000.		
	3	FINE.	10.		
	4	INTENSITY.	Clockwise.		
	5	HOR POSITION.	Middle of range.		
	6	VERT POSITION.	Middle of range.		
	7	TIMING PIP PHASE.	OFF.		
	8	CAL VOLTAGE.	5.		
	9	VERT ATTEN.	CAL.		
	10	VERT GAIN.	Clockwise.		
	11	TRIGGER.	Counterclockwise.		
	12	STAB.	Counterclockwise.		
OPERATION	13	ON-OFF switch.	Set to ON.	POWER on indicator lamp glows, blower operates.	Check input power source, indicator lamp, and blower. Check fuses. Check V1 through V7.
	14	STAB control.	Turn control clockwise	Sweep appears.	Refer to paragraph 127*c* (4).
			Turn control counterclockwise.	Sweep disappears.	Refer to paragraph 127*c* (4).
	15	TRIGGER control.	Turn control clockwise.	Stable image of a clipped sine wave appears (fig. 37).	Refer to paragraph 127*c* (4).
	16	HOR POSITION.	Very control.	Position of presentation on screen moves to left or right.	Refer to paragraph 127*c* (4).
	17	VERT POSITION.	Very control.	Position of presentation on screen moves up or down.	Refer to paragraph 127*c* (4).
	18	INTENSITY.	Turn control counterclockwise.	Image is blanked out.	Refer to paragraph 127*c* (4).
	19	INTENSITY.	Turn control clockwise.	Image appears and brightness increases.	Refer to paragraph 127*c* (4).
	20	FOCUS, ASTIG, and INTENSITY.	Vary controls until a sharply focused trace is obtained.	Sharply focused trace.	Check V1, V2, and probe.
	21	VERT GAIN.	Turn control clockwise.	Vertical size of image increases.	Check V12 through V15, and V2 (par. 127*c*(4)).
	22	VERT GAIN.	Turn control counterclockwise.	Vertical size of image decreases.	Check VERT GAIN control.
STOP	23	ON-OFF switch.	Set to OFF.	POWER ON indicator light goes off, motor stops.	Check switch.

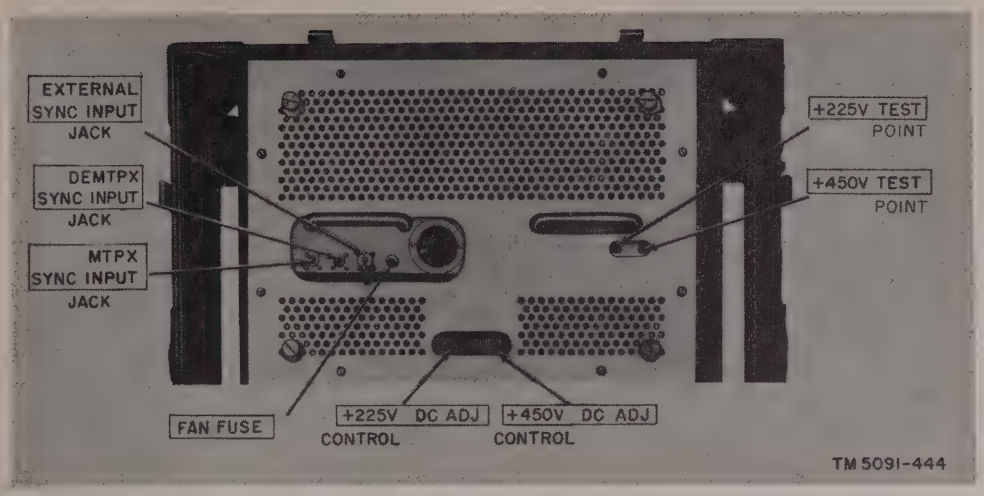


Figure 110. Oscilloscope test point.

125. Audio Test Set TS–762/TC, Trouble-Shooting Procedure

a. Audio Test Set TS–762/TC is completely independent of the remainder of the multiplexer set or multiplexer group and usually cannot effect the operation of the rest of the set.

b. Failure of the power system will be apparent if the POWER ON indicator lamp does not light. This is usually caused by a blown fuse. No harm is done if the fuse is replaced and the power switch turned on again. However, if the fuse blows again, the trouble can be serious and the fuse should not again be replaced without first localizing and correcting the trouble. The information given in the *Action, condition, or position* column consists of calibrating the audio test set and the information given in the *Normal indication* column includes the indications of a calibrated audio test set. If it is impossible to calibrate the audio test set or erroneous indications are given, follow the corrective measures recommended in the *Corrective measure* column. If the set is completely inoperative or if the recommended corrective measures do not yield results, trouble shooting by an experienced repairman is necessary.

126. Audio Test Set TS–762/TC, Performance Check List

	Item No.	Item or control	Action, condition, or position	Normal indication	Corrective measure
START	1	ON-OFF switch.	Set to ON position.	POWER ON indicator lamp glows.	Check fuse F1 (par. 125*b*).
OPERATION	2	Send-calibrate circuit.	Adjust as indicated in paragraph 46.	As indicated in paragraph 46.	Check lamp I 1, tubes V1 through V4, and rectifier V8. Replace if defective.
	3	Receive-calibrate circuit.	Adjust as indicated in paragraph 46.	As indicated in paragraph 46.	Check tubes V6 and V7. See note below.
	4	Meter circuit.	Items 1 and 2 above.	Meter indications.	Check tube V5.
STOP	5	ON-OFF switch.	Set to OFF position.	POWER ON indicator lamp is extinguished.	Check switch S2.

Note. If the incoming tone can be measured, but the receive-calibrate circuit cannot be adjusted, repeat the procedure given in item 2 of the check list. If the trouble cannot be corrected, refer to paragraphs 362 through 366.

127. Tube Trouble-shooting Data

a. Tube Checking. Tube failures are responsible for a large percentage of the faults that occur in the equipment. There are, however, too many tubes in this set for a trouble shooter to attempt to find a fault by indiscriminate tube changing. Do not resort to tube changing until the fault has been traced to a particular stage. When placing a new tube in a circuit, note the position of all controls before making any changes. If turning the controls with the new tube in the circuit does not correct the abnormal condition, return the controls to their original positions and put the old tube back in the circuit, unless a tube test shows that the original tube was bad. Do not change the tubes indiscriminately because the spare box will become full of tubes, the exact age and condition of which will be uncertain.

b. Use of Tube Tester. Electron Tube Test Set TV–7/U is used to check for shorted elements, emission, and mutual conductance of receiving type tubes. The tube tester will not test the performance of high-voltage tubes or rectifiers or some special tubes. Tube testers are useful, however, for checking receiving tubes. Results obtained from a tube tester are not always conclusive, because the conditions are not the same as those under which the tube operates in this set. Therefore, the final test of a tube must be its replacement with a tube which is known to be good. It is quicker and more reliable to replace a suspected tube with a good one than to check it with the tube tester. TM 11–5083 contains operating and maintenance instructions for Electron Tube Test Set TV–7/U.

c. Tube Trouble-shooting Charts.

(1) *Multiplexer TD–60/TCC–13* (fig. 111).

Item No.	Symptoms	Tubes
	Multiplexer	
1	No pulse train.	V2 through V5 and V11 through V13.
2	No pulse train, but synchronizing voltage to oscilloscope present.	V11 through V13.
3	Marker missing, otherwise normal.	V7, V8.
4	All channel pulses missing, marker present.	V9, V10.
5	Marker gate abnormally high and unlimited.	V14.
6	In master unit, when in 45-channel operation, slave fails although master operates correctly.	V1 in master.
7	In slave unit, slave fails although master operates correctly.	V3 through V6 and V11 through V13.
8	Abnormally high pulse train output.	V14.
9	No 8-kc oscillator wave form.	V2.
10	Correct wave form at 8-kc test point, but no wave form at MTPX GATE test point.	V3 through V6.
	Demultiplexer	
11	Wave form present at MODEMS PULSE TRAIN test point, but no wave form at DEMTPX GATE test point.	V22 through V25.
12	No modem pulse train.	V15 through V21.
13	Operation normal, but alarm rings.	V26, V27.
14	Cannot ring.	V28, V29.

(2) *Telephone Modem MD–179/TC* (fig. 113).

Item No.	Symptoms	Tubes
1	Cannot modulate a channel.	V1 in that channel.
2	Low modulation sensitivity.	CR1, CR2, V1.
3	No channel pulse.	V1, V2.
4	Improper channel pulse.	V1, V3, CR3.
5	Cannot receive audio over a channel although oscilloscope shows modulated pulse present.	V3, V4.
6	Insufficient audio gain.	V4.
7	Cannot signal.	V3, V5.
8	Continuous signaling.	V3, V5.
9	Improper pwm wave form.	V3, CR4, CR5.
10	Excessive distortion in individual channel.	CR1, CR2, V1, V4.

(3) *Voltage Regulator CN–236/G* (fig. 114)

Item No.	Symptoms	Tubes
	Lack of regulation; motor does not operate in both directions.	V1, V2.

(4) *Oscilloscope OS–25/G* (fig. 115 through 117).

Item No.	Symptoms	Tubes
1	Screen blank when horizontal control is turned fully clockwise.	V32 (crt).
2	Vertical deflection, but no horizontal deflection.	V15 through V27, 10 neon coupling tubes, and V1 and V2.
3	Horizontal deflection, but no vertical deflection.	V12 through V15, V2 and probe.
4	Cannot focus display.	V1, V2, and probe.
5	Cannot position horizontally.	V1 through V11, V25, V26, 10 neons.
6	Cannot position vertically.	V6 through V19.
7	Cannot stop (synchronize) display.	V16 through V19.
8	Cannot phase display with sweep-phase control despite normal synchronizing voltage input from multiplexer.	V16 through V19.
9	No timing pip markers.	V28 through V31.
10	Incorrect spacing between markers.	V28 through V31.
11	Extreme vertical distortion or clipping.	V12 through V15.
12	Oscilloscope repeatedly blows fuse F1.	V1 through V7.
13	Timing pips distorted.	V30, V31.
14	No blanking of retrace.	V19.
15	Weak or dim pattern.	V1, V2, V32.

(5) *Audio Test Set TS–762/TC* (fig. 118).

Item No.	Symptoms	Tubes
1	No 1,000-cycle output.	V1 through V4.
2	Meter M1 does not operate on receive.	V6 and V7.
3	Set completely inoperative.	V8.

128. Tube Replacement

The following table identifies all the tubes used throughout the multiplexer set by component, reference symbol, tube type, and function. When changing tubes, change them one at a time. If tube substitution does not correct the trouble, reinsert the original tube in the original socket. *Be sure that the correct tube is placed in its proper socket* (fig. 111 through 118).

a. Multiplexer TD–60/TCC–13.

Tube symbol	Tube type	Function
V1	6AG7	Sync output.
V2	6AG5	8-kc oscillator.
V3	6AG5	8-kc amplifier.
V4	12AT7WA	Shaper and sync output.
V5	5726/6AL5W	Diode clipper
V6	6AG7	Power amplifier.
V7	12AT7WA	Duotriode shapers.
V8	12AT7WA	Marker generator and amplifier.
V9	12AT7WA	Modem pulse amplifier.
V10	12AT7WA	Modem pulse amplifier.
V11	6AG5	Mixed train shaper.
V12	6AG7	Mixed train power amplifier.
V13	6AG7	Pulse train output.
V14	OB2	Voltage regulator.
V15	6AG7	Video amplifier.
V16	6AG5	Video amplifier.
V17	6AL5W	Detector clipper.
V18	6AG5	Pulse splicer amplifier.
V19	6AG5	Video shaper.
V20	6AG7	Pulse amplifier.
V21	6AS7	Power amplifier.
V22	6AG7	Marker separator.
V23	6AG5	Marker selector.
V24	6AG5	Gate shaper.
V25	6AG7	Gate amplifier.
V26	12AT7WA	Alarm.
V27	12AT7WA	8-kc amplifier and alarm control.
V28	OA3	Voltage regulator.
V29	OA3	Voltage regulator.

b. Telephone Modem MD–179/TC.

Tube symbol	Tube type	Function
V1	12AT7WA	Audio amplifier and ppm mod.
V2	12AT7WA	Clipper shaper and mixer.
V3	12AT7WA	Gate generator and pwm converter.
V4	12AT7WA	Clipper and audio output.
V5	12AT7WA	Dc amplifier and ringing relay control.

c. Voltage Regulator CN–236/G.

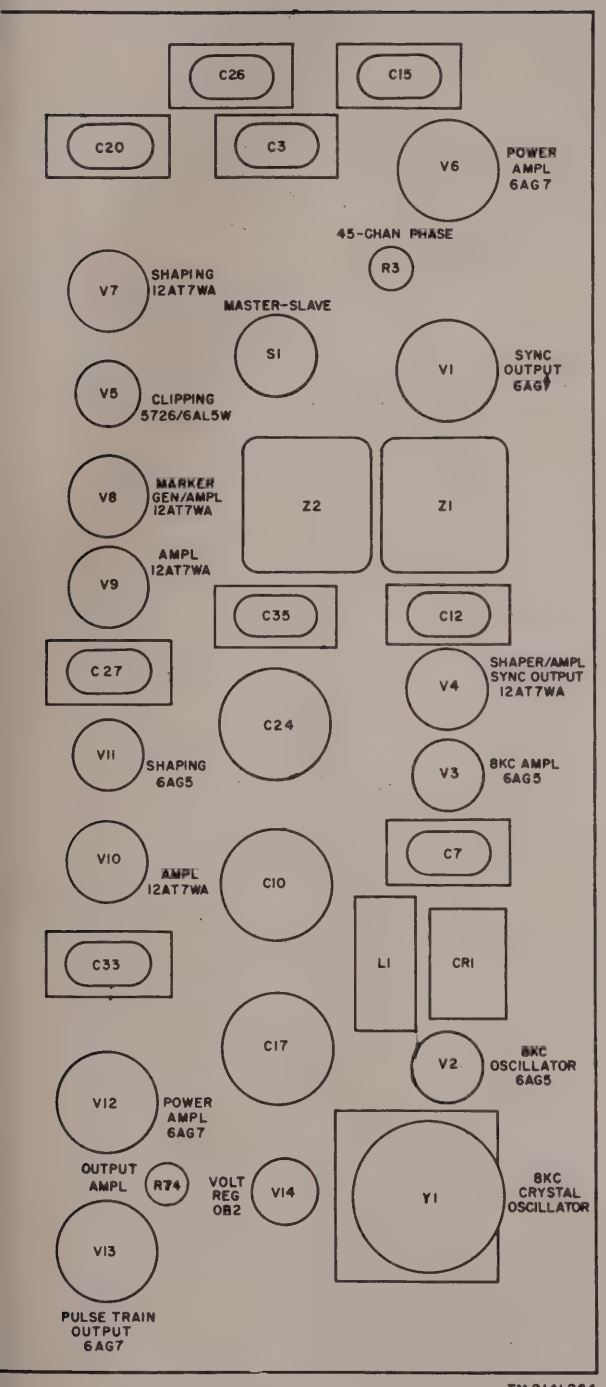
Tube symbol	Tube type	Function
V1	5727/2D21W	Motor drive.
V2	5727/2D21W	Motor drive.

d. Oscilloscope OS–25/G.

Tube symbol	Tube type	Function
V1	2X2A	+1,800-volt rectifier.
V2	2X2A	—1,500-volt rectifier.
V3	6X4W	+450-volt rectifier.
V4	6005/6AQ5W	+450-volt series regulator.
V5	6AG5	+450-volt regulating amplifier.
V6	5R4WGY	+225-volt rectifier.
V7	5R4WGY	+225-volt rectifier.
V8	6X4W	—140-volt rectifier.
V9	6AS7G	+225-volt series regulator.
V10	6AG5	+225-volt regulating amplifier.
V11	OA2	—140-volt regulator.
V12	6AG7	Vertical input amplifier.
V13	6AG7	Cathode follower.
V14	6AG7	Push-pull vertical output.
V15	6AG7	Push-pull vertical output.
V16	12AT7WA	8-kc and phase shift amplifier.
V17	6AG7	Phase splitter sync amplifier.
V18	6AG7	Sync amplifier.
V19	5726/6AL5W	Trigger coupler and blanking restorer.
V20	6AG7	Multivibrator.
V21	6AG7	Multivibrator.
V22	6AG7	Sawtooth sweep generator.
V23	6005/6AQ5W	Sweep control.
V24	5726/6AL5W	Horizontal output and dc restorer.
V25	6AU6	Push-pull horizontal output.
V26	6AU6	Push-pull horizontal output.
V27	12AT7WA	Crt blanking and unblanking buffer amplifier.
V28	12AT7WA	Timing pip phase amplifier.
V29	5726/6AL5W	Discriminator.
V30	12AT7WA	Reactance modulator and 192-kc oscillator.
V31	12AT7WA	192-kc amplifier and differentiating shaper.
V32	5CP1WA	Crt.

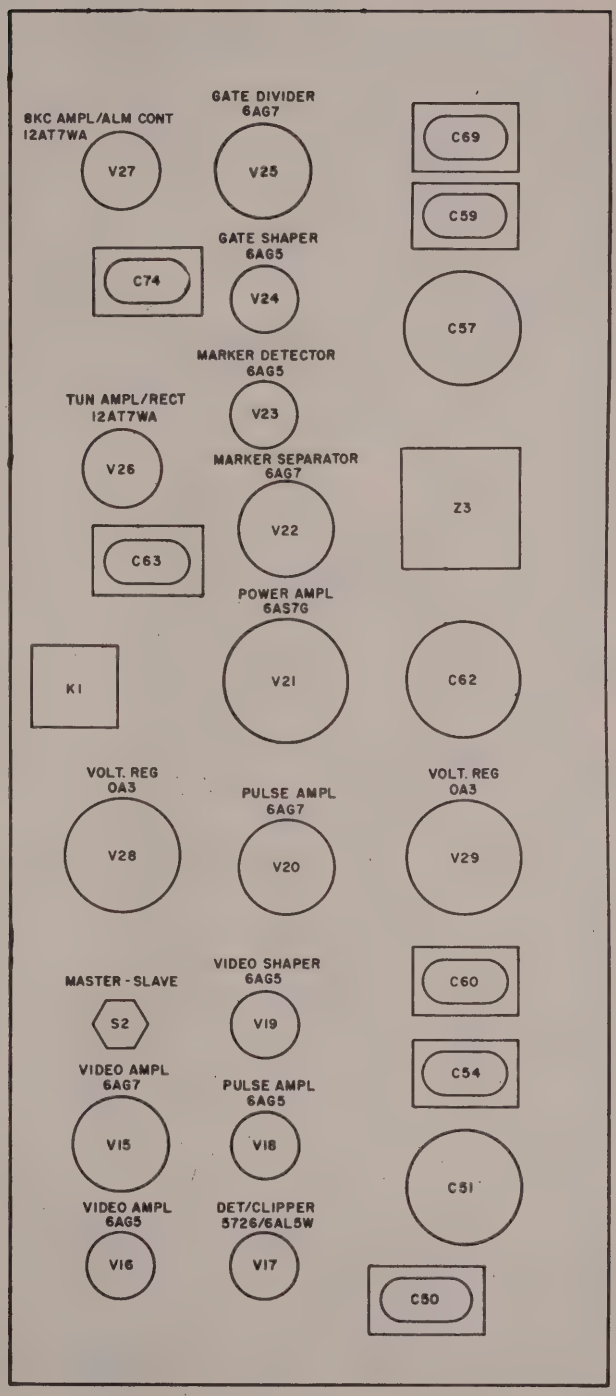
e. Audio Test Set TS–762/TC.

Tube symbol	Tube type	Function
V1	6AG5	Oscillator.
V2	6AG5	Amplifier.
V3	12AT7	Phase inverter.
V4	12AT7	Push-pull amplifier.
V5	12AT7	Limiter.
V6	12AT7	Amplifier.
V7	12AT7	Amplifier.
V8	5R4WGY	Rectifier.
V9	OA2	Voltage regulator.



TM 2141-264

Figure 111. Common unit multiplexer section, tube location diagram.



TM2141-283

Figure 112. Common unit demultiplexer section, tube location diagram.

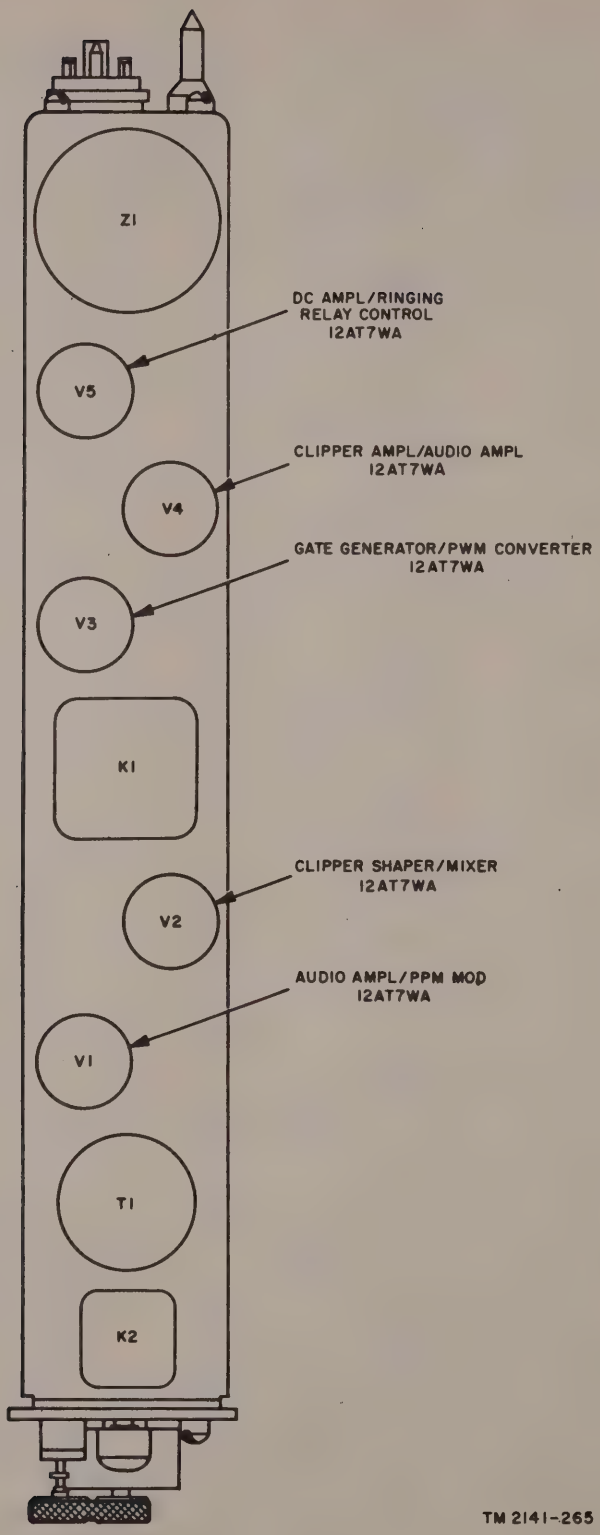


Figure 113. Modem tube location diagram.

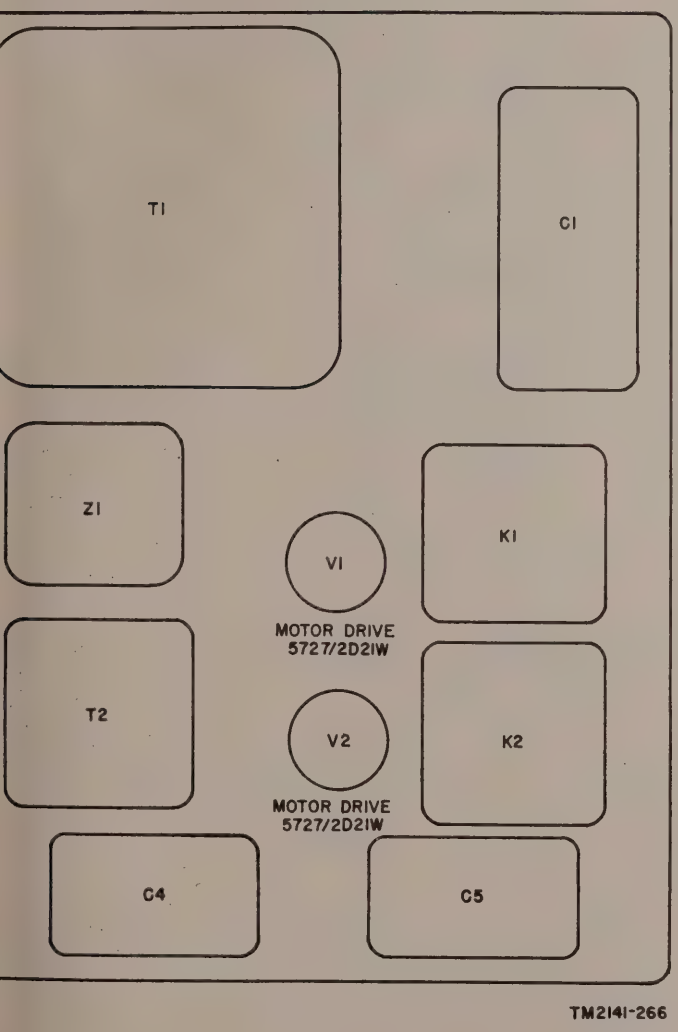


Figure 114. Voltage regulator, tube location diagram.

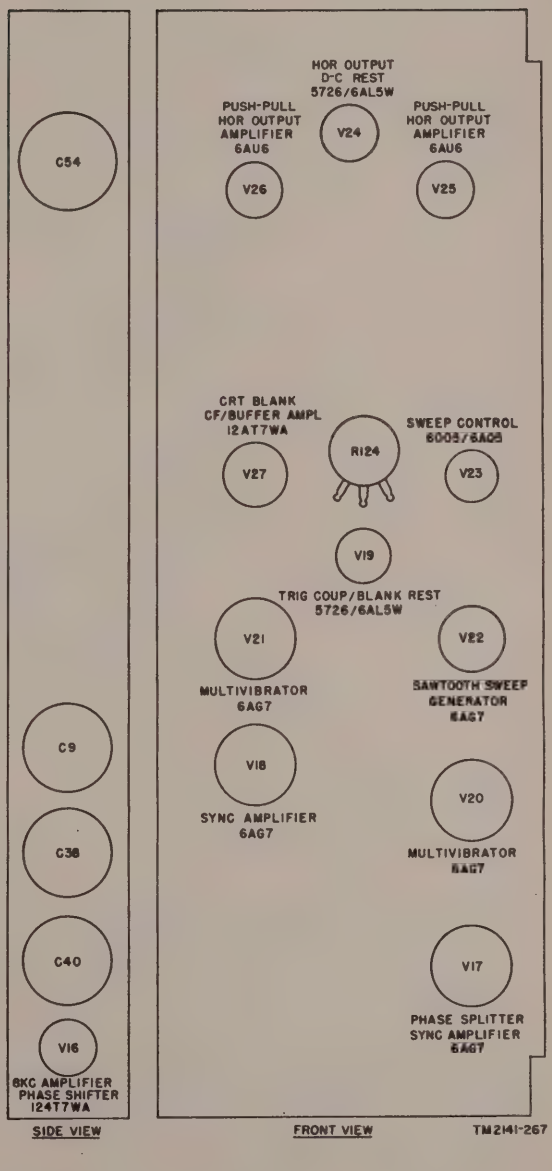


Figure 115. Oscilloscope, bottom right section, tube location diagram.

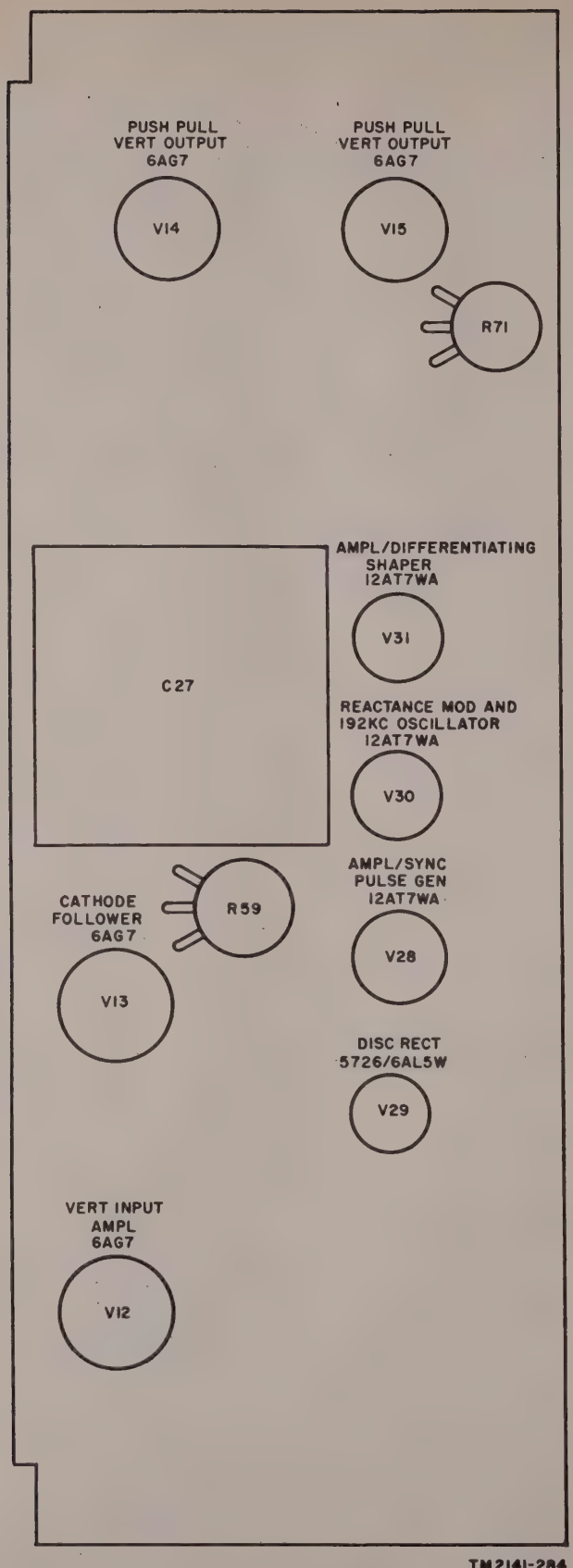


Figure 116. Oscilloscope, bottom left section, tube location diagram.

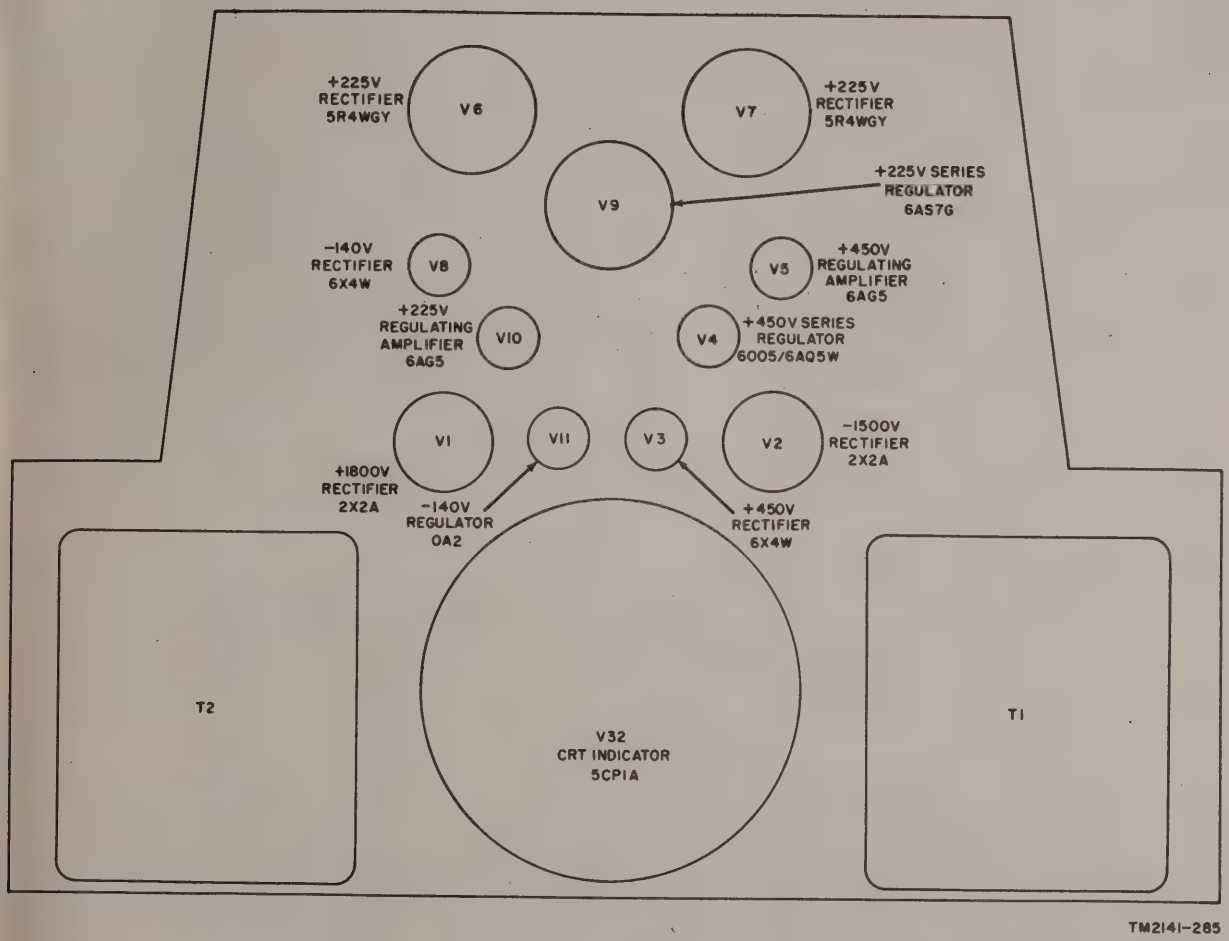


Figure 117. Oscilloscope, bottom center section, tube location diagram.

Section V. TROUBLE SHOOTING MULTIPLEXER GROUP AN/TCA-1 AND PULSE FORM RESTORER GROUP AN/TRA-10 AT ORGANIZATIONAL MAINTENANCE LEVEL

129. General

a. Trouble shooting the multiplexer group and pulse form restorer group at an organizational level is limited in scope by the tools, test equipment, and replaceable parts issued. Accordingly, trouble shooting is based on the performance of the equipment, visual inspection, and the use of the senses in determining such troubles as burned-out tubes, broken leads, and interpretation of the wave forms at the various test points. The majority of trouble can be found by comparison of wave forms (par. 116*c* and *d*) in conjunction with the oscilloscope probe.

b. Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10 are functionally identical, therefore, the trouble-shooting techniques and repair procedures are the same. Many components of the multiplexer and pulse form restorer are identical with those supplied with Multiplexer Group AN/TCC–13. Refer to the table below when trouble is encountered in the test equipment, power supply, filament supply, voltage regulator, or modems.

Component	Par. ref
Oscilloscope OS–25/G	124, 127*c*, 128*d*
Audio Test Set TS–762/TC	125, 126, 127*c*, 128*e*
Power Supply PP–691/G	123*a*
Filament supply	123*b*
Voltage regulator	123*c*
Modem tube trouble-shooting data.	127*c*, 128*b*

130. Sectionalization of Trouble to a Drop-and-insert Repeater Terminal

a. The first step in servicing the multiplexer or pulse form restorer group is to localize the fault to the restorer group rather than to some other part of the radio-relay system in which it may be operating. This can be done by in-

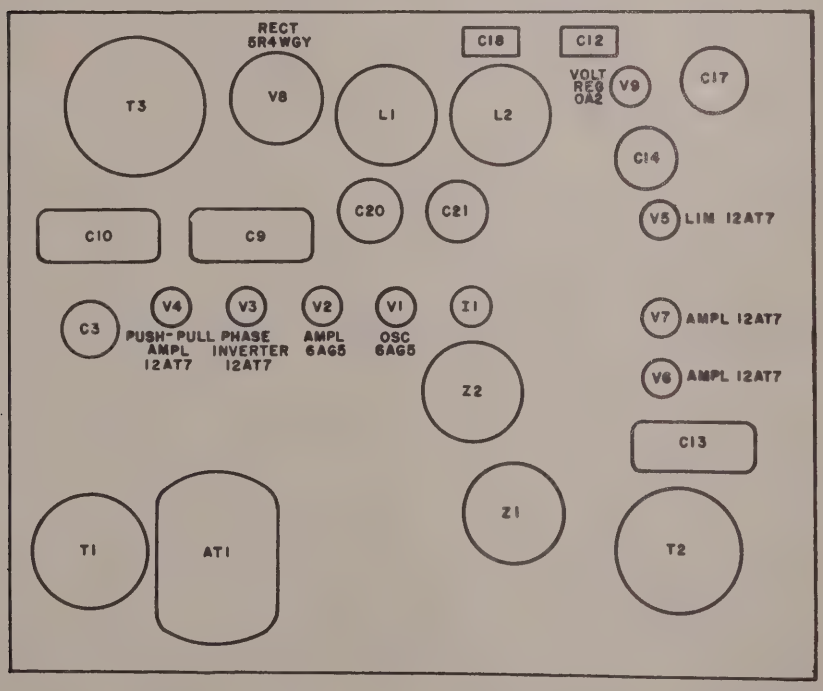


Figure 118. Audio test set, tube location diagram.

specting the input and output wave shapes. Refer to paragraph 116*d* and *e* for instructions on checking and comparing wave forms.

Note. The unit has two identical parts, one eastgoing and one westgoing; therefore, all procedures hereafter will refer to eastgoing, with the understanding that such procedures should also be applied to the westgoing section in the same way.

b. When the buzzer sounds and the ALARM lamp lights, follow the procedure described below to determine whether the drop-and-insert terminal or some other link in the system is at fault.

(1) Set up the oscilloscope as described in paragraph 45.

(2) Insert the oscilloscope probe into the video restorer OUTPUT TO EASTFACING XMTR test point (or OUTPUT TO WESTFACING XMTR test point). When the system is operating normally, a wave form similar to that shown in figure 119 should be displayed on the crt screen. The absence of this signal indicates that either the equipment or the system is faulty.

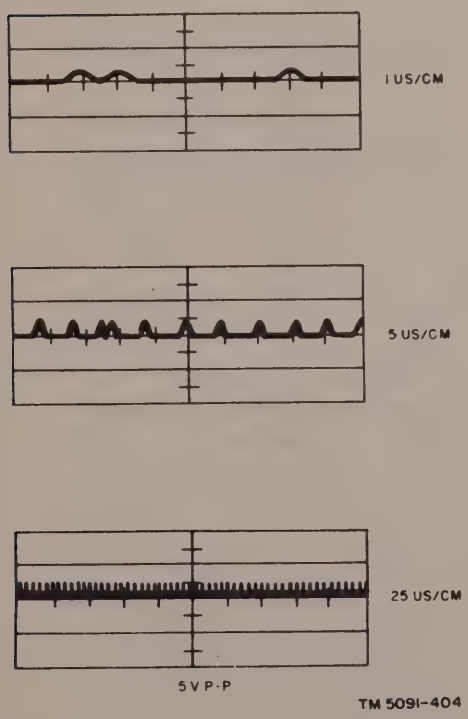


Figure 119. Wave form at INPUT FROM EASTFACING REC and OUTPUT TO WESTFACING XMTR test points.

(3) If the output is not correct or present, check the wave form at the INPUT FROM EASTFACING REC test point. If this wave form is the same as that described in (2) above, the trouble is in some other unit in the system. If the input and output wave shapes are the same and the ALARM lamp is on or if the input is correct and the output is not, the fault probably lies in the drop-and-insert equipment. In that case, proceed as outlined in paragraphs 131 through 137. Whenever possible, perform all the indicated checks in the order given.

131. Service Sectionalization of Trouble to a Component

When servicing the equipment, the first procedure is to localize the difficulty to a component. The difficulty may be in the video restorer, mounting rack, power supply, test equipment, or voltage regulator.

Note. For convenience, all wave shapes are shown for a 23-channel pulse train, unless otherwise noted.

a. Video Restorer. The video restorer may be separated functionally into two sections. The first section is the *series* section; that is, that part through which the signal progresses. In general, this consists of the reshaping circuit (V1 through V5, V6 through V9, and V10) and the blanking and insert circuit (V11 through V13). The second section is the *bridged* section, which consists of a marker-separator gate-shaping circuit and an alarm circuit. Failure of either of these sections (series or bridged) will be immediately apparent because the alarm will operate. Failure of each of these sections will be considered separately.

(1) *Series or reshaping section.* Failure of the series section will be apparent since the signal will bypass the circuits. In normal operation, P.T. OUT AMPL switch S2 is in the LOW position and the output puse train amplitude is set to one-half of the input pulse train amplitude observed at the INPUT FROM EASTFACING (or WESTFACING) REC test jack (J2). In the event of a failure, the ampli-

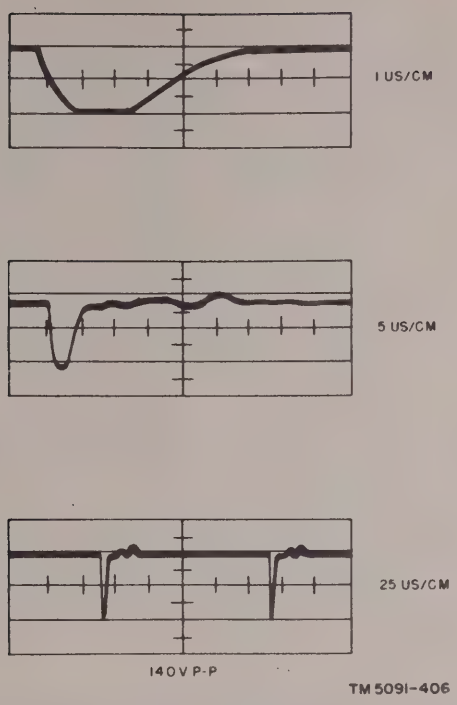


Figure 120. Wave form at DEMTPX GATE test point.

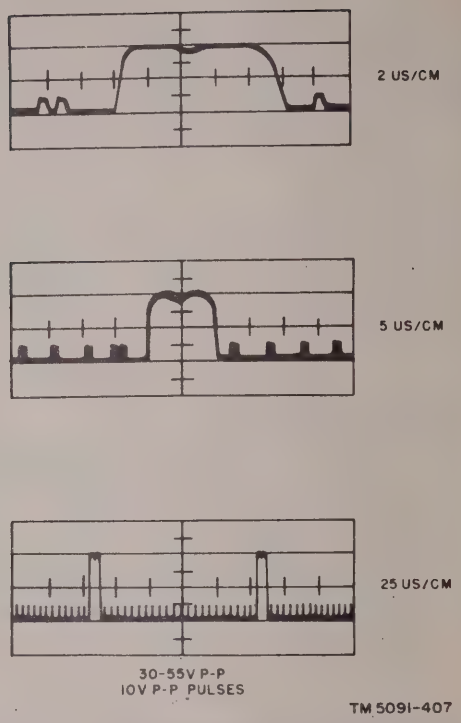


Figure 121. Wave form at BLANKING GATE test point (channels 1 and 2 in D and I).

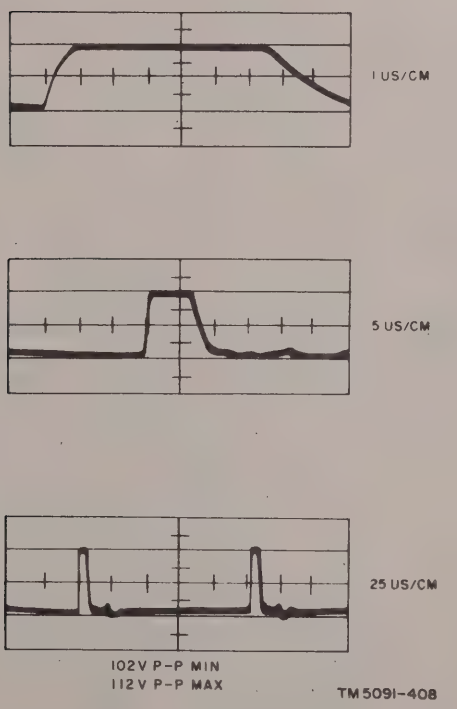


Figure 122. Wave form at MTPX Gate test point.

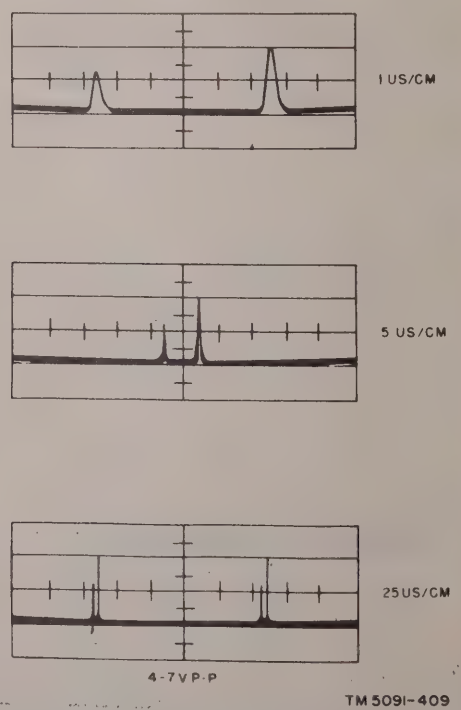


Figure 123. Wave form at MODEM CHAN PULSES test point.

tude of the output pulse train observed at the OUTPUT to EAST-FACING (or WESTFACING) XMTR test jack (J4) should not change. When P.T. OUT AMPL switch S2 is in the LOW position, a 12-db pad attenuates the signal and the output amplitude is set to be one-half the input video level when P.T. OUT AMPL switch S2 is in the HIGH position, a 6-db pad attenuates the output pulse train instead of the 12-db pad). When the video restorer is in the *alarmed* condition, a 6-db pad also attenuates the bypassed input signal and, consequently, in the event of failure, the amplitude of the output pulse train should not change.

Note. Tubes V1 through V5 are inoperative with 23 CHAN-45 CHAN switch S1 in the 23-CHAN position.

(2) *Bridged circuit.* If the alarm sounds and the fault is not in the series circuit, it must be in the bridged circuit. Always observe the waveforms above before proceeding. In addition to the alarm sounding, it may become impossible to drop and insert signals. If the trouble appears to be in the bridged circuits, observe the following wave forms.

(*a*) DEMTPX GATE E5 (fig. 120).

(*b*) BLANKING GATE E4 (fig. 121).

(*c*) MTPX GATE E6 (fig. 122).

(*d*) MODEM CHAN PULSES E3 (fig. 123).

(3) *Stage-by-stage wave forms.* If all the wave forms mentioned in (2) above are present and correct, no further inspection is necessary. If not, check the stage wave forms of the appropriate section as listed in the following chart. Refer to figure 144 for tube locations. Check tubes V6 to V13 for trouble in the series section, and tubes V19 to V27 for trouble in the shunt section (refer to paragraph 127*a* and *b* for tube checking information). The remainder of the tubes are in the alarm and miscellaneous circuits. Absence or distortion of any one of the wave forms indicates that the stage is faulty. When such a stage is located, change the tube of that stage. If a tube change does not correct the situation, the equipment must be serviced. For servicing, refer to paragraphs 302 through 308.

Tube No.	Pin No.	Fig. ref
V1	8	124
V2	5	125
V3	7	126
V4	5	127
V5	6	128
V6	8	94
V7	5	129
V8	7	126
V9	5	130
V10	6	131
V11	6	132
V12	1	133
V13	3	121
V15A	1	135
V16	6	136
V19	5	137
V20	8	138
V21	8	139
V22	8	140
V23	5	141
V24	5	142
V25	8	120
V26	5	133
V27	5	122

b. Modem Modulator.

(1) *Test points* (fig. 50). Check the PPM test point on each modem against the wave form shown in figure 87.

(2) *Stage plate wave forms.* If the PPM test point wave form is satisfactory, the modem modulator is operating properly. If it is not, check the modem stage plate wave forms as in the chart below. Refer to figure 113 for the location of all tubes. Replace any tubes of the defective stages. If the trouble does not disappear, the unit must be serviced. Refer to paragraph 313 through 315.

Tube No.	Pin No.	Fig. ref
V1A	1	88
V1B	6	89
V2	1	90

c. Modem Demodulator.

(1) *Test point* (fig. 50). Check the wave form at the modem PWM test point. The wave form should be similar to that shown in figure 104.

(2) *Stage-by-stage plate wave forms.* If the PWM test point wave form is present and correct, no further inspection is necessary. If it is not, check the modem stage plate wave forms as shown in the chart below. Refer to figure 113 for the location of all tubes. Absence or distortion of any one of the wave forms in the chart indicates a faulty stage. When such a stage is located, change the tube of that stage. If changing the tube does not correct the situation, service the equipment as described in paragraph 316.

Tube No.	Pin No.	Fig. ref
V3B	6	104
V3A	1	105
V4A	1	106
V4B	6	107

132. Multiplexer Group AN/TCA-1 and Pulse Form Restorer Group AN/TRA-10, Performance Check List

Refer to paragraph 116 before performing the checks indicated below.

	Item No.	Unit	Item	Action or condition	Normal indication	Corrective measure
PREPARATORY	1		Cables	Check connections (par. 64).		
	2	Equipment rack.	1. D&I-THRU switches.	1. Place in D&I position.		
			2. PARTY LINE-PRIV switch	2. Check seating.		
	3	All Modems.	Selector switch.	Place in NORMAL position.		
	4	Video restorer.	1. Video restorer fan.	1. Turn fan by hand (par. 66*a*(5)).	1. Fan turns freely.	Check binding.
			2. P.T. OUTPUT AMPL switch.	2. Place in LOW position.		
	5	Control monitor[a].	Selector switch.	Depress NORMAL button.		
	6	Filament supply.	Remote keying knits.	In NORMAL OPERTION or REMOTE KEYING OPERATION position.		
	7	Switch box.	INPUT SELECTOR SWITCH.	Throw in 115/230 VAC INPUT 1 or 115/230 VAC INPUT 2 depending upon which connector is connected to input primary source.		

[a] This step applies to Multiplexer Group AN/TCA-1 only.

	Item No.	Unit	Item	Action or condition	Normal indication	Corrective measure
START	8	Voltage regulator.	230V AC INPUT ON or 115V AC INPUT ON circuit breaker.	Set to ON position.	115 VAC OUTPUT lamp glows. No chatter.	Adjust SENSITIVITY control (par. 66*b* (5)). Check tubes V1 and V2.
	9	Power supply.	FILAMENT circuit breaker.	Set to ON position.	FILAMENT ON indicates on filament supply and power supply glows. LINE VOLTS meter indicates 115 volts ±1 per cent.	Check cable connections to voltage regulator. Adjust OUTPUT VOLTAGE control. Check voltage regulator tubes V1 and V2.
	10	Power supply.	+250V circuit breaker.	*Wait 30 seconds.* Set to ON position.	+250 ON pilot lamp glow.	Check cable connections.
EQUIPMENT PERFORMANCE	11	Video restorer	Series section, negative pulse train reshaper.	Check OUTPUT TO EASTFACING XMTR test point E2.	As shown in figure 119, ALARM light out.	Adjust SYM ADJ control (par 75). Check wave form at pin 6 of V10 (fig. 131), pin 1 of V12 (fig. 133), pin 6 of V11 (fig. 132), pin 5 of V9 (fig. 130), pin 7 of V8 (fig. 126), pin 5 of V7 (fig. 129), and pin 8 of V6 (fig. 94). Replace defective tube.
	12	Video restorer[b]	Series section, positive pulse train reshaper.	Check OUTPUT TO EASTFACING XMTR test point E2.	As shown in figure 119. If P.T. OUT AMPL switch on Video restorer is in LOW, the voltage will be .5 volt peak to peak.	Adjust SYM ADJ control. Check wave form at pin 6 of V5 (fig. 128), pin 5 of V4 (fig. 127), pin 7 of V3 (fig. 124), pin 5 of V2 (fig. 123), and pin 8 of V1 (fig. 122). Replace defective tubes.
	13	Video restorer	SHUNT section.	Check wave form at DEMTPX GATE test pack E5.	As shown in figure 120.	Check wave form at pin 5 of V19 (fig. 137), pin 8 of V20 (fig. 138), pin 8 of V21 (fig. 139), pin 8 of V22 (fig. 140), pin 5 of V23 (fig. 141), pin 5 of V24 (fig. 142), and pin 8 of V25 (fig. 120). Replace defective tube.

[b] This check is for 45-channel operation only. Be sure that a 45-channel pulse train is being received and that the 23 CHAN-45 CHAN switch on the video restorer is in the 45 CHAN position

	Item No.	Unit	Item	Action or condition	Normal indication	Corrective measure
EQUIPMENT PERFORMANCE	14	Video restorer	SHUNT section.	Check wave form at MTPX GATE point E6.	As shown in figure 122.	Check wave form at pin 5 of V26 (fig. 143) and pin 5 of V27 (fig. 122). Replace defective tube.
	15	Video restorer.	Bridged section.	Check wave form at BLANKING GATE test point E4.	As shown in figure 121.	Check wave form at pin 3 of V13 (fig. 121). Replace V13.
		Video restorer.	Bridged circuit.	Check wave form at MODEM CHAN PULSES test point E3.	As shown in figure 123.	Check modems, step 17.
	16	Video restorer.	Alarm circuit.		ALARM light out, alarm buzzer quiet.	Check wave form at pin 1 of V15A (fig. 135), and pin 6 of V16 (fig. 136). Check tubes V15 through V18. Replace defective tube.
	17	All modems.	Modulator circuit.	Check wave form at PPM test point J1.	Wave form as shown in figure 87.	Check wave form at pin 1 of V1A (fig. 88), pin 6 of V1B (fig. 89), and pin 1 of V2 (fig. 90). Replace defective tube.
	18		Demodulator circuits.	Check wave form at PWM test point.	As shown in figure 104. Reception satisfactory on all drop-and-insert channels.	Check wave form at pin 6 of V3B (fig. 104), pin 1 of V3A (fig. 105), pin 1 of V4A (fig. 106), and pin 6 of V4B (fig. 107). Replace defective tube.
STOP	19			Set to OFF position.	POWER ON indicator light goes off.	Check switch S2.
	20			Set to OFF position.	POWER ON indicator lamp goes off, blower motor stops.	Check switch S1.
	21	Power supply.	+250V circuit breaker.	Set to OFF position.	+250V ON indicator lamps go out.	Check circuit breaker.
	22	Power supply.	FILAMENT circuit breaker.	Set to OFF position.	FILAMENT ON indicator lamps go out.	Check circuit breaker.
	23	Voltage regulator	230V AC INPUT ON or 115V circuit breaker.	Set to OFF position.	115 VAC OUTPUT indicator lamp goes out.	Check circuit breaker.

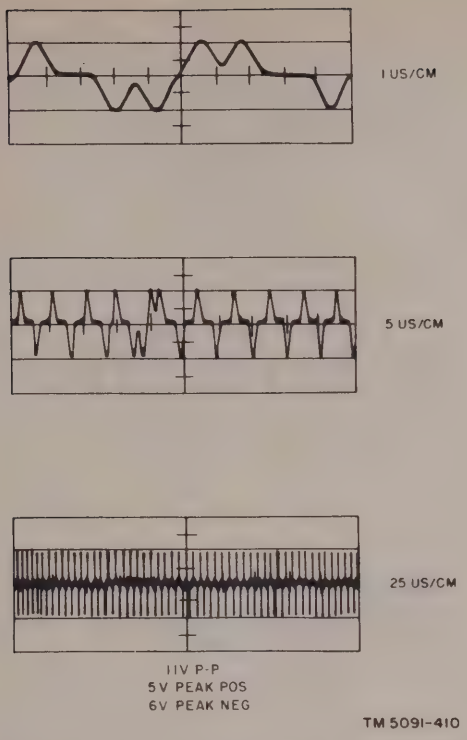


Figure 124. Wave form at pin 8 (plate) of V1 (45-channel operation).

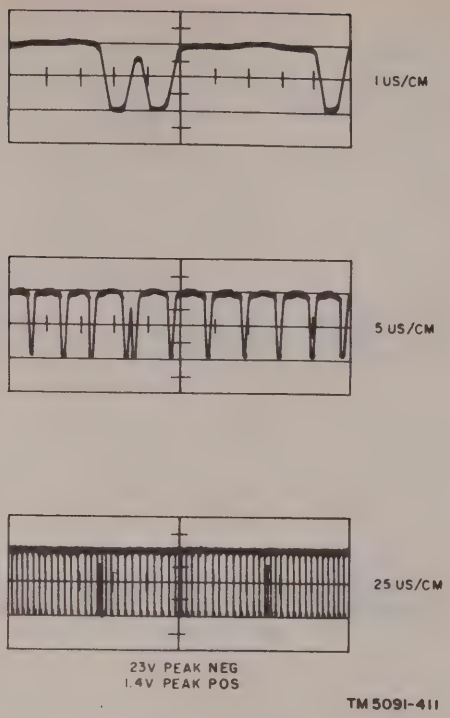


Figure 125. Wave form at pin 5 (plate) of V2 (45-channel operation).

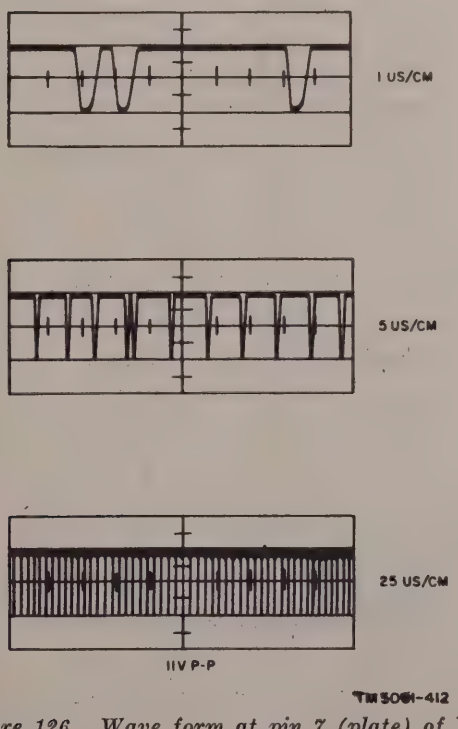


Figure 126. Wave form at pin 7 (plate) of V3 (45-channel operation) and V8.

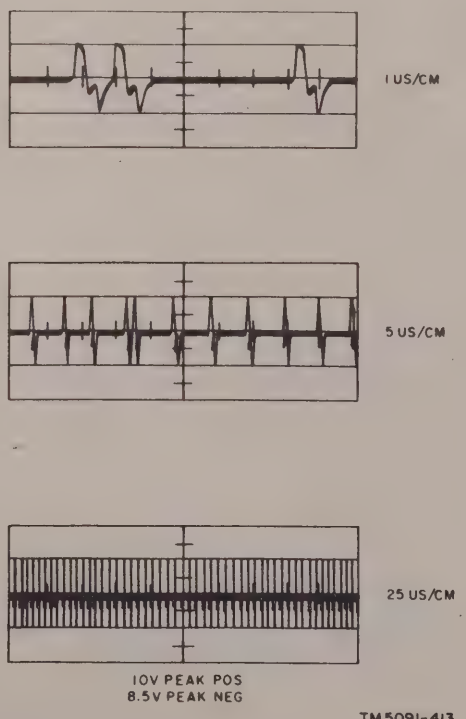


Figure 127. Wave form at pin 5 (plate) of V4 (45-channel operation).

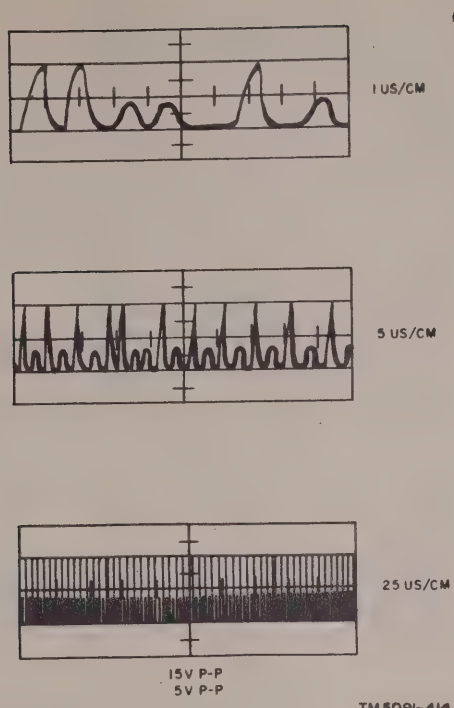


Figure 128. Wave form at pin 6 (plate) of V5 (45-channel operation).

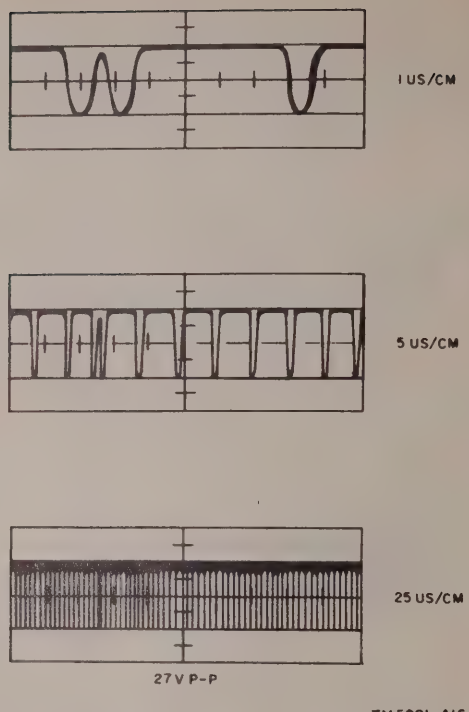


Figure 129. Wave form at pin 5 (plate) of V7.

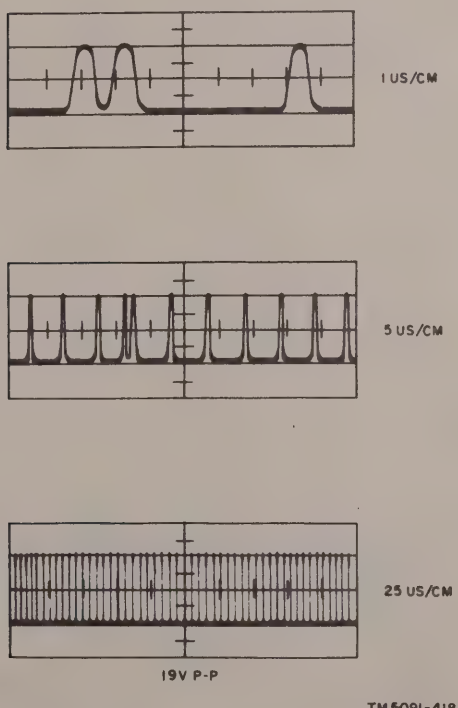


Figure 130. Wave form at pin 5 (plate) of V9.

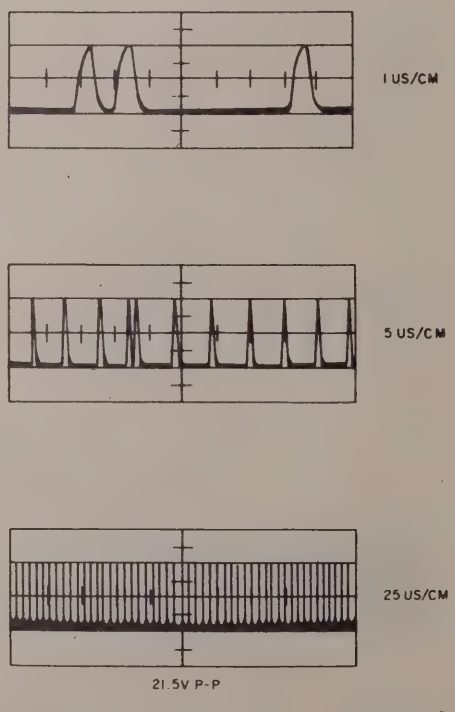


Figure 131. Wave form at pin 6 (plate) of V10.

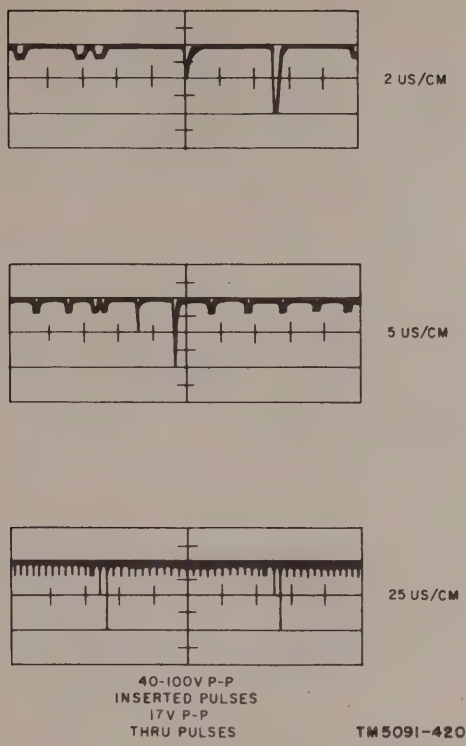


Figure 132. Wave form at pin 6 (plate) of V11.

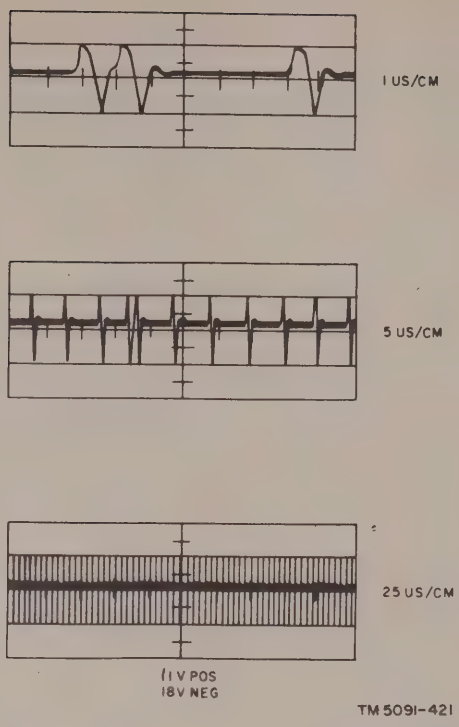


Figure 133. Wave form at pin 1 (plate) of V12.

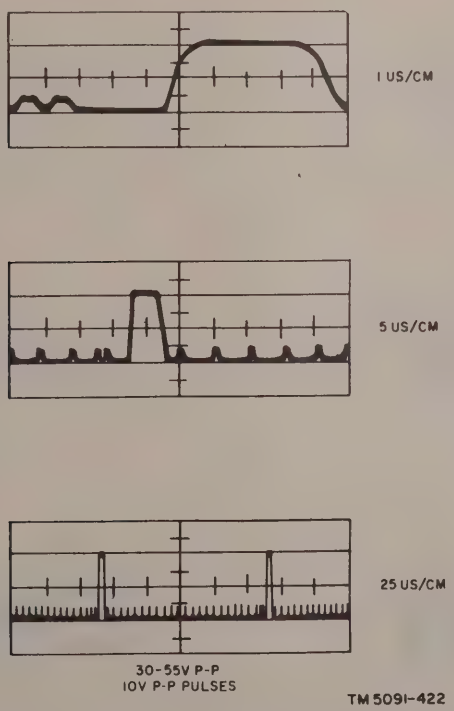


Figure 134. Wave form at pin 3 (cathode) of V13 (channel 1 in D & I).

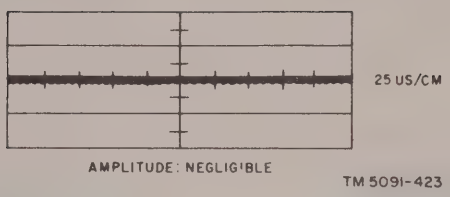


Figure 135. Wave form at pin 1 (plate) of V15A.

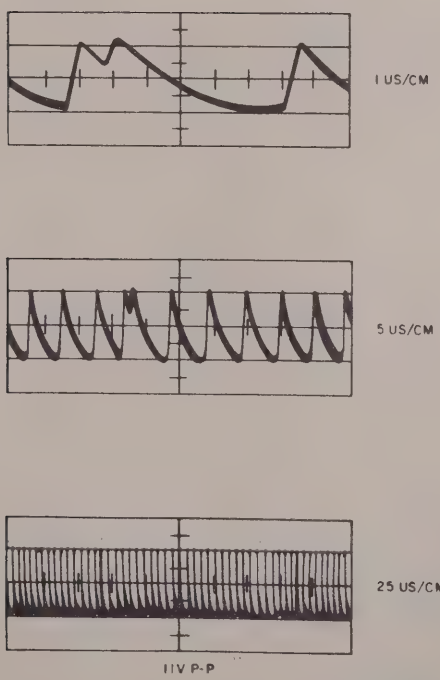


Figure 136. Wave form at pin 6 (plate) of V16.

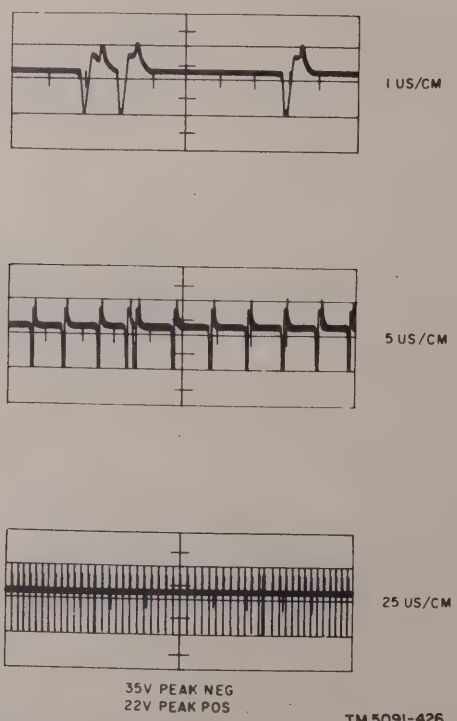


Figure 137. Wave form at pin 5 (plate) of V19.

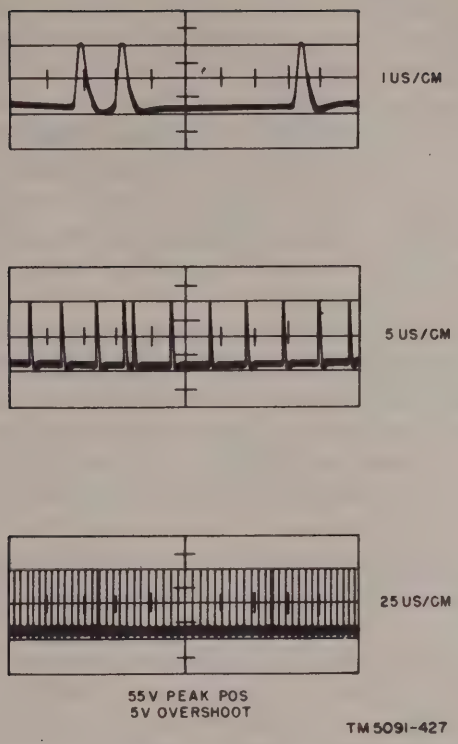


Figure 138. Wave form at pin 8 (plate) of V20.

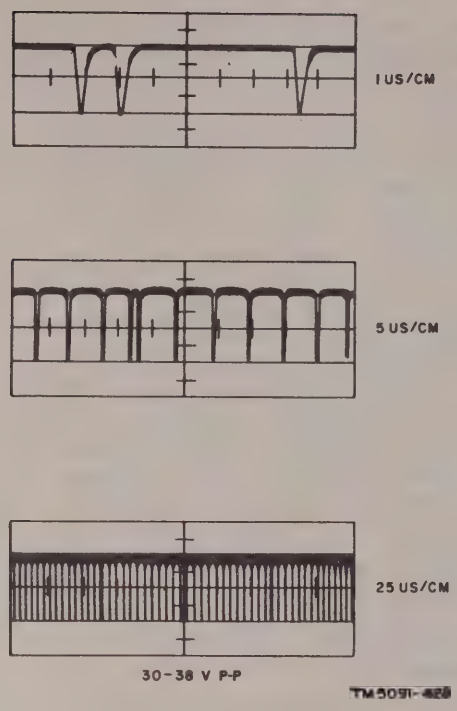


Figure 139. Wave form at pin 8 (plate) of V21.

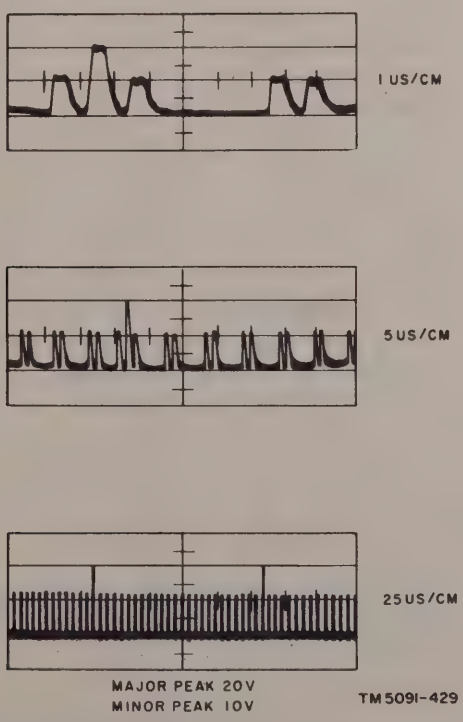


Figure 140. Wave form at pin 8 (plate) of V22.

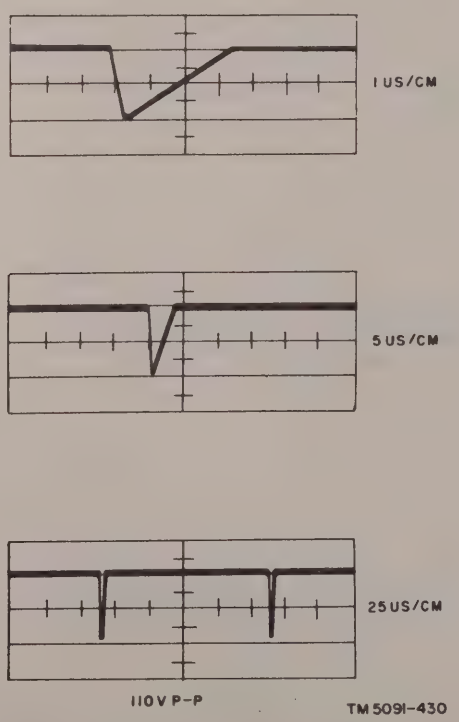


Figure 141. Wave form at pin 5 (plate) of V23.

133. Miscellaneous Circuit Checks for Multiplexer Group AN/TCA-1

a. Filament Supply. Check the output of the filament supply transformer by placing Multimeter TS–352/U across Terminals 1 and 2 of Terminal board TB1A, located on Multiplexer TD–60/TCC–13. If 115 volts ac is applied to the primary, the secondary output voltage should be 6.3 volts ac. If this value is not obtained, trouble shooting by field maintenance personnel is required.

b. Drop and Insert. See that the 16 D&I switches (fig. 47) are firmly seated and are correctly positioned.

c. Party-line-private. Check the two PARTY LINE-PRIV switches (fig. 47) to be sure they are firmly seated and are correctly positioned.

d. Control Monitor Checks. Control Monitor C–1151/TC is supplied with Multiplexer Set AN/TCC–13 *only.* The procedure for checking the control monitor is given in paragraph 118.

e. Ringing Circuit Checks. Check the ringing circuits of the multiplexer set as described in paragraph 119.

f. Remote Keying Circuits. Check the remote keying circuits of the multiplexer set as described in paragraph 120.

134. Miscellaneous Circuit Checks of Pulse Form Restorer Group AN/TRA-10

a. Drop and Insert. See that the four D&I switches (fig. 49) are firmly seated and correctly positioned.

b. Party-line-private. See that the two PARTY LINE-PRIV switches (fig. 49) are firmly seated and correctly positioned.

c. Twenty-cycle Supply. Check tube V1 located on the mounting rack. If the tube checks *good,* refer to the test procedures in paragraphs 327 through 333.

d. Filament Supply. Check the output of filament transformer T3. This can be done by placing Multimeter TS–325/U across terminals 8 and 9 of TB1A, which is located on Electrical Equipment Rack MT–1434/TRA–10. If 115 volts ac is applied to the primary, the secondary output should be 6.3 volts ac. If this value is not obtained, trouble shooting at a field maintenance level is indicated (par. 327 through 333).

e. Ringing Circuits. Ringing may be checked by having the east and west operators ring to see whether a phone at the terminal rings. In the same manner, the terminal operator may ring to the west or east terminals. If this

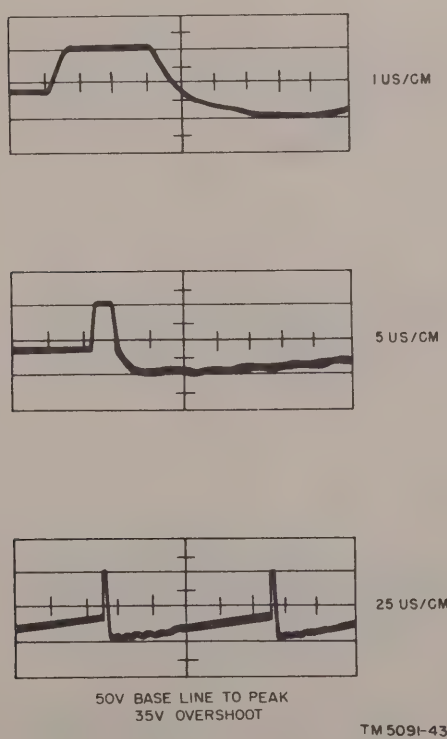


Figure 142. Wave form at pin 5 (plate) of V24.

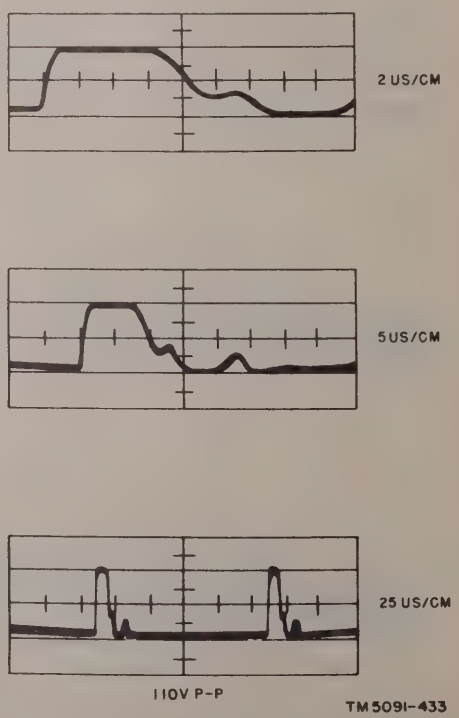


Figure 143. Wave form at pin 5 (plate) of V26.

operates on the party-line connection (both incoming and outgoing), further tests are not necessary because the ringing is operating correctly. If it does not operate on a party line, the difficulty is in the remote keying circuit. If it does not operate correctly in either the party or private connection, the trouble is probably in the modems.

f. Remote Keying Circuits.

(1) *Normal operation.* If the terminal has gone through the preceding tests, the remote keying units should be working properly in the NORMAL position.

(2) *Remote keying operation.* Have both terminals and the repeater placed in the remote keying position. In the normal idle condition, channels 1 and 2 should be blanked out in both the eastgoing and westgoing signals. There should be an open circuit between E16 and E17 (remote keying channel 1 OUT) and E27 and E28 (remote keying channel 2 OUT) of the repeater.

(*a*) Put a short circuit across E12 and E13 (remote keying channel 1 IN) of the terminal. This should put the channel 1 pulse back into the outgoing pulse train, both eastgoing and westgoing.

(*b*) Put a short circuit across E23 and E24 (remote keying channel 2 IN) of the terminal. This should put the channel 2 pulse back in the outgoing pulse trains.

(*c*) Request the operators to put a short circuit across E13 and E14 of the east and west terminals in turn. There should also be a short across E16 and E17 of the repeater when this is done.

(*d*) Request the operators to put a short circuit across E3 and E4 of the east and west terminals in turn. There should also be a short across E27 and E28 of the repeater when this is done.

135. Video Restorer Tube Trouble-shooting Chart

Refer to paragraph 127*a* and *b* before substituting or changing any tubes in the video restorer.

Item No.	Symptoms	Tube
1	No gate at the DEMTPX GATE test point.	V6 through V9 and V19 through V25.
2	All blanking gates missing at the BLANKING GATE test point (with all channels in D&I and NORMAL operation).	V13.
3	No gate at the MTPX GATE test point.	V26 and V27.
4	MTPX GATE wave shape improper.	V18 or V28 if gate is greater than 110 volts.
5	Channel pulse too small at the MODEM CHAN PULSES test point.	V1 or V2.
6	No inserted pulse at the OUTPUT TO EASTFACING (or WESTFACING) XMTR test point (in D&I and NORMAL).	V10 or V12.
7	In 45-channel operation, negative pulses at the OUTPUT TO EASTFACING, or WEST FACING) XMTR test point too wide.	V1, V2, V3, V4, or V5.
8	Alarm is actuated.	V10, V11, V12, V15, V17, or V18.

136. Video Restorer, Tube Replacement Data

(fig. 144)

The following table identifies the tubes in the TD–68/G by reference symbol, tube type, and function. When changing tubes, change them one at a time. Be sure that the correct tube is in the proper socket.

Tube symbol	Tube type	Function	Tube symbol	Tube type	Function
V1	6AG7	Video amplifier.	V14	OA3	75-volt supply.
V2	6AG5	Video amplifier.	V15	12AT7WA	Noise amplifier; relay control.
V3	5726/6AL5W	Rectifier clipper.	V16	12AT7WA	Damper; monitor amplifier.
V4	6AG5	Shaper.	V17	12AT7WA	Damper, rectifier.
V5	12AT7WA	Pulse amplifier; output amplifier.	V18	5726/6AL5W	Clamp; clipper.
			V19	6AG5	Shaper.
V6	6AG7	Video amplifier.	V20	6AG7	Pulse amplifier.
V7	6AG5	Video amplifier.	V21	6AG7	Power amplifier.
V8	5726/6AL5W	Rectifier clipper.	V22	6AG7	Marker-separator.
V9	6AG5	Pulse amplifier.	V23	6AG5	Marker detector.
V10	12AT7WA	Pulse amplifier; output amplifier.	V24	6AG5	Gate shaper.
			V25	6AG7	Gate amplifier.
V11	12AT7WA	Cathode follower; blanker.	V26	6AG5	Inverter.
V12	12AT7WA	Shaper; mixer amplifier.	V27	6AG7	Gate amplifier.
V13	12AT7WA	Cathode follower; amplifier.	V28	OB2	105-volt supply.

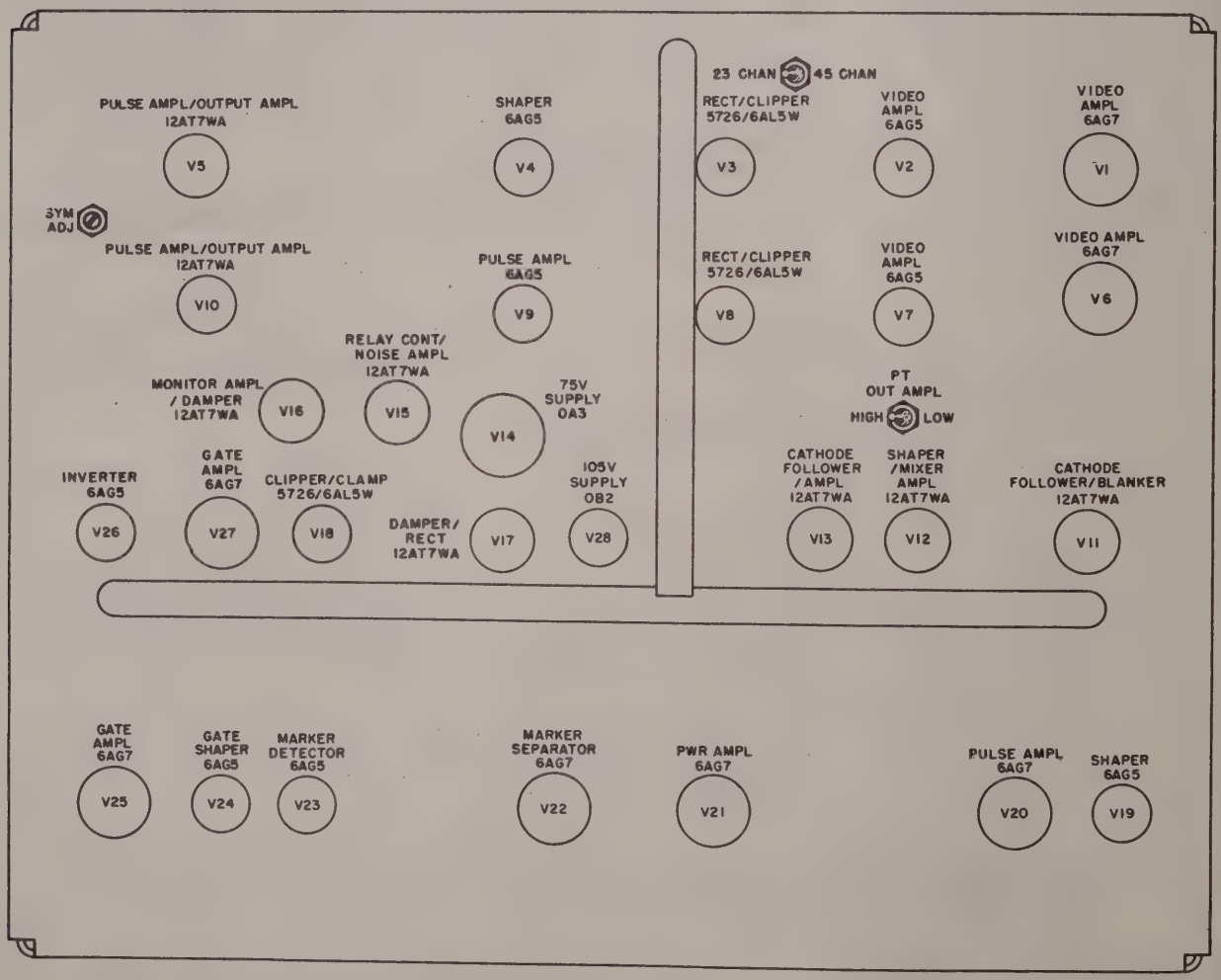


Figure 144. Video restorer, tube location diagram.

CHAPTER 6

AUXILIARY EQUIPMENT

137. General

a. Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 part of the transportable multichannel radio communication system. Multiplexer Set AN/TCC–13 (terminal equipment) modulates and multiplexes up to 23 channels of audio information into a single pulse train. This pulse train is then fed to a radio-frequency link which transmits the signal to the desired terminal by means of a series of repeaters. At this terminal, the pulse train is fed to another multiplexer set that demultiplexes and demodulates it into the original number of channels of audio information. At the repeater point, the signal is fed into Multiplexer Group AN/TCA–1 or Pulse Form Restorer Group AN/TRA–10, which reshapes the signal into its original configuration. At repeater points, it is also possible to drop channels from the transmitted pulse train by means of drop-channel facilities, and to insert new signals if desired. If the multiplexer group is used, eight channels may be dropped and inserted and if the pulse form restorer group is used, two channels may be dropped and inserted.

b. The audio channels fed to, and obtained from, the multiplexer set are generally connected to a standard military switchboard. The switchboard is not part of the multiplexer set, and reference should be made to the manual that covers the switchboard.

138. Radio-frequency Link

Radio Set AN/TRC–29 is usually used to transmit and receive the pulse train output of the multiplexer set. The AN/TRC–29 consists basically of a transmitter rack (which accepts a pulse train signal and uses it to frequency modulate a microwave signal), a receiver rack (which accepts a frequency-modulated microwave signal and detects the original pulse train), and an antenna system (which transmits and receives microwave signals). Refer to the applicble component manual for further information on Radio Set AN/TRC–29.

139. Use With Other Rf Equipment

a. General. The Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10 can be used with any radio equipment that accepts the video output signal of the multiplexing portion of the AN/TCC–13. The radio equipment must transmit this signal with proper fidelity and provide a video output signal that can be fed to the demultiplexing portion of the AN/TCC–13. To meet these requirements, the radio equipment must have certain characteristics which are, in part, a function of the type of modulation used (amplitude modulation (am) or frequency modulation (fm).) The radio equipment characteristics that are required in an fm system are described in *b* below. The characteristics that are required in an am system are described in *c* below.

b. Fm System. Multiplexer Set AN/TCC–13 can be used with any fm radio equipment that meets the characteristics described in (1) through (3) below. The requirements for 23-channel operation are different from those for 45-channel operation.

(1) *Signal input characteristics.*

	23-channel operation	*45-channel operation*
Amplitude	5 volt, peak-to-peak positive, variable down to zero.	1 volt (.5 volt positive and .5 volt negative) peak-to-peak, variable down to zero.
Repetition rate	200 kc.	400 kc.
Impedance	50 ohms.	50 ohms.

(2) *Signal output characteristics.*

Amplitude	Between .2 and .5 volt, peak-to-peak positive.	Between .4 and 1 volt (half positive and half negative), peak-to-peak.
Impedance	50 ohms.	50 ohms.

(3) *System characteristics.*

Bandwidth	4 kc to 1 mc.	4 kc to 1 mc.
Video signal-to-noise ratio (with 1-mc bandwidth) to achieve 55-db audio signal-to-noise ratio (F1A weighted)	50 db.	50 db.

c. Am System.

(1) *System considerations.* The am system that is most adaptable to transmit tdm pulses is a keyed system. That is, the tdm pulse train is amplified and then used to key the am transmitter. During the period between pulses, the transmitter is off and no rf energy is transmitted. In such a system, the signal-to-noise ratio improves as the rise time of the tdm pulse decreases. Therefore, the video filter should be bypassed when the AN/TCC–13 is used in an am radio-relay system, thereby decreasing the rise time of the tdm pulses. Because the video filter is not required, it is possible to obtain the tdm pulses from the SLAVE OUTPUT jack, thereby bypassing the 6-db pad, and increasing the maximum output level to about 1 volt (instead of .5 volt). Similarly, the input level of the tdm pulse train can be as low as 1 volt by using the SLAVE INPUT jack and again bypassing the input 6-db pad. As am system should also include clipping and limiting circuits at each repeater to eliminate am noise after each hop. Because the AN/TCC–13 includes the necessary slicing circuits, the radio equipment does not have to meet any special clipping requirements. The 23-channel ppm signal has a duty cycle of 10 per cent. Because a keyed system can respond only to pulses of one polarity, 45-channel operation is not possible in a keyed am system.

(2) *System characteristics.* Besides the considerations outlined in (1) above, the am system should have the following characteristics:

(*a*) *Signal input characteristics.*

Amplitude ..... .5 volt, or 1.0 volt, peak-to-peak, variable down to zero.
Repetition rate . 200 kc.
Impedance ..... 50 ohms.

(*b*) *Signal output characteristics.*

Amplitude ..... Between .2 and .5 volt, or down to .1 volt by using the SLAVE INPUT jack.
Impedance ..... 50 ohms.

(*c*) *System characteristics.*

Bandwidth ..... 4 kc to about 3 mc (video filter bypassed).
Video signal-to-noise 38 db.
ratio to achieve 55 db audio signal-to-noise ratio (F1A weighted).

140. System Alarm Considerations

a. Each of the three equipments (AN/TRA–10, AN/TCC–13, and AN/TCA–1) contains alarm circuits to provide visible and audible alarms in the event of internal or external failure. With a few exceptions, the alarm circuit at each equipment is completely independent of other radio and video equipment and provides an alarm indication only at the station of internal or external failure. The alarm signal is not transmitted down the system. For example, failure at a repeater station does not cause an alarm indication at the terminals. Instead, alarm circuitry within the equipment bypasses the repeater equipment in the direction of failure so that a proper pulse signal is fed to the repeater radio equipment, and from there to the terminal.

b. The alarm indication is limited to the direction of failure. Thus, at each repeater, there is an *eastgoing* and *westgoing* alarm indication, and an *eastgoing* failure does not affect the *westgoing* signal or vice versa. At a terminal, an alarm signal is initiated by a failure in the demultiplexing equipment. None of the alarm circuits include a lockup feature. Restoration of the correct signal automatically removes the alarm indication and returns the equipment to normal operation.

141. Remote Keying Considerations

The operation of the remote keying system is explained in paragraphs 195 through 197.

142. System Alignment of Audio Levels

The system alignment procedures (par. 143 through 147) preclude a talking circuit in operation independent of the equipment until the channel 1 order-wire circuit is aligned. After the order-wire channel is available, connect Telephone EE–8–B to the PARTY LINE channel 1 binding posts at all repeaters and use the order-wire circuit as directed in paragraph 95. When a channel has been aligned on a four-wire basis, it will not require adjustment if it is switched to two-wire service. See figures 145 and 146 for system audio levels for private-line and party-line operation.

143. Alignment of Channels 1 and 2 at Terminal and Repeater

Channels 1 and 2 of Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1 are aligned identically in the following manner:

a. At East Terminal (AN/TCC–13).

(1) Set the control monitor test switch to the SEND position.

(2) Turn the modem channel 1 selector switch to the SR position.

(3) Place the remote keying unit in the NORMAL OPERATION position.

b. At Repeater (AN/TRA–10 or AN TCA–1).

(1) Set the modem channel 1 eastfacing and westfacing 2W–4W switch in the 4W position.

(2) Place the remote keying unit in the NORMAL OPERATION position.

(3) Place the channel 1 PARTY LINE-PRIV switch in the PARTY LINE position.

(4) Place the channel 1 D&I-THRU switch in the D&I position.

(5) At the AN/TCA–1 only, set the control monitor test switch to the NORMAL position.

c. At East Terminal (AN/TCC–13). Modulate channel 1 with full modulation (—4 dbm for four-wire (4W) and 0 dbm for two-wire (2W) operation).

d. At Repeater (AN/TRA–10 or AN/TCA–1).

(1) Connect the oscilloscope and direct probe to the front panel OUTPUT TO WESTFACING XMTR test jack.

(2) Adjust channel 1 modem OUTPUT AUDIO GAIN control R37 until a deviation of $\pm$.5 usec is obtained on the oscilloscope.

e. At West Terminal (AN/TCC–13).

(1) Place the remote keying unit in the NORMAL OPERATION position.

(2) Set the control monitor test switch to the REC position.

(3) Turn the channel 1 modem selector switch to the RR position.

(4) Adjust the channel 1 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire (4W) or a reading of —3 dbm for two-wire (2W) operation is obtained on the audio test set.

f. Alignment of Channel 2. Repeat the procedures outlined in *a* through *e* above for channel 2.

g. Alignment in Other Direction. Repeat the procedures outlined in *a* through *f* above for the other direction of transmission.

144. Alignment of Channels 3 through 8 from Terminal to Repeater (AN/TCA–1)

a. At East Terminal (AN TCC–13).

(1) Set the control monitor test switch to the SEND position.

(2) Turn the channel 3 modem selector switch to the SR position.

b. At Repeater (AN/TCA–1).

(1) Set the control monitor test switch to the REC position.

(2) Turn the eastfacing channel 3 modem selector switch to the RR position.

(3) Place the eastfacing channel 3 D&I-THRU switch in the D&I position.

c. At East Terminal (AN/TCC–13). Modulate channel 3 with full modulation (—4 dbm for four-wire (4W) or 0 dbm for two-wire (2W) operation).

d. At Repeater (AN/TCA–1). Adjust the eastfacing channel 3 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire or a reading of —3 dbm for two-wire operation is obtained on the audio test set.

e. Alignment of Channels 4 through 8. Repeat the procedure outlined in *a* through *d* above for channels 4 through 8.

f. Alignment in Opposite Direction. Repeat the procedures outlined in *a* through *e* above for the other direction of transmission (west).

145. Alignment of Channels 3 through 8 from Repeater AN/TCA–1 to Terminal

a. At Repeater (AN/TCA–1).

(1) Set the control monitor test switch to the SEND position.

(2) Place the channel 3 eastfacing D&I-THRU switch in the D&I position.

(3) Turn the eastfacing channel 3 modem selector switch to the SR position.

b. At East Terminal (AN/TCC–13).

(1) Set the control monitor test switch to the REC position.

(2) Turn the channel 3 modem selector switch to the RR position.

c. At Repeater (AN/TCA–1). Modulate eastfacing channel 3 with full modulation (—4 dbm for four-wire (4W) or 0 dbm for two-wire (2W) operation).

d. At East Terminal (AN/TCC–13). Adjust the channel 3 modem OUTPUT AUDIO GAIN control until a reading of 0 dbm for four-wire or a reading of —3 dbm for two-wire operation is obtained on the audio test set.

e. Alignment of Channels 4 through 8. Repeat the procedures outlined in *a* through *d* above for channels 4 through 8.

f. Alignment for Opposite Direction. Repeat the procedures outlined in *a* through *e* above for other direction of transmission (west).

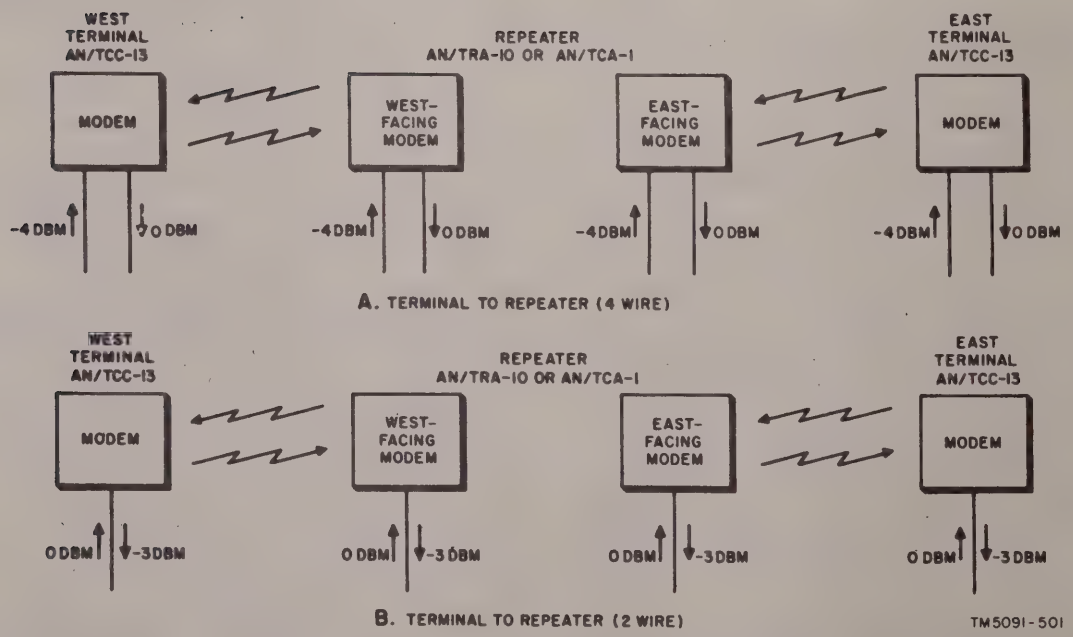


Figure 145. System audio levels, private operation.

146. System Alignment of Video Levels, 23-channel Operation

a. General. When Radio Set AN/TRC–29, Multiplexer Set AN/TCC–13, and Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 are set up in a multihop radio-relay link (fig. 5), the following video level requirements will result in optimum operation of the system. Set all transmitters for 100 per cent modulation with video input levels as follows:

(1) Set all Multiplexer Set AN/TCC–13 video input and output levels at .5 volt.

(2) Set the output video level of each Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1 to one-half of its input video level.

Note. Difficulty will be found only under the extreme condition of exceedingly long lengths of cable between equipments and under certain conditions of 45-channel operation.

b. Normal Operating Conditions. Align the system video levels as follows:

(1) At the east terminal Multiplexer Set AN/TCC–13, adjust OUTPUT AMPL

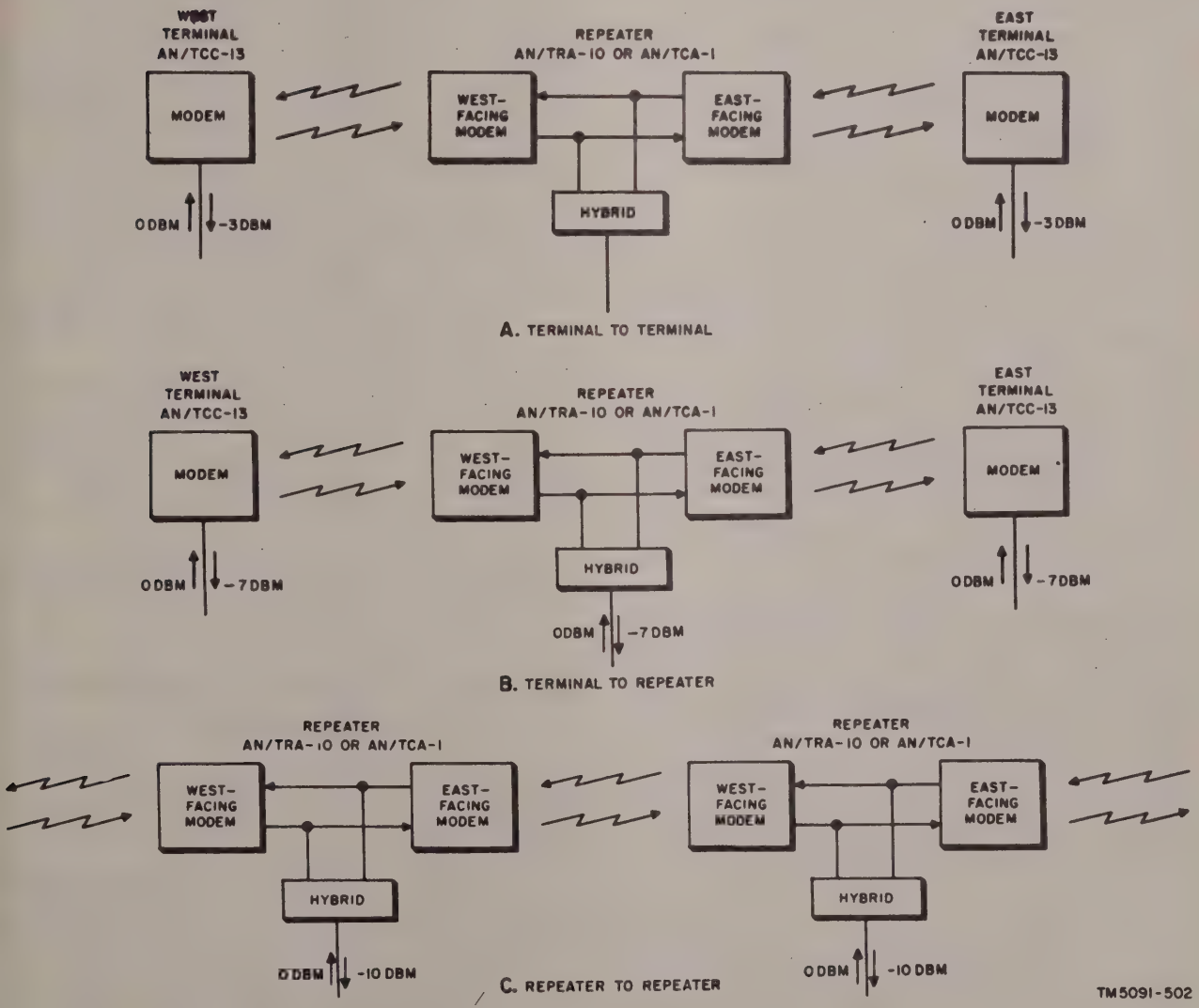


Figure 146. System audio levels, party-line operation.

potentiometer R74 so that there is a base line-to-peak amplitude of .5 volt at the front panel MASTER OUTPUT TO RF test jack.

(2) At the east terminal Radio Set AN/TRC–29, adjust the transmitter video input level control to obtain 100 per cent modulation.

(3) At the repeater station, observe the wave form on the AN/TRA–10 or AN/TCA–1 at the INPUT FROM EASTFACING REC test jack, and adjust the video output level control on the eastfacing receiver for a base line-to-peak pulse amplitude of .5 volt.

(4) At the AN/TRA–10 or AN/TCA–1 repeater station, set the westgoing video restorer P.T. OUT AMPL switch in the low position, and adjust the westgoing video restorer SYM ADJ potentiometer for a base line-to-peak pulse train amplitude of .25 volt at the OUTPUT TO WESTFACING XMTR test jack.

(5) At the repeater station Radio Set AN/TRC–29, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

(6) At the west terminal Radio Set AN/TRC–29, adjust the video output level control so that the base line-to-peak pulse amplitude at Multiplexer Set AN/TCC–13 MASTER INPUT FROM RF test jack is .5 volt.

(7) Repeat the procedures outlined in (1) through (6) above for the other direction of transmission.

c. Nonoptimum Operating Conditions. The nonoptimum operating conditions of the AN/TRA–10 or AN/TCA–1 (such that cause lower than .5-volt pulse amplitude input to the AN/TRA–10 or AN/TCA–1) may be caused by an exceedingly long cable length between the AN/TRA–10 or AN/TCA–1 and Radio Set AN/TRC–29. Under this condition, set the video level of the system as follows:

(1) At the east terminal Multiplexer Set AN/TCC–13, adjust OUTPUT AMPL potentiometer R74 so that the base line-to-peak pulse amplitude at the front panel MASTER OUTPUT TO RF test jack is .5 volt.

Note. If the video cable between the AN/TCC–13 and the AN/TRC–29 is very long, it may not be possible to modulate 100 per cent with an output of .5 volt from the AN/TCC–13. If this occurs, adjust the output of the AN/TCC–13 for 100 per cent modulation.

(2) At the east terminal Radio Set AN/TRC–29, adjust the transmitter video input level control to obtain 100 per cent modulation.

(3) At the repeater station, observe the wave form on the AN/TRA–10 or the AN/TCA–1 at the INPUT FROM EASTFACING REC test jack and adjust the video output level control at the eastfacing receiver for a maximum input pulse level.

(4) At the repeater station AN/TRA–10 and AN/TCA–1, set the westgoing P.T. OUT AMPL switch in the HIGH position.

(5) With the field telephone, contact personnel at the westfacing transmitter and adjust the westgoing SYM ADJUST potentiometer on the AN/TRA–10 or AN/TCA–1 for as low a level as will modulate the transmitter 100 per cent.

(6) At the west terminal Radio Set AN/TRC–29, adjust the video output level control so that the base line-to-peak pulse amplitude at the AN/TCC–13 MASTER INPUT FROM RF test jack is .5 volt.

(7) Repeat the procedures outlined in (1) through (6) above for the other direction of transmission.

147. System Alignment of Video Channels, 45-channel Operation

a. Set all transmitters for 100 per cent modulation as described in paragraph 146.

b. For normal operation, align the system video levels as follows:

(1) At the east *master* and *slave* terminal Multiplexer Sets AN/TCC–13, adjust each (*master* and *slave*) OUTPUT AMPL potentiometer R74 so that the base line-to-positive peak and base line-to-negative peak pulse amplitude

at the front panel MASTER OUTPUT TO RF test jack on *master* Multiplexer TD–60/TCC–13 are .5 volt each.

(2) At the east terminal *master* Multiplexer Set AN/TCC–13, adjust 45 CHAN PHASE potentiometer R3 until the spacing between the second positive marker pulse and the second negative marker pulse is 2.6 usec.

(3) At the east terminal Radio Set AN/TRC–29, adjust the transmitter video input level control to obtain 100 per cent modulation. (Positive and negative should be within 10 per cent of each other.)

(4) At the repeater station, observe the wave form on the AN/TRA–10 or AN/TCA–1 at the INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing receiver for a peak pulse train amplitude of 1 volt.

(5) At the repeater station AN/TRA–10 or AN/TCA–1 westgoing side, place the 23 CHAN-45 CHAN switch in the 45 CHAN position, P.T. OUT AMPL switch in the LOW position, and adjust the SYM ADJ potentiometer for a symmetrical pulse train of equal amplitude at the OUTPUT TO WESTFACING XMTR test jack.

(6) At the repeater Radio Set AN/TRC–29, adjust the video input level control on the westfacing transmitter for 100 per cent modulation.

(7) At the west terminal Radio Set AN/TRC–29, adjust the video output level control so that the peak-to-peak pulse train amplitude at the Multiplexer Set AN/TCC–13 MASTER INPUT FROM RF test jack is 1 volt.

(8) Repeat the procedures outlined in (1) through (7) above for the other direction of transmission.

c. The nonoptimum operating conditions of the AN/TCA–1 or AN/TRA–10 are those that cause lower than 1-volt peak-to-peak pulse amplitude input to the AN/TRA–10 or AN/TCA–1. These may be caused by exceedingly long cable lengths between the AN/TRA–10 or AN/TCA–1 and the rf equipment (AN/TRC–29) or insufficient output from the receiver of the rf equipment. Under these conditions, set the system video levels as follows:

(1) Proceed as directed in *b* (1) through (3) above. If the video cable between the AN/TCC–13 and the AN/TRC–29 is very long it may not be possible to modulate 100 per cent with .5-volt output from the AN/TCC–13. If this occurs, make the output from the AN/TCC–13 large enough to be able to get 100 per cent modulation.

(2) At the repeater station, observe the wave form on the AN/TRA–10 or AN/TCA–1 at the front panel INPUT FROM EASTFACING REC test jack and adjust the video output level control on the eastfacing receiver for a maximum peak-to-peak level.

(3) At the repeater station AN/TRA–10 or AN/TCA–1 westgoing side, place 23 CHAN-45 CHAN switch S1 in the 45 CHAN position, P.T. OUT AMPL switch S2 in the HIGH position, and adjust SYM ADJ potentiometer R33 for a symmetrical pulse train at the OUTPUT TO WESTFACING XMTR test jack.

(4) Perform the adjustments described in *b* (6) through (8) above. If the amplitude into the AN/TCC–13 is too small, set the AN/TRC–29 receiver video output level control for maximum.

CHAPTER 7

MULTIPLEXER SET AN/TCC–13 THEORY OF OPERATION

Section I. BASIC PRINCIPLES

148. General

Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10 are part of a microwave radio-relay system. The units are used to provide 23-channel telephone service between the two terminals of a time-sharing pulse-position modulated radio-relay system. Multiplexer Set AN/TCC–13 converts the 23 voice channels from a manual switchboard to a pulse-position modulated time-division multiplexed, pulse train. At the distant terminal, the ppm-tdm train is converted back to the original voice frequencies in the original channels. Multiplexer Group AN/TCA–1 provides drop-and-insert facilities (channels one through eight) and wave-form reshaping at a drop-and-insert repeater station. Pulse Form Restorer Group AN/TRA–10 provides wave-form reshaping and drop-and-insert facilities (channels one and two) at a pulse forming repeater station. Paragraphs 149 through 152 describe the basic principles of pulse-position modulation, time-division multiplexing, and the combination of the two which results in the ppm-tdm train. Paragraph 153 describes the basic principles of wave-form reshaping.

149. Principles of Multiplexing

a. General. The simultaneous transmission and reception of many channels of information or intelligence over a single line or carrier is called multiplexing. There are two basic methods of multiplexing, multiplexing in frequency and in time. The method known as *frequency-division* multiplexing identifies each channel with a separate subcarrier frequency. Each vf signal modulates a subcarrier identified with its channel. The modulated subcarriers are then combined and transmitted. At the opposite terminal these combined subcarriers are separated, usually by filters, and the subcarrier identified with each channel is demodulated (the subcarrier removed), restoring the original vf signal. The second method is known as *time-division multiplexing.* In this method, samples of each channel are transmitted in time sequence.

b. Time-division Multiplexing. In a time-division multiplexed system, the message information is transmitted intermittently rather than continuously. The audio signal to be transmitted is converted into a series of modulated pulses rather than a continuously changing wave.

(1) In the telephone system shown in figure 147, switches S1 and S2 are synchronized so that when S1 is in position A, S2 is in position A, and similarly, both are in position B at the same time. If a telephone call is made on telephone line 1, it is completed when the switches are in position A. Similarly, the calls on telephone line 2 are completed when the switches are in position B.

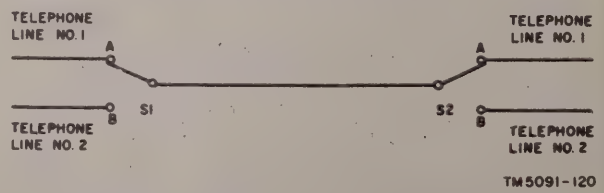


Figure 147. Simple time-division multiplexing example.

(2) Assume that both lines are in use and that the switches are moving back and forth between positions A and B. If this is done at a slow rate, each party loses an appreciable part of the signal. However, as the rate of the switching increases, less and less of the signal is lost. Finally, when the switching rate is high enough (twice the frequency of the highest audio component being transmitted), no audio information is lost and two conversations can be held over the same line simultaneously. Each line is actually connected, but half the time. By this method instead of transmitting a continuous signal about the instantaneous amplitude of the input wave form, periodic *samples* of the signal are taken. No information is lost because the human ear cannot detect the high-speed interruption and the listener does not notice any perceptible difference between what he hears and normal uninterrupted sound. This method of splitting up the time that is used by each telephone is called *time division.*

(3) This same method of splitting the time can be used with two eight-position rotary switches. In the example shown in figure 148, each of the lines is connected by the transmitting medium only one-eighth of the time, but continuous sound is heard when the sampling rate is high enough. As the switch completes a cycle, each channel is sampled once. That is, the instantaneous amplitude of the first channel is sampled, then the second channel is sampled; when all channels have been once sampled, the switch is at its original position and the process is repeated. With the proper circuitry the switch can be closed for as short a period as desired. In this equipment, the transmission time is broken up into 24 parts, one portion for each of the voice-frequency channels plus one for a sychronizing channel. Electronic switching rather than mechanical switching is used.

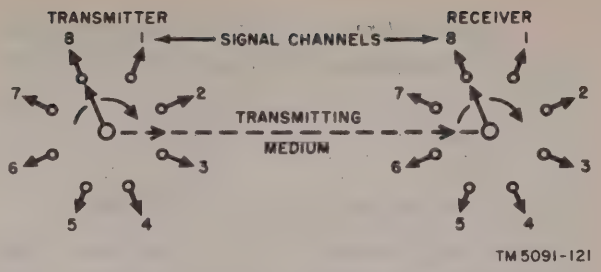


Figure 148. Eight-channel, time-division multiplexing example.

150. Principle of Pulse-position Modulation

a. General. When a carrier conveys audio information, the carrier must be changed, or modulated, according to the audio information. Various characteristics of the carrier may be modulated for this purpose.

b. Pulse-position Modulation. Pulse-position modulation consists of using information, such as an audio-frequency signal, to change relative positions of pulses in accordance with the modulating signal applied to the circuit. With no audio signal present, pulses are produced at constant intervals. When an audio signal is present, the time position of the pulse relative to its position when there is no modulation is varied as a function of the instantaneous amplitude of the audio signal. Curve A (fig. 149) is the modulating signal and curve B is the resulting pulse-position modulated series. As shown in B, figure 149, the position of each pulse varies around *zero,* the unmodulated position. Viewing curve B from the top down, the following sequence occurs:

(1) With the modulating voltage slightly positive, the modulated pulse is shifted to the right (occurring later in time).

(2) With the modulating voltage still more positive, the modulated pulse is shifted further to the right (occurring still later in time).

(3) With the modulating voltage negative, the pulse is shifted to the left (occurring earlier in time).

(4) With the modulating voltage still more negative, the modulated pulse is shifted further to the left (occurring still earlier in time).

(5) The speed at which the pulse varies is determined by the frequency of the audio signal and the distance which

the pulse varies is determined by the amplitude of the audio signal.

Note. This principle applies to each pulse in the pulse train.

151. Modulation of Channel Pulses

a. In the absence of an af signal, pulses from a given channel are produced at constant time intervals of 125 microseconds (8,000 times per second). When a 1,000-cps audio signal (A, fig. 149) is used to position-modulate these channel pulses, the time interval (period) for a full cycle of the 1,000-cps signal is 1,000 microseconds. During this cycle, eight channel pulses are formed at 125-microsecond intervals. Assume also that the first pulse appears at the beginning of the cycle (B, fig. 149). When the amplitude of the sine wave is zero, the first pulse remains in its unmodulated position. By the time the second pulse (in the second frame) is formed, however, the 1,000-cycle signal has become positive. The effect is to cause the second pulse to appear later than an unmodulated pulse. At the time of the third channel pulse (during the third frame), the sine wave has reached its maximum positive amplitude resulting in a maximum displacement of that pulse from its unmodulated position. The amount of time displacement is directly proportional to the instantaneous amplitude of the modulating signal.

b. At the time of fourth channel 1 pulse the sine wave has decreased in amplitude toward zero, and the displacement has decreased accordingly. When the fifth sample is taken, the modulating voltage is at zero and there is no displacement of the pulse. An increase in amplitude of the signal in the negative direction then causes the succeeding channel pulses to appear earlier than would the unmodulated pulse. This opposite displacement is also directly proportional to the instantaneous amplitude of the sine wave. In this specific example, after 1,000 microseconds, the amplitude of the signal again is zero, and the cycle begins over again. The ninth pulse corresponds to the first pulse, thus beginning a new series.

c. The time interval between pulses in each channel of the multiplexer set is 125 microseconds. Since the 1,000-cps sine wave in figure 149 is sampled eight times during each cycle, each interval or period corresponds to a frequency of 8,000 cps. This is called the sampling rate, or scanning frequency.

d. Each of the 23 channels of the multiplexer set is modulated as described above.

e. The pulse is said to be 100 per cent modulated, when it reaches the maximum allowable displacement. Maximum allowable displacement of the pulse (100 per cent modulation) in the multiplexer set is .5 microsecond.

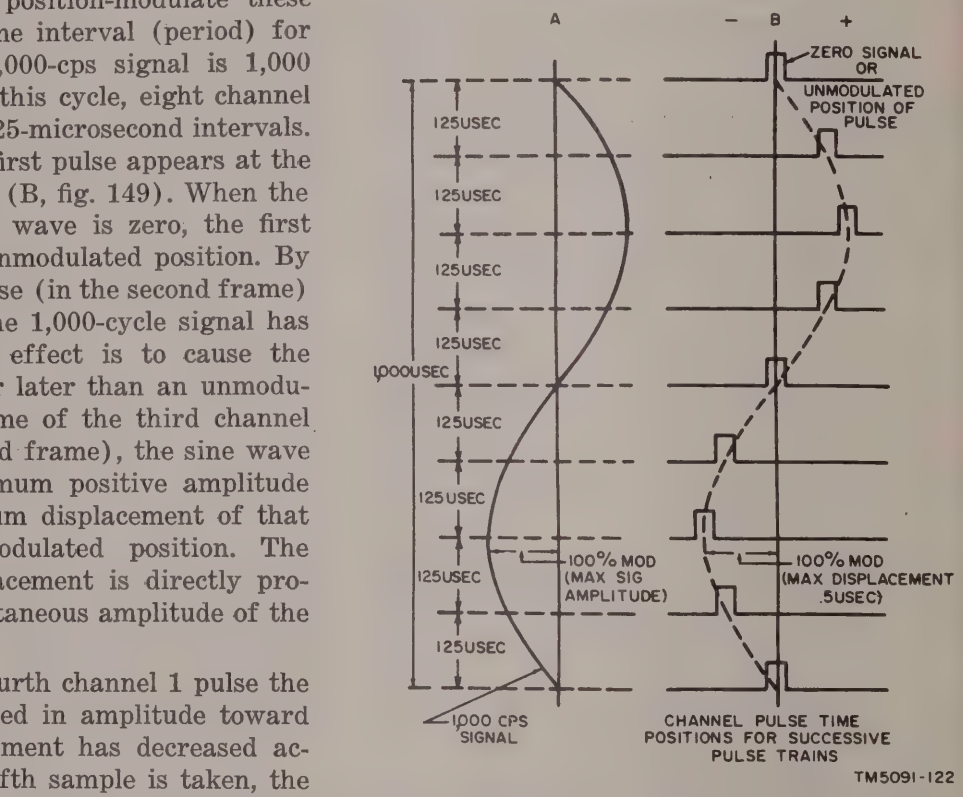


Figure 149. Principles of pulse-position modulation.

152. Time-division Multiplex Operation

The multiplexer set combines ppm with tdm. Each channel pulse displacement is only a small fraction of the total available time. During the remaining portion of time other modulating pulses are inserted. The total time is divided among 23 channels and a double marker pulse.

a. The multiplexer set combines 23 vf signals received from a manual switchboard, in such a manner that all may be transmitted on one carrier. This is done by sampling each of the channels sequentially by means of sampling pulses that are separated in time. A demulti-

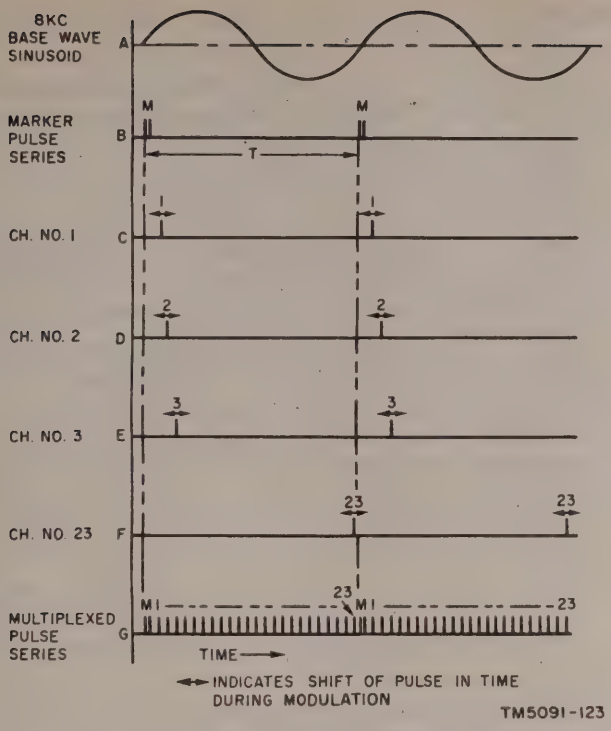


Figure 150. Principles of time-division multiplexing.

plexer can then separate the channels, demodulate each channel pulse series, and thus recover the 23 original vf signals.

b. Each complete pulse train fed to the transmitter consists of 23 channel pulses plus a marker pulse. The marker pulse at B, figure 150 is a double pulse and is used as a reference. The pulse that occurs immediately after the marker pulse is called the channel 1 pulse (C). The next pulse is called the channel 2 pulse (D), and so on to the channel 23 pulse (F). There another marker pulse is formed and the entire train is repeated.

c. The marker pulse and signal pulses in any one channel occur at 125-usec intervals (the time duration of 1 cycle at 8,000 cps). The individual channel pulses occur only once each frame.

d. In B, figure 150, the marker pulse starts the train. If the channel pulses are unmodulated, the channel 1 pulse occurs 6.2 microseconds after the leading edge of the second marker pulse. The time is measured from the leading edge of the second marker pulse to the leading edge of the channel 1 pulse. After 5.2 microseconds, the channel 2 pulse occurs. After another 5.2 microseconds the channel 3 pulse occurs, and so on, to the channel 23 pulse (at F). The second marker pulse appears again 5.2 microseconds after the occurrence of the channel 23 pulse, and the entire pulse train is repeated. The time for one complete pulse train is 125 microseconds.

e. The channel pulses and the marker pulses taken together form the pulse train (or the multiplex pulse train). The number of channels can be as many as the equipment permits.

f. The 45-channel operation is obtained by applying the time-division principle to two 23-channel pulse trains. That is, a 23-channel *positive* pulse train and a 23-channel *negative* pulse train are added together with a delay. One channel is deleted to add a marker pulse.

g. To prevent interference (cross talk) between successive channels, the amount of modulation (delay or advance) of a channel pulse is limited to .5 microsecond. Limiting action starts at .5 microsecond but overmodulation will cause greater deviation. Even if the channel 1 pulse is at its maximum right-hand position and the channel 2 pulse at its maximum left-hand position, enough space (guard time), is allowed so that these pulses do not run together.

153. Wave-form Reshaping
(fig. 151)

Whenever pulses are used, their shape must meet and hold certain predetermined requirements. When the width, amplitude, or rise and decay time of a pulse shape deteriorates, it is necessary to restore it to its original shape. The following parameters must be considered:

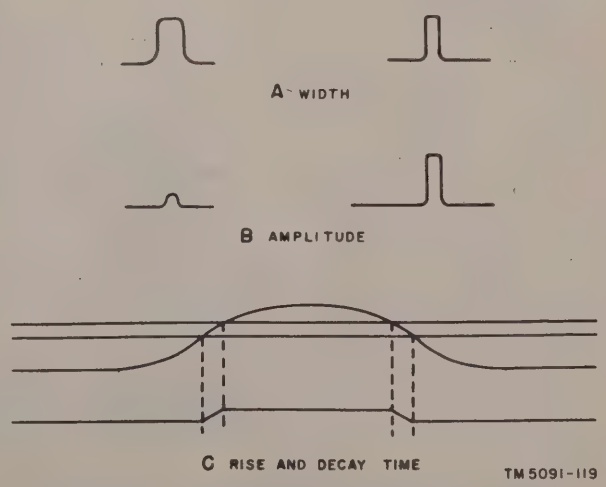


Figure 151. Principles of wave-form reshaping.

a. Width. If the pulse width has changed and it becomes necessary to narrow or widen the received pulses, differentiating and slicing circuits are used. A, figure 151, depicts an incoming pulse whose width has deteriorated, and an outgoing pulse whose width has been restored to the standard wave shape.

b. Rise and Decay Time. Multihop transmission tends to reduce the bandwidth of the transmitted signal and increase the rise and decay time. To restore the original characteristics, clipping and slicing operations are performed on the pulses. Clipping is an operation wherein the top and bottom of a pulse is clipped off. Slicing is an operation wherein a narrow (10 per cent) slice of the pulse (in amplitude) is taken out. Part C, figure 151, depicts an example of a pulse with rise and decay time restored. The top portion of C, figure 151 shows an incoming pulse whose rise and decay time has been increased. The lower section shows the result of clipping and slicing.

c. Amplitude. If the pulse amplitude has changed, the desired amplitude can be obtained by providing sufficient gain so that the incoming signal will be amplified to the correct level. B, figure 151, depicts an incoming pulse whose amplitude has deteriorated and an outgoing pulse whose amplitude has been increased to the desired level. Use of clipping and limiting circuits limits the output pulses to the required amplitude.

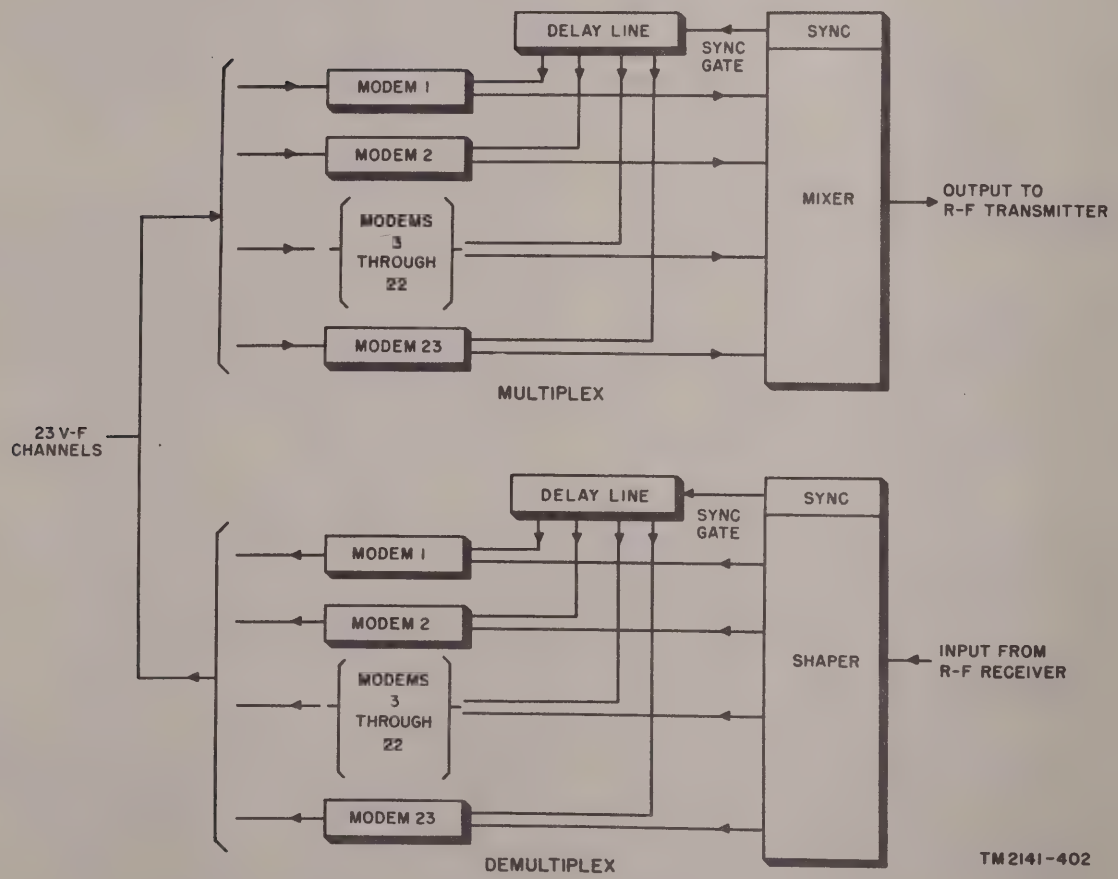


Figure 152. Multiplexer Set AN/TCC–13, over-all functional block diagram.

154. General Applications

a. Multiplexer Set AN/TCC–13 is a transportable, pulse-position, multiplexing equipment designed to combine 23 vf channels so that they can be transmitted over a suitable transmission system. The equipment is also capable of demultiplexing the pulse train that originates at another station. Forty-five channels can be transmitted over a suitable transmission system by using two multiplexer sets. For 45-channel operation, refer to paragraphs 195 through 197.

b. The multiplexer set performs two separate functions. multiplexing and demultiplexing. The modem, delay line, and common unit each have both the multiplexing and demultiplexing sections combined physically, in one chassis. During multiplexing operation, the vf signals to be relayed are fed into the modems, converted to pulses, mixed in the common unit, and fed to a transmitter. During demultiplexing operation, the video signals from the rf receiver are fed to the common unit. The common unit reshapes and amplifies the channel pulses and feeds them to the modems. The common unit also generates a gate that is fed through the delay line into the 23 modems.

c. Paragraphs 155 through 156 describe the multiplexing and demultiplexing functional sections of Multiplexer Set AN/TCC–13. The various power supplies and test equipment supplied as part of the multiplexer set are described in paragraphs 157 and 158.

155. Functional Description of Multiplexer Section

(fig. 153)

a. Modulation of the channel pulses is accomplished in 23 individual and identical modem units. These units include provisions for either two- or four-wire operations. A functional block diagram of the modem modulator is shown in figure 153. The audio signal is fed into a crystal diode clipper whose function is to limit the modulating voltage to a specific maximum value. The clipped audio signal is then fed to an amplifier whose output feeds the pulse position modulator. Twenty-three gates separated in time (one for each modem) are fed from the delay line to the pulse position

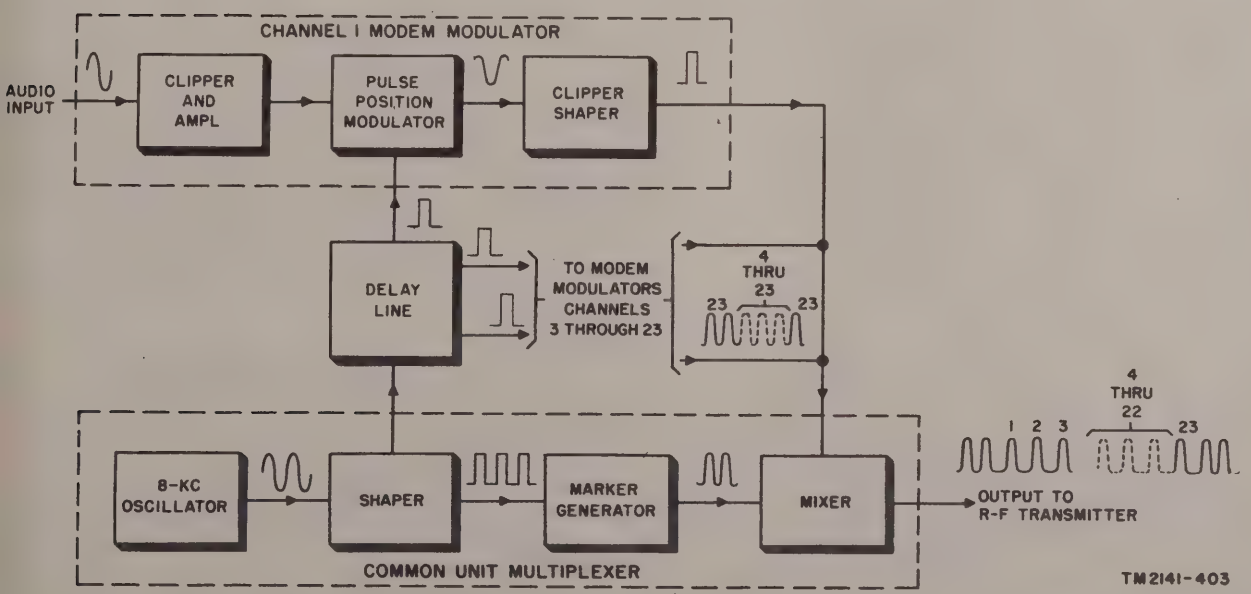


Figure 153. Multiplexer Set AN/TCC–13, multiplexer section, functional block diagram.

modulator. In each modem, the output of the audio amplifier modulates the pulses from the delay line in the pulse position modulator. The ppm pulse is clipped and shaped and fed to the mixer in the common unit.

b. The common unit multiplexer section contains circuits for generating an 8-kc sine wave signal (8-kc oscillator), clipping and amplifying the signal into a gate pulse (shaper), and applying this gate pulse to the delay line. The output of the shaper is also fed to a marker generator which produces pulse marker pulses to synchronize the entire system.

c. The delay line produces 23 gate pulses for each generator gate pulse, each of the 23 being delayed approximately 5.2 microseconds from the adjacent one, establishing the time position of the 23 channel pulses. Each of these gate pulses is applied to one of the 23 modems, where it is used to generate the channel pulses.

d. In the mixer, the output of all the modems is combined with the output of the marker generator to form the pulse train which is the video output signal of the multiplexer set.

156. Functional Description of Demultiplexer Section

(fig. 154)

a. The received pulse train is applied from the receiver to a shaper circuit and then to the 23 individual modems. A gating signal is also applied to each modem as described in *b* and *c* below. Each modem contains a demodulator section that changes the pulse signal associated with it into an audio signal, described in *d* below. The audio signal is then fed to the telephone lines on either a two-wire or four-wire basis, whichever is desired.

b. The pulse train from the shaper circuit is also applied to the marker separator circuit which extracts the marker pulse, shapes it into a gate pulse, and applies it to the delay line.

c. As with the modulator (par. 155) the delay line provides 23 gate pulses for each marker gate pulse, each of the 23 gates pulses being delayed approximately 5.2 microseconds from the previous one, establishing the time position of the 23 channel pulses. Each resultant gate pulse is applied to one of the 23 modems, which operates only during the gating time. As a result, each modem demodulates only that channel pulse of the full pulse train which is being applied to it. The pulse train is therefore separated into 23 channel signals, one for each modem.

d. The modem demodulator operates to convert a pulse-position modulated signal to a pulse-width modulated signal, which contains the audio component and needs only to be filtered to give the audio output. The delay line

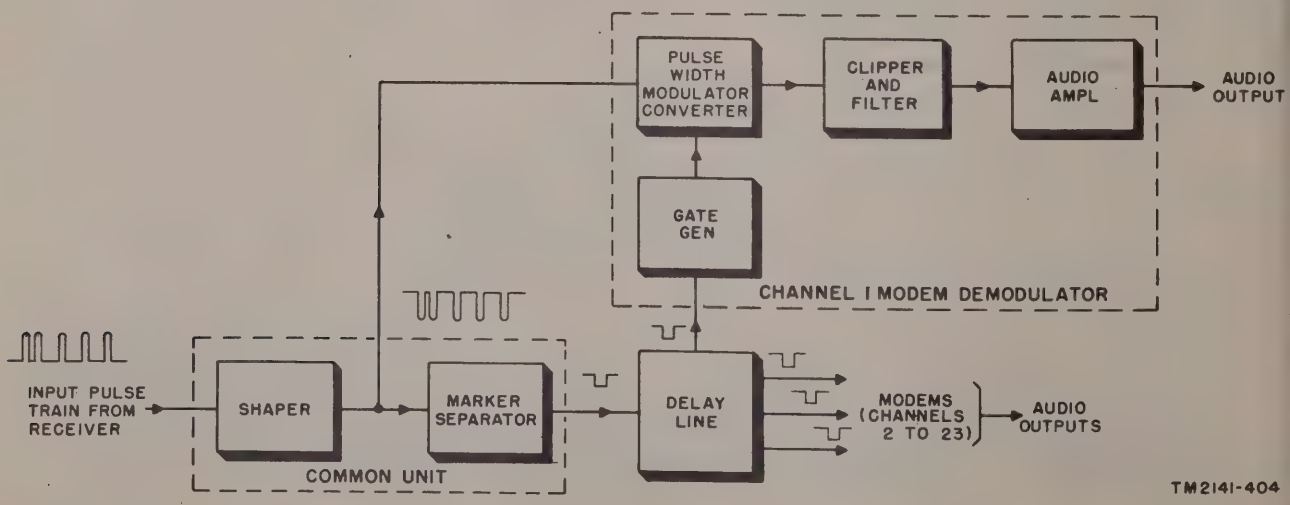


Figure 154. Multiplexer Set AN/TCC–13, demodulation section, functional block diagram.

output is applied to the gate generator of the modem. The gate generator produces a gate for operating the demodulator. The gate determines the time during which the demodulator accepts the signal. The input pulse train is also fed to the demodulator ppm converter. During the gate, conversion of the ppm pulses to a pwm pulse takes place. The pwm signal is applied to the clipper amplifier and then to a low-pass filter which extracts the audio signal. The audio output is amplified and fed to the line.

57. Power Supplies

The power supply for the multiplexer set is composed of Voltage Regulator CN–236/G, Multiplexer Subassembly MX–1442/TC (filament supply), and Power Supply PP–691/G (plate supply). Refer to Chapter 10 for detailed analysis of the power supplies.

a. Voltage Regulator CN–236/G. The voltage regulator is an electromechanically controlled voltage regulator that delivers a constant output independent of line voltage or load current. An autotransformer is included for 115- or 230-volt line voltage operation.

b. Multiplexer Subassembly MX–1442/TC. The multiplexer subassembly contains two 6.3-volt filament transformers for the filament supply of the multiplexer set. In addition, it contains a blower, which provides cooling for the modem units directly above it, and two remote keying units that plug into receptacles mounted on the rear of a multiplexer subassembly.

c. Power Supply PP–691/G. The power supply is the main B+ power supply and provides +250-volt dc with a total capacity of 1.6 amperes. It also acts as the main ac power input chassis and contains the main ac power plate circuit breakers. The line voltage of 115/230 volts should be within ± 10 per cent.

58. Test Equipment

a. General. The accessory test equipment necessary to align and maintain the multiplexer is mounted in one test rack. The accessory test equipment comprises the following: Audio Test Set TS–762/TC, Control Monitor C–1151/TC, and Oscilloscope OS–25/G. Refer to chapter 10 for circuit analyses of the test equipment supplied with the set.

b. Audio Test Set TS–762/TC. This test set is a general purpose, ac operated instrument, designed for the measurement of voice transmission systems. The audio test set incorporates extra connectors for particular use with the multiplexer. The audio test set provides the following:

(1) A low-distortion, variable output, 1,000-cycle oscillator.

(2) A 1,000-cycle level measuring meter.

(3) A 1,000-cycle distortion measuring circuit.

(4) A noise measuring circuit with F1A line weighting.

v. Control Monitor C–1151/TC. The test set is a general purpose, ac operated instrument designed for the measurement of voice transmission systems. The test set incorporates extra connectors for particular use with the multiplexer. The control monitor provides the following:

(1) Circuitry and telephone headset to provide an order-wire telephone.

(2) A push-button switch circuit which, associated with the audio test set, allows testing of the 23 audio channels.

(3) A 20-cycle ringing supply.

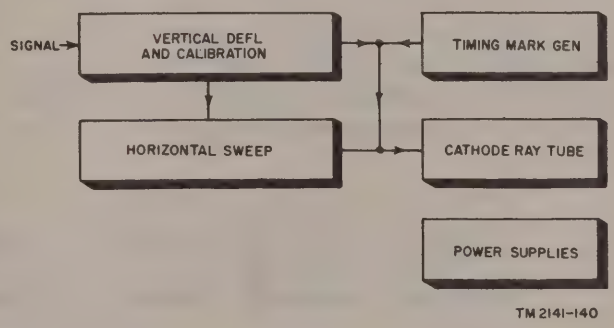


Figure 155. Oscilloscope OS–25/G, functional block diagram.

d. Oscilloscope OS–25/G (fig. 155). Oscilloscope OS–25/G is a 5-mc bandwidth oscilloscope that meets the requirements for the maintenance and alignment of the various sections of the equipment. It differs from an ordinary test oscilloscope because it includes a continuously variable phase synchronizing circuit and 5.2-

microsecond timing pips for the alignment of the unmodulated channel pulses. In addition, it may be used as a high-quality, general purpose, wide band oscilloscope for trouble shooting. The oscilloscope consists of a vertical deflection amplifier, timing mark generator, horizontal sweep, cathode-ray tube, and power supplies. The vertical deflection and calibration circuits amplify the input signal and tap off a 60-cycle signal for voltage calibration. The horizontal sweep provides horizontal deflection for the cathode-ray tube. A timing marker generator provides calibrated crt time signals. Power supplies for all circuits are included.

Section III. 23-CHANNEL MODULATING AND MULTIPLEXING THEORY

159. Common Unit TD–60/TCC–13 Modulation and Multiplexing Block Diagram

(fig. 156)

Common Unit TD–60/TCC–13 contains the circuits for generating an 8-kc sine wave, clipping and amplifying the sine wave, and converting the sine wave into a gate pulse. The gate pulse is then fed from the common unit to the delay line. The common unit develops the marker pulse which synchronizes the entire system. The common unit also mixes all outputs of the modems with the marker pulse and feeds it to the transmitter of a microwave radio-relay system.

a. The sine wave developed in the 8-kc oscillator is fed to 8-kc buffer amplifier V3. The amplified output of the buffer is supplied to shaper V4A, where it is transformed into an 8-microsecond gate.

b. The gate output of the shaper circuit is clipped by diode clipper V5A. It is then amplified by synchronizing output amplifier tube V4B and by power amplifier tube V6. Power amplifier tube V6 is a cathode follower stage whose output is fed to jacks J6. Clipper V5B is coupled across the cathode load of V6 to insure that the amplitudes of the pulses are uniform despite variation of tube and component characteristics. The power amplifier output is also fed to the grid shaper tube V7A.

c. Shaper V7A determines the timing of the marker pulses relative to all channel pulses. Shaper V7B further shapes and amplifies the marker. The output pulse from V7A is applied to marker generator V8A, which produces a pair of pulses that will be used as the marker pulses. The marker pulses are amplified in marker amplifier V8B and fed to mixed train shaper V11.

d. The position modulated pulses of all modems are fed to modem pulse amplifiers V9A, V9B, V10A, and V10B through MODEM CHAN PULSES INPUT jack J3. The amplifiers raise the level of the pulses.

e. Marker amplifier V8B and modem pulse amplifier V10B have a common plate load. The marker pulses and modem channel pulses are mixed there and then fed to the grid of mixed

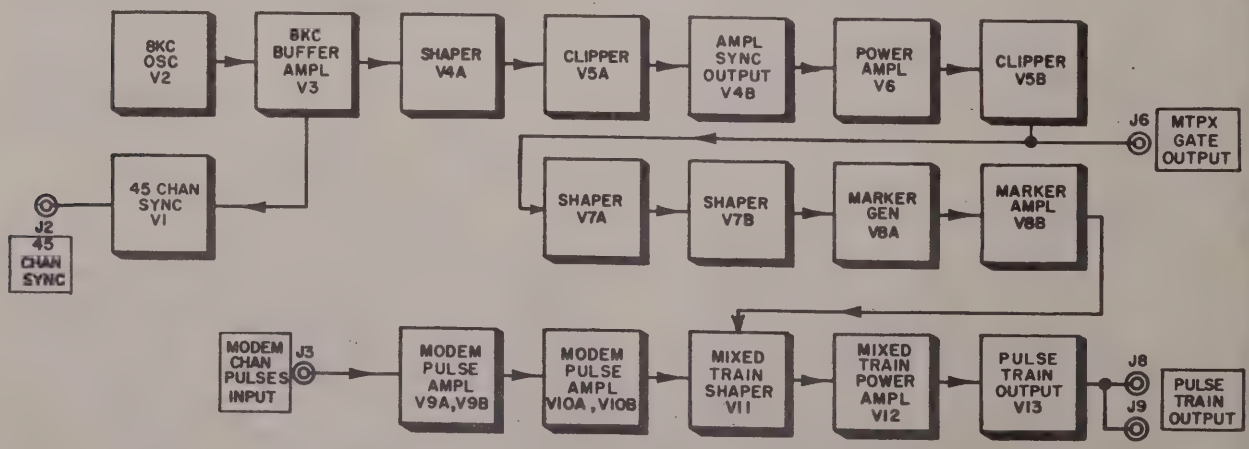


Figure 156. Common unit multiplexer, block diagram.

train shaper V11. The output of V11 is amplified by mixed train power amplifier V12 and pulse train output amplifier V13 and fed to PULSE TRAIN OUTPUT jacks J8 and J9.

f. The output of the 8-kc buffer amplifier is also fed to the *slave multiplexer* through 45-channel synchronizing tube V1. One 8-kc oscillator is used during 45-channel operation to insure proper synchronization of the positive and negative pulse trains. 45-channel sync tube V1 is a synchronizing output cathode follower used only during 45-channel operation.

160. Oscillator Stage, 8-kc (fig. 157)

a. A stable source of 8-kc sine wave voltage is obtained from the generator circuit, tube V2 and crystal Y1. The crystal is cut to have a natural period of vibration at this 8-kc frequency. The circuit used is essentially that of a tuned-grid, tuned-plate oscillator, the crystal constituting the tuned-grid circuit. Oscillations occur when enough energy is fed back to the grid circuit to overcome the grid circuit losses. The crystal keeps the frequency to within a few parts in a million; it will permit oscillations to occur only at the 8-kc frequency to which it is cut. The plate circuit is selectively tuned to 8-kc by inductor L1 and capacitor C6. Since the crystal can only stand a limited voltage, varistor CR1 is included in the output circuit, and has the effect of limiting the oscillator output and the feedback to the crystal.

b. Resistor R8 is a grid parastic resistor, and R7 is the grid return resistor. The cathode bias is developed across resistor R9. Screen voltage is applied through voltage-dropping resistor R10. Resistors R11 and R12 form a voltage divider network. The voltage developed across R12 is fed back to the crystal. Capacitor C5 is a high-frequency bypass on the tube grid. Capacitor C7A is the screen bypass capacitor, C9 is the feed-back coupling capacitor, C8 is the output coupling capacitor to tube V3, and E2 is the 8-kc oscillator test point (8KC OSC).

c. If the unit is to be used as a slave station in a 45-channel system, the 8-kc oscillator is disabled by placing switch S1 in the SLAVE position. This disables the 8-kc oscillator by removing the +250-volt B+ voltage.

161. Diode Clipper CR2 and Amplifier V3 (fig. 158)

a. The output of the oscillator stage, appearing across varistor CR1, is fed into a diode clipping circuit that consists of R13, R14, and CR2. The negative half cycle of the signal causes diode CR2 to conduct. When CR2 conducts the resistance of the parallel combination, CR2 and R14 drops to a low value. Most of the output voltage of the oscillator is dropped across R13 and an insignificant voltage is ap-

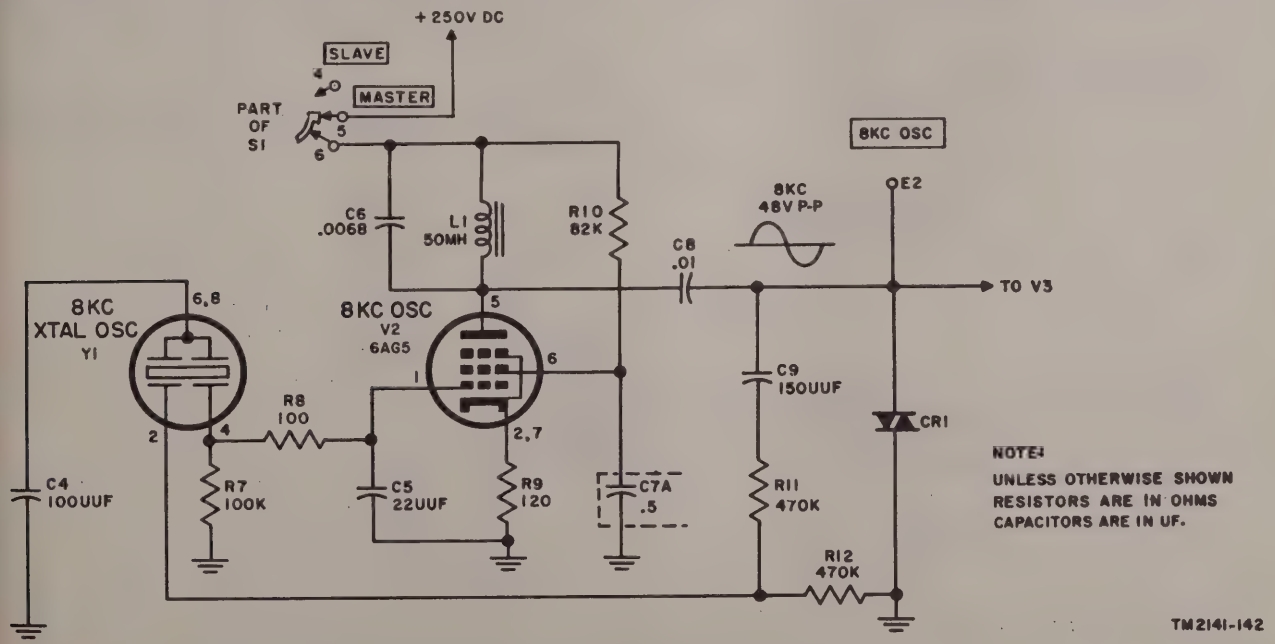


Figure 157. Oscillator, 8-kc, simplified schematic diagram.

plied to the grid of V3. When the incoming signal goes positive, the resistance of parallel combination CR2 and R14 increases (CR2 is no longer conducting and the resistance of the parallel combination increases) and a large voltage is applied to the grid of V3. Resistor R13 and, parallel combination, CR2 and R14 form a voltage divider network limiting the voltage developed across R14, and CR2.

b. The positive voltage applied to the grid is amplified and inverted by V3, and the 8-kc amplifier. Output voltage for the stage is developed across resistor R16 and fed through coupling capacitor C11 and switch S1 to shaper V4A. Capacitor C10A and resistor R17 form the cathode-biasing network for the stage. Capacitor C7B is the screen bypass capacitor and R15 is the grid clipping resistor. Resistor R18 is the screen dropping reistor.

162. Shaper V4A (8-Usec Gate Generator) (fig. 159)

The input to 8-usec gate generator V4A can be fed from two sources. One is from the 8-kc amplifier stage V3 and the other is from the 45 CHAN SYNC output jack J2. When the equipment is being used for 23-channel operation, the input to V4A is from V3; when the equipment is being used as a slave station in a 45-channel system, the input to V4A is from 45 CHANNEL SYNC jack J2. Paragraphs 192 through 194 describe the switching theory when the equipment is being used in a 45-channel system. The subparagraphs below describe the tube operation in a 23-channel system.

a. The output of V3 is fed to the 8-usec gate generator through switch S2 (SLAVE-MASTER switch). The voltage developed across grid leak resistor R20 is fed through parasitic suppressor R21 to the grid. The amplified signal that appears at the plate is fed to short-circuited delay line Z2 where a positive and a negative pulse are formed and fed through capacitor C13 to diode clipper V5A. V5A will conduct only when the cathode becomes negative (with respect to the plate), therefore, only the negative pulse will be impressed on the grid of synchronizing output amplifier V4B. When the cathode of V5A becomes positive (with respect to the plate), no current flows through the tube and no signal is coupled to V4B.

b. When a pulse is applied to a transmission (delay) line, a definite period of time is required for the pulse to travel from the input of the line to the output. This is known as the delay time. To obtain a relatively large delay in a small space, an artificial delay line, that consists of inductors and capacitors, is used. The 8-usec delay line Z1 can be compared to a transmission line.

c. Every transmission line has a characteristic impedance. When the transmission line is terminated in its characteristic impedance, no reflection of energy takes place at its end. If the transmission line is terminated in a short circuit, all of the energy fed into it is reflected back, but the polarity of the reflected voltage is reversed.

d. When the negative pulse from the plate of tube V3 is applied to the grid of tube V4A,

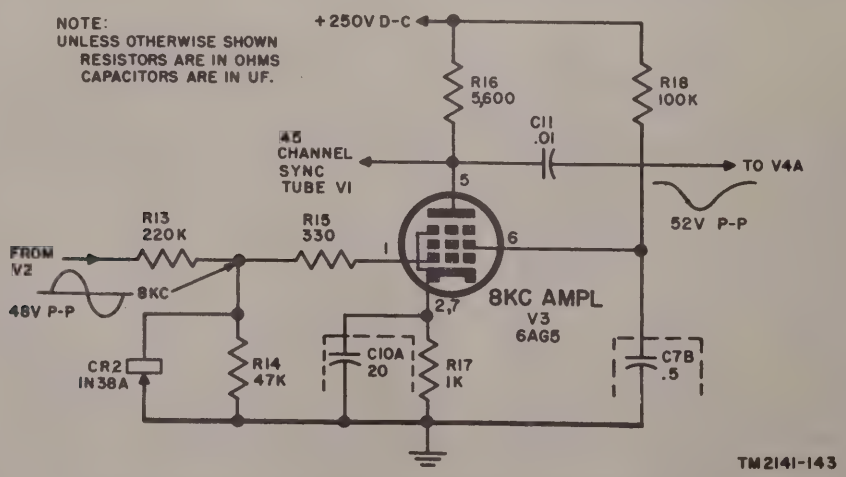


Figure 158. Diode clipper CR2 and 8-kc amplifier V3, simplified schematic diagram.

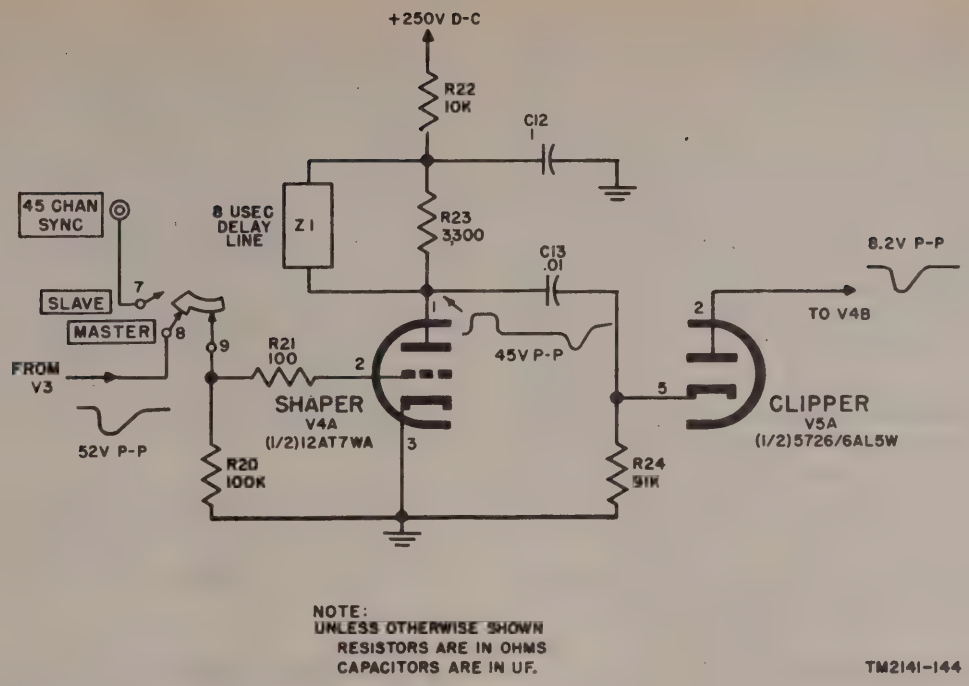


Figure 159. Shaper V4A, 8-usec gate generator, simplified schematic diagram.

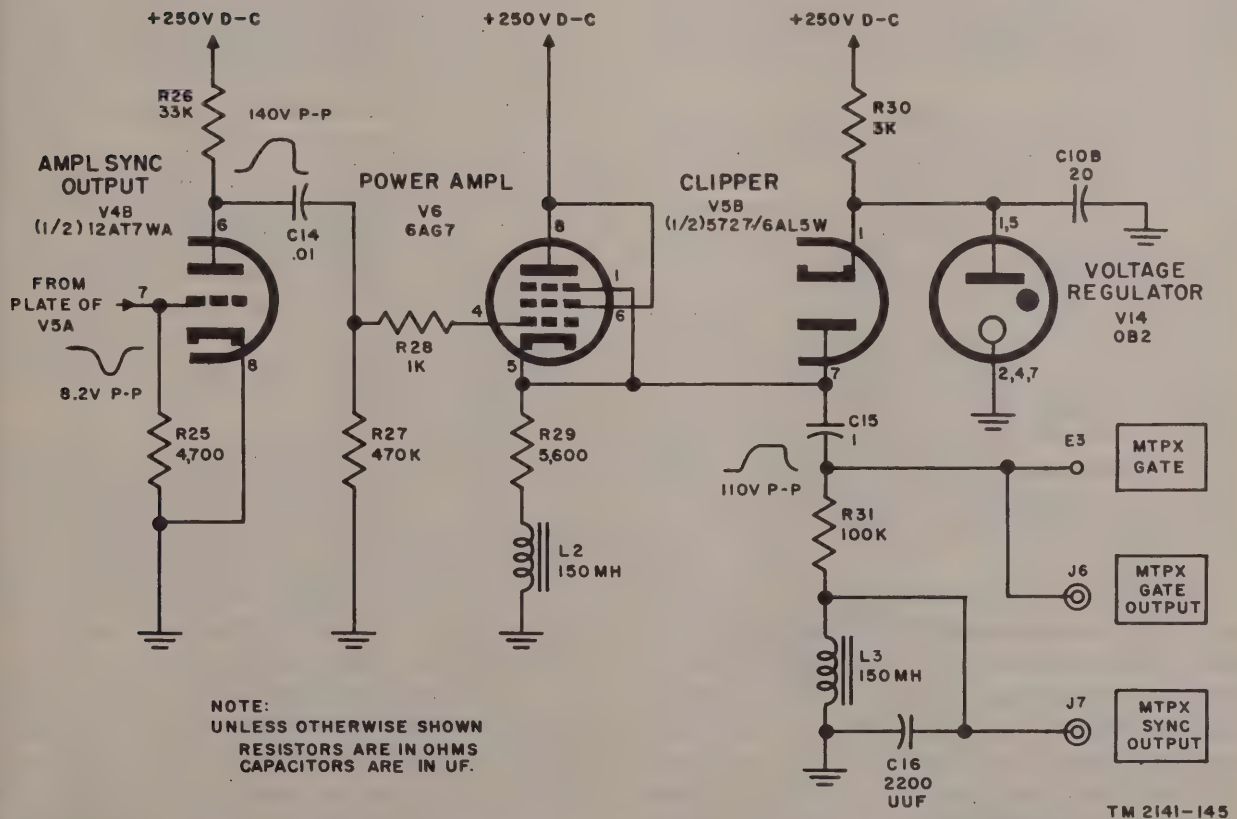


Figure 160. Synchronizing output amplifier V4B and power amplifier V6, simplified schematic diagram.

a large positive rectangular wave is developed across resistor R23. Between the plate and ac ground (junction of R22 and C12) are connected the input terminals of a 4-usec length delay line whose output terminals are short-circuited. The reflection that occurs at the end of the short-circuited delay line sends back a negative pulse. Since the short-circuited delay line is 4 usec long, the leading edge of the reflected wave appears 8 usec after the leading edge of the transmitted wave (4 usec to the end and 4 usec back to the input terminal). The reflection adds algebraically to the original pulse at the plate of V4A with the resultant wave form shown in figure 159. The wave form consists of a positive 8-usec pulse followed by a negative 8-usec pulse.

e. Capacitor C12 and resistor R22 form the plate decoupling network.

163. Amplifiers VB4 and V6 (fig. 160)

The negative gate output of diode-clipper V5 is fed to the grid of amplifier V4B. Amplifier V4B is a voltage amplifier and increases the peak-to-peak voltage of the gate pulse to about 140 volts. The amplified gate is fed to power amplifier V6.

a. The negative gate pulse from V5A is fed to the grid of synchronizing output amplifier V4B. Resistor R25 is the grid leak resistor. Output voltage of the stage is developed across plate load resistor R26 and fed through coupling capacitor C14 to power amplifier V6.

b. Power amplifier V6 is a triode-connected cathode follower. The input signal is applied to the grid across resistor R27, the input load resistor grid return. Resistor R28 is a grid clipping resistor. The output voltage for the stage is taken across resistor R29 and inductor L2, thus making the cathode impedance for the stage high while keeping the bias for the stage low.

c. To insure that the amplitudes of the pulses are uniform despite variation of tube characteristics and components, clipper diode V5B is coupled between the cathode of V6 and a regulated +180-volt potential obtained with voltage regulator tube V14. Tube V5B will only conduct when the signal applied to its plate overcomes the +108 volts applied to the cathode. This prevents the cathode voltage of V5B from becoming greater than +108 volts. Thus, an 8-microsecond positive wave form of 108 volts amplitude is applied through coupling capacitor C15 to the delay line at J6 (MTPX GATE OUTPUT). Between the input to the delay line and ground is connected an 8-kc filter (parallel resonant circuit L3 and C16) in series with resistor R31. This parallel resonant circuit has its maximum impedance at 8 kc. Consequently, the 8-kc component of the main pulse into the delay line appears across it and is available at jack J7 MTPX SYNC OUTPUT to provide a synchronizing signal for the oscilloscope.

d. Tube V14 is a conventional voltage regulator tube across which appears +108 volts. Resistor R30 is the dc voltage-dropping resistor, and C10B is a filter capacitor across the B+ supply.

164. Shaper Stages V7A and V7B (fig. 161)

a. Part of the positive pulse at the cathode of tube V6 is applied to the grid of tube V7A through capacitor C18, through parallel combination C19 and R32 and across resistor R33. The voltage developed across R33 is applied to the grid of V7A. Shaper V7A determines the timing of the marker pulses relative to all channel pulses, and has inductor L4 shunted by crystal diode CR3 as its plate load. The positive pulse at the grid of this stage causes the plate voltage to start oscillating with a negative-going signal. However, when the plate voltage attempts to swing positive, CR3 conducts, shunting the coil with a low resistance, thus damping further oscillation after the first negative-going swing.

b. Resistor R33 is the grid return resistor, C18 is the input coupling capacitor, and resistor R32 in parallel with capacitor C19 is an input coupling network whose function is to shape and delay the input signal. Resistor R35 and C22 is the cathode-biasing network; C20A is the plate decoupling capacitor, and R34 is the plate decoupling resistor.

c. The negative-going pulse from the plate of shaper V7A is applied to the grid of shaper V7B. Tube V7B is normally held at saturation by the B+ potential applied to the grid. The high positive voltage is applied through resistors R37 and R36. The negative input signal

ulse is of sufficient amplitude to drive the tube rom saturation to cut-off. A positive pulse of 5 microsecond width appears at the plate of his stage and is applied to the grid of marker enerator V8A. Plate coil L5 shunted by resis- or R38 determines the width of the marker ulse. For V7B, R36 is the grid return resistor, 37 is the grid current limiting resistor, R39 nd R40 in series are the plate decoupling re- istors, L5 shunted by R38 in addition to etermining the width of the marker pulse is he plate load, C20B is the plate decoupling apacitor, and C23 is the output coupling ca- acitor.

65. Marker Generator V8A and Amplifier V8B

(fig. 162)

a. The positive pulse applied to the grid of 8A produces a negative pulse at the plate. The egative pulse is applied to the input terminals f an open-circuited delay line, Z2, which is 5 usec long. Since Z2 is open-circuited, it eflects a pulse of the same polarity (negative) s that applied to its input terminals. As a esult, the two negative pulses appear at the late of tube V8A, each .5 usec wide. Their leading edges are separated by 1.3 usec (twice .65). This pulse pair constitutes the marker pulse.

b. For V8A, R41 is the grid return resistor, R42 matches the impedance of the delay line Z2 (which acts as the plate load), R44 and R43 comprise a voltage divider and cathode return (which biases the cathode with a positive voltage), C24B is the cathode bypass capacitor, and C25 is the pulse pair output coupling capacitor.

c. The output of marker generator V8A is applied to the grid of marker amplifier V8B through grid clipping resistor R46. The double pulse is amplified and inverted by V8B. The output voltage of V8B is developed across plate load resistor R49. Resistor R49 is also the plate load resistor for modem pulse amplifier V10B. Thus, the marker pulses generated by V8A and the individual channel pulse amplified by modem pulse amplifier V10B are mixed. The voltage developed across R49 is fed to mixed train shaper V11. Resistor R45 serves as the grid return resistor, across which the input signal is developed. Resistors R47 and R48 with capacitor C26A form a plate supply decoupling network.

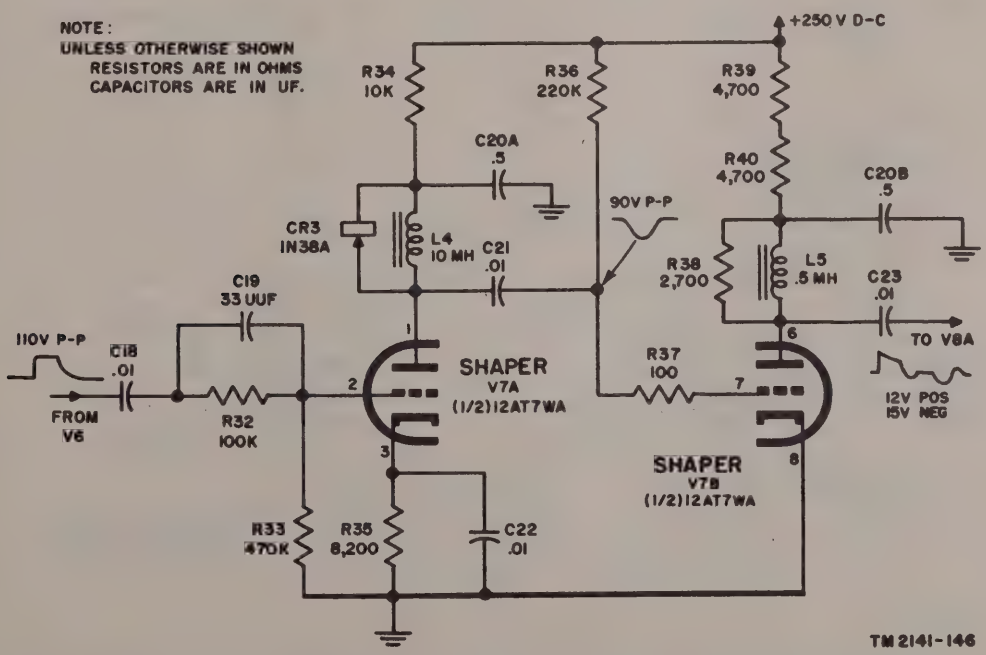


Figure 161. Shaper stages V7A and V7B, simplified schematic diagram.

166. Modem Pulse Amplifier Stages V9A and V9B

(fig. 163)

a. The output of all the modems are fed to the grid of the amplifier V9A via MODEM CHAN PULSES INPUT jack J3 and coupling capacitor C27. Voltage divider network R50 and R51 place a positive potential on the 23 modem output stages cathodes, thereby keeping them at cut-off if no signal is applied to their grids. The output pulse train at the plate of V9A is fed to the grid of amplifier V9B through coupling capacitors C28. Resistor R52 is the grid return resistor for V9A. Bias for V9A is developed across biasing network R54 and C24C. Resistor R55 and capacitor C24A form a decoupling network for V9A and V9B.

b. Amplifier V9B is a conventional voltage amplifier with the input pulse train applied to the grid and the amplified voltage taken from the plate. Capacitor C29 couples the pulse train to V10A. R57 is the plate load and R58 the cathode biasing resistor.

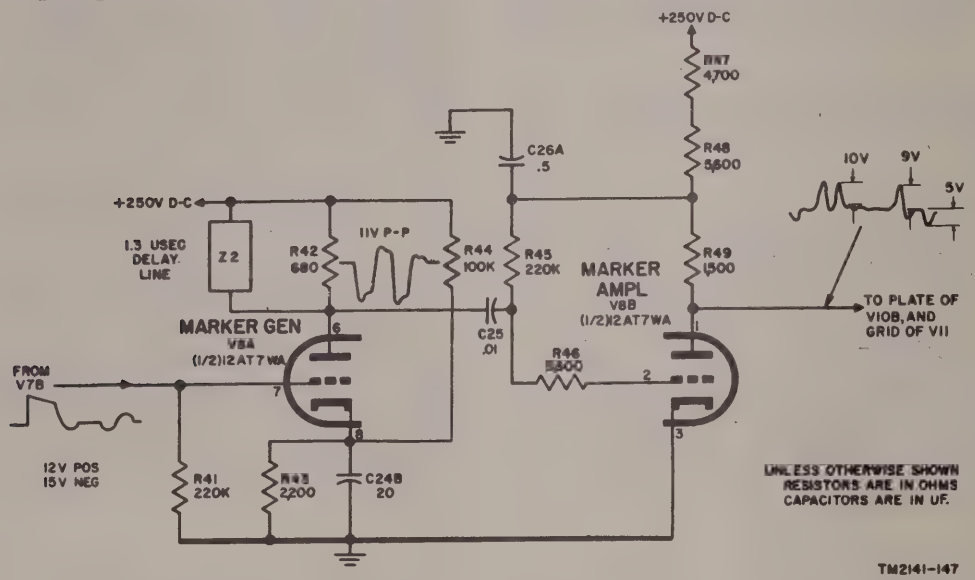


Figure 162. Marker generator V8A and marker amplifier V8B, simplified schematic diagram.

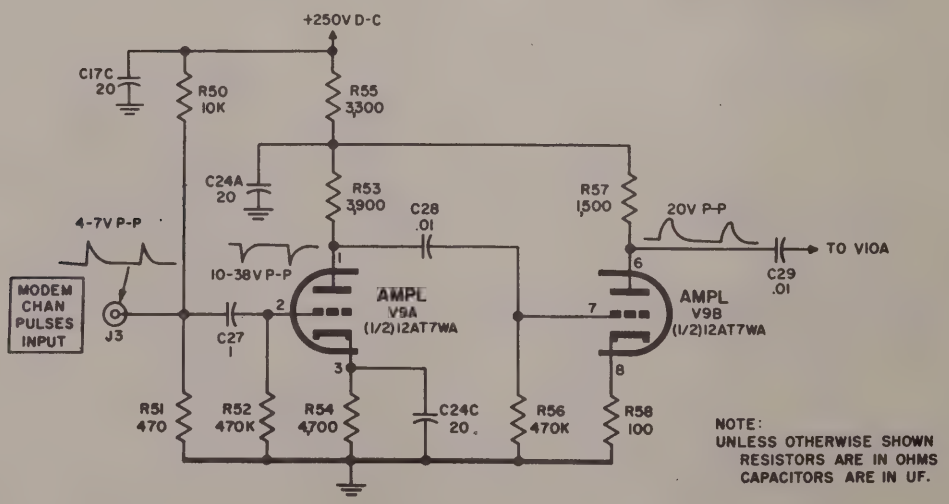


Figure 163. Modem pulse amplifier stages V9A and V9B, simplified schematic diagram.

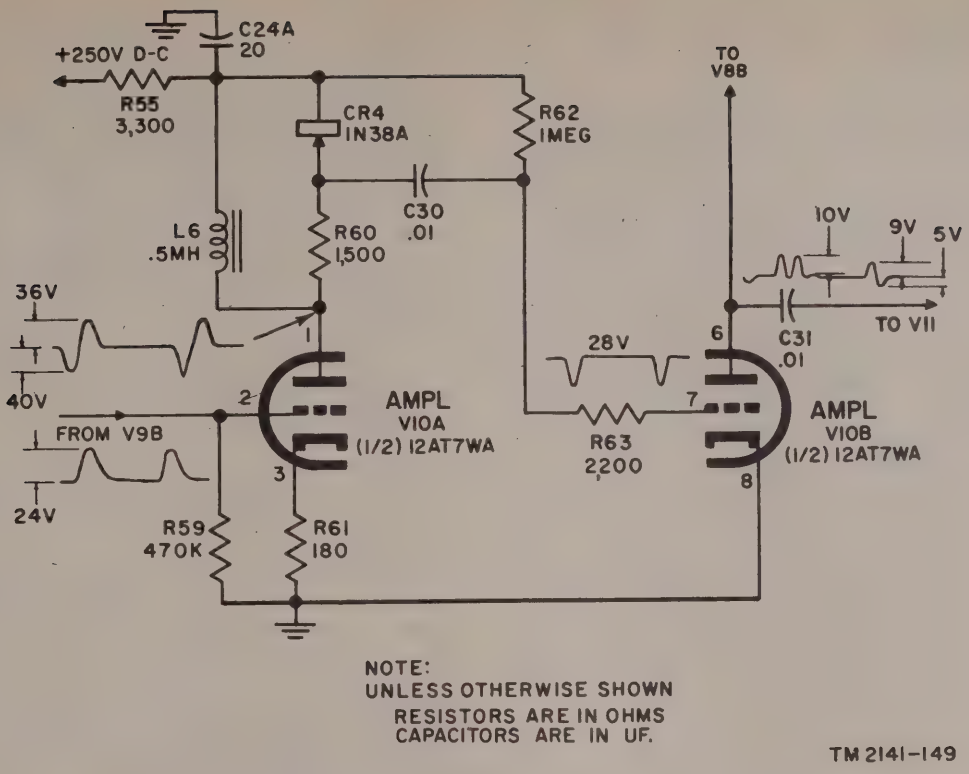


Figure 164. Modem pulse amplifier stages V10A and V10B, simplified schematic diagram.

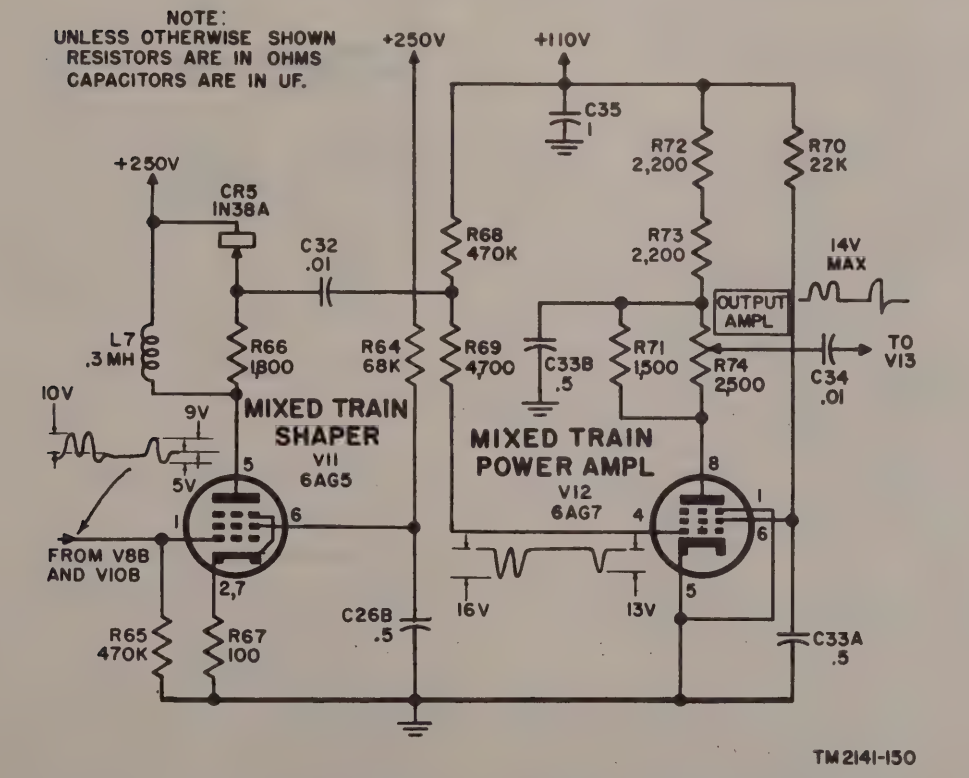


Figure 165. Mixed train shaper V11 and mixed train power amplifier V12, simplified schematic diagram.

167. Modem Pulse Amplifier Stages V10A and V10B

(fig. 164)

a. The signal is fed from stage V9B to tube V10A, where it is further amplified and shaped. Resistor R60 provides a voltage divider action with the conducting diode, giving greater attenuation to the clipped portion of the input signal. When a pulse is impressed across an inductor, an action known as ringing occurs. Crystal CR4 critically damps this ringing so that only the amplified negative pulse is applied to the following stage. Refer to the input and output wave shapes shown in figure 164.

b. Resistor R59 is the grid return resistor, R61 is the cathode resistor, R60 in combination with inductor L6 and diode CR4 is the plate load, and C30 is the output coupling capacitor.

c. Amplifier V10B operates at saturation since its grid is connected to B+ through resistor R62 and current limiting resistor R63. The plate load of tube V10B is common with that of marker amplifier V8B. As a result, the signal coupled through capacitor C31 to mixed train shaper V11 is the mixed output of marker amplifier modem pulse amplifier V8B and V10B.

168. Mixed Train Shaper V11

(fig. 165)

The mixed pulse train is coupled to the grid of V11, a pentode shaping circuit that contains an inductive plate circuit electrically identical to the type described as the plate load of V10A (par. 167*a*). The negative pulses that occur at the junction of R66 and CR5 are coupled to the input of tube mixed train power simplifier V12. For tube V11, R67 is the unbypassed cathode resistor, R65 is the grid return resistor, R64 is the screen voltage dropping resistor, C26B is the screen decoupling capacitor, and the plate load consists of L7, R66, and CR5.

169. Mixed Train Power Amplifier V12

(fig. 165)

Negative pulses applied to the grid of mixed train power amplifier V12 appear as positive pulses in the plate circuit. These positive pulses are applied to the OUTPUT AMPL potentiometer, R74. The arm of the potentiometer is connected to the grid of the output tube (V13) through C34. For the V12, R69 is the grid clipping resistor, R68 couples the grid to B+, and C34 is the output coupling capacitor. Parallel-connected resistors R71 and R74 provide the plate load. Capacitor C33B is the plate circuit decoupling capacitor. Series-connected R72 and R73 complete the decoupling circuit and connect the plate to B+. Resistor R70 is the screen grid voltage dropping resistor. Capacitor C33A is the screen grid bypass capacitor.

170. Pulse Train Output V13

(fig. 166)

Pulse train output stage operates as a triode-connected cathode follower. The input signal, from the mixed train power amplifier, is developed across the grid return. R76 is the grid limiting resistor, and R78 is the cathode load. The output developed across R78 is coupled through C36 to PULSE TRAIN OUTPUT jacks J8 and J9. Resistor R79 provides for an output impedance of approximately 50 ohms. Refer to paragraph 193 for 45-channel operation.

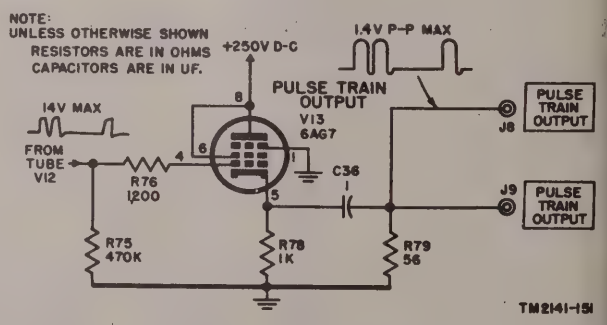


Figure 166. Operation, 23-channel pulse train output, cathode follower V13, simplified schematic diagram.

171. Output Filter, 1 Mc

(fig. 167)

The bandwidth of the pulse train output is limited by the action of the 1-mc filter that consists of L8, L9, L10, L11, C37, C38, C39, C40, C41, R80, and R81. The filter has a nominal cutoff of 1-mc and is down 30 db at 3-mc. The input is fed from PULSE TRAIN OUTPUT jack J8 to INPUT plug P4, while the output is fed from OUTPUT jack J10 to plug P5.

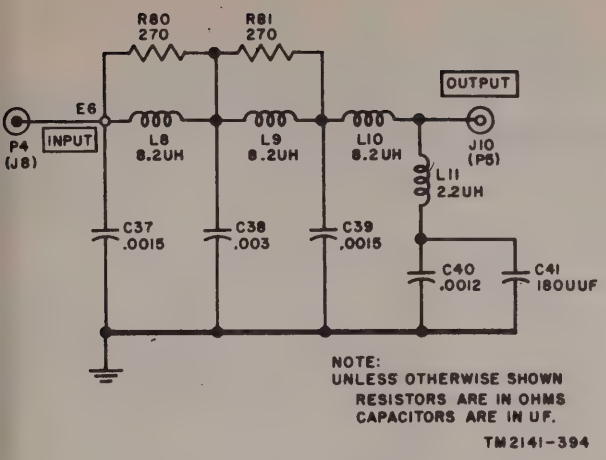


Figure 167. Output filter, 1 mc.

172. Delay Line Circuit

(fig. 168)

a. A delay line is a filter, or a group of filters which have the characteristics of delaying the input signal so that the output is later in time than the input. This is caused by one of the fundamental properties of filters; phase shift. When a number of sections are cascaded, the phase shift becomes additive, and of considerable size. The delay line circuit for the multiplexer set consists of 46 independent 10.4 microsecond delay lines. Twenty-three delay lines are associated with each direction of transmission 23 for the multiplexer half of the common unit and 23 for the demultiplexer half of the common unit. Each of the delay lines provides 23 separate outputs, each delayed by 5.2 microseconds from the adjacent one, thereby maintaining the time position of the channels.

b. A basic section of the delay line is shown in A, figure 168. The entire line consists of repeated sections of this kind of pi-type filters connected to give the desired total time delay. Taps are brought out for the connections to the resistance coupling shaping circuit. Each single section is basically a pi-section, constant K, low-pass filter. Each individual section is referred to as a coil section. When two sections are combined, B, figure 168, a capacitor C is connected across the combination (to correct for phase distortion). The sections are connected in series to give greater delay.

c. The delay line at each section junction is approximately 1.05 microseconds. Five of these sections in series make a nominal 5.2 second delay between successive taps. A tap is always available within 1 microsecond of the correct position.

d. Each of the output taps of the delay line is connected to the respective modem modulator through an integrating circuit which consists of series resistor R38 and shunt capacitor C313 (C, fig. 168). This circuit changes the gate into a sawtooth wave shape. The capacitor is adjustable, to compensate for the difference capacitances of the varying length of shielded wire connecting the individual modem modulators to the delay line. The adjustment is made at the factory and normally would only be changed when a delay line is replaced. The sawtooth voltages to the individual modulators have an amplitude of 20 volts and a rise time of approximately 8 microseconds.

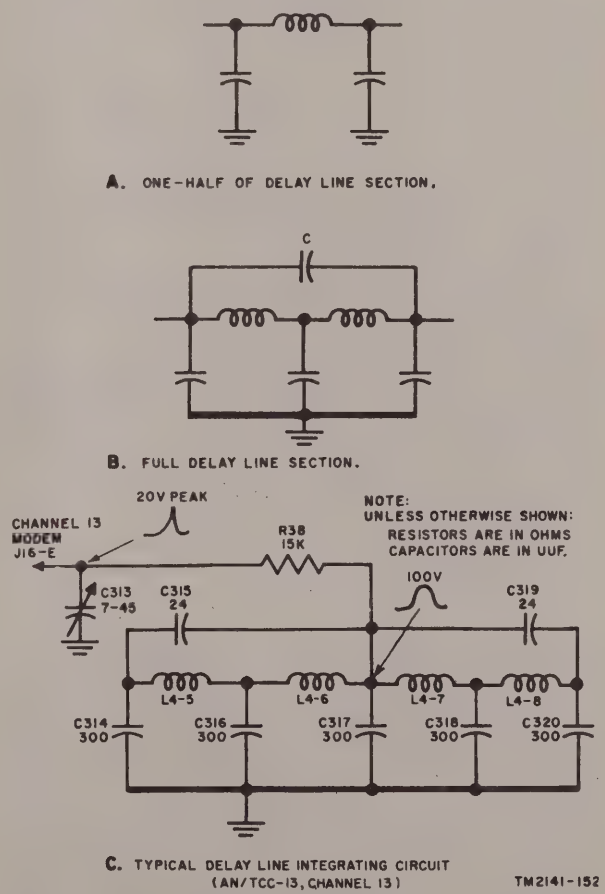


Figure 168. Multiplexer delay line section, simplified schematic diagram.

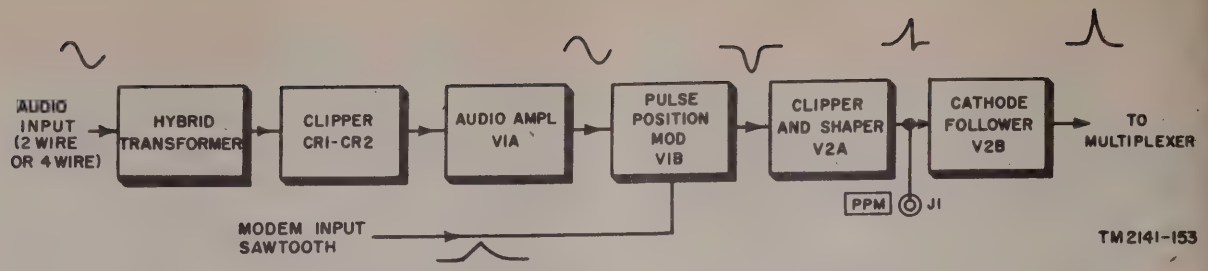


Figure 169. Modem MD–179/TL modulator, block diagram.

173. Modem Modulator

a. General. Modulation of the pulse train is accomplished in 23 individual and identical modem units. Twenty-four modems are supplied with the AN/TCC–13, one is a spare. These units include provision for signaling and provide means for either two- or four-wire operation. The modulator section of the modem consists of two tubes, V1 and V2. The modulator converts the audio input signal into a pulse which is position-modulated.

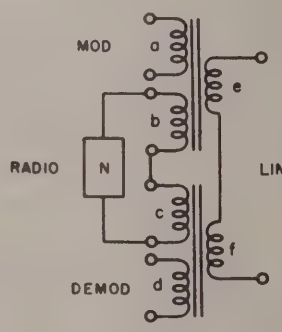
b. Block Diagram. A functional block diagram of the modem modulator is shown in figure 169. The two-wire or four-wire line signal is fed into hybrid transformer T1. The output of the hybrid transformer is fed into a crystal diode clipper (CR1 and CR2) whose function is to limit the modulation voltage to a specific maximum value corresponding to a four-wire input of —4 dbm. The clipped audio signal is then fed to audio amplifier tube V1A from which it is applied to the pulse position modulator tube V1B. Also applied to the pulse-position modulator is a sawtooth from the delay line. It is this sawtooth that the audio signal from audio amplifier V1 modulates. The output of V1B is clipped and shaped in clipper-shaper V2A and fed through cathode follower V2B to the common unit mixer circuits.

174. Hybrid Transformer (fig. 170)

a. General. Provision is made in the modem for either two- or four-wire operation. The audio input and output information can be carried on two wires or four wires (two for transmitting, and two for receiving). A hybrid transformer is basically a means for converting a two-wire system to a four-wire system or vice-versa, as well as an input and output matching device. The most common type of hybrid transformer is shown in A, figure 170. Winding a is the modulator; windings b and c contain a network, N, which matches the input line; winding d goes to the demodulator; and windings e and f in series are the line input. Note the two separate cores.

b. Two-wire Operation.

(1) Consider the action when a signal is being received from the line. The line signal is coupled to each of two inde-



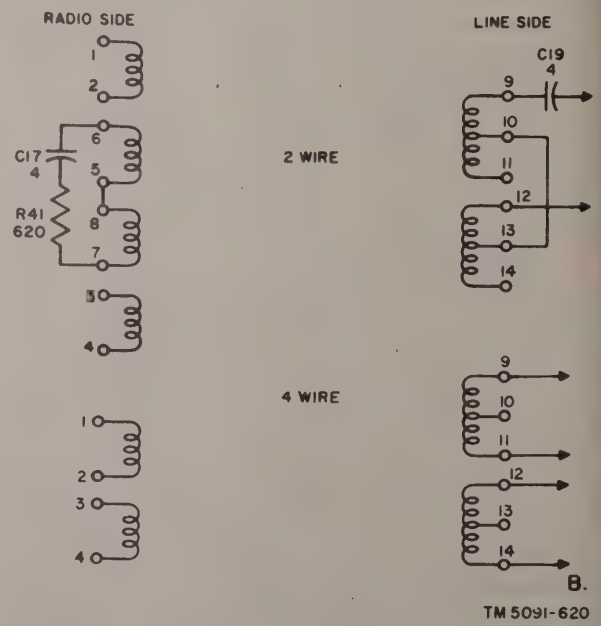


Figure 170. Modem hybrid transformer connections.

pendent cores through windings e and f. Line signal voltages will, therefore, be induced into all other windings, a, b, c, and d. Windings b and c are polarized so that the induced voltages applied to the N-network buck each other and cancel; hence, no power is lost in the network. Windings a and d are similar and therefore half the power appears across each. That voltage that appears across the demodulator winding is applied to the plate of audio amplifier V4B and is lost. The fact that half the power is lost means a 3-db loss is encountered in passing a two-wire input through the hybrid transformer.

(2) Now consider the action in receiving a signal from the demodulator (winding d). The power applied to winding d comes from audio amplifier V4B. Since winding d is coupled to one core only, equal voltages are induced in windings c and f. These induced voltages cause current to flow in both the line and network circuits. Note that if the network impedance accurately matches the line impedance, equal currents will flow through these circuits and through windings b and e. Windings b and e are so polarized that the currents in these windings produce opposing magnetizing forces in the core; hence, no flux changes are produced and no voltage is produced in winding a. The result is that the demodulator signal is not fed to the modulator, and hence no undesirable feed-back signal results. It is this action for which the hybrid transformer is primarily provided.

(3) The two-wire connection for the hybrid transformer is shown in B, figure 170. Capacitor C17 and resistor R41 comprise the matching network. For two-wire operation, one-half the line windings are open-circuited by the connection of terminal 10 and 13. Capacitor C19 is a deblocking capacitor.

c. Four-wire Operation. In four-wire operation, the network is disconnected from the circuit. Note that since the network winding is open, the line side windings are separated, and since the cores are independent, there is now in effect two separate line transformers. Removing the connection between terminals 10 and 13 gives each line winding (e and f) the same number of turns as the single connection for two-wire operation. This hybrid circuit change from two-wire to four-wire operation is accomplished by the 2W–4W switch in the modem.

d. Hybrid Impedance. In four-wire operation, there are essentially two transformers with an impedance ratio of 50 to 1 (30,000 ohms to 600 ohms). In two-wire operation, parts of the two-line side windings are connected in series to give 600 ohms. The network windings are identical to these parts of the line side windings and the network is therefore chosen to match a typical line, and is termed a *compromise network.* The modulator and demodulator windings remain 30,000 ohms. In four-wire operation, windings 5, 6, 7, and 8 are open.

175. Modem Switching
(fig. 171)

a. Modem switching is accomplished by two switches, 2W–4W switch S1 and selector switch S2. The 2W–4W switch connects the hybrid transformer for either two- or four-wire operation. Selector switch S2 has five positions; in the OPER position, the modem is connected to the output terminals. In SL, the output from the audio test set is fed to the modem. In RR, the output of the modem is fed to the level measuring section of the audio test set, and in RL, the output of the lines is fed to the audio test set. The selector switch basically controls a pair of lines (TEST PAIR) between the modem and the audio test set.

b. Resistors R45 and R46 are terminating resistors for the TEST PAIR on one side of the hybrid transformer. Capacitor C18 is a dc blocking capacitor, and C19 drops the 20 cycles to the value necessary to operate the relay. When the selector switch is placed in the SL position, R45 is connected across terminals 12 and 9 of the hybrid transformer. When the selector switch is placed in the RL position, R46 is connected across terminals 12 and 9 of the hybrid transformer.

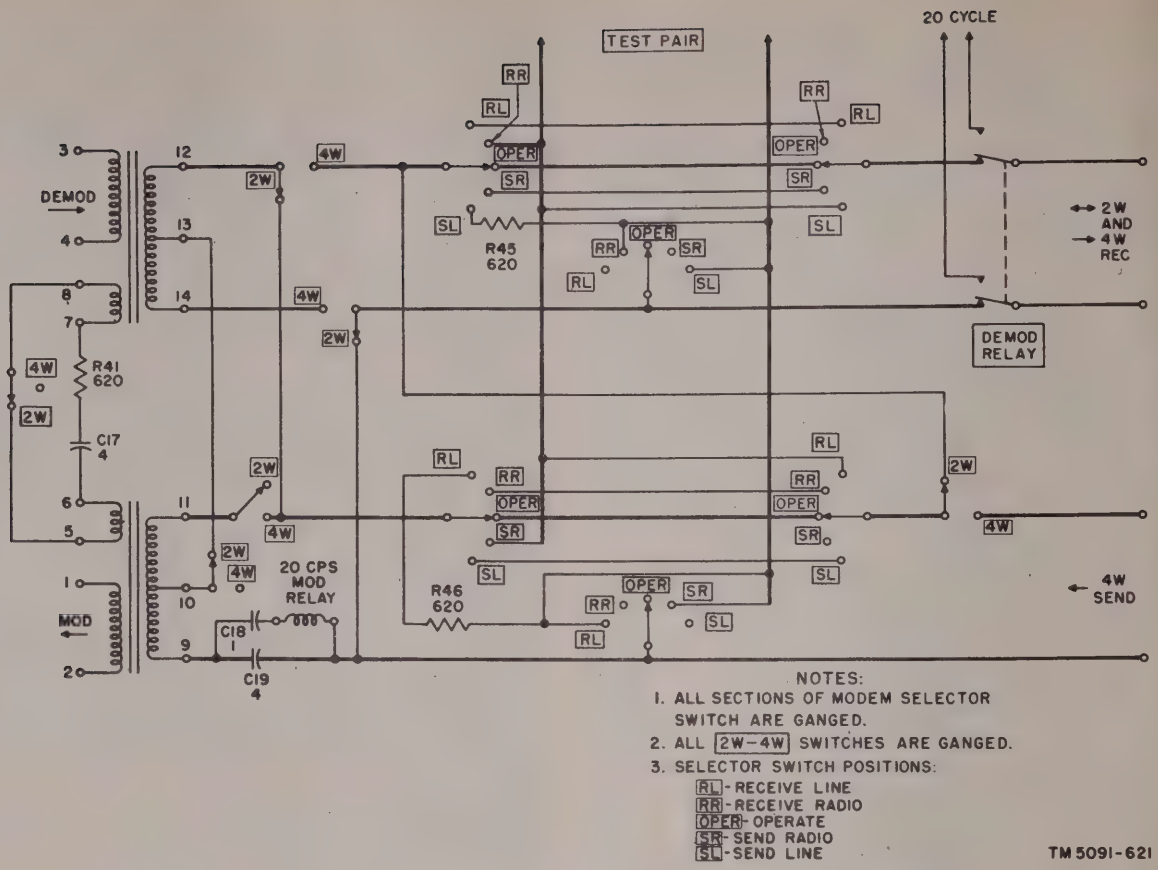


Figure 171. Modem switching circuit, simplified schematic diagram.

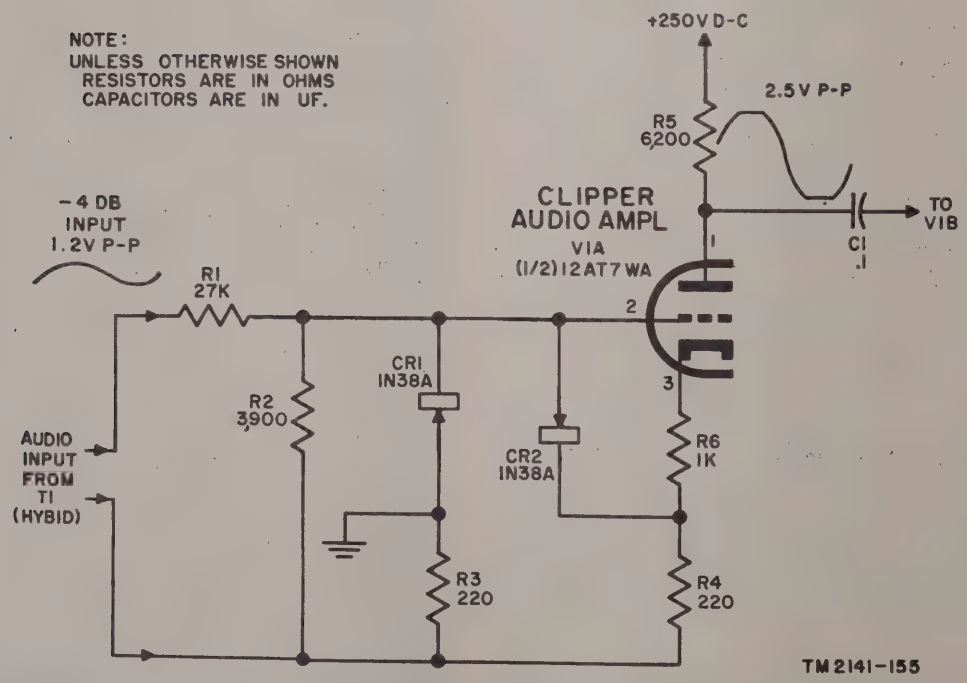


Figure 172. Clipper audio amplifier V1A, simplified schematic diagram.

176. Audio Amplifier V1A
(fig. 172)

a. Audio amplifier V1A amplifies and limits the audio signal applied across resistor R2. Degeneration is provided by unbypassed cathode resistor R6. Crystal diodes CR1 and CR2 limit the audio input signal to prevent excessive modulation or deviation of the channel pulse beyond ±5 usec. Overmodulation will cause an undesirable deviation of more than ±5 usec.

b. Limiting of the audio input is accomplished in the following manner. The cathode of tube V1A develops a positive voltage caused by Class A type plate to cathode current. One side of R2 is connected to the grid and the other to ac ground. The audio input is applied through R1 to the grid. A bias of —.6 volt exists at the junction of R2, R3, and R4. When the input signal is greater than .6 volt, and negative, clipper crystal CR1 conducts, cutting off the signal above that level. When the signal is greater than .6 volt, and positive, CR2 conducts, cutting off the signal which is more positive than .6 volt. In this way, effective limiting of the audio signal applied to the first stage audio amplifier is obtained. Resistors R1 and R2 are a voltage divider on the input voltage to provide correct level. The audio signal developed across plate load resistor R5 is fed to the cathode of V1B through coupling capacitor C1.

177. Pulse-position Modulator Stage, V1B
(fig. 173)

a. Position modulation is accomplished in tube V1B. This stage is normally kept near cut off by the large bias developed across cathode resistors R8 and pulse position potentiometer R9. Two inputs are fed to this stage. One, the sawtooth, is applied to the grid of V1B from the delay line. The other is the amplified audio signal from the plate of V1A and is fed to the cathode of V1B.

b. The af signal applied to the cathode of V1B varies the value of the cathode voltage above and below the normal zero signal value. The sawtooth wave applied to the grid causes plate current to flow when the actual bias (grid-to-cathode voltage) is approximately —5 volts. The value of the af signal applied to the cathode determines the time when this occurs, since the combination of both signals determines the next bias. Since the sawtooth is linear over the range of modulation, the variation of the time of increasing plate current is also linear. The delay line taps are selected so that the center of the sawtooth corresponds in time with the no-modulation pulse position.

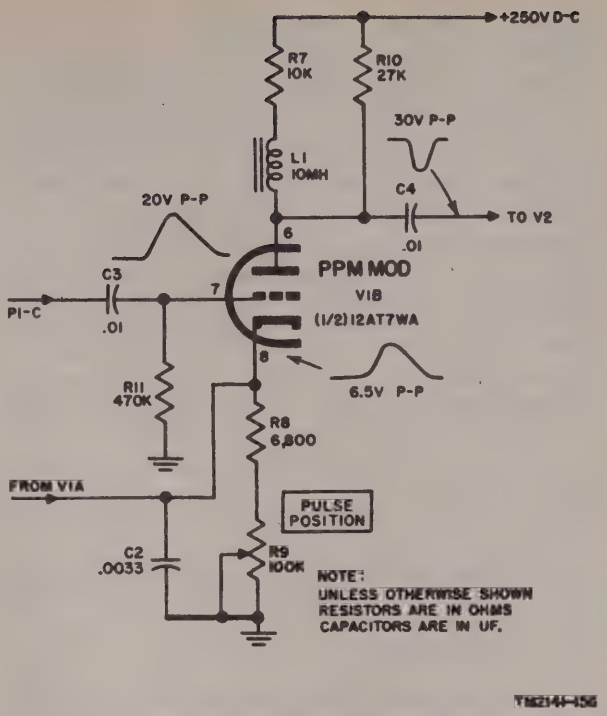


Figure 173. Pulse-position modulator V1B, simplified schematic diagram.

c. Resistor R11 is the grid return and C3 is the sawtooth delay line input coupling capacitor. Resistor R7, inductor L1, and resistor R10 provide the plate load. Capacitor C4 is the output coupling capacitor, R8 and R9 are the cathode-biasing resistors, and C2 is the cathode-bypassing capacitor, offering high impedance at audio frequencies.

d. Changing potentiometer R9 will change the cathode bias and therefore the unmodulated pulse-position. This is a front panel control (PULSE POSITION) and is provided so that no adjustment of the delay line is necessary.

e. The plate wave shape generated across L1 is critically damped by resistors R7 and R10 and a single broad pulse results.

178. Modem Clipper-shaper-mixer V2
(fig. 174)

Clipper-shaper tube V2A has its cathode grounded and its grid returned to a positive

potential through resistors R12 and R13 to insure heavy plate current in the absence of a signal. The negative input pulse is applied to the grid of tube V2A through a 10,000-ohm resistor, R13. This large negative input pulse is of sufficient strength to drive the tube to cut off. This produces a positive pulse at the plate, through the differentiating action of inductor L2 in parallel with the resistor-crystal combination of R17 and CR3, and parallel resistor R16, which ring for a time determined by the component values. These oscillations are damped by diode CR3. The positive output pulse is applied to mixer cathode follower tube V2B through capacitor C6. Mixer tube V2B has a load in common with the load of the same tube in all the modem modulators. This load, R80, is located in the common unit. Resistors R14 and R15 are in series with inductor L2 and form part of the plate load of tube V2A. The plate of tube V2B goes to the remote keying unit for channels 1 and 2 only. For channels 3 through 23, the plate of V2B is connected to the +250 volts dc supply. The modem modulator output pulse is taken from the cathode of V2B.

Section IV. 23-CHANNEL DEMULTIPLEXING AND DEMODULATING THEORY

179. Common Unit Demultiplexer Block Diagram

(fig. 175)

a. The common unit demultiplexer amplifies the received signal, separates the markers, and feeds channel pulses to the modems.

b. The first two stages, tubes V15 and V16, are video amplifiers. From these amplifiers, the signal is fed into the rectifier slicer circuit, V17, which removes noise by taking a thin slice out of the center of the pulse. A part of the signal is fed to pulse amplifier V18, then to video shaper V19, which differentiates the signal in width. The signal is then fed to two stages of amplification, V20 and V21. The output of V21 is fed to marker-separator tube V22, which separates the marker from the rest of the signal. Tube V23 amplifies only the marker. The marker is shaped by tube V24, and then amplified and fed to DEMTPX GATE OUTPUT jack J24 by gate amplifier V25. Tubes V27A and V26 and relay K1 provide alarm functions and are described in paragraph 186.

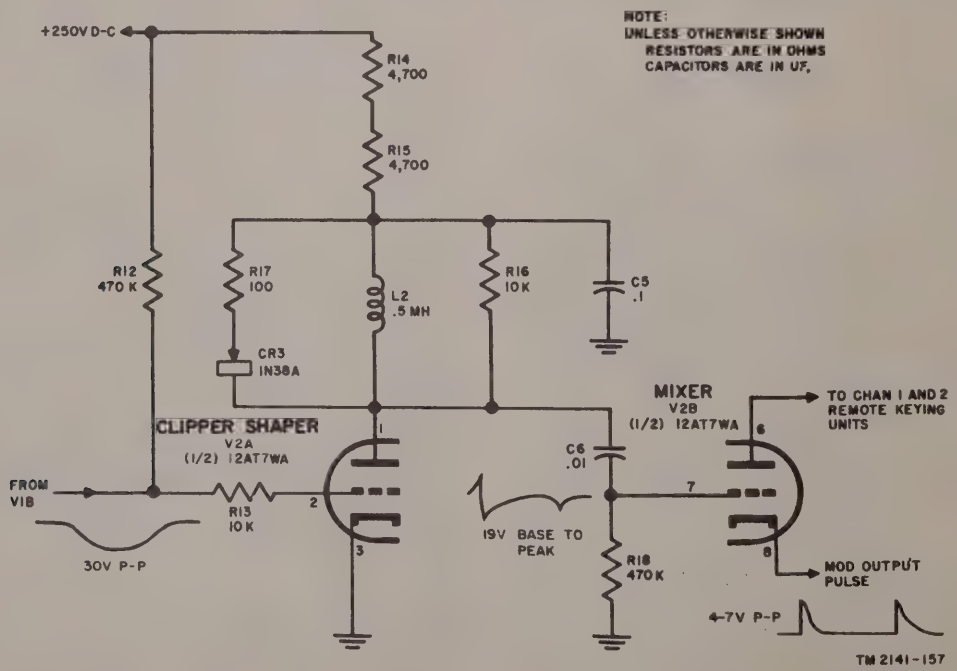


Figure 174. Modem clipper-shaper tube V2A and mixer tube V2B, simplified schematic diagram.

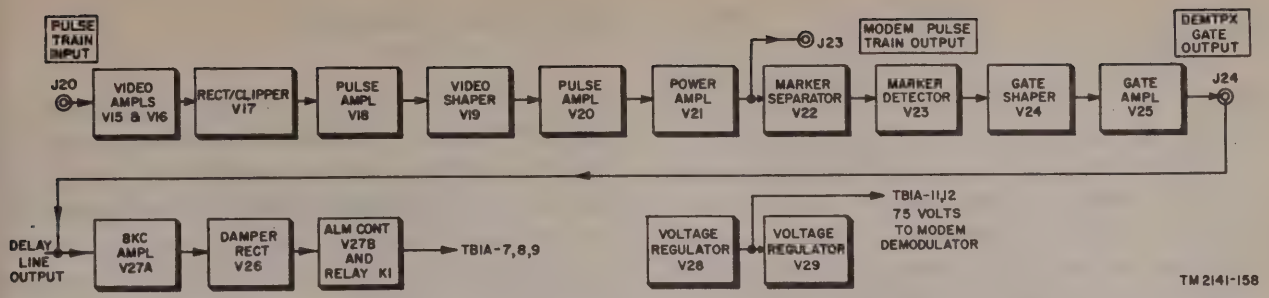


Figure 175. Common Unit TD–60/TCC–13, demultiplexer section, block diagram.

180. Video Amplifiers V15 and V16 (fig. 176)

Video amplifiers V15 and V16 increase the amplitude of the 23-channel pulse train applied to the common unit from the radio receiver.

a. Video Amplifier V15. The pulse train applied to the PULSE TRAIN INPUT jack J20 from the radio receiver is resistance-capacitance coupled to the cathode of V15 by R165, C48, and R88. (R88 also serves as the cathode-biasing resistor.) The input pulse train is coupled to the cathode so that there will be no phase change in this stage. Resistor R85 is used as a dc return path for the grid. Capacitors C47 and C49 keep the grid at an ac ground potential. Signals developed across R84 and R87 and inductor L16 are coupled by capacitor C52 to the grid of second video amplifier V16. Inductor L16 is used in series with the plate load resistors to increase the bandwidth of the stage. Resistor R86 in conjunction with capacitor C51B isolate the pulse train from the common B+ supply. Screen voltage for the video amplifier is supplied from the common B+ supply through dropping resistors R86 and R89. Resistor R89 and capacitor C51B form a screen decoupling filter, which filters any screen voltage variations.

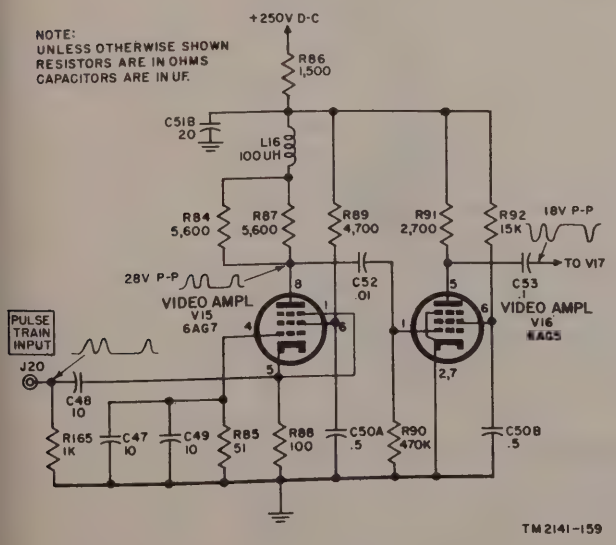


Figure 176. Video amplifiers V15 and V16, simplified schematic diagram.

b. Video Amplifier V16. Video amplifier V16 is a conventional resistance-coupled amplifier whose cathode is returned directly to ground. Resistor R91 is the plate load across which is developed the output voltage for the next stage. The amplified pulse train is coupled to rectifier clipper stage V17 by capacitor C53. Resistor R92 is the screen dropping resistor and resistor R90 is the grid return. Capacitor C50B is the screen bypass capacitor.

181. Rectifier-clipper and Slicer Stages V17 and V18 (fig. 177)

a. Rectifier-clipper V17 and V18 act as a slicer circuit to minimize noise by taking a small slice out of the center of the pulse. The input is applied to both cathodes of V17. The input signal voltage is developed across resistor R93. The plate, pin 2, of this diode tube is grounded through capacitor C54A. The plate (pin 2) circuit of this stage develops a bias across C54A equal to the amplitude of the pulse train. Plate, pin 7, the other half of V17, obtains its bias from resistors R94 and R95, which act as a divider on the bias voltage detected across C54A. The plate, pin 7, circuit therefore rejects approximately that 60 per cent of the signal nearest the base. The output of the plate, pin 7, circuit is coupled by capacitor C55 to pulse slicer amplifier stage V18. The

other part of the slicing action takes place in tube V18.

b. The dc voltage developed across C54A also is used to provide bias voltage for tube V26 in the alarm circuit (par. 186).

c. The control grid of tube V18 is connected to B+ through R96, and its cathode is grounded. Only negative input pulses will cause a change of emission through the tube. By lowering the positive potential of the grid, these negative pulses produce positive pulses at the plate. The screen grid of this tube is operated at a low voltage. Screen grid voltage is obtained at the junction of the voltage divider resistors R98 and R99. With low screen grid voltage, plate current is cutoff at —2 volts on the grid. The remainder of the pulse (above —2 volts) is therefore discarded. This is part of the slicing action. Plate voltage is applied through resistor R97. Capacitor C54B is the screen grid bypass capacitor.

182. Video Shaper V19

(fig. 178)

a. Positive pulses are fed to video shaper tube V19 from V18. The video shaper has an inductive differentiation circuit (L17, R103, and CR6) in its plate circuit. The first pulse is negative, but when the oscillation attempts to go positive, crystal diode CR6 conducts cutting off the signal. As a result, the stage produces negative output pulses.

b. Resistor R100 is the grid return resistor; R101 is the grid limiting resistor; and R102 is the cathode-biasing resistor. Resistors R105, R104, and R102 act as the screen grid voltage divider. These three resistors also hold the cathode at a positive potential. Capacitor C57C is the cathode bypass capacitor; C59A is the screen grid bypass capacitor; and C58 is the output coupling capacitor.

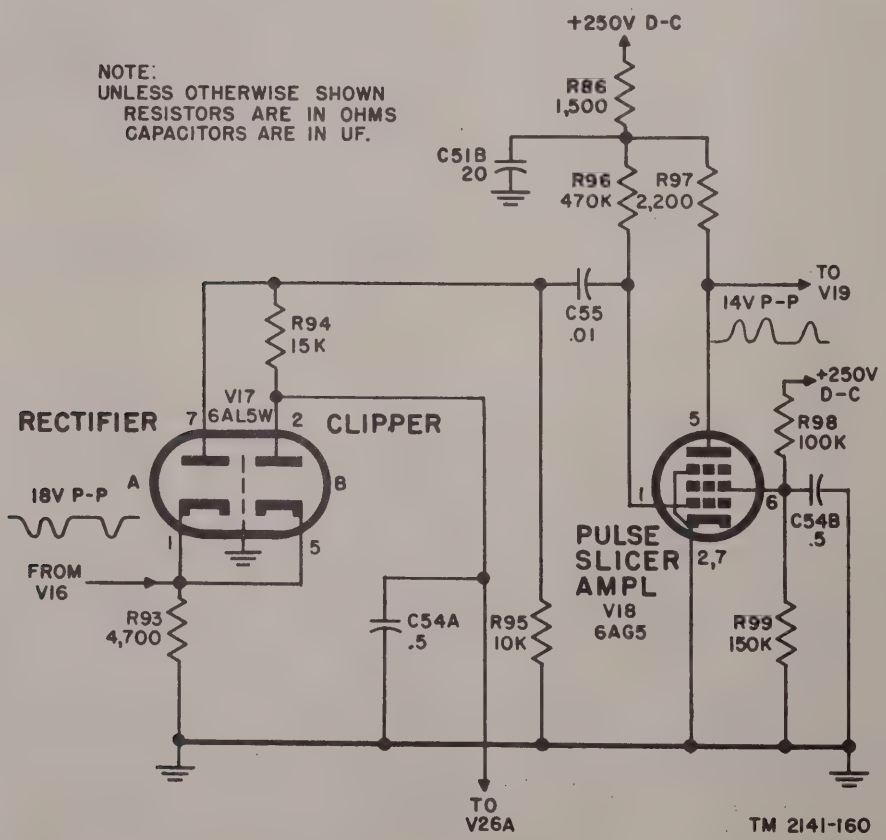


Figure 177. Rectifier/clipper V17, and pulses (slicer) amplifier V18, simplified schematic diagram.

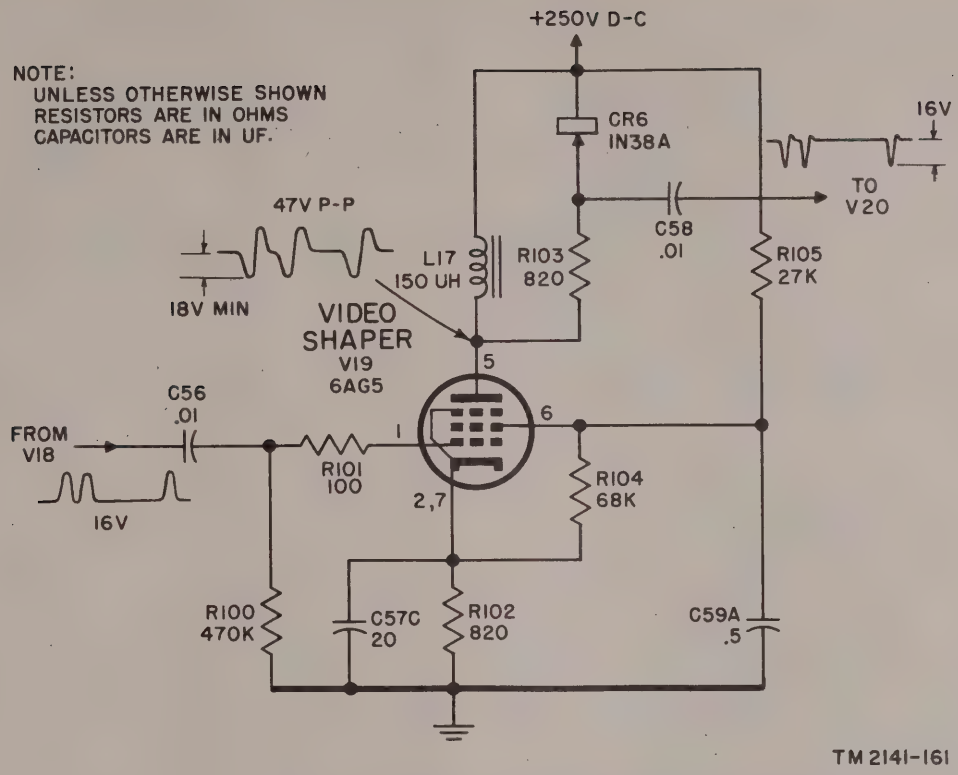


Figure 178. Video shaper stage V19, simplified schematic diagram.

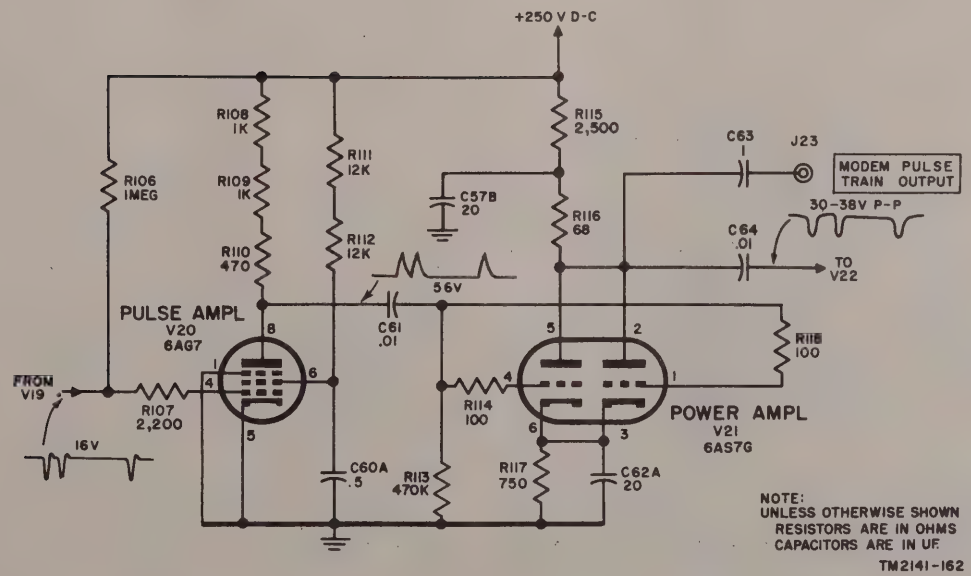


Figure 179. Pulse amplifier V20 and power amplier V21, simplified schematic diagram.

183. Pulse Amplifier V20 and Power Amplifier V21

(fig. 179)

a. The negative output pulse from tube V19 is fed to the control grid of pulse amplifier V20. This stage operates at saturation, since the grid is connected to B+ through R106. Resistor R107 is a grid clipping resistor and further clips the positive section of the signal. Resistors R108, R109, and R110 in series are the plate load. The negative input pulses decrease the emission through the tube, producing positive pulses in the plate circuit. Resistors R111 and R112 are the screen grid voltage-dropping resistors. Capacitor C61 is the output coupling capacitor, and C60A is the screen grid bypass capacitor.

b. The positive train of pulses from the plate circuit is applied to both grids of tube V21. This power stage is operated with its two triode sections connected in parallel to increase the power rating and tube transconductance. Each of the two sections has a 100-ohm parasitic suppressor resistor (R114 and R118) in series with the grid to prevent the dual triode from oscillating. The negative pulses from the plate of this stage are fed to the inputs of the modem demodulators, where the appropriate position-modulated channel pulse is demodulated.

c. Resistor R113 is the grid return for both power amplifier grids. Resistor R117 is the cathode-biasing resistor. Resistor R116 is the low-impedance plate load resistor, and R115 is the plate decoupling resistor. Capacitor C62A is the cathode decoupling capacitor, and C57B is the plate load decoupling capacitor. Capacitor C63 is the output coupling capacitor to MODEM PULSE TRAIN OUTPUT jack J23. Capacitor C64 couples the negative output pulses to the grid of marker separator tube V22.

184. Marker Separator V22 and Marker Detector V23

(fig. 180)

a. Within the demultiplexer common unit, the train of pulses is fed to the marker separator stage, V22. This stage is held at saturation by connecting the grid to B+ through R119. In the plate circuit, a .65-usec open-circuited delay line (Z3) is used as part of the plate load to separate the marker pulses. Each negative pulse of the input pulse train is amplified by tube V22 and appears as a positive pulse at the plate of the tube. Since a delay line is connected across the late load resistors (R120 and R121), the voltage that appears across the plate load acts as the input to the delay line. The pulse that reaches the open-circuited end arrives .65 usec after it has been applied to the input terminals. At the far end of the line there is no termination, and so the wave starts back to the transmitting end of the line with

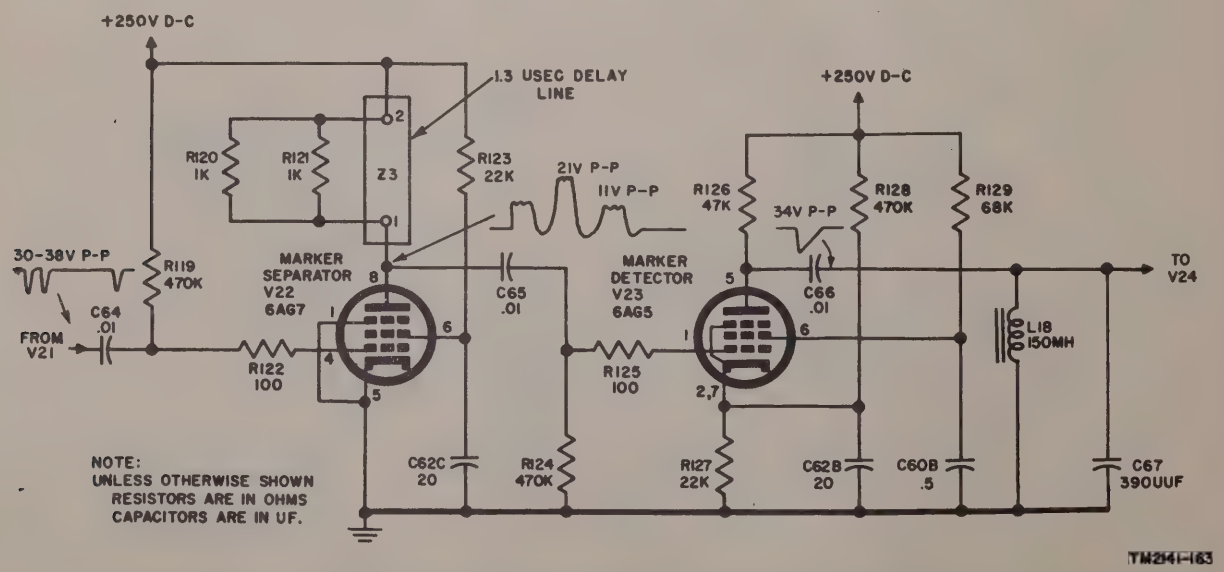


Figure 180. Marker separator V22 and marker detector V23, simplified schematic diagram.

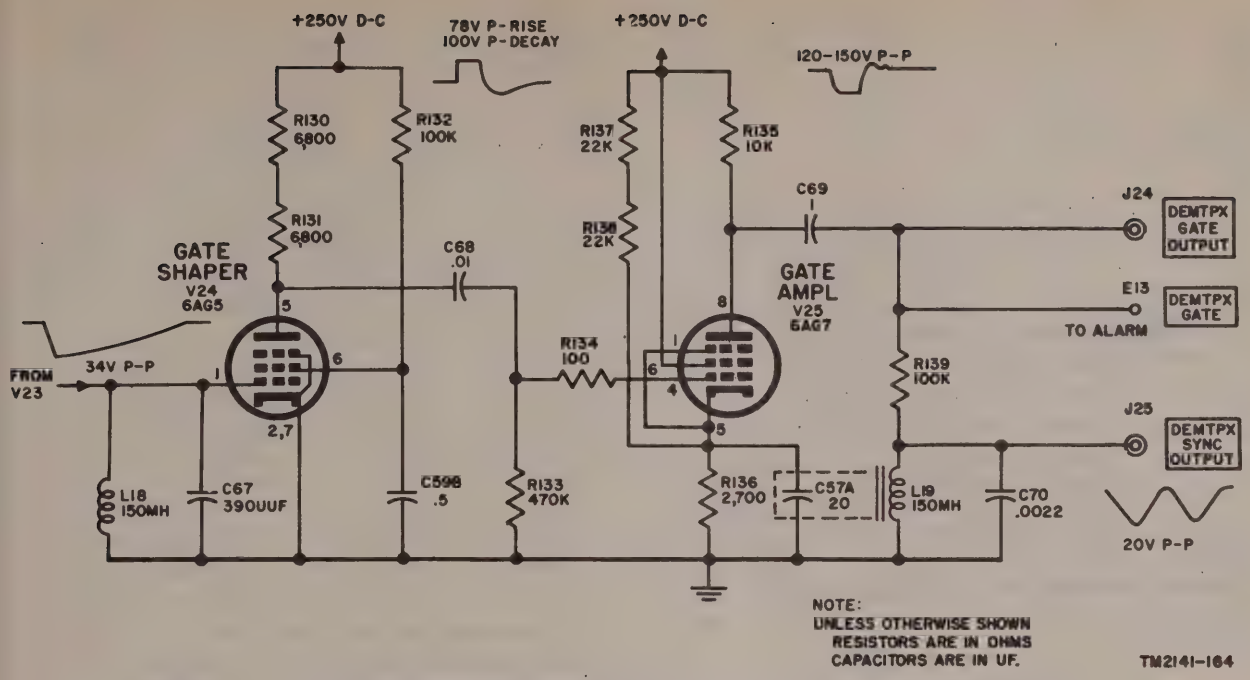


Figure 181. Gate shaper V24 and gate amplifier V25, simplified schematic diagram.

the same polarity. The pulse is received at the sending end, 1.3 usec after it has been transmitted (.65 + .65 = 1.3 usec). Since the second pulse of the marker also occurs 1.3 usec after the first pulse, the echo pulse coincides in time with it, and across the sending end of the delay line there will appear a double amplitude pulse at the time corresponding to the position of the second pulse. In addition, there is a third pulse that corresponds to the echo from the second portion of the double marker pulse.

b. Resistor R122 is the marker separator grid limiting resistor, and R123 is the screen grid voltage dropping resistor. Capacitor C62C is the screen grid bypass capacitor and C65 is the output coupling capacitor.

c. The whole pulse train is applied to the control grid of marker detector tube V23. This tube is biased at cutoff by using a cathode divider that consists of R128 and R127, which places a positive voltage on the cathode and therefore a fixed negative potential on the grid. The negative bias prevents any tube current from flowing until it is overcome by the double amplitude second pulse of the marker (fig. 180). Current then flows in the marker detector stage and results in a negative wave shape in its plate circuit.

d. Resistor R124 is the grid return resistor and R125 is the grid limiting resistor. Resistor R128 is the screen grid voltage-dropping resistor. Capacitor C62B is the cathode bypass, C60B is the screen grid bypass capacitor, and C66 is the output coupling capacitor. Although R126 is part of the plate load, it is the combination of L18 and C67 which produces the desired triangular pulse output load, a characteristic of the marker detector stage.

185. Gate Shaper V24 and Gate Amplifier V25

(fig. 181)

a. The negative pulse of plate current from V23 charges C67 to 25 volts during the .5-microsecond pulse. At the end of the pulse, there is a transient oscillation that drives the grid of V24 positive causing the grid to draw current, thus damping the oscillations. Shaper tube V24 is designed to produce quick cutoff by providing low screen voltage, and therefore the triangular negative pulse of 7-microsecond duration on the grid produces a positive square pulse on the plate. The plate pulse has a large overshoot that is lost by grid cutoff action in the following gate amplifier stage V25.

b. Resistors R130 and R131 in series constitute the plate load resistance for tube gate shaper V24. Resistor R132 is the screen grid

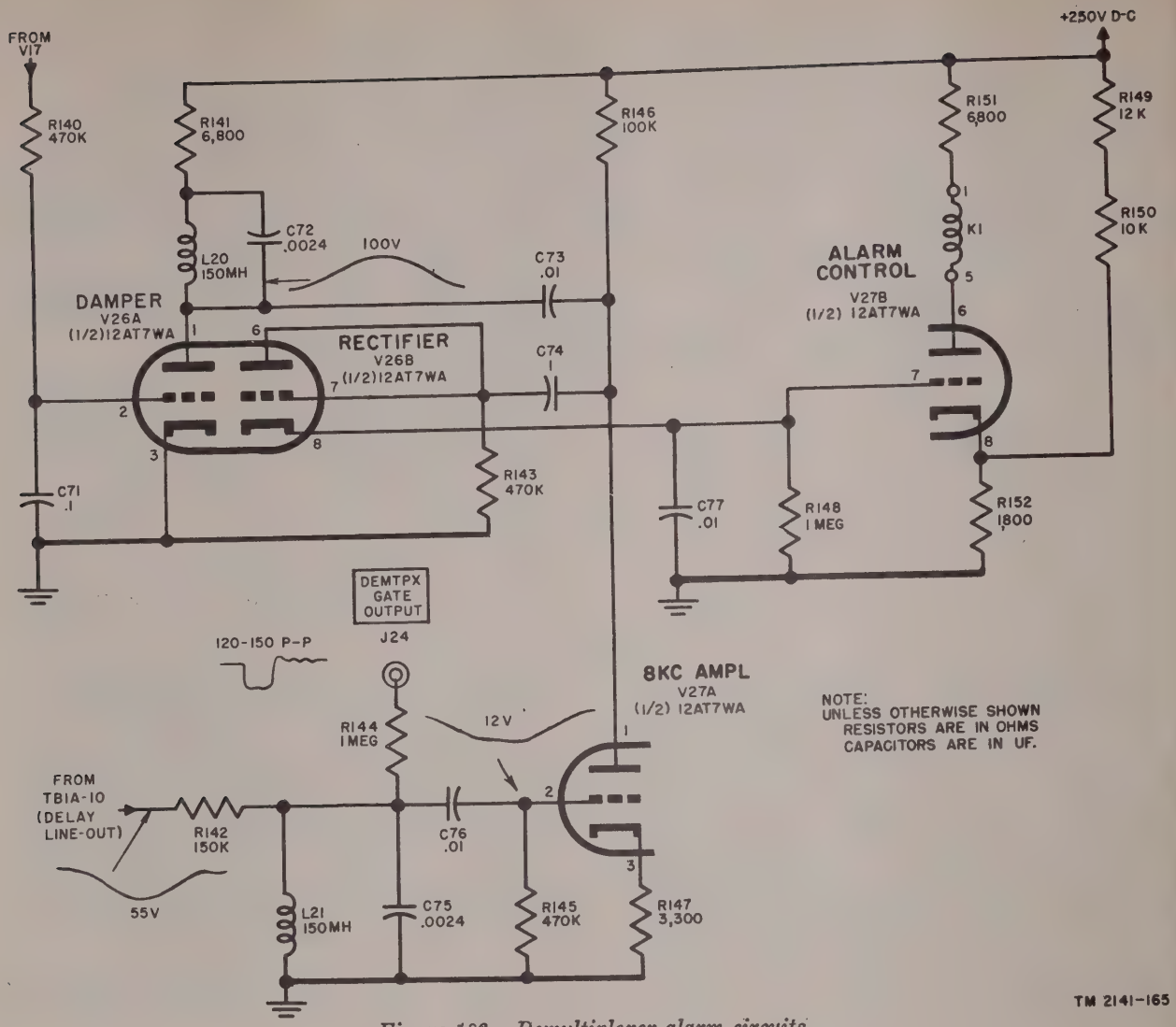


Figure 182. Demultiplexer alarm circuits.

voltage-dropping resistor. Capacitor C59B is the screen grid bypass capacitor, and C68 is the output coupling capacitor.

c. The positive gate is fed to the grid of gate amplifier V25 through parasitic suppressor R134. Gate amplifier V25 is normally at cutoff, as its cathode is held positive by the voltage divider network, which consists of R136, R137, and R138. The positive gate overcomes the negative grid potential and causes the tube to conduct, producing a negative gate in the plate output circuit that is fed through capacitor C69 to DEMTPX GATE OUTPUT jack J24. Resistor R135 provides the plate load and C57A is the cathode bypass capacitor. The ac load of this stage is the characteristic impedance of the 125-microsecond delay line, 3,900 ohms.

d. The output is fed to E13, the alarm circuits, and through R139 to an 8-kc resonant circuit, which consists of coil L19 and capacitor C70. The output is also coupled to DEMTPX SYNC OUTPUT J25 to provide a synchronizing signal for the oscilloscope.

186. Alarm Circuits
(fig. 182)

a. Damper-rectifier V26, 8-kc amplifier V27A, and relay K1 provide the alarm function. Input pulses are taken from the output of the delay line and from DEMTPX GATE OUTPUT jack J24. These are both applied to the grid of 8-kc amplifier V27A. If they arrive simultaneously, they add in amplitude. When these gates are present, alarm relay K1 is

energized, and the alarm is off. Damper-rectifier V26B is a diode that provides bias for alarm control tube V27B. Tube V26A takes bias from V17 and damps the signal across R146. Coil L21 and capacitor C75 are tuned to 8 kc to favor signals of that frequency.

b. The two inputs are amplified in tube V27A, whose plate load is the combination of resistor R146, and through C73 inductor L20 and C72. The combination of L20 and C72 provides an 8-kc tuned-plate load. The 8-kc amplifier output is coupled through C74 to plate pins 6 and 7 of diode connected V26B. This typical diode action rectifies the signal and feeds the output as a dc positive bias to the grid of alarm control tube V27B. Tube V27B under normal conditions is conducting, which energizes the coil of relay K1. Failure of either of the input signals or of the dc supply will de-energize the relay, causing the relay contacts to change, and the alarm circuit will operate. The combination of signals is required for action, because noise pulses through the circuit might otherwise also energize the relay. The cathode is maintained at a positive potential by the voltage drop across R152.

c. Triode connected V26A is normally cut off by the slicer bias applied through resistor R140 to its grid. When the signal drops, the bias drops, allowing the tube to conduct and shunt tuned circuit indicator L20 and capacitor C72. This shunt action lowers the output load of V27A, which cuts down the gain of tube V27A. Thus, if the signal fails, alarm circuit relay K1 will de-energize.

187. Voltage Regulators V28 and V29 (fig. 183)

Voltage regulator tubes V28 and V29 are conventional type OA3 gas discharge tubes and

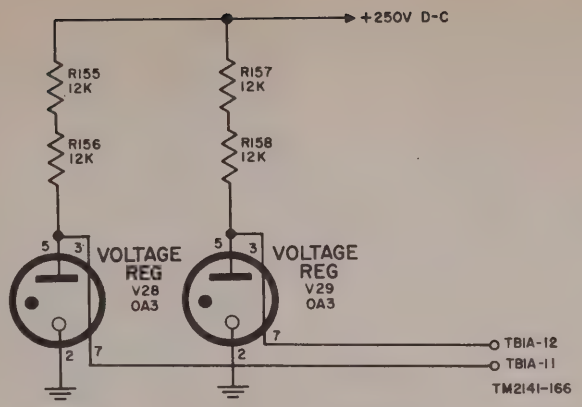


Figure 183. Voltage regulators V28 and V29, simplified schematic diagram.

will maintain a constant voltage regardless of variation of load current. Resistors R155 through R158 are voltage-dropping resistors. These tubes supply the +75-volt dc bias for the demodulator section of the modem ringing circuit.

188. Modem Demodulator Circuit

The modem demodulator operates to convert a position-modulated pulse to a width-modulated pulse, which contains the audio component and only needs to be filtered to give the audio output. Figure 184 depicts a block diagram of the modem demodulator circuit. The delay line sawtooth is applied to gate generator V3A. This produces a gate for operating the demodulator. The gate determines the time during which the demodulator accepts signals. The input pulse train is also fed to demodulator pwm converter V3B. During the gate time, conversion to pwm takes place. The pwm signal is applied to clipped amplifier V4A and then is applied to the low-pass filter, which extracts the audio signal. The audio output is amplified by audio output stage V4B, which is fed to the output TEST PAIR terminals.

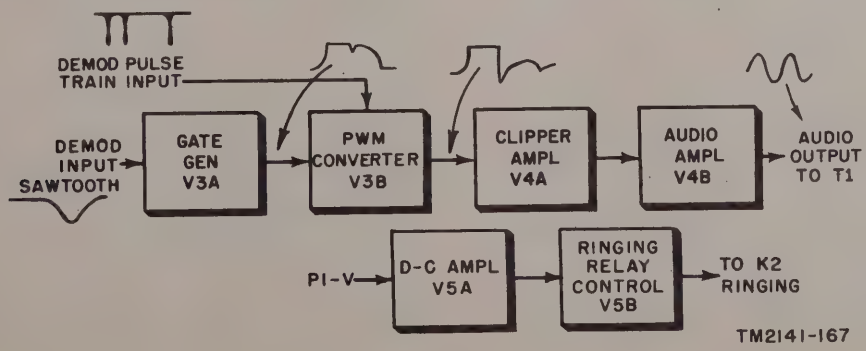


Figure 184. Modem demodulator section, block diagram.

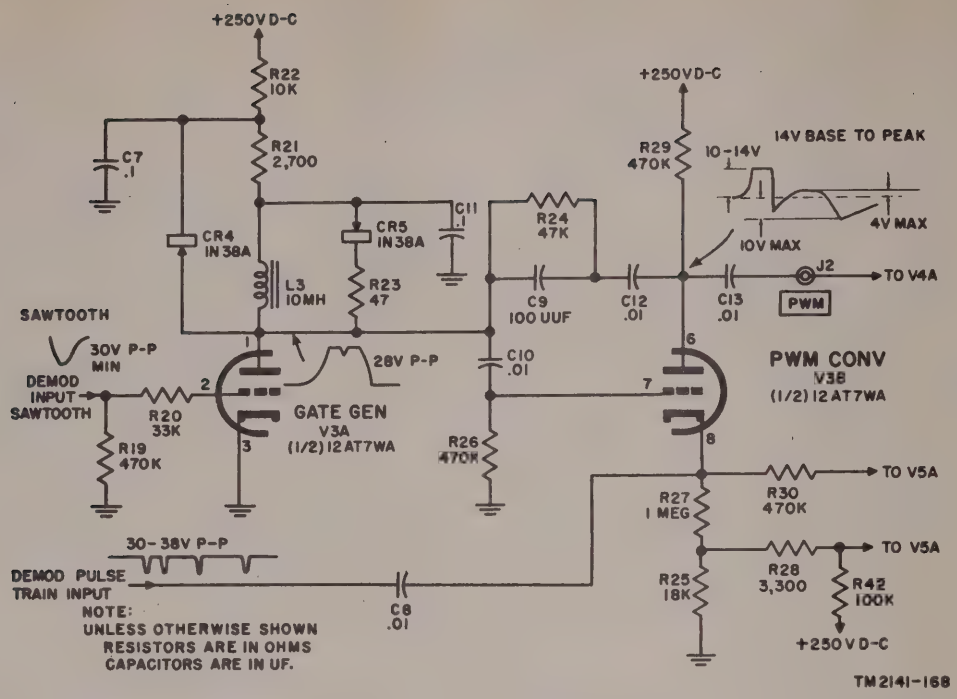


Figure 185. Demodulator gate generator V3A and pwm converter V3B, simplified schematic diagram.

189. Modem Gate Generator V3A and Pwm Converter V3B
(fig. 185)

a. The negative sawtooth from the delay line is applied to the grid of tube V3A in the modem demodulator. These negative sawtooth waves cut off plate current, producing positive gates in the plate circuit. A voltage transient appears on the plate. This is fed back from the following stage. The cathode of crystal diode CR4 is about 30 volts positive with respect to the quiescent plate voltage established by the current flowing through resistor R21 and filtered by capacitor C11. Diode CR4 conducts at about 30 volts. This conducts and clips the top of the first positive half-cycle, giving a flat top pulse as shown by the 28-volt wave form at the plate of V3A. The succeeding negative cycle after the first positive swing is damped by the action of the current flowing through diode CR5 in series with limiting resistor R23. Thus, a 28-volt pulse is generated by this stage, which corresponds in time to the negative sawtooth applied to the grid of gate generator V3A. This is the time allocated to this channel by the demultiplexer delay line. The gate starts when the sawtooth grid voltage goes beyond cutoff.

b. Resistor R19 is the grid return and R20 is a grid limiter. The tube is normally at zero bias and is conducting. Resistor R22 is the plate decoupling resistor and C7 is the plate decoupling capacitor. Resistor R20 limits grid current.

c. Pwm converter V3B is normally held at cutoff by the negative fixed bias, which results from the large potential (approximately 47 to 52 volts) applied to its cathode through the voltage divider which consists of R25, R28, and R42. The demodulated pulse train is fed to the cathode of V3B, through coupling capacitor C8. Taken individually, neither the gate applied to the grid (28 volts) nor the channel pulse (35 volts) decreases the positive cathode potential enough to cause plate current to flow. However, when these two occur together, plate current flows in tube V3B.

d. Part of the 28-volt pulse generated by the inductive differentiator plate circuit of gate

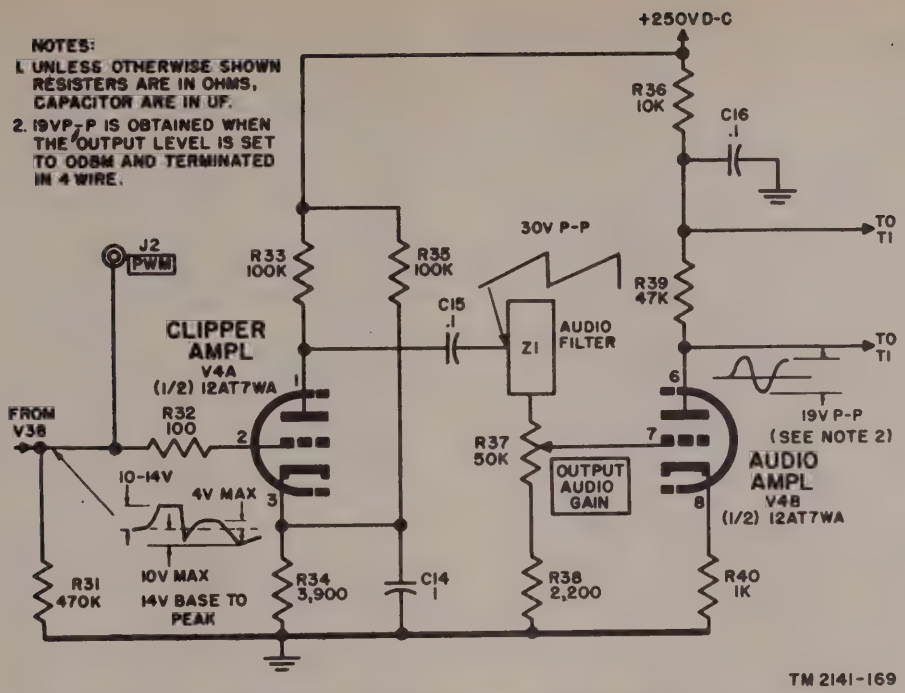


Figure 186. Demodulator clipper and audio amplifier stages V4A and V4B, simplified schematic diagram.

generator V3A is coupled to the plate of pwm converter V3B through a parallel combination of R24 and C9 in series with C12. Thus, V3B plate voltage contains a positive gate starting at the time the unblocking sawtooth is applied to the demodulator. The coincidence of the gate on the grid and the channel pulse on the cathode of tube V3B results in a large current flow through plate load resistor R29, making the plate more negative only at the time the channel pulse occurs. Because of circuit capacity, the negative swing does not recover until the gate ends; consequently, a pulse width-modulated signal is generated, which starts at the time the unblocking pulse appears and ends at the time the position-modulated channel pulse appears and causes the tube to draw current. This is the process of time demultiplexing which selects the appropriate channel to be detected in each stage.

e. Resistor R26 is the grid return; capacitor C10 is the input coupling capacitor; and C13 is the output coupling capacitor. Resistor R30 is a dropping resistor and R27 acts as a voltage divider with R25.

190. Clipper and Audio Amplifier Stages V4A and V4B

(fig. 186)

a. The positive pwm signal generated at the plate of pulse-width modulator V3B has a fixed leading edge in time; that is, it is fixed with respect to the received marker pulse. It has a trailing edge that is time-modulated since it is derived from the ppm pulse. This signal is applied to clipper amplifier V4A, through resistor R32, a grid parasitic suppressor. Clipper-amplifier V4A is biased below cutoff by returning the cathode to B+ through resistor R35. This stage will accept only the top of the signal (true pwm). The amplified output is impressed across plate load resistor R33 and is fed through coupling capacitor C15 to low-pass audio filter Z1. The low-pass audio filter removes all but the audio portion of the signal and through its tank circuit effect produces a sinusoidal wave. The 30-volt audio output signal from the filter is impressed on the grid of audio amplifier V4B. The signal applied to OUTPUT AUDIO GAIN control R37 in series with resistor R38 will be the duplicate of the af signal, which modulates the channel pulse

at the transmitter end. The cathode of V4A gets bias through divider network R34 and R35. Capacitor C14 acts as the cathode bypass capacitor.

b. OUTPUT AUDIO GAIN potentiometer R37 is an audio gain control that regulates the signal input to amplifier tube V4B. The plate load of V4B consists of one winding of hybrid transformer T1 in parallel with resistor R39, which provides the correct output impedance for the transformer. Resistor R38 completes the grid return circuit and is inserted in series with potentiometer R37 so that the arm of the potentiometer can never be turned so low that no output is obtained from this channel. Resistor R40 provides cathode bias. The omission of a cathode bypass capacitor provides improved fidelity. Capacitor C16 is the plate decoupling capacitor and R36 is the plate decoupling resistor. Hybrid transformer T1 provides for the audio output to be connected to either a two-wire or four-wire local line.

191. Modem Ringing Amplifier V5 (fig. 187)

Ringing amplifier tube V5 is a dc amplifier used to control alarm ringing relay K2. When the system is operating normally, dc amplifier V5A is conducting heavily and ringing relay control tube V5B is held at cutoff by having its cathode returned to a +75-volt dc source. The grid of V5B is conected directly to the plate of V5A, and its plate is connected through R44, a limiting resistor, to the relay coil and then to B+. The demodulator positive pulse train input is applied to the grid of V5A through R30. Therefore, tube V5A is kept conducting, and its plate voltage is low. Since the plate voltage of the dc amplifier is low, the grid voltage of tube V5B is also low. When the demodulator pulse train input is not present, tube V5A stops conducting, the plate voltage rises, and the grid voltage of V5B also rises, causing V5B to conduct and alarm ringing relay K2 to become energized. As previously explained, when pulses are not present the relay throws causing an alarm to sound (indicating malfunction). Resistor R43 is the plate resistor of V5A. Its cathode is connected through R28 and R25 to ground and through R42 to B+. The cathode is also connected to the demodulator pulse train input through R27. The demodulator pulse train input is also fed to the grid through R30.

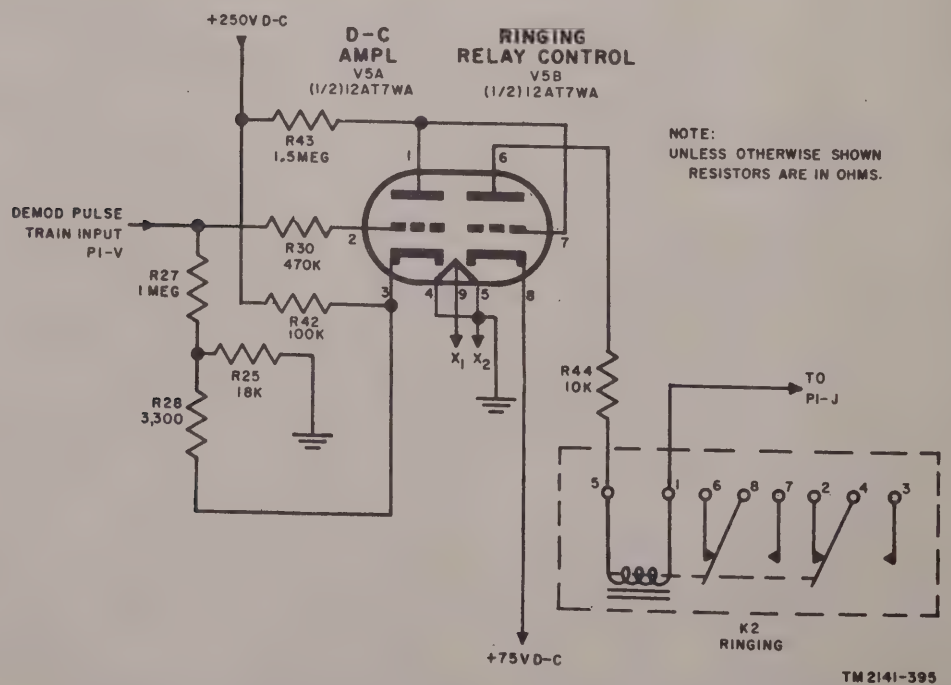


Figure 187. Modem ringing amplifier V5, simplified schematic diagram.

192. General

a. When two Multiplexer Sets AN/TCC–13 are operated to provide 45-channel operation, it is necessary to disable the 8-kc oscillator circuit of one of the two multiplexer common units and to synchronize one unit with the other. (One unit must be a *master,* and the other a *slave.*) This is necessary because the frequency of one 8-kc crystal will differ from that of the other by some very small amount. This difference would cause the pulse train developed by one multiplexer set to shift slowly with respect to that produced by the other. Other circuit changes are listed below.

b. Figure 188 illustrates how 45-channel operation is accomplished. Nothing is changed in the over-all circuitry except in the common unit.

c. When used as a *master* on a 45-channel basis, operation is identical with that for 23-channel operation. When used as a *slave* on a 45-channel basis, the following switching is done on the slave:

(1) The 8-kc oscillator, tube V2, is disabled by removing plate voltage.

(2) The 45-channel synchronizing input is fed to shaper tube V4A.

(3) The multiplexer output is taken from the plate instead of the cathode of pulse train output tube V13.

(4) In the demultiplexer section of the common unit, the input is fed to either the cathode or grid, depending on whether master or slave operation is desired. At the master multiplexer, the 45-channel pulse train is fed to the grid of video amplifier V15. At the slave multiplexer, the 45-channel pulse train is fed to the cathode of video amplifier V15. This keeps the phase of the output signal at the plate of each tube the same.

d. To properly time-division-multiplex the two pulse trains, 45 CHAN SYNC jack J2 of the slave common unit is fed a synchronizing signal from 45 CHAN SYNC jack J2 of the master common unit. The circuit of tube V1 is arranged to delay pulses by 2.6 microseconds.

e. Because, in time, the negative pulse train of channel 23 is very close to the positive pulse

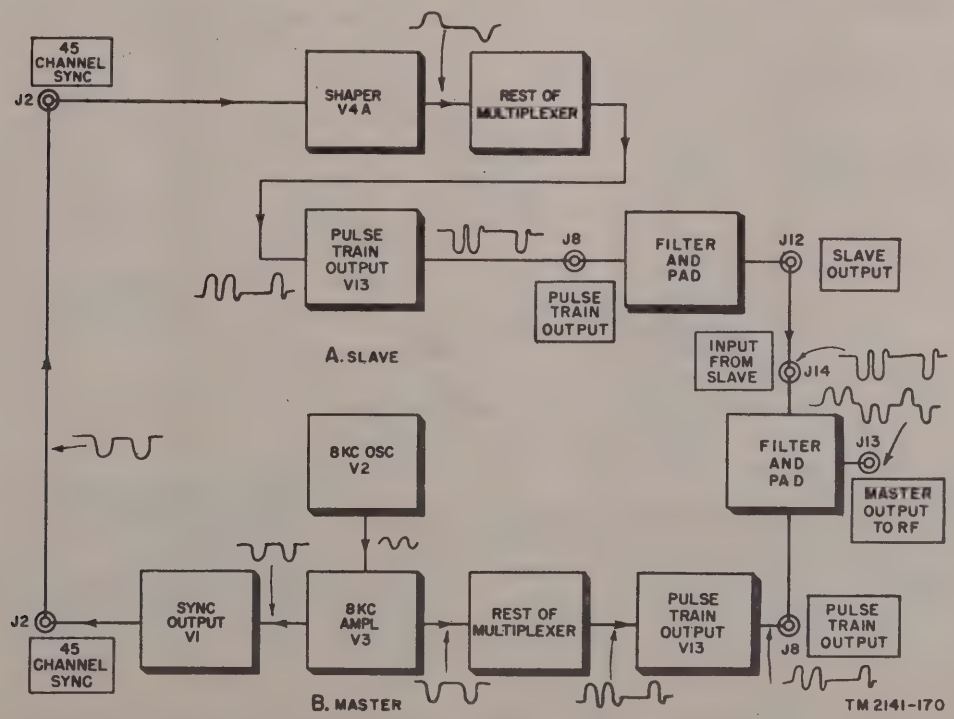


Figure 188 Common unit functional 45-channel operation, block diagram.

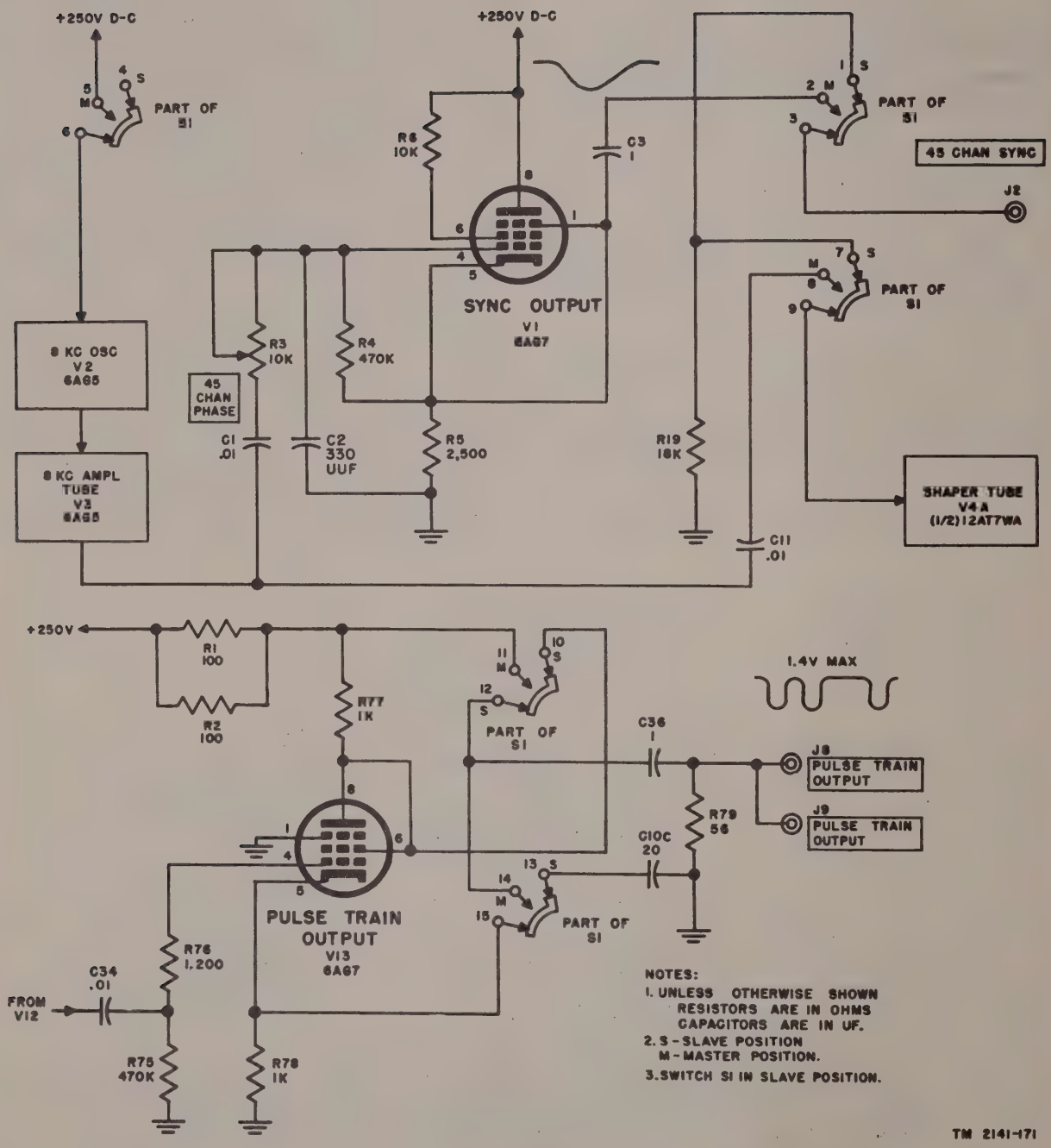


Figure 189. Multiplexer switching, master or slave operation, simplified schematic diagram.

train first marker pulse, it is necessary that the other channels be used first, and what would be the 46th channel remains unused. If traffic requirements are so heavy that it must be used, then the negative channel 23 pulse of the slave must be advanced 1 microsecond (toward channel 22) to avoid excessive cross talk into the following position marker.

f. The termination of the common unit is chosen so that when the master and slave terminals are used together (in 45-channel operation) the impedance is approximately 50 ohms. When only one common unit is used (in 23-channel operation), it is necessary to compensate for the fact that the other one has been removed; therefore, plug ATI (50-ohm impedance) is inserted in its place. The output impedance therefore remains constant under both conditions of operation.

193. Multiplexer Switching
(fig. 189)

a. The multiplexer section may be operated either as a *master* or *slave* in 45-channel operation. Operation as a *master* is the same as 23-channel operation except that a 45-channel synchronizing output is taken from 45 CHANNEL SYNC jack J2, for synchronization of the slave.

b. When the MASTER-SLAVE switch is in the MASTER position, B+ is applied to the 8-kc oscillator and the output is fed to shaper tube V4A and also to the grid of synchronizing output tube V1. The synchronizing output tube feeds a 45-channel synchronizing signal to 45 CHANNEL SYNC jack J2. The output of the 8-kc amplifier tube V3 is fed to the grid of tube V1 through coupling capacitor C1 and 45 CHANNEL PHASE potentiometer R3 to accomplish a 2.6-usec delay of the slave pulse train in reference to the master pulse train. The 45 CHANNEL PHASE control acts as an adjustment in series with grid return resistor R4 and cathode-biasing resistor R5 and is used to provide a fine adjustment of the relative position of the positive and negative pulse trains. Resistor R6 is the screen grid voltage-dropping resistor. Capacitor C3 is the output coupling capacitor. The output signal is fed from the cathode circuit of V1 through C3, then through SLAVE MASTER switch S1 to J2.

c. In slave operation, the 23-channel pulse train output of the slave multiplexer is developed across R77, in the plate circuit of pulse train output tube V13, and is fed through output coupling capacitor C36 to PULSE TRAIN OUTPUT jack J8. The pulse train is taken from the plate so that the pulse train from the slave will be negative. Thus, the composite train will be 45 pulses interleaved. Slave station 8-kc oscillator tube V2 is disabled by having its plate voltage disconnected. The output of synchronizing output tube V1 is removed from the circuit and the input synchronizing signal from the master multiplexer is fed to J2 through switch S1 and a parasitic resistor to the grid of shaper tube V4A.

d. When the MASTER-SLAVE switch is in the MASTER position the output of tube V13 is taken from the cathode instead of the plate. The cathode is bypassed by capacitor C10C and a jumper is placed across plate load resistor R77 by the switch.

194. Demultiplexer Circuit Switching
(fig. 190)

a. The only change in operation of the demultiplexer is provided by MASTER-SLAVE switch S2.

b. In master operation (the MASTER-SLAVE switch in MASTER position), switch S2 disconnects the cathode capacitor and places it across the grid of tube V15, thus bypassing all signals at that point. The signal from PULSE TRAIN INPUT jack J20 through capacitor C48 is fed to the cathode. The effect is to maintain unchanged the polarity of the signal at the output of tube V15.

c. In slave operation (the MASTER-SLAVE switch in SLAVE position), the input from PULSE TRAIN INPUT jack J20 is fed through coupling capacitor C48 to switch S2, and then to the grid of tube V15. Cathode bypass capacitors C47 and C49 in parallel are shunted across cathode-biasing resistor R88. Resistor R165 provides C148 with a ground return.

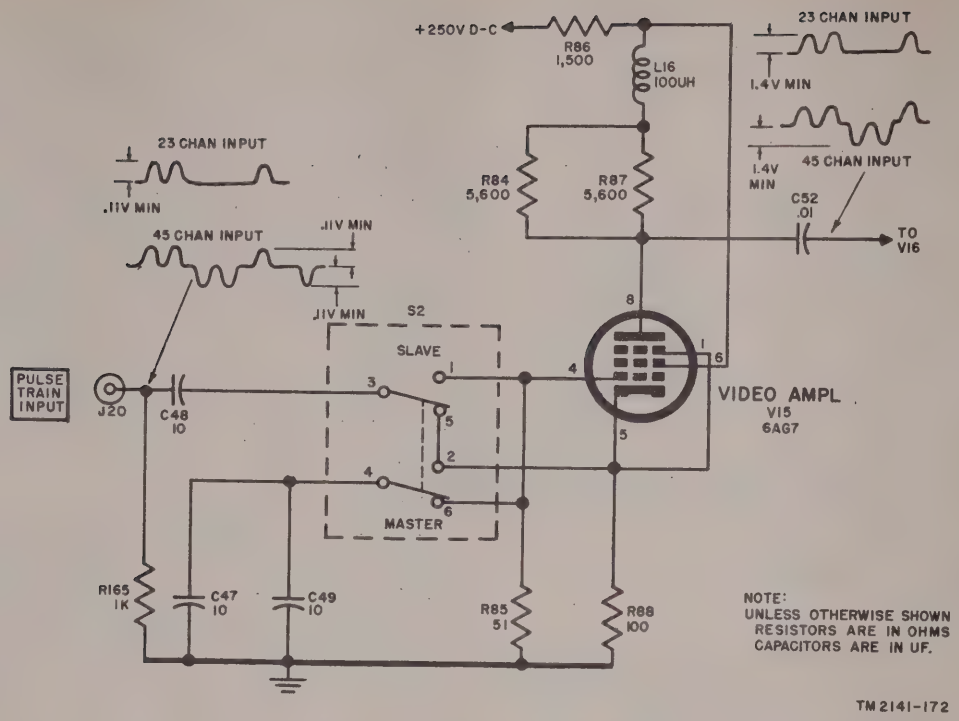


Figure 190. Demultiplexer switching, for MASTER or SLAVE operation, simplified schematic diagram.

Section VI. REMOTE KEYING CIRCUITS

195. General

a. Description.

(1) The remote keying circuits remotely switches the operation of units associated with the remote keying terminals. Each assembly consists of two identical subunits mounted side by side. These units are alike in every way except for reference symbol numbering. Plugs P1 and P2 on these units match a receptacle when inserted either way (that is, either end up). The assembly may be turned upside-down and may still be plugged in. When the whole unit is reversed in this manner, the two subunits are not only also reversed, but each one is now inserted into the receptacle formerly occupied by the other. This action has been used to switch from normal to remote operation.

(2) The double arrangement described above is necessary for the operation of the units at repeater stations, and is also used at the terminals to standardize the construction of the remote keying units.

(3) To clearly understand the path taken by the keying signal in any one unit, refer to figures 191 and 192. These figures show all pin and terminal connections in this path from the modem through the mounting rack and multiplexer subassembly to the remote keying unit. Figure 191 shows the remote keying units set up for normal operation and figure 192 shows the remote keying units set up for remote keying operation. Figures 195 and 196 also show this path.

b. Function. The remote keying facility is provided to allow two types of remote keying operation on either or both channel 1 and channel 2.

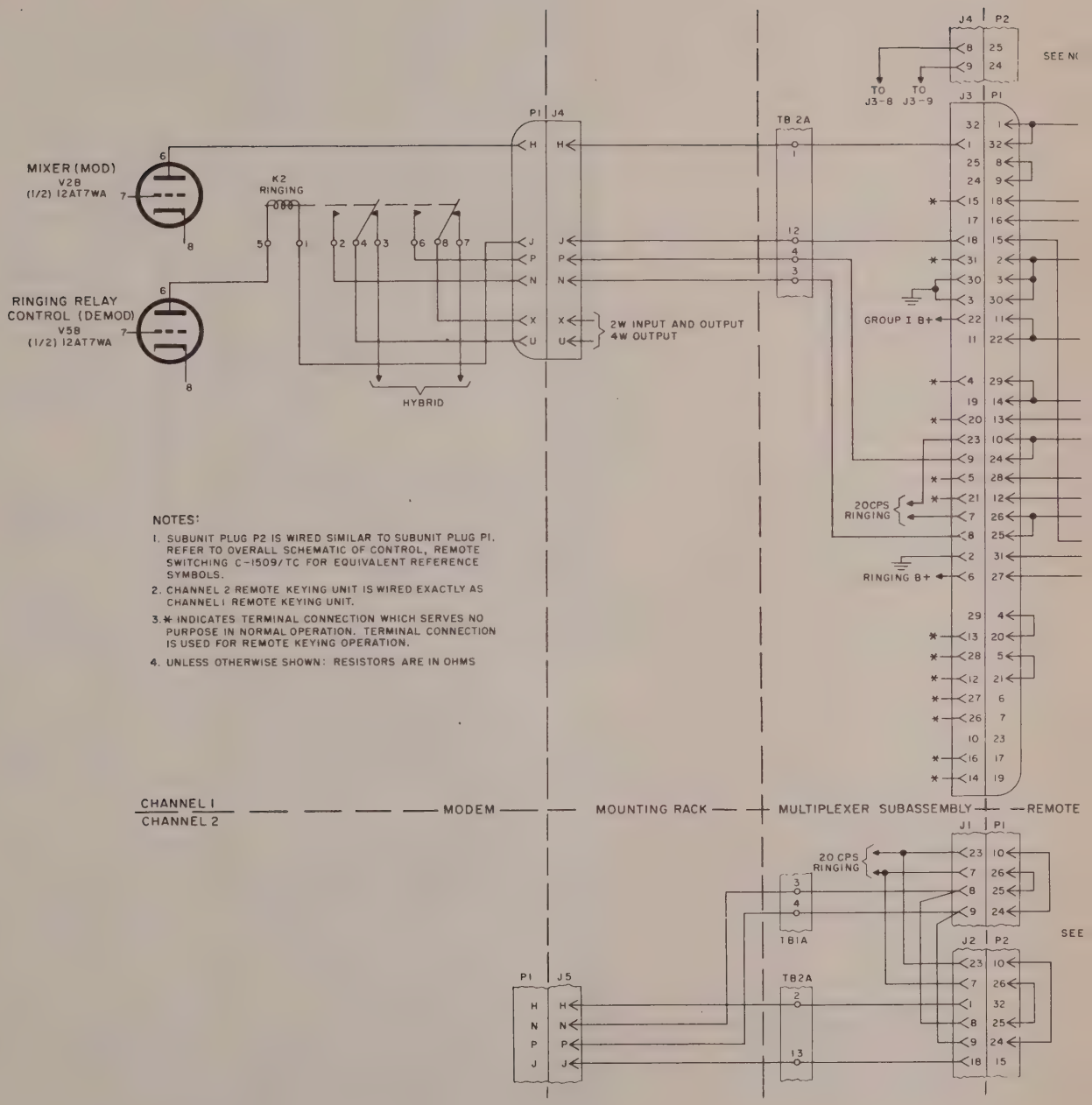


Figure 191. Remote keying circuit, Multiplexer SET AN/TCC–13, normal ope

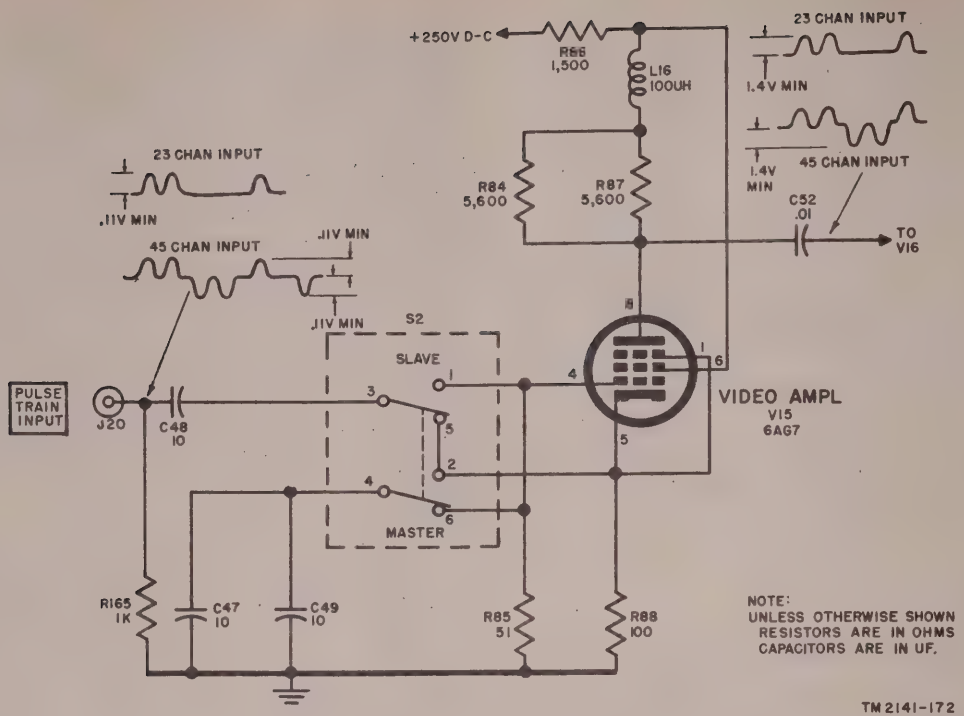


Figure 190. Demultiplexer switching, for MASTER or SLAVE operation, simplified schematic diagram.

Section VI. REMOTE KEYING CIRCUITS

195. General

a. Description.

(1) The remote keying circuits remotely switches the operation of units associated with the remote keying terminals. Each assembly consists of two identical subunits mounted side by side. These units are alike in every way except for reference symbol numbering. Plugs P1 and P2 on these units match a receptacle when inserted either way (that is, either end up). The assembly may be turned upside-down and may still be plugged in. When the whole unit is reversed in this manner, the two subunits are not only also reversed, but each one is now inserted into the receptacle formerly occupied by the other. This action has been used to switch from normal to remote operation.

(2) The double arrangement described above is necessary for the operation of the units at repeater stations, and is also used at the terminals to standardize the construction of the remote keying units.

(3) To clearly understand the path taken by the keying signal in any one unit, refer to figures 191 and 192. These figures show all pin and terminal connections in this path from the modem through the mounting rack and multiplexer subassembly to the remote keying unit. Figure 191 shows the remote keying units set up for normal operation and figure 192 shows the remote keying units set up for remote keying operation. Figures 195 and 196 also show this path.

b. Function. The remote keying facility is provided to allow two types of remote keying operation on either or both channel 1 and channel 2,

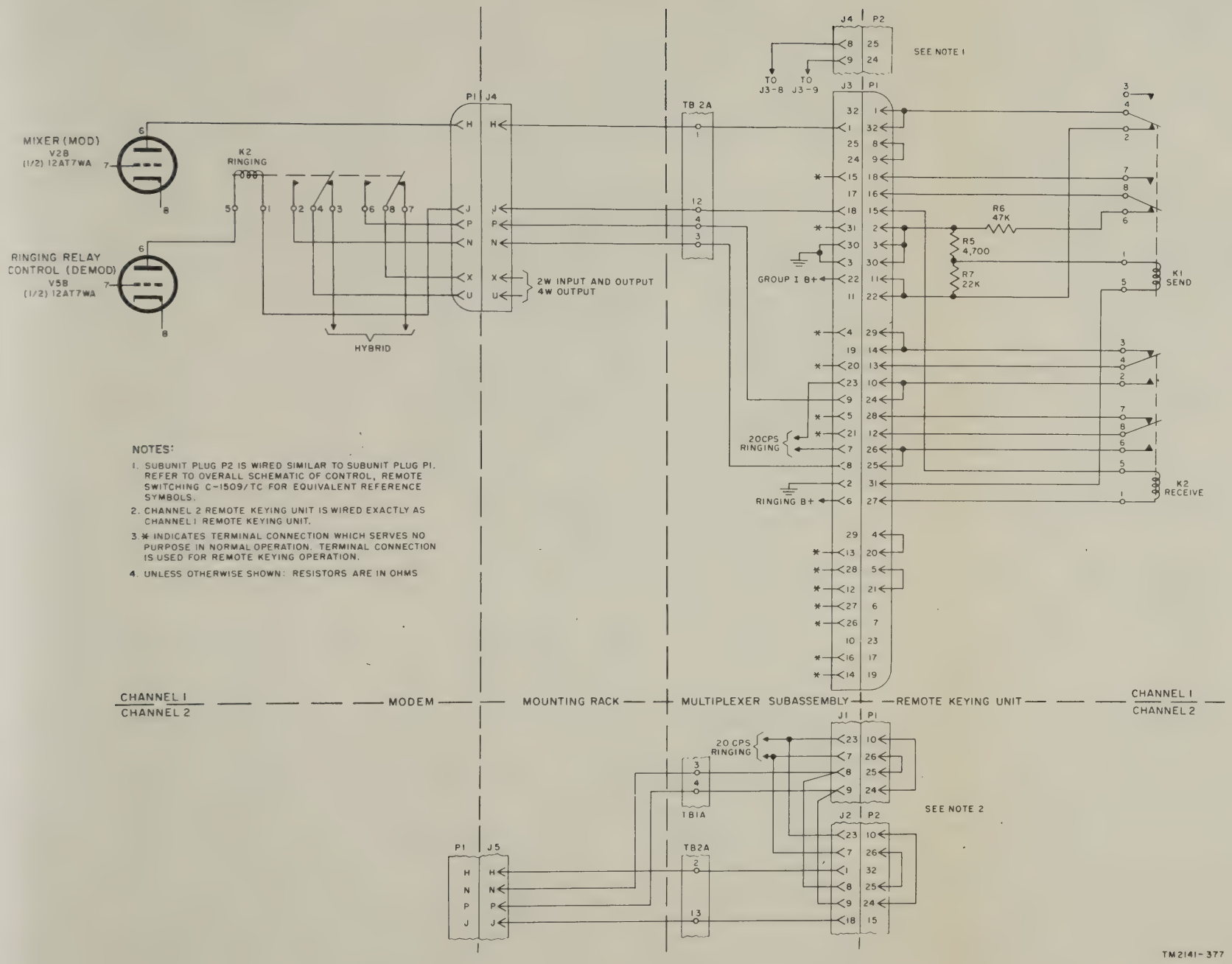
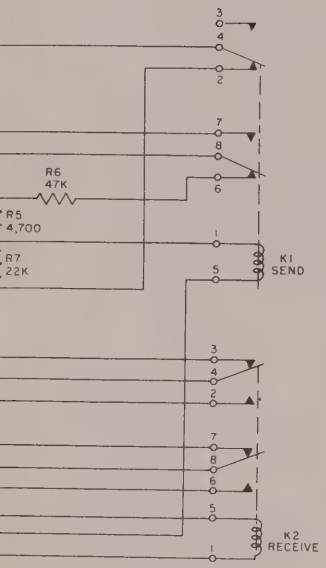


Figure 191. Remote keying circuit, Multiplexer SET AN/TCC–13, normal operation.



CHANNEL 1 / CHANNEL 2

TM2141-377

tion.

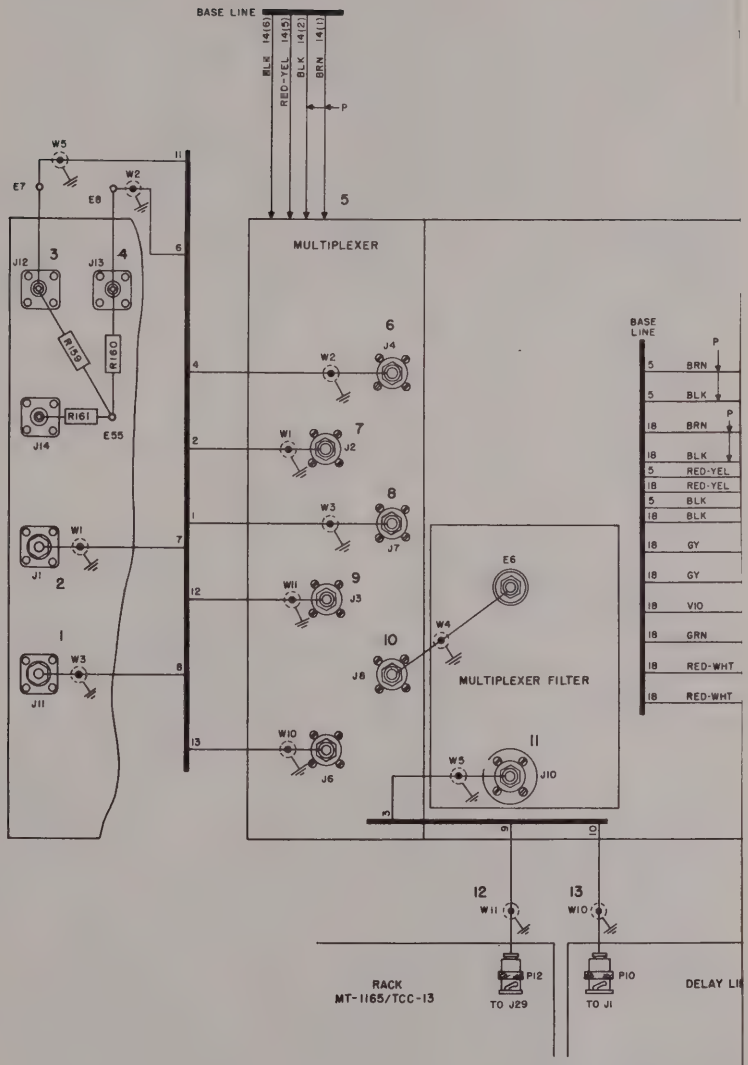
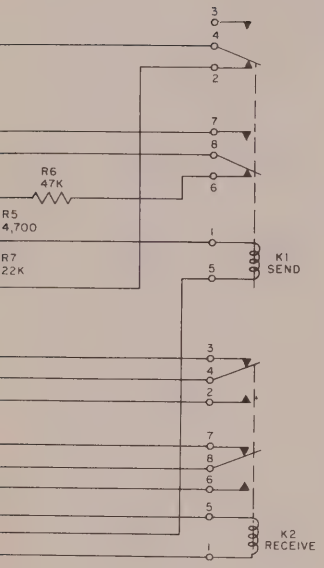


Figure 192. Remote keying circuit, Mult



YING UNIT — — — CHANNEL 1 / CHANNEL 2 —

TE 2

TM 2141-377

tion.

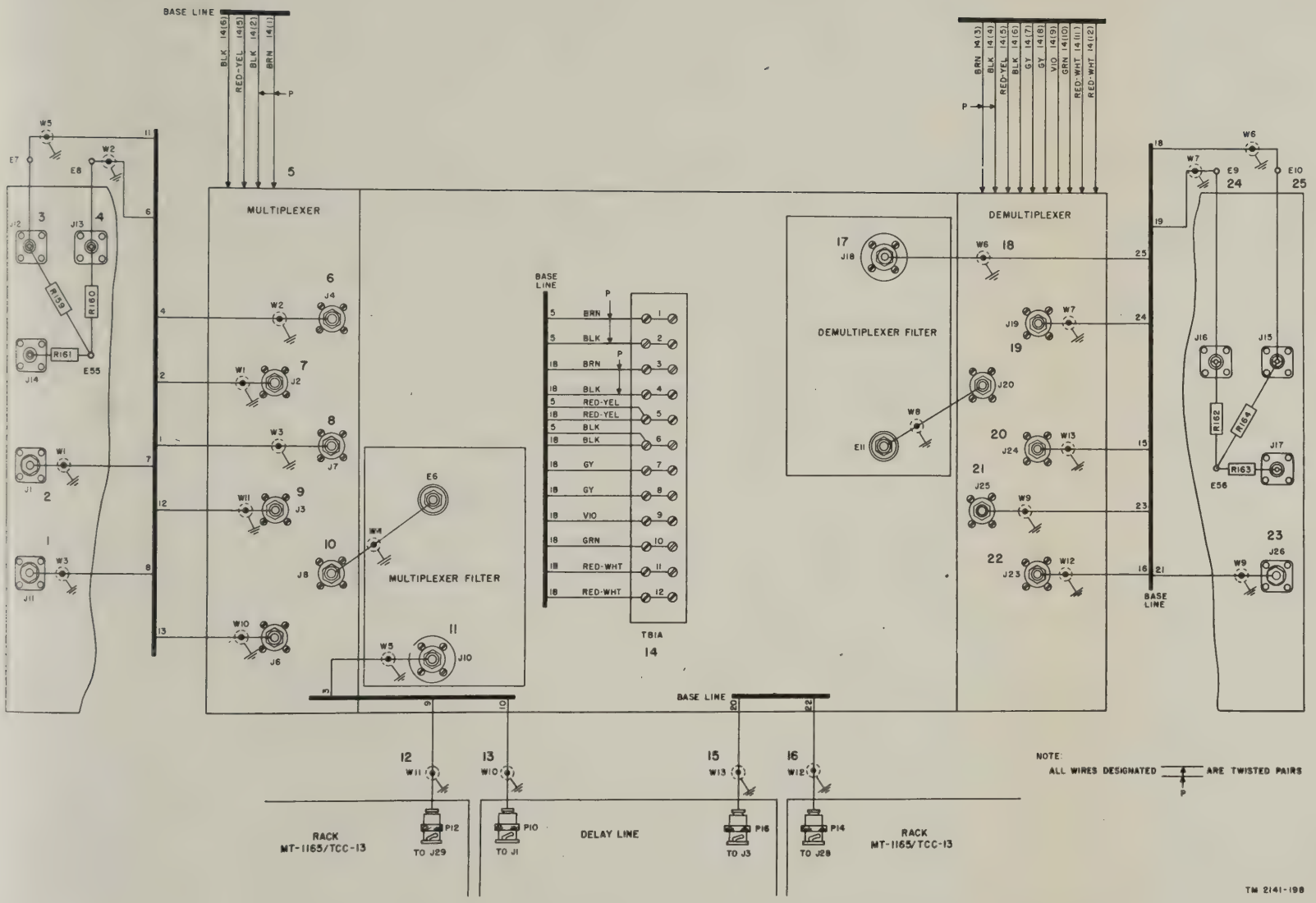


Figure 192. Remote keying circuit, Multiplexer Set AN/TCC–13, remote keying operation.

(1) To permit an operator located at a *multiplex location* to control a vhf fixed station located near another multiplex location.

Note. The phrase *multiplex location* is used to designate a Multiplexer Set AN/TCC–13 terminal, a Pulse Form Restorer Group AN/TRA–10 repeater, or a Multiplexer Group AN/TCA–1 repeater; all of these act similarly for remote keying operation.

(2) To permit a vhf mobile unit to *talk through* a vhf fixed station at a multiplex location, then through a microwave system (such as Radio Set AN/TRA–29) to another multiplex location, then through another vhf fixed station to a second mobile unit.

(3) Basically, remote keying is accomplished by blanking out the channel pulse in the idle condition. When the local transmitter is keyed, a keying signal is generated and the keying signal causes the pulse to be inserted. It is the presence of the pulse at the far terminal that provides the operation of the keying contacts. The audio (voice) signal is always accompanied by the keying signal, hence the channel pulse is always available to carry the audio signal.

196. Remote Keying Operation

a. Between Multiplex Location and Mobile Unit (fig. 193). For the east operator to talk through the vhf transmitter at the west terminal, the operator must close his remote keying switch which causes the following:

(1) Because this switch is connected to the REMOTE KEYING IN binding posts at the multiplexer set, closing the remote keying switch short-circuits these binding posts. This, in turn, causes the pulse for the given channel to be inserted in the pulse train and to be sent through Radio Set AN/TRC–29 (or some other applicable radio set) to the west terminal. The presence of this pulse at the west terminal causes a relay to operate, which causes the vhf transmitter to be *keyed on.* Hence, when the east operator talks, the voice signal is transmitted through the radio-relay system by modulation of the inserted pulse and thus modulates the distant vhf transmitter signal. Assuming the mobile unit is within range of the vhf transmitter, the vhf signal will be received and heard by the mobile unit operator.

(2) To reply, the mobile unit operator transmits a modulated vhf signal which is picked up by the fixed vhf receiver at the west terminal. The receipt of this signal causes a squelch relay to operate. The contacts of this relay are connected to the REMOTE KEYING IN binding posts of the multiplexer set. When the squelch relay shorts these contacts, it causes the proper channel pulse to be inserted in the output pulse train. Consequently, when the mobile unit operator talks, his speech signal is received by the vhf receiver at the west multiplex location, where it is connected to the multiplexer set and modulates the inserted pulse. The modulated pulse train is transmitted to the east terminal through the radio-relay system. There it is demultiplexed and demodulated by the multiplexer set east terminal and the audio signal fed through the normal binding posts to the original east operator.

b. Between Two Mobile Units (fig. 194). To talk from one mobile unit to another unit by way of two fixed vhf stations at two different multiplex locations, it is only necessary for either unit operator to operate exactly as if he were talking to another mobile unit. The signal is carried through the multiplexer set and radio-relay system exactly as described in *a* above, except that there is a vhf station at both locations.

Note. At a repeater when the local vhf fixed station receives a signal from a mobile unit, the keying and audio signal is fed to both the east and west terminals because the remote keying circuit is always on a party-line basis. Similarly, the fixed vhf transmitter will be keyed on by a signal from either the east or west terminal.

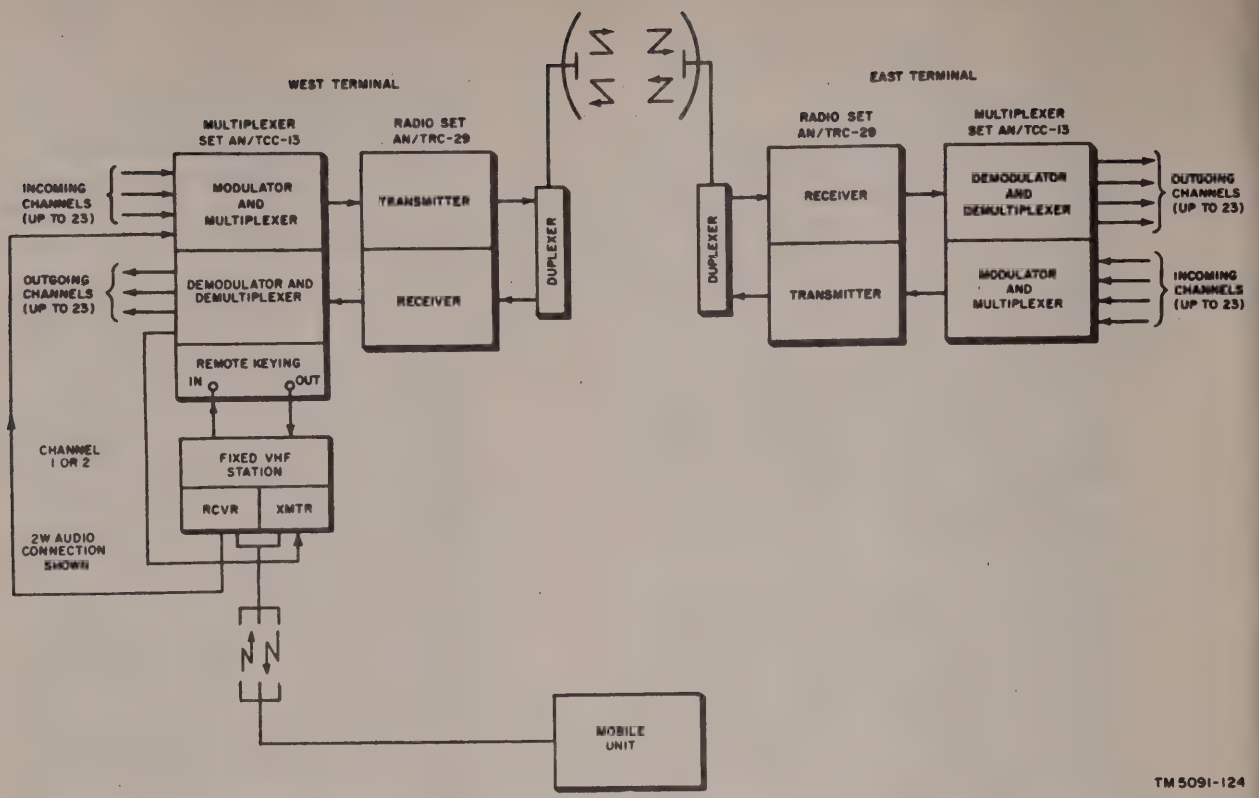


Figure 193. Remote keying operation between multiplex location and mobile unit, block diagram.

197. Internal Multiplexer Remote Keying Operation

a. General.

(1) The remote keying facility is provided to allow remote keying on either or both channel 1 and channel 2. The operation is identical on both channels; therefore, only one case will be discussed.

(2) Remote keying is accomplished by removing the plug-in unit, rotating it 180° and reinserting it. When inserted in the proper polarity, this unit has the function of blanking or inserting the pulse as required for sending, or of being operated (while receiving) by the pulse which has been blanked or inserted.

(3) Audio connections remain the same on the channels being remotely keyed as on all other channels.

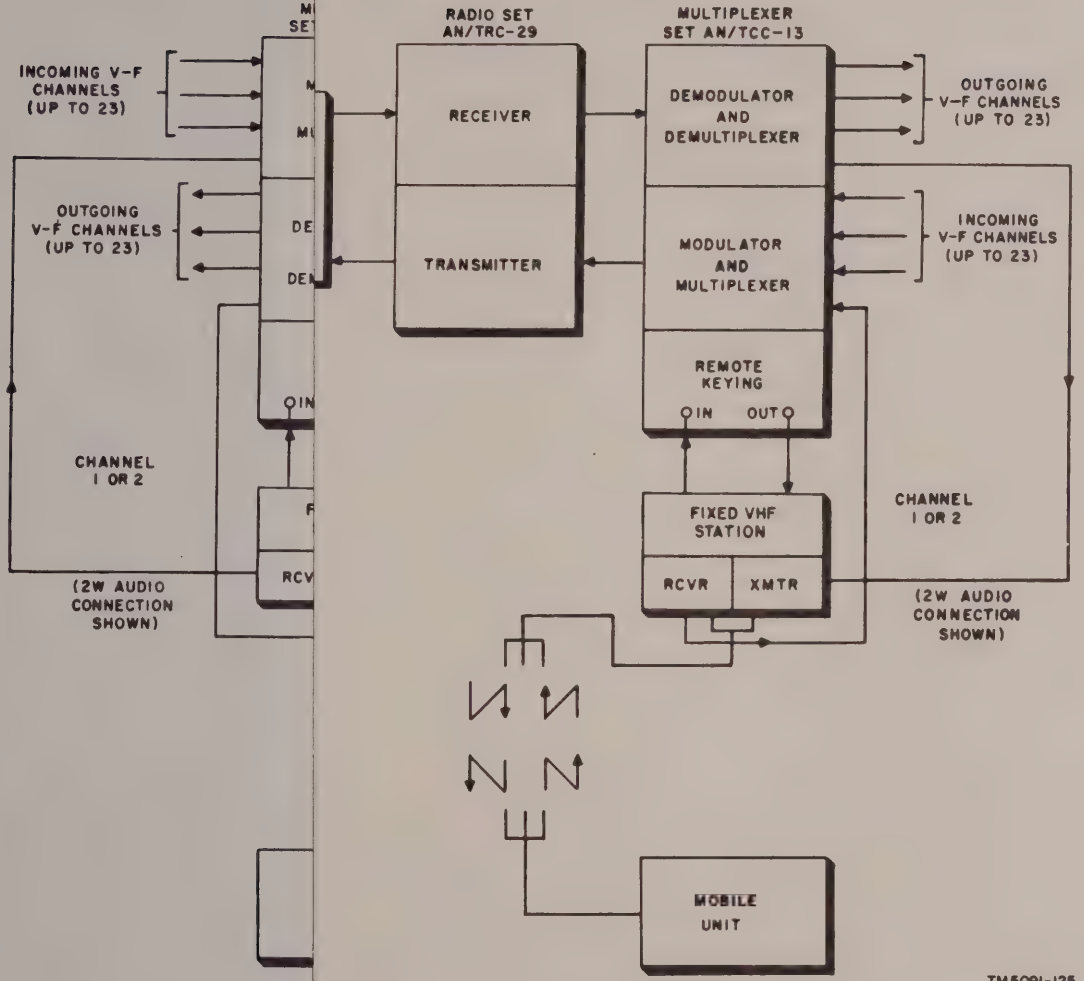
(4) Either two- or four-wire connections may be used at a terminal only. Only party-line operation is available at a repeater, and this terminates in a two-wire connection.

(5) In *b* and *c* below, a detailed description is given of the operation of remote keying in a multiplexer set. This is independent of whether it is used with two mobile units, or with a single mobile unit with an operator located near a multiplex location. The description therefore applies to either case. Figure 379 is a complete schematic of Remote Switching Control C–1509/TC. It should be noted that the relays in the remote keying unit are still a part of the circuit in NORMAL operation, although they have no function except to connect B+ to V2 in the modems. Remote keying operation will be described in two steps: sending into a multiplexer group and receiving from a multiplexer set.

b. Sending into Multiplexer Set (fig. 195). A short circuit may be placed across the RE-

RADIO TELEPHONE TERMINAL SET AN/TRC-38

EAST TERMINAL



TM5091-125

NOTE:
RADIO REPEATER SET AN/TRC-41 MAY BE SUBSTITUTED FOR RADIO REPEATER SET AN/TRC-40.

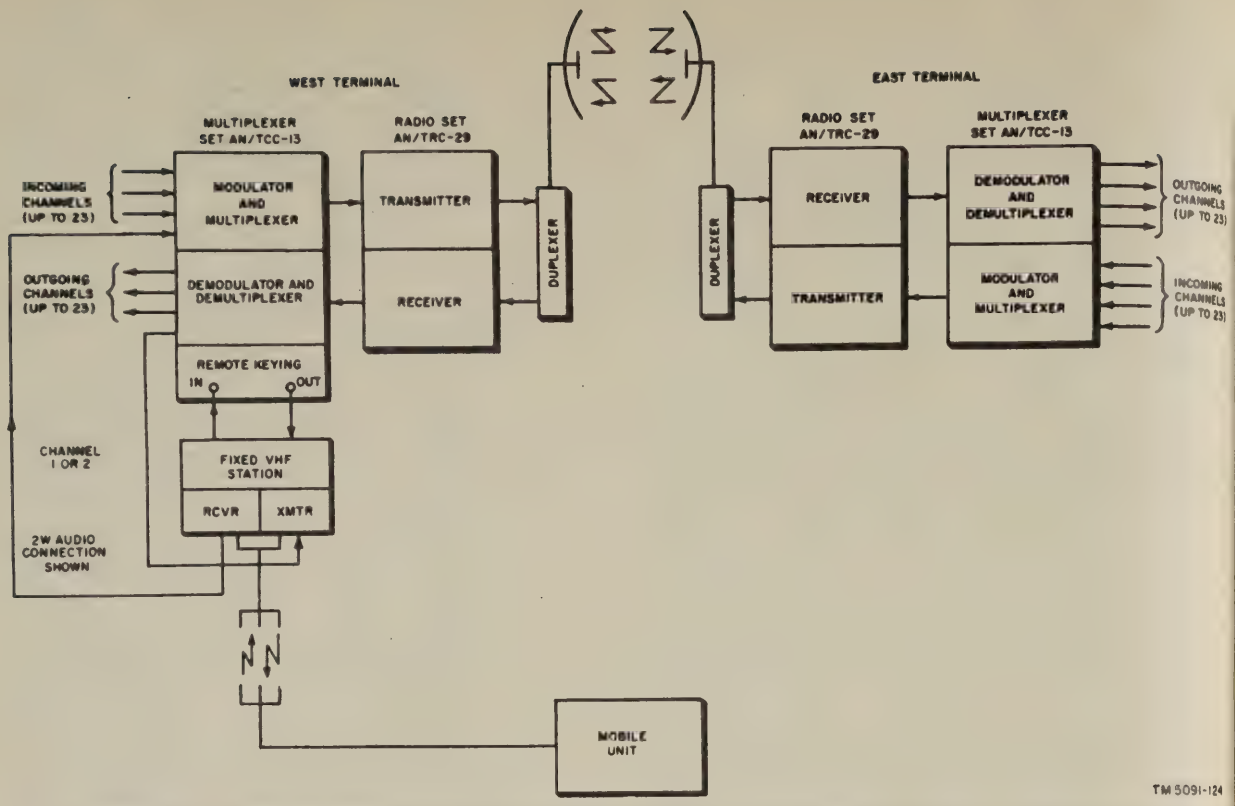


Figure 193. Remote keying operation between multiplex location and mobile unit, block diagram.

197. Internal Multiplexer Remote Keying Operation

a. General.

(1) The remote keying facility is provided to allow remote keying on either or both channel 1 and channel 2. The operation is identical on both channels; therefore, only one case will be discussed.

(2) Remote keying is accomplished by removing the plug-in unit, rotating it 180° and reinserting it. When inserted in the proper polarity, this unit has the function of blanking or inserting the pulse as required for sending, or of being operated (while receiving) by the pulse which has been blanked or inserted.

(3) Audio connections remain the same on the channels being remotely keyed as on all other channels.

(4) Either two- or four-wire connections may be used at a terminal only. Only party-line operation is available at a repeater, and this terminates in a two-wire connection.

(5) In *b* and *c* below, a detailed description is given of the operation of remote keying in a multiplexer set. This is independent of whether it is used with two mobile units, or with a single mobile unit with an operator located near a multiplex location. The description therefore applies to either case. Figure 379 is a complete schematic of Remote Switching Control C–1509/TC. It should be noted that the relays in the remote keying unit are still a part of the circuit in NORMAL operation, although they have no function except to connect B+ to V2 in the modems. Remote keying operation will be described in two steps: sending into a multiplexer group and receiving from a multiplexer set.

b. Sending into Multiplexer Set (fig. 195). A short circuit may be placed across the RE-

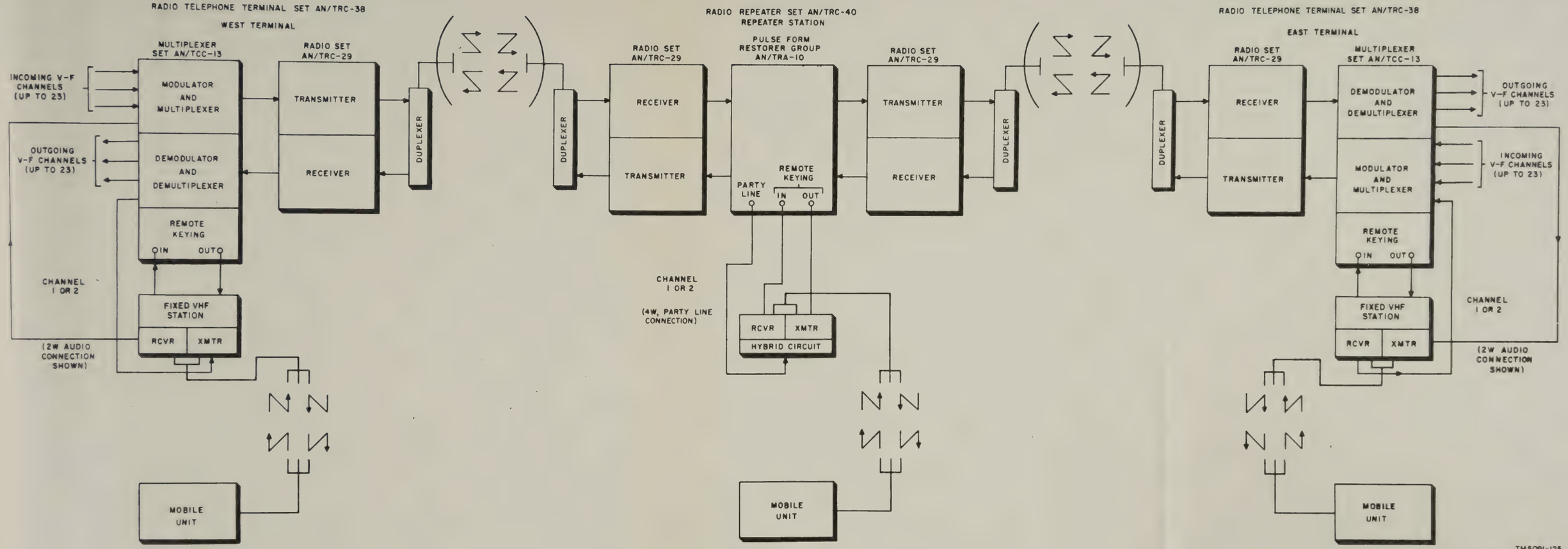


Figure 194. Remote keying operation between two mobile units, block diagram.

NOTE:
RADIO REPEATER SET AN/TRC-41 MAY BE SUBSTITUTED FOR RADIO REPEATER SET AN/TRC-40.

MOTE KEYING IN terminals (located on the multiplexer subassembly) by either a local operator with a keying switch or as the result of vhf receiver that operates a squelch relay to o the same thing. The following actions esults:

(1) Relay K1 operates, because one end of its coil is keyed to ground and the other end is returned to the bleeder (consisting of R1 and R3) from B+. Relay contacts 6 and 8 of K1 close, causing relay K2 to remain operated by the coil being returned from B+ through R2 to ground. Relay contacts 2 and 4 of relay K1 close and complete the circuit from the plate of V2 to B+. This energizes V2 and inserts the pulse. Relay K2, which had previously been connected through contacts 7 and 8 of relay K1 through the coil of relay K2 to B+, is now de-energized, and as a result the hybrid transformer is disconnected from terminating resistors R4 and R8 and is connected to the two-wire terminals to complete the voice circuit.

c. Receiving from Multiplexer Set (fig. 196). The presence of the correct channel pulse on the video signal fed from the rf equipment into the multiplexer set causes V5 to be cut off, causing relay K2 to release. The following actions occur:

(1) The output of the hybrid is connected to the output terminals, which are disconnected from terminating resistors R4 and R8.

(2) Remote keying relay K2 is in series with modem relay K2 and, therefore also releases, connecting contacts 3 and 4 (of remote keying K2) and placing a short circuit across E16 and E17, the REMOTE KEYING OUT binding posts. This operates the associated vhf transmitter.

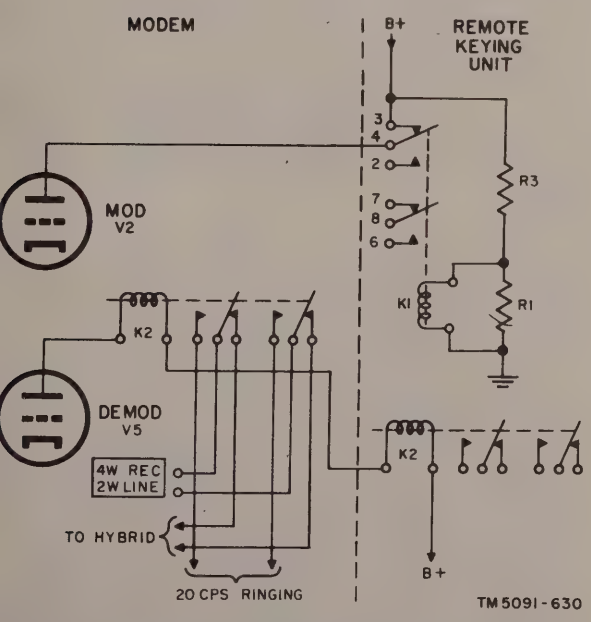


Figure 195. Remote keying normal operation, simplified schematic diagram.

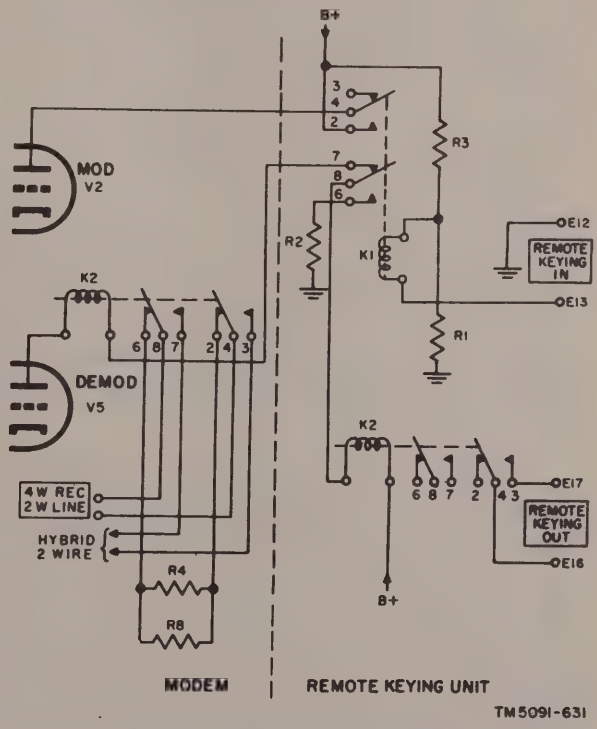


Figure 196. Remote keying, operation, simplified schematic diagram.

CHAPTER 8
MULTIPLEXER GROUP AN/TCA–1
AND
PULSE FORM RESTORER GROUP AN/TRA–10 THEORY OF OPERATION

Section I. APPLICATION THEORY

198. General

Note. Refer to paragraphs 148 through 153 for basic principles of time-division multiplexing and pulse-position modulation.

a. Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10 are transportable equipments designed to be used at repeater sites. The equipments provide reshaping of the 23- or 45-channel ppm pulse train received from the radio receiver in a radio link before it is fed to the radio transmitter at a repeater station. Multiplexer Group AN/TCA–1 can also be used to drop-and-insert the first eight channels at the radio-relay site. Pulse Form Restorer Group AN/TRA–10 can be used to drop-and-insert channels 1 and 2 at the radio-relay site. This enables the repeater station to communicate with either terminal or another relay site.

b. Because communication is normally conducted in two directions through a repeater station, identical facilities are provided, one for each direction of communication. Because the two sections, eastgoing and westgoing, of the multiplexer group and pulse form restorer group are mechanically and electrically identical, only one section will be considered in the following discussion. Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10 operate in a similar manner. The basic differences are that the pulse form restorer operates primarily as a restorer and has two drop-and-insert channels, while the multiplexer group is designed primarily to drop-and-insert eight channels and secondly, as a restorer. The modulating, multiplexing, demodulating and demultiplexing circuits are identical except for the number of channels dropped and inserted.

c. The drop-and-insert channels are supplied so that the operator at the repeater may elect to drop (remove) signals being received (channels 1 through 8 for the AN/TCA–1 and channels 1 and 2 for the AN/TRA–10), and locally insert a signal which then replaces the removed signal and travels on as part of the regular pulse train. The inserted signals take the place of the dropped signals and appear identical with signals from the original point of transmission.

d. The pulses in the received pulse train may vary in shape. One function of the video restorer is to make all pulses uniform and of the shape described in paragraph 199*b*.

e. An over-all block diagram of the multiplexer group and pulse form restorer group is shown in figure 197. For through signals, with no channels dropped or inserted at the repeater, the incoming pulse train is fed to both the positive and negative pulse train reshapers. The pulses are reshaped to the desired level and fed to the output, where they are applied to the transmitter for retransmission. A switch, which enables the operator to disconnect the negative pulse train reshaper filaments when the equipment is used in a 23-channel system, is provided. If the operator wishes to drop and insert channels, the desired pulses of the received positive train are dropped and the locally generated signal pulses are inserted in the

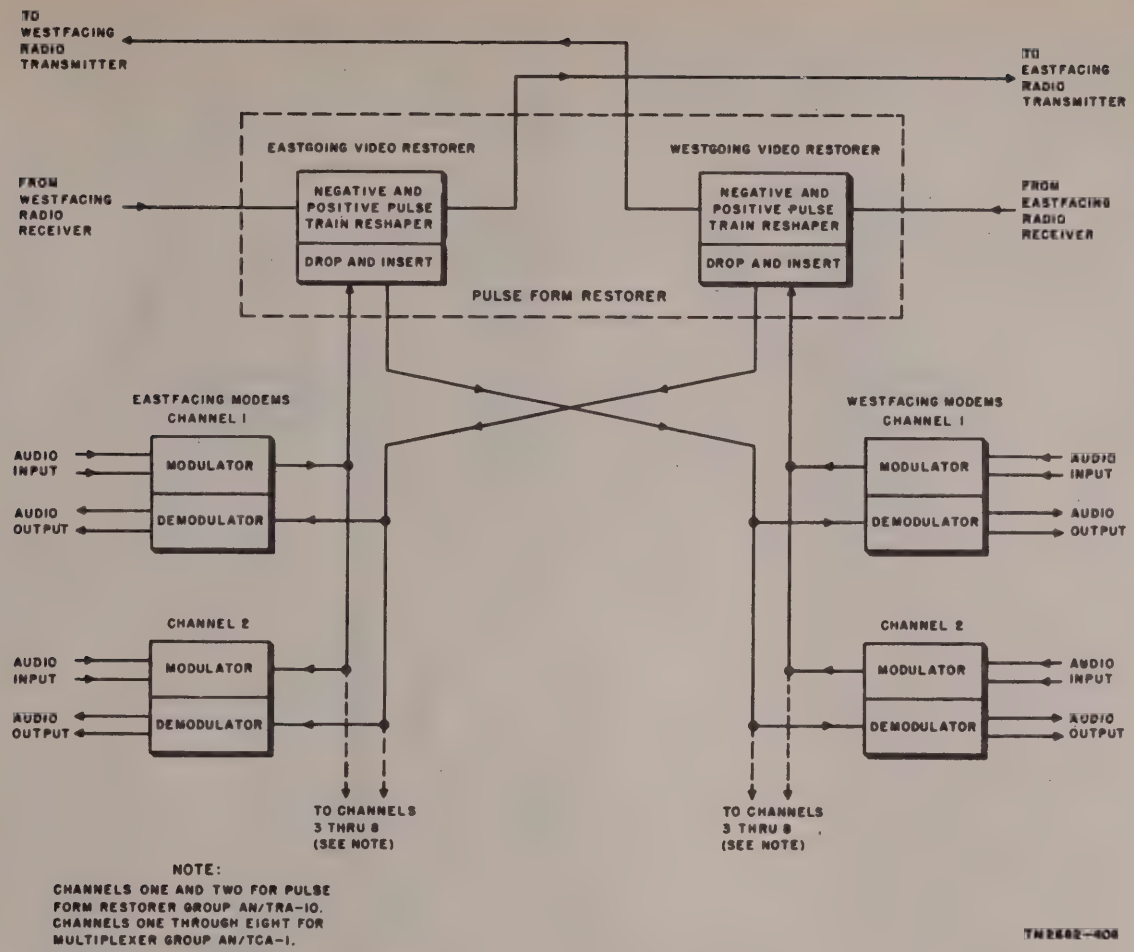


Figure 197. Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10, over-all block diagram.

ulse train. The drop-and-insert circuits of the ideo restorer feed the dropped pulses to de-ultiplexer and demodulator circuits that ransform the pulses into usable audio informa-on. The audio signals to be inserted are fed the modulator and multiplexer circuits that ransform them into pulse-position-modulated ulses. The pulses are then inserted into the ulse train by the insert circuit. As seen in gure 197, the negative pulse train reshaper eshapes the negative pulse train and feeds it irectly to the system output. The positive ulse train reshaper, however, is broken into vo sections. The positive pulse train is fed rough the first section and then is tapped off nd passes through the blank-and-insert chan-els before going to the second section and the utput. In addition, the positive signals are so fed to the demultiplexer and demodulator. nserted signals are fed through the multi-plexer and modulator and then directly to the second section and the output.

199. Reshaping Circuit

a. The simplest function of the multiplexer group and pulse form restorer group is to reshape the pulses without dropping or inserting any signals. This function is carried out by the reshaper section of the video restorer. Tubes V1 through V5 provide negative pulse train reshaping, while tubes V6 through V10 provide positive pulse train reshaping. The reshaping section will:

(1) Reshape the 23-or 45-channel pulse train to a standard wave shape for both directions of transmission.

(2) Bypass the input to the output in the event of unit failure and actuate the alarm circuit.

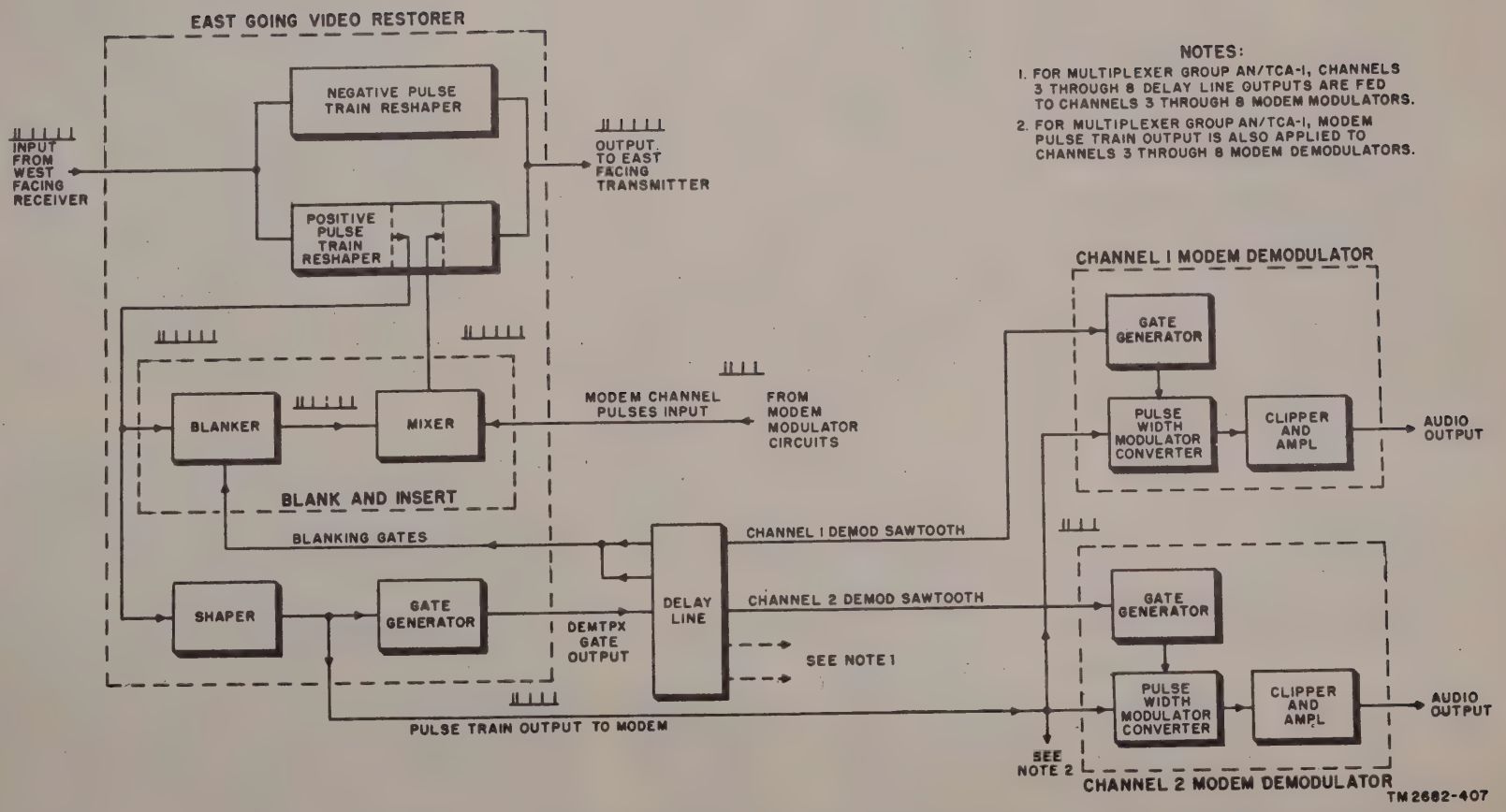


Figure 198. Demultiplexing and demodulating circuit, block diagram.

(3) Provide an 8-kc sine wave for synchronization of the oscilloscope.

Note. These functions apply to signals in either direction.

b. The video restorer must accept a pulse train that is nominally .5 volt peak from the rf receiver. If the pulse train is a composite one (45-channel operation) consisting of two 23-channel pulse trains, one of which is the opposite polarity from the other end interleaved, the amplitude of the composite will be nominally 1 volt peak-to-peak; that is, each pulse train in the composite will be nominally .5 volt peak. Each pulse train in the composite may vary from .3 to .7 volt peak, independently, and the overshoot of either pulse train in the composite cannot exceed 30 per cent of the amplitude of the other pulse train. The input impedance of the unit is 50 ohms ±10 per cent. The width of the pulses in the input pulse train will be nominally .5 microsecond but may vary from .3 to .7 microsecond. The pulse train described above must be reshaped to a standard wave shape and fed to a 50-ohm output impedance with an amplitude that is at least .7 volt peak (1.4 volts peak-to-peak for a composite 45-channel pulse train). The standard wave shape is as follows: the width of each pulse should be .5 ±.2 microsecond measured at the 50 per cent amplitude point.

200. Demultiplexing and Demodulating Circuit

(fig. 198)

a. When the local operator elects to drop-and-insert a signal, the video restorer performs all the operations described in paragraph 199. In addition, the video restorer provides the proper pulses to the modems (one for each direction of transmission) to allow demodulation of the desired channels of the positive pulse train. On reception, the positive pulse train is taken from the positive reshaper and fed into the blanking circuits. It is also fed to the pulse amplifier and then to the gate generator. The gate generator output is sent through the delay line to provide channel separation signals that are fed back to the demodulator circuits. The pulse train is also fed into the demodulators and converts them to an audio signal.

b. The following video restorer waves shapes are necesary for demodulation of the dropped channels in the modems.

(1) The entire positive pulse train must be available from an impedance source of less than 400 ohms. The positive pulse train must be changed to a negative polarity with an amplitude of 35 volts ±10 per cent. The wave shape at this point represents a 10 per cent or smaller slice from the center portion of the input pulse train to achieve the maximum signal-to-noise advantage. Therefore, it must also have been differentiated to remove any noise that may be present on the trailing edges of the pulses.

(2) A negative gate must be supplied to the delay line (which is terminated in 3,000 ohms). The amplitude of this gate must be 130 ±10 volts and should be approximately 4 microseconds wide (±10 per cent) measured at the 50 per cent amplitude point. The delay line is not part of the video restorer; it is made sufficiently long in delay to provide suitable selecting gates to the demodulators in the modems, by adding sections. It is located on the rack.

c. An 8-kc sine wave, which is synchronous with the incoming pulse train for the purpose of synchronizing the oscilloscope, must be obtained.

201. Modulating and Multiplexing Circuit

(fig. 199)

a. General. During insert, the reshaped pulse train is taken from the positive pulse train reshaper and fed to the blank and insert section, to allow the insertion of locally generated signals. It is also fed to the pulse amplifier and gate generator to produce gates that are fed to the delay line. The delay line produces channel pulses from the gate; these are then modulated in the local modulator and fed to the insert channels then back into the positive pulse train reshaper. When a signal is to be modulated and multiplexed, the video restorer performs the following functions in addition to those already listed:

(1) Provides the proper wave shapes to the modems (one for each direction of

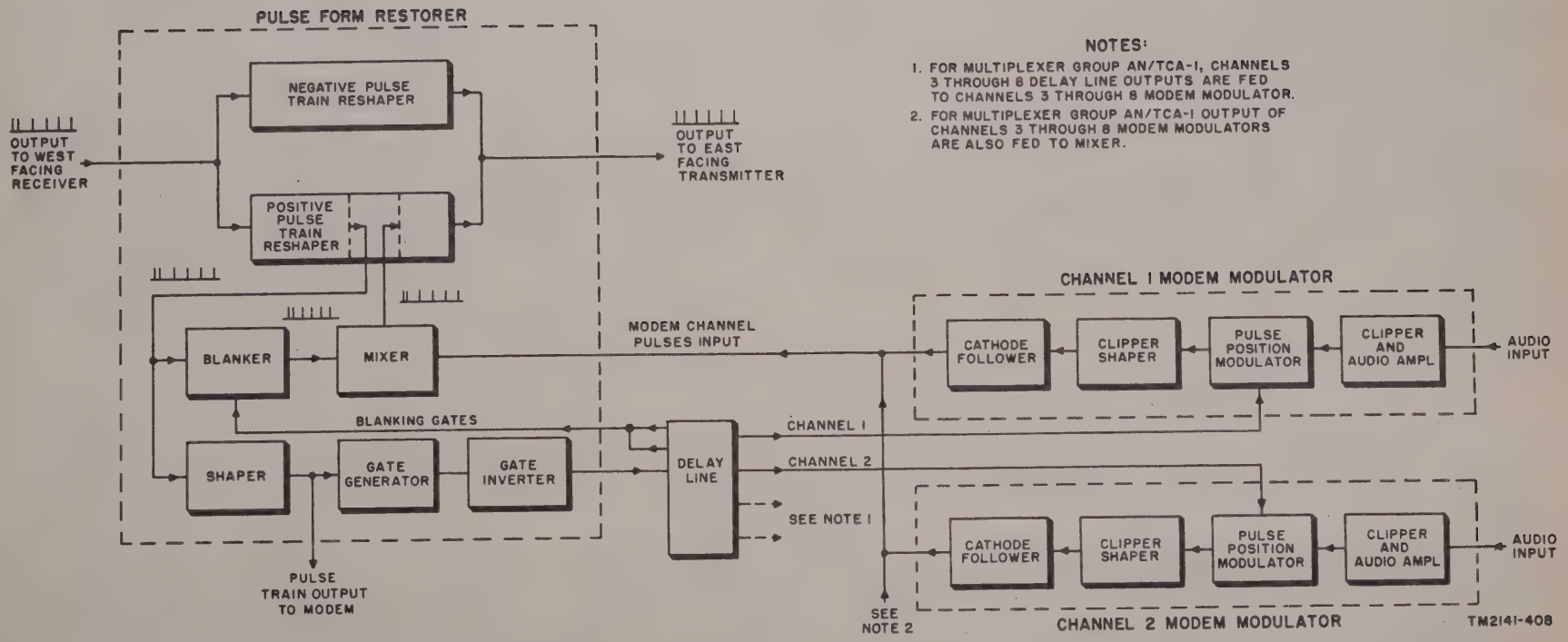


Figure 199. Modulating and multiplexing circuit, block diagram.

transmission) to allow generation and modulation of new channel pulses to be inserted in the pulse trains.

(2) Accepts pulses for each direction of transmission from these modems and inserts them in the outgoing pulse trains in place of the pulses that have been blanked.

b. Modem Modulator.

(1) The audio information to be relayed is applied to the individual modems, using either a two- or four-wire connection. The modems act on this audio-frequency (af) signal to produce ppm channel pulses. Refer to paragraphs 148 through 152 for the principles of ppm and tdm and wave form reshaping.

(2) The video restorer provides means to blank (drop) channels of the positive pulse train in each direction of transmission to allow new channel pulses locally generated and modulated to be inserted in their place. These inserted signals are generated and modulated in the modems for the two directions of transmission. The video restorer provides the proper wave shapes for these modems. The ppm pulses from the modems are then inserted by the video restorer in the outgoing wave train.

c. Wave Shape Supplied to Modem for Modulation. The modulator in each modem must receive a positive sawtooth wave shape which is 8 microseconds wide and has an amplitude of 20-volts to generate and allow modulation of a new channel pulse. To accomplish this, the video restorer must supply a positive gate which is 100 to 110 volts in amplitude and 8 ± 1 microseconds wide at its 50 per cent amplitude points. This gate should correspond in time to the marker pulse in the input pulse train. The proper phasing for the channels and the proper sawtooth wave shape are provided by the delay line (not part of the video restorer). The sawtooth wave shape is obtained from the delay line outputs by integrating circuits.

202. Blanking and Insert

a. General. The video restorer is capable of blanking any of the channels (channels 1 and 2 of the pulse form restorer and channels 1 through 8 of the multiplexer group) of the positive pulse train sufficiently so that the signal-to-cross talk ratio is not worse than 55 db (when measured from a modulated pulse which is blanked to a new pulse inserted in its place). This type of cross talk is called *feedthrough cross talk.* In addition, the video restorer provides facilities for inserting a new pulse into the pulse train after having blanked the original pulse. This action is shown in figure 199, and is explained in paragraph 201.

b. Insertion of Channel Pulses into Pulse Train. The video restorer provides a common resistance of 470 ohms in which to mix the channel pulses from the modulators of the local modems. It also provides +11-volts dc across this resistor in order to properly bias the cathode follower outputs in each modem. The pulses existing at this point will be 4 to 7 volts (peak) and will have varying widths. These pulses must be inserted in the positive pulse train in place of the blanked channel pulses, *and must have the same shape and amplitude as the other pulses at the output of the video restorer.*

203. Power Supplies

The power supply for the multiplexer group consists of Voltage Regulator CN–236/G (par. 233), Multiplexer Subassembly MX–1442/TC (filament supply) (par. 234), and Power Supply PP–691/G (par. 236). The power supply for the pulse form group is composed of Voltage Regulator CN–236/G and Power Supply PP–691/G. In addition, the pulse form restorer has a filament transformer for the modems and video restorer. This transformer is mounted on Electrical Equipment Rack MT–1434/TRA–10.

204. Test Equipment

a. General.

(1) *Multiplexer Group AN/TCA–1.* The accessory test equipment necessary to perform maintenance and alignment of the multiplexer group is mounted in one test rack. The accessory test equipment comprises Audio Test Set TS–762/TC, Control Monitor C–1151/TC, and Oscilloscope OS–25/G.

(2) *Pulse Form Restorer Group AN/TRA–10.* The accessory test equipment

necessary for maintenance and alignment of the pulse form restorer group is included at the top of the equipment rack. It consists of Oscilloscope OS–25/G.

b. Audio Test Set TS–762/TC. The audio test set is a general purpose ac operated instrument, designed for the measurement of voice transmission systems. Refer to paragraph 263 through 267 for description and detailed analyses of the audio test set.

c. Control Monitor C–1151/TC. Refer to paragraph 268 through 272 for a detailed description of each of the control monitor circuits.

d. Oscilloscope OS–25/G. This unit is a 5-mc bandwidth oscilloscope that meets the requirements for the maintenance and alignment of the various sections of the multiplexer and pulse form restorer groups. Refer to paragraph 237 through 262 for a detailed description of each of the functional circuits of the oscilloscope.

Section II. THEORY OF VIDEO RESTORER

205. Video Restorer Block Diagram
(fig. 200)

a. Refer to the video restorer block diagram (fig. 200) and the over-all schematic diagram (fig. 370). Note that the block diagram is divided into sections, each of which performs one or more of the desired functions. Stages V1 through V5B provide reshaping of the negative part of the pulse train if the input is a 45-channel composite pulse train. Stages V6 through V10 provide reshaping of the positive part of the pulse train. As shown in the block diagram, the composite signal appears at the input, and the negative and positive components are separated and reshaped in their respective reshaper sections. Transformer T1 provides mixing of the two reshaped pulse trains to re-form the 45-channel composite as shown at the output, and it also provides matching of the two pulse output tubes, V5B and V10B, to the 50-ohm output load. The output of the 1-megacycle filter is applied to the transmitter through P. T. OUT AMPL switch S2, which is used to select either a 6-db or 12-db attenuating pad. Stage V11 provides blanking of one to eight channels from the positive pulse train; stage V12 provides for shaping of the channel pulses generated in the local modems and mixes them with the pulse train that has had channels blanked from it. Stage V13 provides a low source impedance from which to drive the shaped blanking gates into stages V11 for blanking. Stages V15 through V18B provide detectors for various alarm and ringing disconnect conditions. Stage V14 provides a low impedance source of 75 volts dc for the signaling circuits in the modems. Stages V19 through V21 provide the negative 35-volt pulse train required for demodulation in the modems. Stages V22 through V25 provide a negative gate to drive the demodulator delay line for selection of the channel pulses in the modems, and stages V26 and V27 provide for generation of a positive gate to drive the modulator delay line for generating channel pulses in the modems. A diode (V18A) and a VR tube (V28) provide for clipping of this gate at ± 105 volts. The 8-kc synchronizing voltage for the oscilloscope is derived from this gate by the tuned circuit that consists of L17 and C71.

b. The input wave train passes through a 1-megacycle filter. This is used to remove the 6-megacycle component of the signal that otherwise results in undesirable cross talk. The filter is a high cutoff type; that is, all frequencies above 1 megacycle are attenuated.

c. The function of the P. T. OUT AMPL switch S2 is as follows: When the multiplexer group or the pulse form restorer group are in close proximity to the rf equipment, the P. T. OUT AMPL switch is placed in the LOW position, thus attenuating the output of the video restorer by 12 db under normal conditions. When the multiplexer group or pulse form restorer group are some distance from the rf equipment the P. T. OUT AMPL switch is set in the HIGH position, thus attenuating the output of the video restorer only 6 db to compensate for the additional cable loss. When a failure occurs in the video restorer, relay K1 is de-energized and the input from EASTFACING REC jack J2 is applied directly to OUTPUT TO WESTFACING XMTR jacks J3 and


INPUT FROM
EASTFACING
REC

necessary for maintenance and alignment of the pulse form restorer group is included at the top of the equipment rack. It consists of Oscilloscope OS–25/G.

b. Audio Test Set TS–762/TC. The audio test set is a general purpose ac operated instrument, designed for the measurement of voice transmission systems. Refer to paragraph 263 through 267 for description and detailed analyses of the audio test set.

c. Control Monitor C–1151/TC. Refer to paragraph 268 through 272 for a detailed description of each of the control monitor circuits.

d. Oscilloscope OS–25/G. This unit is a 5-mc bandwidth oscilloscope that meets the requirements for the maintenance and alignment of the various sections of the multiplexer and pulse form restorer groups. Refer to paragraph 237 through 262 for a detailed description of each of the functional circuits of the oscilloscope.

Section II. THEORY OF VIDEO RESTORER

205. Video Restorer Block Diagram
(fig. 200)

a. Refer to the video restorer block diagram (fig. 200) and the over-all schematic diagram (fig. 370). Note that the block diagram is divided into sections, each of which performs one or more of the desired functions. Stages V1 through V5B provide reshaping of the negative part of the pulse train if the input is a 45-channel composite pulse train. Stages V6 through V10 provide reshaping of the positive part of the pulse train. As shown in the block diagram, the composite signal appears at the input, and the negative and positive components are separated and reshaped in their respective reshaper sections. Transformer T1 provides mixing of the two reshaped pulse trains to re-form the 45-channel composite as shown at the output, and it also provides matching of the two pulse output tubes, V5B and V10B, to the 50-ohm output load. The output of the 1-megacycle filter is applied to the transmitter through P. T. OUT AMPL switch S2, which is used to select either a 6-db or 12-db attenuating pad. Stage V11 provides blanking of one to eight channels from the positive pulse train; stage V12 provides for shaping of the channel pulses generated in the local modems and mixes them with the pulse train that has had channels blanked from it. Stage V13 provides a low source impedance from which to drive the shaped blanking gates into stages V11 for blanking. Stages V15 through V18B provide detectors for various alarm and ringing disconnect conditions. Stage V14 provides a low impedance source of 75 volts dc for the signaling circuits in the modems. Stages V19 through V21 provide the negative 35-volt pulse train required for demodulation in the modems. Stages V22 through V25 provide a negative gate to drive the demodulator delay line for selection of the channel pulses in the modems, and stages V26 and V27 provide for generation of a positive gate to drive the modulator delay line for generating channel pulses in the modems. A diode (V18A) and a VR tube (V28) provide for clipping of this gate at ±105 volts. The 8-kc synchronizing voltage for the oscilloscope is derived from this gate by the tuned circuit that consists of L17 and C71.

b. The input wave train passes through a 1-megacycle filter. This is used to remove the 6-megacycle component of the signal that otherwise results in undesirable cross talk. The filter is a high cutoff type; that is, all frequencies above 1 megacycle are attenuated.

c. The function of the P. T. OUT AMPL switch S2 is as follows: When the multiplexer group or the pulse form restorer group are in close proximity to the rf equipment, the P. T. OUT AMPL switch is placed in the LOW position, thus attenuating the output of the video restorer by 12 db under normal conditions. When the multiplexer group or pulse form restorer group are some distance from the rf equipment the P. T. OUT AMPL switch is set in the HIGH position, thus attenuating the output of the video restorer only 6 db to compensate for the additional cable loss. When a failure occurs in the video restorer, relay K1 is de-energized and the input from EASTFACING REC jack J2 is applied directly to OUTPUT TO WESTFACING XMTR jacks J3 and

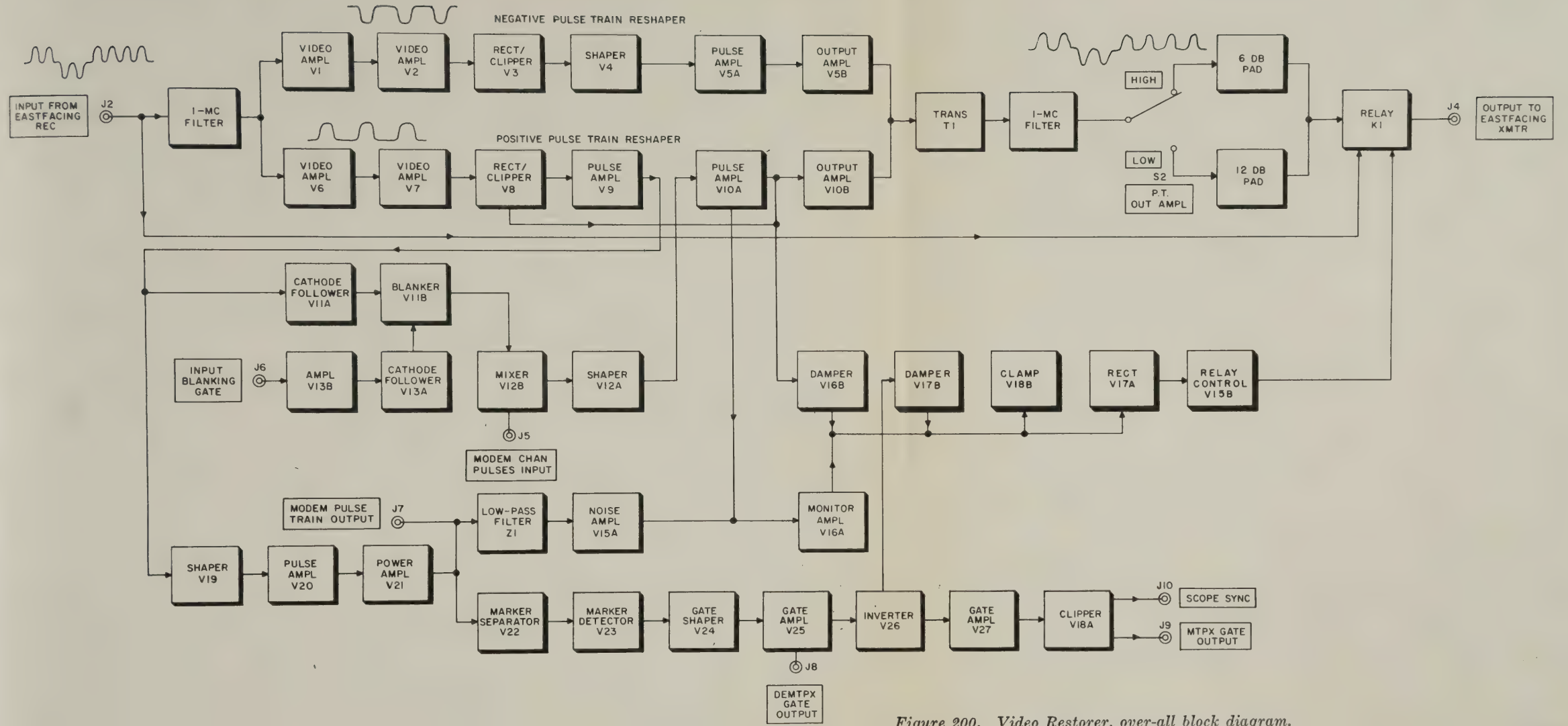


Figure 200. Video Restorer, over-all block diagram.

TM5091-51

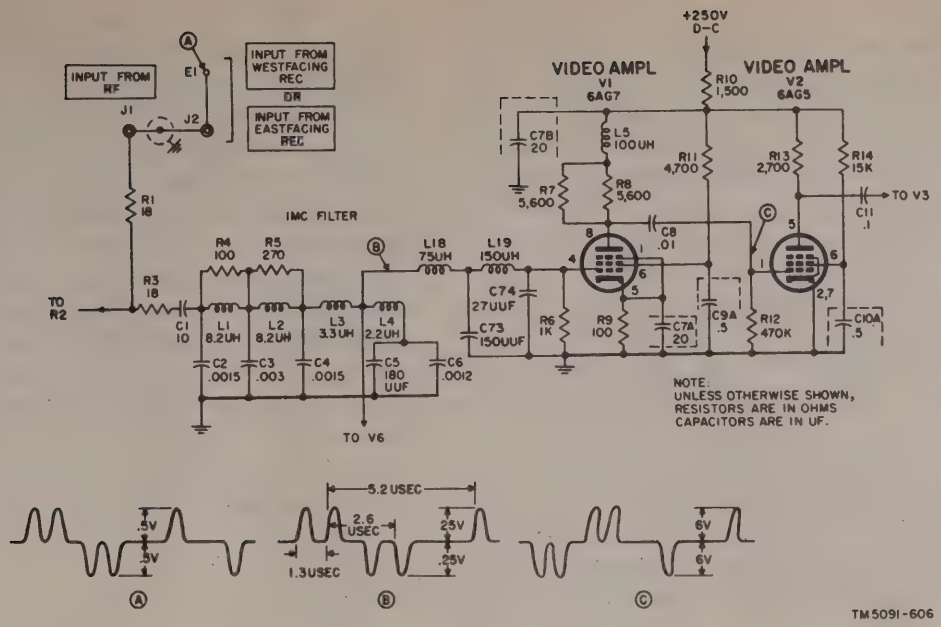


Figure 201. Video amplifiers V1 and V2.

4, thus bypassing the faulty equipment and naintaining communications.

Note. When relay K1 is de-energized there re no drop-and-insert facilities available at he repeater.

206. Negative Reshaping Circuit

The negative reshaping circuit consists of ideo amplifiers V1 and V2, rectifier clipper V3, shaper V4, pulse amplifier V5A, and output mplifier V5B. The output of the 1-mc filter is pplied to the negative pulse train reshaper. With the 23 CHAN-45 CHAN switch in the 45 CHAN position, filament voltage is applied to he negative reshaping stage. If the switch is in he 23 CHAN position stage, tubes V1 through V5 are inoperative.

207. Video Amplifier V1
(fig. 201)

The output of the 1-mc filter is applied to delay network, L18, L19, C73, and C74, and s developed across grid return resistor R6. The delay network has been added to compensate for the slight difference in phase delay between the positive and negative pulse train reshaper. The positive pulse train reshaper has a nominal delay of .22 microsecond more than the negative because of the additional stages of amplification. Without this delay network the effect on long systems would accumulate in phase to the extent that eventually the two markers would merge and marker separation would be impossible. The positive and negative pulses are applied to the grid of V1 and are amplified. The output voltage, developed across resistor R7 and R8 in series with shunt peaking coil L5, is coupled to the grid of V2 by coupling capacitor C8. Peaking coil L5 is placed in the circuit as part of the plate load to compensate for the loss that would normally occur at higher frequencies. Screen voltage is supplied by screen voltage-dropping resistor R11. The screen is kept at an rf ground potential by capacitor C9A; plate voltage is applied through the plate decoupling network R10 and C7B. Cathode bias is developed across R9 and C7A.

208. Video Amplifier V2
(fig. 201)

a. The second video amplifier, V2, is operated as a grid-leak type limiter. The 45-channel pulse train applied to the grid of V2 from the plate of V1 will contain both negative and positive pulses. This stage suppresses the negative pulses and amplifies the positive pulses.

b. When no signal is applied to the grid, the tube will conduct heavily. A grid-leak combination, which consists of C8 and R12, is placed in

the input circuit of the tube. Positive peaks from the incoming signal drive the grid positive, causing the grid to draw current. This current charges capacitor C8. During the negative portion of the input signal, the grid no longer draws current. This allows capacitor C8 to discharge through grid-leak resistor R12, developing the negative operating bias of the tube. Because of this bias, the incoming positive pulses will be amplified while the negative pulses will drive the tube beyond cutoff, suppressing the peaks of the negative pulses. In this manner, the output voltage developed across R13 consists of large negative pulses and small positive pulses (A, fig. 202).

c. Capacitor C11 is the output coupling capacitor that feeds the output of V2 to rectifier-clipper V3. Resistor R14 is the screen dropping resistor. Capacitor C10A is the screen bypass capacitor.

209. Rectifier-clipper V3 and Shaper V4 (fig. 202)

a. Rectifier-clipper tube V3 is arranged so that one-half of it rectifies the negative peak of the pulse train supplied to it. About 40 per cent of this rectified voltage is developed across resistor R17 and is used to bias the lower diode so that it will not conduct until the negative pulse train reaches 40 per cent of its final value. In this manner, the lower limit on the slice taken out of the pulse train is set at 40 per cent. Since the second stage uses grid-leak bias, some of the pulse train in the vicinity of the base line will be clipped when the input to the entire circuit is greater than .6 volt; therefore, the lower clipping level will be somewhat larger than 40 per cent of the original pulse when the input exceeds this amount.

b. Resistor R15 is the cathode load resistor for both sections of V3. Resistor R16 in series with R17 forms a voltage divider network in the plate circuit of the rectifier section of V3 and is bypassed by capacitor C12A. Resistor R17 is the plate biasing resistor of the other section. The output signal voltage is coupled to the grid of shaper V4 by coupling capacitor C13.

c. The 10-volt negative output of diode clipper V3 is fed to the grid of shaper V4 (B, fig. 202). In shaper stage V4, all the pulses in the train are narrowed to about ¼ microsecond by the action of ringing coil L6 (C, fig. 202). The germanium diodes, CR1 and CR2, clip the top and bottom of this pulse train to improve the wave shape. Resistor R21 damps the ringing. In addition, CR2 overdamps the shock-excited oscillations after the first half-cycle (note the damping effect on the second half-oscillation cycle in D, figure 202). Resistor R19 and capacitor C14 form the plate power supply decoupling network. The plate is further decoupled by R20 and C15. Resistor R22 is the screen resistor and is bypassed by C16. The grid of V4 is returned through R18 to B+. This positive bias causes the tube to conduct and clip the positive pulses that appear on the grid. Capacitor C17 is the output coupling capacitor to V5.

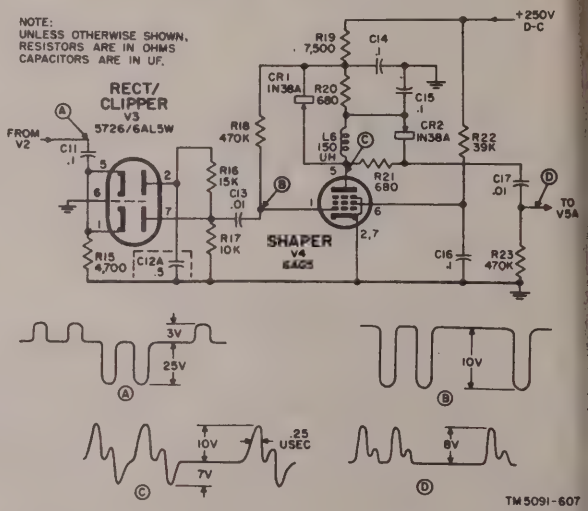


Figure 202. Rectifier-clipper V3 and shaper V4.

210. Pulse Amplifier V5A and Output Amplifier V5B (fig. 203)

a. The wave form at the output of shaper V4 (D, fig. 202) is applied to the grid of pulse amplifier V5A. The grid of pulse amplifier V5A is returned to ground through R23. Resistor R24 is the plate load. Plate decoupling is provided by R26 and C20A. The cathode is biased by resistor R25 which with R26 and R27 forms a voltage divider network in the B+ circuit to get a proper positive voltage on the cathode in order to bias the tube negatively. Capacitor C18 is the cathode-bypass capacitor. The signal

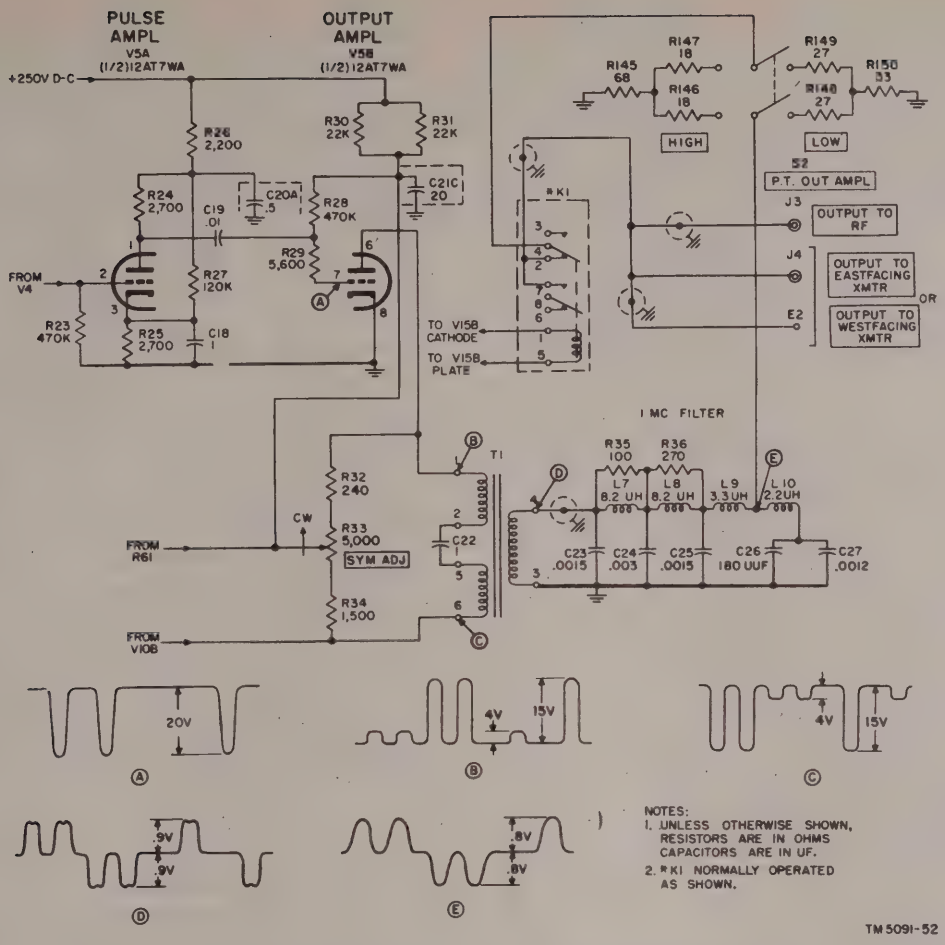


Figure 203. Pulse amplifier V5A and output amplifier V5B.

eveloped in the plate circuit of V5A is coupled o the grid of V5B through capacitor C19. The utput of C5A is fed to the junction of resistors 28 and R29. The signal as it appears on the rid of C5B is shown in A, figure 203, after mplification by V5A, and grid clipping V5B. he grid of V5B is not returned to the cathode ut through a high resistance (R29 and R28) o the plate voltage supply. With this arrangeent, the grid to cathode voltage is maintained t a value close to zero. When the grid is made ositive with respect to the cathode, grid curent will effectively reduce the grid-to-cathode nternal resistance, and the voltage drop across he internal resistance will be very small. When he input voltage drives the grid positive, the nput grid resistance is very low. Therefore, the nput voltage is very low and results in very ittle change in plate current. However, if a negative voltage is applied to the grid, the grid resistance will increase, causing the full input voltage to appear between grid and cathode and consequently a large change in plate current. The result is to clip the positive pulses and produce the wave shape shown at B, figure 203. A similar wave shape from the positive reshaper appears at C, figure 203. It is then mixed in transformer T1 and appears in the output, as shown in D, figure 203. After going through the 1-mc filter, it appears as shown in E, figure 203.

b. For V5B, resistors R30, and R31 with capacitor C21C provide decoupling. Resistor R28 is the grid return to B+. Resistor R29 is in series with the grid to produce clipping. SYM ADJ R33 is included to allow balancing of the positive and negative portions of the output wave shape. The output of the pulse amplifier

is mixed in transformer T1. The output of the T1 is fed to the P. T. OUT AMPL switch.

c. To increase the low frequency response of T1, dc is blocked from the primary windings of transformer T1 by capacitor C22. This eliminates the inductance usually caused by the dc current in the primary. The inverted reshaped pulse train is fed to a 1-megacycle low-pass filter to re-establish the standard wave shape. The output of the filter is fed to the output jack, J4, through a T-pad network and through contacts on the bypass relay K1. This relay is so arranged that in event of failure of the equipment it will apply the input signal directly to the output terminals. Otherwise, it connects the output jacks to the output of the reshaper. P. T. OUT AMPL switch, S2, connects either resistors R146, R147, and R145 (HIGH) or resistors R148, R149, and R150 (LOW) T pad into the circuit. When placed in the LOW position, a 12-db pad is inserted across the output. When placed in the HIGH position, a 6 db pad is inserted across the output. The output pulse train is nominally .9-volt peak when fed to a 50-ohm load and nominally 1.8-volts peak open circuit. This, therefore, meets the requirements of a .7-volt peak output and 50-ohm output impedance.

211. 1-mc Output Filter

In frequency-modulated systems, bandwidth must be limited by filtering the output. This is done by the filter system consisting of inductors L7, L8, L9, L10, resistors R35, R36, capacitors C23, C24, C25, C26, and C27 (fig. 370). The filter has a nominal cutoff frequency of 1 mc and is down 30 db at 3 mc. The input is fed in from transformer T1, while the output is fed to the P. T. OUT AMPL switch.

212. Positive Reshaping Circuit

a. The positive pulse train reshaper circuit consists of tubes V6 through V10 (fig. 200 and 370.) Note that the circuit is essentially the same as the negative pulse train reshaper described in paragraphs 207 through 210. The input stage, V6, is operated as a grounded grid amplifier and is fed in parallel with V1. There is no phase inversion in the first stage; hence the wave form polarities following this stage are identical to those in the negative pulse train reshaper. Resistor R37 is the grid return to ground. Resistors R38 and R39 in parallel are the plate load; R40 is the cathode return. Decoupling is provided by R41 and C7C. Resistor R42 is the screen resistor and is bypassed by C9B. The output coupling capacitor is C28.

b. Video amplifier V7 is identical in operation to video amplifier V2. Resistor R43 is the grid return, R44 is the plate resistor, R45 is the screen resistor, C10B is the screen bypass capacitor, and C29 is the output coupling capacitor.

c. Rectifier/clipper V8 is identical to rectifier/clipper V3. Resistor R46 is the cathode load resistor; R47 and R48, in series, are the plate load of one section; R48 is the plate load of the other. The first plate is bypassed by C12B. The output coupling capacitor is C31.

d. Pulse amplifier V9 is a shunt peaked voltage amplifier and operates in a manner similar to shaper V4 in the negative pulse train reshaper. The output of V9 is a positive pulse train and is fed to the blank and insert stages, which consist of V11 and V12 by coupling capacitor C33. Resistor R50 and capacitor C30 are the decoupling network; resistor R49, the grid return; resistor R51 and inductor L12, the plate load; and resistors R52 and R53, the screen divider. The screen is bypassed by C32.

e. The pulse shaping that narrows all pulses in the train to about ¼ microsecond is done in the plate of shaper V12A (fig. 209). The output of this tube is then fed to pulse amplifier V10A, a twin triode amplifier like pulse amplifier V5 (fig. 203), in the negative pulse train reshaper. The output of V10B is then supplied to the lower primary of output coupling transformer T1. The secondary of the transformer then feeds the reformed 45-channel composite pulse train to the 1-megacycle low-pass filter. The plate load resistances of the two output tubes, V5 and V10, contain the common 2,500-ohm SYM ADJ control R33 the movable arm of which is returned to the B+ supply. The SYM ADJ control enables the operator to adjust the positive and negative pulse trains in the composite to equal peak amplitudes. When the 45-CHAN-23 CHAN switch is in the 23 CHAN position, the SYM ADJ control varies the amplitude of the positive pulse train. Resistors R32 and R34 are the plate-to-plate resistance. Capacitor C34 is the input coupling capacitor to V10A. Resistor R54 is the grid

return; R55, the plate load; R58 and C20B, the decoupling combination; R56 and and R59 form a divider for cathode bias; and C35 is the cathode bypass. Capacitor C36 is the input coupling to V10B, R62 is a series grid resistor (as in the tube V5B), and R61 is the grid return.

Section III. DEMULTIPLEXING AND DEMODULATING CIRCUIT

Note. The demultiplexing and demodulating circuit accepts the pulse train and produces a negative pulse which is applied to the modem demodulator.

213. Circuits for Demodulation Wave Shapes (fig. 204)

a. Shaper V19. The entire positive pulse train is taken from pulse amplifier V9 and fed to the grid of V19, which is a shaper stage similar to V4. That is, all of the pulses in the train are narrowed to about ¼ microsecond by shock excitation of L14 and then by overdamping by CR7 after the first half-cycle (Review shaper stage V4 (par. 209) for explanation of shock-excited .25-microsecond pulses.) The plate of V19 is decoupled from the B+ supply by L15 and C50B. This decoupling circuit also prevents self-sustained oscillations for the entire section consisting of tubes V19 through V27. For shaper tube V19, resistor R98 is the grid return and R99 is a parasitic suppressor. Coil L15 with resistors R103, R102, and R100 form a voltage divider network supplying the correct screen grid and cathode voltage. Capacitor C55A is the screen grid bypass capacitor. Capacitor C54A is the cathode bypass capacitor. Resistor R101 is a limiting resistor. Capacitor C56 couples the output of V19 to the grid of pulse amplifier V20.

b. Pulse Amplifier V20. The output of shaper V19 consists of negative pulses (B, fig. 204) and is fed through coupling capacitor C56 to the grid of pulse amplifier V20. The grid of pulse amplifier V20 is returned to the B+ supply through a 1-megohm resistor R104 to cause the grid to clip any remaining positive overshoot. (Refer to paragraph 210*a* for explanation of grid limiting when the grid is connected to B+.) A normal grid signal of approximately 18 volts is more than sufficient to drive this tube to cutoff, thus giving a square output pulse as shown in figure 204. Resistor R105 is a grid series resistor to aid clipping; resistors R106, R107, and R108, in series, are the plate load; resistors R109 and R110, in series, are the screen grid voltage dropping resistors. The screen is bypassed by C55B.

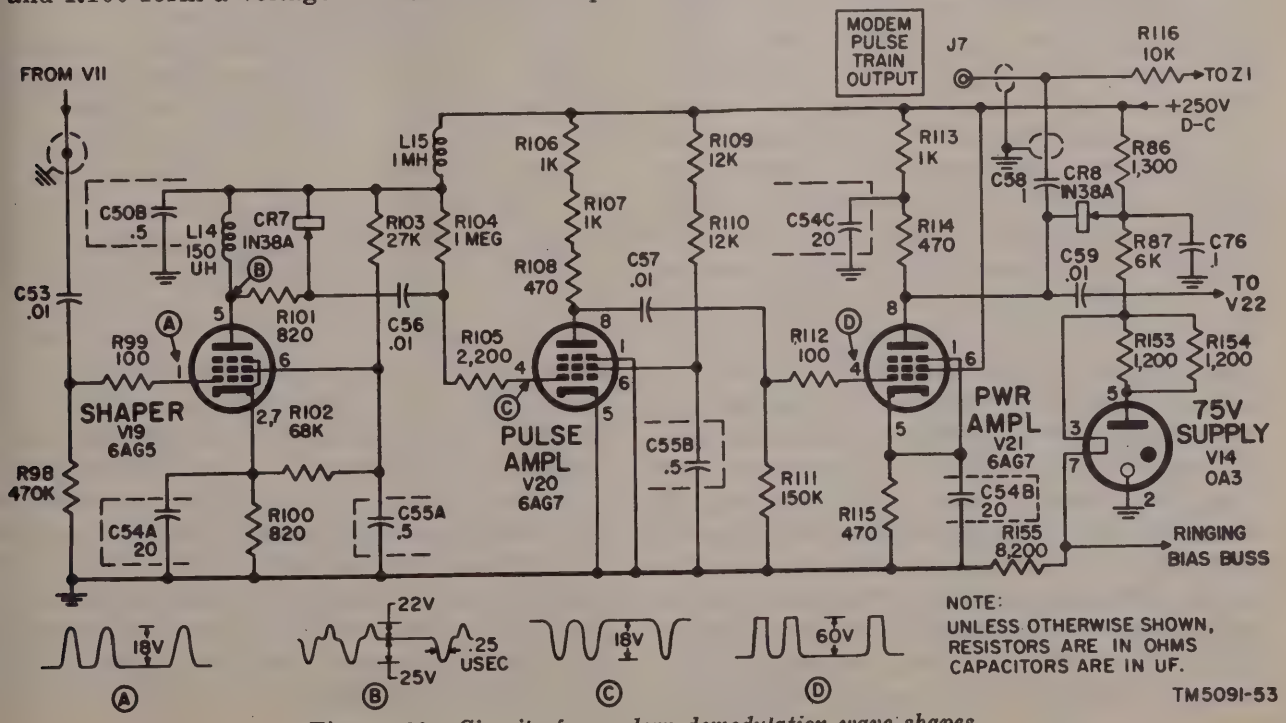


Figure 204. Circuits for modern demodulation wave shapes.

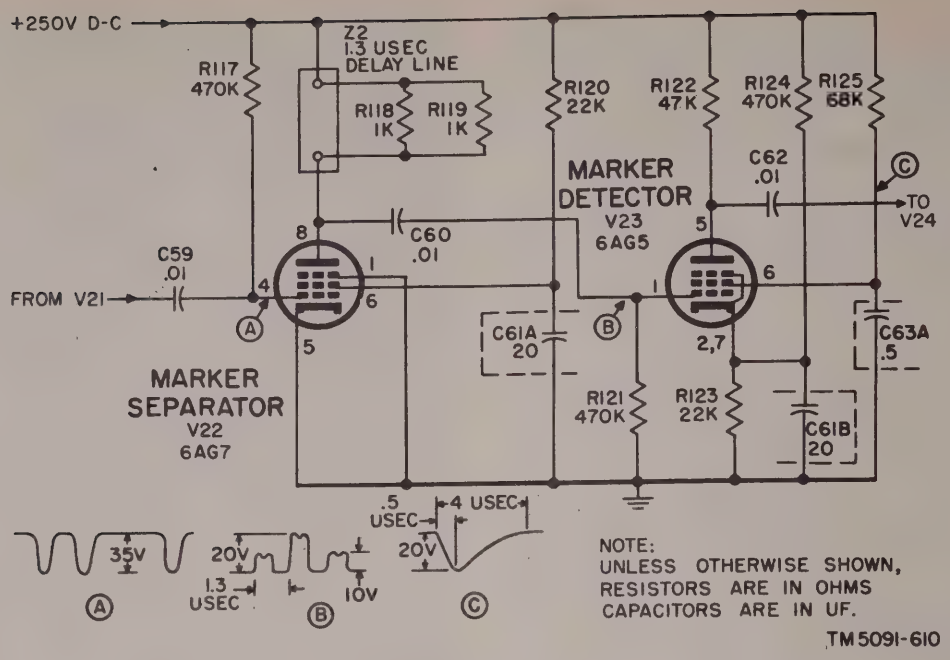


Figure 205. Marker separator V22 and marker detector V23.

c. Power Amplifier V21. The output of pulse amplifier V20 is fed to power amplifier V21 through coupling capacitor C57. The output of V21, a 35-volt negative pulse train, is applied to the grid of V22 and to J7 (A, fig. 205). This pulse train is used to supply the demodulators in the modems. Power amplifier V21 is a 6AG7 pentode. The 6AG7 pentode can be used in this circuit since it need supply only a maximum of eight modems in the AN/TCA–1 and two modems in the AN/TRA–10. Resistor R111 is the grid return, R112 is a grid harmonic suppressor, R113 and C54C provide the plate decoupling network, R114 is the plate load, and R115 is the cathode bias resistor, bypassed by C54B. Capacitor C58 is the output coupling capacitor that feeds the output to J7, and C59 couples the output to marker separator tube V2.

d. Coupling Diode CR8. When a number of channels ring simultaneously (pulses absent) the voltage at the plate of power amplifier V21 increases to a high potential. The presence of this high potential may prevent ringing. To overcome this condition, diode CR8 is used to regulate the voltage at the plate of V21. Normally, CR8 is biased to cutoff because of its connection to the voltage divider, consisting of R86, R87, and R153, in the plate circuit of 75V supply V14. When the voltage at the plate of V21 increases, the CR8 draws current and returns the plate voltage of V21 to the proper potential.

214. Marker Separator V22 and Detector Stage V23

a. General. The negative gate that must be supplied to the demodulator delay line is formed from the pulse train at the output of power amplifier V21 by the stages that consist of marker separator V22 through gate amplifier V25.

b. Marker Separator V22. Marker separator V22 has a 500-ohm, .65-microsecond, open-circuited delay line, Z2, as its plate load. The input to this delay line consists of the entire pulse train that appears on the grid of V22 (inverted) (A, fig. 205) plus the entire pulse train, which is reflected from the open-circuited delay line. Since Z2 is a .65-microsecond, open-circuited delay line, this reflected pulse train appears 1.3 microseconds later than the input pulse train (.65+ .65 = 1.3) and is absorbed by the 500-ohm input termination that consists of R118 and R119, so that no further reffections occur. Since the spacing of the two pulses in the marker is 1.3 microseconds, a double amplitude pulse appears at the time of the second pulse at the plate of V22 (B, fig. 205). Resistor

R117 is the grid return, C60 is the output coupling capacitor, and R120 is the screen resistor, bypassed by C61A.

c. Marker Detector V23. The output of the marker separator (B, fig. 205) is then fed to marker detector V23 through coupling capacitor C60. The marker detector is operated considerably below cutoff so that only the more positive double amplitude pulses from the marker separator will cause it to conduct. The ac plate load of V23 consists essentially of plate resistor R122 and L16 in the grid circuit of gate shaper V24 (fig. 206). When the driving pulse disappears, the shunt capacitance of the coil discharges through the coil. This causes the circuit to become oscillatory but the overshoots are clipped by the grid of gate shaper V24. Thus, the wave form at the grid of waveshaper V24 is a negative triangle as shown at C, figure 205. The leading edge of this wave form lasts for the duration of the driving pulse on the grid of V23 (about .5 microsecond), and the length of the trailing edge is determined by the rate of discharge of the shunt capacitance of L16. The width of this wave form near the base line is about 4 microseconds, and its amplitude is more than sufficient to cut off gate shaper V24. Resistor R121 is the grid return of tube V23; R122, is the plate resistor, capacitor C62 is the output coupling capacitor, R123 is the cathode resistor, which is bypassed by C61B. Resistor R124, in series with R123, is a voltage divider to put fixed bias on the cathode; R125 is the screen grid voltage dropping resistor, and C63A is the screen grid bypass capacitor.

215. Gate Shaper V24 and Amplifier Stage V25

(fig. 206)

a. The output wave shape is applied to choke L16 and appears at the plate of gate shaper V24 as the wave form as shown in A, figure 206. However, since gate amplifier V25 is biased below cutoff, the base line is lost at the plate of gate amplifier V25 and only the wave shape shown at B, figure 206, appears. Resistors R126 and R127 are in series and form the plate load resistor; R128 is the screen resistor, capacitor C63B is the screen bypass, and C64 is the output coupling capacitor.

b. The output of gate amplifier V25 is a negative rectangular voltage of about 4-microsecond width and 130-volt amplitude when fed to a 3,000-ohm load at J8. This 4-microsecond 130-volt negative pulse is the required wave form to be fed to the demodulator delay line. Resistor R129 is the grid return; R130 is the plate load; resistors R131, R132, and R133 function as a divider to give cathode bias; capacitor C61C is the cathode bypass; and C65 couples the output to DEMTPX GATE output jack J8 and DEMTPX GATE test point E5.

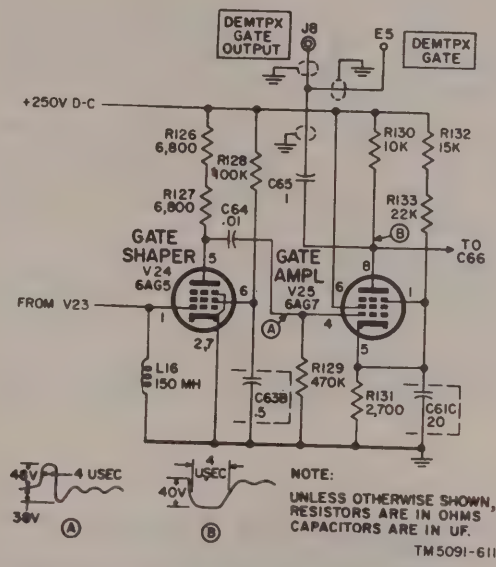


Figure 206. Gate shaper V24 and amplifier stage V25.

216. Modem Demodulator Circuit

The modem demodulator operates to convert a ppm signal to a pwm signal, which contains the audio component and only needs to be filtered to give the audio output.

a. Refer to the block diagram shown in figure 184. Video restorer gate amplifier V25 provides the pulse for the delay line. The delay line sawtooth is applied to a gate generator (V3A). This produces a gate for operating the demodulator. The gate determines the time during which the demodulator accepts signals. The input pulse train developed at the output of video restorer power amplifier V21 is also fed to the demodulator pwm converter (V3B). During the gate time, conversion to pwm takes place. The pwm signal is applied to the clipper amplifier (V4A) and then is applied to the

low-pass filter, which extracts the audio signal. The audio output is amplified by the audio output stage (V4B), and the output of V4B is fed to the output TEST PAIR terminals.

b. The 16 modems of the multiplexer group and the 4 modems of the pulse form restorer group are identical and interchangeable with those of Multiplexer Set AN/TCC–13. For detailed analyses of the stages in the modem demodulator, refer to paragraphs 189 through 191.

217. Delay Line Circuit

A delay line is a filter, or a group of filters, that have the characteristic of delaying the input signal, so that the output is later in time than the input. This is caused by the fact that one of the fundamental properties of filters is phase shift. When a number of sections are cascaded, the phase shift becomes additive, and of considerable size.

a. Multiplexer Group AN/TCA–1 Delay Line. The delay line circuit consists of 16 independent 10.4-microsecond delay lines. Eight delay lines are associated with each direction of transmission, four for the multiplexer half of the drop-and-insert and four for the demultiplexer half of the drop-and-insert. Each of the delay lines provides eight separate outputs, each delayed by 5.2 microseconds from the adjacent one, to maintain the time position of the channels 1 through 8. Refer to paragraph 172 and to figure 168 for delay line theory. For overall schematic of Multiplexer Group AN/TSA–1 delay line, refer to figure 376.

b. Pulse Form Restorer Group AN/TRA–10. The delay line circuit of the pulse form restorer group (fig. 377) consists of four independent 10.4 microsecond delay lines. Two delay lines for each direction of transmission, one for the multiplexer half of the drop-and-insert and one for the demultiplexer half of the drop-and-insert. Each of the delay lines provide two separate outputs delayed by 5.2 microseconds from the adjacent one, thereby maintaining the time position of channels 1 and 2. Refer to paragraph 172 for theory of delay lines. The overall schematic of the pulse form restorer group delay line is shown on figure 377.

Note. The sawtooth voltage to the individual modulators have an amplitude of 20 volts and rise time of approximately 8 microseconds.

Section IV. MODULATING AND MULTIPLEXING CIRCUIT

218. Modulating and Multiplexing Circuit (Wave Shape Supplied to Modems for Modulation)

To provide the properly shaped and timed sawtooth pulses to the modulators in the modems, a positive 8-microsecond gate must be fed to a modem delay line. This is obtained by inverting and stretching the 4-microsecond negative gate which is fed into the demodulator delay line at J8 of the video restorer. The demodulator delay line is purposely terminated with a 3,000-ohm resistance, which is lower than its nominal characteristic impedance of 3,900 ohms. This is done to insure that any reflections from the end of the delay line appearing back at its input will be opposite in polarity to the main input gate.

Note. In Electrical Equipment Rack MT–1434/TRA–10, the value for the terminating resistor has been lowered to 2,700 ohms. This was necessary to reduce the reflection which appears on the multiplexer gate wave form.

219. Inverter V26

(fig. 207)

The importance of the step described in paragraph 218 becomes apparent in the video restorer inverter (and stretching) stage, V26. To stretch the 4-microsecond gate to 8 microseconds, it is necessary to integrate (stretch) the base line signal slightly with resistors R134, R135, and capacitor C67 and then amplify the portion near the base line. B, figure 206, shows the gate before integration and A, figure 207, shows the gate *after* integration. If any irregularities in the base line are of positive polarity, they are clipped by the grid since the tube operates at zero bias. If they appear with the same polarity as the gate to be amplified, they will appear as full amplitude gates in the output of inverter V26 and cause each channel modulator to generate more than one pulse. This condition is prevented by using the 3,000-ohm termination on the demodulator delay line. The amplified and stretched output as shown

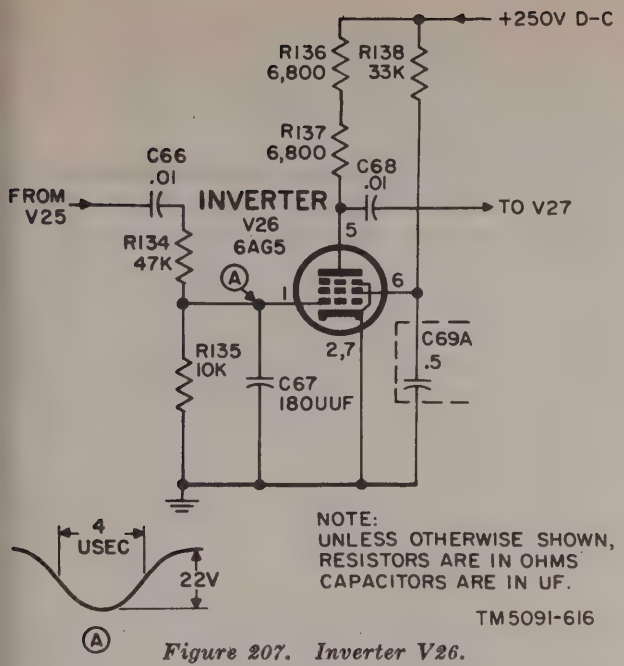


Figure 207. Inverter V26.

at A, figure 208, is applied to the grid of gate amplifier V27. Capacitor C66 is the input coupling capacitor, R136 and R137 are the plate resistors, R138 is the screen resistor, C69A is the screen bypass, and C68 is the output coupling capacitor.

220. Gate Amplifier V27 and Clipper V18A
(fig. 208)

a. The output of inverter V26 is fed to the control grid of cathode follower gate amplifier V27. The cathode follower output across resistor R142 drives a positive gate into the modulator delay line. The gate output of V27 is maintained at a maximum of 105 volts by the action of diode clipper V18A. When the gate voltage across R142 exceeds 105 volts, clipper V18A will conduct to clip the voltage. The +105 volts dc for the cathode of clipper V18A is provided by gas voltage regulator tube V28. This gate output voltage is critically regulated because the stability of the gate amplitude determines the stability of the individual channel pulse position.

b. Resistor R140 is the grid return, R141 is a clipping resistor, R142 is the cathode load resistor, R143 is a series voltage dropping resistor for gas tube V28, and C69B is the bypass capacitor across the 105-volt supply. The output of V27 is taken through C70 to E6 (MTPX GATE) and (MTPX GATE OUTPUT) and through R144 across an 8-kc tuned circuit, L17 and C71, to J10 (SCOPE SYNC), to provide the oscilloscope with a synchronizing gate.

221. Insertion of Channel Pulses into Pulse Train
(fig. 209)

a. General. The local modem generated and modulated channel pulses (which occur at the time the received channel pulses have been blanked) are fed into MODEM CHAN

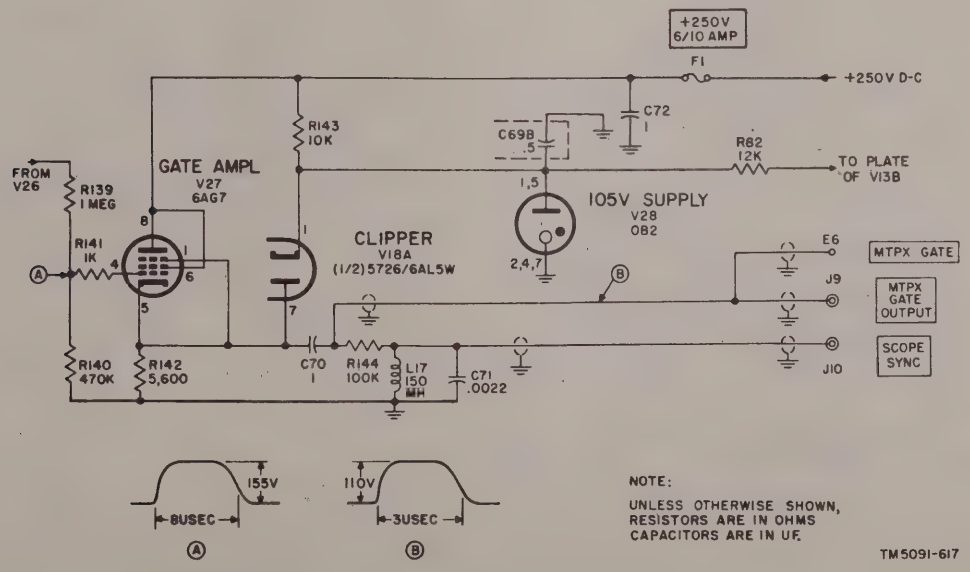


Figure 208. Gate amplifier V27 and clipper V18A.

PULSES INPUT jack J5. A voltage divider network, which consists of R79 and R80, provides an 11-volt drop across R79. A common bias of 11 volts, for the local modulator tubes of all the modems, is obtained at J5.

b. Cathode Follower V11 and Shaper-mixed Amplifier V12.

(1) The 4- to 7-volt modem channel pulses (G, fig. 209) are developed across R80 and directly coupled to the grid of mixer amplifier V12B from MODEM CHAN PULSES INPUT jack J5. This direct coupling between the cathode of modem tube V2B and the grid of mixer amplifier V12B prevents the larger amplitude pulses from supressing those of lower amplitude as would happen with conventional-type coupling and its attendant grid leak bias. (Paragraph 202*b* provides additional pulse insertion information.) The plate of V12B is in parallel with blanking tube V11B, and the two share a common plate load resistor, R67. Since the channel pulses are impressed on the grid of V12B and the plate is in parallel with the plate of V11B, the signal at the plate of V12B consists of the entire pulse train with new locally generated channel pulses inserted.

(2) This entire pulse train is then amplified and shaped in shaper V12A in a manner similar to that of shaper V4. These pulses are then fed to pulse amplifier V10A where further reshaping takes place as explained in paragraph 250. Refer to paragraphs 223 through 225 for a detailed description of cathode-follower and blanker tube V11.

(3) For cathode follower tube V11A, R65 is the grid return resistor. Resistor R65 is the signal input load resistor and R66 is the cathode follower output load resistor. The signal voltage developed across R66 is fed through capacitor C38 to the grid of blanker V11B.

(4) For blanker tube V11B, R67 is the plate load and R68 provides the blanking load. Resistor R69 with capacitor C21A assists in the rapid decay of the blanking pulse (C, fig. 209). The volt-

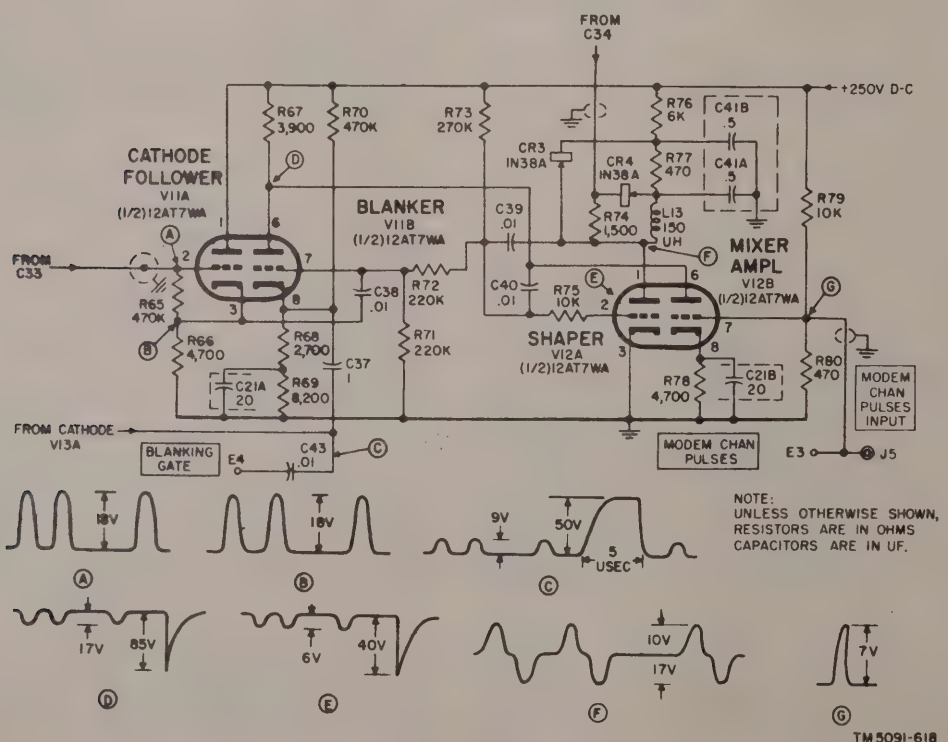


Figure 209. Cathode follower-blanker V11B and mixer amplifier V12.

age divider network of resistors R70, R68, and R69 provides a voltage which places the cathode of V11B at a fixed +12 volts. A blanking gate from cathode follower C13A is fed through C37 to V11B. Resistors R71, R72, and R73 form a voltage divider network applying the proper grid voltages to tubes V11B and V12A.

(5) Resistor R78 is the cathode-bias resistor for V12B and is bypassed by C21B. Capacitor C40 is the input coupling capacitor for V12A and V12B, R73 is the grid return, and R75 is a series grid limiting resistor. Resistors R76 and R77 with capacitors C41A and C41B form a pi-type plate decoupling network. The germanium diodes CR3 and CR4 clip the top and bottom of the pulses which have been narrowed to about a quarter microsecond by ringing coil L13 (F, fig. 209).

222. Modem Modulator Circuit

a. General. Modulation of the pulse train is accomplished in individual and identical modem units. These units include provision for signaling and provide means for either two- or four-wire operation. The modulator section of the modem consists of two tubes, V1 and V2. The modulator converts the audio input signal into a pulse which is position-modulated and may then be inserted in the pulse train.

b. Block Diagram. A functional block diagram is shown in figure 169. The two-wire or four-wire line signal is fed into hybrid transformer T1. The output of T1 is fed into a crystal diode clipper (CR1 and CR2) which limits the modulation to a specific maximum value corresponding to a four-wire input of —4 dbm. The clipped audio signal is then fed to audio amplifier tube V1A from which it goes into ppm tube V1B. The output is then clipped and shaped in tube V2A and fed through cathode-follower tube V2B to the video restorer mixer circuits.

c. Circuit Theory. The 16 modems of Multiplexer Group AN/TCA–1 and the 4 modems of Pulse Form Restorer Group AN/TRA–10 are identical to those supplied with Multiplexer Set AN/TCC–13. Refer to paragraph 173 through 178 for circuit theory of modem modulators.

Section V. BLANKING AND INSERT CIRCUITS

223. Blanking and Insert

The blanking gates are signals that cut off the blanking tube at the time a channel pulse is being received so that the blanking tube cannot pass the pulse. Each gate *blanks* a channel. The taps on the demodulator delay line (corresponding to the individual channel time positions) provide the signals for blanking. These signals are negative gates about 4 microseconds wide and are mixed through resistance of about 100 K and fed to the grid of V13B to be amplified (fig. 210). The amplitude of the blanking gate is 7 to 8 volts peak-to-peak.

224. Amplifier V13B and Cathode Follower V13A

(fig. 210)

The blanking gate is taken from INPUT BLANKING GATES J6 and applied through coupling capacitor C44 to the grid of V13B (B, fig. 210). The blanking gate is developed across grid leak resistor R151 and the grid resistance of V13B. Tube V13B is biased to operate as a grid limiter. The blanking gate is amplified by V13B (A, fig. 210), developed across cathode load resistor R84 of cathode follower V13A and coupled through capacitor C37 to the cathode of blanker tube V11B. A sample of the signal being fed to the cathode of V11B is brought out to BLANKING GATE test point through capacitor C43. For V13B, resistor R85 is the grid return to B+. Resistor R81 is used to prevent parasitic oscillations. Resistor R82 is the plate load resistor for V13B, and C42 is the output coupling capacitor that couples the signal from V13B to the grid of V13A. For V13A, resistor R83 is the grid return, and R87 is the cathode load resistor. Capacitor C75 is the cathode bypass capacitor for both V13A and V13B. Capacitor C43 couples the blanking gate to test point E4.

225. Blanking Tube V11B
(fig. 209)

a. The grid of blanking tube V11B receives the entire positive pulse train from the output of V9 through isolating cathode follower V11A. The first cathode follower (V13A) provides a low-impedance source from which to drive the blanking gates into cathode resistor R68 of the blanking tube. The second cathode follower V11A is used to isolate the grid of shaper V19 from the grid of V11B as follows: The locally generated and inserted channel pulses will appear on the plate of blanking tube V11B. These pulses may be coupled to the grid of V11B through the grid-to-plate capacitance of the tube. If these low-amplitude pulses were to reach the grid of V19, a phenomenon would take place which is known as *reverse-feed-through* cross talk. That is, modulation on a locally generated channel pulse would cross talk into the local demodulator that faces the opposite rf direction from that of the demodulator.

b. In blanking tube V11B, the cathode is biased below cutoff so that the channel pulses appearing on the grid (B, fig. 209) drive the tube into conduction. The positive blanking gates that appear on the cathode of this tube (C, fig. 209) drive the bias further into cutoff; therefore, channel pulses that occur at the time of a blanking gate cannot cause the tube to conduct and will not appear in the output at the plate of V11B. The output of the blanker tube will have a wave shape similar to one shown in D, figure 209. Resistor R67 is the plate resistor of V11B, and resistors R68, R69, and R70 form a voltage divider that supplies bias to the cathode. Part of the cathode resistance (R69) is bypassed by C21A. Resistor R71 is the blanker grid return resistor.

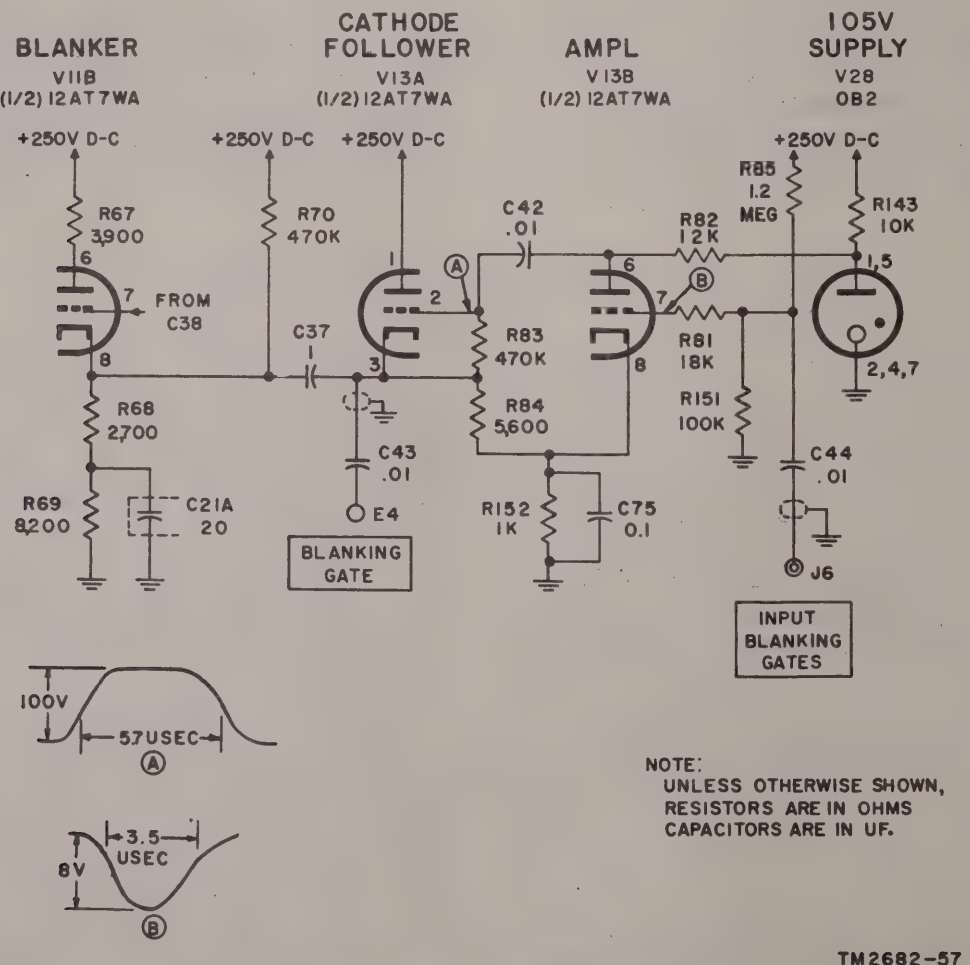


Figure 210. Cathode follower amplifier V13.

226. Audio Terminations
(fig. 211 and 212)

a. Following is a description of the party-line termination on the order wires of Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10. Party-line termination allows the operators at both ends of the system and the operator at the repeater to communicate with one another.

b. For party-line operation, the modems are terminated as four-wire units. The output of the four-wire receiver line of each modem feeds the 600-ohm input of the four-wire transmit line of the sending modem in parallel with a 600-ohm hybrid. Each demodulator is terminated in 300 ohms and is mismatched two to one. This causes a 1-db loss in power transmission. In addition, there is a power split between the four-wire transmit line and the hybrid, which causes a net loss of 4 db. For the local line, there is an additional 4-db loss through the hybrid.

c. The normal audio output level is —4 dbm, and the normal level into the modulator is —4 dbm for 100 per cent modulation. Therefore, for the party-line connection, if the demodulator output is adjusted to 0 dbm, the modulator input level is —4 dbm. This causes 100 per cent modulation and no less for the through connection. As shown in the block diagram (fig. 211), the output level of the local line is —8 dbm or only 4 db below that of a terminal. If the sending level from the local line is 0 dbm, it will cause a modulating level of —8 dbm or only 4 db below that of a terminal.

d. The operator at a local line at the repeater will listen to a terminal station 4 db down from normal, and will be heard at a terminal station 4 db down from normal. For repeater-to-repeater communications, the operator at the local line will hear and be heard 8 db below normal. However, there is no loss in level for terminal - to - terminal communications. The terminal equipment gives a 4-db net loss circuit on each channel. This is maintained regardless of the number of repeater stations that have the proposed party-line connection on the order wire. For party-line connection, two hybrid coils and appropriate terminating networks are provided in the rack, one for each channel.

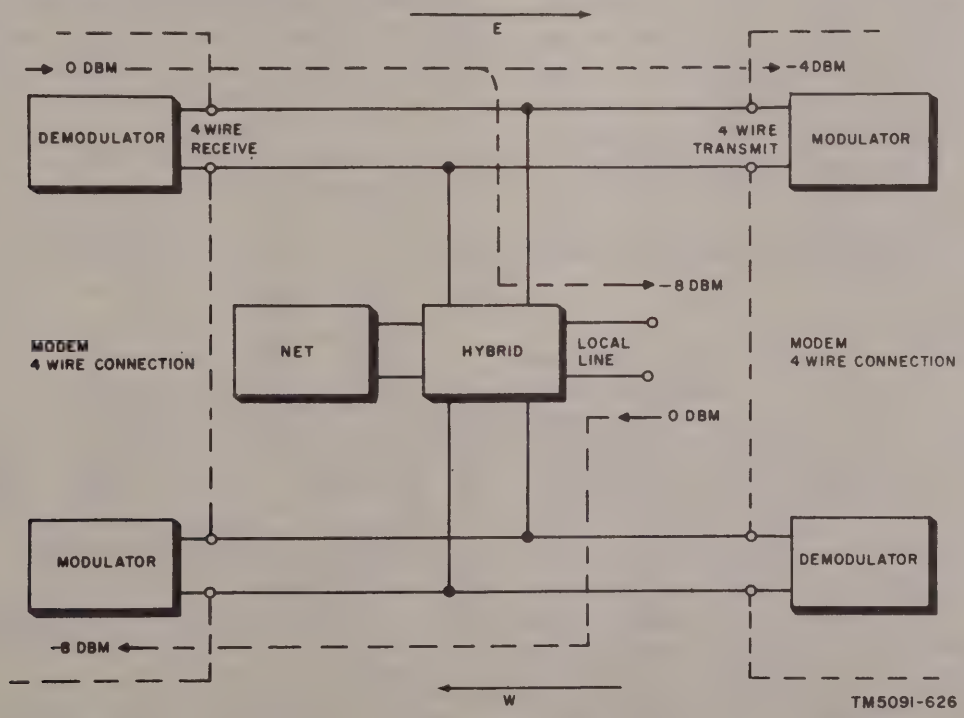


Figure 211. Party-line audio terminations.

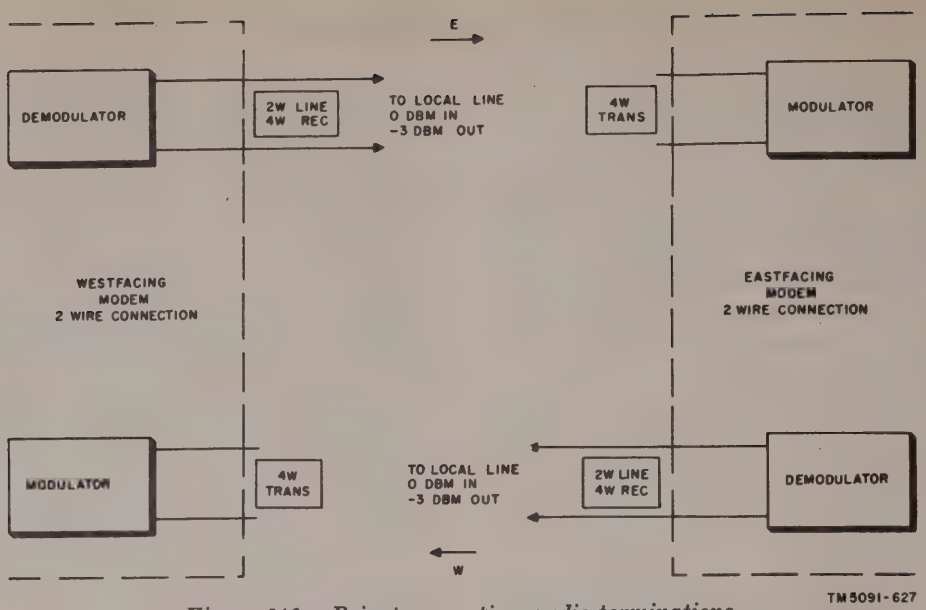


Figure 212. Private operation, audio terminations.

e. When the audio termination is private, the unit may be connected by either two- or four-wire, and gives two independent circuits, one eastfacing and one westfacing.

227. Alarm Circuit

If any part of the circuit fails, the alarm circuit operates by monitoring points in the circuit. For example, the positive pulse train reshaper is monitored for output, input, and noise. In general, failure of any one of the above listed signals will cause visible and audible alarm signals. This is done by having these signals control the input to the alarm operating relays through their respective amplifiers.

228. Output (Alarm Circuit V16A, V18B, V17A and V15B)

(fig. 213)

The pulse train at the grid of the last stage in the positive pulse train reshaper is monitored by monitor amplifier V16A. The pulse train available across grid return resistor R92 is about 14 volts negative. The voltage developed across plate load resistor R93 is 12.3 volts peak-to-peak. This voltage is fed to camper tube V18B and rectifier V17A by coupling capacitor C51. This results in a 12.3-volt positive dc voltage being built up across cathode load resistor R95. This +12.3 voltage is applied to the grid of relay control amplifier V15B. Therefore, the relay control tube conducts and causes the bypass and alarm relays K1 and K2 to be held in the operate condition. If any of the tubes fail prior to the point monitored in the positive pulse train reshaper, the dc voltage at the grid of the relay control amplifier will decrease, causing plate current to decrease, which in turn releases the bypass and alarm relays. This causes an audible and visual alarm to operate, bypassing the reshaper through a 6-db pad and disconnecting the 20-cycle ringing voltage from the local drop channels. Relay con-

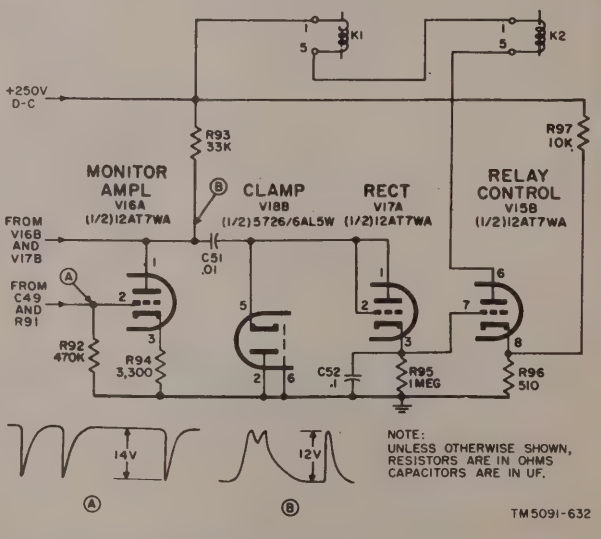


Figure 213. Alarm circuit V16A, V18B, V17A, and V15B.

trol tube V15B is biased by the voltage divider network of resistors R96 and R97 so that under *no signal* conditions tube V15 will not have sufficient plate current to operate relays K1 and K2. If the very last stage of the positive pulse train reshaper fails, it will not be indicated to the alarm relays by this path. However, if the filament of the last stage should burn out, its grid would rise to about +75 volts. This would result in zero bias applied to damper V16B through R63, thereby resulting in sufficient conduction to load output pulse train monitor amplifier V16A to a point where V15B will become cutoff and the alarm will operate.

229. Input (Alarm Circuit V15A, V16B, and V17B)

(fig. 213)

a. With normal signal input voltage (.5 volt peak), the negative dc voltage available at the plate of peak detector V8 in the reshaping clipping circuit is sufficient to hold a 12AT7WA in the cutoff condition.

b. When the input voltage decreases to .1 volt peak, the negative dc voltage obtained from the diode bias circuit is about —3 volts. This voltage is applied to the grid of damper V16B, which is in parallel with the output pulse train amplifier. The —3-volt bias on V16B allows sufficient conduction of this tube to decrease the gain of monitor amplifier V16A so that the voltage applied to the grid of relay control V15B will decrease the current in V15B to less than 1 milliampere, which is the relay release current. Therefore, the reshaper will be bypassed, ringing will be disconnected, and the audible and visible alarms will be energized.

230. Noise

The demodulator MODEM PULSE TRAIN OUTPUT at J7 is monitored for detection of large noise inputs. With a normal pulse train input, the frequency spectrum of the wave form at this point will contain insignificant components below 8 kc. However, if an rf transmitter in the link fails, the receiver at the local station will put a large noise signal into the restorer. This noise signal will contain appreciable frequency components below 4 kc. These components will be available with large amplitudes at the noise monitored point. This signal is fed into a 4-kc low-pass filter, Z1 (fig. 214), and is amplified by V15A. Capacitor C49 is the input coupling capacitor for V15A. The filter output is developed across grid return resistor R88 and applied to the grid. Resistor R90 and capacitor C45 form the biasing network for V15A. The voltage developed across plate load resistor R89 is coupled through coupling capacitor C46 and applied to two germanium rectifiers CR5 and CR6, which results in a large negative voltage when high noise is present, and 0 volt when the normal pulse train condition is restored. When the large negative voltage is available, it is applied to the grid of output pulse train monitor amplifier V16A and cuts off this tube, thereby resulting in 0 volts applied to the grid of V15B, cutting off the tubes and de-energizing the relays.

231. Marker Separator and Gate-shaping Circuit Failure

When the marker separator and gate-shaping stages are operating normally, a negative voltage of approximately 30 volts is available

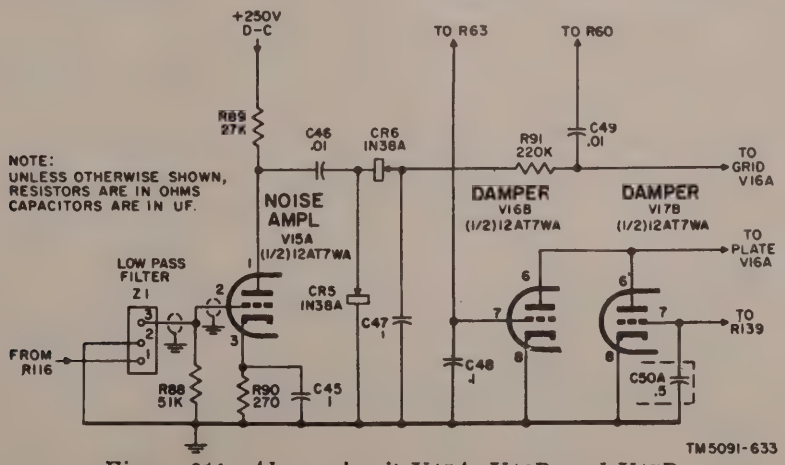


Figure 214. Alarm circuit V15A, V16B, and V17B.

at the grid of the multiplexer gate driver. This voltage is used to hold damper V17B at cutoff. This is in parallel with the output pulse train monitor amplifier. If any of the tubes in the marker separator and gate-shaping section should fail, the voltage applied to the grid of damper V16B will be 0 volt. This will cause sufficient conduction of V17B to decrease the gain of monitor amplifier V16A to the point where relay control V15B will be cut off. Therefore, if any of the tubes in this section fail, the 20-cycle ringing will be disconnected from the local drop channels and audible and visual alarms will be energized. In addition, the pulse train reshaper will be bypassed, because the 20-cycle ringing disconnect relay and bypass relay are operated by the same tube.

232. Remote Keying Circuits

There are two remote keying units supplied with the multiplexer group and pulse form restorer group. The operation of these units is identical to that described for the multiplexer set (par. 195 and 196). The keying signal path for the pulse form restorer group and the multiplexer group are the same, as shown in figures 215 and 216. These figures show all pin and terminal connections in this path; from the modem, through the mounting rack to the remote keying units.

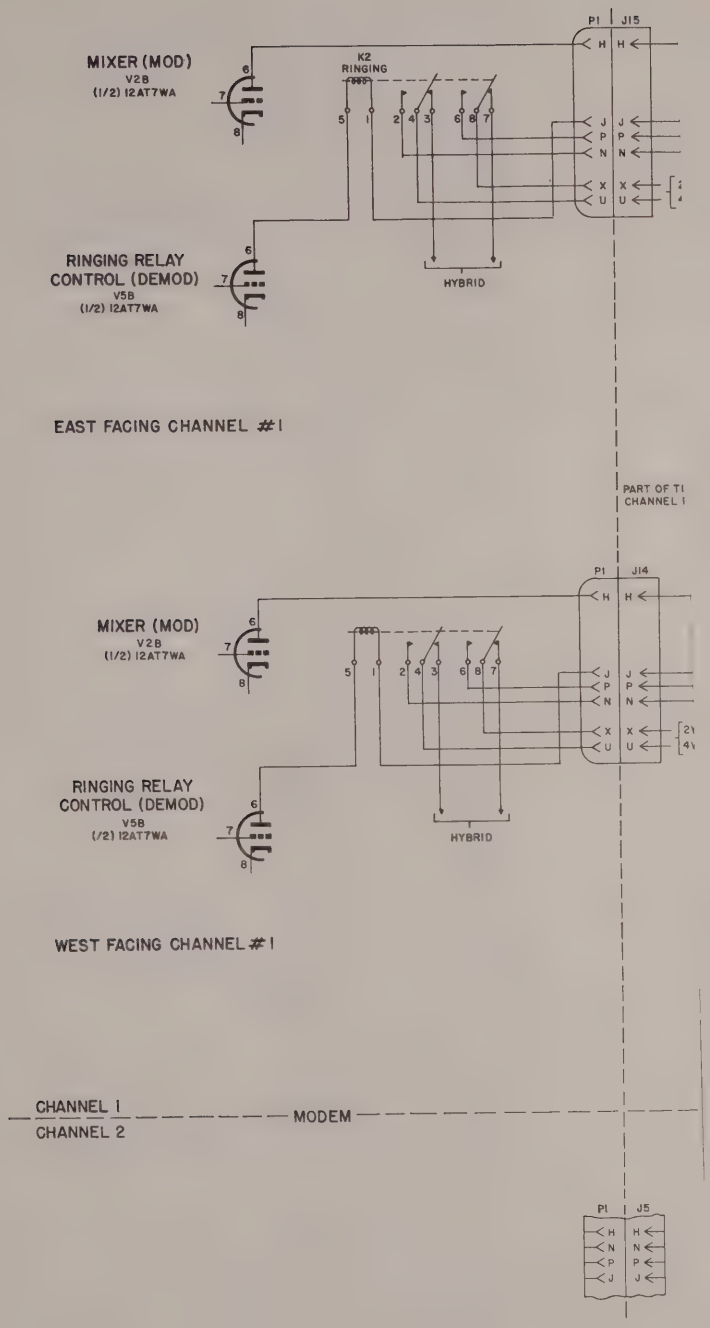


Figure 215. Remote keying circuit, Pulse Form Res

at the grid of the multiplexer gate driver. This voltage is used to hold damper V17B at cutoff. This is in parallel with the output pulse train monitor amplifier. If any of the tubes in the marker separator and gate-shaping section should fail, the voltage applied to the grid of damper V16B will be 0 volt. This will cause sufficient conduction of V17B to decrease the gain of monitor amplifier V16A to the point where relay control V15B will be cut off. Therefore, if any of the tubes in this section fail, the 20-cycle ringing will be disconnected from the local drop channels and audible and visual alarms will be energized. In addition, the pulse train reshaper will be bypassed, because the 20-cycle ringing disconnect relay and bypass relay are operated by the same tube.

232. Remote Keying Circuits

There are two remote keying units supplied with the multiplexer group and pulse form restorer group. The operation of these units is identical to that described for the multiplexer set (par. 195 and 196). The keying signal path for the pulse form restorer group and the multiplexer group are the same, as shown in figures 215 and 216. These figures show all pin and terminal connections in this path; from the modem, through the mounting rack to the remote keying units.

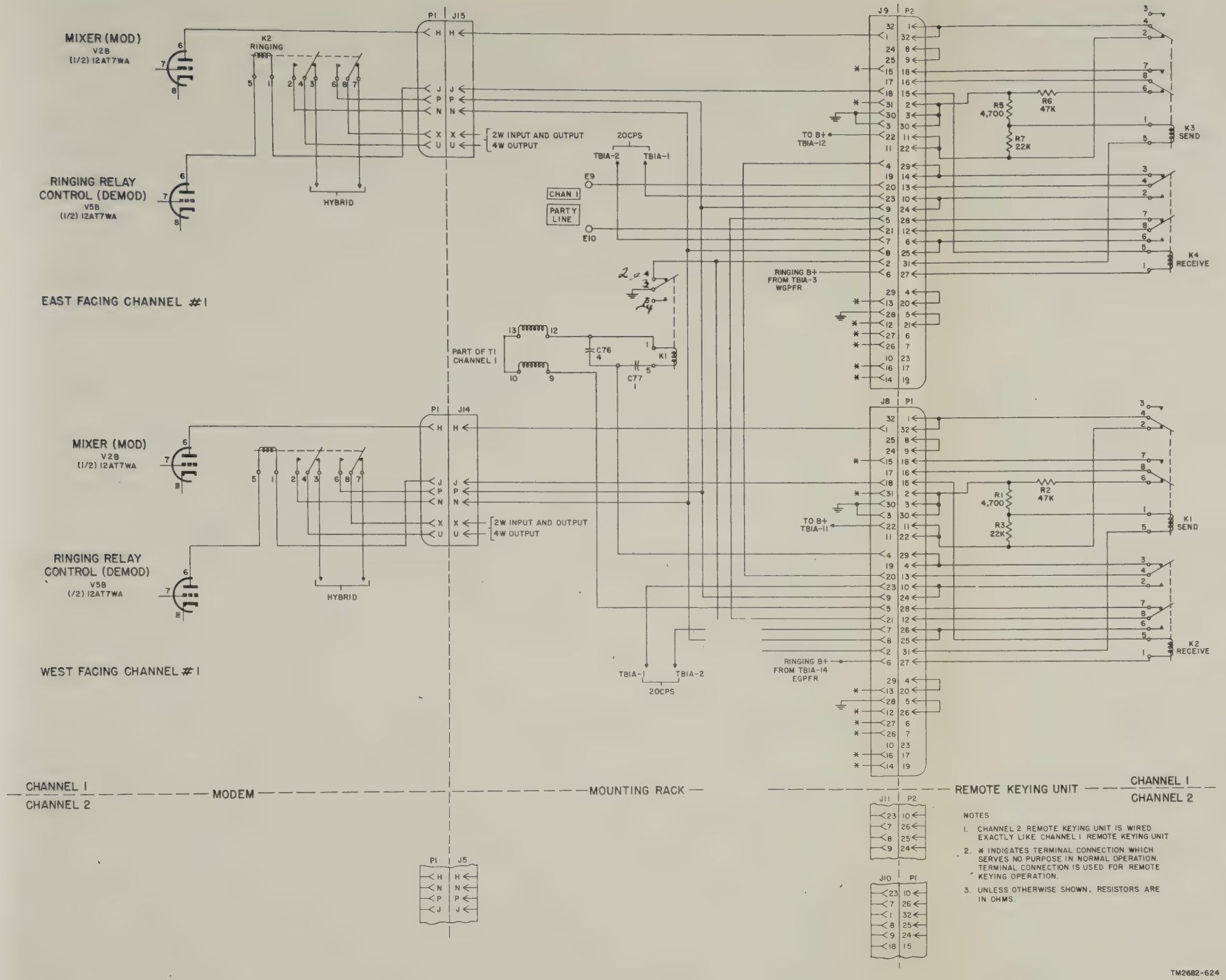
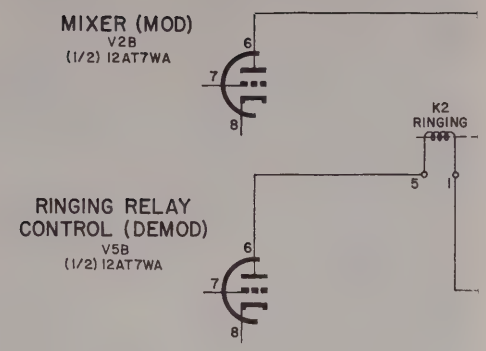
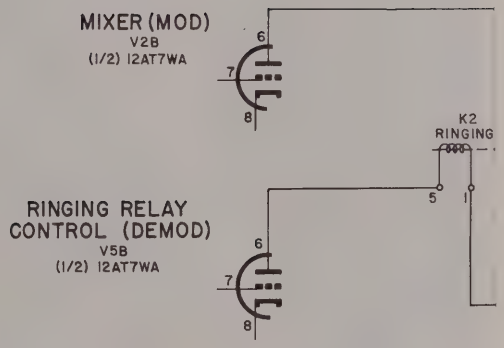


Figure 215. Remote keying circuit, Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1, normal operation.



EAST FACE CHANNEL #1



WEST FACE CHANNEL #1

CHANNEL 1
CHANNEL 2

Figure 216. Remote keying circuit

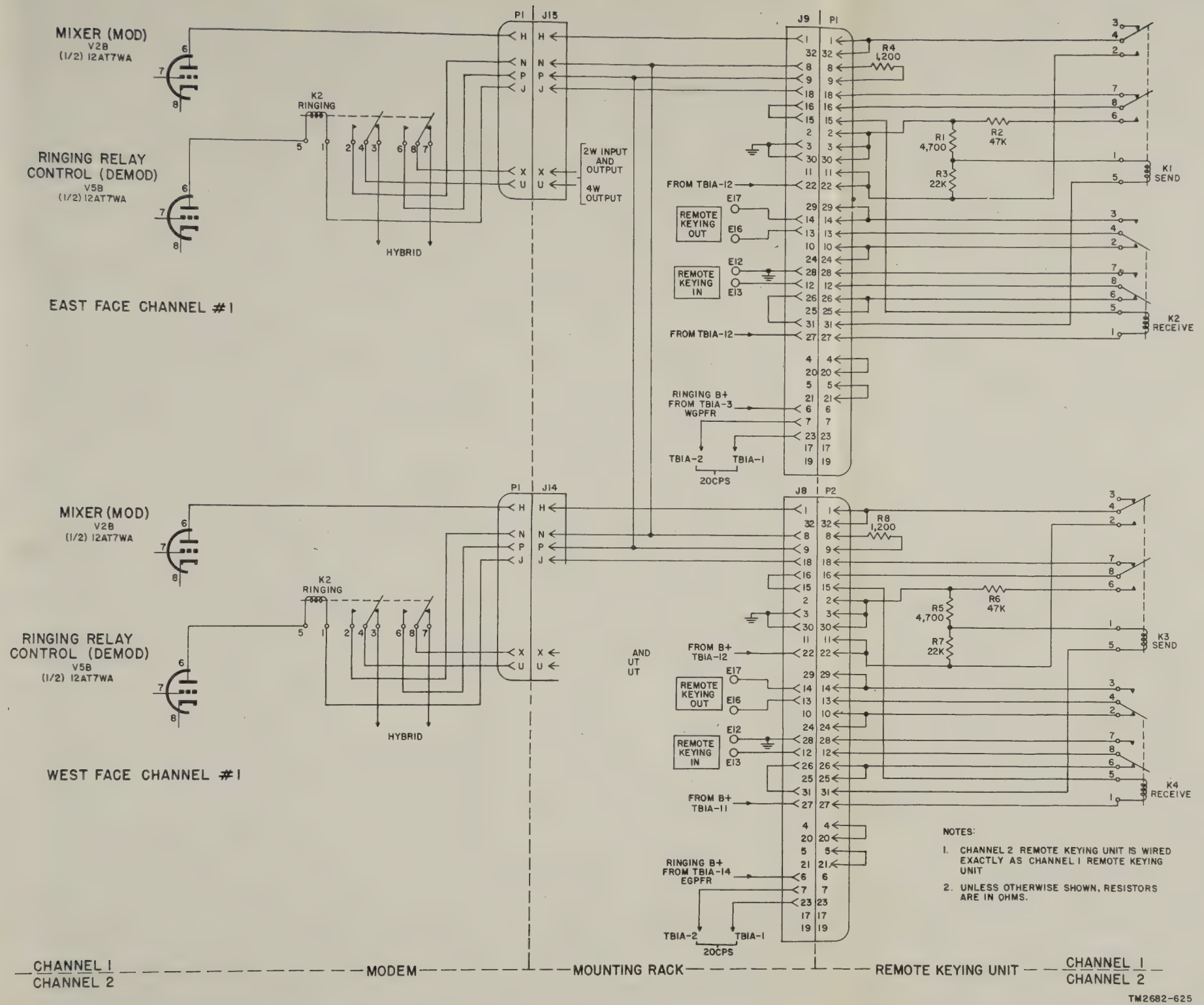


Figure 216. Remote keying circuit, Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1, remote keying operation.

CHAPTER 9

POWER SUPPLIES AND TEST EQUIPMENT THEORY OF OPERATION

Section I. POWER SUPPLIES

233. Voltage Regulator CN–236/G (fig. 217)

Voltage Regulator CN–236/G is supplied as part of Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10.

a. General. Voltage Regulator CN–236/G is an electromechanical unit. It consists of buck-boost transformer T4 in series with the applied power, a bridge across which is impressed any error signal, gas tubes to select the direction of the error, and reversible motor B1, controlled by the gas tubes that operate variable transformer T3. Transformer T3 controls the primary of the buck-boost unit T4. A buck-boost transformer has a secondary in series with the voltage source, which causes the output voltage to subtract (buck) or add (boost) to the source voltage.

b. Power Circuit (fig. 218). The unregulated ac input is applied to either J2 (230V AC POWER INPUT) or J4 (115V AC POWER INPUT), depending on the input voltage. The +230 V circuit breakers CB1 and CB2, protect the input from J2, while 115V circuit breakers CB3 and CB4 protect the input from J4. The 115-volt ac output of T5 is applied to terminals 1 and 2 of variable autotransformer T3. The corrective voltage output of T3 appears between terminals 3 and 4. Terminal 4 connects to the motor-driven brush of the brush assembly of T3. The output from terminals 3 and 4 represents the corrective electromotive force (emf) for the primary of series-compensating buck-boost transformer T4. The secondary of T4 (terminals X1 and X2) then gives the proper series-compensating voltage so that the output of the power circuit is maintained at a constant voltage of 115 volts ac. This 115-volt ac output appears across terminals D and E of AC POWER OUTPUT jack J3. Fuse F3 prevents damage to the sliding contacts. Pilot light I 1 indicates the presence of output voltage.

c. Control Circuit (fig. 219).

(1) *General operation.* The control circuit maintains a regulated ac output by correctly positioning the brush of variable autotransformer T3. This control is accomplished as follows: an ac bridge gives an output ac voltage proportional to any change in the monitored power circuit output. This bridge-detected error voltage then causes one of the thyratrons to fire, energizing its associated relay. This,

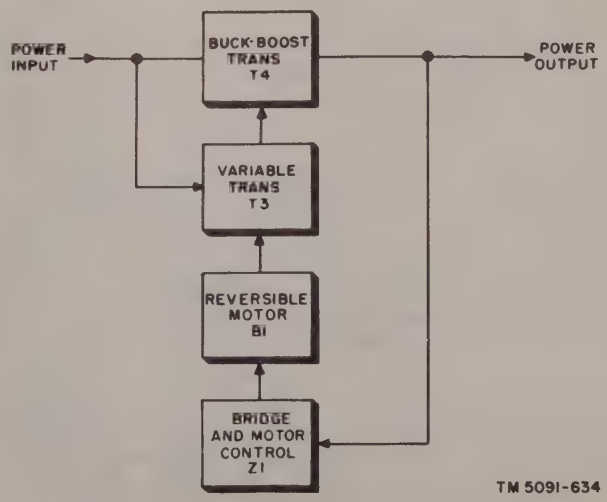


Figure 217. Voltage Regulator CN–236/G, block diagram.

in turn, applies line voltage to the split-phase motor; the motor then rotates to correct for either the rise or fall of the power circuit output voltage. When the brush moves to the correct position, the drive motor stops. The system is then in equilibrium, awaiting another rise or fall in the regulated output voltage.

(2) *Detailed operation and characteristics* (fig. 219).

(*a*) *Control circuit input transformer T1.* The secondary transformer T1 supplies a balanced input to the ac bridge from terminals 3 and 5 (with terminal 4 as center tap); 12.6 volts ac between terminals 3 and 6 for the series connected filaments of thyratrons V1 and V2; and the same ac source given above but for the fixed dc bias circuit for the thyratrons.

(*b*) *Ac bridge.* The balanced secondary windings of T1 serve as two arms of the ac bridge and also supply the driving voltage for the bridge. The center tap (4) of T1 then serves as one bridge output terminal. The opposite two arms consist of the thermistor, fixed resistors, and potentiometer R11, the variable arm of which serves as the adjustable center tap, and other bridge output terminal. The resistors shown within the dotted rectangle on figure 219 comprise inclosed sensing unit Z1. With the proper voltage applied to input transformer T1, equal but opposite voltages are developed across the input arms of the bridge. This results in a current flow through resistor R1, through the thermistor, through the OUTPUT VOLTAGE control arm, and through the primary of grid transformer T2 to terminal 4 of the input transformer. At the same time, an equal current will be flowing from terminal 4 through the grid transformer to the arm of R11 through the lower resistor of Z1 through R2 to terminal 3 of the input transformer. The action described above results in a zero voltage in the secondary of T2, because currents in the primary are equal but opposite. If the input ac voltage should increase, the current through the bridge would also increase. Any increase in current flowing through the thermistor bead would cause an increase in its resistance, thus unbalancing the bridge. Grid transformer T2 will then receive its input voltage from the 3 to 4 winding of transformer T1. This

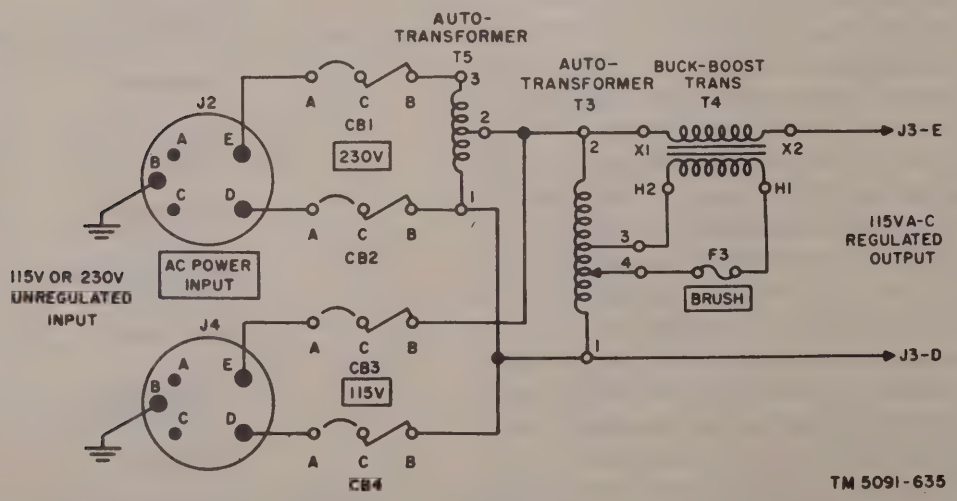


Figure 218. Voltage Regulator CN-236/G, power circuit

will cause the motor to rotate so that the applied ac voltage decreases. If the input voltage should decrease, the current flowing through the bridge will also decrease. This will cause the resistance of the thermistor to decrease. The grid transformer will now receive its voltage from the 4 to 5 winding of transformer T1. This causes the motor to rotate in the opposite direction, increasing the applied ac voltage.

(*c*) *Push-pull thyratrons.* The output of the bridge is applied to the primary of transformer T2. Opposite ends of the secondary of T2 are connected to the grids of V1 and V2 (fig. 240). The signals applied to two thyratron grids are always out of phase with each other. One of the two signals will be in phase with V1 ac plate voltage and out of phase with V2 ac plate voltage. For this reason, only one tube will conduct for any given error signal. When the phase of the error signal is reversed, the other tube will conduct. Germanium diodes CR1 and CR2 are the rectifiers biasing the thyratrons. The com-

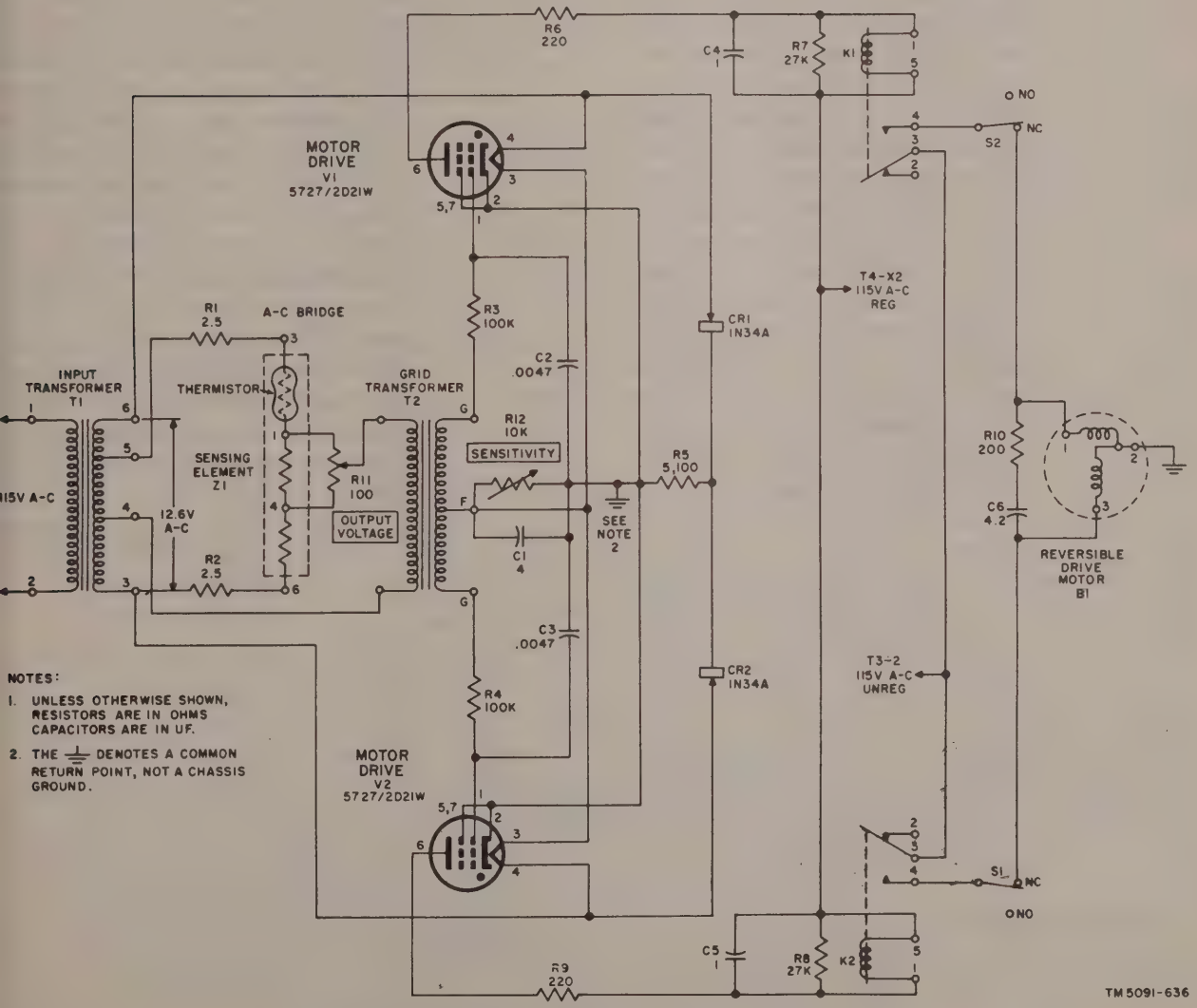


Figure 219. Voltage Regulator CN-236/G, control circuit.

mon filament connection is used as an artificial center tap of T1. In the normal (no error) signal condition, both thyratrons are held beyond cutoff by the fixed bias developed across potentiometer R12 connected between cathode and grid of the two thyratrons. The bias voltage may be varied by adjusting R12. With the SENSITIVITY CONTROL turned clockwise, the bias voltage will be near zero because the resistance of R12 will be almost zero. In this condition, the slightest error voltage will be detected and the servo motor will accordingly be required to operate more frequently to maintain the output ac voltage constant. Any higher sensitivity requirements will prove a detriment, for the system will go into oscillation or *hunting*. Hunting displays itself as a violent gear chatter, as a result of the rapid reversals of the drive motor. Therefore, the proper adjustment of R12 involves increasing the sensitivity until chatter occurs and then turning it back slightly. The motor will then remain relatively quiet, only moving occasionally to follow input line fluctuations. The other extreme involves adjusting R12 for full resistance, thus giving a maximum negative bias. A large error signal is then necessary to cause thyratron conduction, relay operation, and correction of ac voltage error. Potentiometer R11 controls the voltage applied to the thyratron grids. By varying the voltage applied to the grids, a new reference voltage is established. Varying this control adjusts the output voltage from the voltage regulator to the power supply.

(*d*) *Motor circuit.* To aid in the discussion of the motor circuit, assume that a rise occurs in the output voltage. The bridge circuit detects an error voltage. This error voltage is then applied to the grids of the thyratrons. The error voltage will be out of phase with the regulated ac common plate voltage on one grid, and in phase with the plate voltage for the grid of the other thyratron. The tube which has both the grid and plate driven positively will fire when the electrode voltages are sufficiently positive for breakdown. The relay associated with this tube will then be energized. The unregulated ac input will be applied to the split-phase motor, directly across one motor winding and in series with C6 and R10 across the other motor winding.

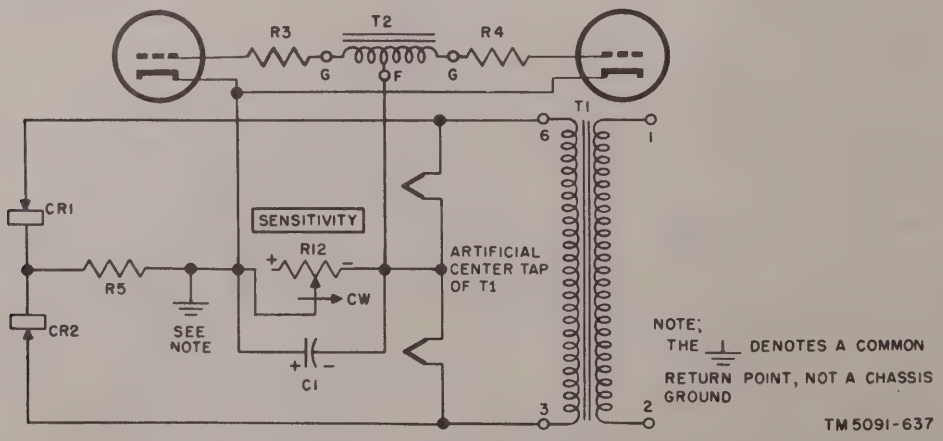


Figure 220. Voltage Regulator CN–236/G, filament and full-wave rectifier bias arrangement.

This condition results in a rotation of the motor shaft (and thus the motor-coupled autotransformer brush (T3)) to compensate for the rise in output. Caacitor C6 and resistor R10 supply the necessary 90° phase shift between the voltages across the two motor windings. If any overshoot occurs, the first tube will extinguish, de-energizing its relay, and the tube will fire, energizing its relay. The autotransformer brush will be driven in the reverse direction because R10 and C6 will be in series with the other motor winding, giving a change in the direction of rotation. Also included in the motor circuit is end-stop protection. Microswitches S1 and S2 are actuated when the end-stops of the brush assembly are reached. Thus, when either extreme is reached, the associated switch opens. This disconnects the motor and prevents any further attempt on the part of the motor to operate in the blocked rotor direction.

(*e*) *Regulated output.* Output is taken from pins D and E of AC POWER OUTPUT jack J3. Pilot light I 1 indicates that output power is present. Fuse F2 is in series with the pilot light.

234. Multiplexer Subassembly MX-1442/TC (Filament Supply)

(fig. 378)

a. Multiplexer Subassembly MX-1442/TC is only supplied as part of Multiplexer Set AN/TCC-13 and Multiplexer Group AN/TCA-1. The filament supply provides filament power to the entire multiplexer group and multiplexer set. It contains the alarm and indicator circuits and blower B1. B+ voltage is brought into this unit through +250V INPUT jack J5, pins B and C. Ac is brought in through 115V AC INPUT jack J6, pins C and D. Indicator lamp I 2 on the filament supply unit (FILAMENT ON) is energized when power is applied. Fuses F1 through F4 are in series with the B+ voltage applied to the modems. The 100-microfarad (uf) filter capacitors C1 through C4 are connected between the modem side of these fuses and ground to provide additional filtering of the B+ voltage. The B+ voltage is taken from terminal 8 of terminal board TB4A. Filter capacitor C5 is connected between this point and ground.

b. Filament supply terminals are:

(1) Terminals 9 and 10 of TB3A, which provide ringing current by connecting the 20-cps generator to each of the modems through pins E and F of J11.

(2) Terminals 7 and 8 of TB2A, which connect the modems with the test pair from the audio test set through pins C and D of J11.

(3) Terminals 5 and 6 of TB3A, which connect the control monitor to the channel 1 order-wire circuit through pins A and B of J11.

c. A regulated 115-volt, 60-cps ac voltage is applied across the primaries of filament transformers T1 and T2 through 2-ampere fuses F5, F6, F7, and F8. The secondary of transformers T1 and T2 provides 6.3-volt ac filament power to the equipments.

d. Application of 115 volts ac to the filament supply energizes blower motor B1 (a 115-volt, 60-cps, split-phase induction motor) and lights FILAMENT ON indicator lamp I 2. Four convenience UTILITY POWER outlets, J7 through J10, are located in the filament supply. Two outlets are on the front panel and the two others are on the rear panel. Lamp I 1 is a neon light that indicates the presence of 250 volts dc. Lamp I 4 indicates operation of the alarm. Connectors J1 and J2 are the receptacles for the channel 2 remote keying plug-in units, and J3 and J4 are the receptacles for the channel 1 remote keying plug-in units. Connector J11 (TEST PAIR) is the receptacle for the channel 1 order wire and modem test pair. Switch S1 is the audible alarm disconnect push-button switch. Contacts E5 through E10 are gaps used for surge protection. Relays K1 and K2 are used to stop ringing.

235. Pulse Form Restorer Group AN/TRA-10 (Filament Supply)

The filament supply for all equipment of the restorer group, except the oscilloscope, consists

of 30-ampere 6.3 volt transformer T3, mounted on the drawer of the electrical equipment rack. The oscilloscope contains its own supply.

236. Power Supply PP-691/G

Power Supply PP-691/G is supplied as part of Multiplexer Set AN/TCC-13, Multiplexer Group AN/TCA-1, and Pulse Form Restorer Group AN/TRA-10. Power Supply PP-691/G consists of power transformer T1, the output of which is rectified by selenium rectifiers CR1 and CR2. The dc output CR1 and CR2 is filtered by chokes L1 and L2 and capacitors C1 through C8. The dc output then is taken from output receptacles J2, J3, and J6. The four principal sections of the power supply are shown in the block diagram in figure 221. The power supply for the multiplexer group supplies the +250-volt plate supply for all components except the test equipment. Refer to figure 383 for the power supply schematic diagram.

a. The 115-volt ac input ±1 volt, 47.5 to 63 cps, is applied to AC POWER INPUT connector J1, pins D and E. Ganged circuit breakers CB1 and CB2 (FILAMENT) apply the 115 volts to the filament chassis through connector J6. When the circuit breaker combination is operated, 250V ON indicator lamp I 2 lights to show that power has been applied. With the application of power, 115 volts ac is applied to 115V AC OUTPUT jacks J4 and J5. Four convenience outlets, J7, J8, J9, and J10, UTILITY POWER, are provided on the power supply chassis. Power to these outlets is applied through 5-ampere fuses F1 and F2.

b. Operation of the AC POWER INPUT switch, CB1 and CB2, applies primary power to power supply transformer T1 through +250V circuit breaker CB3 and to +250V lamp I 1. The secondary of T2 supplies 339-volts root mean square (rms) to bridge rectifiers CR1 and CR2. Note the extra taps on the transformers. Selenium rectifiers have a tendency to age; the voltage drop across each rectifier element will increase with time, thus reducing the output dc voltage. To compensate for this loss, terminals 3 and 4 are provided on T1. If the output voltage of the rectifier drops below the rated value, connecting the yellow terminals of the rectifier to terminals 3 and 4 will increase the applied ac voltage and hence the dc voltage. The rectified dc is fed to a choke input filter consisting of inductor L1 and L2, filter capacitors C1 and C4 in parallel, and C5 to C8 in parallel, with bleeder resistor R1 across the dc output. The 250-volt dc output is connected to J2, pins B and C, and to 250V-115V AC OUTPUT jack J3, pins A and B.

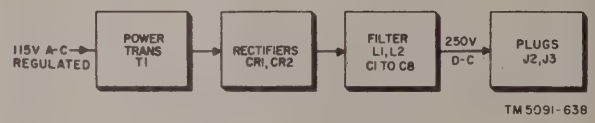


Figure 221. Power Supply PP-691/G, block diagram.

Section II. OSCILLOSCOPE OS-25/G

Note. Oscilloscope OS-25/G is supplied as part of Multiplexer Set AN/TCC-13, Multiplexer Group AN/TCA-1, and Pulse Form Restorer Group AN/TRA-10.

237. Oscilloscope OS-25/G, Block Diagram

a. Oscilloscope OS-25/G consists of five sections (fig. 155 and 222). These sections consist of a vertical deflection and calibration section with a bandwidth from 30 cps to 5 mc; a horizontal sweep generator (amplifier system) variable in speed from 5 milliseconds per cm to .5 microsecond per cm; a timing-marker generator to produce 5.2-microsecond timing pips; a power supply with various voltage supplies; and a cathode-ray tube.

b. The vertical deflection section amplifies or attenuates the signal being observed. It consists of an attenuator, vertical input amplifier V12, cathode follower V13, and push-pull vertical output V14 and V15.

c. The horizontal deflection system provides the voltage required to deflect the beam across the crt and is the most complex of the oscilloscope circuits. The stage-by-stage function of the horizontal system is described in paragraph 141. The horizontal system contains the following:

(1) The 8-kc amplifier, triggering and synchronizing stages, tubes V16A through V19A.
(2) The multivibrator, V20 and V21, provides the horizontal deflection timing signal, and with buffer amplifier V27B and blanking restorer V19B, it provides the unblanking pulse to the crt.
(3) Sweep generator and control tubes V22 and V23 provide the regulated sawtooth voltage required for the horizontal deflection of the beam.
(4) Dc restorer V24 assures horizontal stability by returning the circuit to its original dc state after each horizontal sweep.
(5) Final horizontal output amplifiers V25 and V26 provide the necessary amplification to obtain the 350 volts required to deflect the beam across the face of the crt.

d. The timing marker circuit provides pulses separated by 5.2 usec. It is sometimes called the timing-pip generator and consists of 8-kc amplifiers V27A and V28A, synchronizing pulse generator V28B, discriminator rectifier V29, reactance modulator and 192-kc oscillator V30, 192-kc amplifier V31A, and differentiating shaper V31B.

e. The oscilloscope power supply produces six dc voltages. These are +450 volts regulated, +225 volts regulated, —1,500 volts, —600 volts, —140 volts, and +1,800 volts. Tubes V1 and V2 provide +1,800 volts and —1,500 volts; V3, V4, and V5 provide +450 volts; V6, V7, V9, and V10 provide +225 volts; and V8 provides —140 volts.

f. The crt section contains control circuits for proper operation of the tube.

238. Technical Specifications

The technical specifications of the oscilloscope are:

a. Vertical Amplifier Bandwidth. The response of the vertical amplifier is from 30 cps to 5 mc (the 3 db points with respect to the response at 100 kc).

b. Vertical Sensitivity. Maximum of .4 volt per cm with additional attenuation provided by the input attenuator of 1, 2, 10, and 100 and further attenuation of 10 when the probe is used. Thus, with the vertical attenuator at 100:1 and the low capacitance probe being used, the deflection sensitivity is 400 volts per cm.

c. Input Impedance with Probe. Normally 10 megohm in parallel with 12 uuf capacitance.

d. Input Impedance without Probe. Normally 1 megohm in parallel with 40 uuf capacitance.

e. Horizontal Sweep Spreads. Continuously variable from 5 milliseconds per cm to .5 microseconds per cm.

f. Horizontal Sweep Snychronization. Sweep synchronization can be accomplished by an external or internal source. In addition, the sweep can be made free running by advancing the STAB control. Provision is made to synchronize and phase the observed wave forms by use of an 8-kc signal obtained from either the multiplexer or demultiplexer section of the common unit.

g. Synchronizing Trigger Requirements. At least .5 volt and not more than 50-volt peak can be used to trigger the horizontal synchronizing circuits. Satisfactory triggering can be obtained from sine waves or pulses of either polarity which are as short as .1 usec. The sine wave obtained from the multiplexer section of the common unit to provide synchronization should be at least 2.2 volts rms for satisfactory continuous phasing.

h. Vertical Amplifier Voltage Calibration. Means are provided to calibrate the vertical sensitivity of the oscilloscope, through substitution of a square wave of power line frequency for the wave form applied to the vertical input terminals. By adjusting the height of this wave form to correspond to the deflection to be measured, the vertical sensitivity for the particular setting of the vertical gain controls can be obtained.

i. Timing Markers. For purposes of aligning the individual channel pulses, precise 5.2-microsecond timing pips are provided which are derived from the 8-kc sine wave from the common unit. These timing pips are applied to the vertical deflection plates and appear as a vertical deflection of the trace. They can be phased with respect to the observed wave form over a range of about 7 microseconds.

239. Oscilloscope Cathode-ray Tube Circuit (fig. 223)

The oscilloscope uses a type 5CP1A cathode-ray tube, V32. This is a 5-inch tube with elec-

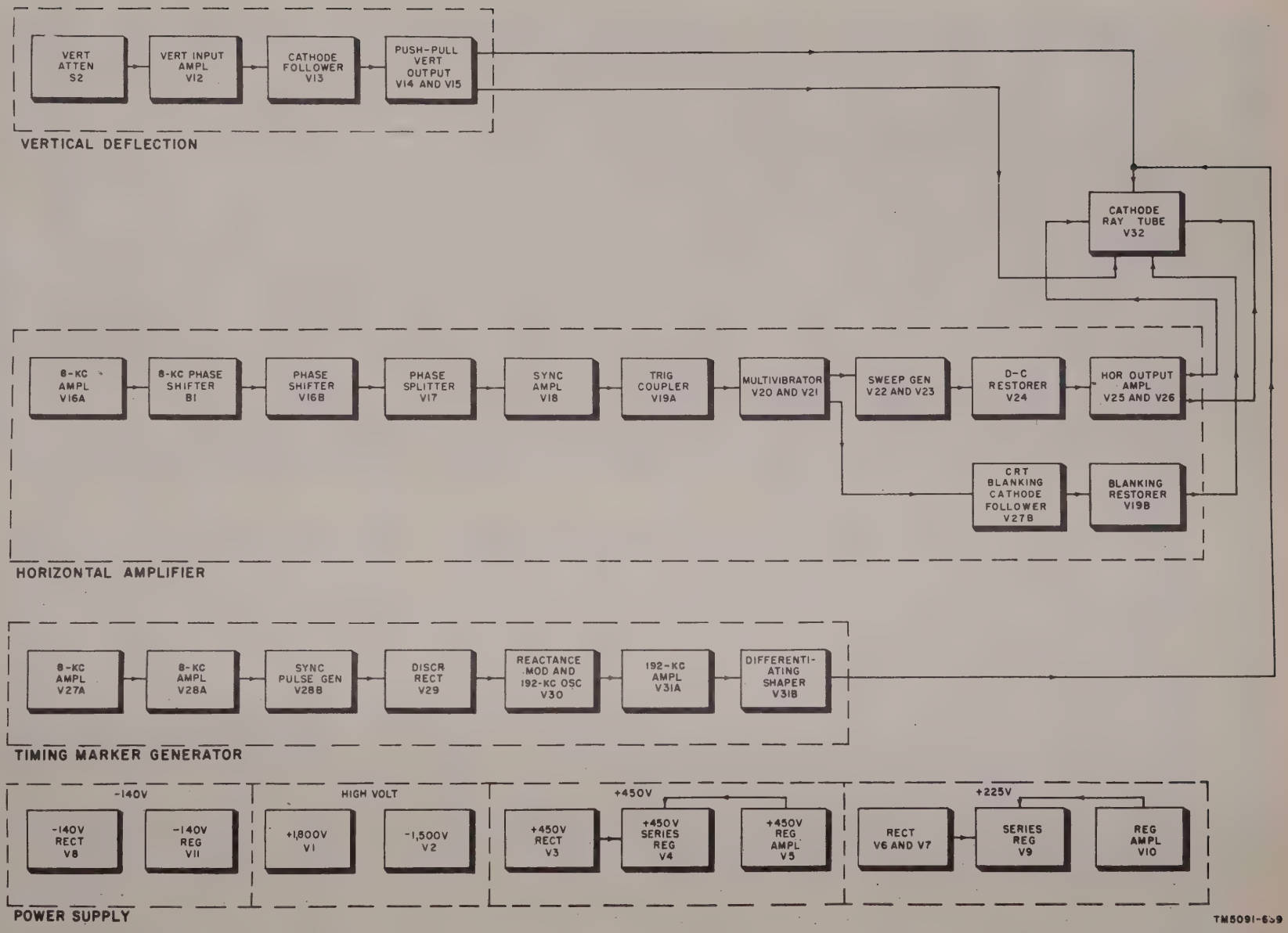


Figure 222. Oscilloscope OS-25/G, over-all block diagram.

trostatic focus and deflection. It uses post-deflection intensification; the electron beam is accelerated before and after deflection so that lower voltages can be used for deflection and good-viewing intensity is provided.

a. The —1,500-volt power supply is applied to the cathode of tube V32 through 500,000-ohm intensity control R186. Accordingly, the first grid, which is returned to the arm of this control through 1.5-megohm resistor R184, has a potential applied to it which is negative with respect to the cathode, and which can be varied to control the intensity of the electron beam. Potentiometer R187 controls pin 5, the first anode potential, which also is derived from the —1,500-volt supply and is at a positive potential with respect to the cathode.

b. The second anode potential is adjusted by means of an adjustment on the front panel (ASTIG). This controls the voltage at the arm of potentiometer R174 and insures that equal focus is maintained in both the horizontal and vertical axis. Vertical positioning of the trace is accomplished with a dual potentiometer, R180, connected between the +225- and —140-volt supplies. Turning this control increases the potential applied to one vertical deflection plate of the crt and decreases the other. The distribution of voltage along the beam axis of the crt is unchanged, and no change of the focusing controls is required to maintain proper focusing.

c. Resistors R176 and R177 act as voltage dividers in series with the vertical positioning potentiometers. Resistors R179 and R181 are decoupling resistors, and capacitors C87 and C88 are decoupling capacitors.

d. Unblanking of the trace is accomplished by an unblanking pulse applied to the grid of the crt.

e. Plus 1,800 volts is fed directly to the high-voltage capacitor of the crt from the oscilloscope high-voltage power supply.

f. Vertical deflection signals are fed through

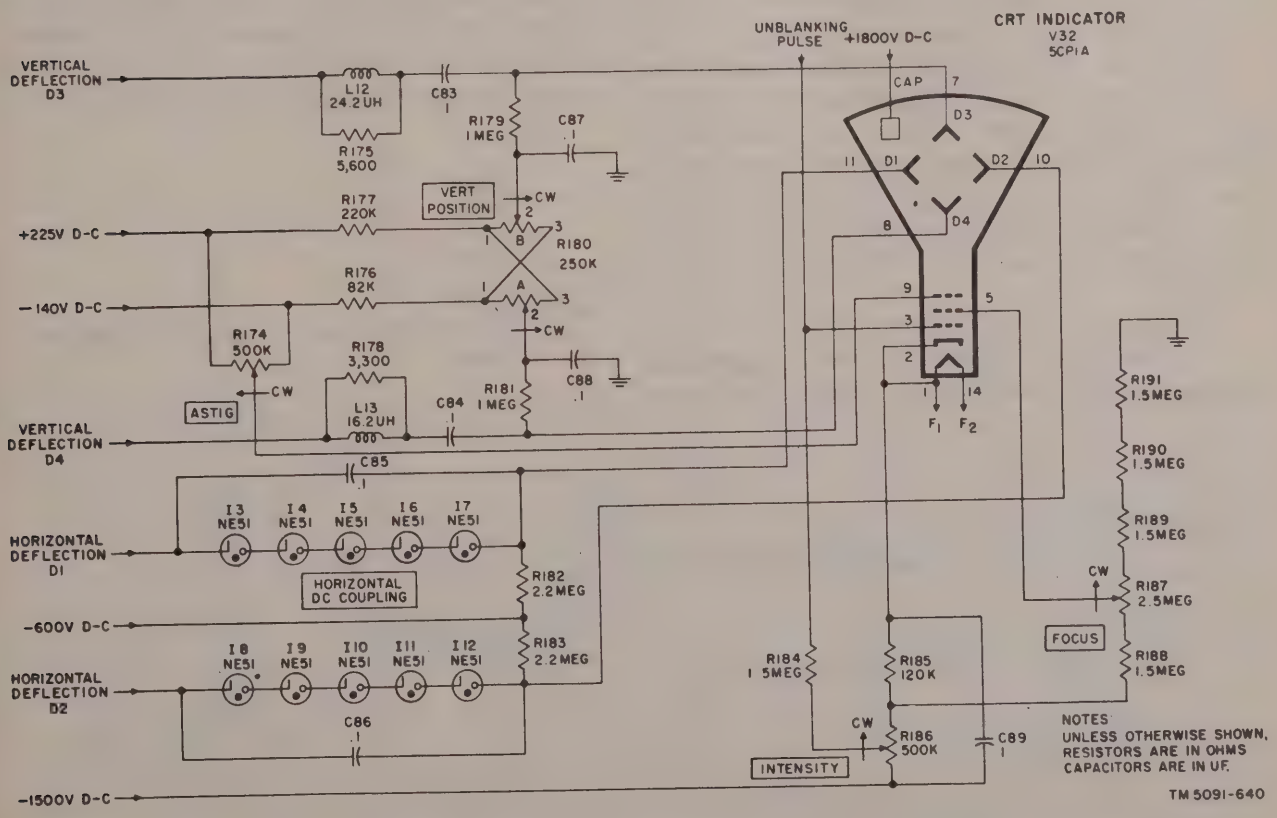


Figure 223. Cathode-ray tube circuits.

resistor R175 in parallel with L12, and resistor R178 in parallel with L13, then through capacitors C83 and C84.

g. Horizontal deflection voltages are coupled to the crt plates through capacitors C85 and C86. Capacitor C85 is in parallel with neon lamps I 3 through I 7. Capacitor C86 is in parallel with neon lamps I 8 through I 12. The neon lamps maintain the voltage across the capacitors constant and prevent defocusing. Resistors R182 and R183 return the plates to —600 volts.

240. Oscilloscope Power Supply Circuits (fig. 224)

The oscilloscope contains power supplies that produce —1,500 and —600 volts dc, +1,800 volts dc, +450 volts regulated, +225 volts regulated, and —140 volts.

a. The ac input is applied through switch S1, indicator pilot light I 1, and through fuse F1 to transformer T1 and through fuse F2 to transformer T2.

b. Transformer T1 produces the following voltages: terminals 5 and 6 provide 6.3 volts ac for the crt filament, terminals 10 and 11 provide 2.5 volts ac for the filament of V2 (—1,500-volt rectifier), terminals 3 and 4 furnish 2.5 volts ac for the filament of V1 (+1,800-volt rectifier), 1,400 volts ac for both high voltages (—1,500- and +1,800-volt rectifiers), 520 volts ac to the diode-connected plates of V3, terminals 14 and 16 supply 6.3 volts for the filaments in the horizontal and vertical circuits.

c. Transformer T2 produces 6.3 volts ac for the filament of V5, 640 volts center-tapped to ground for the +225-volts supply, 5 volts ac for the filaments of tubes V6 and V7, 6.3 volts ac for the filament of V8, and 6.3 volts ac for horizontal sweep control tube V23.

d. The —1,500-volt supply (fig. 225) is rectified by V2 and filtered by resistor R6 and capacitors C2 and C3. The —600 volts is obtained from the same rectifier tube but dropped through R7 and R8.

e. The +1,800-volt supply (fig. 226) is rectified by V1 and is filtered by resistor R5 and capacitor C1. Resistors R1 through R4 act as a bleeder circuit and provide a discharge path for capacitor C1.

f. The +450-volt rectifier, V3 (fig. 227), is operated as a diode because both plates are tied together. The tube current is limited by resistors R192 and R193 in parallel. The output is regulated electronically by series regulator V4, the series resistance of which changes to keep the output voltage constant. The +225-volt regulated supply is used as a reference for the +450-volt supply and must be adjusted first. The output of the +450-volt supply is across the voltage divider R15, R16, and R17. The grid of regulator tube V5 is connected to a tap on potentiometer R16 through current limiting resistor R14, and is connected through capacitor C5 to +450 volts. The screen of tube V5 is operated from a voltage divider, which consists

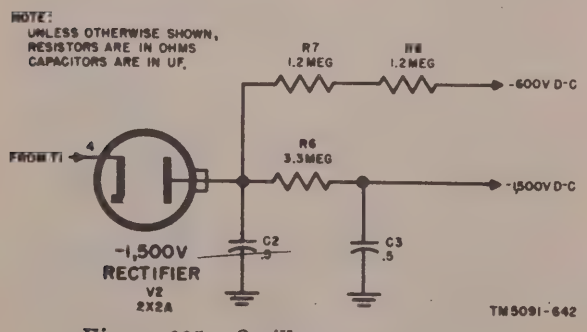


Figure 225. Oscilloscope —1,500- and —600-volt supply.

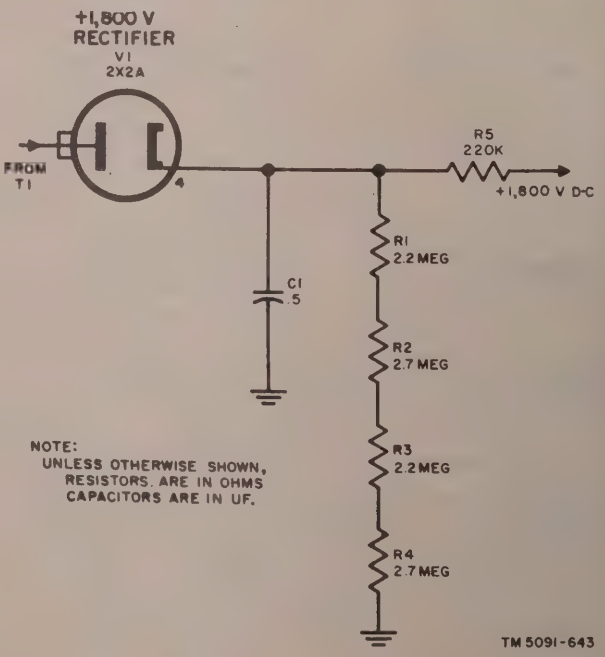


Figure 226. Oscilloscope 1,800-volt supply.

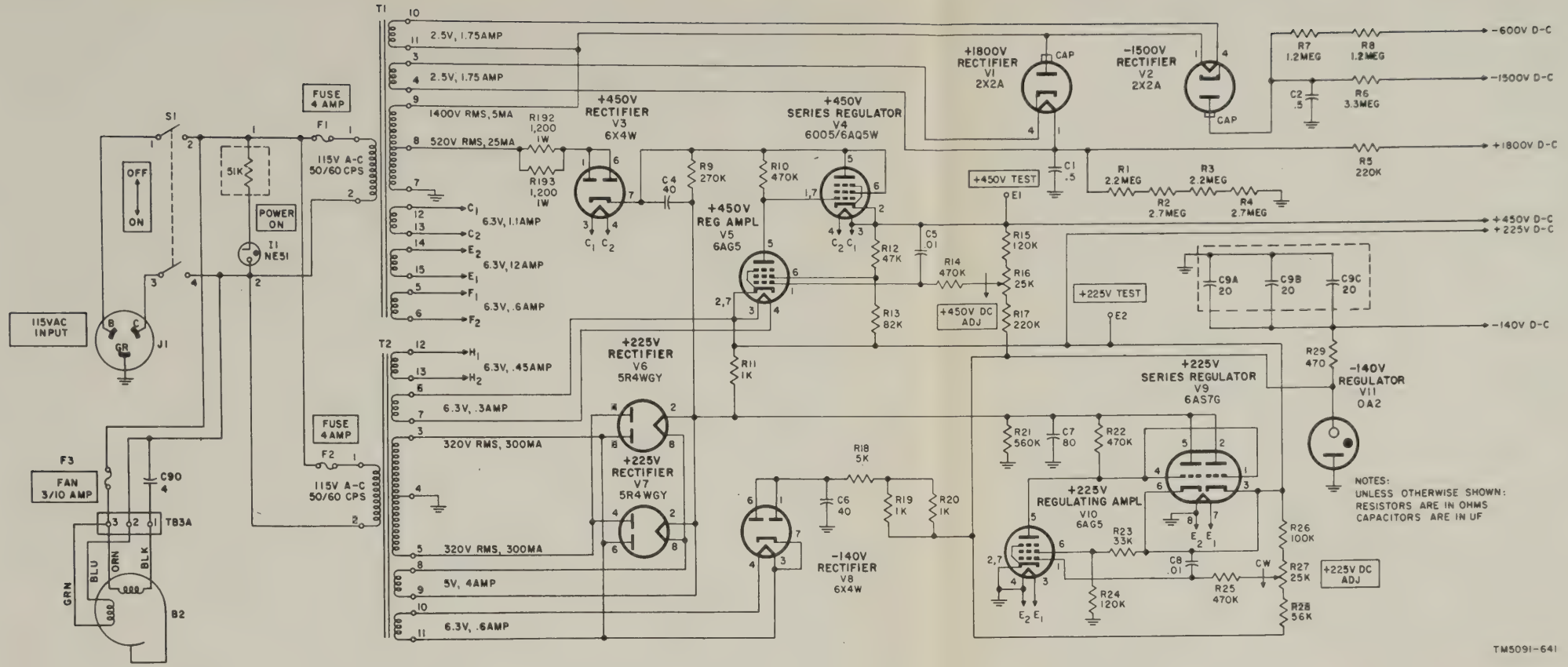


Figure 224. Oscilloscope Power Supply

of resistors R12 and R13. The cathode of tube V5 is returned to the +225-volt reference voltage. The grid of tube V4 is connected to the plate of tube V4. The output voltage variations from the power supply impressed across C5 are fed to the grid of tube V5. The plate current of tube V5 will therefore vary with its grid. The plate of V5 being connected to the plate of V4 controls the current flow through tube V4, which acts as a variable resistor in series with the output current and maintains the output voltage constant. Capacitor C4 filters irregularities in rectifier V3 output. Resistor R9 is a discharge path for C4.

g. The dc voltage is used to operate the low-voltage stages of the oscilloscope. It is provided by rectifying ac applied to the plates of V6 and V7. Current can flow only one way in the tubes; therefore, dc appears at their cathodes. This output is pulsating and is filtered by capacitor C7 and the regulator circuit consisting of V9 and V10. The +225-volt (fig. 228) full-wave rectifier-type power supply uses parallel connected rectifier tubes V6 and V7 for greater current capacity. Capacitor C7 filters the output of these rectifier tubes. Resistor R21 is a bleeder resistor for filter capacitor C7. When the equipment is shut off, capacitor C7 will discharge through R21. Tube V10 is the regulating amplifier. Resistor R22 is the plate resistor for tube V10. Resistors R23 and R24 provide a screen voltage divider network, capacitor C8 is the grid ac bypass capacitor, resistor R25 is the grid current limiting resistor, and resistors R26, R27, and R28 are the +225-volt dc output voltage divider. Parallel-connected tube V9 is the series regulator tube. Resistor R11 shunts V9, which reduces the tube dissipation while keeping the regulation within acceptable limits.

h. A voltage calibration circuit (fig. 229) is included to measure the voltage deflection of the oscilloscope. This circuit provides a squared 60-cycle ac voltage, which is displayed on the scope and is calibrated so that its value may be read directly from the panel controls. To measure an unknown voltage, adjust the height of the calibrating voltage to match the height of the unknown signal, then read the value from the panel controls. Both signals are the same height, therefore both are of the same value (par. 45). The ac voltage is applied to crystal

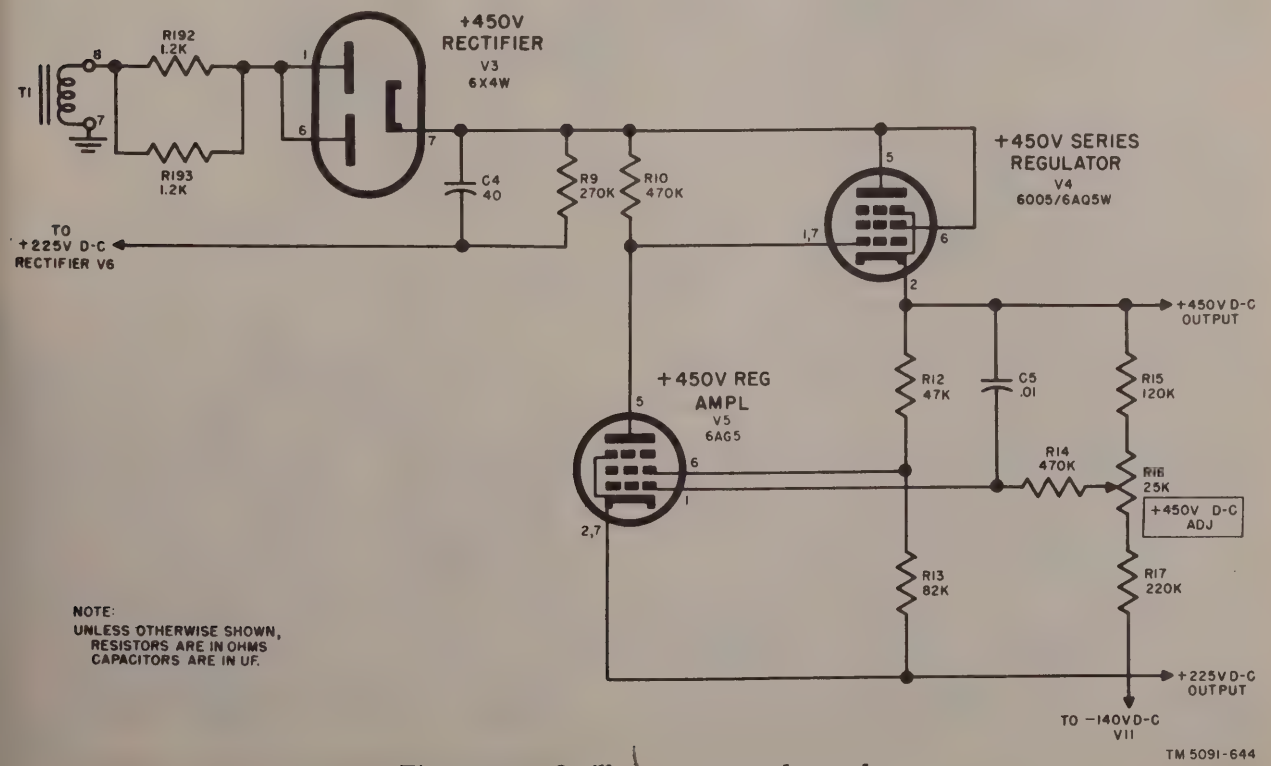


Figure 227. Oscilloscope +450-volt supply.

rectifiers CR1, CR2, and CR3 through R30. The output is developed across R31, R4, and applied to voltage divider R33, R34, and R3. It is then fed through switch S2B to vertical input amplifier V12. Resistor R35 is calibrated, so that voltage may be read directly from it when the switch is in the calibrate position.

i. The —140-volt supply (fig. 230) is provided by rectifier tube V8 and is filtered by resistor R18 and capacitor C6. Resistor R19, in parallel with R20, is the series voltage dropping resistor for gas-type voltage regulator tube V11. The output is then taken through resistor R29 and is filtered by capacitors C9A, C9B and C9C. The current flow through voltage regulator V11 varies inversely with the voltage change across V11. This change is dissipated across resistors R19 and R20, resulting in a constant —140-volt dc output.

241. Oscillator Vertical Amplifier Circuits

The vertical deflection system amplifies or attenuates the signal being observed and couples it to the vertical deflection plates of the crt. The maximum gain of the circuit is 100. Use of an oscilloscope probe is necessary so that desired voltages can be observed without loading. The probe is a 9-megohm resistor (R36 and R37) in parallel with capacitor C10, both in series with the normal input circuit of the oscilloscope (fig. 380). When the time constant of this resistance-capacitance circuit is adjusted to be equal to the time constant of the oscilloscope, attenuation of the input signal is achieved without distortion of any of the frequency components of the observed signal. The following stages comprise the vertical deflection system: vertical input amplifier V12, phase splitter cathode follower V13, and push-pull

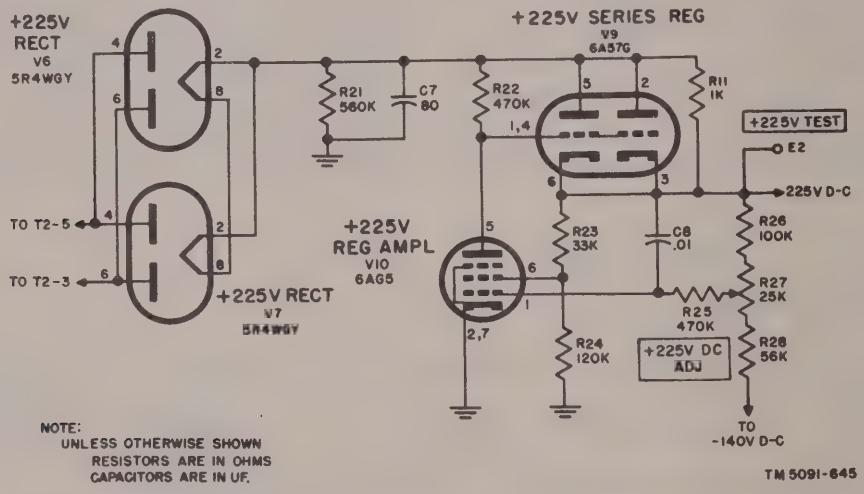


Figure 228. Oscilloscope +225-volt supply.

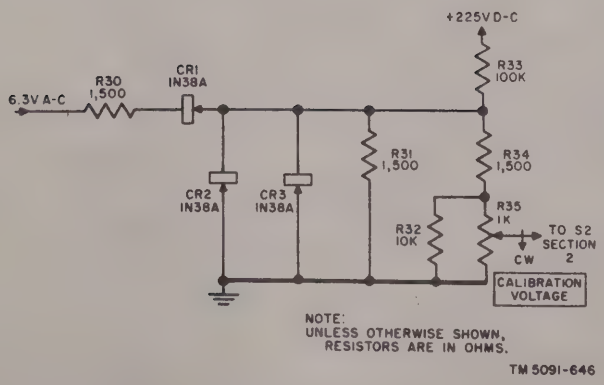


Figure 229. Oscilloscope voltage calibration circuit.

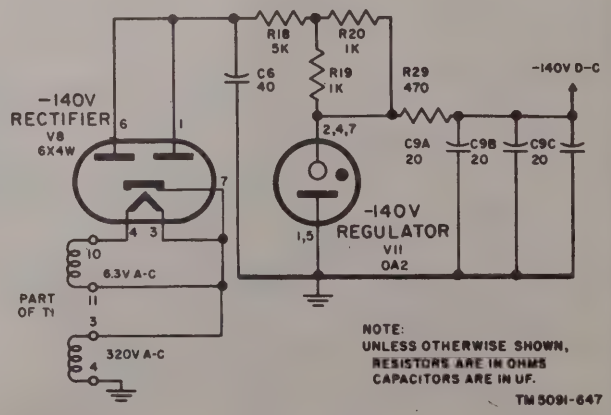


Figure 230. Oscilloscope —140-volt supply.

vertical output amplifier tubes V14 and V15. The output of V14 and V15 is coupled to crt vertical deflection plates D3 and D4.

242. Vertical Attenuator
(fig. 231)

The signals applied to the input of the vertical amplifier are introduced through the vertical attenuator, which is a five-position rotary switch (S2). Four positions provide attenuations of 100:1, 10:1, 2:1, and 1:1. The fifth position is for calibration purposes. The attenuation is achieved without distortion by shunting the attenuator resistors with capacitors, so that the product of resistance-capacitance is constant. These capacitors can be adjusted to provide minimum distortion. The 100:1 attenuator consists of resistors R38, R39, R40, and R41 and capacitors C11, C12, C13, and C14. The 10:1 unit consists of resistors R42 and R43 and capacitors C15, C16, C17, and C18. The 2:1 attenuator consists of resistors R44 and R45 and capacitors C19, C20, and C21.

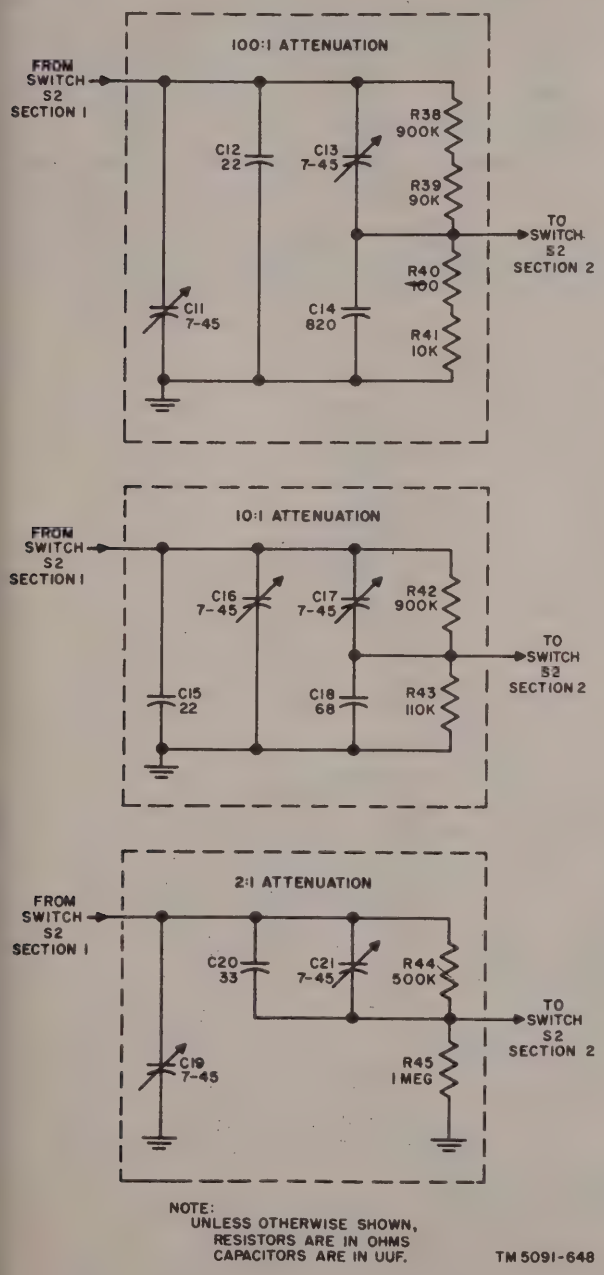


Figure 231. Oscilloscope vertical attenuator.

243. Vertical Input Amplifier
(fig. 232)

a. A video amplifier must be able to amplify uniformly a wide band of frequencies. However, a typical resistance-coupled audio amplifier has a characteristic amplification that falls off both at high and low frequencies. To prevent this, some form of *compensation* is necessary. The reduced gain at the high frequencies is due to the reduction of plate load impedance caused by the shunting effect of interelectrode and distributed capacity. This may be compensated by adding an inductance in series with the load resistor. This is known as *shunt* compensation. The same effect may be accomplished by a coil in *series* with the coupling capacitor. Both methods are used in the vertical input amplifier circuit.

b. The input stage, tube V12, uses a method of series-shunt peaking to achieve the maximum gain at high frequencies. Series peaking is accomplished by isolating the input capacitance of tube V13 from the output capacitance of tube V12 by the network that consists of series compensating inductor L2 and resistor R57. Resistors R50 and R51 are decoupling resistors for the plate circuit of V12. Capacitor C24A is the decoupling capacitor, resistors R53 and R52 in parallel are the plate load, L1 is the shunt compensating inductor, R54 is a parasitic suppressor resistor, R56 is the screen grid voltage dropping resistor, and C24B is the screen grid bypass capacitor. Resistor R46 is the grid return, and resistors R47 and R48 form a voltage divider to set the grid bias. Capacitor C23 is the coupling capacitor from S2B, and R49 is a parasitic suppressor resistor. Parallel-connected resistors R55 and R64 provide screen grid decoupling

and C24C is the decoupling capacitor. Capacitor C22 is the attenuator trimmer bypass capacitor.

c. The gain of the over-all plate coupling circuit of amplifier tube V12 is maintained constant from very low audio frequencies to video frequencies as high as 5 mc. Potentiometer R59 is used to adjust the low-frequency response as the signal is coupled from V12 to V13 (fig. 233). Low frequency compensation is achieved with the circuit that consists of resistor R58 and R59 and capacitor C26A. This circuit overcomes the reduction in gain at low frequencies that results from the increase in reactance of C25.

244. Cathode Follower V13

(fig. 233)

Cathode follower stage V13 isolates the relatively high input capacitance of tube V14 from the plate circuit of tube V12, and drives low resistance potentiometer VERT GAIN control R68. This low value of resistance helps to avoid high-frequency (hf) attenuation caused by distributed capacitance. The grid of V13 is a high-impedance circuit, but the cathode (from which part of the output is taken) is a low-impedance circuit. To maintain a good low-frequency response, in this cathode follower stage, a large coupling capacitor, C27, is required. This capacitor is mounted to minimize its capacitance to ground, which would otherwise decrease the hf response of the circuit. Resistor R61 is the grid return resistor, R60 and R62 are the voltage divider network to set the fixed grid bias. Resistors R66 and R67 are the cathode load resistors. Resistor R65 is a low value plate load resistor which permits a small out-of-phase signal to be taken off the plate to feed the internal synchronizing circuit. Capacitor C27 is the output coupling capacitor, and resistors R68 and R69 (VERT GAIN) are the cathode-follower load. Voltage developed

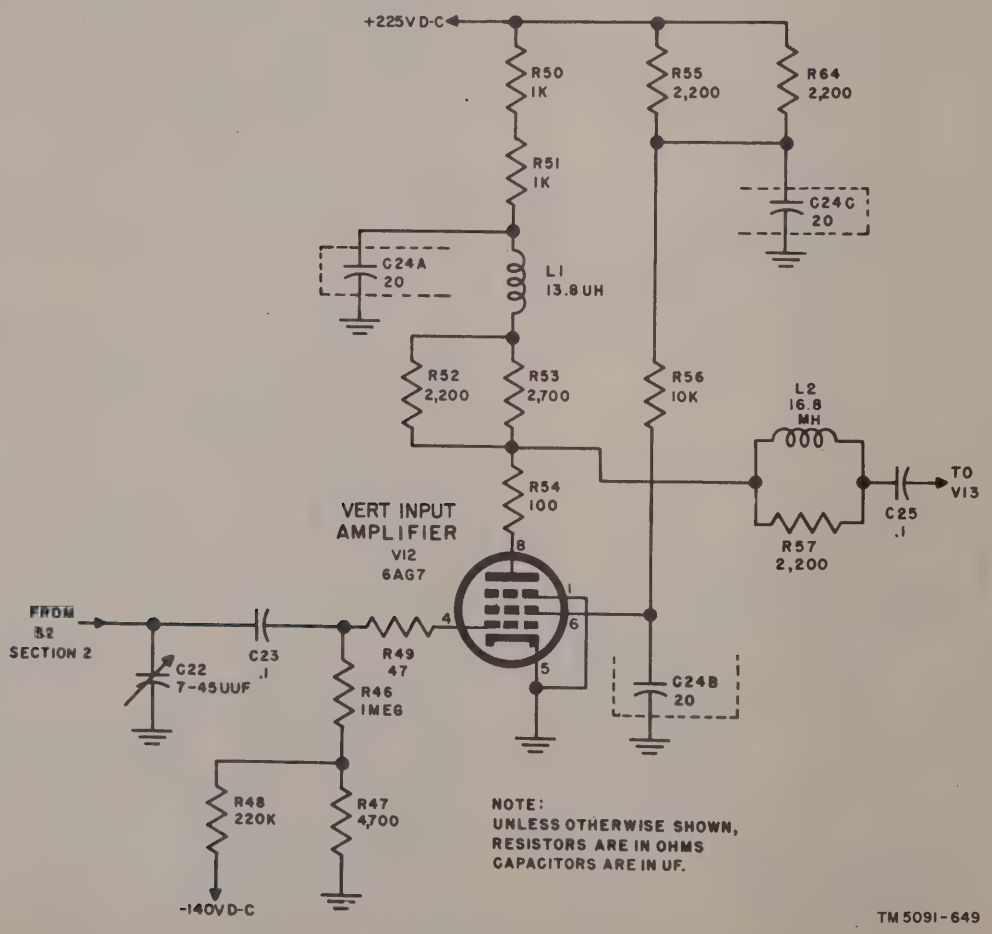


Figure 232. Oscilloscope vertical input amplifier.

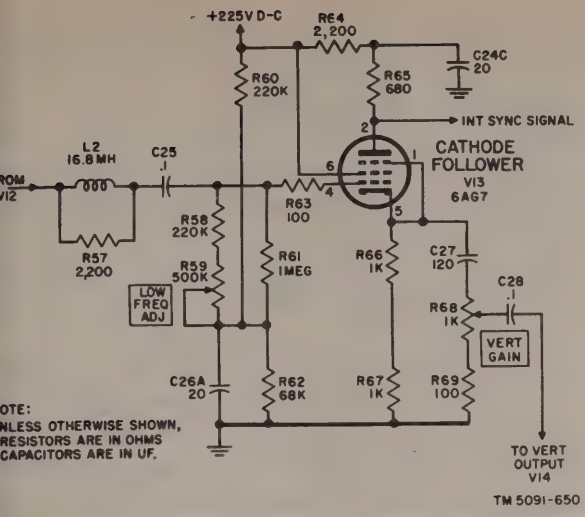


Figure 233. Oscilloscope cathode-follower stage V13.

across R69 and R68 (VERT GAIN) is fed to vertical output tube V14 through coupling capacitor C28.

245. Push-pull Vertical Amplifier

(fig. 234)

a. The output stage of the vertical amplifier consists of tubes V14 and V15. Push-pull operation of this stage is achieved without the use of a transformer but by using common cathode resistors R79 and R80. For a description of a cathode-coupled push-pull amplifier, refer to paragraph 254. The portion of the output from tube V14 is cathode-coupled to the grid of V15.

b. By proper selection of cathode resistors, the signals applied to the grids will be equal. Each stage includes a low-frequency compensation network to correct for the coupling effect of the vertical deflection plates of the cathode-ray tube. The input load circuit to tube V14 contains variable resistor R71, which adjusts for variations in the tolerances of resistors R58 and R61. Inductor L3 isolates the input capacitance of tube V14, thus providing hf peaking. As in the output of tube V12, series-shunt

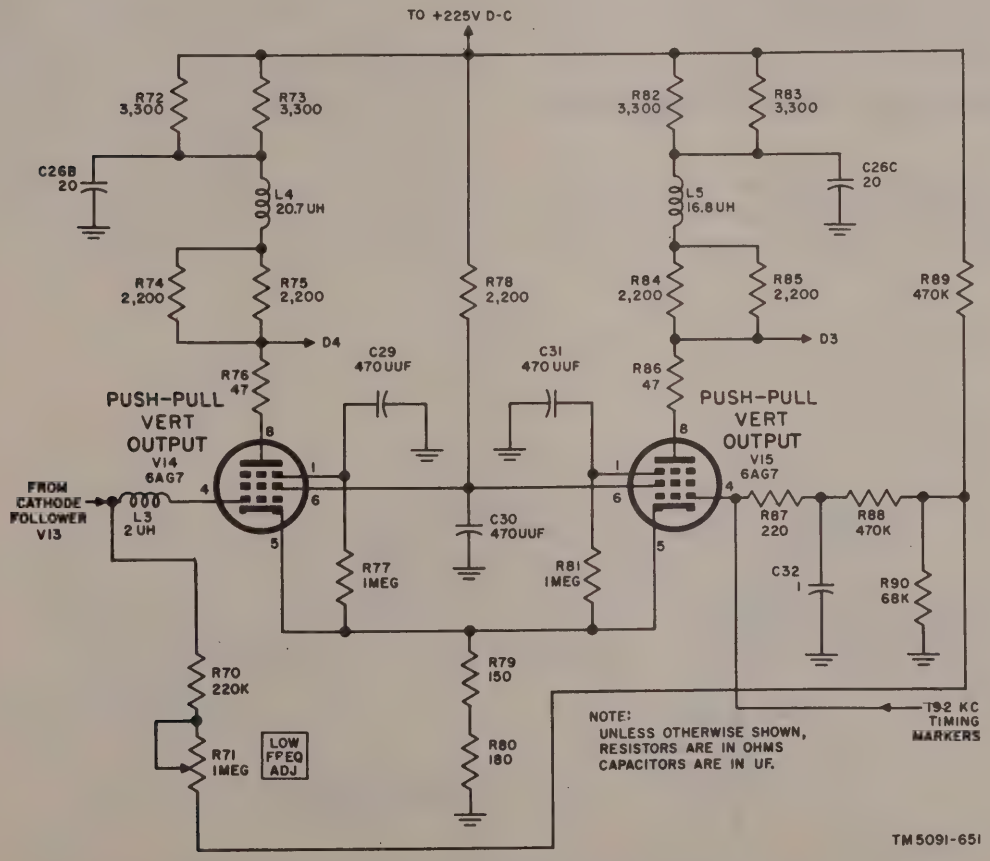


Figure 234. Oscilloscope vertical amplifier output stage.

peaking is used in tubes V14 and V15 to provide compensation. Resistors R76 and R86 are plate parasitic suppressor resistors; resistors R74 and R75 in parallel, and R84 and R85 in parallel, are the tube plate loads; L4 and L5 are the series-shunt peaking coils; and resistors R72 and R73 in parallel, and R82 and R83 in parallel, are the plate decoupling resistors. Capacitors C26B and C26C are the plate decoupling capacitors. Resistor R78 is the screen grid voltage decoupling resistor for both tubes and C30 is the bypass capacitor. Resistors R77 and R81 connect the suppressor grid to the cathode return circuit and capacitors C29 and C31 are the suppressor grid bypass capacitors. Resistors R89 and R90 are a voltage divider network and provide the bias for both tubes. Resistors R87, R88, R70, R71 and R90, connected in series, are the grid return for V14. Resistor R87 provides a load for the timing pips and R88 and C32 provide a filter to isolate the signal applied to V14 from the grid of V15. The timing-pip circuit is described in paragraph 257. Capacitor C32 bypasses the timing markers (pips), isolating them from the voltage divider network.

246. Oscilloscope Horizontal Amplifier Circuit

The sweep circuits provide means for horizontally deflecting the beam of the crt, for synchronizing the horizontal with the vertical pattern, and for positioning the pattern so that any desired portion of it may be observed. An unblanking circuit is provided so that the beam is brightened during sweeps. (The spot that appears at the left-hand portion of the sweep during triggered operation can be reduced in intensity by turning the INTENSITY control counterclockwise.)

247. Sweep-phase Circuit (fig. 235)

A synchronizing signal from the common unit multiplexer or demultiplexer sections is fed through J4 (MTPX SYNC INPUT) or J5 (DEMTPX SYNC INPUT) to the grid of 8-kc amplifier tube V16A. This signal can be used to trigger the sweep circuits when the SYNC SELECTOR switch is in the DEMULTIPLEXER SYNC or MULTIPLEXER SYNC position. The output taken from the tuned plate tank circuit (C33 and L6) of tube V16A is applied to the rotor of two-phase autosyn B1. This autosyn functions as a transformer that has a rotary primary coil with two stationary secondary coils. One stationary coil acts as the transformer secondary with the other stationary coil mounted at a right angle to this secondary coil. The rotor, as the primary of the transformer, induces voltages into the fixed stators of the autosyn. These voltages vary in amplitude, but not in phase, as the rotor is turned. Because the stator coils are mounted

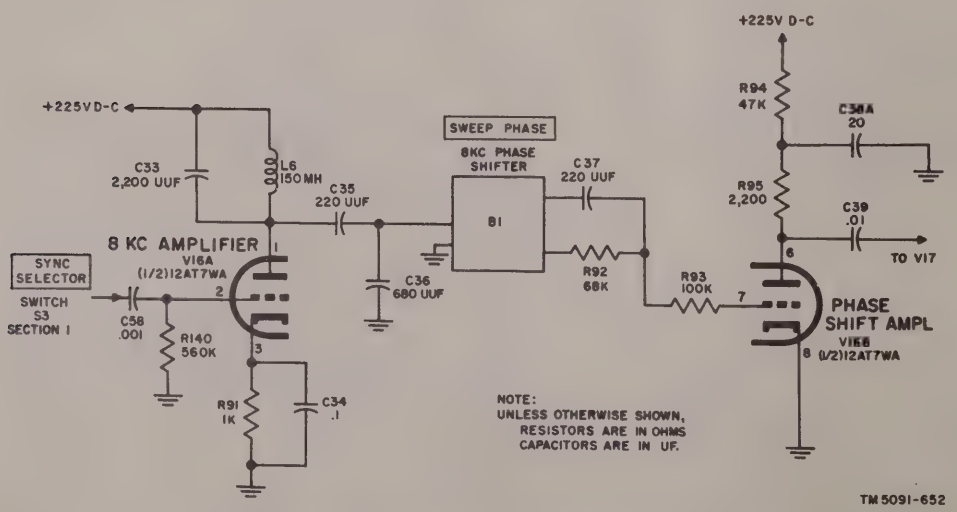


Figure 235. Oscilloscope horizontal sweep-phase circuit.

at right angles to each other when the voltage in one is a maximum, the voltages in the other is a minimum. The sum of these voltages is applied across a phase-shift combination consisting of resistor R92 and capacitor C37. The phase of the voltage that appears on pin 7 of tube V16B, therefore, is a function of the angle through which the rotor of B1 is turned. Thus, turning over the autosyn rotor 360° will rotate the phase of the signal that appears at pin 7 of tube V16B over 360° with respect to the 8-kc sync signal applied to jack J4 or J5. Inductor L6 and capacitor C33 form a resonant circuit at 8-kc and are the plate load of tube V16A; resistor R91 is the cathode-biasing resistor. Capacitor C34 is the cathode bypass capacitor; C35 provides the output coupling; and C36 is the bypass capacitor across the load. Tube V16B amplifies the sweep phase as adjusted by SWEEP PHASE B1. Resistor R95 is the plate load, and R94, with capacitor C38A, provides power supply decoupling. Capacitor C39 is the outut coupling capacitor.

248. Trigger Phase Splitter V17
(fig. 236)

The trigger phase splitter controls the polarity of the signal applied to the grid of sync amplifier V18 of the sweep-trigger circuit so that proper triggering is accomplished, regardless of the signal applied to the grid of tube V17. When SYNC SELECTOR switch S3B is in the DEMTPX position, the trigger signal to the grid of tube V18 is applied from the cathode of tube V17. Accordingly, there is no phase inversion. When the switch is in the MTPX position, the grid signal to tube V18 is taken from the plate of tube V17, and thereby inverted. Resistor R96 is the grid return for tube V17. Capacitor C41 is the coupling capacitor to the arm of SYNC SELECTOR switch S3. Resistor R99 and capacitor C40B are a decoupling network. Resistors R97 and R98 form a screen grid voltage divider, and C40A is the screen grid bypass capacitor. Resistor R100 is the plate load, and R101 is the cathode load.

249. Sync Amplifier V18
(fig. 236)

Sync amplifier tube V18 is used to amplify the signal from tube V17, the trigger phase splitter. By adjusting the negative bias applied to its grid with TRIGGER potentiometer R102, the amplitude of the signal, which controls the triggering of the sweep multivibrator, can be adjusted. Resistors R103 and R102 are

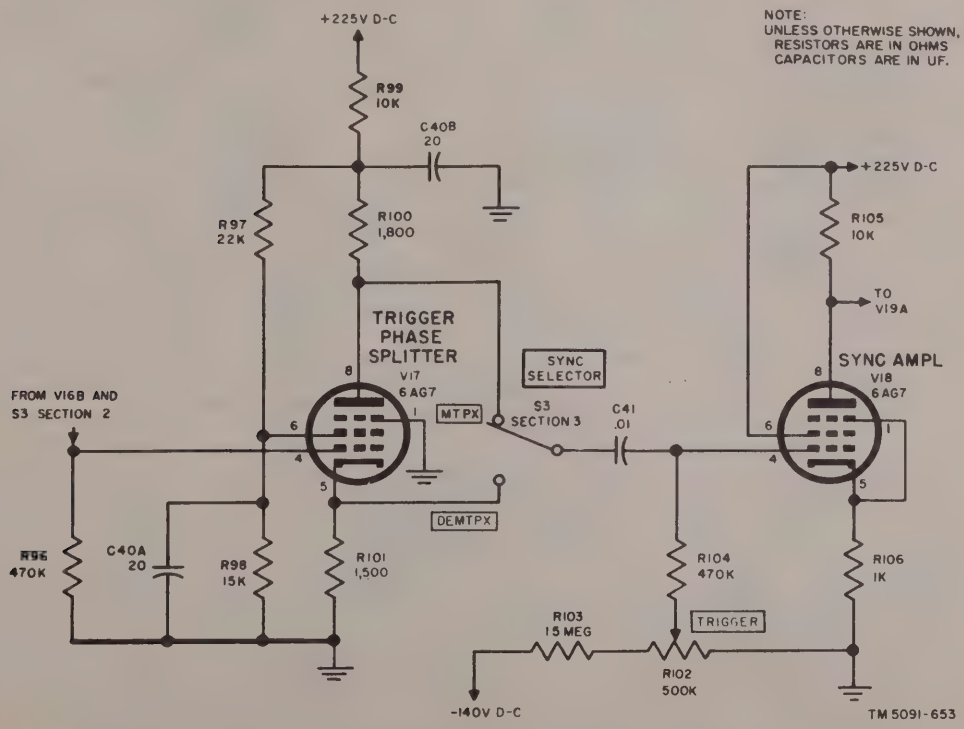


Figure 236. Oscilloscope trigger phase splitter V17 and sync amplifier V18.

the bias voltage divider circuit. Resistor R104 is the grid return, R105 is the plate load, and R106 is the cathode resistor.

250. Trigger-coupling Diode V19A

(fig. 237)

Triggering of the sweep multivibrator is accomplished through the plate circuit of multivibrator V20 by the trigger-coupling diode, tube V19A. The diode is connected so that only the negative signals applied to its cathode are passed through to the plate of multivibrator tube V20. When the trigger pulse has once triggered the multivibrator, it is disconnected from the remaining multivibrator tube V21, and multivibrator V20 will not trigger again until it returns to its quiescent state.

251. Multivibrator Circuit

(fig. 237)

a. The multivibrator consists of tubes V20 and V21 and provides the sweep gate signal and an unblanking pulse to the crt.

b. When quiescent, tube V21 is conducting and V20 is cut off. The plate of V21 is connected through resistor R113, and capacitor C42 is connected to the control grid of V20. The plate of V20 is connected through switch S4A, which connects either one of timing capacitors C43, C44, C45, or C46 into the circuit to the control grid of V21. The cathodes of the two tubes V20 and V21 are grounded. The grid of V20 is returned to ground through potentiometer R110 (STAB control). This control provides up to —140-volt negative bias and permits either triggered or recurrent operation.

c. In the quiescent state, tube V21 is conducting and tube V20 is cut off. When a negative pulse passes through trigger-coupling tube V19A, it decreases the voltage on the plate of tube V20 and on the grid of tube V21. This more negative grid voltage cuts off V21, the plate of which goes more positive. The plate of V21 is coupled to the grid of V20. The positive-going plate of tube V21 causes the control grid of V20 to become more positive and tube V20 will start to conduct.

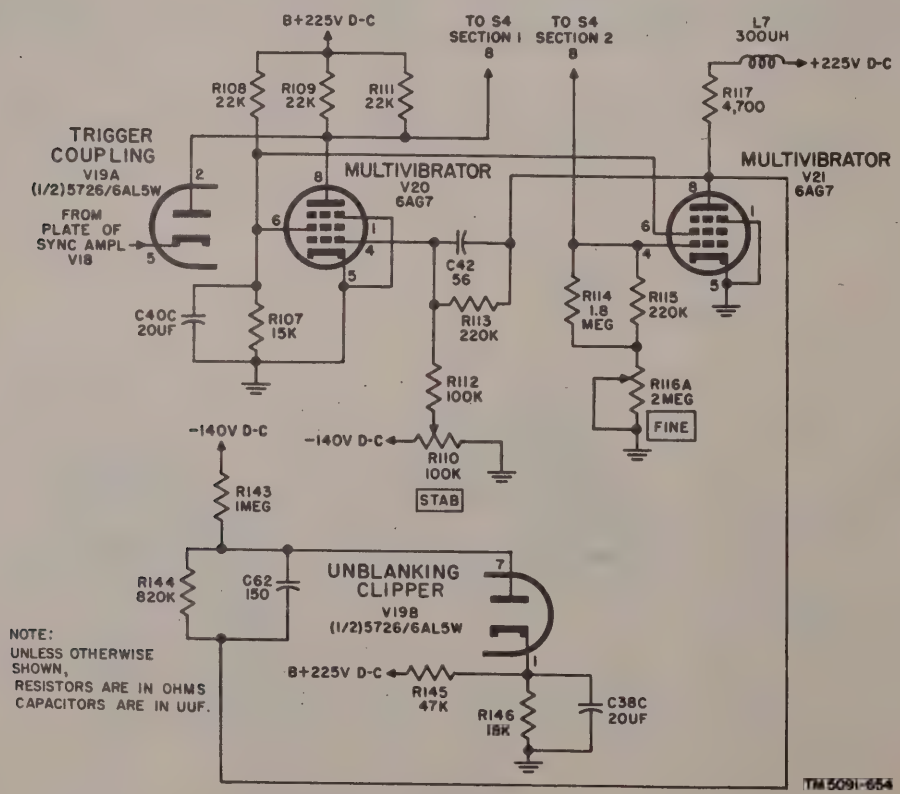


Figure 237. Oscilloscope multivibrator.

d. When V20 starts to conduct, its plate voltage drops. This voltage is coupled to the grid of V21, which causes the plate current to decrease and plate voltage to increase. The triggering action is complete when V21 is cut off and V20 is conducting heavily.

e. Timing capacitors C43, C44, C45 or C46 (fig. 238 and 380) will hold the grid of V21 at cutoff potential for a time, determined by its capacitance and the resistance R114, R115, and R116A. Once the capacitor discharges, tube V21 will again conduct and the tubes return to their original, or quiescent, condition.

f. Resistors R108 and R107 form the screen grid voltage divider, and C40C is the screen grid bypass capacitor. Resistor R112 is the grid return resistor for V20; R111 and R109 provide the plate load for V20; and R117 and L7 act as the plate load of V21.

252. Unblanking Circuit

The trace of the crt is normally cut off and visible during sweeps; the positive rectangular wave that appears at the plate of tube V21 is applied to the crt control grid through crt blanking cathode follower V27B (fig. 240). This wave is clipped by diode unblanking clipper V19B to insure a uniform intensity of the trace as the beam sweeps across the face of the tube. The buffer cathode-follower tube V27B, acts as an impedance transformer, preventing the wiring and grid capacitance of the crt from loading the plate circuit of the multivibrator. This is because the cathode follower has a high input (grid) impedance and a low output (cathode) impedance. For V19B (fig. 237), resistor R146 and capacitor C38C are the diode load; R143 and R144 act as a voltage divider to set the V27B grid bias, at —140 volts, and resistors R145 and R146 act as a voltage divider to set the voltage on the cathode of V19B. For V27B (fig. 240), resistor R142 is the cathode resistor and C61 is the output coupling capacitor.

253. Sweep Generator Circuit
(fig. 238)

a. The crt requires a voltage varying linearly with time to move its spot from one side of the scope screen to the other (sweep). This is accomplished by changing a capacitor to a given voltage at a linear rate, then discharging it rapidly. The rate of charge, and therefore, the sweep speed, is a function of the capacitor and the resistance through which the charging and discharging current must flow. Predetermined ranges are provided by switching in various combinations of capacitors.

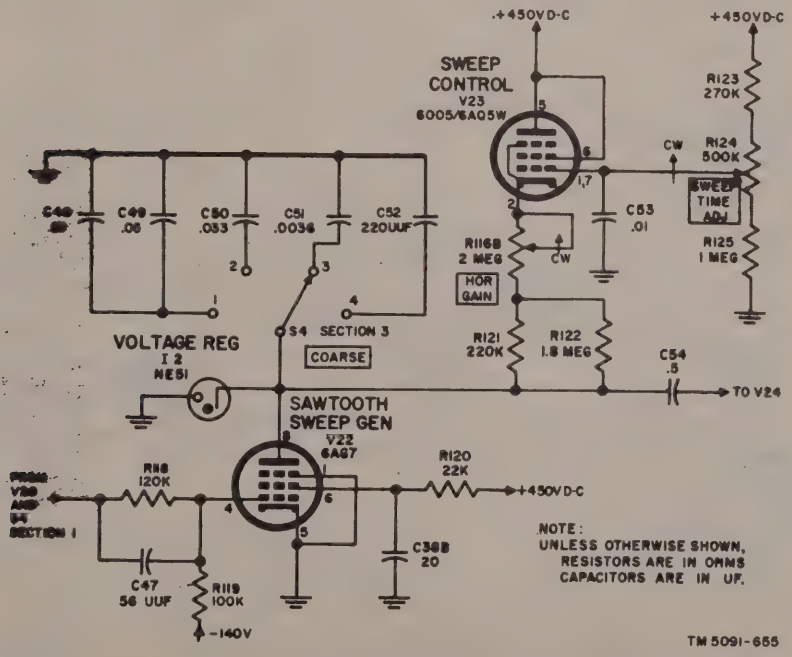


Figure 238. Oscilloscope sweep generator.

b. The sweep generator consists of sawtooth sweep generator tube V22 and sweep control tube V23. These tubes provide voltage for deflecting the crt spot across the screen at a chosen rate. Multivibrator tube V20 applies a negative pulse to the grid of normally heavily conducting sawtooth sweep generator tube V22. The negative pulse cuts off this stage and permits the plate voltage to rise exponentially toward the +450 B+ supply to which it is connected. The exponential rate of rise is determined by HOR GAIN resistor R116B in series with parallel-connected resistors R121 and R122, tube V23, and any one of capacitors C50, C51, C52, or C48 in parallel with C49. The capacitor is in series with the resistance network. To maintain as linear a charge rate as possible, the capacitor is permitted to charge to only 25 volts (about 6 per cent of the driving voltage) by shunting it with neon bulb I 2, which conducts at that voltage. When the voltage across the capacitor rises to 25 volts, I 2 conducts, placing a low resistance across the capacitor. The maximum voltage that can be developed across the capacitor is therefore 25 volts. By that time the negative pulse applied to the grid has disappeared, and tube V22 returns to its normally heavily conducting state. This discharges the capacitor and permits the cycle to repeat. Sweep control tube V23 is used to control the rate at which the capacitor selected by COARSE switch S4 will charge, thereby controlling the frequency of the horizontal sweep.

c. Resistor R119 is the grid biasing resistor for V30, R120 is the screen grid voltage dropping resistor, and C38B is the screen grid bypass capacitor. Resistor R118 maintains the grid positive by returning to B+, and capacitor C47 is the grid coupling capacitor.

d. Sweep control tube V23 is a cathode follower. With the control grid of V23 held at ac ground by capacitor C53, its cathode provides a low-impedance source of voltage. The adjustable grid bias provided by resistors R123, R125, and potentiometer R124 (SWEEP TIME ADJUST) permits adjusting the sweep time without disturbing the required resistance ratio in the cathode circuit. It does this by varying the conduction of the tube, thus effectively changing its resistance.

254. Sweep Amplifier Circuit

(fig. 239)

a. Because the sawtooth sweep generator provides only 25 volts of sweep voltage at the plate of tube V22, amplification is required to obtain the 350 volts necessary to deflect the beam across the face of the crt. This amplification is obtained with tubes V25 and V26, which comprise a cathode-coupled push-pull

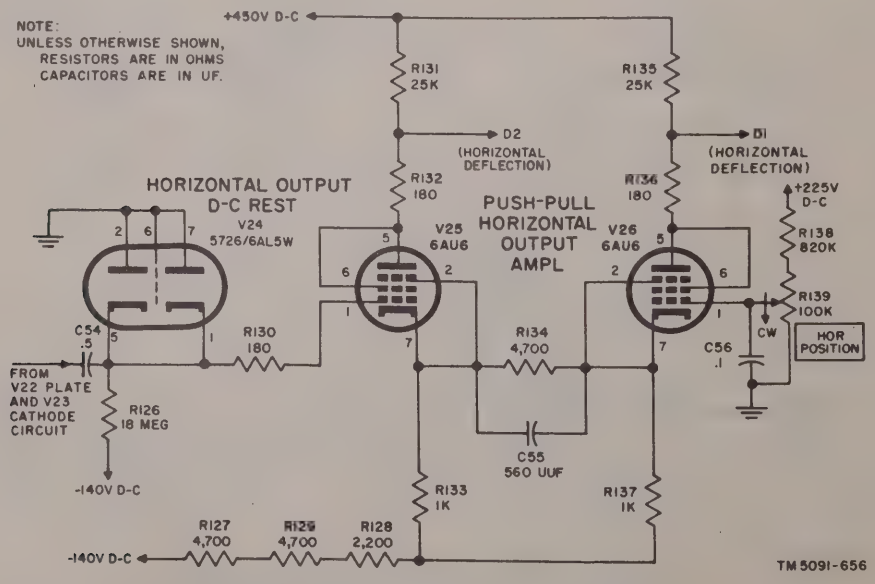


Figure 239. Oscilloscope sweep amplifier.

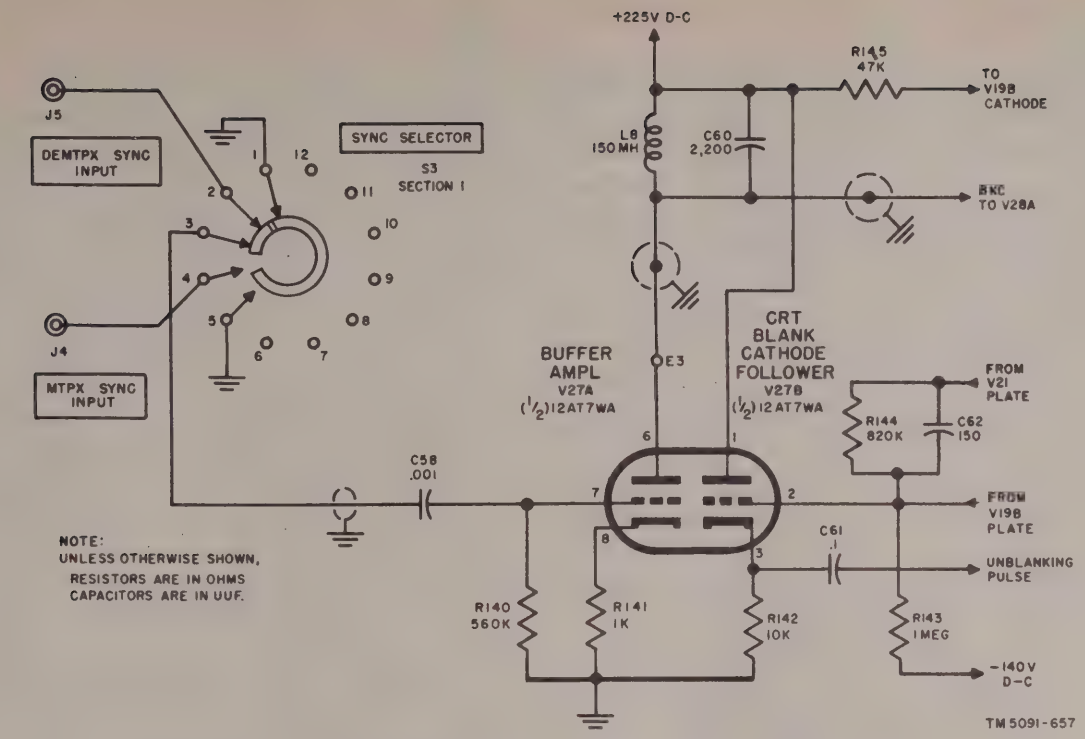


Figure 240. Buffer amplifier and crt blanking cathode follower V27.

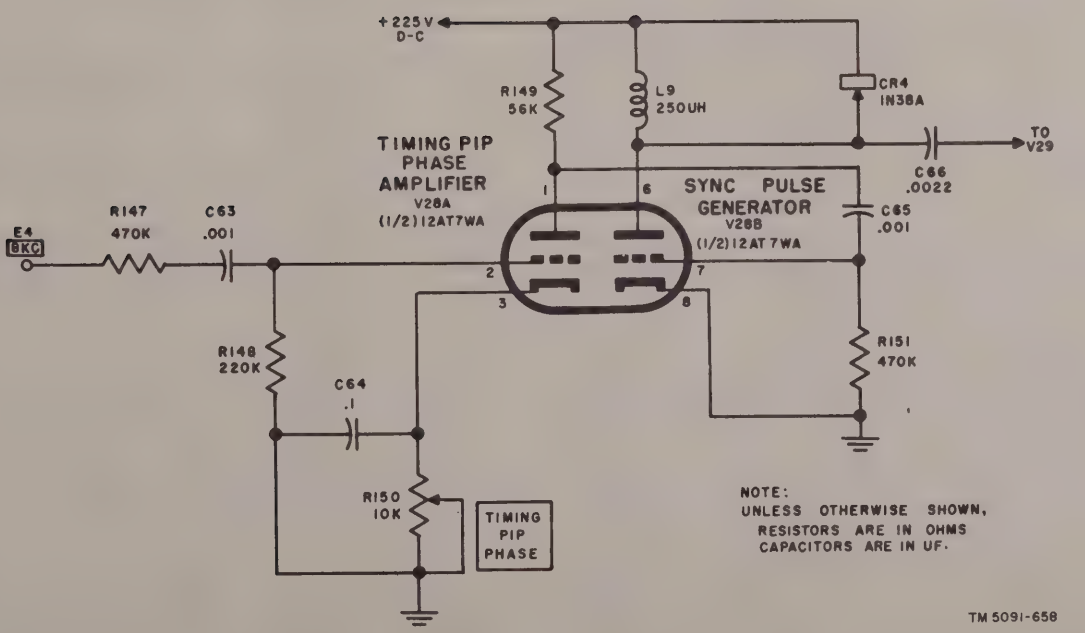


Figure 241. Oscilloscope timing-pip-phase amplifier and sync pulse generator.

driver stage for the horizontal deflection plate of the crt.

b. A positive signal applied to the grid of V25 appears positive on its cathode. Tubes V25 and V26 have a common cathode circuit. Thus, a positive voltage on the cathode of V26 causes a positive-going signal to appear on the plate of V26, which is out of phase with the negative signal on the plate of V25. The cathode coupling generates equal but opposite signals on the plates of V25 and V26.

c. The HOR POSITION control R139, in the grid circuit of tube V26, controls the dc potential applied to the grid and, therefore, the current which the tube draws. By controlling the current flow through the tubes, the dc voltages on the plates of V25 and V26 are also controlled, which fixes the horizontal position of the trace.

d. The sweep voltage is coupled through capacitor C54. Some charge may remain on this capacitor after a single sweep. This charge, when added to the next sweep voltage, would cause a slight horizontal displacement of the trace. To prevent trace displacement with change in sweep speed, horizontal output dc restorer diode V24 is connected from the grid side of the capacitor with the plate connected to ground to insure that the horizontal trace always starts from zero potential. It does this by conducting whenever a positive voltage appears on its plate. Accordingly, the capacitor is discharged whenever a positive voltage appears on its plate. Resistor R126 is the grid return for tube V25, and also provides the cathode potential for dc restorer V24. Resistor R130 is a grid limiting resistor, R131 is the plate load, and R133 is part of the cathode load. For tube V26, resistor R135 is the plate load, and R137 is part of the cathode load. Resistors R132 and R136 are parasitic suppressor resistors, and R127, R128, and R129 are voltage dropping resistors in the cathode circuit of both tubes. Capacitor C55 is the cathode-coupling capacitor, and resistor R134 is its discharge path. The output voltage of V25 is coupled to crt horizontal deflection plate D2, and the output of V26 is coupled to crt horizontal deflection plate D1. The sweep, or movement of the beam across the screen, is thereby controlled by the output of V25 and V26.

255. Timing-pip Generator Circuit

To align the channel pulses of the multiplexer group, a timing-pip generator (sometimes referred to as the timing-marker generator) circuit provides pulses separated by 5.2 usec. These timing pips can be used for calibrating the time base of the screen when viewing other wave forms. The repetition rate of a wave form with a period of 5.2 usec is 192 kc; therefore, one of the important functions of the timing-marker generator is to obtain an accurate 192-kc signal from an 8-kc sync signal. This 8-kc oscillator sync signal is obtained from the multiplexer set, multiplexer group, or pulse form restorer and applied to the grid of 8-kc amplifier V27A through SYNC SELECTOR switch S3A.

256. Buffer Amplifier V27A
(fig. 240)

The buffer amplifier tube, V27A, provides a single stage of 8-kc amplification. The signal is obtained from MTPX SYNC INPUT jack J4 or DEMTPX SYNC INPUT jack J5 through switch S3A. Capacitor C58 is the coupling capacitor from switch S3A, R140 is the grid return resistor, R141 is the cathode resistor, and inductor L8 with capacitor C60 acts as the 8-kc plate load. The output of V27A is coupled to the grid of timing-pip-phase amplifier V28A through isolation resistor R147 and coupling capacitor C63.

257. Timing-pip-phase Amplifier V28A
(fig. 241)

Tube V28A may be operated at various bias points on its characteristic curve by varying potentiometer R150 to determine at what point tube V28A will conduct and to position its plate signal in time. Resistor R148 is the grid return resistor, R149 is the plate load, and capacitor C64 is the cathode bypass capacitor. The square wave output of V28A is developed by the large grid signal driving the tube to saturation.

258. Sync Pulse Generator V28B
(fig. 241)

The square wave output of V28A is fed through coupling capacitor C65 to the grid of sync pulse generator V28B. This tube has a shock-excited inductor L9 in its plate circuit.

The inductor is shock-excited by the negative cycle of the input signal. Damping diode CR4 is connected so that L9 is damped when the plate end attempts to go positive, and thus dissipates all the energy stored in inductor L9 after the first negative switching. This generates an 8-kc negative pulse, which is coupled by capacitor C66 to discriminator tube V29. Resistor R151 is the grid return resistor.

259. Discriminator V29

(fig. 242)

A discriminator is a circuit, the output of which varies with some characteristic of the input, usually frequency. Discriminator V29 compares the output of V30B (192-kc oscillator) with an external signal of the same frequency (the 8-kc pulses). The 8-kc reference is applied to the cathodes of V29 through R154 and R155. One output of the 192-kc oscillator is fed through capacitor C67 and resistor R152 to the cathode of V29A. The other output of the 192-kc oscillator is fed through C73, amplified by V31A, and then fed through C81 and R155 to the cathode of V29B. The total discriminator output appears across resistors R156, R157, and R158 as a dc voltage, filtered by capacitor C68. The dc level of this signal is biased to the proper value by a power supply voltage taken across divider network resistors R160 and R161 and isolated by R159. This level may be adjusted by PIP LOCKING control R161 to set the point of operation and, therefore, the frequency of V30B. The voltage from the discriminator will then add or subtract from this level to vary the frequency. However, values are chosen so that when the 192-kc oscillator goes up, the voltage from the discriminator resulting from that rise brings it back down, and vice versa.

260. Reactance Modulator V30A

(fig. 242)

The reactance modulator controls the frequency of V30B by functioning as a reactor in parallel with the plate circuit. The V30A reactance modulator plate is connected directly to the plate of oscillator V30B. Capacitor C70, connected between plate and cathode of this reactance modulator stage, has a current flowing through it that leads the voltage across it by 90°. This current flows through resistor R164 and produces a voltage drop across it that is in phase with this current. The voltage across resistor R164 is the 192-kc signal applied to this stage and is almost 90° displaced in phase with the instantaneous plate voltage. This causes a current to flow in the tube which is almost 90° out of phase with the voltage across it and the magnitude of which is proportional to the transconductance of the tube. This condition is similar to the action of an inductance shunted across the tank circuit of the oscillator. The transconductance, and therefore the magnitude of the inductance, is controlled by the grid voltage obtained from the discriminator. This control results in an automatic method for stabilizing the frequency of the 192-kc oscillator. Resistors R162 and R163 in parallel supply the +225 volts to tube V30. TIMING PIP PHASE switch S5 disables V30B when turned fully counterclockwise.

261. 192-kc Oscillator V30B

(fig. 242)

Tube V30B comprises a modified Colpitts oscillator that generates the 192-kc sine wave. When the tank circuit, consisting of inductance L10 and capacitors C75 and C76, goes into oscillation, voltages 180° out of phase with each other exist at opposite ends of L10. The voltage that appears at the grid of V30B is amplified and inverted in phase at the plate, thus sustaining oscillations in the tank circuit. Capacitors C73 and C74 couple the tank circuit to V30B. Resistor R165 is the cathode return resistor, C71 is the cathode bypass capacitor, R166 is the grid return resistor, and C78 is the signal output coupling capacitor.

262. 192-kc Amplifier V31A and Differentiating Shaper V31B

(fig. 242)

The train of sine waves that appears at the plate of V30B is coupled by capacitor C78 to the grid of 192-kc amplifier V31A where it is further amplified and applied to the grid of differentiating shaper V31B. This wave is of sufficiently large amplitude to cause a large current to flow as the positive swing is applied to the grid. The oscillation normally caused in the plate circuit by the inductive plate load L11 is damped after the first negative swing by

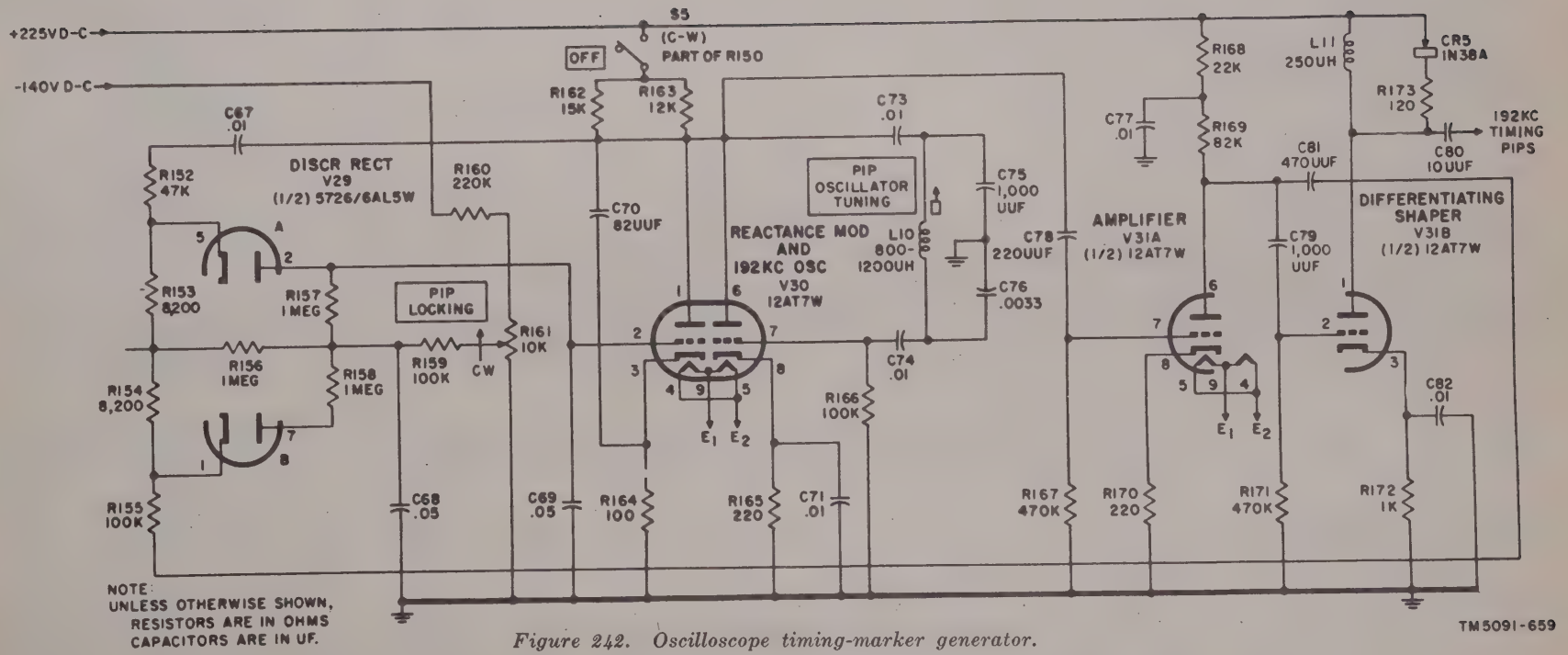


Figure 242. Oscilloscope timing-marker generator.

the damping diode (CR5 in series with resistor R173). A sharp negative pulse is generated by this stage on each positive half-cycle applied to the grid of V31B. This is the timing pip. For V31A, resistor R168 and capacitor C77 form the plate decoupling network; R169 is the plate load, R167 is the grid return, and R170 is the cathode resistor. Capacitor C79 is the output coupling capacitor, and resistor R171 is the grid return of V31B. Resistor R172 is the cathode resistor, and C82 is its bypass capacitor. The output is fed through capacitor C80 to the grid of push-pull vertical amplifier V15 (par. 245).

Section III. AUDIO TEST SET TS–762/TC

263. General

Audio Test Set TS–762/TC is a transmission-measuring set used to test the audio operation of the multiplexer set or multiplexer group. The major sections of the audio test set are: a calibrated 1,000-cycle low distortion oscillator, frequency variable over a range of 970 to 1,030 cycles with output level of —35 to +10 dbm in calibrated steps of 1 db, and a high gain amplifier that provides one response with F1A line weighting and another response with 1,000-cycle elimination. The receiving section can measure +10 to —70 dbm and the receive attenuator is calibrated in steps of 10 db. In addition, there is a specially damped db meter that measures from +3 to —20 db, a regulated power supply, and provisions for rapidly checking and recalibrating the level of the oscillator and amplifier.

Note. Audio Test Sets TS–762/TC is not supplied with Pulse Form Restorer Group AN/TRA–10.

264. Audio Test Set Block Diagram

(fig. 243)

a. Tubes V1 and V2 comprise the 1,000-cycle Wein bridge oscillator, V3 is a phase inverter, and V4 is a push-pull amplifier. These tubes are in the *oscillator* or *transmitting section.* In the *receiver* section, V5 is a limiter of the input and V6 and V7 are amplifiers. Tube V8 is the power supply rectifier, and V9 the associated voltage regulator. The F1A filter provides a means of distortion measurement.

b. F1A represents a type of frequency response typical of telephone circuits determined by the response of telephone components, such as headsets. A typical curve is shown in figure 244. Only the frequencies shown in this curve can be received; therefore, it would not be significant to measure noise except in relation to this curve because noise outside of the response cannot be received. In measuring distortion, use a frequency of 1,000 cycles because the F1A curve has no effect at this frequency.

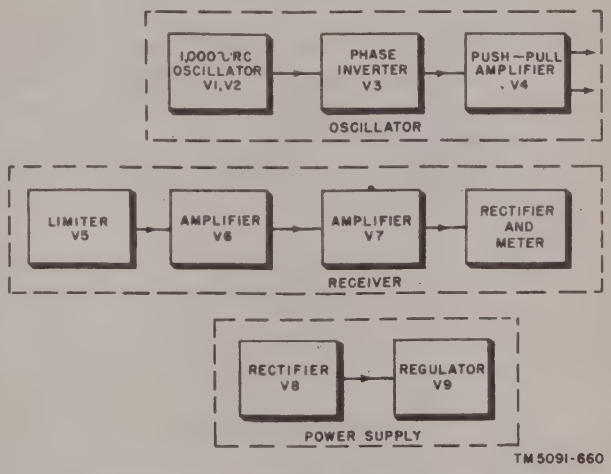


Figure 243. Audio Test Set TS–762/TC, block diagram.

265. Oscillator Section

a. Oscillator V1 and Amplifier V2 (fig. 245). The oscillator is a resistance-capacitance (Wein bridge) type. The voltage is fed back from the output to the input in the proper phase to sustain oscillations. The amplitude of the feedback is controlled by lamp I 1, the resistance of which varies with the current. The oscillator consists of tube V1 and associated components, isolation amplifier tube V2, and thermistor I 1. The fixed-frequency-determining elements are capacitors C1 and C2, resistors R1, R3, R5, and R7, and potentiometers R2 and R4. The 970- to 1,030-cycle adjustment is obtained from dual potentiometer R4, where maximum resistance corresponds to 970 cycles, and minimum resistance corresponds to 1,030 cycles. BRIDGE

BALANCE potentiometer R3 is a frequency vernier adjustment. The amount of signal fed back to the cathode of tube V1 is set by resistor R8 and potentiometer R6 (DISTORTION) through capacitor C5. Resistor R11 is the plate load of tube V1, and R9 and R10 form the screen grid voltage divider. Capacitor C3A is the screen bypass capacitor and C4 is the coupling capacitor to tube V2. Resistor R12 is the grid return for tube V2; R13 is the cathode resistor, and R14 and R15 form the screen grid voltage divider; C3B is the screen grid bypass capacitor. The output is taken from the divider, which consists of resistors R17 and R19 and potentiometer R18 (ADJ SEND). Resistor R16 is the plate resistor for V2.

b. Inverter V3 and Push-Pull Amplifier V4 (fig. 246).

(1) The 1,000-cycle signal from the oscillator is fed to tube V3, which consists of two sections in parallel. Inverter tube V3 splits the phase of the input signal and provides the two signals equal in voltage but opposite in phase for the following push-pull amplifier V4. Voltage developed across the ADJ SEND potentiometer is applied through capacitor C6 to the grid of V3A. The ADJ SEND potentiometer controls the voltage applied to the next stage. The parallel tubes allow greater current and lower output impedance. The output signal developed across plate load resistor R21 is fed to the grid of V4A through coupling capacitor C7. The voltage developed across cathode load resistor R23 is fed to the grid of V4B through coupling capacitor C8. Both resistance values are equal, therefore equal but out-of-phase voltages are applied to the grids of the push-pull amplifiers. Resistor R22 is the cathode-biasing resistor; it is purposely left unbypassed to introduce degeneration and thereby cut down distortion.

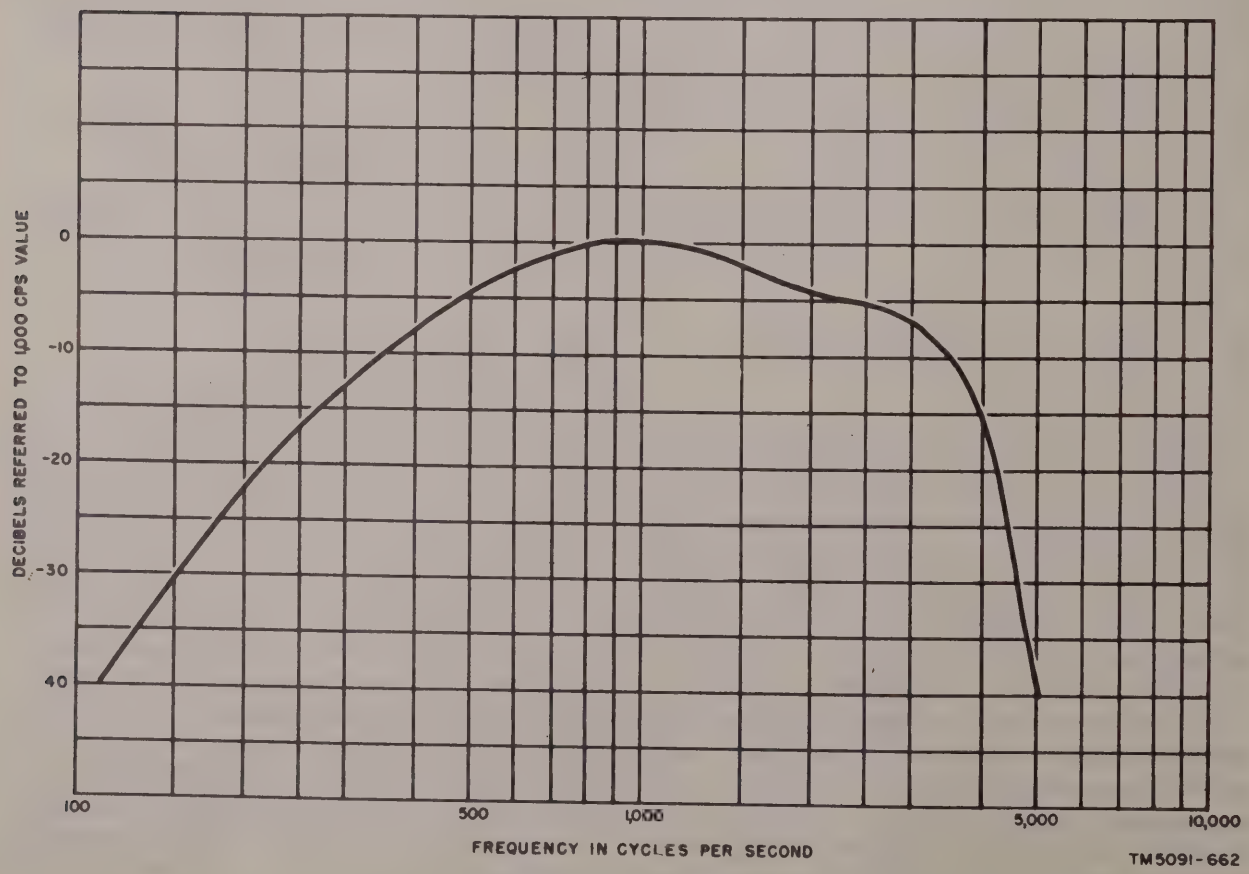


Figure 244. F1A curve.

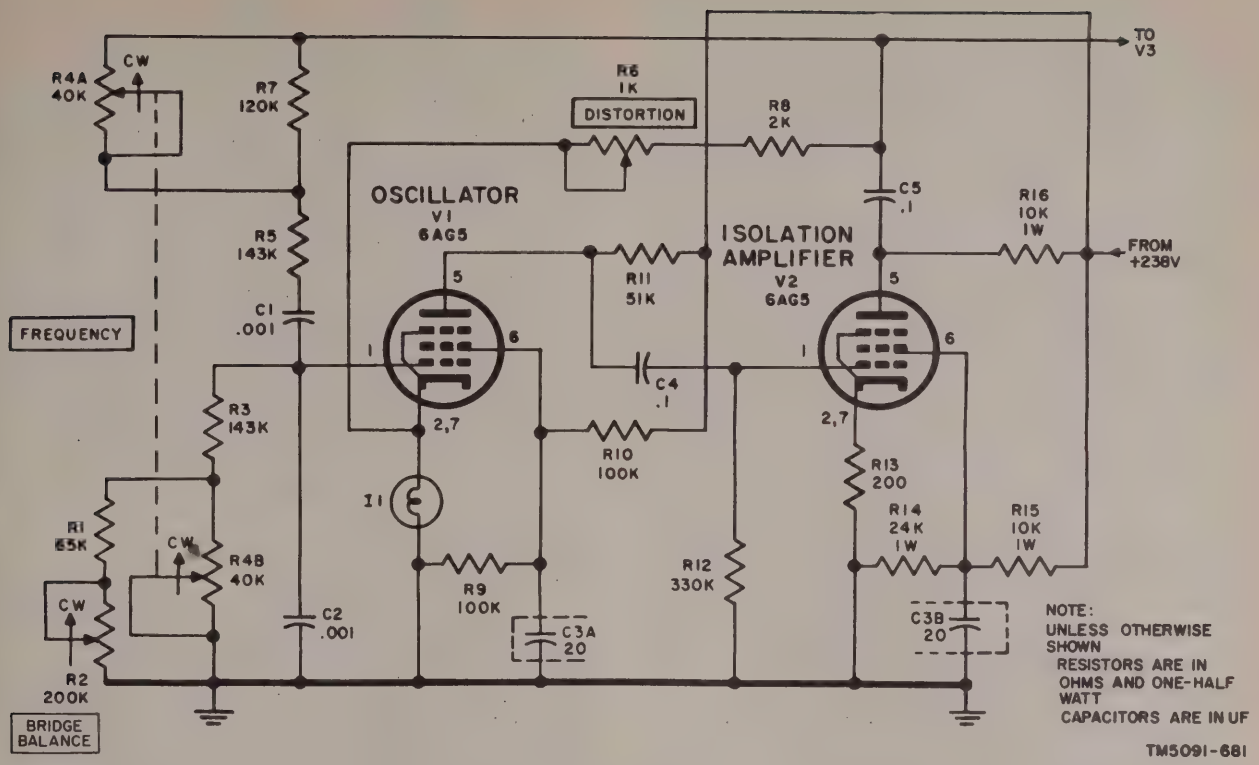


Figure 245. Oscillator V1 and amplifier V2.

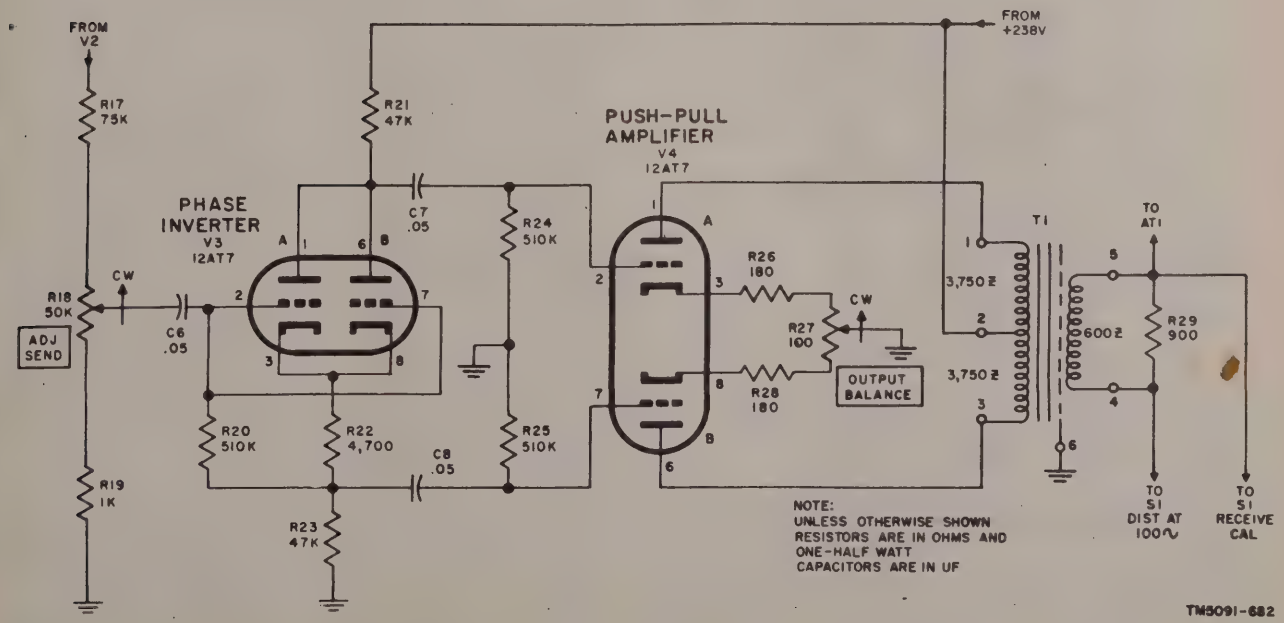


Figure 246. Inverter V3 and push-pull amplifier V4.

(2) Tube V4A and V4B is a push-pull output amplifier. The signal from phase splitter V3 is fed through capacitors C7 and C8 to its grids. Resistors R24 and R25 are the grid return resistors, and R26 and R28 are the cathode resistors in series with sections of potentiometer R27 (OUTPUT BALANCE control). This potentiometer has its center tap grounded and each end in series with the cathode resistor of one of the two tubes. By changing the setting of the OUTPUT BALANCE control, the biasing resistance of both cathodes is changed. It therefore controls the amplification of each tube. Turning the control clockwise results in a greater bias on the grid of tube V4B, thereby decreasing the amplification of this half of the push-pull amplifier. Meanwhile, the bias of V4B has decreased and its amplification increases. By varying the bias of each stage in this manner, the gain of each can be made exactly the same. When the OUTPUT BALANCE control is properly adjusted, the gain characteristics of V4A and V4B are identical. The output is fed through transformer T1 to switch S1 to SEND OUT jacks J1 and J2. Capacitors C9 and C10 are coupling capacitors to the output. Resistor R29 is used to make the output impedance 600 ohms. When the SEND CALIBRATE button is pressed, part of the voltage is fed to meter M1. By adjusting the meter to the red line by potentiometer R40, the output may be read directly in dbm when the F1A button is pressed and a load of 600 ohms is placed across SEND OUT jacks J2 and J3. Attenuator AT1 is used for adjusting the output.

266. Receive Section
(fig. 247 and 248)

a. The receive section is a high gain audio amplifier and associated control. RECEIVE IN jacks J4 and J5 feed into 600-ohm balanced-input transformer T2. Capacitor C13 is a dc blocking capacitor that couples the two halves of the primary. Resistor R43, connected across the secondary of T2, stabilizes the T2 impedance. The secondary of this transformer is loaded with 10,000-ohm calibrated step-type

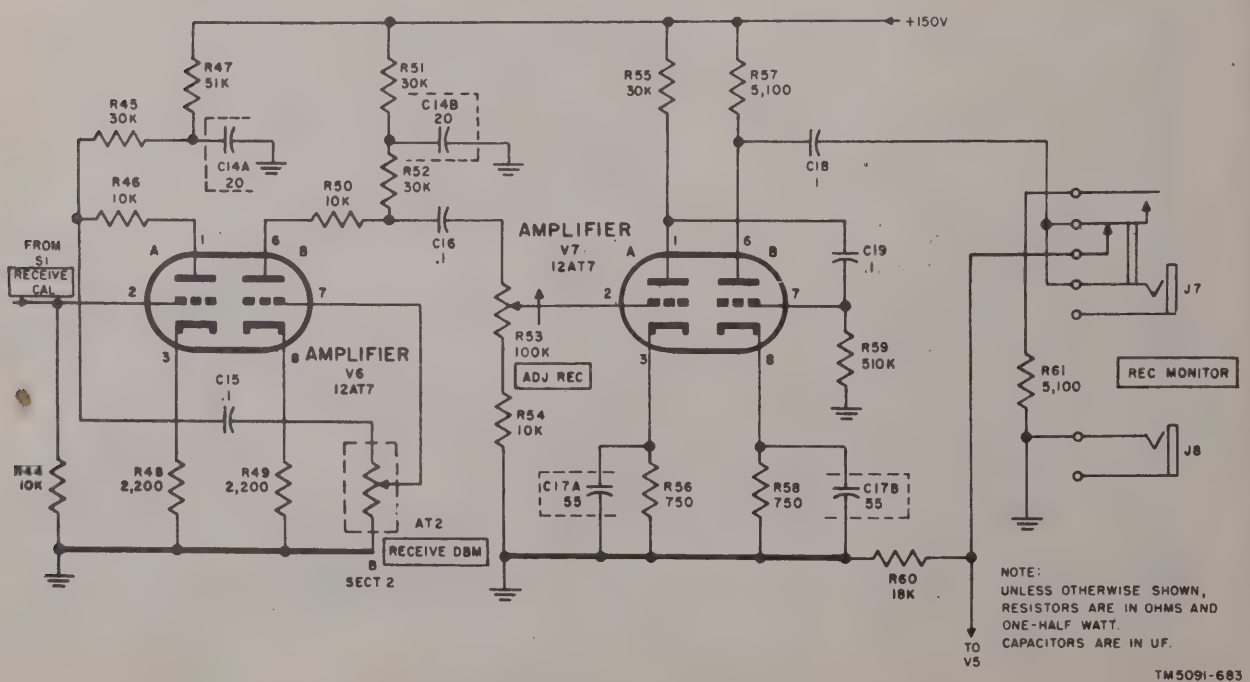


Figure 247. Amplifiers V6 and V7.

ladder attenuator AT2, section 1. The output of T2 is fed into four-gang, push-button switch S1, marked SEND, REC, F1A, and DIST at 1,000 cps. The weighting and band-eliminating filters associated with the F1A and DIST buttons offer some attenuation, and their input impedance varies with frequency. To calibrate the gain control correctly, regardless of frequency, T isolation networks composed of resistors R30, R31, R32 and R33, R34, R35 are inserted into the input circuit of each filter. These networks have 10,000-ohm impedance, with a 6-db loss. Distortion filter Z2 has a loss of 1,000 cycles of 70 db or greater. The response curve of F1A filter Z1 is shown in figure 168.

b. The output of switch S1 is fed into the grid of V6A. Tube V6A and V6B provide two stages of amplification. The RECEIVE DBM calibrated gain control AT2 is divided into two shielded sections operated from a common shaft. This prevents overloading the grid of tube V6A at +10-dbm input and reduces the circuit noises fed to the meter circuit at —30, —40, —50, and —60 dbm. Resistor R44 is the grid return, R46 and R45 are the plate load resistors, R47 is the plate decoupling resistor, R48 is the cathode resistor, and capacitor C14A is the plate decoupling capacitor. Capacitor C15 is the coupling capacitor between the output of V6A and the input of V6B. Resistor R49 is the cathode resistor for V6B. Resistor R50 is a parasitic suppressor, R52 is the plate resistor, R51 is the plate decoupling resistor, and C14B is the plate decoupling capacitor. Tube V7A and V7B provides the final two stages of amplification. The signal from V6B is coupled to the grid through coupling capacitor C16. ADJ REC potentiometer R53 and resistor R54 are grid return resistors. By varying the ADJ REC control, the input signal to V7B is also varied, thereby controlling the signal amplification in the receive section. Resistor R154 is added to the grid circuit so that regardless of the setting of the ADJ REC control, the grid can never be grounded. The output of V17A is taken from across plate load resistor R55, and coupled to V17A through capacitor C19. Bias for V7A is supplied by R56 and C17A. The input signal to V7B is developed across grid resistor R59. Resistor R58 and capacitor C17B supply bias for the stage. The signal developed across plate load resistor R57 is fed through coupling capacitor C18 to J7. C18 is the output coupling. The output is taken from jacks J7 and J8. If no plug is inserted in J7, the output is also fed through J7 to limiter V5. Jacks J7 and J8 monitor the received signal. If a plug is inserted in J7, the output of V7B is disconnected from the limiter and applied to J7 and J8. Use jack J8 to monitor the received signal.

c. Diode-connected limiter V5A and V5B (fig. 248) restricts the output of the receive section. Normally, the +14-volt bias applied to the plates from B+ keeps both tube halves conducting. If the input signal exceeds the bias value in the positive direction, V5B is cut off; if the signal exceeds the bias value in the negative direction, then V5A is cut off. In either case, the output to the meter is limited, which prevents damage. The output from the limiter is then taken through C12, from the cathode (load) resistor R42, to switch S1, and then to the meter bridge, which consists of CR1, CR2, CR3, and CR4. Capacitor C11 is connected across the meter and filters the dc output of the bridge. The bridge rectifies the ac into dc to operate the meter. The meter sensitivity may be set by resistors R36, R37, R38, and R39, of which REC MTR ADJ R38 is variable.

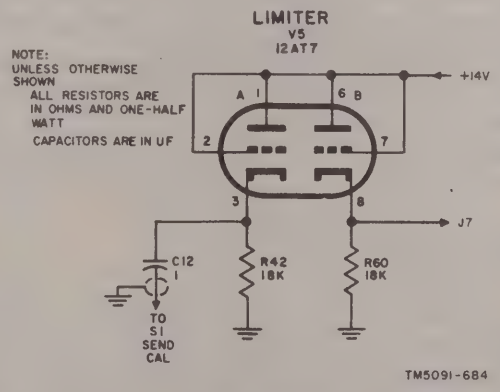


Figure 248. Limiter V5.

267. Audio Test Set Power Supply (fig. 381)

Test set power transformer T3 supplies 235 volts ac to the plates of rectifier tube V8, 5 volts ac for the rectifier filament, and 6.3 volts ac for the heaters of the test set tubes. The filter is a double pi-section, which consists of inductors L1 and L2 and capacitors C20A,

C20B, and C21A. This is followed by an additional filter section, which consists of R62, C21B, then by R63, and a voltage regulator tube, V9. Resistor R63 is the voltage dropping and compensating resistor for the voltage regulator tube. Resistors R65 and R64 in series act as a bleeder and voltage divider. The filter is of the capacitor input-type that provides peak voltage output, and the required 155-volt starting voltage for VR9. The three d-c output voltages are +238 volts for the plate circuits of V1, V2, V3, and V4, +150 volts for the plate circuits of V6 and V7, and +14 volts for the plate voltage of V5. Jack J9 is the ac input jack, S2 the power switch, F1 the fuse, and I 2 is the pilot light.

Section IV. CONTROL MONITOR C–1151/TC

268. General

Note. Control Monitor C–1151/TC is not supplied with Pulse Form Restorer Group AN/TRA–10.

The control monitor provides a switching system for the order-wire handset and a switching arrangement for test signals coming from the modems and mounting rack to the TEL, SEND, or REC section of the audio test set. It provides 20-cps ringing power, an energizing voltage for the microphone of the handset, and contains the signaling bell for order-wire channel 1. In addition, ballast lamp RT1 in series with the 20-cps ringing generator provides short-circuit protection to prevent a direct short circuit from appearing across the output of the 20-cps ringing generator. Any short circuit across the output would burn out RT1, protecting the ringer from short-circuit damage. Resistors R4 and R5 shunt RT1 to provide correct 20-cycle output regulation. Refer to figure 382, the over-all schematic diagram of Control Monitor C–1151/TC.

269. Selector Switch
(fig. 382)

a. The TEST PAIR is paralleled to all the modems, and by setting the modem test switch properly can be connected in various ways (par. 175). The push-button selector switch test pair controls the connections of the test pair at the control monitor. The positions and their functions are as follows:

(1) REC, the test pair is connected to the audio test set receive section.

(2) SEND, the test pair is connected to the audio test set send section.

(3) TEL SET, the test pair is connected to the order-wire circuit.

(4) NORMAL, the test pair is terminated with 620 ohms.

b. A second section of the switch leaves the order-wire telephone connected to channel 1 in all positions except TEL SET, when it is connected to the test pair (subpar. *a* above).

c. Channel 1 should be reserved for order-wire use and normally should not be used for traffic. The bell is attached to channel 1; therefore, it is always possible to use it to ring. The bell is not available when the handset is connected to the test pair.

270. RING Switch
(fig. 382)

RING switch S2 on the test panel is a momentary contact toggle switch that applies a 20-cps ringing tone to the test pair in the TEL SET position or to the order-wire channel when the NORMAL button is depressed. Depressing RING switch S2 disconnects the 20-cycle ringing signal from the handset.

271. Telephone Handset
(fig. 382)

The handset is connected to the test switch by a telephone antisidetone circuit, consisting of L1, C4, C5, and C6. When the push-to-talk switch is depressed, the 6-volt dc output of the rectifier is applied to the microphone. Voice signals modulate the dc. The modulated dc is applied to windings 2 and 3 of coil L1. Through autotransformer action, a large voltage is built up across L1 and is fed to the line. The pulsating dc signal is also impressed across windings 3 and 4 of coil L1 and fed through capacitors C4 and C5 in parallel to the earphone. Capacitors C4 and C5 cancel some of the inductive effect of the 3-4 winding, cutting down some of the audio fed to the earphone. They also

keep dc out of the earphone. When the distant station rings this station, a large ringing signal would be present across coil L1. Capacitor C6 is purposely made large so that its reactance will limit the ringing current through the handset. When a signal is received, L1 acts as a step-down transformer supplying a greater amount of current to drive the earphone.

272. Power Supply
(fig. 382)

A power supply is provided to transform and rectify the 115-volt line voltage to 6 volts dc for energizing the microphone of the handset. Rectification of the 6.3 volts ac from the secondary of transformer T1 is accomplished by bridge rectifier CR1, and filtering by capacitive input filter C2 and C3 in combination with resistor R6. The input to transformer T1 is protected by .1-ampere fuse F1. The 115-volt ac supply for the ringing generator is taken from plug P1. The 1,000-cycle signal is applied through pins A and B of jack J1. Contacts A and B of jack J2 are the order wire, C and D are the test pair, and E and F are the 20-cps ringing contacts. Jack J3 is the ac input and J4 is the signal output. Resistor R1 is a terminating resistor for the test pair and R2 and R3 are isolating resistors.

Section V. PULSE FORM RESTORER GROUP AN/TRA-10 TWENTY-CYCLE RINGING SUPPLY

273. General
(fig. 249)

a. Pulse Form Restorer Group AN/TRA-10 does not contain a power supply with a 20-cycle ringing supply. Therefore, a source of 20-cycles must be included in the unit and is located on Mounting Rack MT-1434/TRA-10.

b. The 20-cycle supply consists of a free running multivibrator, tube V1, a 6AS7G, the frequency of which may be adjusted by the dual grid potentiometer R27 (FREQ ADJUST) in series with grid returns R28 and R29. Capacitor C88 and C89 also determine the frequency. Capacitors C90 and C91 in parallel

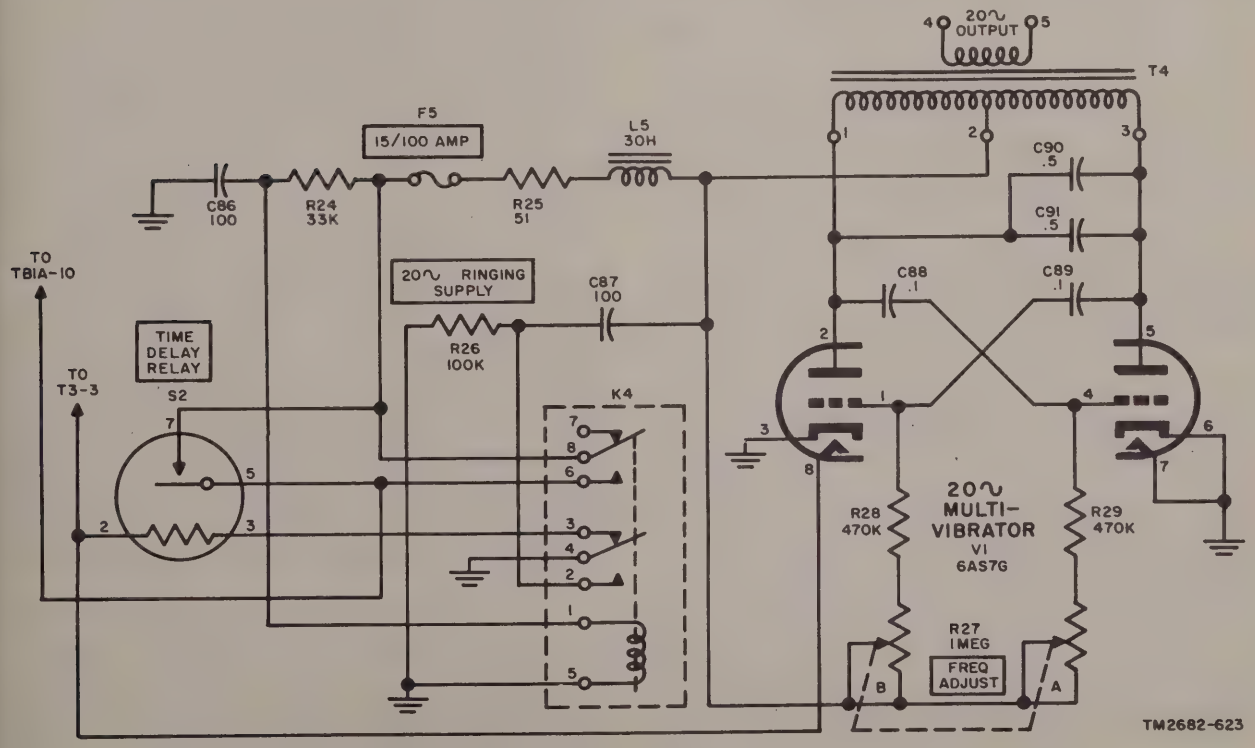


Figure 249. Pulse Form Restorer Group AN/TRA-10, 20-cycle ringing supply.

with the primary of T4 form a tank circuit resonant to 20 cycles. The output is taken from the output winding of T4, and is greater than 75 volts for a single channel load.

274. Multivibrator, 20-Cycle

The multivibrator circuit is a type of oscillator that produces square waves. Capacitor C88 and C89 provide direct coupling between the grids and plates of V1A and V1B. The multivibrator is not a true oscillator, but a circuit with two conditions of equalibrium. One condition occurs when V1A conducts, the other when V1B conducts. When power is first applied, a transient is applied to the multivibrator circuit by C87. This starts either V1A or V1B conducting. Assume that V1A is conducting and a negative charge from C88 is applied to the grid of V1B. The negative charge accumulates and cuts off the current of V1B. After a short time, determined by the time constant of C88 and R28, the voltage developed across C88 begins to discharge (through R28) and causes the grid to become less negative (more positive) and V1B begins to conduct. As V1B begins to conduct, it charges C89 negatively, cutting off V1A. This *flip-flop* action is repeated over and over. The values of capacitors C88 and C89 and resistors R28 and R29 are chosen to give a 20-cycle repetition rate. The square wave output normally obtained from a multivibrator of this sort is changed to an approximation of a sine wave by capacitors C90 and C91 connected between the plates.

275. Adjustment

The frequency of the oscillator is adjusted by wave form comparison (Lissajous figures) on Oscilloscope OS–25/G. Refer to paragraph 331 for the twenty-cycle multivibrator circuit testing and alignment procedure.

276. Thermal Time Delay

A thermal TIME DELAY RELAY and a dc relay, k4, give the necessary delay to assure filament heating before applying the B+. When the thermal relay operates, B+ is applied to the multivibrator circuit. The dc relay has a delay circuit R24 and C86 which delays operation. This relay then applies 100-uf capacitor to the multivibrator plate supply, and its initial charge applies a transient to the multivibrator, which insures its starting. The dc relay also bypasses the thermal contacts, and disconnects its heater, thus returning it to the nonoperative position.

CHAPTER 10

FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

Section I. GENERAL TROUBLE-SHOOTING PROCEDURE

277. Extent of Instructions

a. Trouble shooting at a field maintenance level includes all the techniques outlined for organizational maintenance and other techniques that may be required to isolate a defective part. The field maintenance instructions are not complete, but supplement the instructions described in paragraphs 103 through 136. The systematic trouble-shooting procedure that begins with the operational and sectionalization checks that can be performed at an organizational level must be completed by means of sectionalizing, localizing, and isolating techniques described in paragraphs 290 through 369. These paragraphs also describe localizing and isolating techniques that must be performed at a field maintenance level.

b. Paragraphs 278 through 290 contains general information for personnel engaged in trouble shooting. Subsequent sections give specific trouble-shooting information for the functional units of Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10. Trouble should be located and corrected as quickly as possible to minimize time lost because of breakdowns.

278. Trouble-shooting Procedures

a. The first step in servicing a defective set is to sectionalize the fault. *Sectionalization* means tracing the fault to the component responsible for abnormal operation. The second step is to localize the fault. *Localization* means tracing the fault to the defective part responsible for the abnormal condition The procedure for sectionalizing the trouble is given in paragraphs 113 through 136. .

b. Some faults (such as burned-out resistors) can be located by sight, smell, and hearing. The majority of faults, however, must be located by checking voltages, resistances, and wave forms.

279. Trouble-shooting Data

Take advantage of the material supplied in this manual to help in locating faults rapidly. Consult the following trouble-shooting data when necessary.

a. Block Diagrams of Equipments and Units. The block diagrams present the mechanical and electrical interrelationships of the stages in the units.

b. Complete Schematic Diagrams. The complete schematic diagrams include all components separately, and show connections between components.

c. Voltage and Resistance Diagrams. The voltage and resistance diagrams show the normal voltage and resistance values at the pins of all tube sockets. These values were taken with all tubes in their respective sockets.

d. Illustrations of Components. Front, top, and bottom views aid in locating and identifying parts.

280. Voltage Measurements

Voltage measurements are an indispensable aid to the repairman, because most troubles either result from abnormal voltages or produce abnormal voltages. Voltage measurements can be made without interrupting the circuit.

a. Complete information on the normal operating voltages of each component is given in the trouble-shooting sections. Unless otherwise specified, these voltages are measured between the points indicated and a ground point on the chassis.

b. Always begin by setting the voltmeter at the highest range, so that it will not be overloaded. If necessary, set the voltmeter to a lower range.

c. When checking cathode voltage, a reading can be obtained even when the cathode resistor is open. The resistance of the meter takes place of the cathode resistor. The cathode voltage reading, under this circumstances will appear *higher* than normal.

281. Precautions Against High Voltages

Certain precautions must be followed when voltages above a few hundred volts are being measured. *High voltages are dangerous and can be fatal.* To measure high voltages, observe the following rules:

a. Connect a ground lead from the equipment to the voltmeter.

b. If the voltage is known to be less than 300 volts, connect the test lead to the hot terminal, which may be either positive or negative with respect to ground.

c. If the voltage is greater than 300 volts, shut off the power, connect the hot test lead, step away from the voltmeter, turn on the power, and note the reading on the voltmeter. Do not touch any part of the voltmeter, particularly when measuring the voltage between two points, both of which are above ground.

282. Voltmeter Loading

Note. Multimeter TS–352/U has a 1,000-ohms-per-volt scale and a 20,000-ohms-per-volt scale. These characteristics must be considered when using this meter or erroneous measurements will be taken.

a. It is essential for the voltmeter resistance to be at least 10 times greater than the resistance of the circuit across which the voltage is measured. If the voltmeter resistance is comparable to the circuit resistance, the voltmeter will indicate a voltage lower than the actual voltage present when the voltmeter is not in the circuits.

b. The resistance of the voltmeter range of Multimeter TS–352/U can be calculated by this simple rule: The resistance of the voltmeter equals the ohm-per-volt rating of the meter multiplied by the full-scale range in volts. For example, the resistance of a 1,000-ohm-per-volt voltmeter on the 300-volt range is 1,000 x 300, or 300,000 ohms.

c. If the TS–352/U is used to take voltage measurements and the voltmeter is loading a circuit, the effect usually can be noted by comparing the voltage readings on two successive ranges. If the voltage readings on the two ranges do not agree, voltmeter loading may be excessive. The voltage reading on the higher range usually is slightly greater than that on the lower range. Use Electronic Multimeter TS–505/U when there is a possibility that the voltmeter will load the circuit. The input resistance is 20 to 50 megohms, depending on the scale used, and will provide a minimum loading.

d. To minimize the voltmeter loading effects of the TS–352/U in high-resistance circuits, use the highest voltmeter range. Although only a small deflection will be obtained (possibly only 5 divisions on a 100-division scale), the accuracy of the voltage meaurements will be increased. The decreased loading of the voltmeter often will more than compensate for the inaccuracy that results from reading a small deflection on the scale.

e. The voltage-resistance charts in this manual are based on actual readings. If the resistance of the meter used in checking the voltage produces the same amount of loading as the meter originally used to measure the voltage, it is unnecessary to consider the effect of loading. To be sure that there is no circuit loading use Electronic Multimeter TS–505/U. When Multimeter TS–352/U is used, use the voltmeter jacks for the 20,000 ohm-per-volt scales. (See TM 11–5527, the technical manual covering Multimeter TS–352/U.)

283. Normal Resistance Values

When a fault develops in a circuit, it will often show up as a change in the resistance values. To assist in the localization of such faults, the trouble-shooting data includes the normal terminal resistance values. These values should be measured between the indicating points and ground, unless otherwise stated. The resistance from other points in the circuit should be measured to determine whether the particular points are normal. The normal resistance values at any point can be determined by referring to the resistance values shown in the schematic diagram or by using the resistor color code (fig. 362).

284. Precautions When Measuring Resistance

a. Before making resistance measurements, *turn off all power.* If the ohmmeter is connected to a circuit that already has voltages across it, the needle will be deflected off-scale and the ohmmeter may be burned out or the needle may be bent.

b. Always discharge capacitors before making resistance measurements. This is important when checking power supplies that are disconnected from their lead.

285. Correct Use of Ohmmeter Low and High Ranges

It is important to know when to use the low-resistance range and when to use the high-resistance range of an ohmmeter.

a. When checking circuit continuity, set the ohmmeter on the lowest range. If the medium or high range is used, the pointer may indicate 0 ohm although the resistance may be as high as several hundred ohms.

b. When checking high resistances or measuring the leakage resistance of capacitors or cables, use the highest range. If a low range is used in this case, the pointer will indicate infinite ohms, although the actual resistance may be less than 1 megohm. Be ure to keep fingers off the metal portions of the probe. Body leakage can give erroneous resistance measurements.

286. Parallel Resistor Connections

In a parallel circuit, the total resistance is less than the smallest resistance in the circuit. It is important to remember this when trouble shooting with the aid of a schematic diagram. When a resistance is measured and the value is found to be less than expected, study the schematic diagram carefully to be sure there are no resistances in parallel with the one that has been measured. Before replacing a resistor because of low resistance, disconnect one terminal from the circuit and measure its resistance while it is isolated to be sure that the low reading does not occur because some part of the circuit is in parallel with the resistor.

287. Special Method of Testing Crystals and Rectifiers

a. To check germanium crystal 1N38A electrically, first unsolder one lead, and measure the forward and backward resistance of the crystal with Electronic Multimeter TS–505/U. Use the resistance scale in (1) and (2) below, because the resistance of the crystal depends on the voltage impressed on it. If the limits given below are not met, the crystal is defective and should be replaced.

(1) The forward resistance on the RX1 scale should be less than 100 ohms.

(2) The backward resistance on the RX10K scale should be larger than 200K.

Note. With some crystals, the backward resistance reading will start decreasing from its initial value. When this happens, reject the crystal unless the reading stabilizes above 200K.

b. To check germanium crystals 1N34A, follow the procedure described in *a* above, but apply the following limits:

(1) Less than 100 ohms forward resistance.

(2) More than 50,000 ohms backward resistance.

c. Selenium rectifiers are difficult to test properly: therefore, the simplest test is to substitute a new rectifier for a suspected one. However, always check the rectifier circuit for a short circuit before replacing it with a new rectifier.

Caution: The vapors released by a burned-out selenium rectifier are poisonous. Do not come in contact with these vapors. Wait until the room has been thoroughly aired. Avoid touching the burned-out section of the selenium rectifiers with bare hands until thoroughly cooled.

288. Checking Filament and B+ Circuits

Trouble within a unit may often be detected by checking the resistance of the filament and high-voltage circuits before applying power to the equipment; checking the cold filament resistance and B+ resistance will indicate abnormal power supply circuit conditions and will prevent damage to the equipment.

289. Tube Socket Voltages and Resistances

The voltage and resistance diagrams given for each unit of the equipments show the normal dc voltages between the tube socket terminals and chassis ground as measured by a vacuum-tube voltmeter. The valves given are for normal 23-channel operation, except where noted, and may vary by ±10 per cent. The B+ supply is 250 volts dc. The normal resistances in ohms between the tube socket terminals and chassis ground are given as measured by an ohmmeter. For long-drift capacitor circuits (time-constant circuits), allow enough time for readings to become stabilized. The values given for the modem are for 23-channel operation with the particular modem on the test extension and the modem selector switch in the normal (OPER) position. Resistance values may also vary by ±10 per cent.

290. Test Procedure

Because this equipment is complicated, a specific test sequence should always be followed unless the personnel is completely familiar with servicing the multiplexer set, multiplexer group, or pulse form restorer group. The test sequence is as follows:

a. Perform the test procedures given in the equipment performance check list.

b. Check resistances and voltages of the suspected component.

c. Check the trouble-shooting charts.

d. If a major repair or rebuilding of the equipment has taken place, refer to the final testing procedures described in paragraphs 372 through 404.

Section II. TROUBLE SHOOTING COMMON UNIT MULTIPLEXER CIRCUITS

291. Common Unit Multiplexer Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the common unit multiplexer circuits:

Fig. No.	Description
156	Common unit multiplexer, block diagram.
367	Multiplexer TD–60/TCC–13, multiplexer section, schematic diagram.
389	Multiplexer TD–60/TCC–13, multiplexer section, wiring diagram.
390	Multiplexer TD–60/TCC–13, multiplexer section filter, wiring diagram.
250	Common unit multiplexer section, top view.
251	Common unit multiplexer section, bottom view.
252	Common unit multiplexer filter, cover open.
253	Common unit multiplexer section, tube socket voltages and resistances.

292. Test Equipment Required for Common Unit Multiplexer

The equipment required for trouble shooting the multiplexer set common unit multiplexer circuits is listed below.

a. One Multiplexer Set AN/TCC–13 known to be in good operating condition.

b. One Electronic Multimeter TS–505/U.

293. Common Unit Multiplexer, Trouble-shooting Procedure

a. The best means of trouble shooting this circuit is by means of wave form comparison. A departure from the normal wave form indicates a fault located between the last point where the wave form is normal and the first point where it is observed to be abnormal. The wave form comparison procedures in paragraph 116*c* and *d* permit localization of the trouble to a particular stage. The wave form comparison procedures described in this paragraph may permit localization of the trouble to the particular defective part in the stage. Always complete the procedures in paragraph 116 before proceeding with the procedures described in this paragraph and paragraph 294.

b. The oscilloscope is synchronized by a signal from the common unit through MTPX SYNC OUTPUT jack J7. This signal is developed in the plate circuit of common unit multiplexer clipper V5B. The MTPX XYNC OUT-

PUT signal is comparable to the signal at the MTPX GATE OUTPUT jack J5. A normal signal at J6 (fig. 66) indicates that the early stages of the common unit (stages V1 through V5) are operating properly. Insufficient sync voltage at jack J2 or gate output at J6, however, indicates that the trouble is probably in these early stages.

294. Common Unit Multiplexer Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the common unit multiplexer. This chart lists the symptoms (some of which tne repairman observes either visually or orally while making the tests described in the performance check list par. 117), the probable cause, and the procedure for remedying the trouble. It is supplementary to the equipment performance check list. When the trouble has been isolated to a particular stage by wave form comparison and tube substitution does not correct the trouble, take voltage and resistance measurements.

Symptom	Probable trouble	Correction
1. No 8-kc at E2.	1. Faulty 8-kc crystal Y1. Open L1.	1. Replace Y1. Replace L1.
2. No multiplexer gate at E3.	2. Faulty Z1. Open L2. S1 in SLAVE position with no 45-channel sync input to J2.	2. Replace Z1. Replace L2. Replace S1.
3. Faulty, or no modem channel pulses at E4.	3. No B+ or filament voltage in mounting rack. Shorted or open video cable on rack connecting to J3. Any modem with a short to ground on P1-K.	3. Check power supply (par. 340 through 344), filament supply (par. 334 through 339). Check and rewire video cable. Repair modem.
4. No marker, but with all channels at E5.	4. Open L4. Faulty CR3. Open L54 Faulty Z2.	4. Replace L4. Replace CR3. Replace L5. Replace Z2.
5. No mixed pulse train at E5.	5. Open L7. CR5 faulty.	5. Replace L7. Replace CR5.
6. Marker, but faulty or no channel pulses at E5.	6. Open L6. CR4 faulty.	6. Replace L6. Replace CR4.
7. No pulse train output at MASTER OUT-PUT TO RF test point J5.	7. C36 open. Multiplexer section filter faulty.	7. Replace C36. Replace filter.

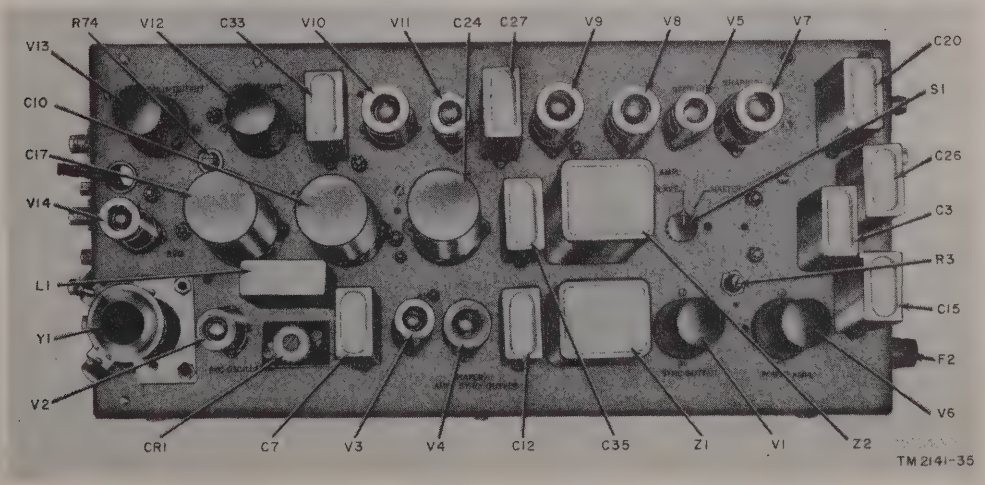


Figure 250. Common unit multiplexer section, top view.

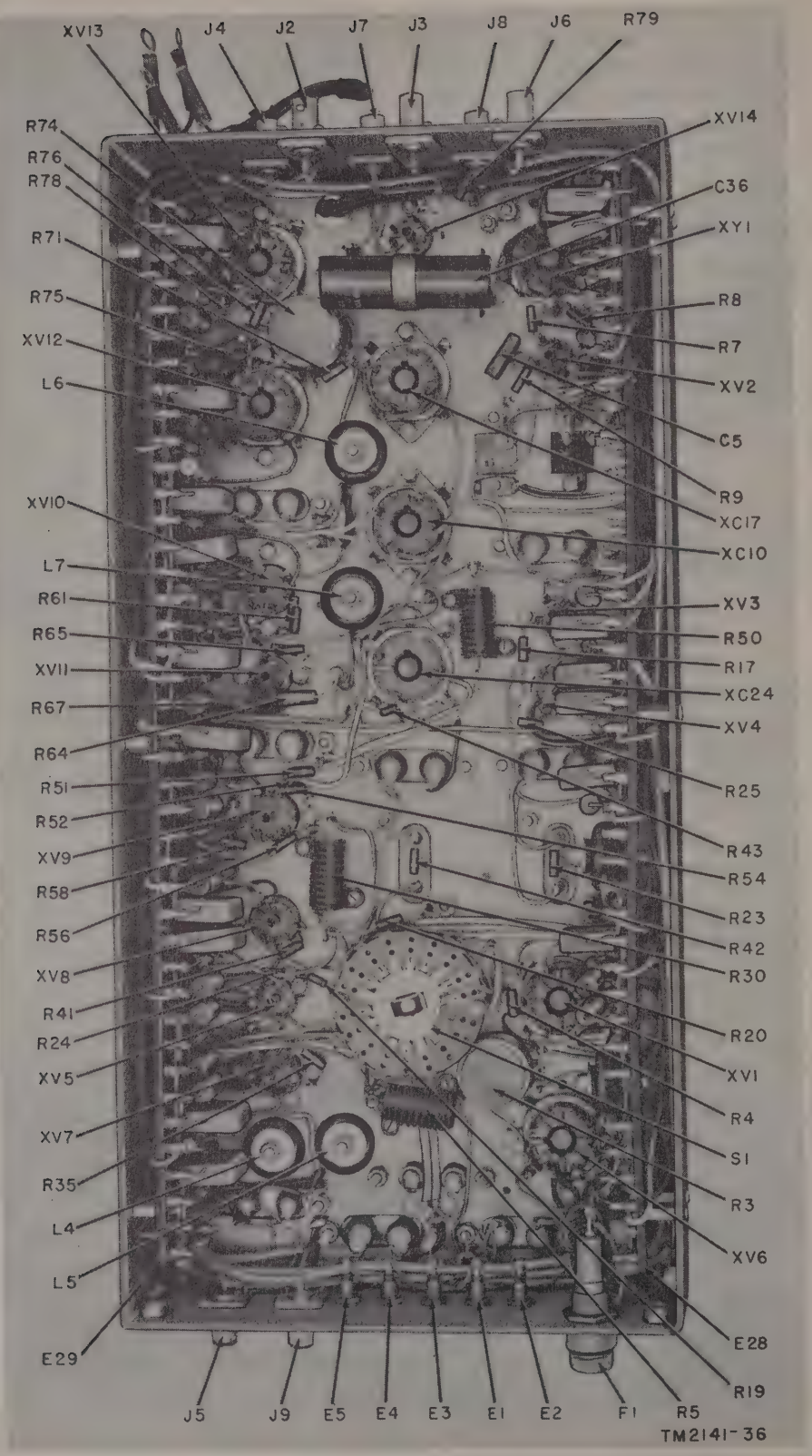


Figure 251. Common unit multiplexer section, bottom view.

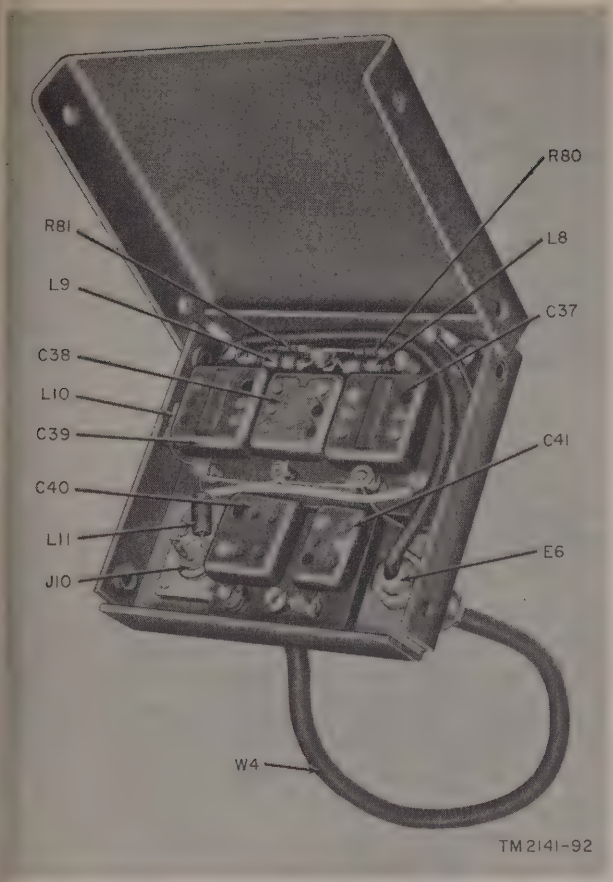


Figure 252. Common unit multiplexer filter, cover open.

295. Common Unit Multiplexer Circuit Tests

The following test should be used as a reference and complete operational check after major repairs. For any normal tests, it will be sufficient to check the resistance and voltage and wave forms on V1.

a. Operation Test Procedures, 23-channel.

(1) *Miscellaneous wave forms.* The following wave forms should be measured and should not vary by more than 20 per cent in width and amplitude from the referenced figures, except where other percentages are indicated in the chart below. When comparing the wave forms, be sure the oscilloscope sweep time controls are set in the same direction as those indicated alongside the referenced wave forms. Refer to paragraph 116*c* and *d* before measuring these wave forms.

Measure wave form at	Fig. ref	Note
Pin 5 of V2	71	±10%
Pin 1 of V3	254	
Pin 5 of V3	82	
Pin 1 of V4	255	
Pin 7 of V4	74	
Pin 6 of V4	73	—10% to +20%
J2	64	
J7	256	
J6 or E3	66	100 to 110v p-p. ±8 usec at 50% amplitude
Pin 2 of V7A	257	
Pin 1 of V7A	76	
Pin 6 of V7B	77	
Pin 6 of V8A	78	
E4	76	4 to 8v p-p
Pin 1 of V9A	80	10 to 50v p-p
Pin 6 of V9B	81	
Pin 1 of V10A	82	
Pin 7 of V10B	258	
Pin 6 of V10B	83	
Pin 5 of V11	84	
E5	68	
Pin 8 of V12	85	

(2) *Pulse train output wave form.* Compare the wave form at the PULSE TRAIN OUTJUT (J9) test point to that shown in figure 69. Vary output gain potentiometer R74 from minimum to maximum. The positive pulse train amplitude should vary from 0 to 1.3 volts (If the amplitude does not

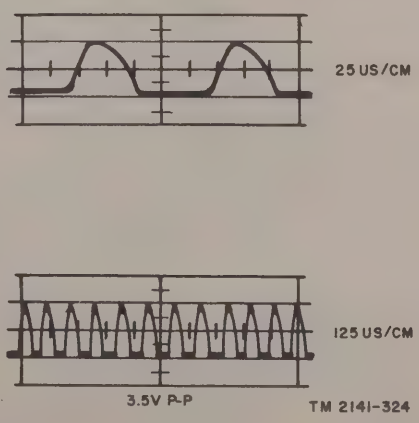


Figure 254. Wave form at pin 1 (grid) of V3.

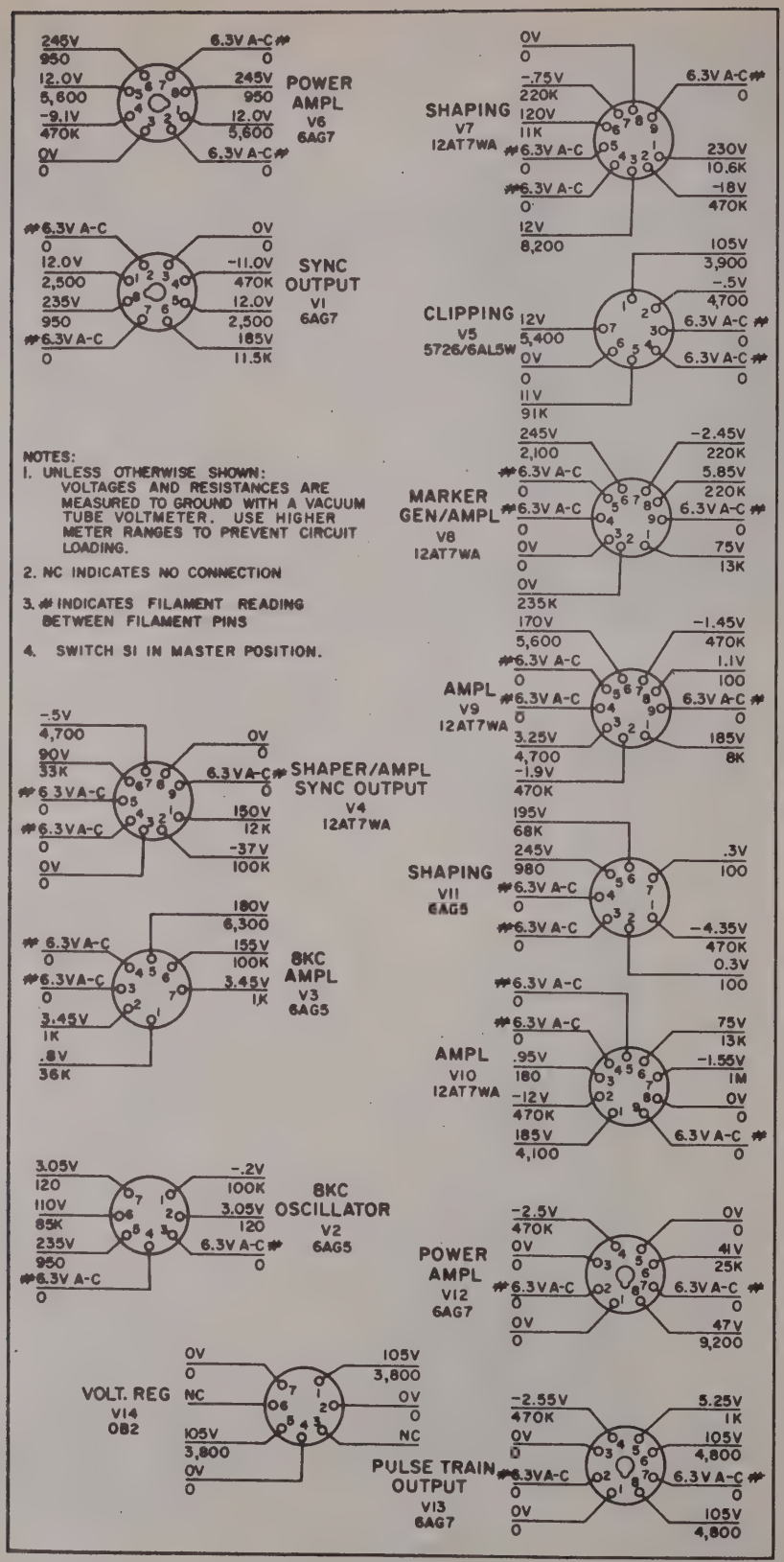


Figure 253. Common unit multiplexer section, tube socket voltages and resistances.

fall within these limits, repeat the trouble-shooting procedure in paragraphs 116 and 117.) Set the potentiometer for a 1-volt reading.

(3) *Master output to rf wave form.* Compare the 45-channel pulse train at the MASTER OUTPUT TO RF (J5) test point to that shown in figure 108. The negative marker pulse should move from 1 microsecond of less to 4 microseconds or more in time, with respect to the positive marker pulse.

b. Operation Test Procedures, 45-channel.

(1) To make the tests below, a second Multiplexer Set AN/TCC–13 is required (if slave operation is to be tested). The multiplexer to be tested should be connected to a Multiplexer Set AN/TCC–13 known to be in good operating condition (hereafter called the test multiplexer set). For master operation tests, the two multiplexer sets should be connected for 45-channel operation with the multiplexer set to be tested in the master position (par. 38). For slave operation tests, the two multiplexer sets should be connected for 45-channel operation with the multiplexer set to be tested in slave position.

(2) The following wave forms should be measured, and they should not vary more than 20 per cent from the referenced wave form figures.

Measure wave form at	Fig. ref	Note
Pin 2 of V4A	259	
J9	260	1 volt ±20%

296. Common Unit Dc Resistance of Transformers and Coils

The dc resistances of all transformer windings, coils, and relays are listed below. An asterisk (*) indicates an ohmmeter reading less than 1 ohm.

Transformer, coil, or relay	Terminal	Ohms
K1	1–5	4,800
L1		6.0
L2, L3, L18 through L21		*
L18, L19, L12, L13		*
L4		5.5
L5, L6, L7		*
L10, L14		*
L11, L15		1.1
L16		2.8
L17		6.0

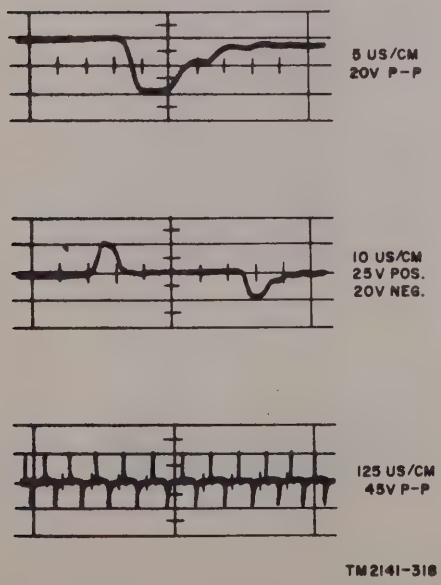


Figure 255. Wave form at pin 1 (plate) of V4.

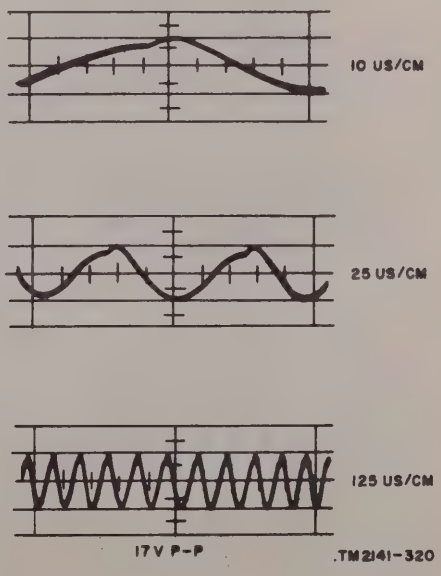


Figure 256. Wave form at J7.

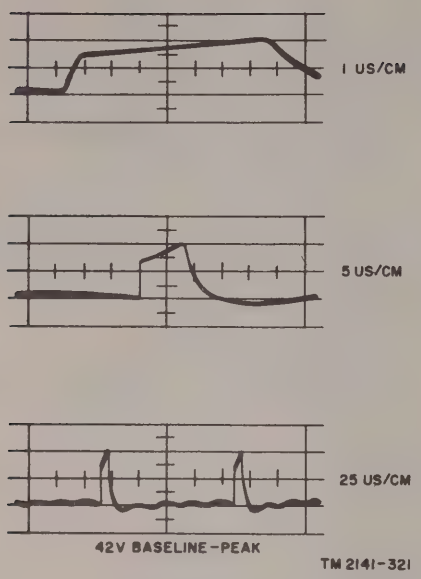


Figure 257. Wave form at pin 2 (grid) of V7A.

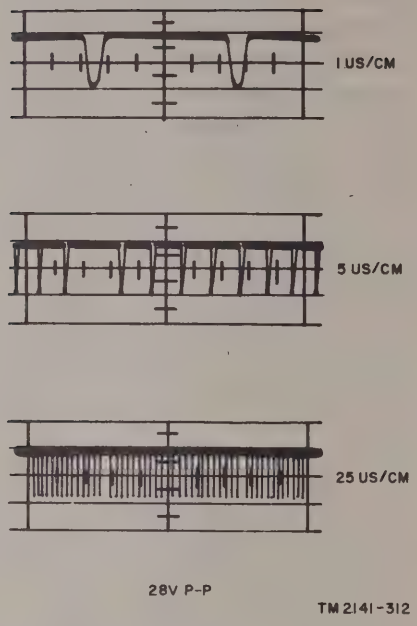


Figure 258. Wave form at pin 7 (grid) of V10B.

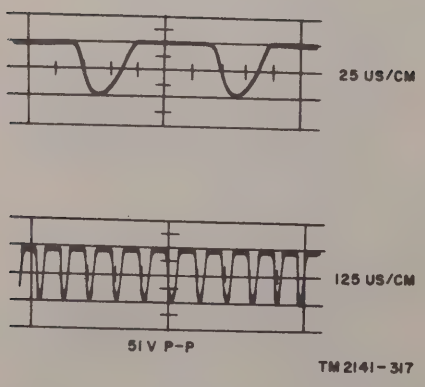


Figure 259. Wave form at pin 2 (grid) of V4A.

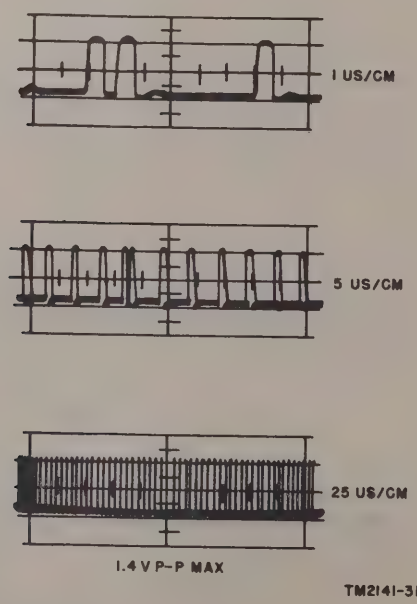


Figure 260. Wave form at J9.

Section III. TROUBLE SHOOTING AND TESTING COMMON UNIT DEMULTIPLEXER CIRCUITS

297. Common Unit Demultiplexer Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the common unit demultiplexer circuit.

Fig. No.	Description
175	Common unit demultiplexer circuit, block diagram.
368	Multiplexer TD–60/TCC–13, demultiplexer section, schematic diagram.
391	Multiplexer TD–60/TCC–13, demultiplexer section, wiring diagram.
392	Common unit demultiplexer filter section, wiring diagram.
261	Common unit demultiplexer section, top view.
262	Common unit demultiplexer section, bottom view.
263	Common unit demultiplexer filter, cover open.
264	Common unit demultiplexer section, tube socket voltage and resistance diagram.

298. Test Equipment Required for Common Unit Demultiplexer

The following test equipment is required:

a. Multiplexer Set AN/TCC–13 (one).
b. Multimeter TS–352/U.
c. Electronic Multimeter TS–505/U.

299. Common Unit Demultiplexer Trouble-shooting Procedure

The best means of trouble shooting this circuit is by wave form comparison. An abnormal wave form indicates a fault between the last point where the wave form is normal and the first point where it is observed to be abnormal. The wave form comparison procedures in paragraph 116 permit localization of the trouble to a particular stage. The wave form comparison procedures described may permit localization of the trouble to the particular defective part in the stage. Always follow the procedures in paragraph 116 before proceeding to paragraphs 300 and 301.

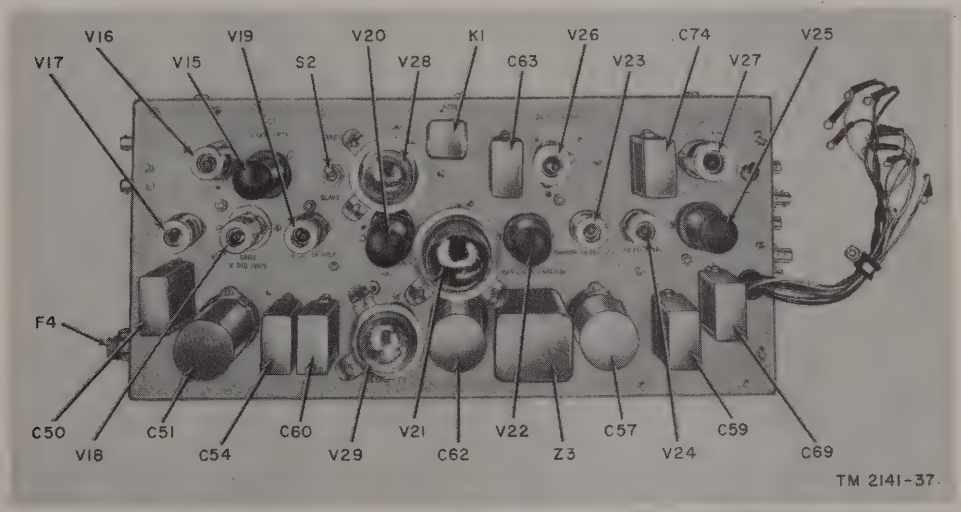


Figure 261. Common unit demultiplexer section, top view.

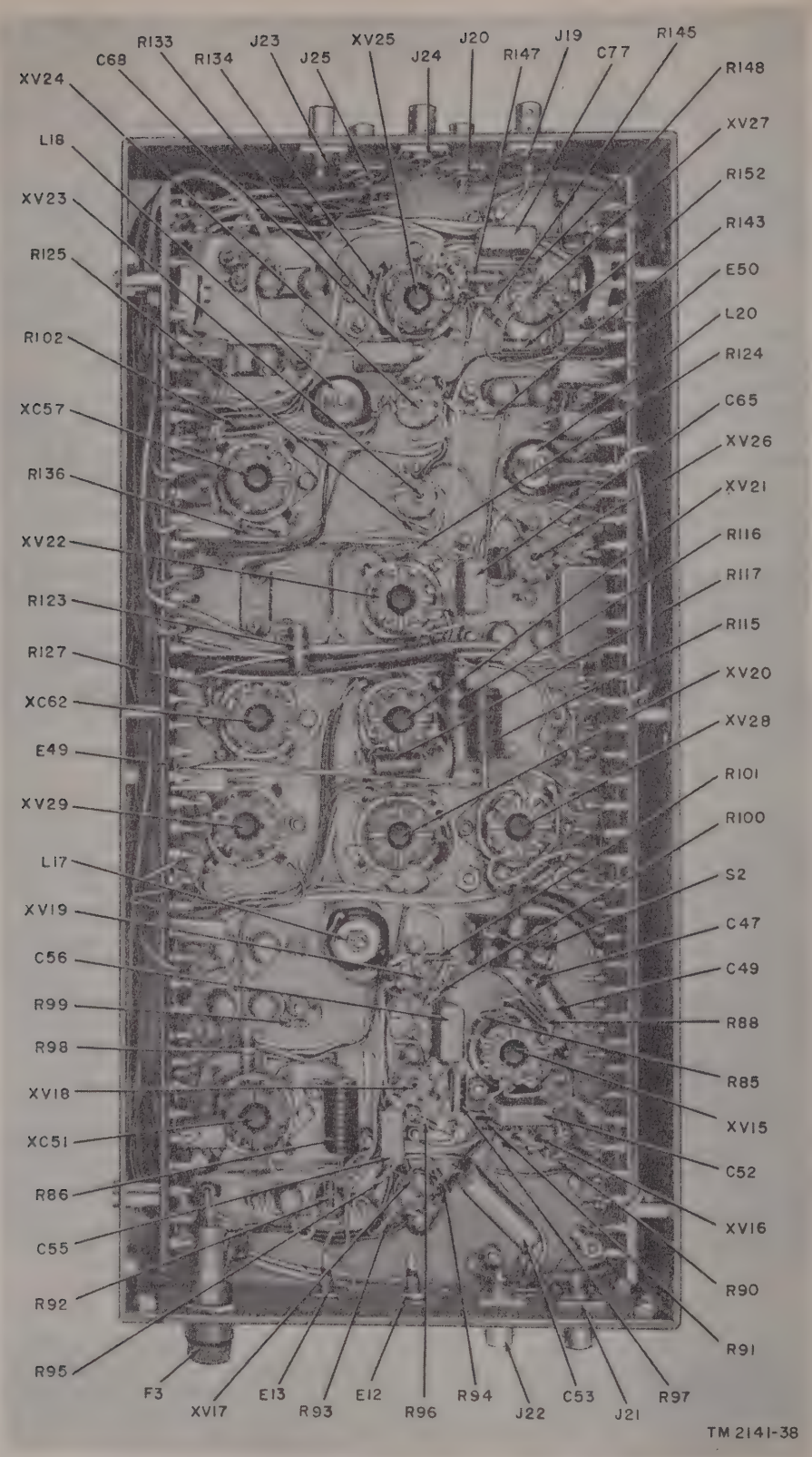


Figure 262. Common unit demultiplexer section, bottom view.

300. Common Unit Demultiplexer Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the common unit demultiplexer circuit.

Symptom	Probable trouble	Correction
1. No pulse train input at J22.	1. Faulty demultiplexer filter.	1. Replace filter.
2. No modem pulse train at E12.	2. L16 faulty.	2. Replace L16.
	L17 faulty.	Replace L17.
	CR6 shorted.	Replace CR6.
	Video coaxial cable on rack connecting to J23 shorted.	Remove short.
	Short to ground on any modem at P1–V.	Remove short.
3. Incorrect wave form at modem pulse train test point E12.	3. Faulty CR6.	3. Replace CR6.
	Faulty L17.	Replace L17.
4. No demultiplexer gate.	4. Z3 faulty.	4. Replace Z3.
	L18 faulty.	Replace L18.
5. No demultiplexer sync voltage at J25.	5. L19 faulty.	5. Replace L19.
6. Alarm circuit malfunctioning.	6. L21 faulty.	6. Replace L21.
	Delay line faulty.	Service per paragraph 318 through 322.
	K1 faulty.	Replace K1.
	L20 faulty.	Replace L20.

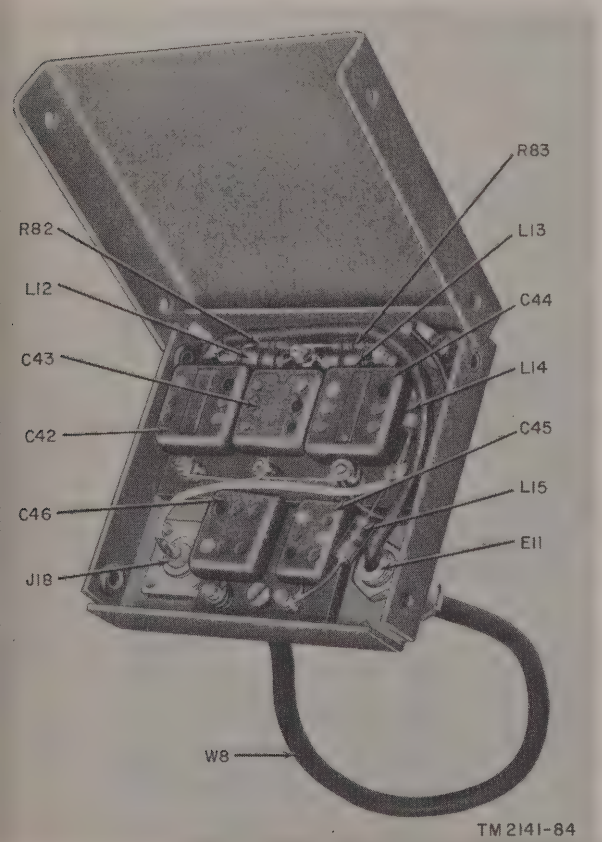


Figure 263. Common unit demultiplexer filter, cover open.

301. Common Unit Demultiplexer Tests

The following tests will be used as reference or as test procedures after a major repair.

a. 23-channel Operation Test Procedure

(1) *Wave forms.* The following wave forms should be measured, and they should not vary by more than 20 per cent in width and amplitude from the referenced figures, except as indicated.

Measure wave form at	Fig. ref	Note
J22	91	
Pin 8 (plate) of V15	94	
Pin 5 (plate) of V16	95	
Pin 1 (grid) of V18	96	
Pin 5 (plate) of V18	97	
Pin 5 (plate) of V19	98	
Pin 8 (plate) of V20	99	
E12	265	±10%
Pin 8 (plate) of V22	100	±10%
Pin 5 (plate) of V23	101	
Pin 5 (plate) of V24	102	
J25	266	
E13	93	110± 10v, 7.0 ±1.0 usec at 50% amplitude
Pin 2 (grid) of V27A	267	
Pin 1 (plate) of V27A	104	

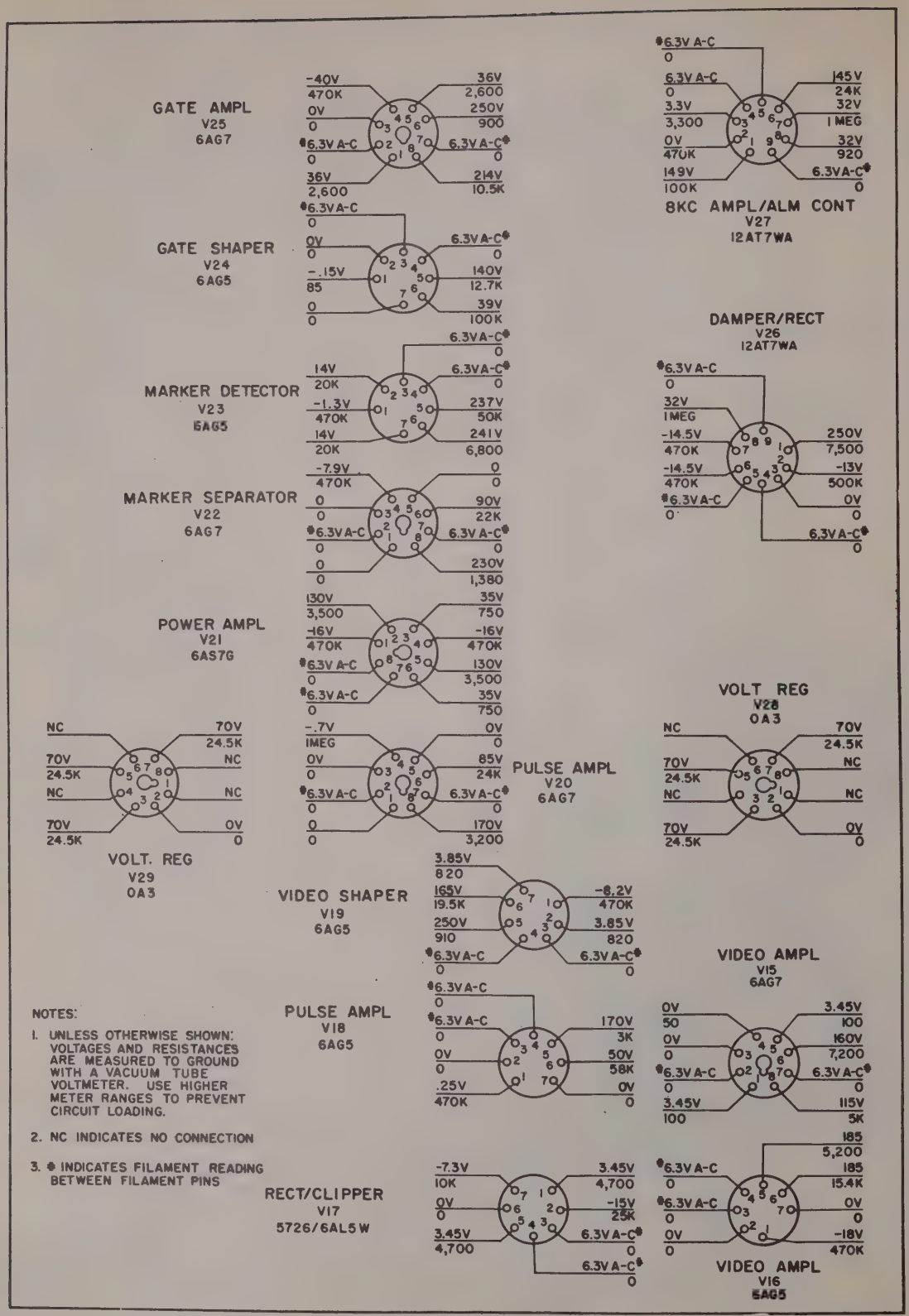


Figure 264. Common unit demultiplexer section, tube socket voltage and resistance diagram.

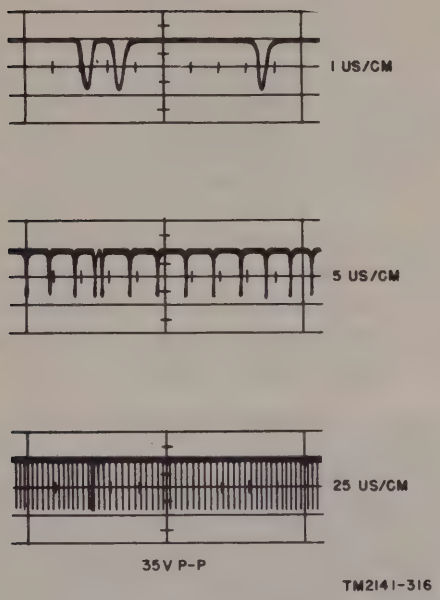


Figure 265. Wave form at E12.

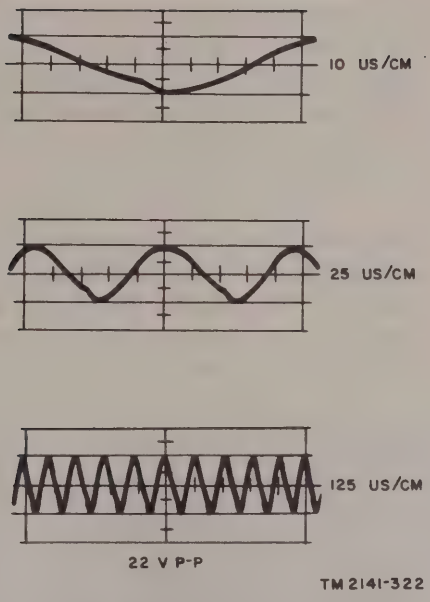


Figure 266. Wave form at J25.

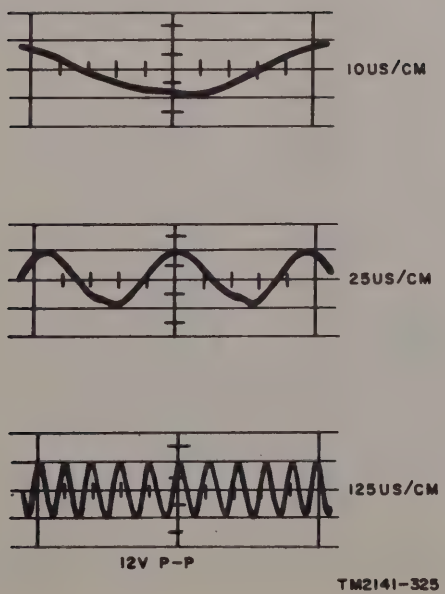


Figure 267. Wave form at pin 2 (grid) of V27A.

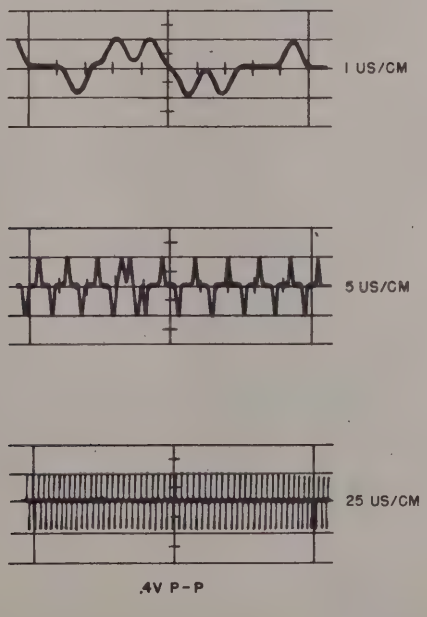


Figure 268. Wave form at pin 4 (grid) of V15, 45-channel operation.

(2) *VR tube voltages.* Measure the voltages across the VR tubes, V28 and V29. They should be 75 volts ±5 volts.

(3) *Alarm circuit.* With a pulse train into the demultiplexer, the alarm should not sound and the alarm indicator, on the multiplexer subassembly panel, should not light. Remove the pulse train input cable to the demultiplexer. The alarm should sound and the alarm indicator should light.

b. 45-channel Operation Test Procedures.

(1) To make the tests below, a second Multiplexer Set AN/TCC–13 is required. For normal tests, check the resistances, voltages, and wave forms at V15. The common unit demultiplexer to be tested should be connected to the test multiplexer set for master or slave operation test as described in paragraph 295*b*(1). The two multiplexers should be connected for 45-channel operation and the multiplexer GAIN control (R74) set so that both the positive and negative pulse trains at the demultiplexer PULSE TRAIN INPUT test point are .25 volt from base line to peak (total amplitude from the top of one pulse train to the top of the other is .5 volt, peak to peak).

(2) Measure the wave form at pin (grid) of V15. It should not vary by more than 20 per cent in width and amplitude from figure 268.

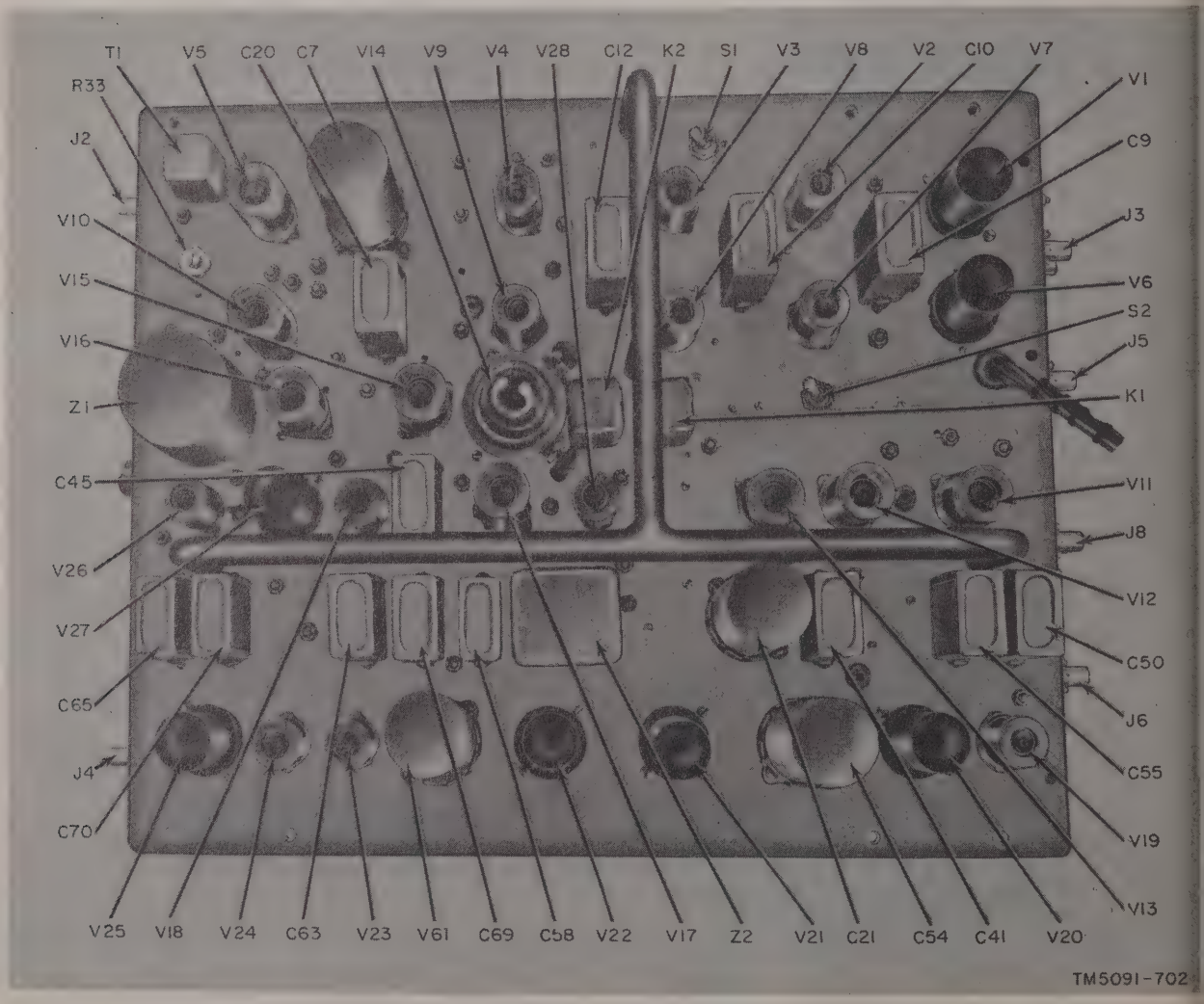


Figure 269. Video restorer, top view.

302. Video Restorer Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the video restorer unit.

Fig. No.	Description
200	Video restorer, over-all block diagram.
370	Video restorer, schematic diagram.
395	Video restorer, wiring diagram.
269	Video restorer, top view.
270	Video restorer, bottom view, showing resistors.
271	Video restorer, bottom view, showing capacitors.
272	Video restorer, bottom view, showing all components except resistors and capacitors.
273	Video restorer, rear view.
274	Video restorer, tube socket voltage and resistance diagram.

303. Test Equipment Required for Video Restorer

The following test equipment is required for alignment and trouble shooting the video restorer:

a. One Multiplexer Group AN/TCA–1 or Pulse Form Restorer Group AN/TRA–10.

b. A source of 23-channel pulse train: .5 volt base line to peak; .6 usec nominal width at 50 per cent amplitude (Multiplexer Set AN/TCC–13).

c. A source of 45-channel pulse train: 1 volt peak to peak, consisting of a 23-channel positive pulse train and a 23-channel negative pulse train, each .5 volt base line to peak; .6 volt nominal width at the 50 per cent amplitude point. The spacing in time between the leading edges of the second pulse of the positive marker and the second pulse of the negative marker should be 2.6 usec. Two Multiplexer Sets AN/TCC–13, connected as master and slave, can be used for this purpose.

d. One Electronic Multimeter TS–505/U.

e. One Multimeter TS–352/U.

304. Video Restorer Trouble-shooting Procedure

a. The best means of trouble shooting this unit is by wave form comparison. Abnormal wave forms indicate a fault located between the last point where the wave form is normal and the first point where it is observed to be abnormal. The wave form comparison procedure in paragraph 116 permits localization of a trouble to a particular stage. The wave form comparison procedures described in paragraphs 305 and 306 permit localization of the trouble to the defective part in the stage. Always complete the procedures in paragraph 117 proceeding to paragraphs 305 and 306.

b. The oscilloscope is synchronized by a signal from the video restorer through SCOPE SNYC jack J10. If this signal is normal, it is an indication that stages V19 through V27 of the video restorer are operating properly. Not enough sync voltage at jack J10 indicates that the trouble probably is in these stages.

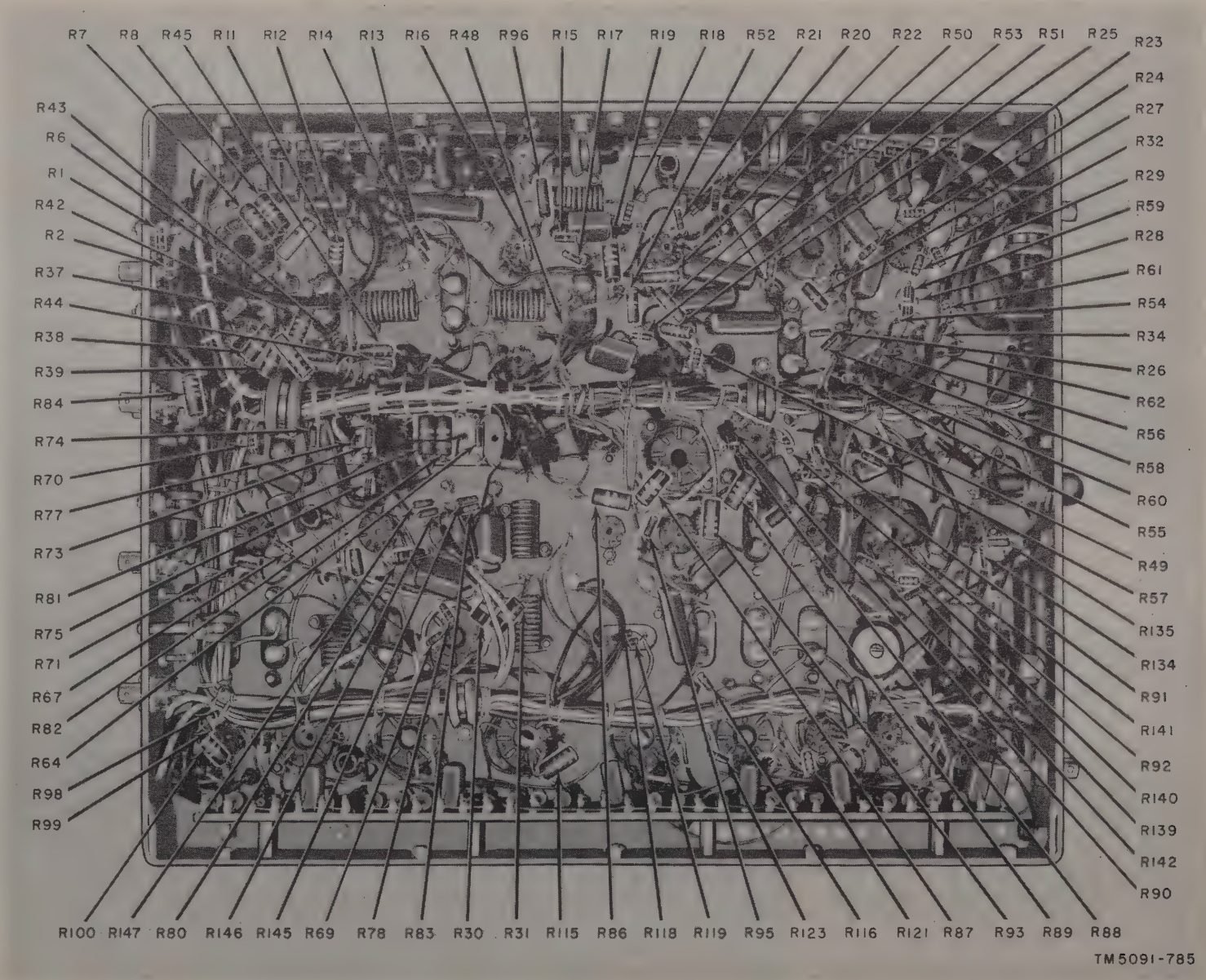


Figure 270. Video restorer, bottom view, showing resistors.

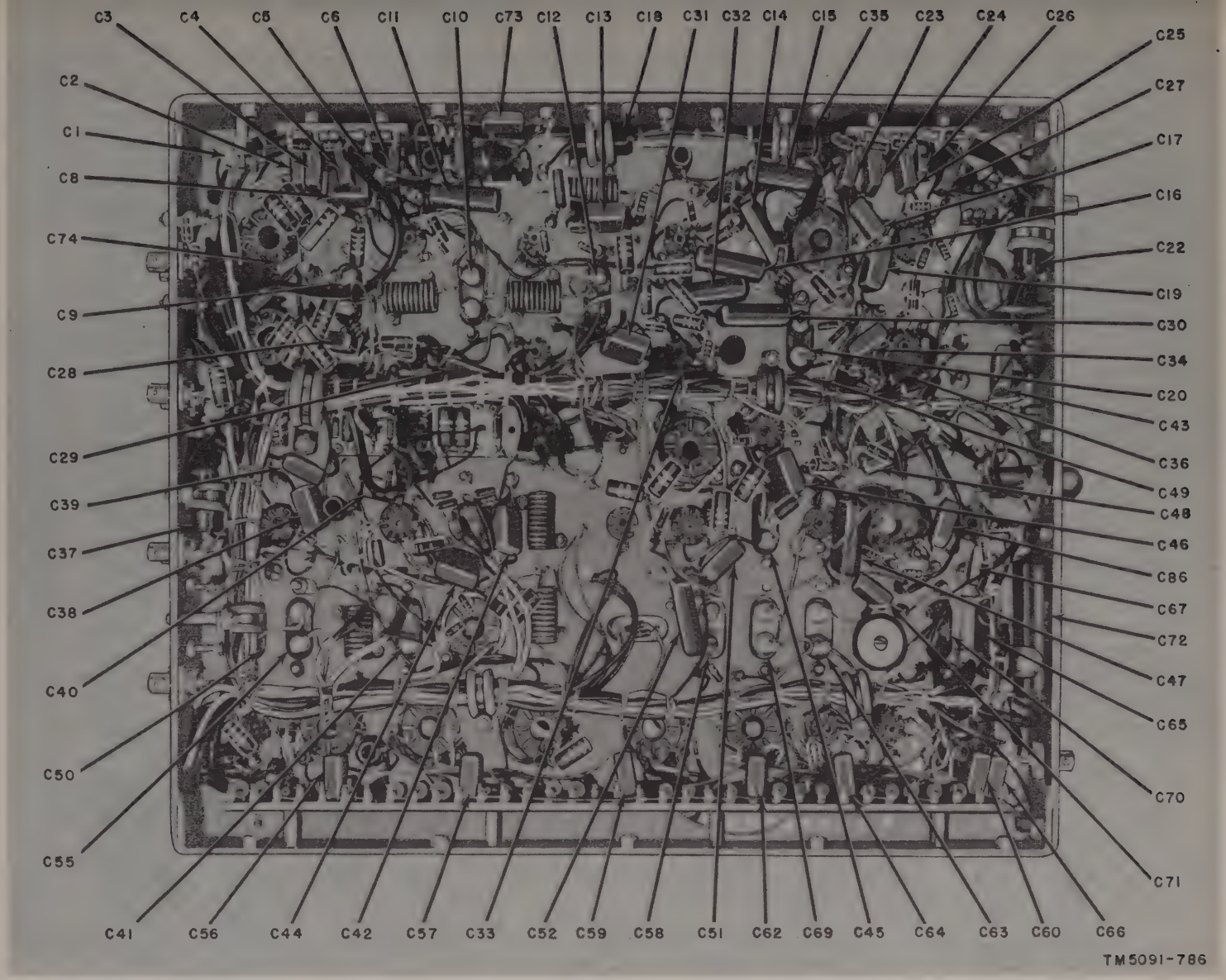


Figure 271. Video restorer, bottom view, showing capacitors.

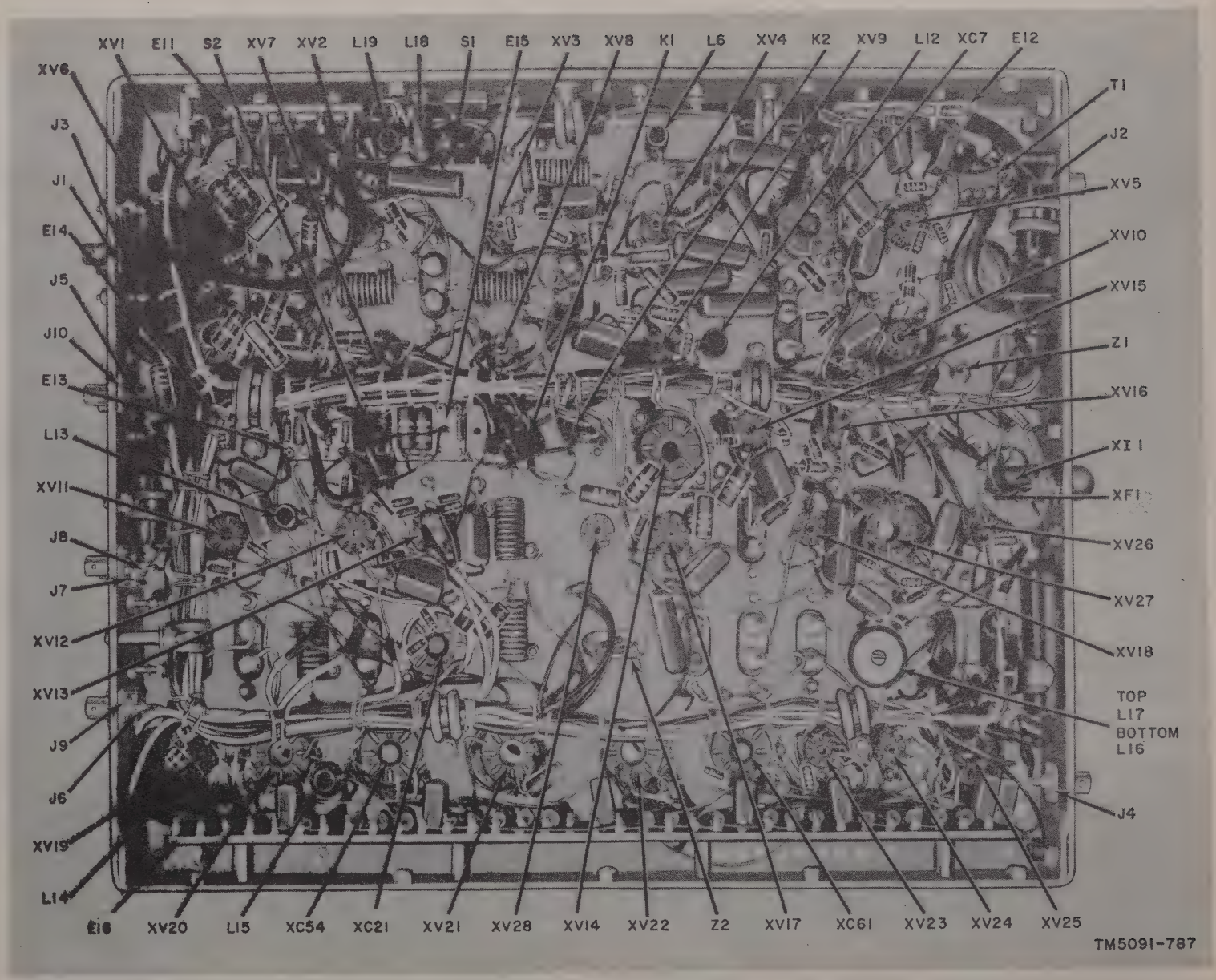


Figure 272. Video restorer, bottom view, showing all components except resistors and capacitors.

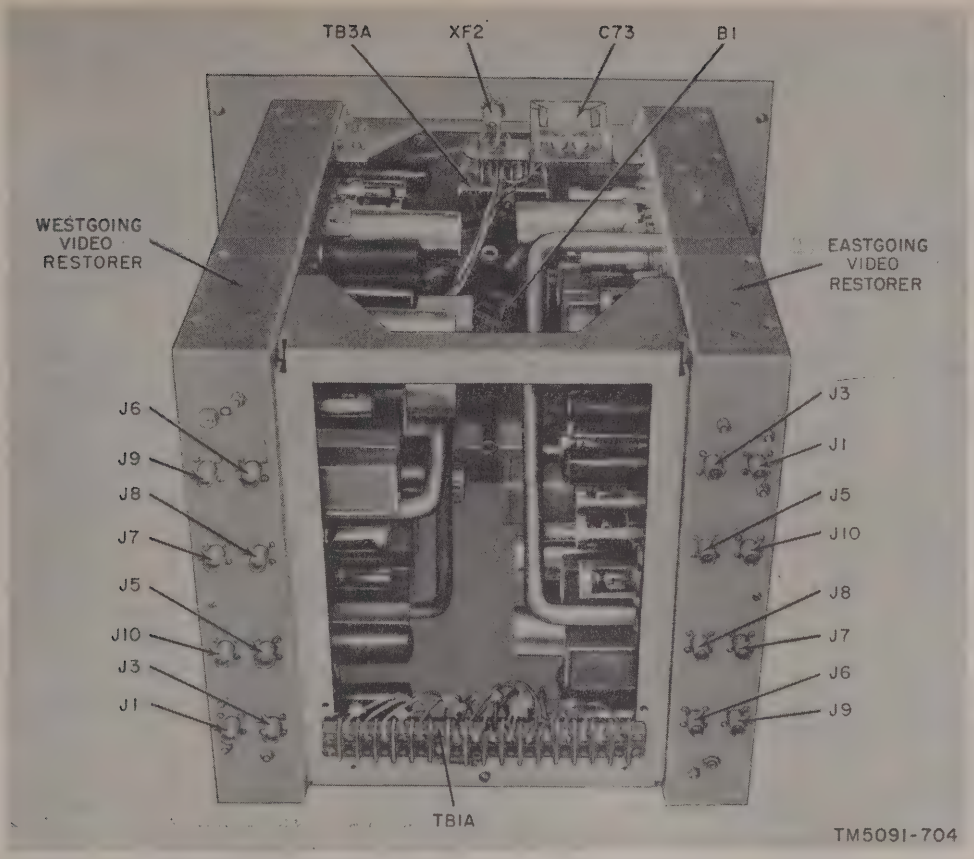


Figure 273. Video restorer, rear view.

205. Video Restorer Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the video restorer. This chart lists the symptoms (some of which the repairman observes either visually or audibly), the probable trouble, and the procedure for remedying the trouble. It is supplementary to the trouble-shooting information contained in paragraphs 131 and 132.

Symptom	Probable trouble	Correction
1. No B+ voltage.	1. Short circuit from B+ to ground.	1. Make continuity checks, locate and remove short.
	Blown +250-volt fuse.	Replace B+ fuse (F1).
2. No filament voltage.	2. Short circuit across filament leads.	2. Make continuity checks, locate and remove short.
	Blown filament fuses.	Replace filament fuses.
3. Fan does not turn.	3. Blown fan fuse.	3. Replace fan fuse (F2).
4. Fan turns in wrong direction.	4. Fan wiring incorrect.	4. Rewire fan correctly.

Symptom	Probable trouble	Correction
5. No pulse train at INPUT FROM REC test point (E1).	5. No pulse train from rf receiver.	5. Check rf receiver output.
	Faulty video connection from rf receiver to video restorer.	Replace interconnecting Cord CG–409C–U.
6. No gate at the DEMTPX GATE test point (E5).	6. No input pulse train.	6. Perform step 5.
	Faulty input filter. If filter is open, there will be no pulse train at pin 5 of V6.	Replace faulty 1-mc filter.
	Coil L11 open in plate of V6. If L11 is open, there will be no pulse train at pin 5 of V6.	Replace L11.
	Coil L12 open in plate of V9. If L12 is open, there will be no pulse train at pin 5 of V9.	Replace L12.
	Coil L15 open in the decoupling circuit of V19. If L15 is open, there will be no pulse train at pin 5 of V19.	Replace L15.
7. Wave shape at DEMTPX GATE test point (E5) improper.	7. Coil L14 open. If L14 is open the channel pulses at pin 4 of V20 will be very wide.	7. Replace L14.
	Delay line Z2 in plate of V22 faulty. If Z2 is faulty, the wave shape is proper at pin 4 of V22, but improper at pin 8 of V22.	Replace Z2.
	Coil L16 open. If L16 is open, the wave shape at pin 1 of V24 is improper.	Replace L16.
	Delay line with an open or shorted section.	Repair faulty section. See paragraph 318 through 322.
8. *All* blanking gates missing at BLANKING GATE test point E4 (with all channels in D&I and channels 1 and 2 in NORMAL OPERATION).	8. No demultiplexer gate.	8. Refer to step 6.
	Faulty connection from DEMTPX delay line to J6 of the video restorer. If the connection is faulty, there will be no gates at J6 of the video restorer.	Replace faulty connection.
9. A channel blanking gate missing at the BLANKING GATE test point (E4).	9. Faulty connection from the DEMTPX delay line to the D&I-THRU plug or from the plug to J6 on the video restorer.	9. Replace the faulty connection.
10. Wave shapes improper at the BLANKING GATE test point (E4).	10. Blanking gates misaligned.	10. Refer to blanking gate alignment procedure (par. 320).
11. No gate at the MTPX GATE test point (E6).	11. No demultiplexer gate or improper demultiplexer gate.	11. Refer to steps 6 and 7.
12. Wave shape at MTPX gate test point improper.	12. Improper demultiplexer gate. Capacitor C67 open if gate is too narrow.	12. Refer to step 7. Replace C67.

Symptom	Probable trouble	Correction
	MTPX delay line section open or shorted.	Repair the faulty section (par. 320 and 321).
13. *All* channel pulses missing at MODEM CHAN PULSES test point (E3). (*All* channels in D&I and channels 1 and 2 in NORMAL OPERATION).	13. No multiplexer gate or improper wave shape.	13. Refer to steps 6, 7, and 12.
	Faulty connections between the modem common cathode (pin K on modem plug) and J3 at the video restorer.	Repair faulty connection.
14. A channel pulse missing at the MODEM CHAN PULSES test point. (*All* channels in D&I and channels 1 and 2 in NORMAL OPERATION.	14. Faulty connection from modem pin K to common cathode cable.	14. Repair faulty connection.
	Faulty connection from MTPX delay line to D&I-THRU plug or from the plug to pin C on the modem.	Repair faulty connection.
	Faulty modem.	Refer to paragraphs 309 through 317.
15. No inserted pulses at the OUTPUT TO XMTR test point (E2). (*All* channels in D&I and channels 1 and 2 in NORMAL OPERATION.)	15. No pulses at MODEM CHAN PULSES test point (E3).	15 Refer to steps 13 and 14.
	Coil L13 open. If L13 is open, there will be no pulse train at pin 1 of V12.	Replace L13.
	Faulty 1-mc output filter. Filter faulty if there is a pulse train into the filter but no output from it.	Replace filter.
	Faulty contacts on relay K1.	Replace K1.
	Transformer T1 faulty.	Replace T1.
16. Pulses at the OUTPUT TO XMTR test point too wide.	16. Coil L13 open in plate of V12. Crystal CR3 or CR4 faulty.	16. Replace L13. Replace faulty crystal.
17. In 45-channel operation, no negative pulse train at the OUTPUT TO XMTR test point.	17. No 45-channel pulse train at INPUT FROM REC test point.	17. Refer to step 5.
	Coil L5 open in plate of V1. If L5 is open, there will be no pulse train at pin 8 of V1.	Replace L5.
	Switch S1 open.	Replace S1.
18. In 45-channel operation, negative pulses at the OUTPUT TO XMTR test point, too wide.	18. Coil L6 open in the plate of V4.	18. Replace L6.
	Crystal CR1 or CR2 faulty.	Replace the faulty crystal.
19. Alarm is activated.	19. No B+ or filament voltage.	19. Refer to steps 1 and 2.
	No gate at pin 7 of V17.	Refer to steps 6 and 7.
	No pulse train at pin 2 of V16.	Refer to steps 1 and 2.
	Crystal CR5 or CR6 faulty.	Replace faulty crystal.
	Relays K1 or KT faulty.	Replace faulty relay.

306. Video Restorer Tests

The following tests should be used as a complete operational check after major repairs. For any normal tests, check the resistance, voltage, and wave forms.

a. 23-channel Operation.
- (1) Wave forms.
- (2) Alarm circuit.
- (3) Voltage-regulator tube voltages.
- (4) Fan rotation.

b. 45-channel Operation.
- (1) Wave forms.
- (2) Symmetry control.

307. Video Restorer Test Procedures

a. General. Both sections of the video restorer are identical; therefore, these procedures may be used to test either section. The equipment to be tested should be connected to two Multiplexer Sets AN/TCC–13 as shown in figures 275 or 276. Throw 23 CHAN-45 CHAN switch S1 to the 23 CHAN position to disconnect the filaments of V1 through V5 from the filament supply. Place P.T. OUT AMPL switch S2 in the LOW position. Place all D&I-THRU switches in the D&I position and connect the 23-channel pulse train source (.5 volt) to J11 (INPUT FROM EASTFACING REC) or J14 (INPUT FROM WESTFACING REC), depending on the side of Pulse Form Restorer TD–68/G to be tested.

b. 23-channel Operation.

(1) *Wave forms.* The wave forms listed below should be measured and should not vary by more than 25 per cent in amplitude and width from the referenced figure.

Measure point	Fig. ref
Pin 8 of V11B	121
Pin 3 of V13A	121
E4	121
Pin 8 of V22	140
Pin 1 of V23	140
Pin 8 of V25	120
J8	120
E5	120
Pin 5 of V27	122
Pin 7 of V18A	122
J9	122
E6	122

(2) *Alarm circuit.*

(*a*) With a pulse train connected to video restorer INPUT FROM RF jack J1, ALARM indicator I 1 on the video restorer panel should not light, and AUDIBLE ALARM buzzer I 1 in the mounting rack should not sound. The indicator will light and the buzzer will sound if the pulse train input cable is removed from the video restorer; if the marker-separator and gate-shaping sections, V19 through V26, fail or operate improperly; the positive pulse train section, V6 through V12, fails or operates improperly; or if the supply fails.

(*b*) When any of the conditions in (*a*) above occur, the alarm relay should operate and bypass INPUT FROM RF pulse train jack J1 to OUTPUT TO RF jack J3, where it may be observed. The pulse train seen at OUTPUT TO WESTFACING XMTR test point E2 will be attenuated by the 6-db pad, consisting of resistors R1, R2, and R3.

(*c*) At the same time that the signal is bypassed, the alarm relay removes the ringing 250 volts dc on terminal 3 or 14 of TB1A (depending on the side being tested).

(3) *Voltage-regulator tube voltages.* Measure the voltage of tubes V14 and V28. The voltage at pins 3, 5, and 7 of tube V14 should be 75 volts ±5 volts; the voltage at pins 1 and 5 of V28 should be 108 volts ±5 volts.

(4) *Fan rotation.* The fan should be turning so that air is sucked in the front of the video restorer.

c. 45-channel Operation. Connect a 45-channel pulse train source (par. 303*c*) (1 volt nominal peak to peak) to J11 or J14. This wave train should consist of both a positive 23-channel pulse train and a negative 23-channel train, each being at least .5 volt from the base line to peak. Throw the 23 CHAN-45 CHAN switch to the 45 CHAN position, thus energizing the filaments of V1 through V5. The equipment to

306. Video Restorer Tests

The following tests should be used as a complete operational check after major repairs. For any normal tests, check the resistance, voltage, and wave forms.

a. 23-channel Operation.
- (1) Wave forms.
- (2) Alarm circuit.
- (3) Voltage-regulator tube voltages.
- (4) Fan rotation.

b. 45-channel Operation.
- (1) Wave forms.
- (2) Symmetry control.

307. Video Restorer Test Procedures

a. General. Both sections of the video restorer are identical; therefore, these procedures may be used to test either section. The equipment to be tested should be connected to two Multiplexer Sets AN/TCC–13 as shown in figures 275 or 276. Throw 23 CHAN-45 CHAN switch S1 to the 23 CHAN position to disconnect the filaments of V1 through V5 from the filament supply. Place P.T. OUT AMPL switch S2 in the LOW position. Place all D&I-THRU switches in the D&I position and connect the 23-channel pulse train source (.5 volt) to J11 (INPUT FROM EASTFACING REC) or J14 (INPUT FROM WESTFACING REC), depending on the side of Pulse Form Restorer TD–68/G to be tested.

b. 23-channel Operation.

(1) *Wave forms.* The wave forms listed below should be measured and should not vary by more than 25 per cent in amplitude and width from the referenced figure.

Measure point	Fig. ref
Pin 8 of V11B	121
Pin 3 of V13A	121
E4	121
Pin 8 of V22	140
Pin 1 of V23	140
Pin 8 of V25	120
J8	120
E5	120
Pin 5 of V27	122
Pin 7 of V18A	122
J9	122
E6	122

(2) *Alarm circuit.*

(*a*) With a pulse train connected to video restorer INPUT FROM RF jack J1, ALARM indicator I 1 on the video restorer panel should not light, and AUDIBLE ALARM buzzer I 1 in the mounting rack should not sound. The indicator will light and the buzzer will sound if the pulse train input cable is removed from the video restorer; if the marker-separator and gate-shaping sections, V19 through V26, fail or operate improperly; the positive pulse train section, V6 through V12, fails or operates improperly; or if the supply fails.

(*b*) When any of the conditions in (*a*) above occur, the alarm relay should operate and bypass INPUT FROM RF pulse train jack J1 to OUTPUT TO RF jack J3, where it may be observed. The pulse train seen at OUTPUT TO WESTFACING XMTR test point E2 will be attenuated by the 6-db pad, consisting of resistors R1, R2, and R3.

(*c*) At the same time that the signal is bypassed, the alarm relay removes the ringing 250 volts dc on terminal 3 or 14 of TB1A (depending on the side being tested).

(3) *Voltage-regulator tube voltages.* Measure the voltage of tubes V14 and V28. The voltage at pins 3, 5, and 7 of tube V14 should be 75 volts ±5 volts; the voltage at pins 1 and 5 of V28 should be 108 volts ±5 volts.

(4) *Fan rotation.* The fan should be turning so that air is sucked in the front of the video restorer.

c. 45-channel Operation. Connect a 45-channel pulse train source (par. 303*c*) (1 volt nominal peak to peak) to J11 or J14. This wave train should consist of both a positive 23-channel pulse train and a negative 23-channel train, each being at least .5 volt from the base line to peak. Throw the 23 CHAN-45 CHAN switch to the 45 CHAN position, thus energizing the filaments of V1 through V5. The equipment to

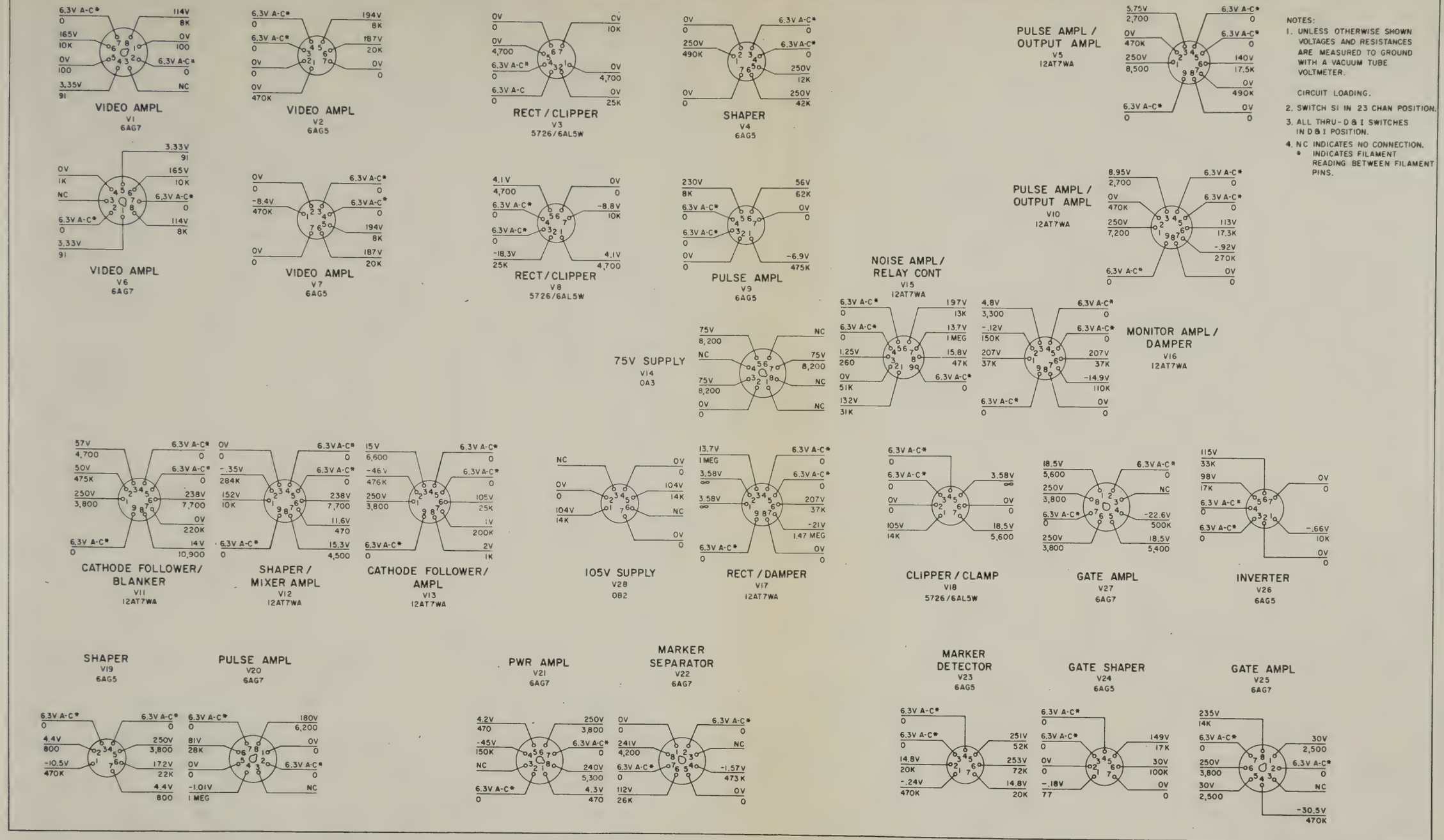


Figure 274. Video restorer, tube socket voltage and resistance diagram.

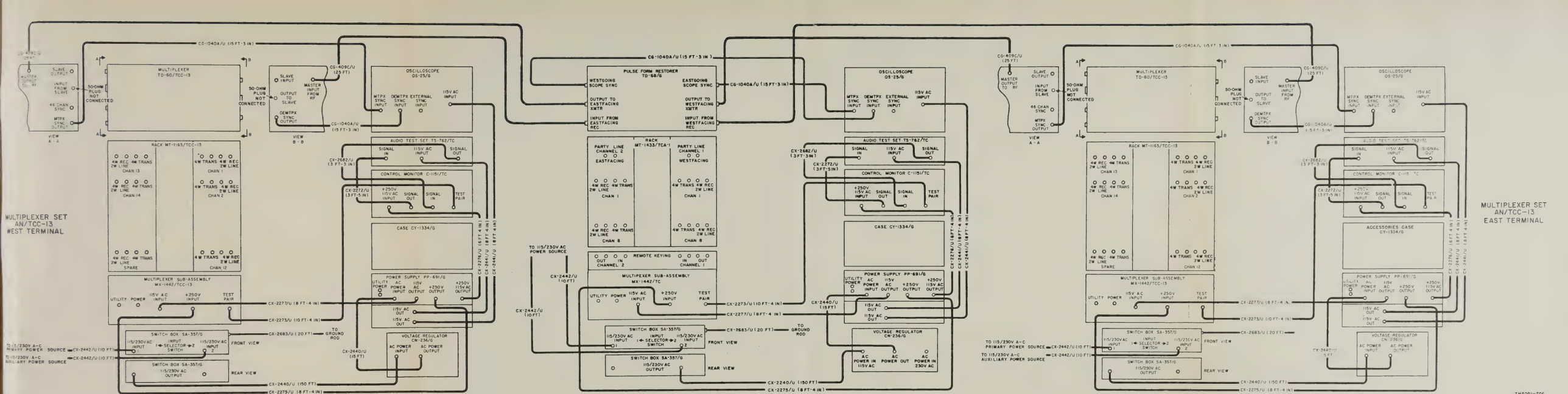
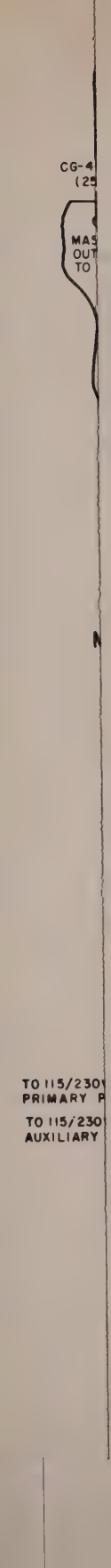


Figure 275. Test setup using Multiplexer Group AN/TCA-1 (23-channel operation).


CG-4
(25
MAS
OUT
TO
TO 115/230
PRIMARY
TO 115/230
AUXILIARY

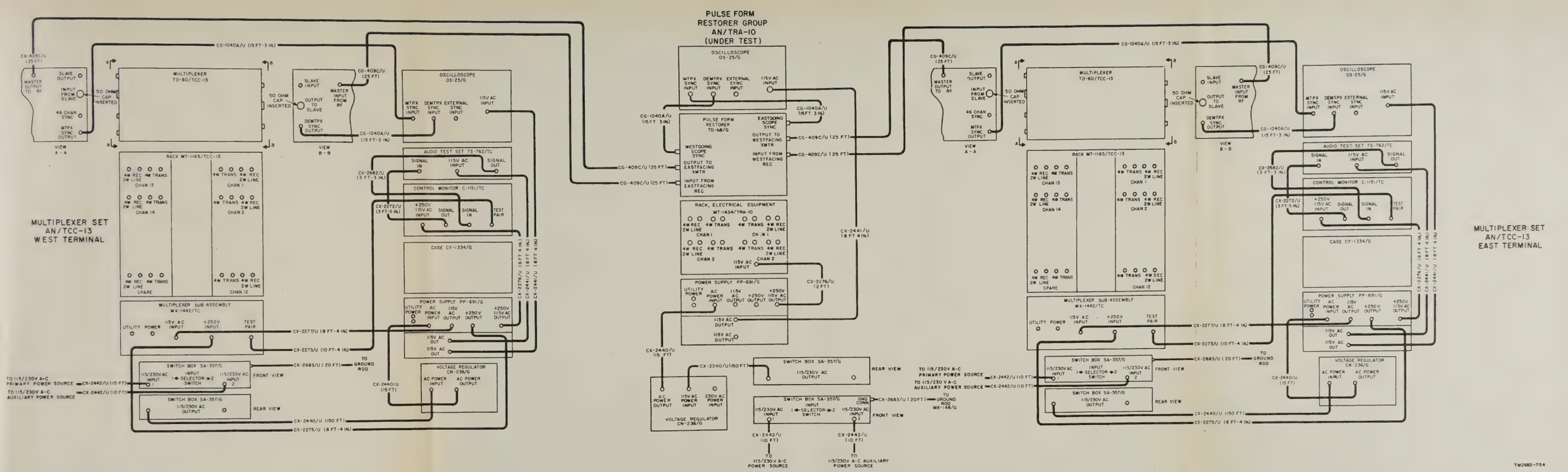


Figure 276. Test setup using Pulse Form Restorer Group AN/TRA–10, (23-channel operation).

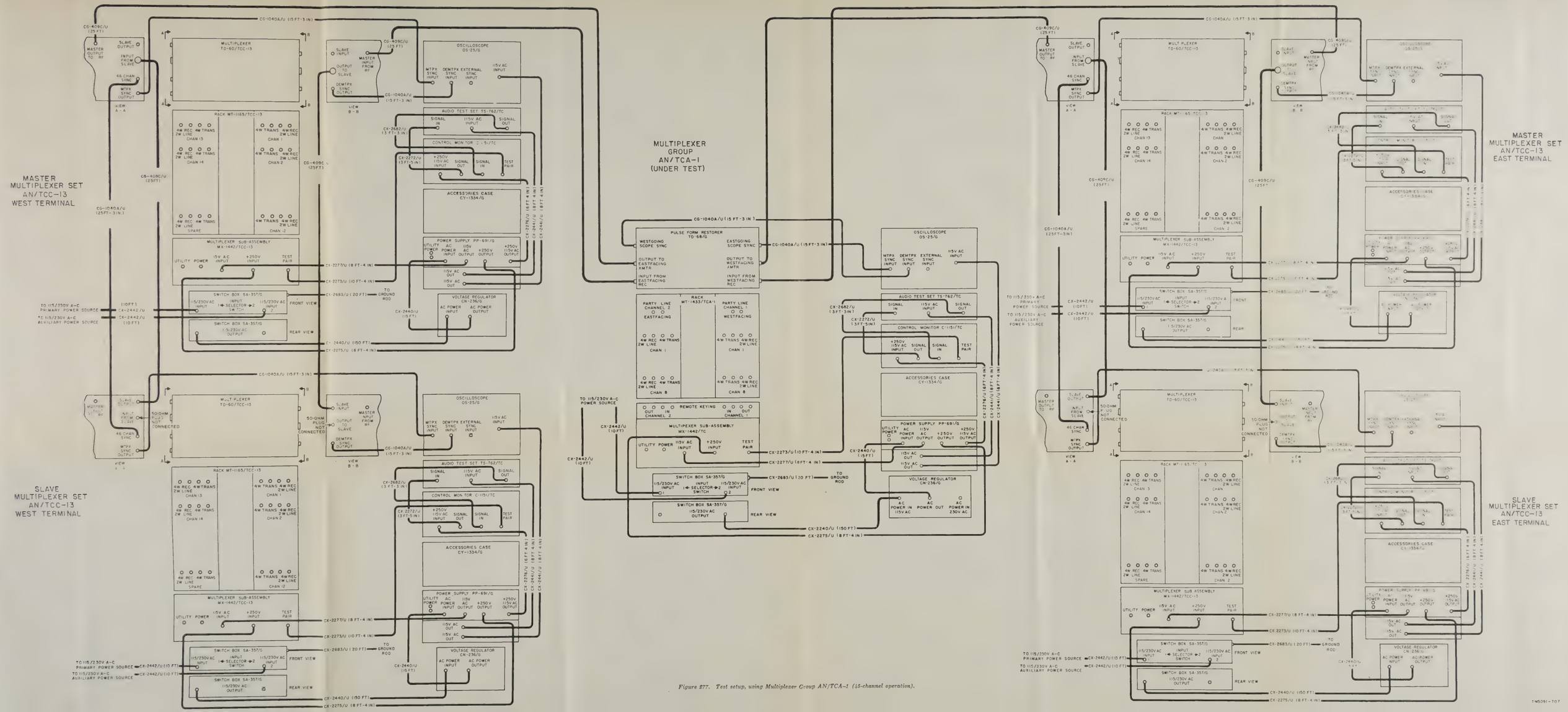


Figure 277. Test setup, using Multiplexer Group AN/TCA-1 (15-channel operation).

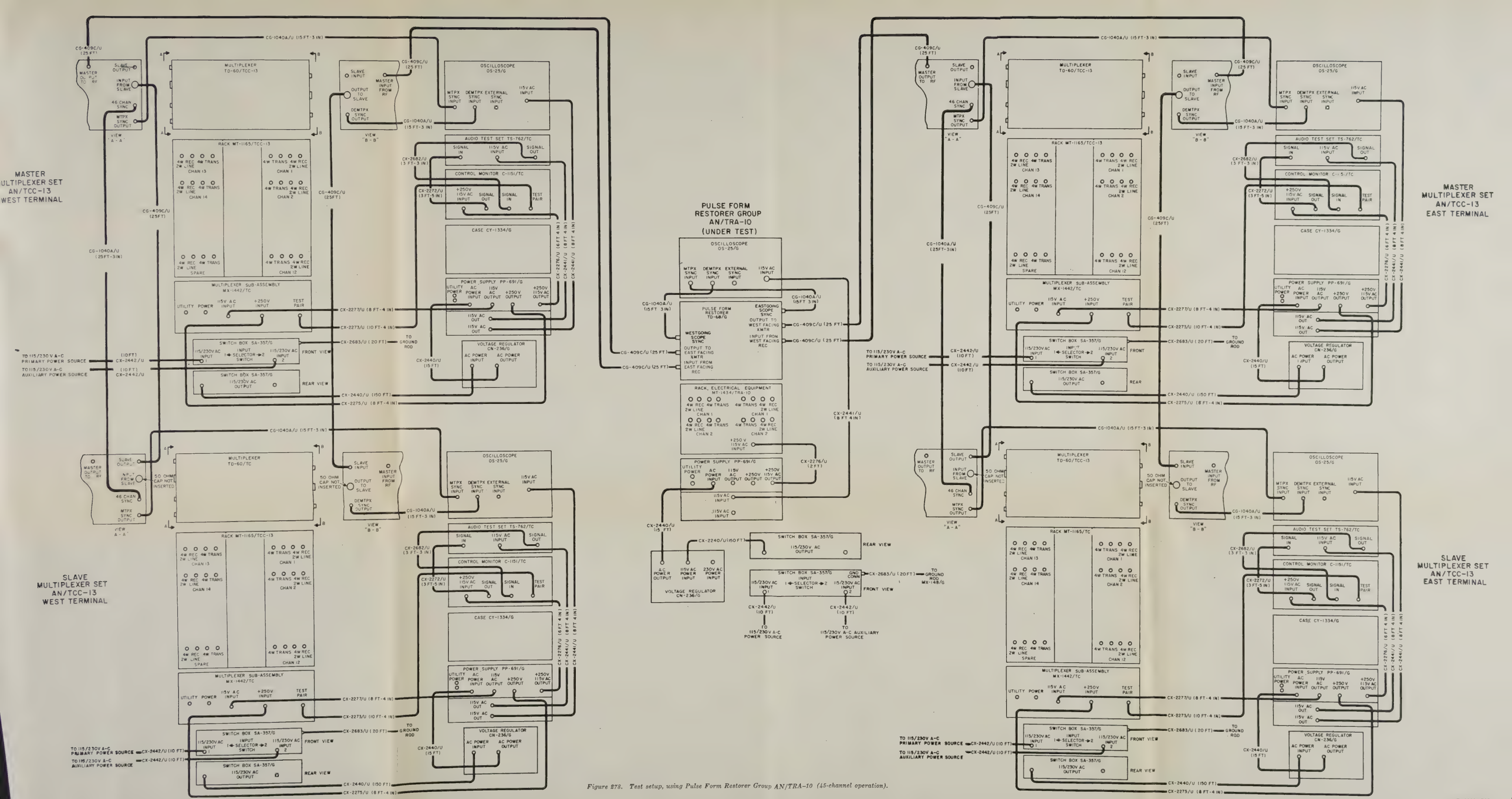


Figure 273. Test setup, using Pulse Form Restorer Group AN/TRA-10 (45-channel operation).

TM2682-767

tested should be connected to four Multixer Sets AN/TCC–13 as shown in figure 277 278. All other conditions remain the same for 23-channel operation tests.

(1) *Wave forms.* The following wave forms should not vary by more than 25 per cent in amplitude and width from the referenced figure.

Measure point	Fig. ref
(OUTPUT TO RF), with direct probe	119
(OUTPUT TO EASTFACING XMTR), with direct probe	119

(2) *Symmetry adjust control.* With the scope probe on J4, adjust the SYM ADJ control (R33) so that both the positive and negative pulse train are of the same amplitude. They should measure .8 to 1.1 volts from base line to peak with P.T. OUT AMPL switch S2 in the HIGH position. When the switch is in the LOW position, the value should be from .4 to .6 volt.

308. Video Restorer Dc Resistance of Transformers, Coils and Relays

The dc resistance of all transformer windings, coils, and relays are listed below. An asterisk (*) indicates an ohmmeter reading of less than 1 ohm.

Transformer, coil or relay	Terminals	Ohms
K1, K2	1–5	3,500
L1, L2, L7, L8		*
L3, L9		*
L4, L10		1.1
L5, L11		2.8
L6, L12, L13, L14		6
L15		17
L16, L17		85
T1	1–2	2
	3–4	*
	5–6	2
Z1	1–2	1,500
	2–3	500
	1–3	1,000

Section V. TROUBLE SHOOTING TELEPHONE MODEM MD–179/TC

9. Modem Trouble-shooting Data

The following data may assist maintenance rsonnel when trouble shooting the modem:

Figure No.	Description
371	Telephone Modem MD–179/TC, schematic diagram.
396	Telephone Modem MD–179/TC, wiring diagram.
279	Modem, right side view.
280	Modem, left side view.
281	Modem test extension in position.
282	Modem test extension, modem in position.
283	Modem tube socket voltage and resistance diagram.
113	Modem, tube location diagram.

310. Test Equipment Required for Modem

The following test equipment is required for trouble shooting and final testing the modem:

Item	Common name	Technical manual
Multiplexer Set AN/TCC–13	Multiplexer set	
Signal Generator SG–71/FCC	Signal generator	TM 11-5088
Decade Resistor TS–679/U	Decade resistance	TM 11-5520
Voltmeter ME–30A/U	Voltmeter	
Electronic Multimeter TS–505/U	Multimeter	TM 11-5511
Telephone EE–8–B (two)	Field telephone	TM 11-333

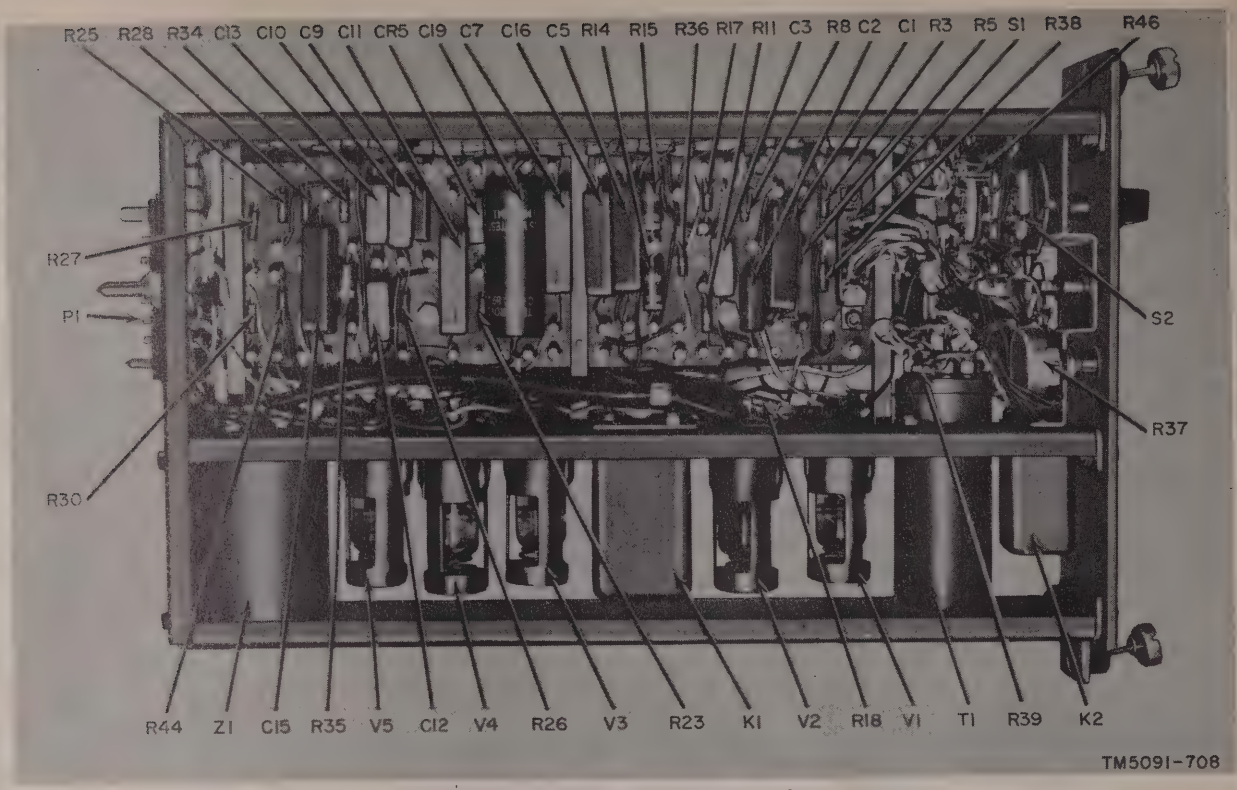


Figure 279. Modem, right side view.

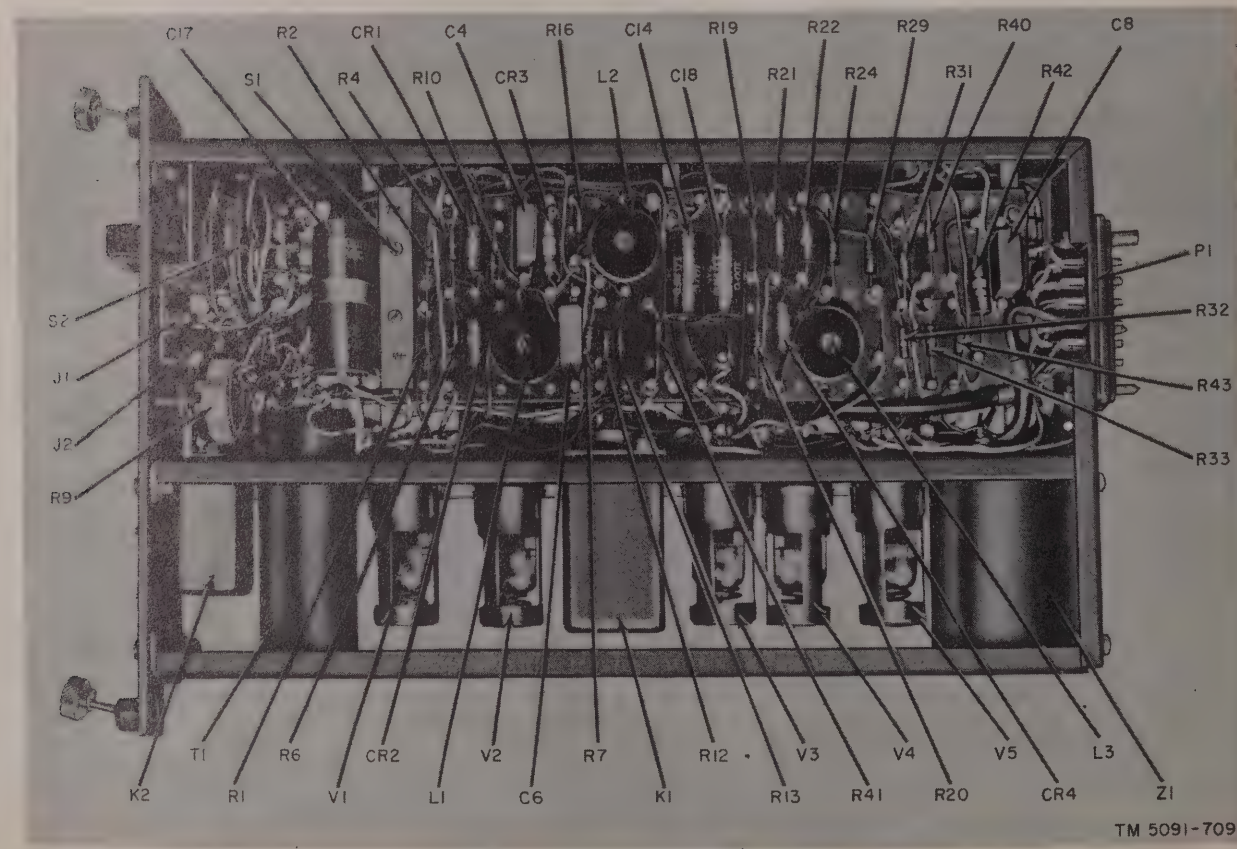


Figure 280. Modem, left side view.

311. Modem Trouble-shooting Procedure

a. The best means of trouble shooting this unit is by means of wave form comparison. An abnormal wave form indicates a fault between the last point where the wave form is normal and the first point where it is observed to be abnormal. The wave form comparison procedures (par. 166) permit localization of the trouble to a particular stage. The wave form comparison procedures described in paragraph 116*c* and *d* and paragraph 313 may permit localization of the trouble to the particular defective part in the stage.

b. Trouble shooting in the modem should not be attempted while the set is carrying traffic. Trouble shooting on the defective unit should be done during a shut-down period or some other appropriate item. Electrical Connector Assembly J–535/G is supplied so that testing can be carried out while operating but not carrying traffic. The modem under test is removed, the assembly is inserted (fig. 281), and the modem then plugged into the assembly (fig. 282).

312. Modem Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the modem.

Symptom	Probable trouble	Correction
1. Incorrect pulse at PPM test point J1.	1. Open L1. No sawtooth at pin 7 of V1. Open L2. CR3 shorted. Grounded J1.	1. Replace L1. Check wave forms (par. 117 step 20). Replace L2. Replace CR3. Replace J1.
2. No pulse-position modulation, but pulse present.	2. Open between terminals 1 and 2 or 9 and 11 of hybrid T1. Shorted CR1. Faulty S1.	2. Replace hybrid T1. Replace CR1. Replace S1.
3. 20-cps ringing input does not blank pulse out.	3. Faulty K1 relay. Faulty S1.	3. Replace K1. Replace S1.
4. No output at PWM test point J2.	4. L3 open. CR4 shorted. No sawtooth at pin 2 of V3.	4. Replace L3. Replace CR4. Check resistance of grid circuit of V2. Replace R20 or R29; no demodulated input sawtooth. Check source.
5. Incorrect wave form at PWM test point J2.	5. CR4 faulty. CR5 faulty. L3 faulty. Faulty modem pulse train at pin 8 of V3.	5. Replace CR4. Replace CR5. Replace L3. Check R27, R28, R25, and C8; faulty demodulator output, refer to paragraph 300 and 305.
6. Wave form at PWM test point correct but low or no audio output.	6. Open filter Z1. Open R37. Defective hybrid T1. Defective S1.	6. Replace Z1. Replace R37. Replace T1. Replace S1.
7. No ringing output when incoming pulse drops.	7. Defective K2. Defective alarm circuit. Incorrect pwm pulse. No 20-cps ringing current.	7. Replace K2. Check 20-cps ringing current supply. Check 20-cps ringing current supply.

[a] If the trouble is not found after checking these parts the trouble is in the common unit or video restorer.

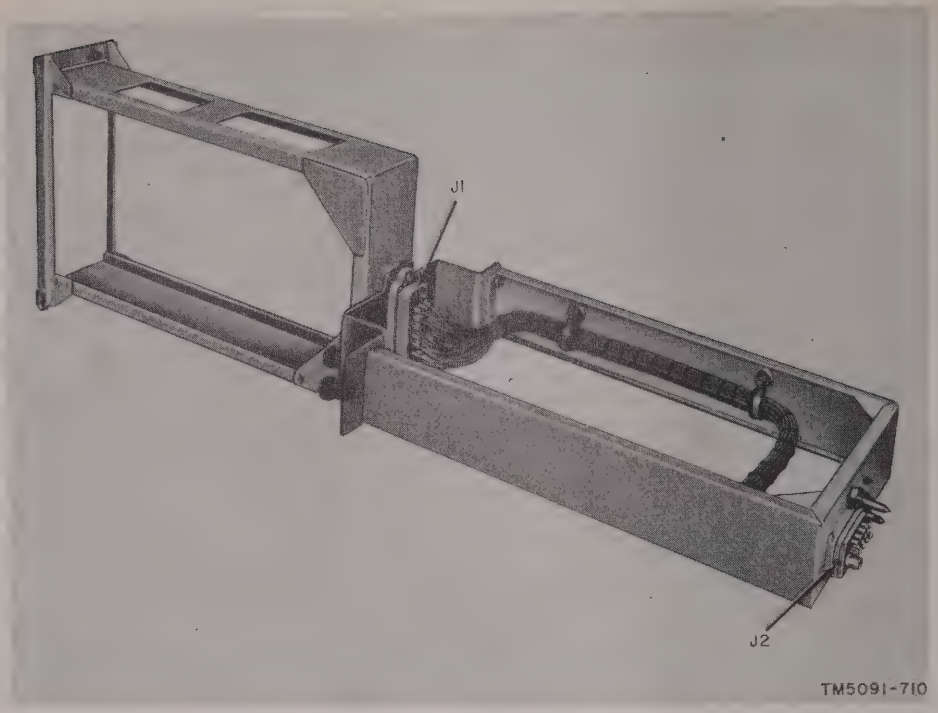


Figure 281. Modem test extension in position.

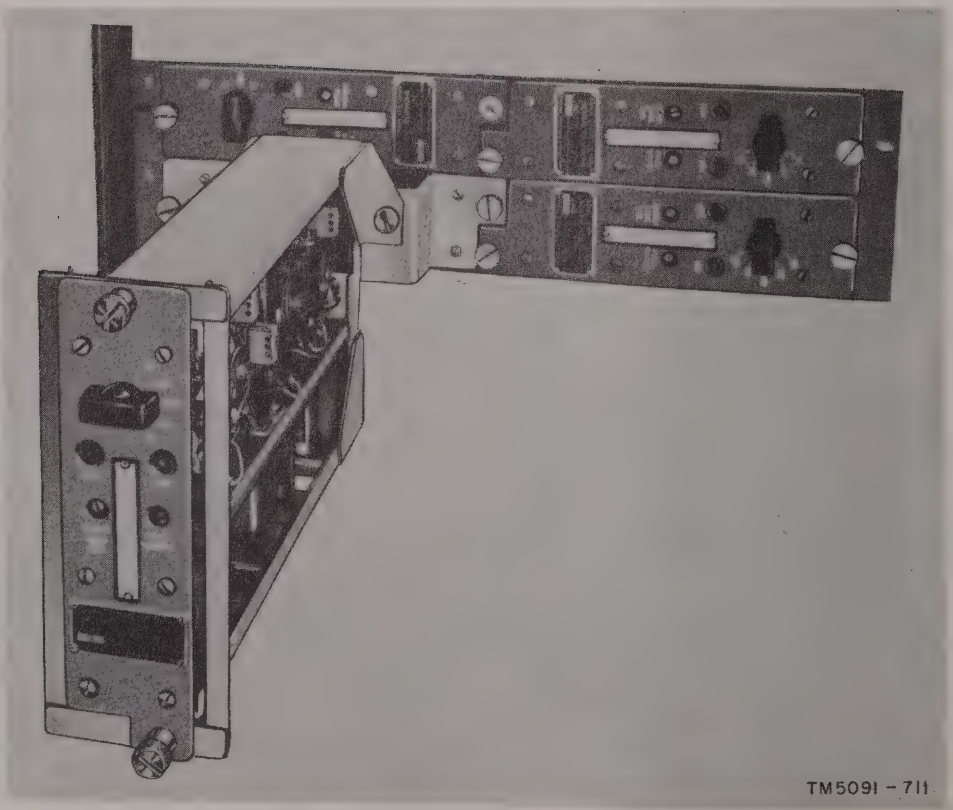


Figure 282. Modem test extension, modem in position.

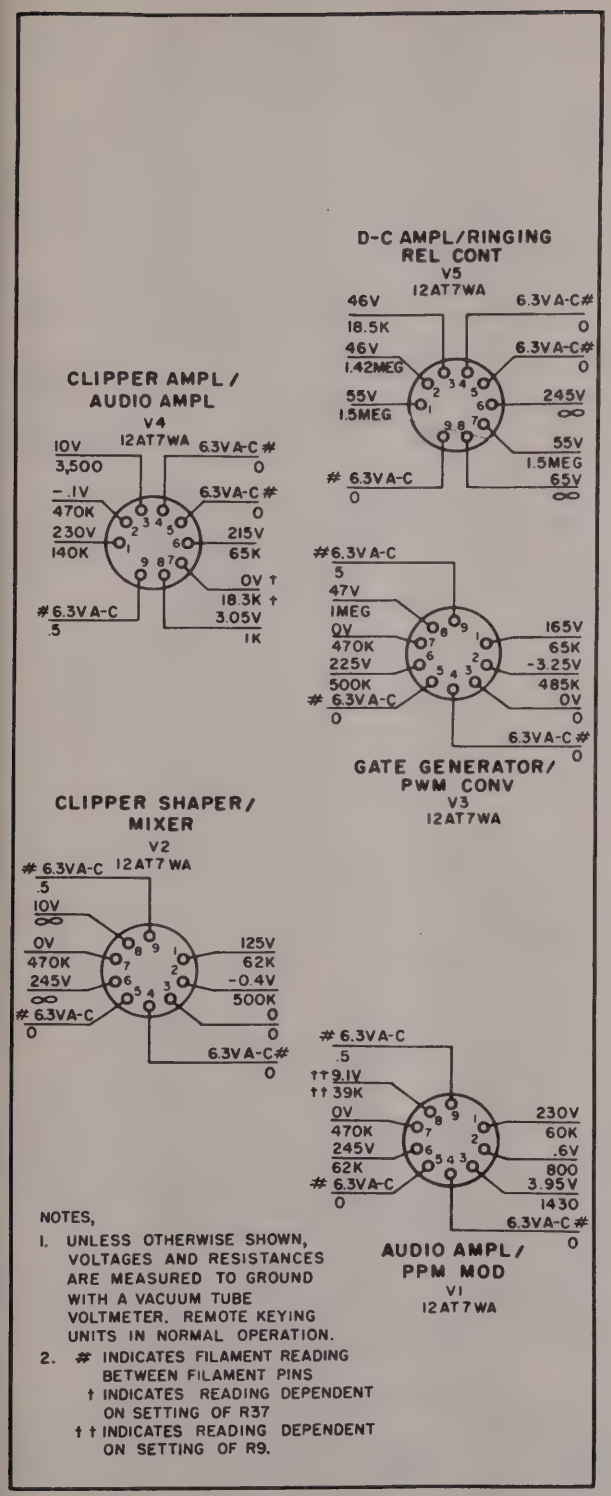


Figure 283. Modem tube socket voltage and resistance diagram.

313. Modem Modulator Tests, Four-wire Operation

a. General. The following tests should be used as a reference and as a test procedure after major repairs. For the four-wire test, one AN/TCC–13 can be used; for the two-wire test, two AN/TCC–13's must be used back to back to prevent singing. It is assumed that the terminals are operating properly and that the channel pulses are aligned. (All 23 channels are not needed.) A modem should be removed from the modem rack of the AN/TCC–13 and the modem to be tested should be inserted in its place. The pulse then should be properly aligned in the pulse train (this can be checked at the PULSE TRAIN OUTPUT test point on the AN/TCC–13 panel). For the four-wire test, the modem 2W–4W switch (fig. 36) must be in the 4W position; for the two-wire test, the modem 2W–4W switch must be in the 2W position.

b. Wave Forms. With the pulse properly positioned in the pulse train, the following wave forms should be measured and they should not vary by more than 25 per cent in width and amplitude from those in the referenced figures:

(1) PPM test point, figure 87.

(2) PWM test point, figure 104.

c. PULSE POSITION Control.

(1) Vary the modem PULSE POSITION control (fig. 50) from maximum to minimum. The pulse should move at least 3.5 microseconds.

(2) Reposition the pulse properly in the pulse train (par. 47).

d. Modulation. Modulate the channel pulse to ±.5 microsecond with a 1,000-cycle tone form Audio Test Set TS–762/TC. The input level for ±.5 microsecond should be —4 dbm ±1 dbm.

e. Output Level and OUTPUT AUDIO GAIN Control.

(1) With the pulse modulated ±.5 microsecond, vary the modem OUTPUT AUDIO GAIN control from maximum to minimum. The output should vary from —6 dbm or less to +4 dbm or greater.

(2) Reset the gain control for +1 dbm output.

f. Distortion.

(1) With the output level set for 0 dbm at full modulation (±.5 microsecond), insert a —10-dbm signal into the modulator as follows:

(*a*) Connect the SEND OUT front panel jacks on the audio test set to the 4W TRANS binding posts of the particular modem being tested.

(*b*) Set the audio test set SEND-DBM knob for —10.

(2) Measure the demodulator output distortion on the audio test set as follows:

(*a*) Push the control monitor REC push button.

(*b*) Turn the selector switch on the particular modem being tested to the RR position.

(*c*) Push the audio test set DIST AT 1000 ∽ button.

(*d*) Rotate the audio test set RECEIVE-DBM knob until a readable value is obtained on the audio test set meter.

(*e*) The distortion is the sum of the meter reading and the RECEIVE-DBM knob setting. The distortion should not be greater than —33 dbm.

(3) Reset the demodulator output to 0 dbm with full modulation.

g. Signal-to-noise Ratio. Remove the modulation and measure the noise at the demodulator output. It should not exceed —65 dbm.

314. Modem Modulator Tests, Two-wire Operation

a. Refer to paragraph 313*a* for operating procedures and hook up.

b. Modulate the channel pulse with a 1,000-cps tone from the audio test set. The input level for ±.5 microsecond should be 0 dbm ±1 dbm.

315. Modem Demodulator Tests, Four-wire Operation

The following tests are used for reference and as test procedures after major repairs. Refer to paragraph 313*a* for operation procedures for two-wire and four-wire operations.

a. Limiting Characteristics (Spot Check).

(1) Set the OUTPUT AUDIO GAIN control for 0 dbm output with full modulation (±.5 microsecond).

(2) Connect an external audio oscillator (Signal Generator SG–71/FCC, or equivalent) to the 4W TRANS binding posts (modulator section) of the modem being tested. Insert a 1,000-cps signal at the levels given below, and measure the modem demodulator output as follows:

(*a*) Set the particular modem selector switch to the RR position.

(*b*) Push the control monitor REC push button.

(*c*) Push the audio test set F1A push button.

(*d*) Rotate the audio test set RECEIVE-DBM knob until a readable value is obtained on the audio test set meter.

(*e*) The output is the sum of the meter reading and the RECEIVE-DBM knob setting. The demodulator output should not vary by more than the values given below. The limiting level normally is that which produced ±.5 usec pulse duration.

Modulator input	Demodulator output
+4 dbm, .49 v rms	0 ±2.5 dbm
+6 dbm, 1.55 v rms	—6 ±2.5 dbm
+16 dbm, 4.9 v rms	—8 ±2.5 dbm

(3) For a three-point curve instead of a two-point curve, repeat the procedure given in (2) above, including the additional point of —24-dbm modulator input giving a +9 ±.4 0-dbm demodulator output.

b. Frequency Characteristics (Spot Check).

(1) Connect the external audio oscillator to the particular modem 4W TRANS binding posts.

(2) Set the external audio oscillator for —4 dbm at 1,000 cps, and the modem OUTPUT AUDIO GAIN control for 0 dbm.

(3) Measure the demodulator output at 300 cps and 3,500 cps with a constant

signal level of +4 dbm into the modulator (*a* (2) above). The demodulator output reading should be +2 dbm at both frequencies. The modulator input should be taken from the external audio oscillator and the demodulator output should be measured on the audio test set.

(4) For a six-point curve instead of a three-point curve, repeat the procedure given in (3) above, including the additional frequencies of 600, 2,000, and 3,000 cps.

c. Input and Output Impedances. The two-wire and four-wire input and output impedances should be 600 ohms +10 per cent at 1,000 cps.

(1) *Input impedance, four-wire.* To find the input and output impedance, use Signal Generator SG–71/FCC, Electronic Multimeter TS–505/U, and Decade Resistor TS–679/U and follow the procedure below:

(*a*) Connect the decade resistor in series between one output terminal of the signal generator and terminal T on plug P1 of the modem under test.

(*b*) Connect the other signal generator terminal directly to terminal W of plug P1 of the modem under test.

(*c*) Set the decade resistor at 600 ohms and the signal generator at 1 kilocycle with an output of .25 volt rms.

(*d*) With the vtvm, read the voltage across terminals T and W of the modem under test and the voltage at the terminals of the decade resistor. If both voltage readings are the same, the impedance at modem terminals T and W is 600 ohms.

(*e*) If the voltage readings across the modem terminals and the decade resistor are not the same, change the resistance value of the decade resistor until identical voltages are read. The resistance reading of the the decade resistor will then indicate the impedance value at the modem terminals.

(2) *Output impedance, four-wire.* To measure the output impedance for four-wire operation of the modem, follow the procedure described in (1) above, substituting terminals U and X for terminals T and W on plug P1.

(3) *Input and output impedances, two-wire.* To measure the input and output impedances for two-wire operation of the modem, follow the procedure described in (1) above, substituting terminals U and X for T and W.

d. Modem Panel Switch Operation. The modem panel switch operations can be tested as follows:

(1) Monitor the demodulator output (four-wire REC terminal) on the audio test set. Place the control monitor switch in the SEND position and the test set SEND-DBM at —4 dbm.

(*a*) With the modem switch in the SR position, the channel pulse should be modulated and the meter on the audio test set should indicate 0 dbm. (It is assumed that the OUTPUT AUDIO GAIN control is still set for 0 dbm output with —4 dbm input.)

(*b*) With the modem switch in the SL position, the channel should no longer be modulated and the audio test set meter should indicate —4 dbm.

(2) Connect the audio test set SEND OUT terminals to the modulator input (four-wire TRANS terminals). Place the control monitor switch in the REC position.

(*a*) With the modem switch in the RR position, the pulse should be modulated and the valve on the test set meter should indicate 0 dbm.

(*b*) With the modem switch in the RL position, the pulse should not be modulated and the audio test set meter should indicate —4 dbm.

e. Ringing Circuits. Inject a 20-cps, 100-volt signal into the modulator (with Telephone EE–

8–B or by placing the control monitor switch in the SEND position, the modem switch in the SR position, and pressing the RING switch on the control monitor). The channel pulse should be blanked out and the demodulator output should have ringing voltage across it (20 cps, 100 volts). A Telephone EE–8–B connected across the demodulator output (four-wire REC) should ring.

f. Terminal Balance to Ground (Input and Output). Construct a bridge as shown in figure 284. When constructing the bridge, select resistors (600 ohms ±5 per cent) to give a zero reading on meter V with the bridge connected to the equipment but the ground connection, from junction R1 and R3, open. Reconnecting the ground connection should produce a voltage reading (V) depending on the unbalance.

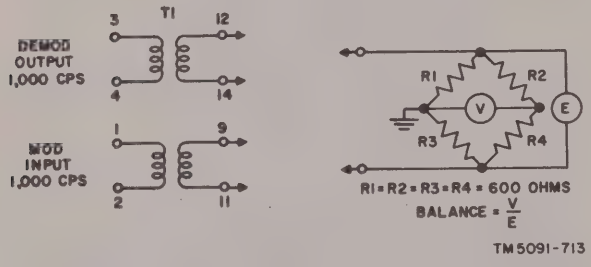


Figure 284. Terminal balance to ground test setup.

(1) Apply a 1,000-cps signal, from an external signal generator, to terminals 1 and 2 of transformer T1. Connect the bridge to terminals 9 and 11. Note the reading on the voltmeters (V and E). The ratio $\frac{V}{E}$ should be less than .01.

(2) Apply a 1,000-cps signal, from an external signal generator or the audio test set, to terminals 3 and transformer T1. Connect the bridge network across terminals 12 and 14. Note the readings on the meters (V and E). The ratio $\frac{V}{E}$ should be less than .01.

g. Output Level. Use a test AN/TCC–13 with its corresponding channel being modulated ±.5 microsecond and monitor the demodulator output on the test channel. Vary the OUTPUT AUDIO GAIN control from maximum to minimum. The output should vary from +4 dbm to +6 dbm.

316. Modem Demodulator Tests, Two-wire Operation

a. Input Impedance. Refer to paragraph 315*c*.

b. Modem Panel Switch Operation. Monitor the two-wire line terminals on the audio test set. Place the control monitor switch in the SEND position, and the audio test set SEND-DBM control at —4 dbm. (Be sure that the corresponding channel is not being modulated in the other terminal.)

(1) With the modem switch at SR or RR, modulate the pulse. The audio test set should not read.

(2) With the modem switch at SL or RL, do not modulate the pulse, and the audio test set should read +4 dbm.

c. Transhybrid Loss. Use the accompanying test circuit (fig. 285) and adjust the input source for E to be 0 dbm (.775 volt). Ed will equal approximately 8.5 volts. Measure Em/Ed, the transhybrid loss. It should be at least 40 db. The hybrid transformer is tested in the modem. Leads to terminals 1 and 2 of T1 must be opened and the test circuit inserted as shown in figure 285. Similarly, the lead between C19 and terminal 12 of T1 must be opened and the 620-ohm resistor inserted.

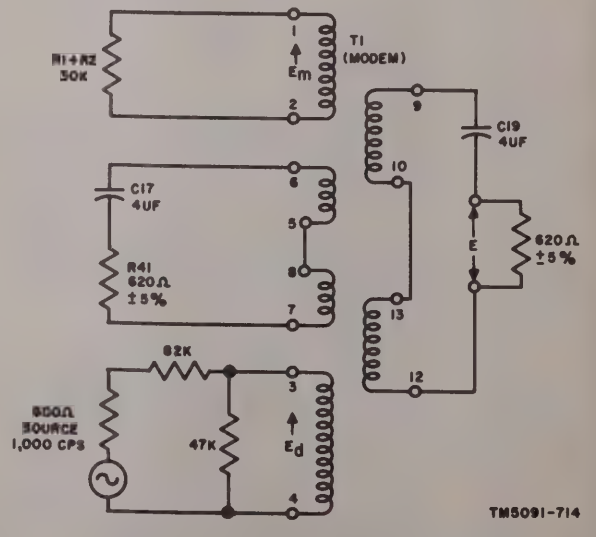


Figure 285. Transhybrid test setup.

317. Modem Dc Resistance of Transformers, Coils and Relays

The dc resistance of all transformer windings coils and relays are listed below. An asterisk (*) indicates an ohmmeter reading of less than 1 ohm.

Transformer, coil, or relay	Terminals	Ohms	Transformer, coil, or relay	Terminals	Ohms
K1	1–5	19K		9–10	13
K2		4,800	T1	10–11	6
L1, L3		5.5		9–11	19
L2		*		12–13	19
T1	1–2	650		13–14	10.5
	3–4	1,525		12–14	29.5
	5–6	12.7	Z1	1–2	1,000
	7–8	19.2		1–3	1,000

Section VI. TROUBLE SHOOTING DELAY LINES

318. Delay Line Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the delay line.

Fig. No.	Description
375	Multiplexer Set AN/TCC–13, delay line, schematic diagram.
376	Multiplexer Group AN/TCA–1, delay line, schematic diagram.
377	Pulse Form Restorer Group AN/TRA–10, delay line, schematic diagram.
400	Multiplexer Set AN/TCC–13, delay line, wiring diagram.
401	Multiplexer Group AN/TCA–1, delay line, wiring diagram.
402	Pulse Form Restorer Group AN/TRA–10, delay line, wiring diagram.
286	Multiplexer Set AN/TCC–13, delay line, rear view.
287	Multiplexer Group AN/TCA–1, delay line, rear view, location of parts.
288	Pulse Form Restorer Group AN/TRA–10, delay line, rear view, location of parts.

319. Test Equipment Required for Delay Line

Oscilloscope OS–25/G or Oscilloscope AN/USM–50 is the only test equipment required to trouble shoot the delay line.

320. Delay Line Test Procedure

Never attempt repairs on the delay line unless it is absolutely necessary. Follow the test procedures below.

Note. When performing the following continuity checks on the AN/TCA–1 and AN/TRA–10, remove all D&I-THRU and PARTY LINE-PRIV plugs.

a. Initial Connections.

(1) *Multiplexer Set AN/TCC–13.* The multiplexer set delay line consists of two 125-microsecond delay lines; inputs for these lines are through MTPX GATE INPUT jack J1 and DEMTPX GATE INPUT jack J3. Connector J6 in the multiplexer should be connected to either J1 or J3, depending on which line is being tested. *Both lines must be tested separately.* Refer to figure 400, the wiring diagram of the delay line, for information as to arrangement of all sections.

(2) *Multiplexer Group AN/TCA–1.* The multiplexer group delay line consists of four 40-usec delay lines, the inputs of which are J1, J2, J3, and J4. DEMTPX GATE OUTPUT jack J8 of the video restorer should be connected to either J1, J2, J3, or J4, depending on which line is being tested. *All lines must be tested separately.* Refer to the delay line wiring diagram (fig. 402) for the arrangement of all sections.

(3) *Pulse Form Restorer Group AN/TRA–10.* The pulse form restorer delay line consists of four 10-microsecond delay lines the inputs of which are J1, J2, J3, and J4. DEMTPX GATE OUTPUT jack J8 of the video

restorer should be conected to either J1, J2, J3, or J4, depending on which line is being tested. *All lines must be tested separately.* Refer to the delay line wiring diagram (fig. 403) for information as to the arrangement of all sections.

b. Reflections. The negative gate input to the delay line should be observed on a scope which is synchronized from the SCOPE SYNC jack. There should be no negative reflections at the input greater than 10 per cent and no positive reflection greater than 20 per cent. A check should be made at each tap to see that there are no double pulses.

c. Time Delay. With the oscilloscope still being synchronized, observe the delay line output as indicated below.

Note. Timing pips 5.2 microseconds apart can be obtained from Oscilloscope OS–25/G for testing purposes.

(1) *Multiplexer Set AN/TCC–13.* The time delay from input pulse to output pulse across the 3,900-ohm terminating resistor should be 125 +4.0 microseconds, measured between the 50 per

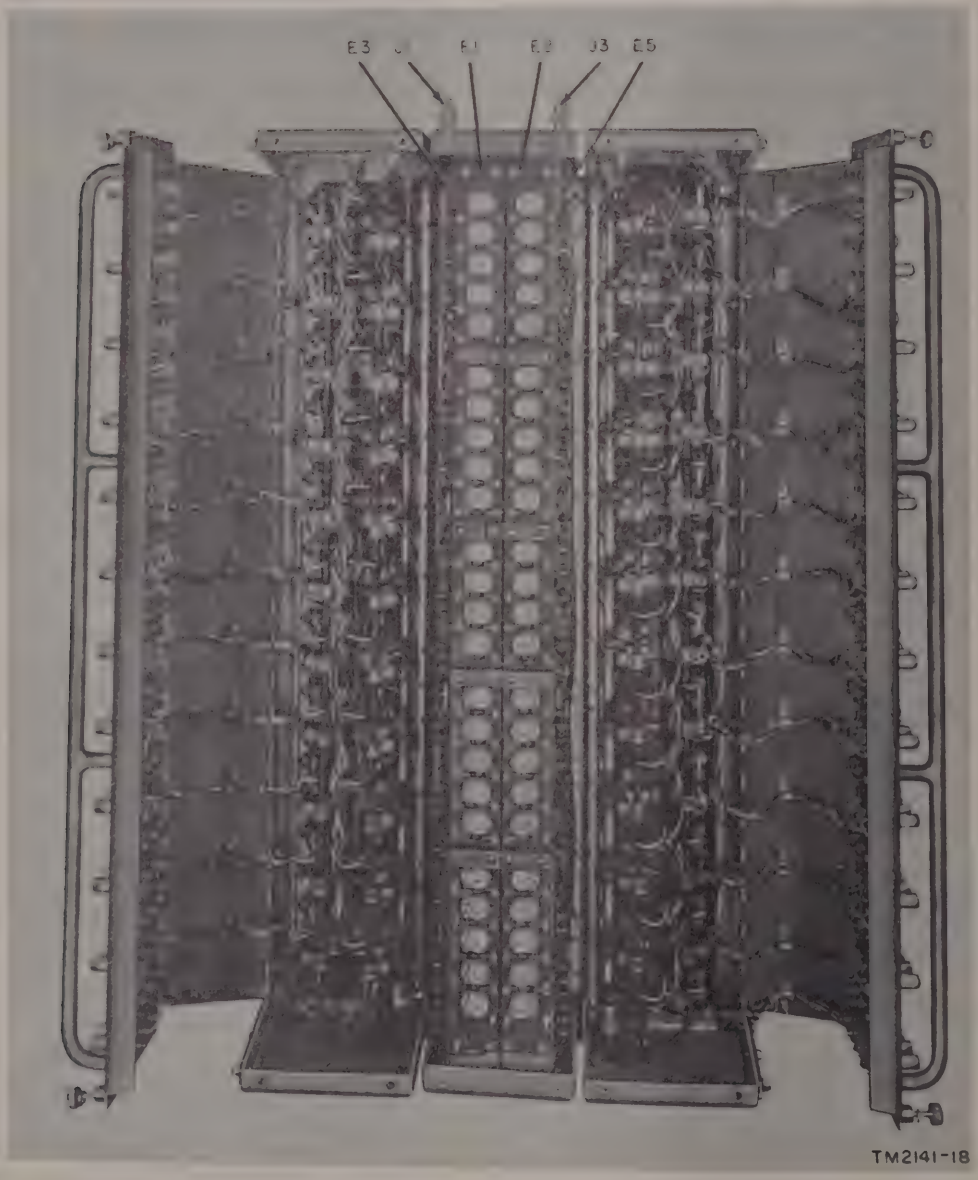


Figure 286. Multiplexer Set AN/TCC–13 delay line, rear view.

cent amplitude points of the leading edge.

(2) *Multiplexer Group AN/TCA–1.* The time delay from input pulse to output pulse across terminating resistors R9, R18, R27, and R35 should be 41 usec minimum and 45 usec maximum, measured between the 50 per cent amplitude points of the leading edge.

(3) *Pulse Form Restorer Group AN/TRA–10.* The time delay from input to output pulse across the 3,000-terminating resistor (R2 or R11, or 2,700 resistor R50Y R9) should be 9 micro-

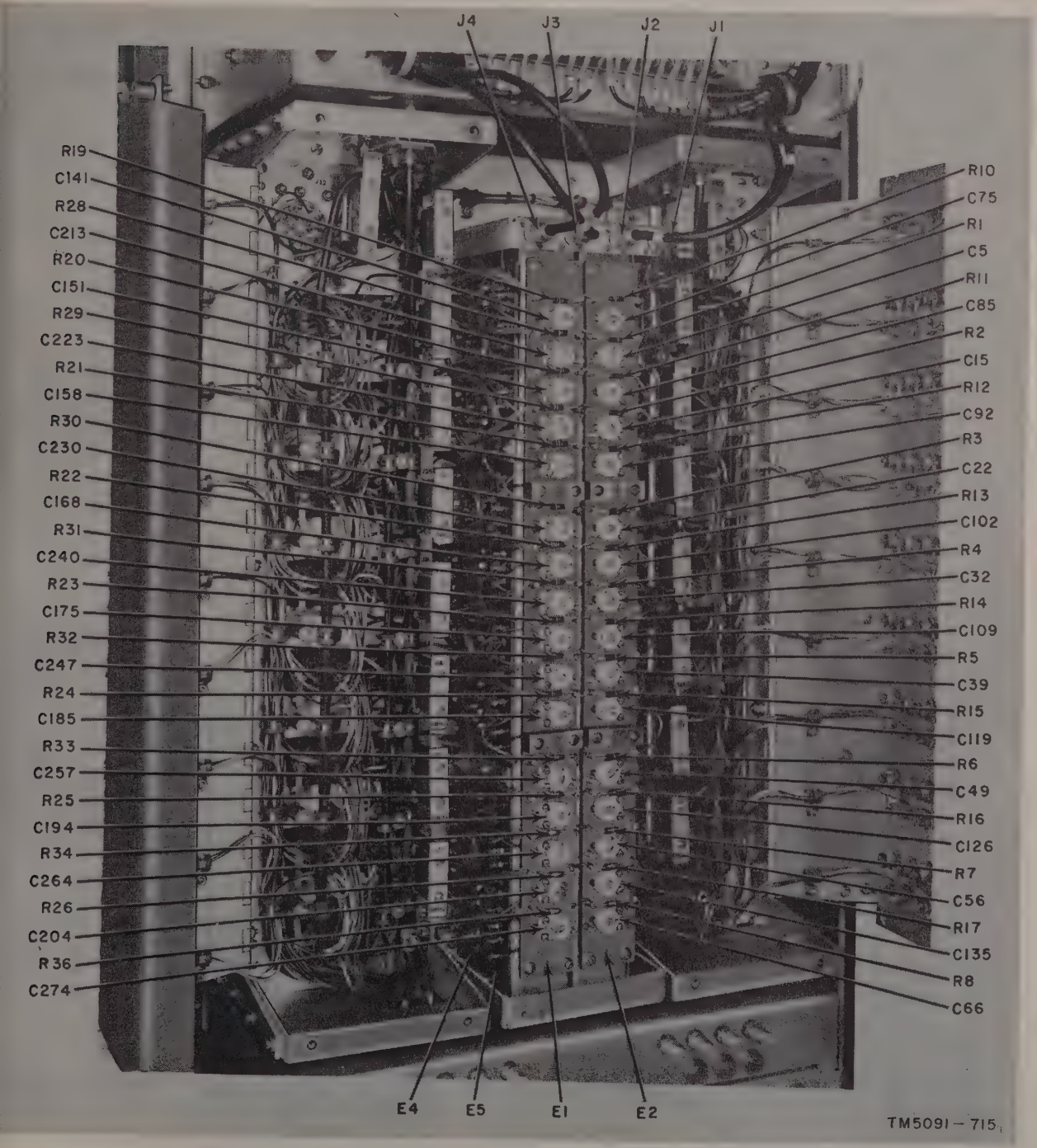


Figure 287. Multiplexer Group AN/TCA–1, rear view, location of parts.

seconds minimum and 11 microseconds maximum measured between the 50 per cent amplitude points of the leading edge.

Note. In Electrical Equipment Rack MT–1434/TRA–10, the values of R5 and R9 are 2,700 ohms. This is necessary to reduce the reflections that appear on the multiplexer gate wave form.

d. Attenuation. The output pulse of the multiplexer set should be at least 50 volts in amplitude. The amplitude of the output pulse of the multiplexer group and pulse form restorer group should be at least 85 per cent that of the input pulse.

321. Delay Line Trouble-shooting Chart

The following chart will assist maintenance personnel in trouble shooting the delay line.

Symptom	Probable trouble	Correction
1. Bad reflections.	1. Open or shorted coil; check resistance between taps of coils (approximately 40 ohms).	1. Replace delay line sections.
	Open coil or shorted capacitor; check resistance to ground from coil junctions (should be greater than 4,000 ohms).	Replace delay line sections.
2. No sawtooth.	2. Check lead to modem for short. Modem modulator is pin C, modem demodulator is pin E of modem receptacle on mounting rack or of modem plug P1.	2. Replace delay line sections.

322. Delay Line Dc Resistance of Coils

The dc resistance of coils L1 through L4 is 1,800 ohms.

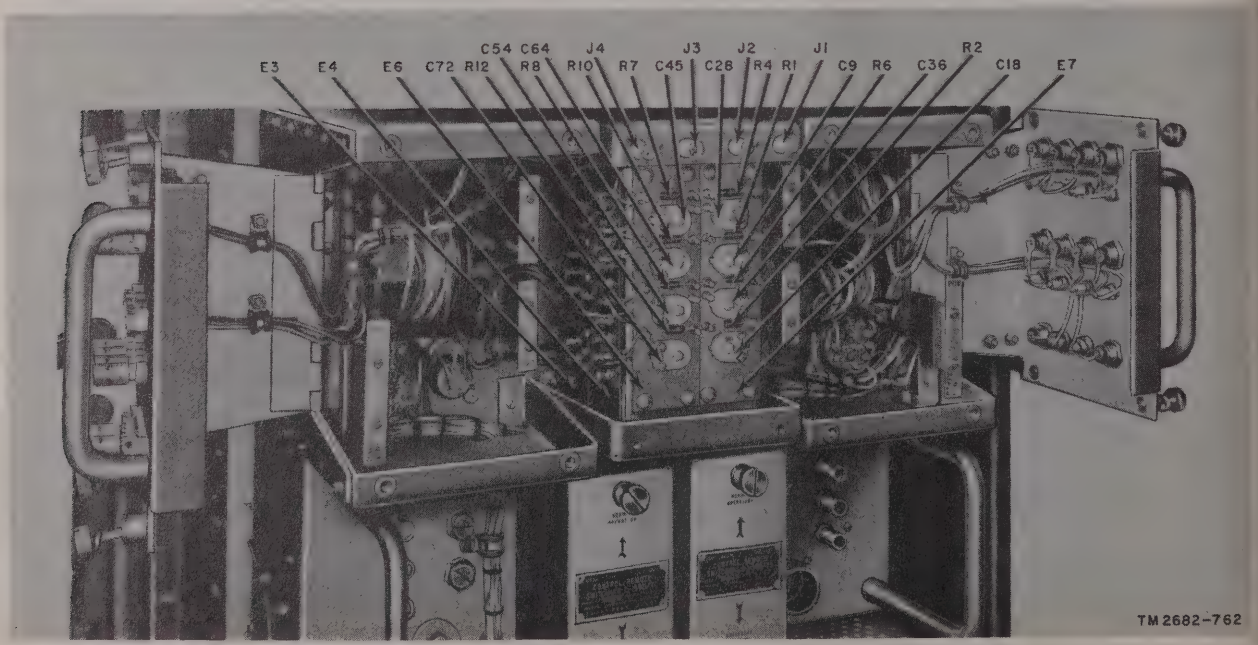


Figure 288. Pulse Form Restorer Group AN/TRA–10 delay line, rear view, location of parts.

323. Mounting Rack MT-1165/TCC-13 Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the mounting rack.

Fig. No.	Description
372	Electrical Equipment Rack MT-1165/TCC-13, over-all schematic diagram.
397	Electrical Equipment Rack MT-1165/TCC-13, over-all wiring diagram.
289	Electrical Equipment Rack MT-1165/TCC-13, front view showing delay line connection jacks.
290	Ac power distribution diagram (AN/TCC-13 and AN/TCA-1).

324. Test Procedure and Test Equipment Required for Mounting Rack

a. Test Equipment. The only test equipment required for trouble shooting the mounting rack is Multimeter TS-352/U.

b. Test Procedure. The only test to be made in trouble shooting the mounting rack is that for continuity. Make the following circuit continuity checks as shown:

Note. Refer to the multiplexer set electrical equipment rack wiring diagram, figure 372, for location of all terminals, pin connections and connectors. When checking continuity, orient the wiring diagram so that the blank connector for the spare modem (J27) is in the same position as the same blank connector on the equipment. Terminal board TB3A, T1 and T2 are located on the Multiplexer Subassembly MX-1442/TC.

c. Filament Circuit.

(1) Check for a short circuit between:
T2–4 and pin S of J4 through J15.
T1–4 and pin S of J16 through J26.
T2–4 and chassis ground.
T1–4 and chassis ground.
T2–3 and pin F of J4 through J15.
T1–3 and pin F of J16 through J26.

(2) Check for an open circuit between:
T2–4 and T2–3.
T2–3 and T1–3.
T1–3 and T1–4.

d. B+ Circuit.

(1) Check for a short circuit between:
J4–D, J5–D, J6–D, J6–H, J7–H, J7–D, J8–D, J8–H, J9–H, J9–D.
J10–H, J10–D, J11–D, J11–H, J12–H, J12–D, J13–D, J13–H, J14–H, J14–D, J15–D, J15–H.
J16–D, J16–H, J17–H, J17–D, J18–D, J18–H, J19–H, J19–D, J20–D, J20–H, J21–H, J21–D.
J22–D, J22–H, J23–H, J23–D, J24–D, J24–H, J25–H, J25–D, J26–D, J26–H.

(2) Check for an open circuit between the four B+ groups coming respectively from terminals TB3A–2, TB3A–3, and TB3A–4. If continuity within groups exists, then check for an open circuit between: J4–D, J10–D, J16–D, J22–D, and no continuity from ground to J4–D, J10–D, J16–D, J22–D.

e. Two-wire and Four-wire Circuits.

(1) Check for continuity between the 4W TRANS pair of the applicable modem channel and pins W and T for J4 through J26.

(2) Check for continuity between the applicable modem channel 4W REC-2W LINE pair and pins U and X for J4 through J26.

f. Connector Pin Continuity Checks. Check for continuity between:

J28 and pins V of J4 through J26.

Pins R of J4 through J15, and J16 through J26.

Pins N of J6 through J15, and J16 through J26.

Pins P of J6 through J15, and J16 through J26.

Pins M of J4 through J15, and J16 through J26.

Pins L of J4 through J15, and J16 through J26.

J29 and pins K of J4 through J26.

Pins J of J6 through J9, J10 through J15, J16 through J21, and J22 through J26.

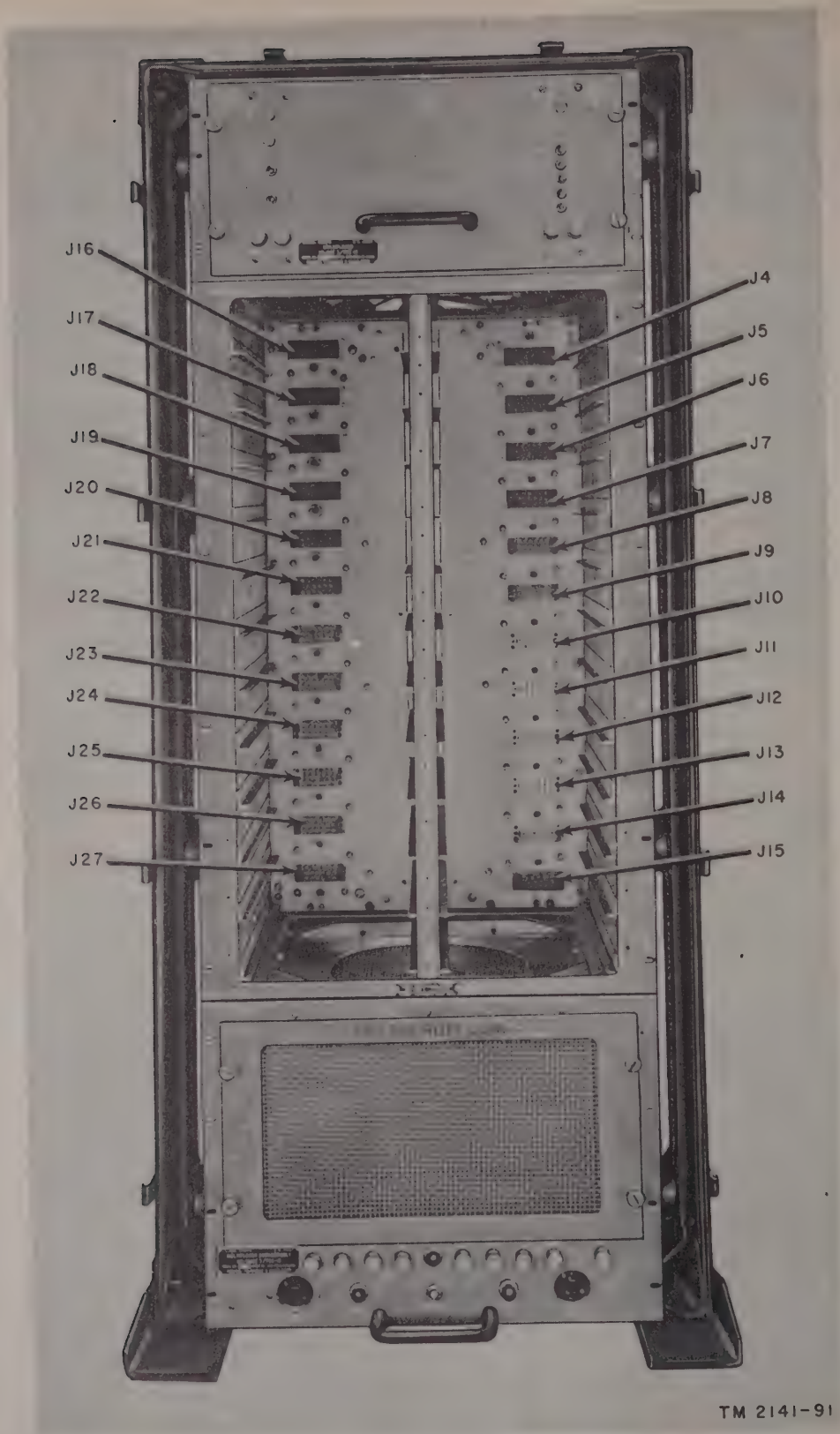
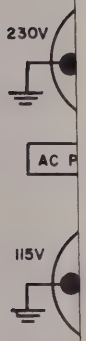


Figure 289. Electrical Equipment Rack MT–1165/TCC–13 front view showing delay line connection jacks.


230V
AC P
115V

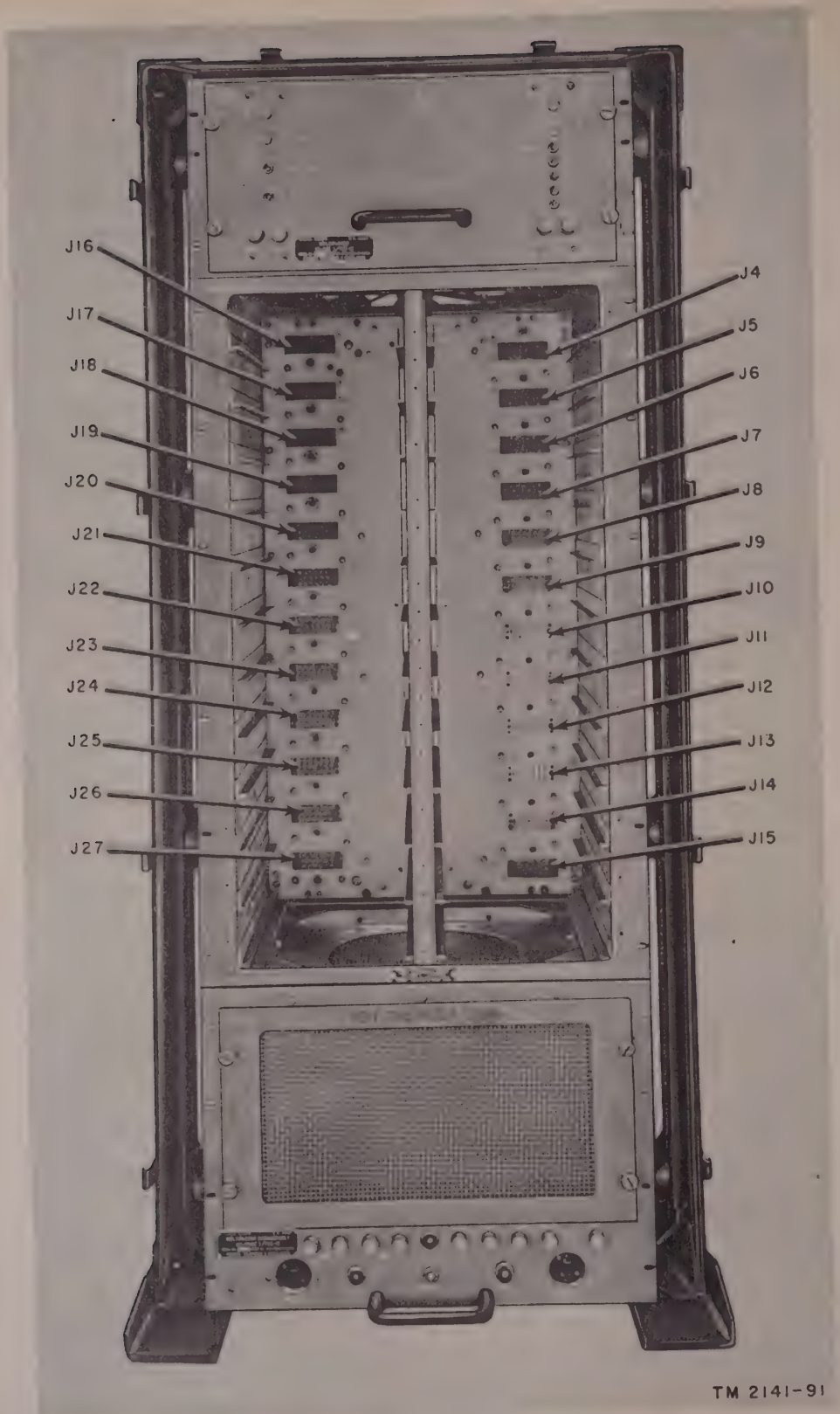


Figure 289. Electrical Equipment Rack MT–1165/TCC–13 front view showing delay line connection jacks.

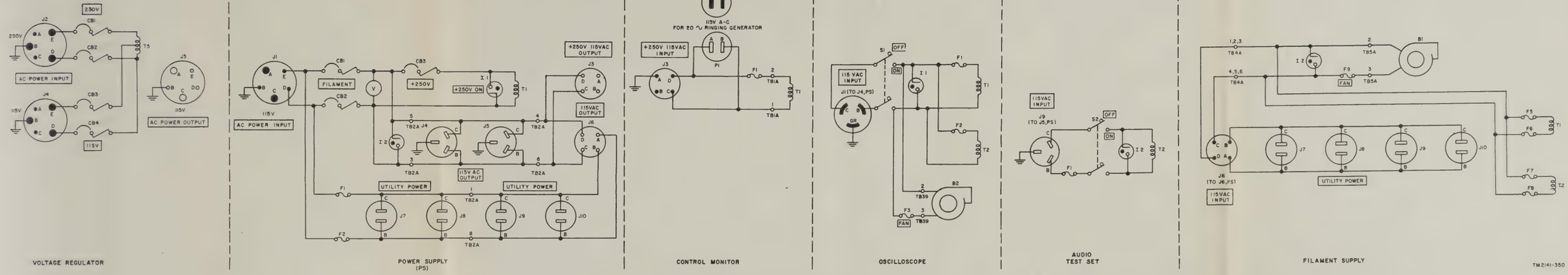


Figure 290. Ac power distribution diagram (AN/TCC–13 and AN/TCA–1).

Section VIII. TROUBLE SHOOTING ELECTRICAL EQUIPMENT RACK MT-1433/TCA-1

325. Electrical Equipment Rack MT-1433/TCA-1 Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the mounting rack:

Fig. No.	Description
373	Electrical Equipment Rack TM-1433/TCA-1 over-all schematic diagram.
398	Electrical Equipment Rack MT-1433/TCA-1, over-all wiring diagram.
291	Electrical Equipment Rack MT-1433/TCA-1, front view modems removed.
292	Electrical Equipment Rack MT-1433/TCA-1, rear view, doors open.
290	Ac power distribution diagram (AN/TCC-13 and AN/TCA-1).

326. Test Procedure and Test Equipment Required for Mounting Rack MT-1433/TCA-1

a. Test Equipment. The only test equipment required for trouble shooting the mounting rack is Multimeter TS-352B/U.

b. Test Procedure. The only test to be made for trouble shooting the mounting rack is that for continuity. Make the following circuit continuity checks:

Note. Refer to the multiplexer group electrical equipment rack wiring diagram, figure 398, for the location of all terminals, pin connections and connectors. When checking continuity, orient the wiring diagram so that transformers T1 and T2 are in the same position as the same transformers on the rack. Refer to figure 393 for external wiring connections of T1, T2, J11, J12, J13, J14 and Terminal boards E152 and E153.

c. Filament Circuit.

(1) Check for a circuit between the following points:
E149 and pin F of J15, J19, J23, J27, J31, J35, J39 and J43.
E146 and pin F of J16, J20, J24, J28, J32, J36, J40 and J44.
E147, E148, and chassis ground.
E148 and pin S of J15, J19, J23, J27, J31, J35, J39, and J43.
E147 and pin S of J16, J20, J24, J28, J32, J36, J40, and J44.

(2) Check for an open circuit between E148 and E149 and E146 and E147.

d. B+ Circuit.

(1) Check for a short circuit between the following points:
J15D, J19D, J23D, J23H, J27D and J27H.
J31D, J31H, J35D, J35H, J39D, J39H, J43D and J43H.
J16D, J20D, J24D, J24H, J28D and J28H.
J32D, J32H, J36D, J36H, J40D, J40H, J44D and J44H.

(2) Check for an open circuit between the four B+ groups. If continuity within the above groups exists, then check for an open circuit between J15D, J31D, J16D, J32D, and an open circuit from ground to J15D, J31D, J16D, J32D.

e. Two-wire and Four-wire Circuits.

(1) *4W TRANS.* Check for continuity between the applicable modem channel 4W TRANS pair and pins T and W for J15, J16, J19, J20, J23, J24, J27, J28, J31, J32, J35, J36, J39, J40, J43 and J44.

(2) *4W REC-2W LINE.* Check for continuity between the applicable modem channel 4W REC-2W LINE pair and pins U and X for J15, J16, J19, J20, J23, J24, J27, J28, J31, J32, J35, J36, J39, J40, J43, and J44.

f. PARTY LINE-PRIV Circuit. Check for continuity between the following points:
Pin A of 11 to pin U of J16.
Pin B of J11 to pin 4 of T1.
Pin C of J11 to pin W of J15.
Pin E of J11 to pin X of J16.
Pin H of J11 to C276.
Pin J of J11 to pin T of J15.
Pin L of J11 to pin T of J16.
Pin P of J11 to pin W of J15.
Pin S of J11 to pin 2 of T1.
Pin T of J11 to pin W of J16.
Pin V of J11 to pin U of J15.
Pin U of J11 to C277.

Pin A of J12 to pin U of J20.
Pin B of J12 to pin 4 of T2.
Pin C of J12 to pin W of J19.
Pin E of J12 to pin X of J20.
Pin H of J12 to C282.
Pin J of J12 to pin T of J15.
Pin L of J12 to pin T of J16.
Pin P of J12 to pin W of J15.
Pin S of J12 to pin 2 of T2.
Pin T of J12 to pin W of J16.
Pin V of J12 to pin U of J15.
Pin U of J12 to C283.

g. D&I-THRU Circuits.

(1) Check for continuity between the following points:
Pin A of J13 to chassis ground.
Pin F of J13 to E4–3 of delay line.
Pin L of J13 to chassis ground.
Pin M of J13 to pin C of J16.
Pin P of J13 to J5.
Pin R of J13 to E2–4 of delay line.
Pin A of J14 to chassis ground.
Pin F of J14 to E5–3 of delay line.
Pin L of J14 to chassis ground.
Pin M of J14 to pin C of J15.
Pin P of J14 to J10.
Pin R of J14 to E1–3 of delay line.
Pin A of J17 to chassis ground.
Pin F of J17 to E4–8 of delay line.
Pin L of J17 to chassis ground.
Pin M of J17 to pin C of J20.
Pin P of J17 to J5.
Pin R of J17 to E2–8 of delay line.
Pin A of J18 to chassis ground.
Pin F of J18 to E5–8 of delay line.
Pin L of J18 to chassis ground.
Pin M of J18 to pin C of J19.
Pin P of J18 to J10.

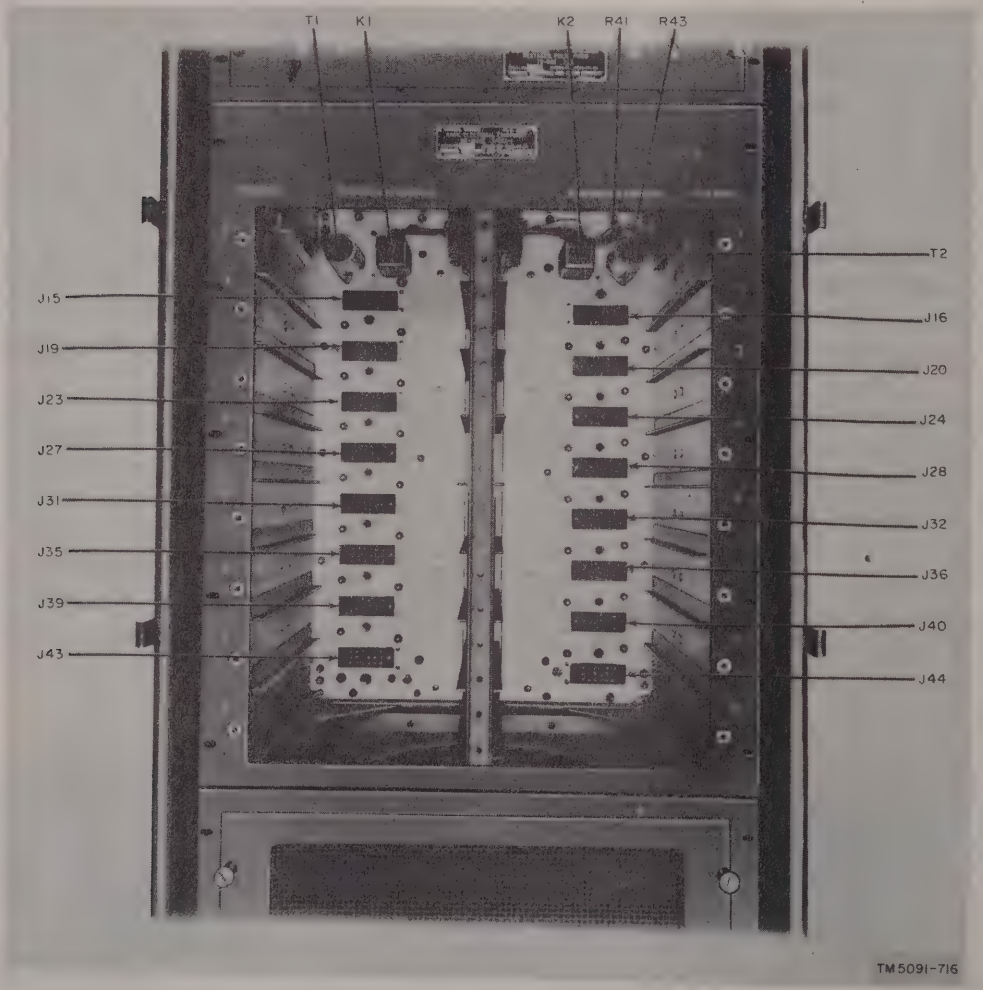


Figure 291. Electrical Equipment Rack MT–1433/TCA–1, front view, modems removed.

Pin R of J18 to E1–7 of delay line.
Pin A of J21 to chassis ground.
Pin F of J21 to E4–13 of delay line.
Pin L of J21 to chassis ground.
Pin M of J21 to pin C of J24.
Pin P of J21 to J5.
Pin R of J21 to E2–12 of delay line.
Pin A of J22 to chassis ground.
Pin F of J22 to E5–13 of delay line.
Pin L of J22 to chassis ground.
Pin M of J22 to pin C of J23.
Pin P of J22 to J10.
Pin R of J22 to E1–11 of delay line.
Pin A of J25 to chassis ground.
Pin F of J25 to E4–18 of delay line.
Pin L of J25 to chassis ground.
Pin M of J25 to pin C of J28.
Pin P of J25 to J5.
Pin R of J25 to E2–16 of delay line.
Pin A of J26 to chassis ground.
Pin F of J26 to E5–18 of delay line.
Pin L of J26 to chassis ground.
Pin M of J26 to pin C of J27.
Pin P of J26 to J10.
Pin R of J26 to E1–15 of delay line.
Pin A of J29 to chassis ground.
Pin F of J29 to E4–23 of delay line.
Pin L of J29 to chassis ground.
Pin M of J29 to pin C of J32.
Pin P of J29 to J5.
Pin R of J29 to E2–20 of delay line.
Pin A of J30 to chassis ground.
Pin F of J30 to E5–23 of delay line.
Pin L of J30 to chassis ground.
Pin M of J30 to pin C of J31.
Pin P of J30 to J10.
Pin R of J30 to E1–19 of delay line.
Pin A of J33 to chassis ground.
Pin F of J33 to E4–28 of delay line.
Pin L of J33 to chassis ground.
Pin M of J33 to pin C of J36.
Pin P of J33 to J5.
Pin R of J33 to E2–24 of delay line.
Pin A of J34 to chassis ground.
Pin F of J34 to E5–28 of delay line.
Pin L of J34 to chassis ground.
Pin M of J34 to pin C of J35.
Pin P of J34 to J10.
Pin R of J34 to E1–23 of delay line.
Pin A of J37 to chassis ground.
Pin F of J37 to E4–33 of delay line.
Pin L of J37 to chassis ground.
Pin M of J37 to pin C of J40.
Pin P of J37 to J5.
Pin R of J37 to E2–28 of delay line.
Pin A of J38 to chassis ground.
Pin F of J38 to E5–33 of delay line.
Pin L of J38 to chassis ground.
Pin M of J38 to pin C of J39.
Pin P of J38 to J10.
Pin R of J38 to E1–27 of delay line.
Pin A of J41 to chassis ground.
Pin F of J41 to E4–38 of delay line.
Pin L of J41 to chassis ground.
Pin M of J41 to pin C of J44.
Pin P of J41 to J5.
Pin R of J41 to E2–26 of delay line.
Pin A of J42 to chassis ground.
Pin F of J42 to E5–38 of delay line.
Pin L of J42 to chassis ground.
Pin M of J42 to pin C of J43.
Pin P of J42 to J10.
Pin R of J42 to E1–31 of delay line.

(2) Check for continuity between the following points:

Pin E of J15 to E2–2 of delay line.
Pin E of J16 to E1–1 of delay line.
Pin E of J19 to E2–6 of delay line.
Pin E of J20 to E1–5 of delay line.
Pin E of J23 to E2–10 of delay line.
Pin E of J24 to E1–9 of delay line.
Pin E of J27 to E2–14 of delay line.
Pin E of J28 to E1–13 of delay line.
Pin E of J31 to E2–18 of delay line.
Pin E of J32 to E1–17 of delay line.
Pin E of J35 to E2–22 of delay line.
Pin E of J36 to E1–21 of delay line.
Pin E of J39 to E2–26 of delay line.
Pin E of J40 to E1–25 of delay line.
Pin E of J43 to E2–30 of delay line.
Pin E of J44 to E1–29 of delay line.

h. Miscellaneous. Check for continuity between the following points:

J6 and pin V of J15, J19, J23, J27, J31, J35, J39, J43.
J9 and pin V of J16, J20, J24, J28, J32, J36, J40, J44.
J7 and pin K of J15, J19, J23, J27, J31, J35, J39, J43.
J8 and pin K of J16, J20, J24, J28, J32, J36, J40, J44.
Pin P of J23, J27, J31, J35, J39, J43.
Pin P of J24, J28, J32, J36, J40, J44.

Pin N of J23, J27, J31, J35, J39, J43.
Pin N of J24, J28, J32, J36, J40, J44.
Pin R of J15, J19, J23, J27, J31, J35, J39, J43.
Pin R of J16, J20, J24, J28, J32, J36, J40, J44.
Pin J of J23, J27.
Pin J of J24, J28.
Pin J of J31, J35, J39, J43.
Pin J of J32, J36, J40, J44.
Pin M of J15, J19, J23, J27, J31, J35, J39, J43.
Pin M of J16, J20, J24, J28, J32, J36, J39, J44.
Pin L of J15, J19, J23, J27, J31, J35, J39, J43.
Pin L of J16, J20, J24, J28, J32, J36, J40, J44.

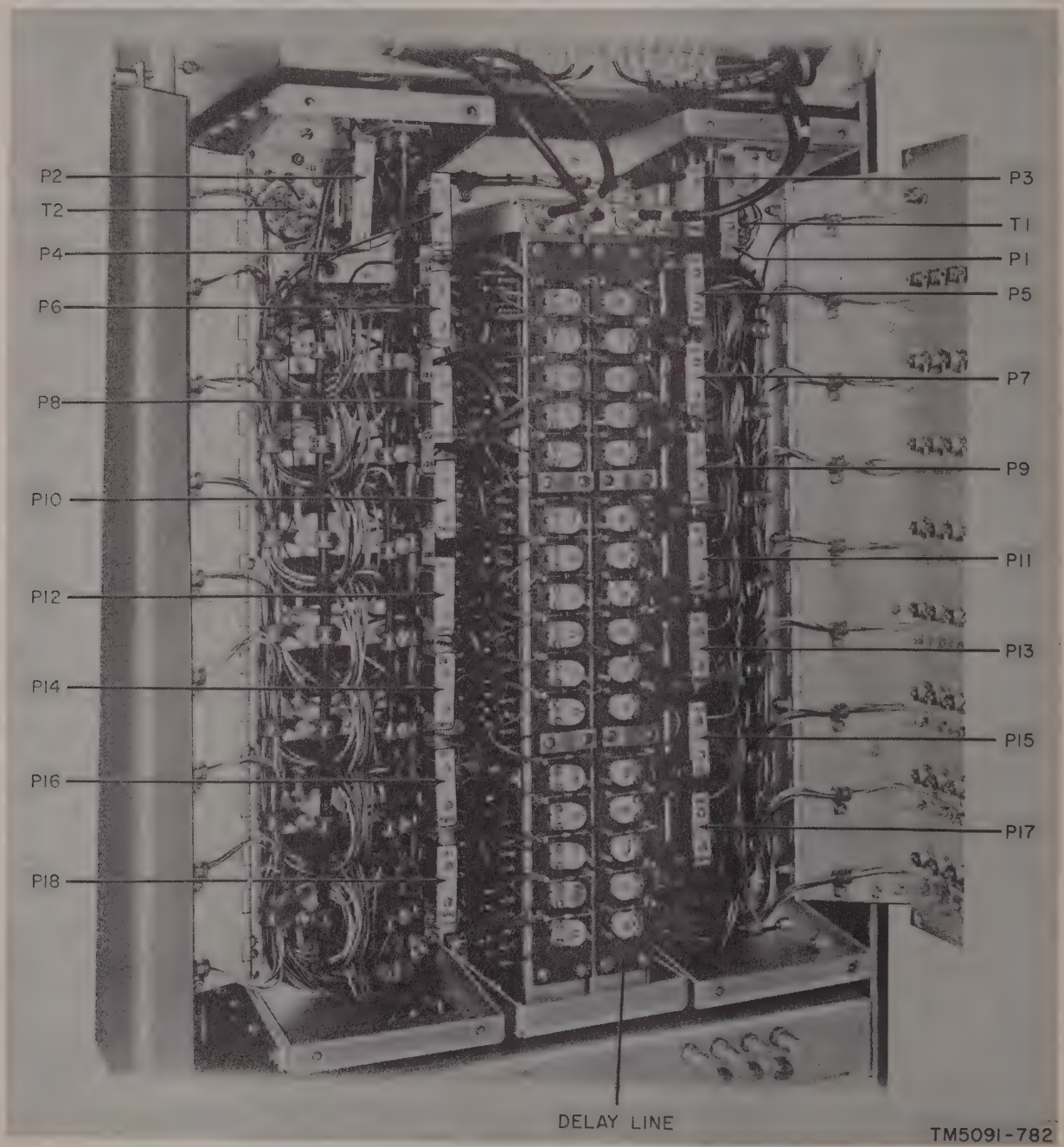


Figure 292. Electrical Equipment Rack MT-1433/TCA-1, rear view, door open.

327. Electrical Equipment Rack MT-1434/TRA-10 Trouble-shooting Data

The following data will assist maintenance personnel in trouble shooting the mounting rack.

Fig. No.	Description
374	Electrical Equipment Rack MT-1434/TRA-10, over-all schematic diagram.
399	Electrical Equipment Rack MT-1434/TRA-10, over-all wiring diagram.
293	Electrical Equipment Rack MT-1434/TRA-10, front view, drawer and modems removed.
294	Electrical Equipment Rack MT-1434/TRA-10, drawer, left side view.
295	Electrical Equipment Rack MT-1434/TRA-10, drawer right side view.
296	Electrical Equipment Rack MT-1434/TRA-10, rear view, doors open.
297	Electrical Equipment Rack MT-1434/TRA-10, tube voltage and resistance diagram.
301	Remote keying unit, location of parts.

328. Test Equipment Required

The test equipment required for trouble shooting the mounting rack is listed below. A common usage name is indicated after each component.

Nomenclature	Common name
Oscilloscope OS-25/G	Oscilloscope
Pulse Form Restorer TD-68/G.	Pulse form restorer
Multimeter TS-352/U.	Multimeter
Four 47K, 2-watt resistors.	
0 to 130 volts Variac, .5 kva.	
Power supply, 260 volts dc (PP-691/G, or equivalent).	B+ supply
Spectrum Analyzer TS-723/U.	Analyzer
10.6 uf, 300 volts rms capacitor.	
75 v rms, 20-cps voltage source.	
Frequency Meter FR-67/U.	Frequency meter
Electrical Power Cable Assembly CX-2276/U (6 ft 0 in.).	Cable

329. Electrical Equipment Rack MT-1434/TRA-10 Tests

a. Alarm circuit.
b. 20-cps multivibrator circuit.
c. Remote keying circuit.
d. Continuity checks. Make the following continuity checks:
(1) Filament circuit.
(2) B+ circuit.
(3) Four-wire and two-wire circuits.
(4) PARTY LINE-PRIV circuits.
(5) D&I-THRU circuits.

330. Alarm Circuit, Test Procedure.

a. Set Electrical Equipment Rack MT-1434/TRA-10 on a table so that terminal board TB1A can be reached.

b. Connect a single-pole, single-throw (SPST) switch across terminals 3 and 6 of TB1A. Place the switch in the open position.

c. Connect receptacle J3 of Power Supply PP-691/G to receptacle J7 of Electrical Equipment Rack MT-1434/TRA-10 by using Electrical Power Cable Assembly CX-2276/U. The cable assembly should be approximately 6 feet long.

Note. Electrical Power Cable Assembly CX-2276/U that is supplied with the AN/TRA-10 is too short.

d. With circuit breakers CB2 and CB3 in the OFF position, connect receptacle J1 of Power Supply PP-691/G to a 115-volt, 60-cycle power source.

e. Close CB2; leave CB3 in the OFF position.

f. Close the external SPST switch. AUDIBLE alarm buzzer I 1 should sound and ALARM indicator light I 2 should light.

g. Press AUDIBLE ALARM DISCONNECT switch S1, on the front panel. The buzzer should cease sounding but the ALARM indicator light should remain on.

h. Open the external SPST switch; the ALARM indicator lamp should go out.

331. Twenty-cps Multivibrator Circuit, Test Procedure

a. Set Electrical Equipment Rack MT-1434/TRA-10 on a table so that the various measuring points can be reached.

b. Connect receptacle J3 of Power Supply PP-691/G to receptacle J7 of Electrical Equipment Rack MT-1434/TRA-10 by using Electrical Power Cable Assembly CX-2276/U. The

cable assembly should be 6 feet long; use Electrical Power Cable Assembly CX–2276/U (6 ft 4 in.) that is supplied with the Multiplexer Set AN/TCC–13 or Multiplexer Group AN/TCA–1.

c. Connect the positive lead of Multimeter TS–352/U to terminal 2 of transformer T4 and the negative test lead to terminal 7 of TB1A, mounted on the mounting rack. Set the multimeter switch to the 500-VDC scale.

d. Connect a 10.6-microfarad, 300-volt capacitor between terminals 1 and 2 of TB1A of the mounting rack.

e. Connect receptacle J1 of Power Supply PP–691/G to a 115-volt 60-cycle power source.

f. Turn circuit breakers CB2 and CB3 to ON. There should be a delay of at least 30 seconds before there is a voltage indication on Multimeter TS–352/U (terminal 2 of T4 and ground).

g. Connect Multimeter TS–352/U between terminals 1 and 2 of TB1A. Set the multimeter to the 250-VAC scale. The ringing voltage measured at these points should be not less than 75 volts.

h. Use Frequency Meter FR–67/U and measure the ringing voltage fundamental. The ringing voltage fundamental frequency should be 20 cps ±4 cycles.

i. With Spectrum Analyzer TS–723/U, check the harmonic distortion of the ringing supply at 60 and 120 cycles. The maximum harmonic distortion should not be greater than 20 per cent of the fundamental.

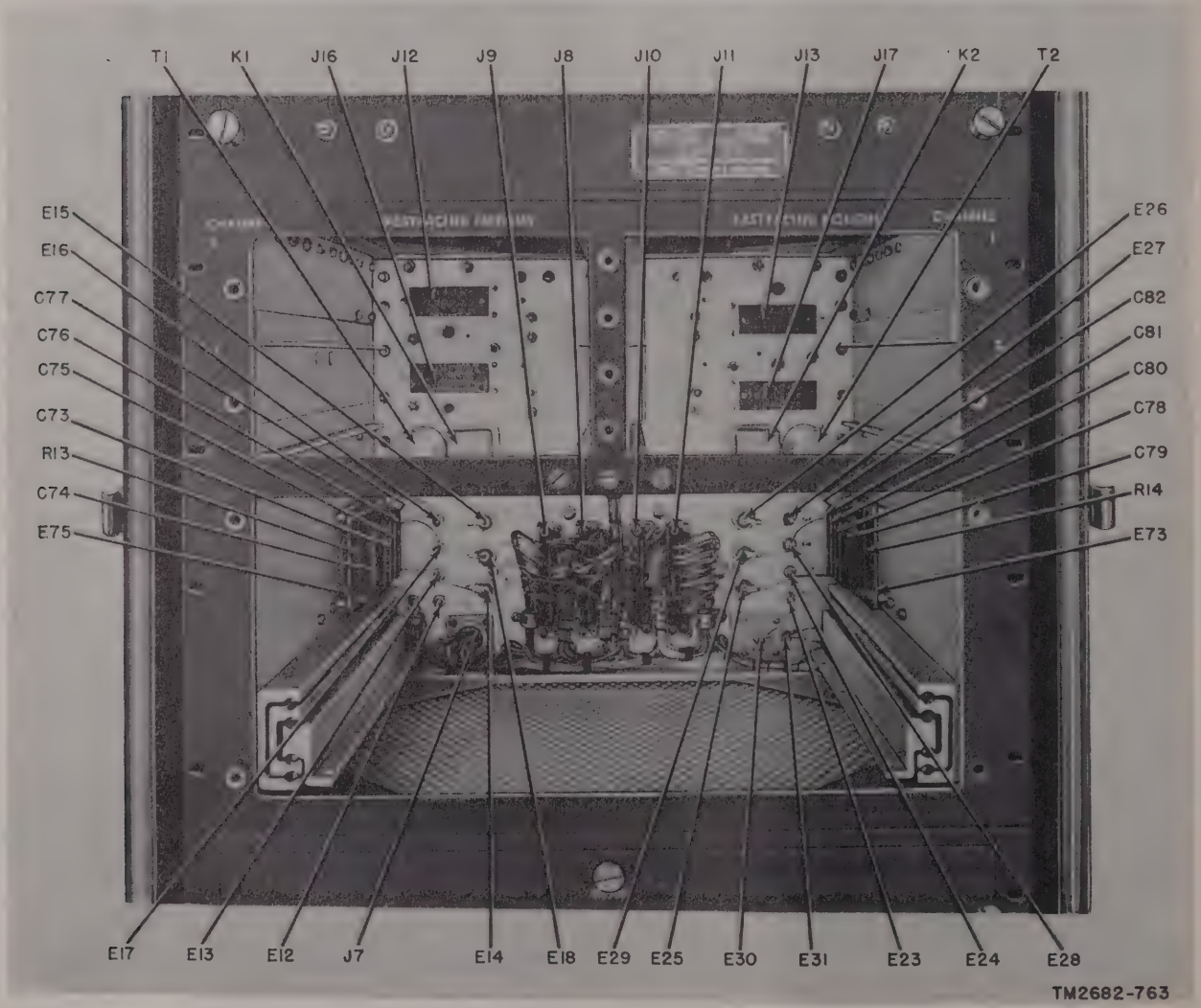


Figure 293. Electrical Equipment Rack MT–1434 TRA–10, front view, drawer and modems removed.

332. Remote Keying Circuit

Before proceeding with the checks below, place the two channel D&I-THRU switches in the D&I position, place the applicable channel PARTY LINE-PRIV switches in the PARTY LINE position, and short terminals 1 and 3 and 14 and 16 of TB1A on the video restorer, to supply voltage disconnected by the alarm relay.

a. Normal Operation.

(1) Place the remote keying units in NORMAL OPERATION.

(*a*) Check for B+ voltage (approximately 250 volts) between terminal H of J14, J15, J18, and J19 and chassis ground.

(*b*) Check for continuity between the following terminals:

E9 to TB1A–1
E20 to TB1A–1
E9 to pin P of J15
E9 to pin P of J14
E10 to TB1A–2
E21 to TB1A–2
E10 to pin N of J14
E10 to pin N of J15
E20 to pin P of J18
E20 to pin P of J19
E21 to pin N of J18
E21 to pin N of J19

Note. Terminals E8 through E11, E32 through E39, E48 through E54 are located on the right-hand door of the electrical equipment rack.

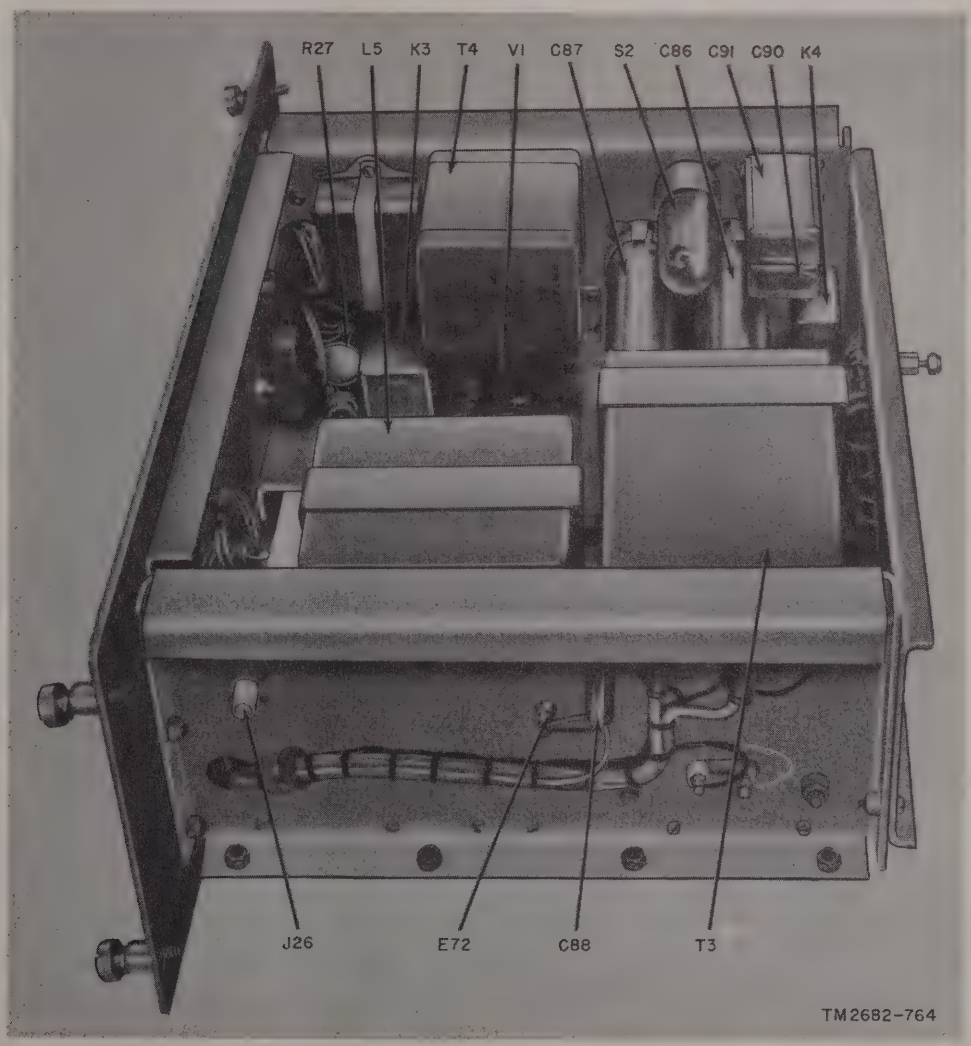


Figure 294. Electrical Equipment Rack MT–1434/TRA–10 drawer, left side view.

(2) Remove the 47K, 2-watt resistors from terminal 18 of J8, J9, J10, and J11 and check for continuity between the following points:
E9 and junction of C76 and C77
E10 and T1–9
E20 and junction of C81 and C82
E21 and T2–9

(3) Connect a source of 20 cps (75 volts ac) to PARTY LINE, CHAN 1 binding posts (E9 and E10). This should remove the B+ voltage from terminal H of J14 and J15. Remove the 20-cps voltage source.

(4) Connect the 20-cps voltage source to PARTY LINE, CHAN 2 binding posts E20 and E21. This should remove the B+ voltage from terminal H of J18 and J19. Remove all sources of voltage.

b. Remote Keying Operation.

(1) Place the two remote keying units in REMOTE KEYING OPERATION position.

(2) Place a 47K, 2-watt resistor from each terminal 18 of J8, J9, J10, and J11 to ground.

(3) Connect the B+ voltage to terminal 10 of TB1A. (Terminals 1 and 3 and 14 and 16 of TB1A on the video restorer are still shorted.)

(4) Place a short circuit between E24 and E23. There should be B+ voltage from terminal H of J18 and ground and terminal H of J19 and to ground. There should be an open circuit between E27 and E28.

(5) Place a short circuit between E12 and E13. There should be B+ voltage from terminal H of J14 and ground and terminal H of J15 and to ground. There should be an open circuit between E16 and E17. Remove the short circuit between E12 and E13. Binding posts E16 and E17 are still open-circuited.

(6) Measure resistances between Terminals N and P of J8, J9, J10, and J11. Each should measure 600 ohms ±5 per cent.

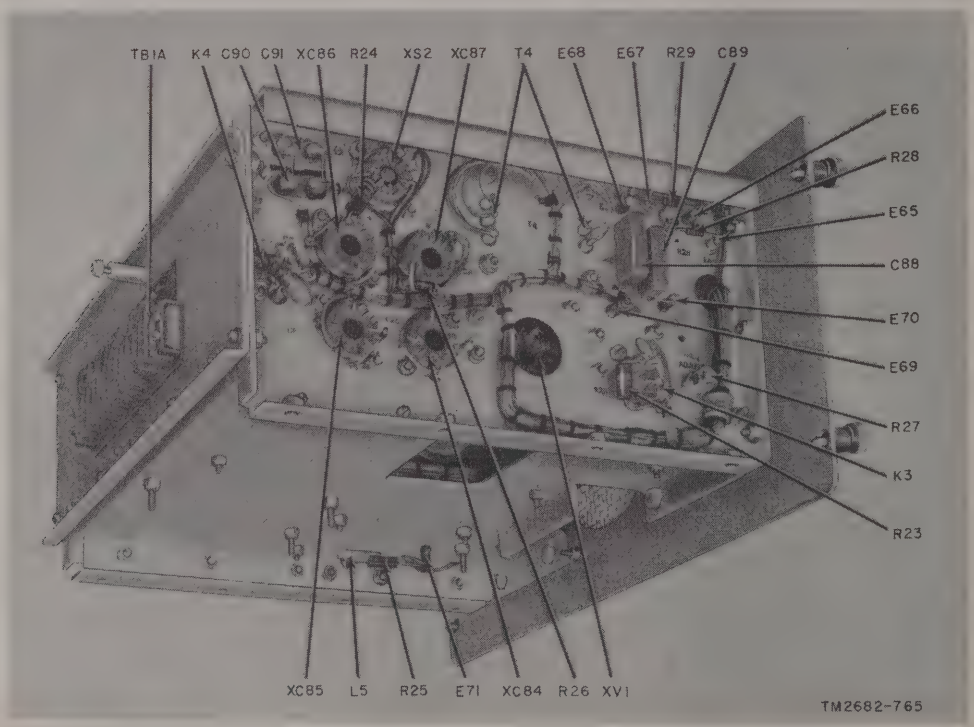


Figure 295. Electrical Equipment Rack MT–1434/TRA–10 drawer, right side view.

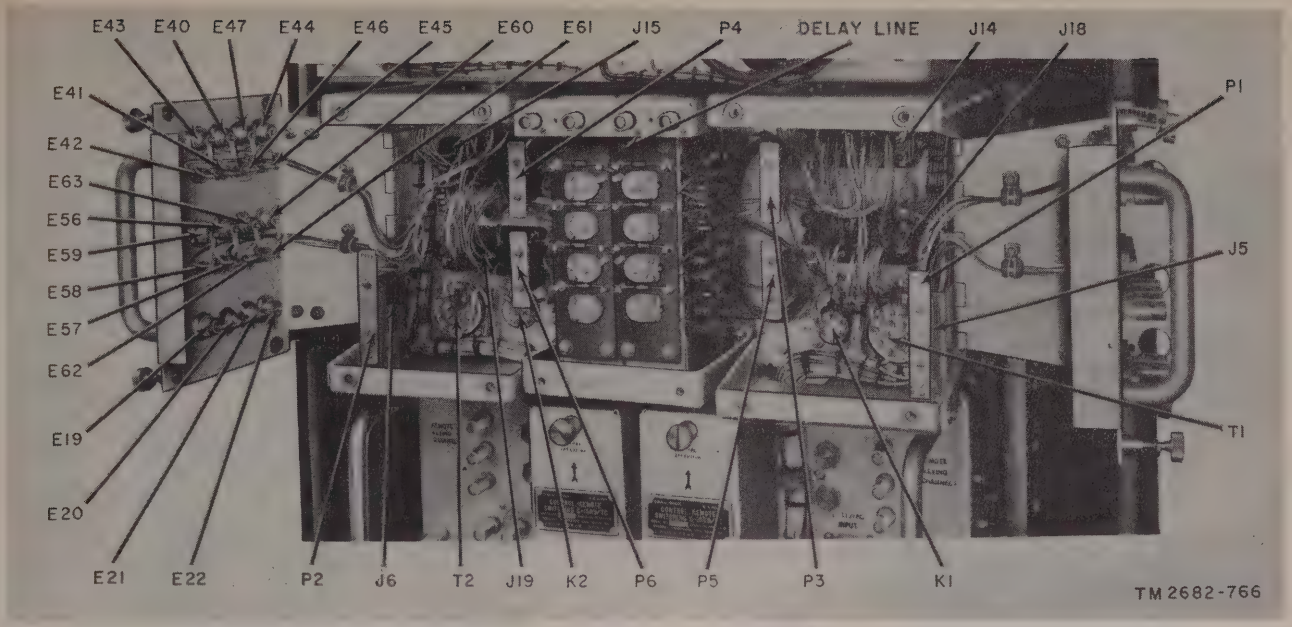


Figure 296. Electrical Equipment Rack MT–1434/TRA–10, rear view, doors open.

(7) Remove the 47K, 2-watt resistor from terminal 18 of J8 to chassis ground. There should be a short circuit between E16 and E17. Replace the 47K, 2-watt resistor to terminal 18 of J8, and remove the 47K, 2-watt resistor from terminal 18 of J9. There should be a short circuit between E16 and E17. Replace the 47K, 2-watt resistor.

(8) Remove the 47K, 2-watt resistor from terminal 18 of J10. There should be a short circuit between E27 and E28. Replace the 47K, 2-watt resistor to terminal 18 of J10, and remove the 47K, 2-watt resistor from terminal 18 of J11. There should be a short circuit between E27 and E28. Restore the mounting rack to its original condition.

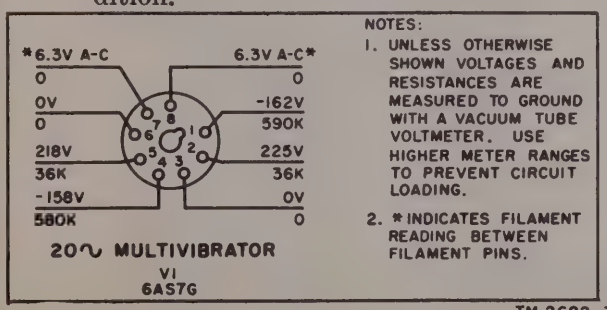


Figure 297. Electrical Equipment Rack MT–1434/TRA–10, tube voltage and resistance diagram.

333. Continuity Checks

a. Filament Circuit. Measure a short circuit between the following points:

(1) *Video restorer.*

Terminal 8 of TB1A to terminal 11 of TB1A.

Terminal 9 of TB1A to terminal 5 of TB1A.

Terminal 5 of TB1A to terminal 12 of TB1A.

Terminal 13 of TB1A to terminal 6 of TB1A.

(2) *Mounting rack.*

Terminal 5 of TB1A to pin F of J14 and J18.

Terminal 9 of TB1A to pin F of J15 and J19.

Pin S of J14, J15, J18, and J19 to chassis ground.

b. B+ Circuit. Measure a short circuit between the following points:

(1) *Video restorer.*

J7 pin B to terminal 10 of TB1A.

Terminal 10 of TB1A to terminals 1 and 16 of TB1A.

Terminal 11 of TB1A to terminal 15 of TB1A.

Terminal 12 of TB1A to terminal 2 of TB1A.

(2) *Mounting rack.*

Terminal 11 of TB1A to pin D of J15 and J19.

Terminal 12 of TB1A to pin D of J14 and J18.

c. Two-wire, Four-wire Circuits. Measure a short circuit between the following points:

E33 to pin W of J14.
E34 to pin T of J14.
E37 to pin X of J14.
E38 to pin U of J14.
E41 to pin T of J15.
E42 to pin W of J15.
E45 to pin U of J15.
E46 to pin X of J15.
E49 to pin W of J18.
E50 to pin T of J18.
E53 to pin X of J18.
E54 to pin U of J18.
E57 to pin T of J19.
E58 to pin W of J19.
E61 to pin U of J19.
E62 to pin X of J19.

d. PARTY LINE-PRIV Circuits. Measure a short circuit between the following points:

Pin A of J5 to pin U of J15.
Pin B of J5 to pin 4 of T1.
Pin C of J5 to pin W of J14.
Pin E of J5 to pin X of J15.
Pin H of J5 to C73.
Pin J of J5 to pin T of J14.
Pin L of J5 to pin T of J15.
Pin P of J5 to pin X of J14.
Pin S of J5 to pin 2 of T1.
Pin T of J5 to pin W of J15.
Pin V of J5 to pin U of J14.
Pin U of J5 to C75.
Pin A of J6 to pin U of J19.
Pin B of J6 to pin 4 of T2.
Pin C of J6 to pin W of J18.
Pin E of J6 to pin X of J19.
Pin H of J6 to C78
Pin J of J6 to pin T of J18.
Pin L of J6 to pin T of J19.
Pin P of J6 to pin X of J18.
Pin S to J6 to pin 2 of T2.
Pin T of J6 to pin W of J19.
Pin V of J6 to pin U of J18.
Pin U of J6 to C80.

e. D&I-THRU and Delay Line Circuits. Measure a short circuit between the following points:

Pin A of J12 to chassis ground.
Pin F of J12 to E2–3 of delay line.
Pin L of J12 to chassis ground.
Pin M of J12 to pin C of J15.
Pin P of J12 to J20.
Pin R of J12 to E7–4 of delay line.
Pin A of J13 to chassis ground.
Pin F of J13 to E3–3 of delay line.
Pin L of J13 to chassis ground.
Pin M of J13 to pin C of J14.
Pin P of J13 to J25.
Pin R of J13 to E6–4 of delay line.
Pin E of J14 to E7–2 of delay line.
Pin E of J15 to E6–2 of delay line.
Pin A of J16 to chassis ground.
Pin F of J16 to E2–8 of delay line.
Pin L of J16 to chassis ground.
Pin M of J16 to pin C of J19.
Pin P of J16 to J20.
Pin R of J16 to E7–8 of delay line.
Pin A of J17 to chassis ground.
Pin F of J17 to E3–8 of delay line.
Pin L of J17 to chassis ground.
Pin M of J17 to pin C of J18.
Pin P of J17 to J25.
Pin R of J17 to E6–8 of delay line.
Pin E of J18 to E7–6 of delay line.
Pin E of J19 to E6–6 of delay line.

f. Miscellaneous. Measure a short circuit between the following points:

J7 pin A to chassis ground.
J7 pin C to terminal 3 of TB1A.
J7 pin D to terminal 4 of TB1A.
J24 to pin K of J19, J15.
J23 to pin V of J19, J15.
J20 to pin V of J18, J14.
J21 to pin K of J18, J14.

Section X. TROUBLE SHOOTING MULTIPLEXER SUBASSEMBLY MX-1442/TC

334. Multiplexer Subassembly MX-1442/TC (Filament Supply) Trouble-shooting Data

The following references will assist maintenance personnel in trouble shooting the filament.

Fig. No.	Description
378	Multiplexer Subassembly MX-1442/TC, over-all schematic diagram.
403	Multiplexer Subassembly MX-1442/TC, over-all wiring diagram.
298	Filament supply, air filter removed, interior view.
299	Filament supply, back view, rear panel and remote keying units removed.
300	Filament supply, bottom view.
301	Remote keying unit, location of parts.

335. Test Equipment Required for Filament Supply

The test equipment required for trouble shooting the filament supply is listed below. A common usage name is indicated after each component.

Nomenclature	Common name
Multimeter TS-352/U	Multimeter
45-volt B battery	Battery
115-volt, 60-cps source	Source
+250-volt dc (B+) source (Power Supply PP-691/G, or equivalent)	B+ supply
47K, 2-watt resistors (4)	

336. Filament Supply Trouble-shooting Procedure

The filament supply can be checked by taking voltage and resistance measurements.

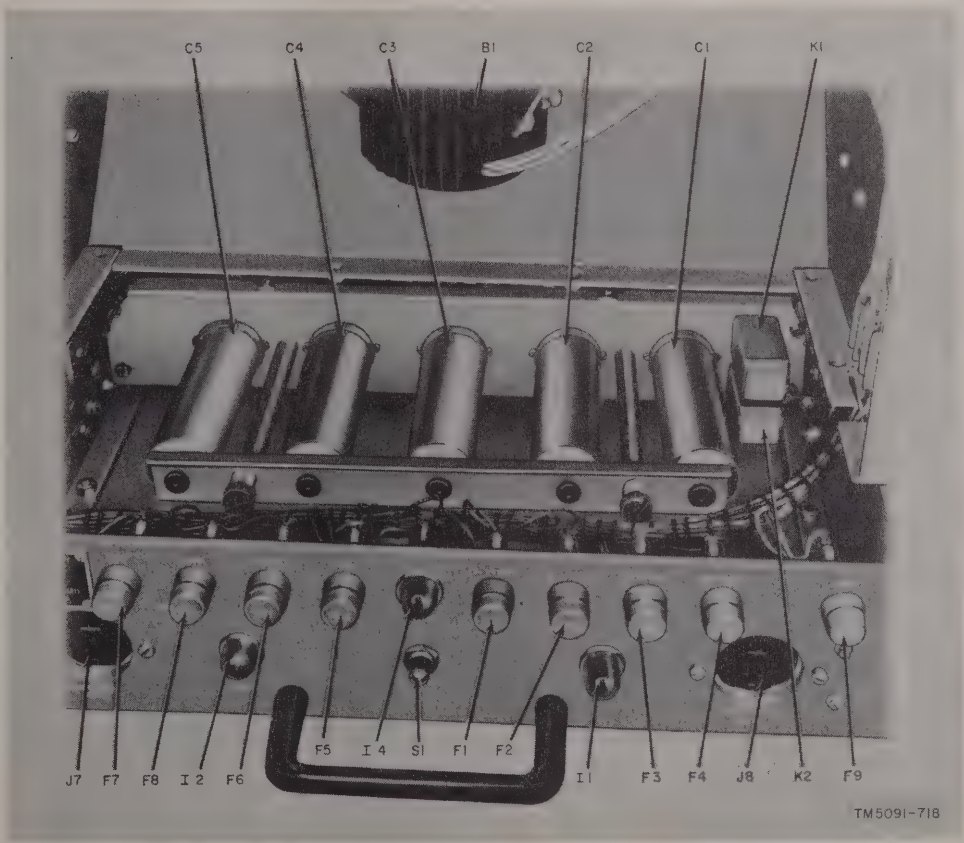


Figure 298. Filament supply, air filter removed, interior view.

337. Filament Supply Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the filament supply.

Symptom	Probable trouble	Correction
1. No 6.3 volts ac on mounting rack.	1. Faulty T1.	1. Replace T1.
	Faulty T2.	Replace T2.
	Short to ground on mounting rack.	Remove short.
	No 115-volt ac input to T1 and T2.	Check input.
2. Inoperative blower.	2. Faulty blower (R1).	2. Replace B1.
	No 115 volts ac to blower (terminal lead off).	Check input.
3. Faulty alarm operation.	3. Faulty buzzer (I 3).	3. Replace I 3.
	Faulty S1.	Replace S1.
	Faulty K3.	Replace K3.
	Faulty K1 or K2.	Replace K1 or K2.
4. Faulty or inoperative remote keying operation.	4. P1 and/or P2 per channel not making good contact in connectors J1 and/or J2.	4. Repair or replace.
	Faulty K4, K5, K6, or K7 relay on remote keying units.	Replace K4, K5, K6, or K7.

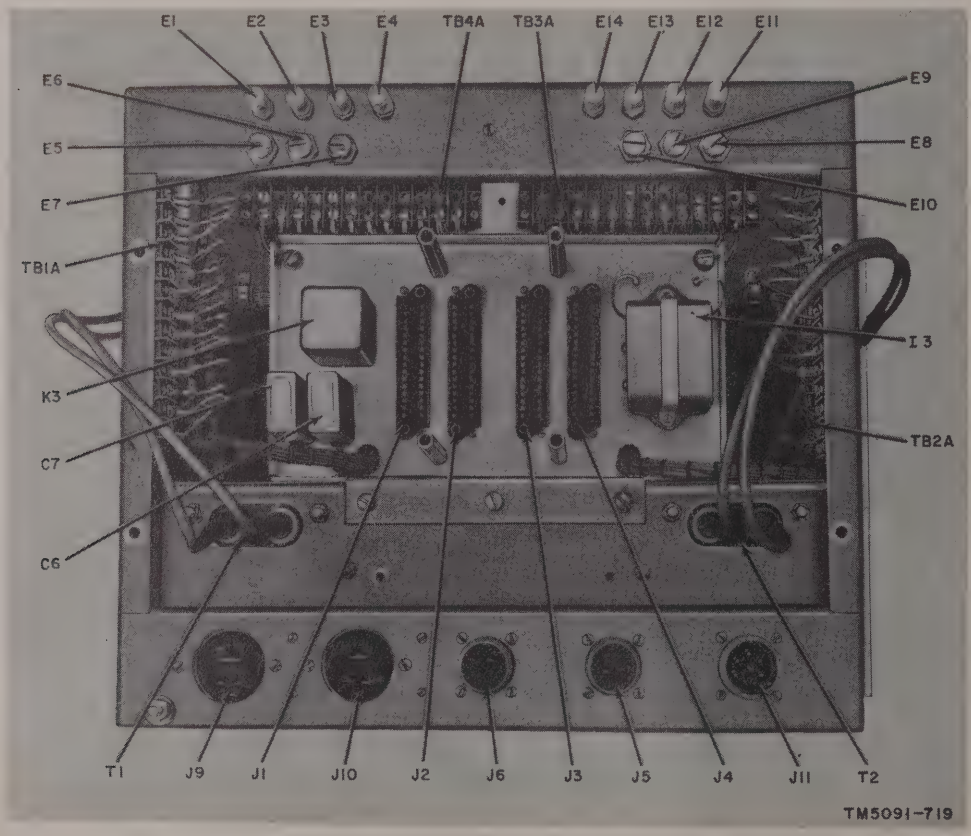


Figure 299. Filament supply, back view, rear panel and remote keying units removed.

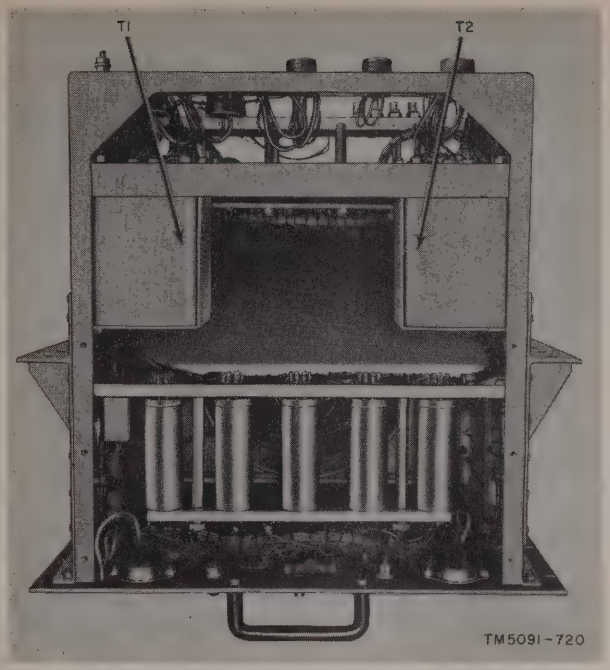


Figure 300. Filament supply, bottom view.

338. Filament Supply Tests

The following tests are helpful to localize trouble to a particular part within the filament supply.

Note. Connect a source of 115 volts ac across terminals 2 and 5 of TB4.

a. Filament Voltage at Full Load. Place the variable resistor across the secondary of each filament transformer (terminals 3 and 4), and vary the resistor until 30 amperes is drawn, for exactly 115 volts across the primary. Measure the secondary filament voltage with the vtvm. It should be 6.3 volts ±2 per cent.

b. Alarm Circuit. Check the alarm buzzer and alarm light by placing a short circuit across terminals 2 and 10 of TB4. The alarm buzzer should sound and the alarm light should light. Press the AUDIBLE ALARM DISCONNECT switch on the panel. The buzzer should no longer sound, but the light should remain on. Remove the ac source for further tests.

Caution: These terminals have 115 volts ac across them in series with the buzzer.

c. B+ Disconnect Relays.

(1) Check B+ disconnect relays K1 and K2 by placing a short circuit between terminal 11 of TB2A and terminal 11 of TB1A. Put 45 volts dc from a B battery across terminal 7 of TB4A and ground (chassis).

(2) With an ohmmeter, check for a short circuit between the following terminals:
Terminals 1 and 11 of TB3A
Terminals 2 and 12 of TB3A
Terminal 3 of TB3A and terminal 11 of TB4A
Terminal 4 of TB3A and terminal 12 of TB4A

(3) Remove the voltage from pin 7 of TB4A. There should now be open circuits between the above terminals.

d. Remote Keying Circuit.

Caution: Before making any of the wiring changes below, disconnect the power.

(1) *General.* Make the following *temporary* connections:
(*a*) Ground (to chassis) terminals 5 of TB2A and TB1A.
(*b*) Place a short circuit between terminal 11 of TB2A and terminal 11 of TB1A.
(*c*) Place a 47K, 2-watt resistor from each of terminals 12 and 13 of TB1A to ground.
(*d*) Connect a source of B+ (250 volts dc) to B+ input connector J5.

(2) *Normal operation.*
(*a*) Place the remote keying units in NORMAL OPERATION. There should be B+ voltage between the following terminals and ground (chassis).

Terminals	Terminal board
1	TB2A
2	TB2A
1	TB1A
2	TB1A

(*b*) Reconnect the 45-volt battery between terminal 7 of TB4A and ground. There should be B+ voltage from both terminals 12 and 13 of TB2A to ground.
(*c*) Remove the ground from terminal 5, TB1A. This should remove the B+ voltage from both terminals 2 of TB2A and TB1A. Replace the ground.

(*d*) Remove the ground from terminal 5 of TB2A. This should remove B+ voltage from both terminals 1 of TB2A and TB1A. Replace the ground.

(*e*) Remove the two 47K resistors from terminals 12 and 13 of TB1A. There should be a short circuit between the folowing terminals:

Terminals	Terminal board
7 and 10	TB2
8 and 9	TB2
7 and 10	TB1
8 and 9	TB1

(*f*) Reconnect the two 47K-ohm resistors to terminals 12 and 13 of TB1A.

(*g*) Connect a 47K, 2-watt resistor from each of terminals 12 and 13 of TB2A to ground. There should now be a short circuit between the following terminals:
Terminal 9 of TB3A and terminal 10 of TB2A.
Terminal 9 of TB3A and terminal 10 of TB1A
Terminal 10 of TB3A and terminal 9 of TB2A
Terminal 10 of TB3A and terminal 9 of TB1A

(*h*) Remove the B+ voltage source and the 45-volt source. There should be a short circuit between the following terminals:
Terminal 9 of TB3A and terminal 3 of TB1A
Terminal 9 of TB3A and terminal 3 of TB2A
Terminal 10 of TB3A and terminal 4 of TB1A
Terminal 10 of TB3A and terminal 4 of TB2A

(3) *Remote keying operation.*

(*a*) Place the two remote keying units in REMOTE KEYING OPERATION. Reconnect the B+ voltage to J5.

(*b*) Place a short circuit between E13 and E14. There should be B+

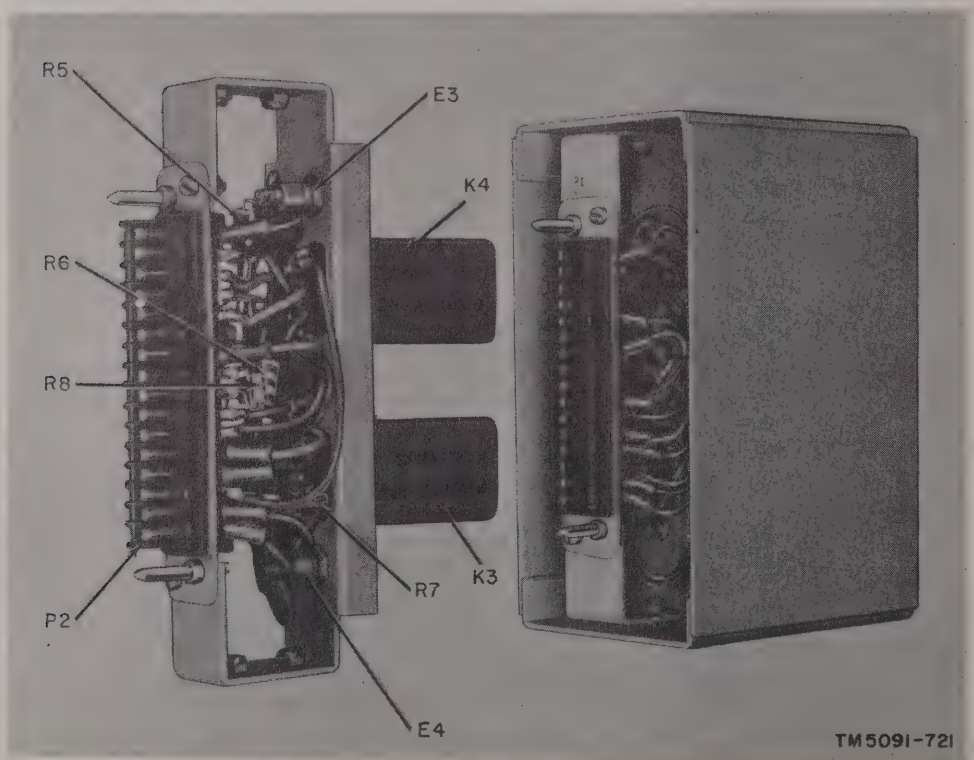


Figure 301. Remote keying unit, location of parts.

voltage from terminal 1 of TB2A to ground, and there should be an open circuit between E11 and E12. Remove the short circuit. There should be no B+ on terminal 1 of TB2A, but E11 and E12 should still be open-circuited.

(*c*) Place a short circuit between E3 and E4. There should be B+ voltage from terminal 2 of TB2A to ground, and there should be an open circuit between E1 and E2. Remove the short circuit. There should be no B+ on terminal 2 of TB2A, but E1 and E2 should still be open-circuited.

(*d*) Measure the resistance across terminals 3 and 4 of TB1A and also across terminals 3 and 4 of TB2A. They should measure a nominal 600 ohms.

(*e*) Remove the 47K resistor from terminal 12 of TB2A. There should be a short circuit across E11 and E12. Replace the 47K resistor on terminal 12 of TB2A, and remove the 47K resistor on terminal 12 of TB1A. Again there should be a short circuit across E11 and E12. Replace the resistor.

(*f*) Remove the 47K resistor from terminal 13 of TB2A. There should be a short circuit across E1 and E2. Replace the 47K resistor on terminal 13 of TB2A, and remove the 47K resistor on terminal 13 of TB1A. Again there should be a short circuit across E1 and E2. *Now remove all external connections.*

e. Convenience Outlets, Fan, and Pilot Lights.

(1) With a 115-volt ac source connected between terminals 2 and 5 of TB4A, the AC POWER pilot lamp should light, and the fan should rotate in the direction that blows air upward.

(2) With B+ voltage (250 volts dc) connected to pin C of J5, the +250V pilot lamp should light.

(3) Place the 115-volt ac source across pins A and B of J6. There should be 115 volts ac on all the convenience outlets.

f. Continuity Checks. Remove all power from the unit. With the multimeter, check for continuity between the following points:

Terminal 5 of TB3A and terminal A of jack J11
Terminal 6 of TB3A and terminal B of jack J11
Terminal 7 of TB3A and terminal C of jack J11
Terminal 8 of TB3A and terminal D of jack J11
Terminal 9 of TB3A and terminal E of jack J11
Terminal 10 of TB3A and terminal F of jack J11
Terminals 1, 2, and 3 of TB4A and terminal D of jack J6
Terminals 4, 5, and 6 of TB4A and terminal C of jack J6
Terminal 8 of TB4A and terminal C of jack J5
Terminal 9 of TB4A and chassis

339. Filament Supply Resistance of Transformer and Relays

The dc resistance of all transformer and relay windings are listed below. An asterisk (*) indicates an ohmmeter reading that is less than 1 ohm.

Transformer or relay	Terminals	Ohms
K1, K2, K3	1–5	4,800
K1 through K4[a]	1–5	
T1, T2	1–5	19K
	3–4	*

[a] Part of Remote Switching Controls C–1509/TC.

340. Power Supply Trouble-shooting Data

The following references will assist maintenance personnel in trouble shooting the power supply.

Fig. No.	Description
221	Power Supply PP–691/G, block diagram.
383	Power Supply PP–691/G, over-all schematic diagram.
408	Power Supply PP–691/G, over-all wiring diagram.
302	Power Supply PP–691/G, interior view.
303	Power Supply PP–691/G, top view.
304	Power Supply PP–691/G, bottom view.
305	Power Supply PP–691/G, back view.

341. Test Equipment Required for Power Supply

The following test equipment is required when trouble shooting the power supply:

Item	Common name
Voltmeter ME–30A/U	Voltmeter
Electronic Multimeter TS–505/U	Vtvm
Multimeter TS–352B/U	Multimeter
Variable resistors (2-ampere rating, 0 to 600 ohms; 20-ampere rating, 0 to 50 ohms)	
Dc ammeter, 1.5 to 3 amperes, full scale.	
Ac ammeter, 7.5 to 30 amperes, full scale.	

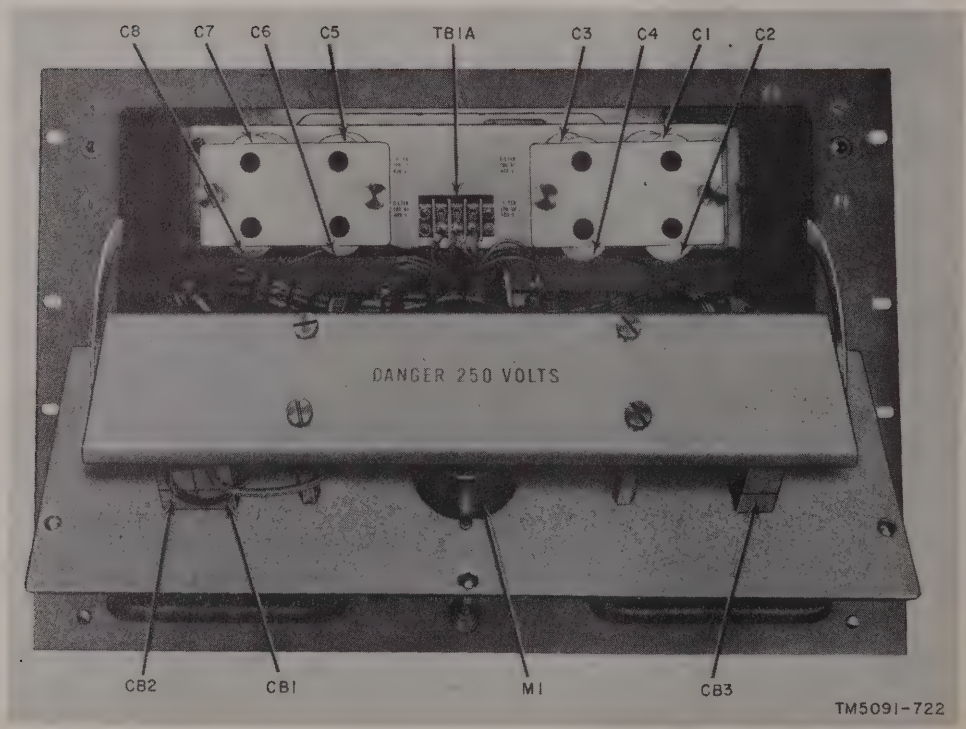


Figure 302. Power Supply PP–691/G, interior view.

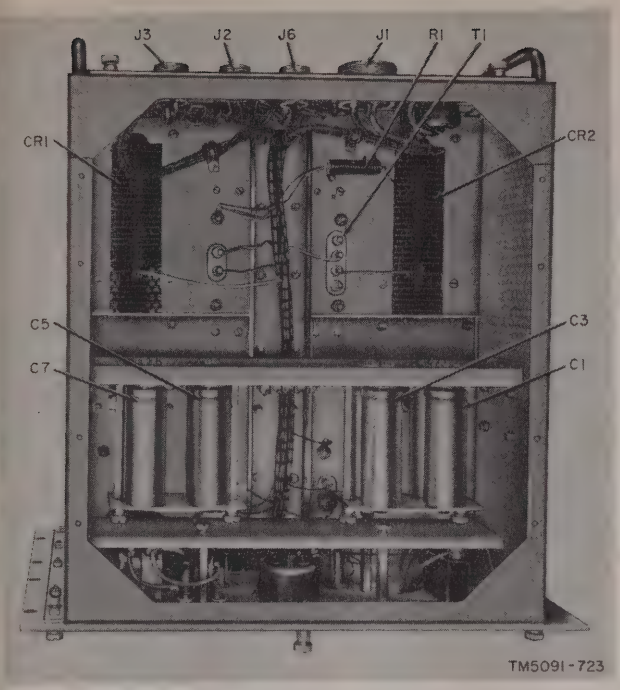


Figure 303. Power Supply PP–691/G, top view.

342. Power Supply Trouble-shooting Procedure

The power supply can be serviced by taking voltage and resistance measurements. The power supply is a full-wave, bridge rectifier-type with choke-input filter.

a. General. The tests below are helpful to localize trouble to a particular part within the power supply. Connect the power supply to a 115-volt regulated ac source.

Caution: Never handle a burned-out selenium rectifier with the bare hands. Use either tools or gloves to handle the rectifier.

b. B+ Voltage at Full Load.

(1) Connect one side of the variable resistor (0 to 600 ohms) to pin C of +250V OUTPUT jack J2.

(2) Connect the other side of the variable resistor to the positive terminal (+) of the dc ammeter (1.5 to 3 amperes full scale).

(3) Connect the negative terminal (—) of the ammeter to terminal B of +250V OUTPUT jack J2.

Caution: Be sure that the variable resistor is set for maximum resistance.

(4) Apply power to the power supply.

(5) Decrease the value of the variable resistor until a reading of 1.6 amperes is obtained on the ammeter. (This is full load.)

(6) Measure the B+ voltage across the variable resistor with Electronic Multimeter TS–505/U, or equivalent. The reading obtained should be 250 volts ±10 volts.

c. Ripple Voltage at Full Load.

(1) Connect the equipment as outlined in subparagraph *b*(1) through (5) above.

(2) Measure the ripple voltage at full load (1.6 amperes) with Voltmeter ME–30A/U. The average reading should not be greater than 40 millivolts.

d. Regulation.

(1) Connect the equipment as outlined in subparagraph *b*(1) through (4) above.

(2) Decrease the value of the variable resistor until a reading of .5 ampere is obtained on the ammeter.

(3) Measure the B+ voltage across the variable resistor with Electronic Multimeter TS–505/U. The reading ob-

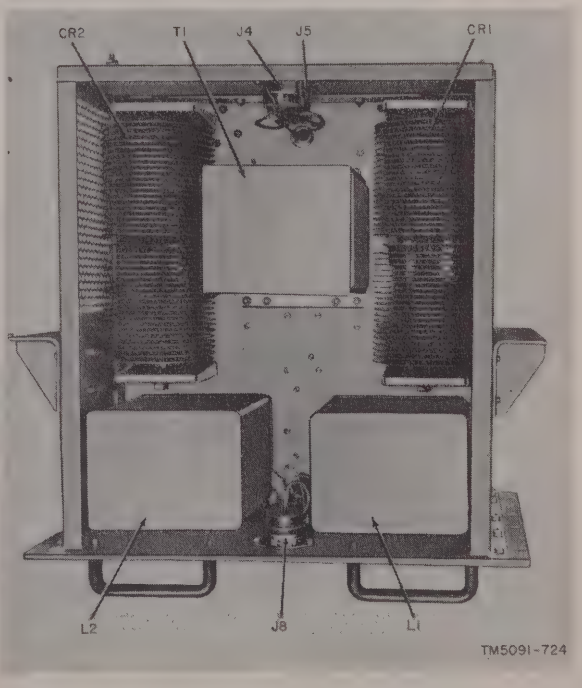


Figure 304. Power Supply PP–691/G, bottom view.

tained should be no greater than +285 volts.

Note. A 10 per cent voltage increase is available on the plate transformer to account for possible selenium rectifier changes caused by aging.

e. Convenience Outlets, Meters, and Pilot Lights. Check all convenience outlets, meters, and pilot lights for proper operation. Check for 115 volts ac between pins A and B of J6 and pins C and D of J3. Check for 250 volts dc between pins A and B of J3 and pins B and C of J2. Pin A of J3 and pin B of J2 should be positive.

f. Circuit Breaker Operation.

(1) *Main circuit breaker.*

(*a*) With the input power disconnected, insert a variable resistive load (0 to 50 ohms, 20-ampere rating) in series with a 30-ampere ac ammeter across terminals B and C of J4 or B and C of J5.

(*b*) Turn the +250V switch off. Connect input power and turn on the main circuit breaker.

(*c*) Gradually reduce the load resistance from full resistance until circuit breakers CB1 and CB2 open.

(*d*) The cutout current should be no less than 15 amperes and no greater than 18.75 amperes.

(*e*) Remove the load resistor.

(2) *+250-volt circuit breaker.*

(*a*) With the input power disconnected, insert a variable resistive load (0 to 600 ohms, 2-ampere rating) across terminals J2B and J2C.

(*b*) Insert a 7.5-ampere ac ammeter in series with the ac input source.

(*c*) Turn on the filament and +250-volt switches.

(*d*) Gradually reduce the load resistance from full resistance until circuit breaker CB3 opens.

(*e*) The cutoff current should be no less than 6 amperes nor greater than 7.5 amperes.

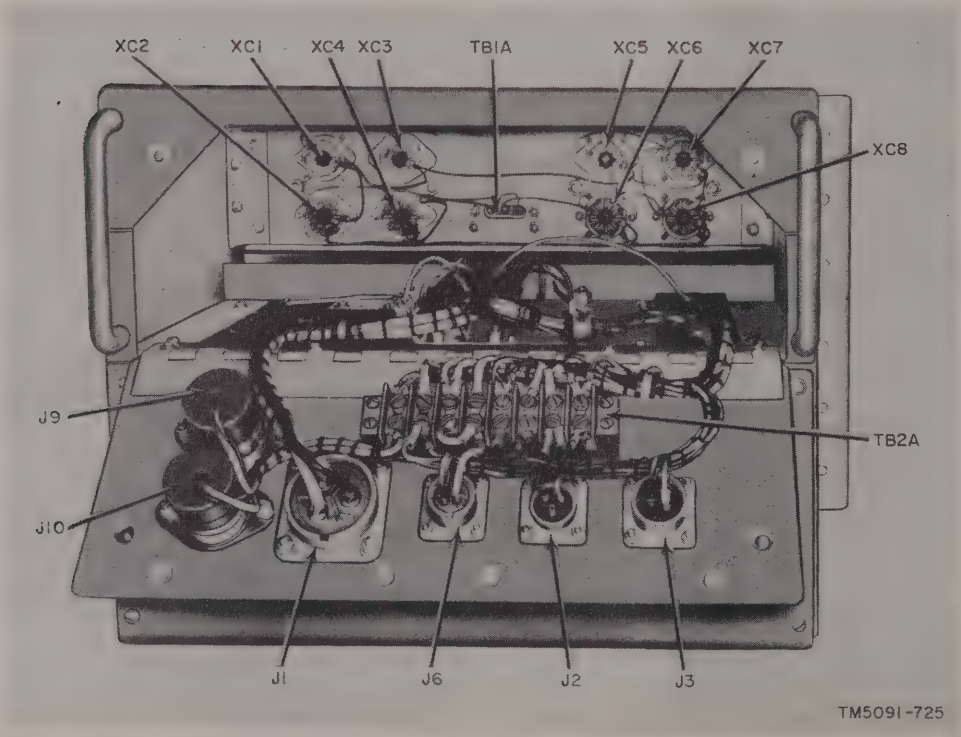


Figure 305. Power Supply PP–691/G, back view.

343. Power Supply Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the power supply:

Symptom	Probable trouble	Correction
1. B+ about 10 per cent low.	1. Aged CR1.	1. Change transformer tap.
2. B+ more than 10 per cent low.	2. Faulty CR1.	2. Replace CR1.
3. No B+ output at terminal 2 of TB2A.	3. Short to ground on pin C of J2.	3. Remove short.
	CR1 faulty.	Replace CR1.
	Faulty T1.	Replace T1.
	Open L1.	Replace L1.
	Open L2.	Replace L2.
	Shorted filter capacitors C1 through C8.	Replace defective capacitor.
4. Increase in B+.	4. Shorted L1.	4. Replace L1.
	Shorted L2.	Replace L2.
5. Increase in output ripple voltage.	5. Open capacitors C1 through C8.	5. Replace defective capacitor.
	Shorted L1 and/or L2.	Remove short or replace L1 and/or L2.

344. Power Supply PP-691/G Dc Resistances of Transformer and Coils

The dc resistances of the transformer and coils are listed below. An asterisk (*) indicates an ohmmeter reading of less than 1 ohm.

Transformer or coil	Terminals	Ohms	Transformer or coil	Terminals	Ohms
L1, L2		6	T1	4–5	2
T1	1–2	*		5–6	*
	3–4	*		3–6	2.2

345. Voltage Regulator Trouble-shooting Data

The following trouble-shooting data will assist maintenance personnel in trouble shooting the voltage regulator.

Fig. No.	Description	Fig. No.	Description
384	Voltage Regulator CN-236/G, over-all schematic diagram.	307	Voltage regulator, bottom view.
		308	Voltage-regulator control unit, top view.
409	Voltage Regulator CN-236/G, over-all wiring diagram.	309	Voltage-regulator control unit, bottom view.
306	Voltage regulator, top view, showing rear of front panel.	310	Voltage regulator, tube socket voltage and resistance diagram.

346. Voltage Regulator Trouble-shooting Chart

The following chart is provided to assist maintenance personnel in trouble shooting the voltage regulator.

Symptom	Probable trouble	Correction
1. No output voltage.	1. T4, X1-X2 winding open. T1 primary (1-2) shorted.	1. Replace T4. Remove short or replace T1.
2. No regulation either way.	2. Sensing element Z1 open. Output voltage control R11 open. C6 open or shorted. Powerstat brush open.	2. Replace Z1. Replace R11. Repair or replace C6. Repair or replace powerstat.
3. No regulation in one direction.	3. Relay K1 or K2 inoperative. Microswitch S1 or S2 open. R3 or R4 open.	3. Repair or replace K1 or K2. Repair or replace S1 or S2. Replace R3 or R4.
4. Output voltage too high. No regulation down or output voltage too low. No regulation up.	4. Sensing element shorted. R11 open at one end. Half of T2 secondary shorted.	4. Repair or replace. Repair or replace R11. Repair or replace T2.
5. No control of output voltage setting.	5. R11 variable arm shorted to either end of potentiometer.	5. Repair or replace R11.
6. Hunting.	6. SENSITIVITY control R12 set too high. R12 open. CR1 or CR2 open.	6. Reset correctly (par. 66*b*(3)). Replace R12. Replace CR1 or CR2.

347. Test Equipment Required for Testing Voltage Regulator

The following test equipment is required:

a. Variac, 0 to 265 volts, 2 kva.

b. Two ac voltmeters, 0 to 250 volts (Multimeter TS-352B/U).

c. Ac ammeter, 0 to 20 amperes.

d. Variable load resistor, 0 to 50 ohms, 20 amperes.

348. Voltage Regulator Trouble-shooting Procedure

a. Tests to Be Made. The following tests may be used as a reference, and as a test procedure after major repairs.

(1) Output voltage with varying input voltage.

(2) Output voltage with varying load.

(3) Range of adjustment of output control.

(4) 230-volt operation.

b. Initial Connections. Connect the variac output terminals to input terminals E and D of AC POWER INPUT jack J4 of the regulator. Connect the ac voltmeter across the same regulator input terminals. Connect the ac ammeter and the variable resistor in series across the regulator output terminals (D and E of AC POWER OUTPUT jack J3). Connect an ac voltmeter across the output terminals.

Caution: Be sure that all variable resistances are set for maximum resistance. Place the voltage-regulator circuit breaker in 230-volt operation position.

349. Voltage Regulator Tests

The following tests are included as test procedures to be used after major repairs.

a. Output Voltage with Varying Input Voltage (Full Load, 60 Cps).

(1) Apply 230 volts ac (60 cps) to the input of the variac and allow 30 seconds for warm up.

(2) Adjust the variac so that there are 115 volts across the input to the regulator.

(3) Throw the 115V AC input switch (on the voltage regulator) to the ON position and adjust the variable resistor so that the ammeter reads 9 amperes.

(4) Increase the SENSITIVITY control until the regulator motor does not cease operating.

(5) Back off the SENSITIVITY control until the motor ceases to operate.

Note. The motor can be heard when it rotates.

(6) Adjust the output voltage control until the meter on the regulator output reads 115 volts.

(7) Adjust the variac so that the input voltage is 98 volts. The output voltage should be ±1 volt.

(8) Adjust the variac so that the input voltage is 132 volts. The output voltage should be ±1 volt.

b. Output Voltage with Varying Load (115 Volts Ac, 60 cps Input). Vary the load resistor so that 17.4 amperes is drawn. The regulator output voltage should be 115 volts ±1 volt.

c. Range of Adjustment Output Control.

(1) Adjust the variac so that there are 115 volts into the regulator with a load of 9 amperes.

(2) Vary the output voltage from fully clockwise to fully counterclockwise. The output voltage should vary from 110 to 120 volts.

(3) Return the output to 115 volts.

d. 230-volt Operation.

(1) Place the 230V AC POWER INPUT switch to ON. Adjust the variac so that 230 volts are applied to the regulator.

(2) Place a load of 9 amperes on the output. The output voltage should be 115 ±1 volt.

(3) Increase the input voltage to 264 volts. The output voltage should be 115 ±1 volt.

(4) Decrease the input voltage to 196 volts. The output voltage should be 115 ±1 volt.

350. Voltage Regulator Dc Resistance of Transformers and Coils

The dc resistance of transformers, coils, or relays is given below. An asterisk (*) indicates an ohmmeter reading less than 1 ohm.

Transformers, coils, or relays	Terminals	Ohms
B1	1–2 (blk-red)	110
	2–3 (blk-grn)	110
K1	1–5	4.800
K2	1–5	4,800
T1	1–2	8.5
	3–4	*
	4–5	*
	5–6	*
T2	3G–4F	500
	4F–5G	600
	3G–5G	1,100
T3	1–3	*
	2–3	*
	1–2	*
T4	X1–X2	*
	H1–H2	*
T5	1–2	*
	2–3	*
	1–3	*

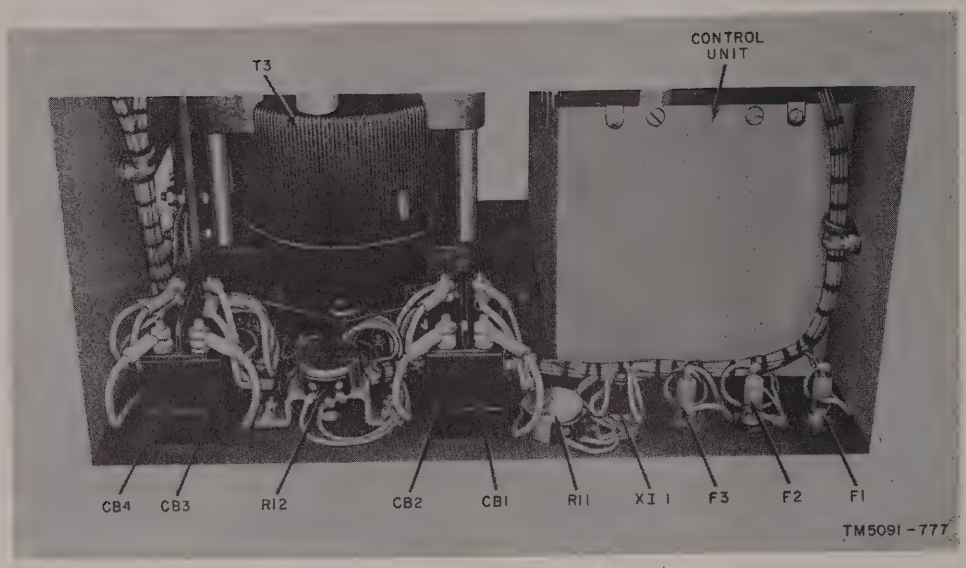


Figure 306. Voltage regulator top view, showing rear of front panel.

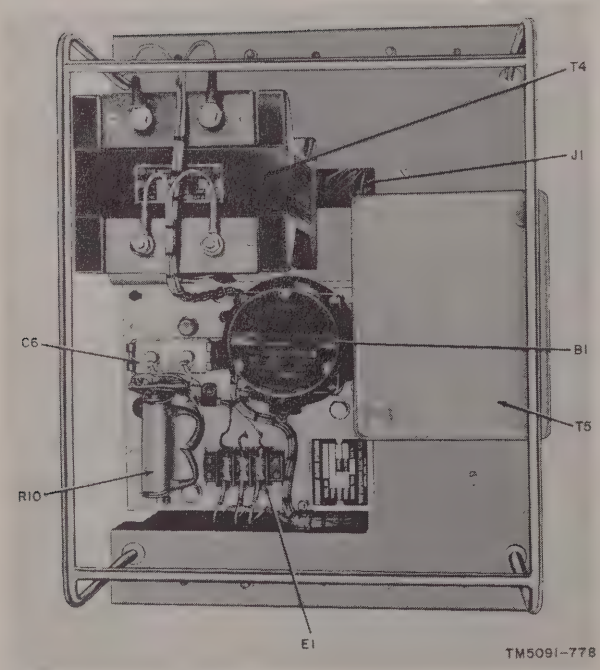


Figure 307. Voltage regulator, bottom view.

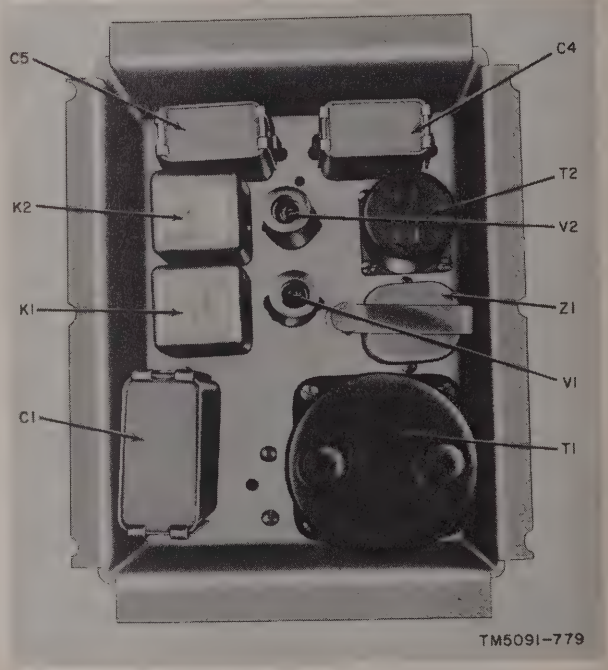


Figure 308. Voltage regulator control unit, top view.

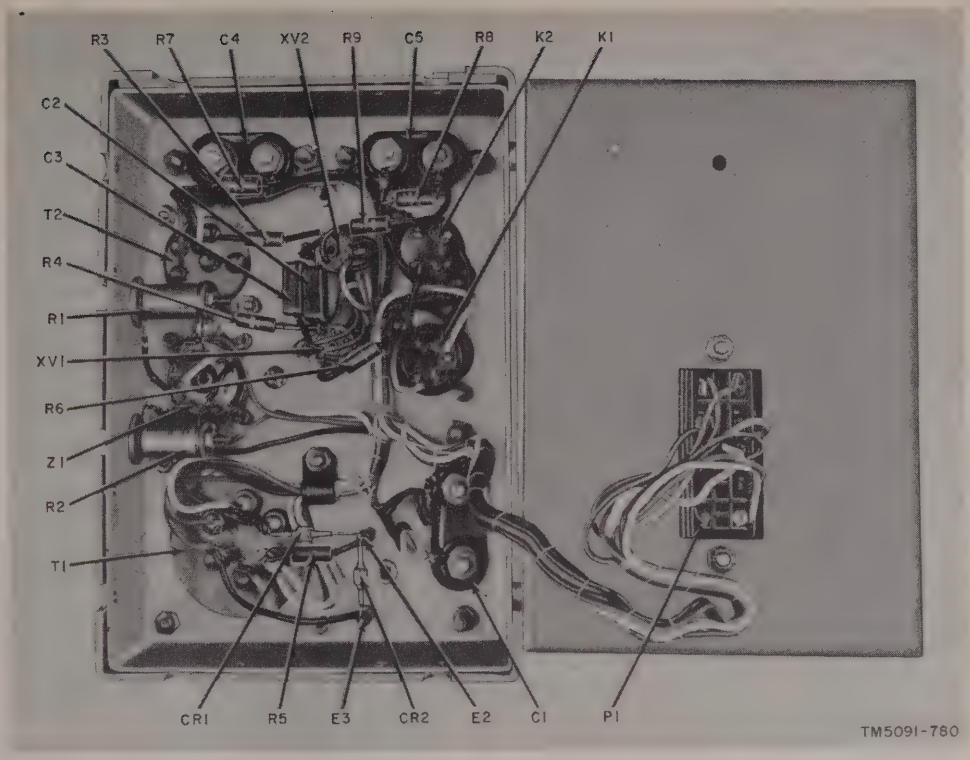
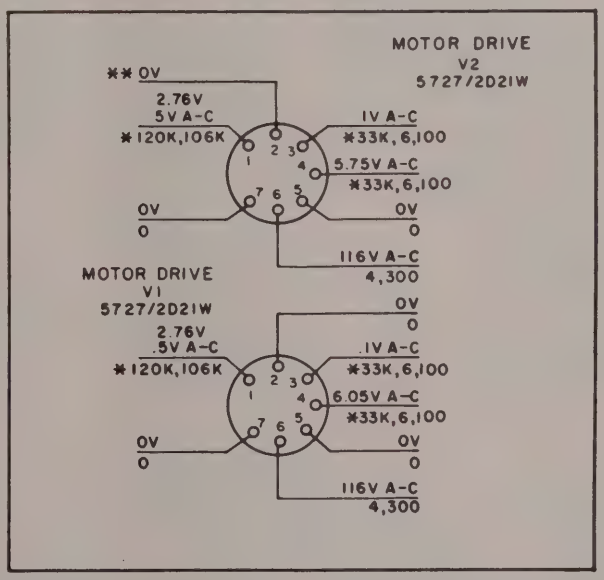


Figure 309. Voltage regulator control unit, bottom view.



NOTES:

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED FROM COMMON CATHODE WITH A VACUUM TUBE VOLTMETER.

2. * INDICATES READING WITH METER LEADS REVERSED
** 115 V A-C TO GROUND

TM5091-781

Figure 310. Voltage regulator, tube socket voltage and resistance diagram.

Section XIII. TROUBLE SHOOTING OSCILLOSCOPE OS-25/G

351. Oscilloscope Trouble-shooting Data

The following references will assist maintenance personnel in trouble shooting the oscilloscope.

Fig. No.	Description
380	Oscilloscope OS–25/G, over-all schematic diagram.
406	Oscilloscope OS–25/G, over-all wiring diagram.
311	Oscilloscope, left side view.
312	Oscilloscope, right side view (looking down).
313	Oscilloscope, right side view (looking up).
314	Oscilloscope, rear view.
315	Oscilloscope, back of front panel, right side view.
316	Oscilloscope, front panel swung down.
342 through 344	Oscilloscope, tube socket voltage and resistance diagrams.

352. Test Equipment Required for Oscilloscope

The following test equipment is required to fully test the oscilloscope.

Item	Common name	Technical manual
Square Wave Generator TS–583/U	Square wave generator.	TM 11–5024
Multimeter TS–352/U	Multimeter.	TM 11–5527A
Electronic Multimeter TS–505/U	Electronic multimeter.	TM 11–5511
Signal Generator SG–71/FCC.	Signal generator.	TM 11–5088
Frequency Meter FR–67/U	Frequency meter.	TM 11–2698
Voltmeter ME–30A/U	Vtvm.	TM 11–5551A
Signal Generator AN/URM–25B.	Signal generator.	
Oscilloscope AN/USM–50		

353. Oscilloscope Terminal Socket Voltages and Resistances

The normal dc voltages (and rms voltages where indicated) between the tube socket and terminals and the chassis ground as measured by a vacuum tube voltmeter are shown in figures 342 through 344. Ac line voltage was held constant at 115 volts and a 6-volt peak-to-peak, 8-kc signal was applied from the common unit or video restorer sync jack. The oscilloscope controls are set as follows:

Control	Position or adjustment	Control	Position or adjustment
HOR POSITION	Trace centered	CAL VOLTAGE	10
VERT POSITION	Trace centered	ASTIG	Sharpest trace
SWEEP PHASE	Pointer vertical	VERT ATTEN	1:1
FOCUS	Sharpest trace	VERT GAIN	Maximum
SYNC SELECTOR	MULTIPLEXER	STAB	Slightly counterclockwise from recurrent sweep
COARSE	5		
FINE	10	TRIGGER	Clockwise until triggered
TIMING PIP PHASE	Fully clockwise	PIP LOCKING	Clockwise until locked
INTENSITY	Maximum	Probe	Grounded

Note. The values given are typical for an input signal giving less than 2-cm peak-to-peak trace and 192-kc timing pips superimposed on the cathode-ray tube face and they may vary by 10 per cent.

354. Oscilloscope Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the oscilloscope.

Symptom	Probable trouble	Correction
1. No power.	1. Switch off. Plug out. Fuse blown.	1. Turn on. Plug in. Replace fuse.
2. No trace.	2. T1 open between terminals 7 and 9. Open C61. Neon tubes on E115 open on both sides. Open L7. Faulty —140-volt supply. Faulty +225-volt or +450-volt supply.	2. Replace T1. Replace C61. Replace neon tubes I 3 through I 12. Replace L7. Check V8 and V11 and associated components. Refer to paragraph 127.
3. Low intensity.	3. Faulty C61. Faulty —1,500-volt supply. Weak crt. Hv, cap off crt. Weak crt. Faulty 1,800-volt supply.	3. Replace C61. Check V2 and associated components. Replace crt. Replace cap. Check VI and associated components.
4. No vertical signal.	4. Open attenuator probe. Open L1. Open L4. Open L3. Open L5. Faulty S2. Faulty VERT GAIN potentiometer R68.	4. Repair probe. Replace L1. Replace L4. Replace L3. Replace L5. Replace S2. Replace R68.
5. Vertical calibration incorrect.	5. Faulty CR1, CR2, or CR3. Trimmer capacitor on input attenuator misadjusted. Faulty R35. Faulty L2, L12, or L13.	5. Replace CR1, CR2, or CR3. Adjust properly. Refer to paragraph 355*g*(6). Replace R35. Replace L2, L12, or L13.
6. No calibration voltage.	6. CR2 or CR3 shorted. CR1 open. Open R35.	6. Replace CR2 or CR3. Replace CR1. Replace R35.
7. Shortened trace.	7. Open connection between I 3 through I 7 or I 8 through I 12. Faulty —140-volt supply.	7. Repair connection. Check above.
8. None or poor sync of trace.	8. Faulty —140-volt supply. Faulty autosyn. Open L6. Open L8. Improper kc voltage.	8. Check above. Replace autosyn. Replace L6. Replace L8. Check oscillator.
9. Timing pips will not lock and/or phase properly.	9. No 8-kc sync. Faulty —140-volt supply. 8-kc sync improper voltage Open L9. Faulty CR4. L10 improperly adjusted for correct bias and corrected timing. L11 open. CR5 faulty.	9. Check VI. Check above. Adjust sync voltage. Refer to paragraph 355*d*(6). Replace L9. Replace CR4. Adjust L10. Replace L11. Replace CR5.

355. Oscilloscope Tests

The tests in *a* and *j* below are included for reference and as a test procedure after major repair or rebuilding. First, connect a source of 60-cycle, 115-volt power to the scope. Allow the scope to warm up for 1 minute.

Note. The oscilloscope requires 300 watts.

a. Power Supply Voltages.

(1) *Measurements.* All the oscilloscope power supply voltages (including the filament voltages) should be measured. The voltages to be measured and tolerances required are given below.

Note. To achieve the accuracy required for the +225-volt and the —450-volt adjustments, the multimeter should be calibrated carefully against a 1 per cent standard at +225 volts dc and +250 volts dc.

Location	Normal voltage	Tolerance
Pin 3 of V9 (note adjustment procedure (2) below).	+225 volts dc	±3 volts dc
Pin 2 of V4 (note adjustment procedure (2) below).	+450 volts dc	±5 volts dc
Filament voltages between pins 2 and 7 of V12 and V17, and pins 3 and 4 of V10.	6.3 volts ac	±2%
Ungrounded side of C3.	—1,500 volts dc	±150 volts dc
Cathode-ray tube, high-voltage cap (cap side of R5 or E16).	+1,800 volts dc	±150 volts dc
Pin 1 of TB1A.	—140 volts dc	±5 volts dc
Junction of R183 and R182.	—600 volts dc	±50 volts dc

(2) *Adjustment of +225-volt supply.* The +225-volt supply must be set within +3 volts. This should be checked and adjusted if necessary by varying +225V DC ADJ potentiometer R27, at the back of the scope (fig. 110). This check should be made if voltage regulator tube OA2 (V11) is changed. The +450-volt supply should always be adjusted *after* making a +225-volt adjustment. It is adjustable by varying +450V DC ADJ potentiometer R16, at the back of the scope (fig. 110).

Caution: The +450-volt supply should never be adjusted without first adjusting the +225-volt supply.

b. Timing-marker Generator.

(1) Connect the output of Signal Generator SK–71/FCC to MTPX SYNC INPUT jack J4. Set the signal generator for a 20-volt, 8-kc output.

(2) Set the panel controls on the oscilloscope as indicated below:

Control	Position
SYNC SELECTOR	DEMTPX
COARSE	5
FINE	2
INTENSITY	Clockwise (normal brightness)
HOR POSITION	Middle of range
VERT POSITION	Middle of range
TIMING PIP PHASE	Middle of range
VERT ATTEN	1:1
VERT GAIN	Two-thirds clockwise
TRIGGER	Fully counterclockwise
STAB	Fully counterclockwise

(3) Advance the STAB control until a trace appears and then turn it in the opposite direction until the sweep just disappears.

(4) Advance the TRIGGER control until the trace reappears. This trace may not be synchronized, and therefore may not remain stationary on the screen.

(5) Slowly turn the PIP LOCKING control until the trace remains stationary. If it is not possible to synchronize the trace, follow the procedure given in (7) below.

(6) If the trace remains stationary, it should consist of timing pips spaced 5.2 microseconds apart. Vary the TIMING PIP PHASE slowly. It should be possible to move the pips at least 6 microseconds.

(7) If it should become impossible to lock the pips with the PIP LOCKING control, proceed as follows for adjusting the timing-marker generator:

(*a*) Attach Electronic Multimeter TS–505/U to the center tap of

potentiometer R161.

(*b*) Adjust the PIP LOCKING control until the voltmeter reads —2.4 volts dc; then remove the voltmeter.

(*c*) Attach the scope probe to E37 (near V29).

(*d*) Adjust the COARSE and FINE controls until two negative pulses (8-kc repetition rate) appear on the screen. The timing pips will be superimposed on these negative 8-kc pulses as shown in figure 318.

(*e*) Loosen the lock nut on L10. Be sure that the coil mounting nut is on tight.

(*f*) Adjust L10 until the 192-kc pips remain stationary.

(*g*) The pips should divide the time between the two negative pulses into exactly 24 equal intervals. If there are more or less than 24 intervals, readjust L10.

Note. It is essential that the 8-kc sync be 8 kc ±.01. Frequency Meter FR–67/U should be used to monitor the output frequency of Signal Generator SG–71/FCC.

(*h*) Tighten the lock nut without disturbing the adjustment.

(*i*) Recheck the —2.4-volt adjustment as follows: Repeat the procedures given in (1) through (5) above, turn the PIP LOCKING control fully counterclockwise and advance in the clockwise direction very slowly until the pips just become synchronous. The voltage at the center tap of R161 or from R159 to ground should be —2.4 +.2 volts dc. Remove the probe from E37.

(8) Turn the SWEEP PHASE control (autosyn) in either direction. The timing pips should be moved continuously across the screen as the control is turned.

c. Calibration of Sweep Speed. The oscilloscope has an accurate time base calibration consisting of timing pips; therefore, it is not necessary that the COARSE and FINE controls be accurately calibrated. The maximum sweep speed of .5 microsecond per centimeter is within the useful range, if sweep speed calibrating potentiometer R124 is adjusted specifically to be sure this speed is available. To make this calibration, proceed as follows:

(1) Provide an 8-kc sync from Signal Generator SG–71/FCC and turn on the timing markers (previously calibrated).

(2) Place the COARSE control in the 5-microsecond position and the FINE control to 1.

(3) Adjust R124 (fig. 311) until two consecutive timing pips are 11 centimeters apart. The maximum speed is now in excess of the desired .5 microsecond per centimeter.

(4) Retighten the lock nut on R124. Check to see that the COARSE and FINE controls operate in all positions as follows:

(*a*) Set the COARSE and FINE controls as shown in the table below.

(*b*) Connect the scope probe to the output of Signal Generator SG–71/FCC. Turn the scope SYNC SELECTOR switch to +INT and the TIMING PIP PHASE control to OFF.

(*c*) Adjust the frequency of the oscillator so that 1 complete cycle covers 10 cm on the scope phase. This will be the frequency given in the *Nominal frequency* column.

Sweep time		Normal frequency	Sweep overlap
Coarse	Fine		
5,000	10	30 cps	
5,000	1	300 cps	20 cps[a]
500	10		
500	1	2.8 kc	200 cps[a]
50	10		
50	1	23 kc	1 kc[a]
5	10		

[a] Equal to or greater than the value listed.

(*d*) To insure a complete and continuous range of sweep speeds, there must be an overlap in the sweep speed when switching the sweep time from one scale to another. The amount that the scales should overlap is given in the *Sweep*

overlap column. The scales that should overlap are bracketed and the overlap should be such that the higher sweep time setting should have the higher frequency (that is, setting 50-1 should have a higher frequency than 5-10). To make the above procedure clearer, assume that the COARSE and FINE controls are in positions 5 and 10, respectively. The oscillator frequency is adjusted until 1 complete cycle covers 10 cm. Assume that this frequency is 20 kc. Switch the COARSE and FINE controls to 50 and 1, respectively. The frequency of the oscillator is again adjusted so that 1 cycle covers 10 cm. This new frequency must be at least 21 kc or greater.

(*e*) Connect J3 to the test oscillator and place the SYNC SELECTOR control in +EXT position. Use the STAB and TRIGGER controls to obtain a stable trace.

(*f*) Repeat the procedure given in (*d*) above with the SYNC SELECTOR control in —EXT position.

d. Adjustment of Vertical Amplifier Low-frequency Response. To adjust the low-frequency response of the vertical amplifier, proceed as follows:

(1) Set the VERT ATTEN control to 1:1 and the SYNC SELECTOR control to +INT, the COARSE switch to 5,000 and the FINE control to 10.

(2) Apply a 50-cycle, 5-volt square wave to the probe, from Square Wave Generator TS–583/U.

(3) Adjust R59 and R71, located on the right side chassis (fig. 313), until a flattop is obtained (fig. 318). This same figure also indicates the effect of incorrect adjustment of these potentiometers.

(4) Set the VERT ATTEN switch to CAL. The wave form should have a flattop (fig. 318).

(5) To check the SYNC SELECTOR control, switch it to —INT. The trace should be 180° out of phase with the +INT trace.

e. Adjustment of Input Attenuator. To compensate for the probe on each attenuator setting, variable capacitors are provided across the input to each divider. The most convenient way to adjust these capacitors is to observe the resulting wave shape on the oscilloscope when supplying the input with a 1,000-cycle square wave that is adjustable from 1 to 50 volts peak to peak. Proceed as follows:

(1) Set the COARSE control to 5,000, the FINE control to 2, and the SYNC SELECTOR switch to +INT.

(2) Set the VERT ATTEN switch to 1:1 and the VERT GAIN control two-thirds clockwise and, with the probe, apply a 5-volt, 1,000-cycle square wave to the scope.

(3) Adjust C22 (located on the vertical amplifier chassis, fig. 312) for the best wave form on the screen (fig. 220).

(4) Set the VERT ATTEN switch to 2:1 and apply a 10-volt, 1,000-cycle square wave to the probe.

(5) Adjust C19 and C21 on VERT ATTEN switch S2 (fig. 316) for best wave form (fig. 321 and 322). These same figures also indicate the wave forms to be expected when C19 and C21 are not properly adjusted.

(6) Set the VERT ATTEN switch to 10:1 and apply a 50-volt 1,000-cycle square wave to the probe.

(7) Adjust C16 and C17 as indicated in (5) above.

(8) Set the VERT ATTEN switch to 100:1 and apply a 50-volt, 1,000-cycle or larger square wave to the probe.

(9) Adjust C11 and C13 as indicated in (5) above.

f. Voltage Calibrator. To check the voltage calibrator accuracy, proceed as follows:

(1) Apply a 100-cycle square wave of known voltage to the probe.

(2) Adjust the VERT GAIN control until the square wave is of a size that corresponds to two boxes in amplitude on the graticule. *Note the VERT ATTEN setting.*

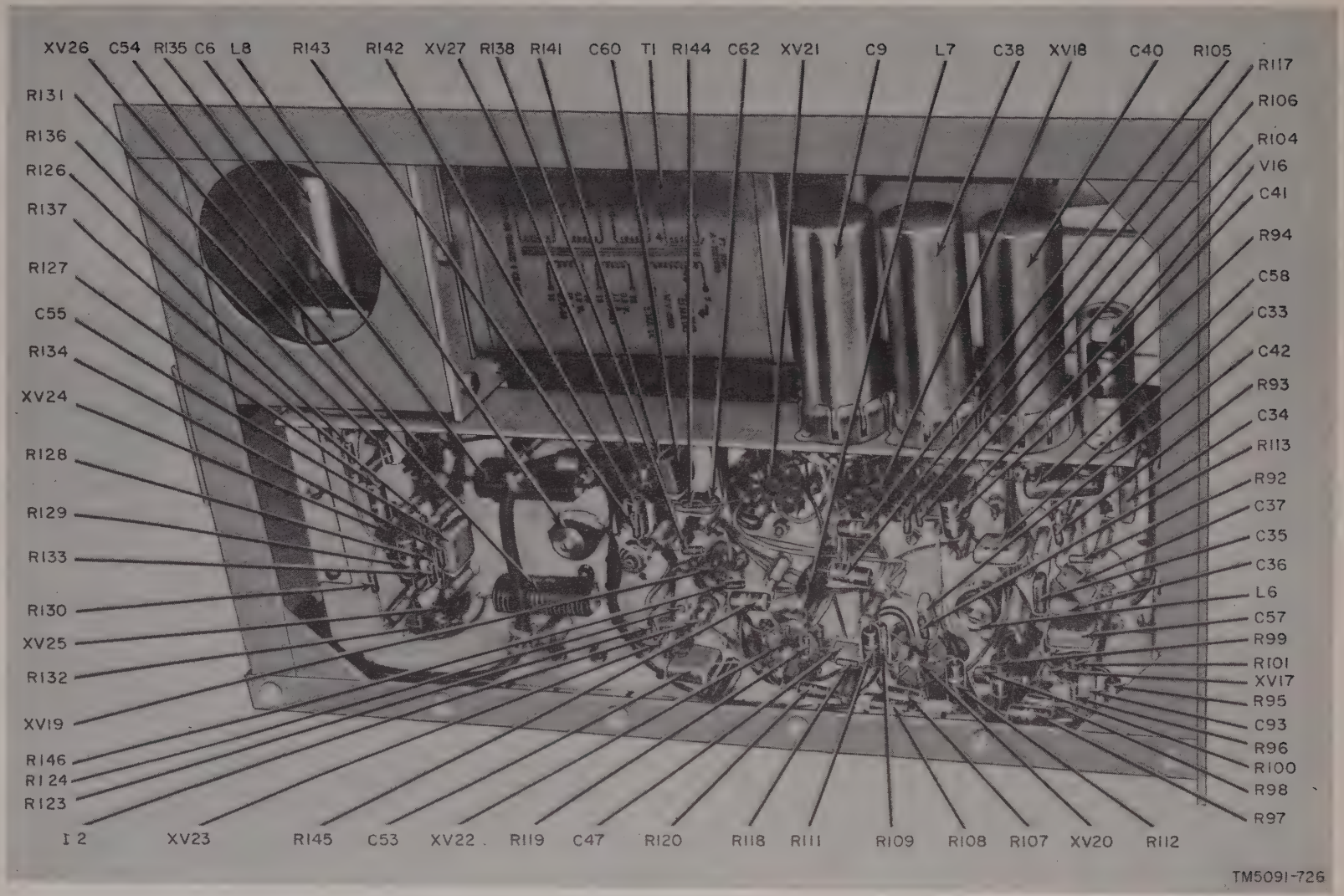


Figure 311. Oscilloscope, left side view.

(3) Set the VERT ATTEN switch on CAL and adjust the trace with the CAL VOLTAGE control until its size corresponds to two boxes on the graticule.

(4) Multiply the reading on CAL VOLTAGE control by the VERT ATTEN setting noted in (2) above. This answer should give the value of the known voltage within 10 per cent.

(5) Apply this procedure in every setting of the VERT ATTEN switch.

Caution: Do not adjust the FOCUS, INTENSITY, or ASTIG control while making voltage calibration tests.

g. Vertical Amplifier Bandwidth.

(1) Connect the output terminals of the signal generator to the scope probe.

(2) Connect Voltmeter ME–30A across these terminals.

(3) Rotate the SYNC SELECTOR switch to +INT and the VERT ATTEN control to 1:1.

(4) Set the signal generator frequency at 100 kc and adjust its output to 1.5 volts. This may be considered as the reference or 0 db level.

(5) Adjust the VERT GAIN control for either a 1-division or a 2-division sine wave, preferably 2, depending on the scope sensitivity. If necessary, adjust the vertical position control to bring the top of the sine wave to the top of the division mark on the scope scale. This can be considered the division marker reference level.

(6) Set the signal generator frequency to 60 cps and adjust the output to the division marker reference level.

(7) Note the oscillator voltage. The reading should be from 1.43 to 1.57 volts, corresponding to —.4 db and +.4 db, with the respect to the reference level.

(8) Disconnect the signal generator from the scope probe and substitute Signal Generator AN/URM–25B. Set the signal generator frequency to 5MC and adjust its output to bring the top of the wave to the division marker reference level. The signal generator reading should be from 1.42 to 2.12 volts corresponding to .5 db to 3 db from the reference level.

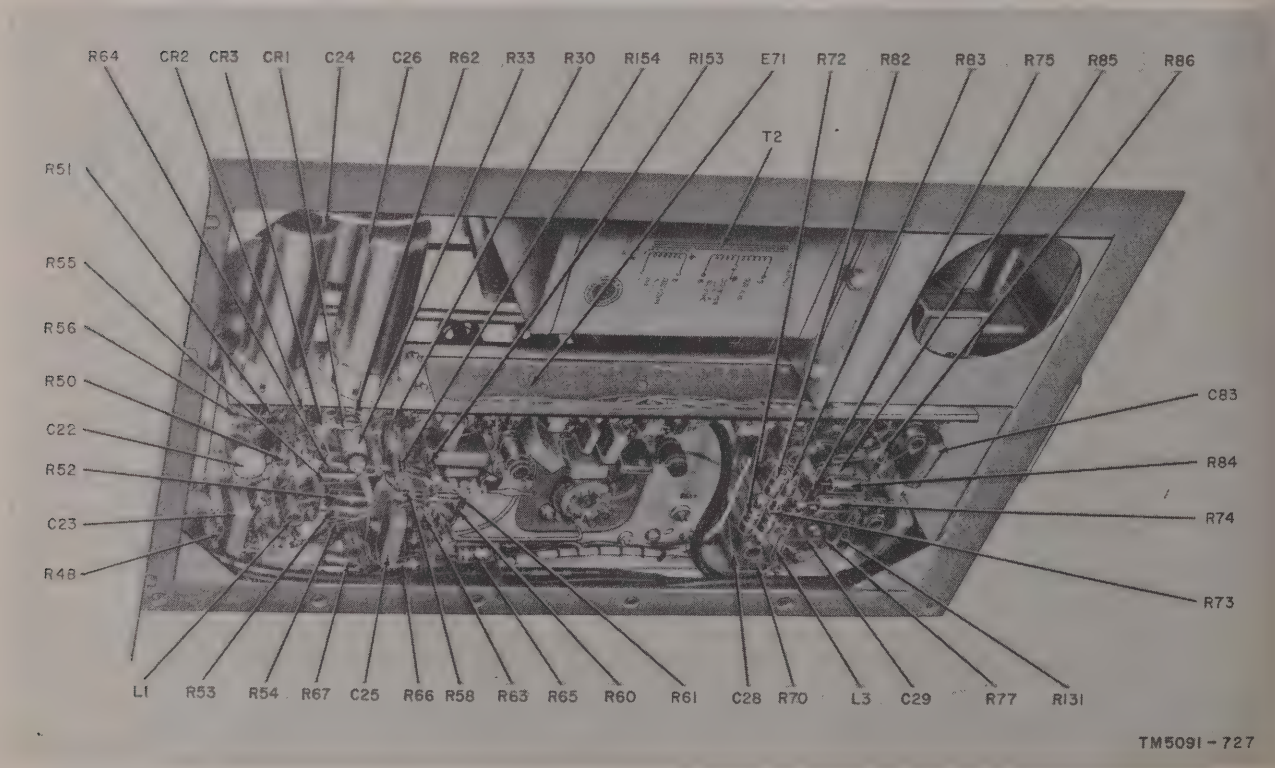


Figure 312. Oscilloscope, right side view (looking down).

Note Other convenience values of voltage may be used throughout as long as the relative decibel values are maintained.

h. Maximum Deflection Sensitivity.

(1) Set the VERT ATTEN control 1:1 and the VERT GAIN control fully clockwise.

(2) Insert a signal to the scope probe from the square wave generator. Increase the signal until there is a vertical deflection of 1 cm on the scope face. This signal voltage should be 3 volts or less.

i. Fan Operation. With the oscilloscope on, the fan should be blowing air upwards and out of the top of the scope.

j. Wave Forms. If the above test shows that the oscilloscope is not operating properly, check the wave forms at the points indicated in the chart below. Use Oscilloscope AN/USM–50 (or another Oscilloscope OS–25/G) for this purpose. Change the tube of the stage which appears defective; if this does not correct the fault, place the original tube back in its socket and check the circuit components.

(1) *Horizontal amplifier (input 1-kc square wave, 10 volts p-p).*

Pin	Tube	Fig. ref
8	V12	323
8	V13	324
8	V14	325
8	V15	326

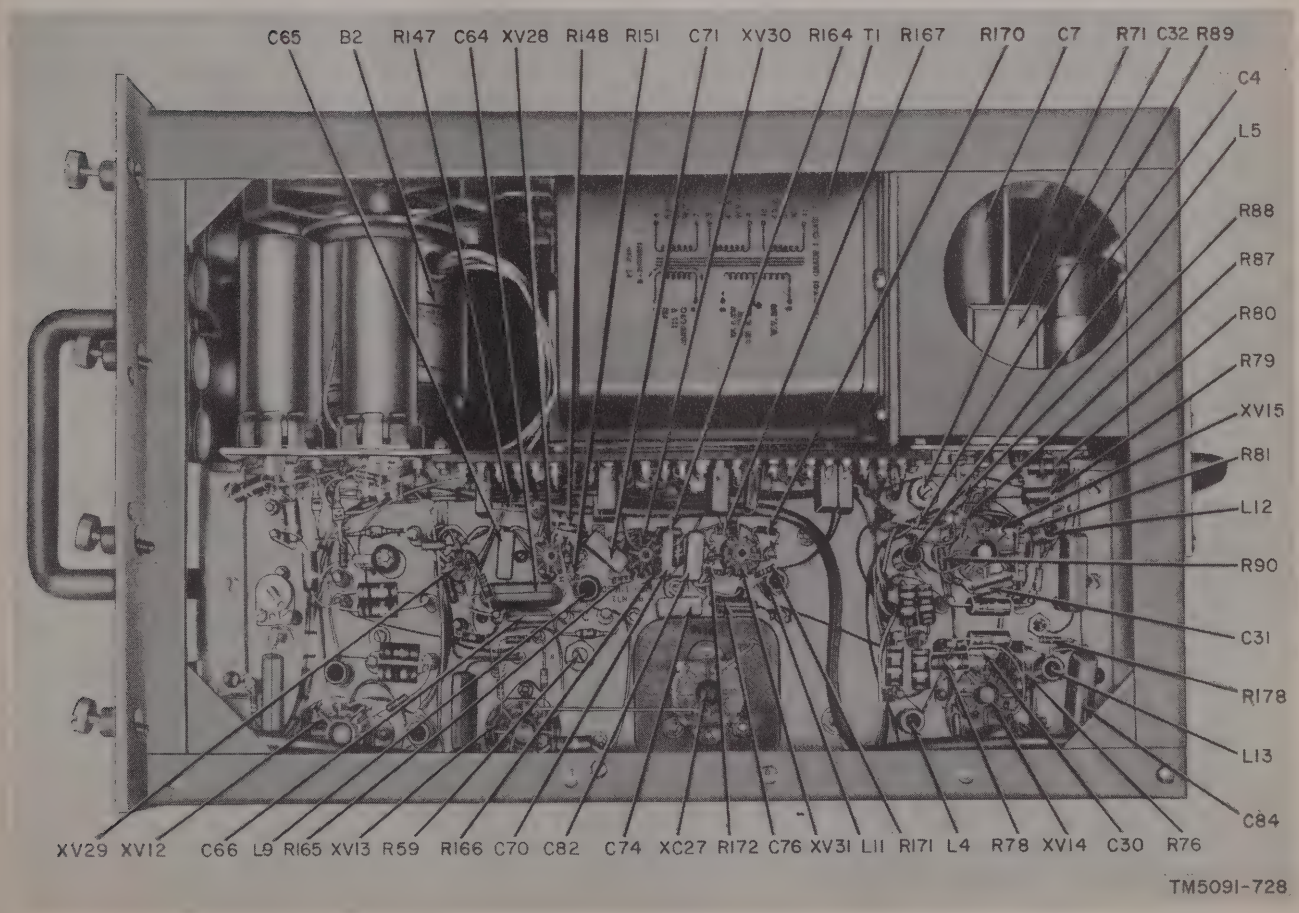


Figure 313. Oscilloscope, right side view (looking up).

(2) *Horizontal amplifier (triggered).*

Pin	Tube	Fig. ref	Pin	Tube	Fig. ref
1	V16A	327	5	V25	334
6	V16B	328	5	V26	335
5, 8	V17	329	1	V28A	336
8	V18	330	6	V28B	317
5	V19A	330	1, 6	V30	337
8	V20	331	7	V30B	338
8	V21	332	6	V31A	339
8	V22	333	J4		340
1, 5	V24	333			

(3) *Voltage calibration circuit.* Observe the cathode-ray tube display. Check the crt display to see that it is similar to the one shown in figure 319.

(4) *Time calibration.* Observe the cathode-ray tube display. Check the crt display to see that it is similar to the one shown in figure 341.

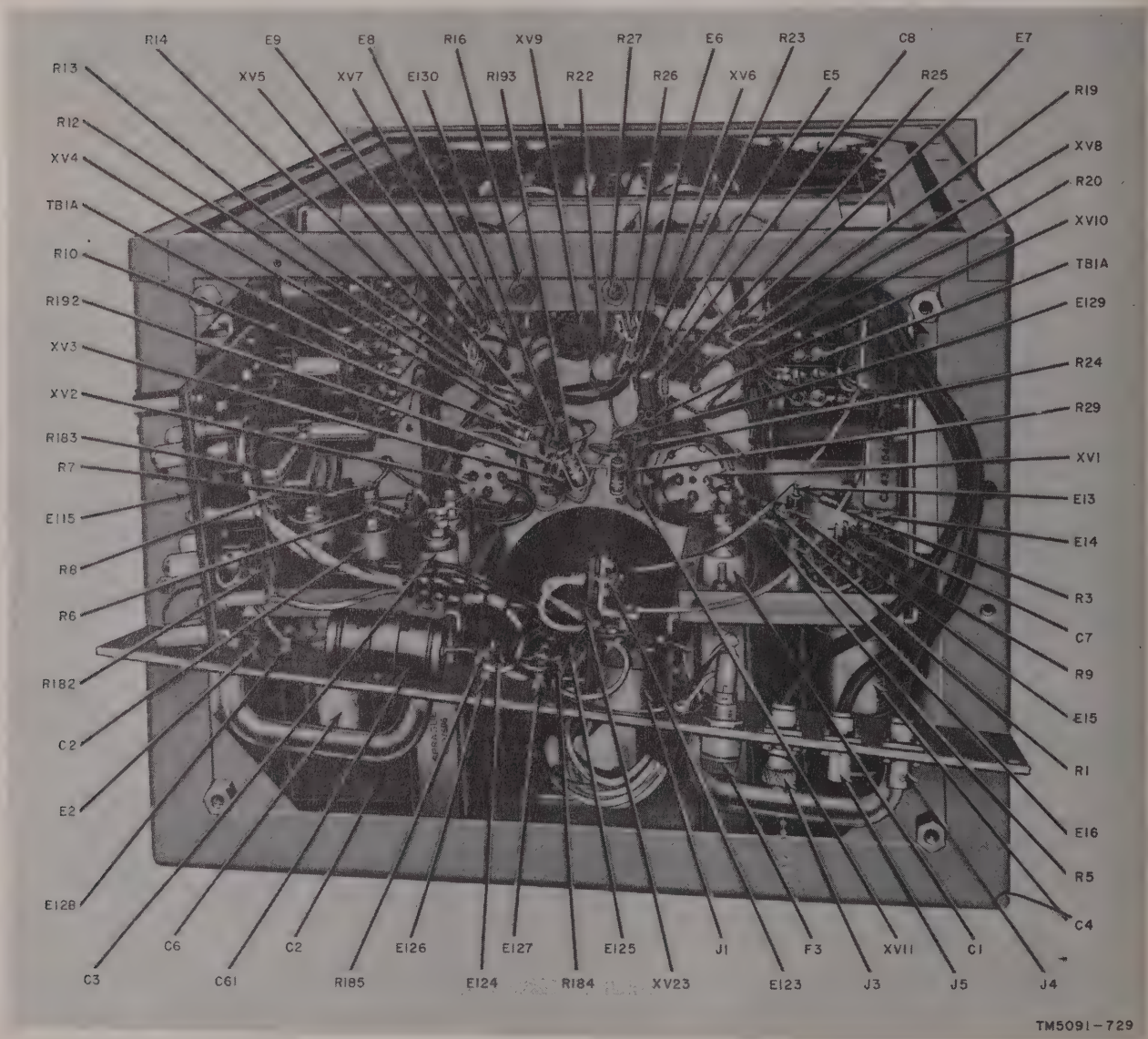


Figure 314. Oscilloscope, rear view.

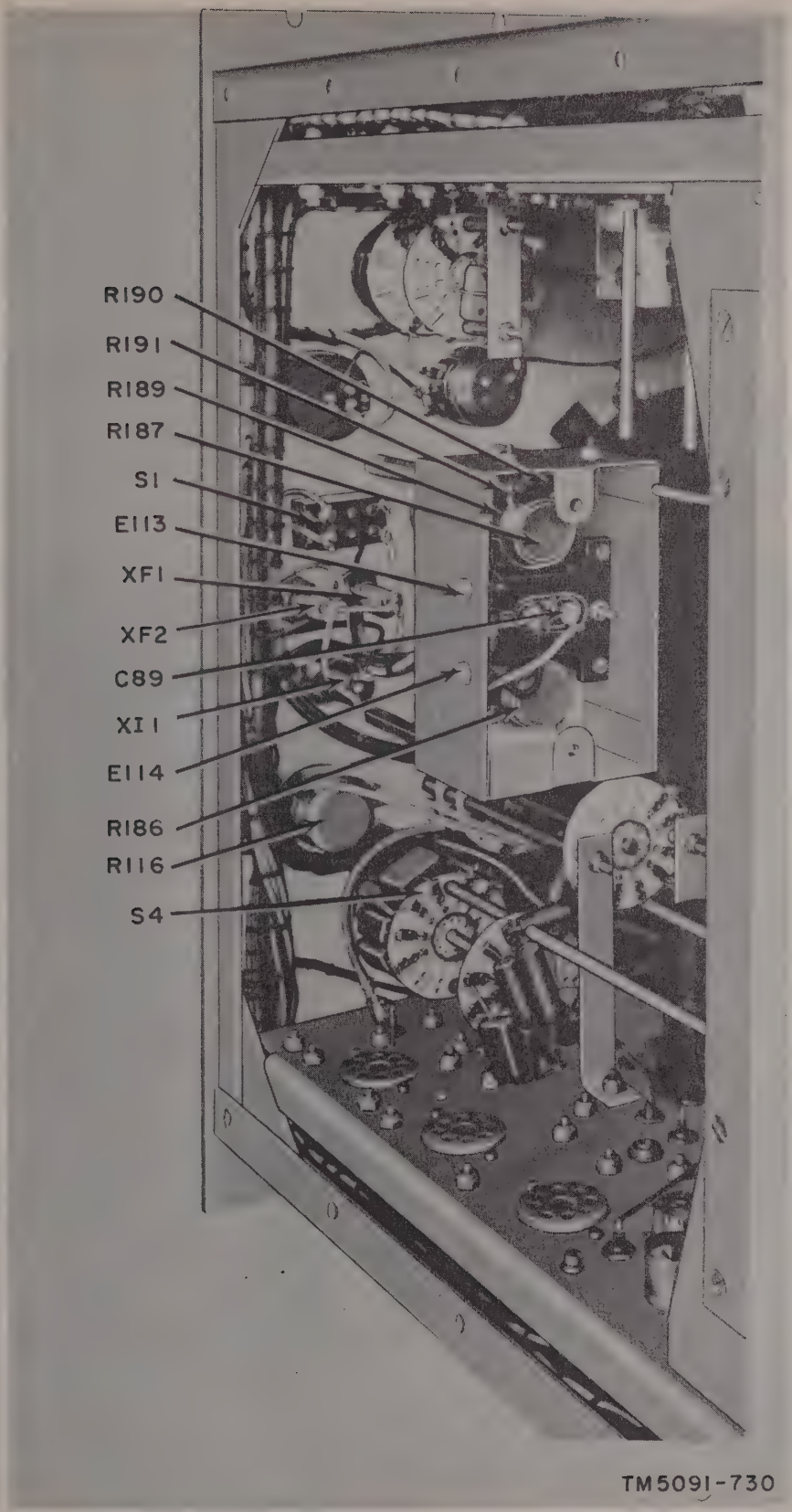


Figure 315. Oscilloscope, back of front panel, right side view.

356. Oscilloscope Dc Resistance of Transformer, Coils

The dc resistances of transformer windings and coils are listed below. An asterisk (*) indicates an ohmmeter reading too low to be reliable.

Transformer, coil, or relay	Terminals	Ohms	Transformer, coil, or relay	Terminals	Ohms
L1		1.55		7–9	1,150
L2, L5		1.75		8–9	960
L3		*		10–11	*
L4		1.95		12–13	*
L6, L8		85		14–15	*
L7		9.15	T2	1–2	1.8
L9, L11		8.40		3–4	13
L10		15.20		4–5	14
L12		2.07		3–5	27
L13		1.70		6–7	*
T1	1–2	13		8–9	*
	3–4	*		10–11	*
	5–6	*		12–13	*
	7–8	190			

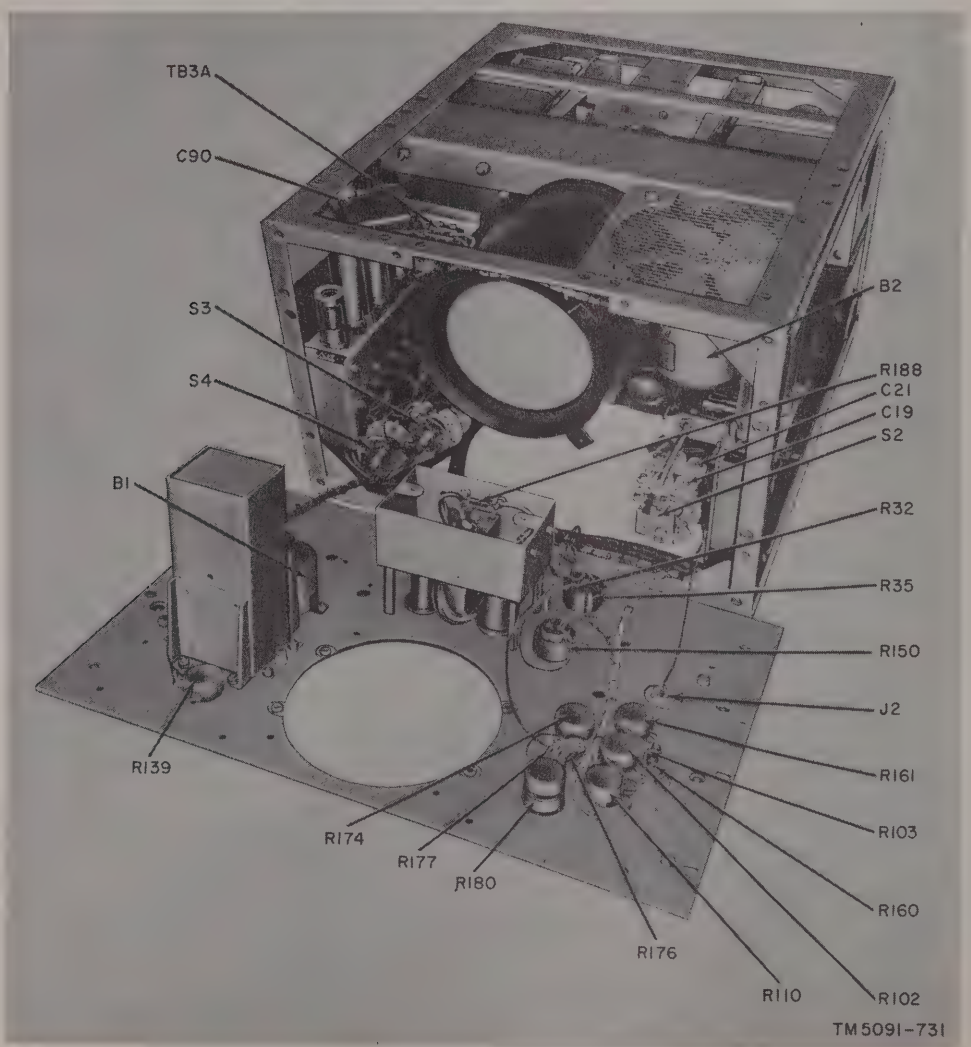


Figure 316. Oscilloscope, front panel swung down.

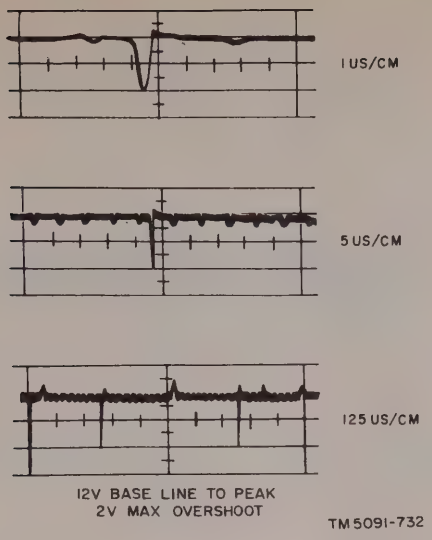


Figure 317. Wave form at pin 6 (plate) of V28B.

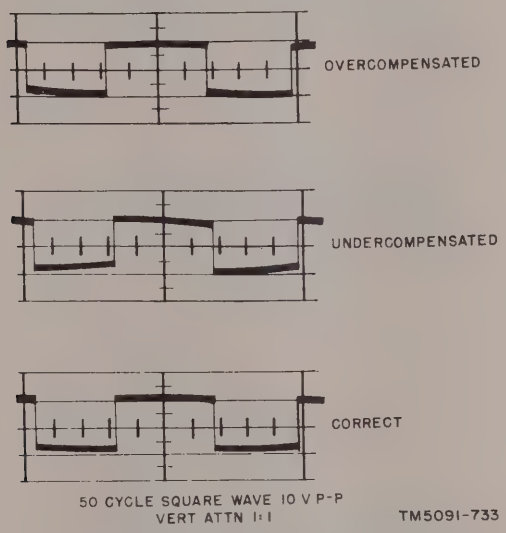


Figure 318. Vertical amplifier adjustment wave form.

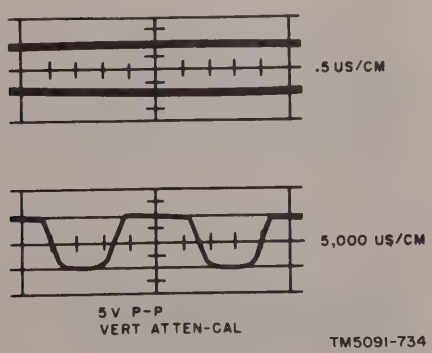


Figure 319. Vertical attenuator adjustment wave form and crt display, voltage calibrator wave form.

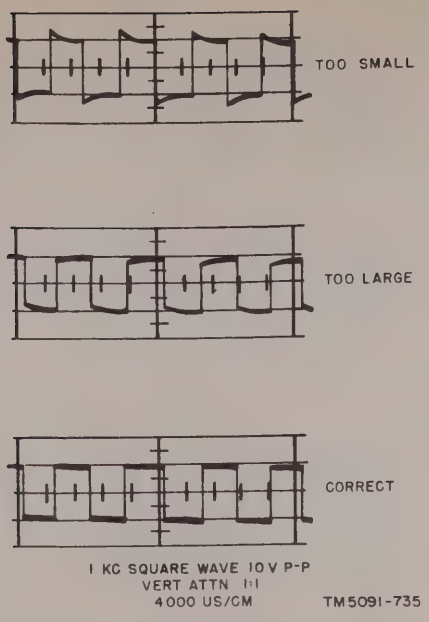


Figure 320. Capacitor C22 adjustment wave form.

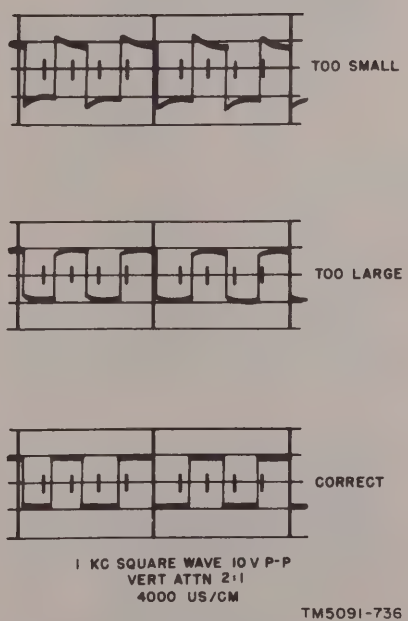


Figure 321. Vertical attenuator adjustment C19 wave form.

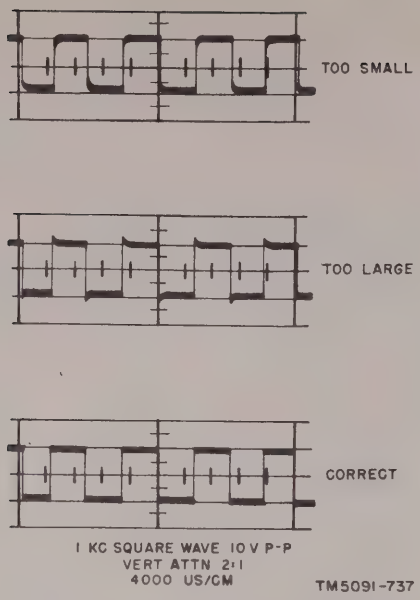


Figure 322. Vertical attenuator adjustment C21 wave form.

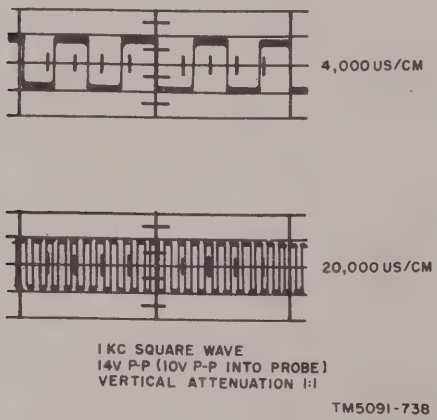


Figure 323. Wave form at pin 8 (plate) of V12.

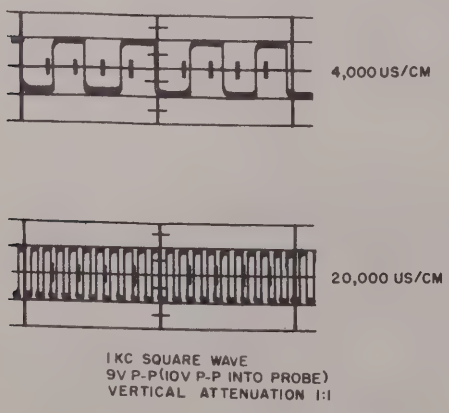


Figure 324. Wave form at pin 8 (plate) of V13.

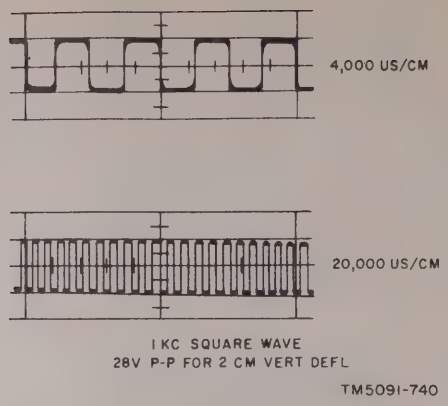


Figure 325. Wave form at pin 8 (plate) of V14.

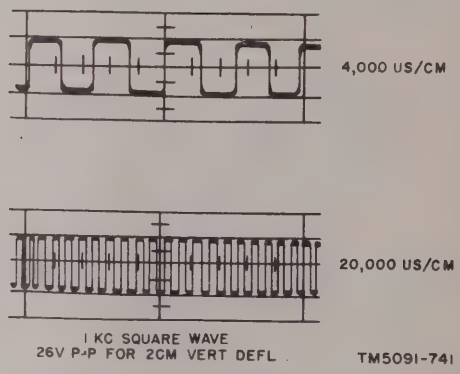


Figure 326. Wave form at pin 8 (plate) of V15.

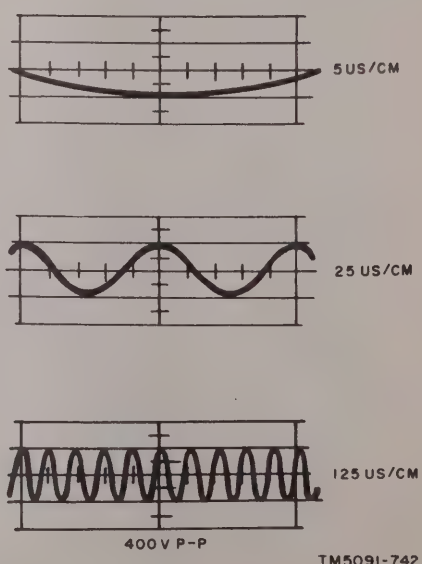


Figure 327. Wave form at pin 1 (plate) of V16A.

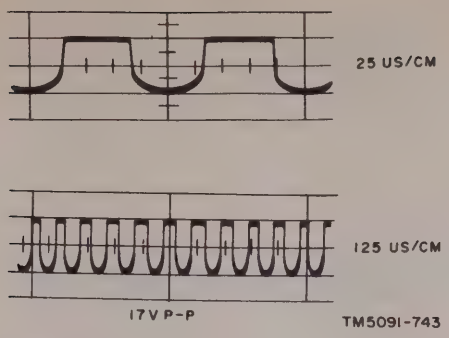


Figure 328. Wave form at pin 6 (plate) of V16B.

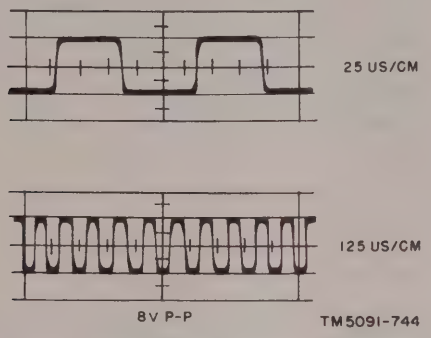


Figure 329. Wave form at pin 5 (cathode) and pin 8 (plate) of V17.

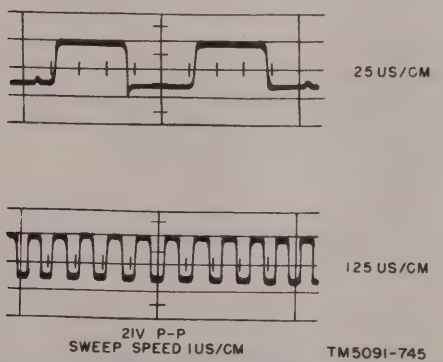


Figure 330. Wave form at pin 8 (plate) of V18 and pin 5 (cathode) of V19A.

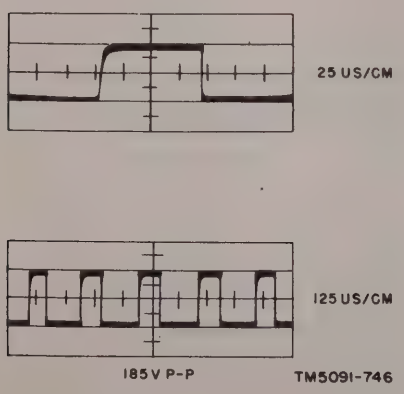


Figure 331. Wave form at pin 8 (plate) of V20.

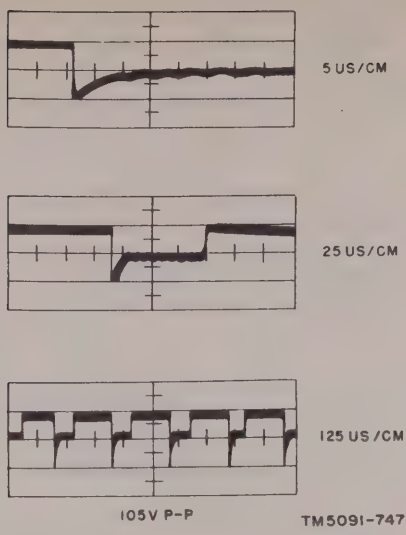


Figure 332. Wave form at pin 8 (plate) of V21.

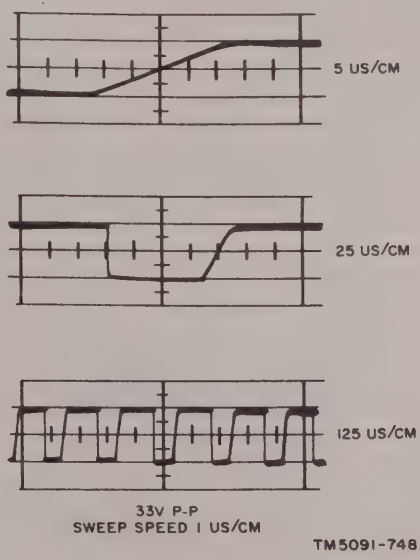


Figure 333. Wave form at pin 8 (plate) of V22 and pins 1 and 5 (cathode) of V24.

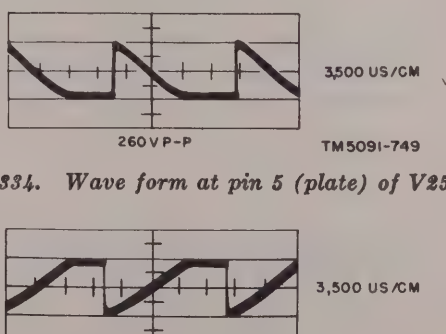


Figure 334. Wave form at pin 5 (plate) of V25.

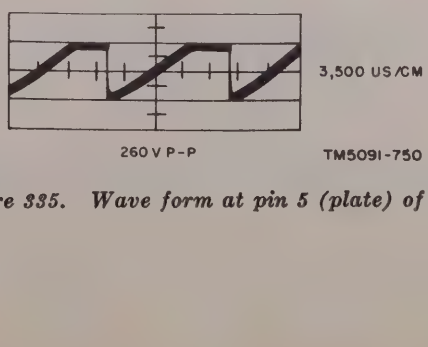


Figure 335. Wave form at pin 5 (plate) of V26.

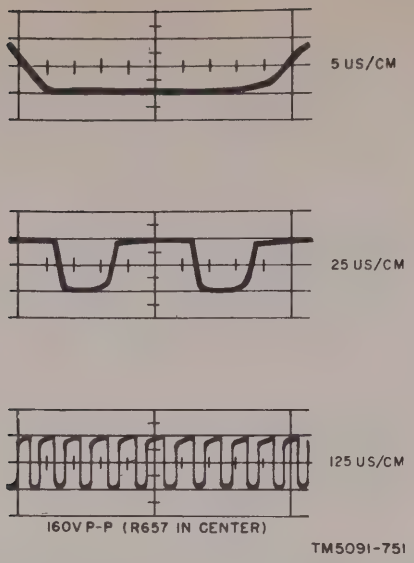


Figure 336. Wave form at pin 1 (plate) of V28A.

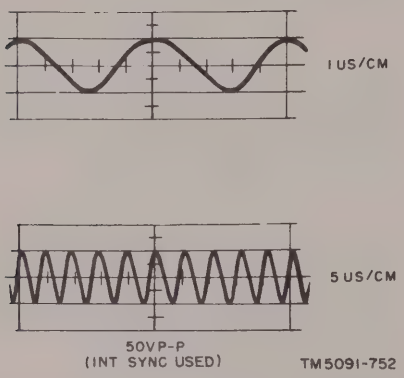


Figure 337. Wave form at pins 1 and 6 (plates) of V30.

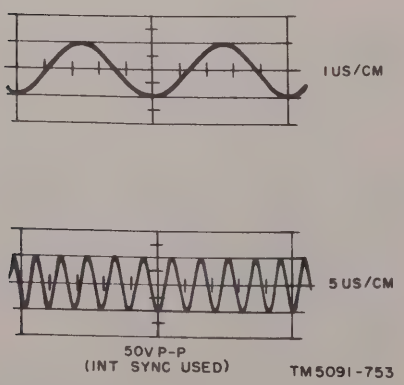


Figure 338. Wave form at pin 7 (grid) of V30B.

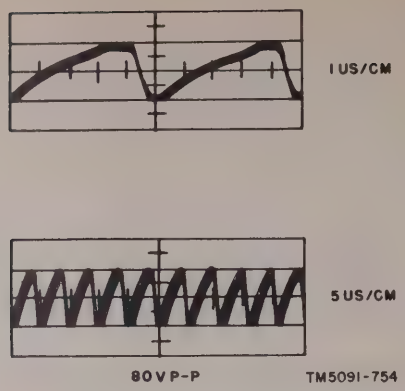


Figure 339. Wave form at pin 6 (plate) of V31A.

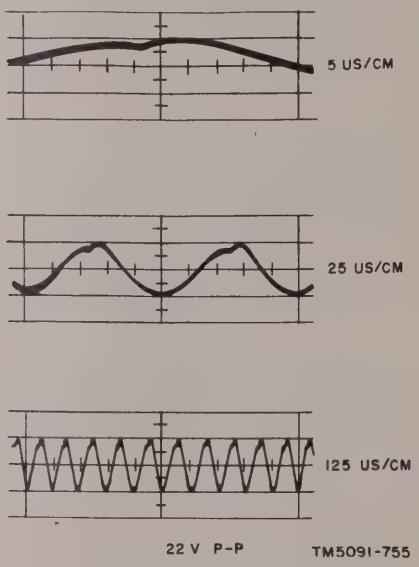


Figure 340. Wave form at J4.

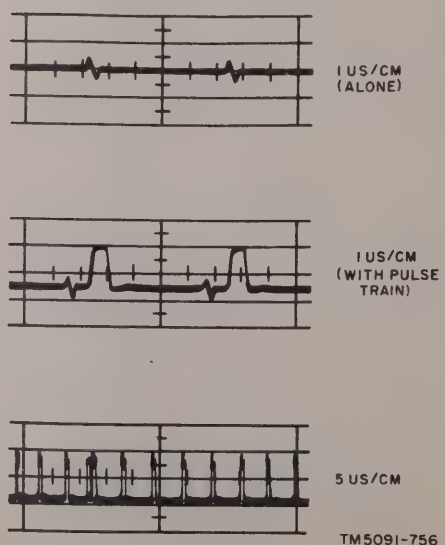
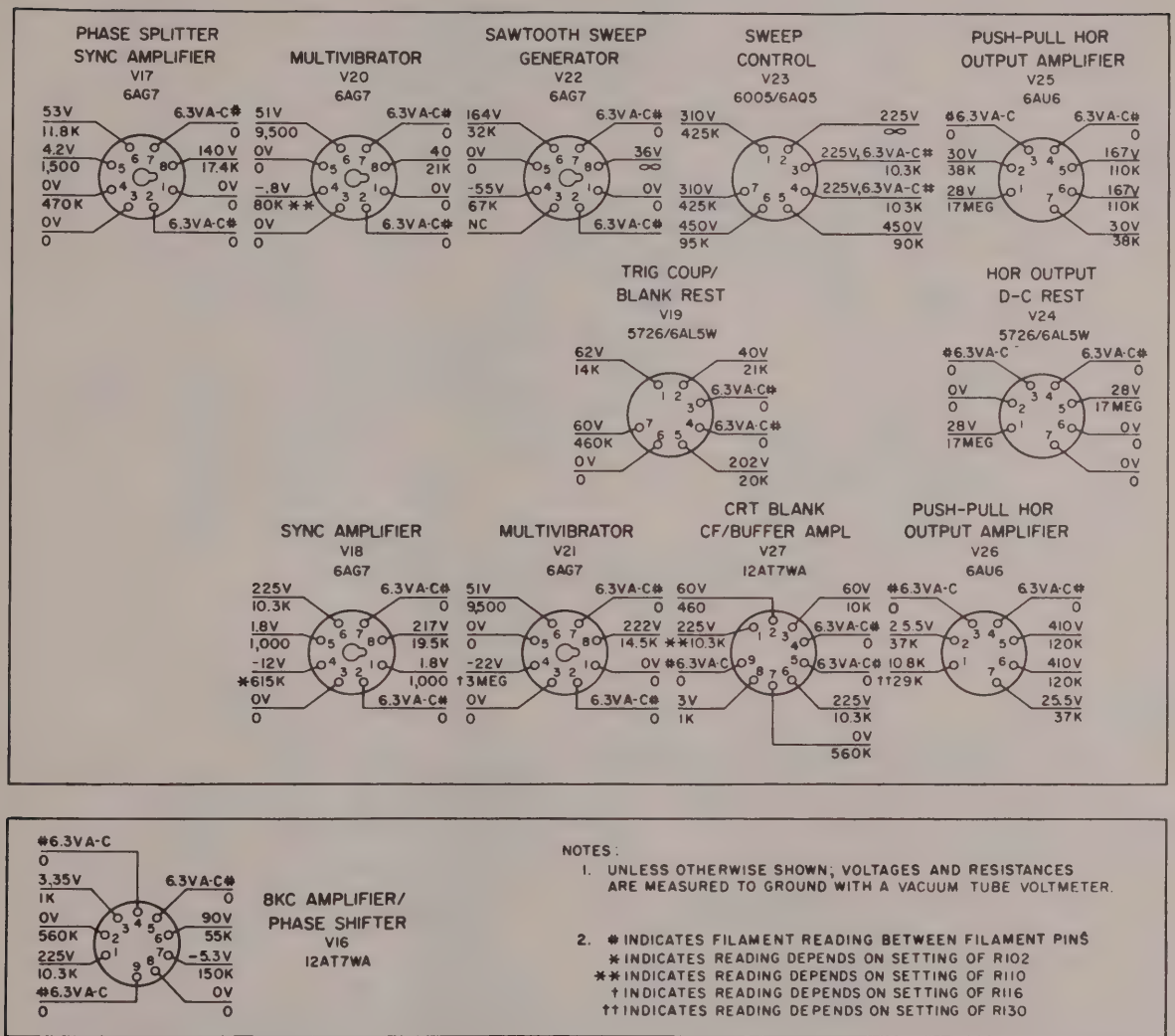


Figure 341. Crt display, time calibrator wave form.

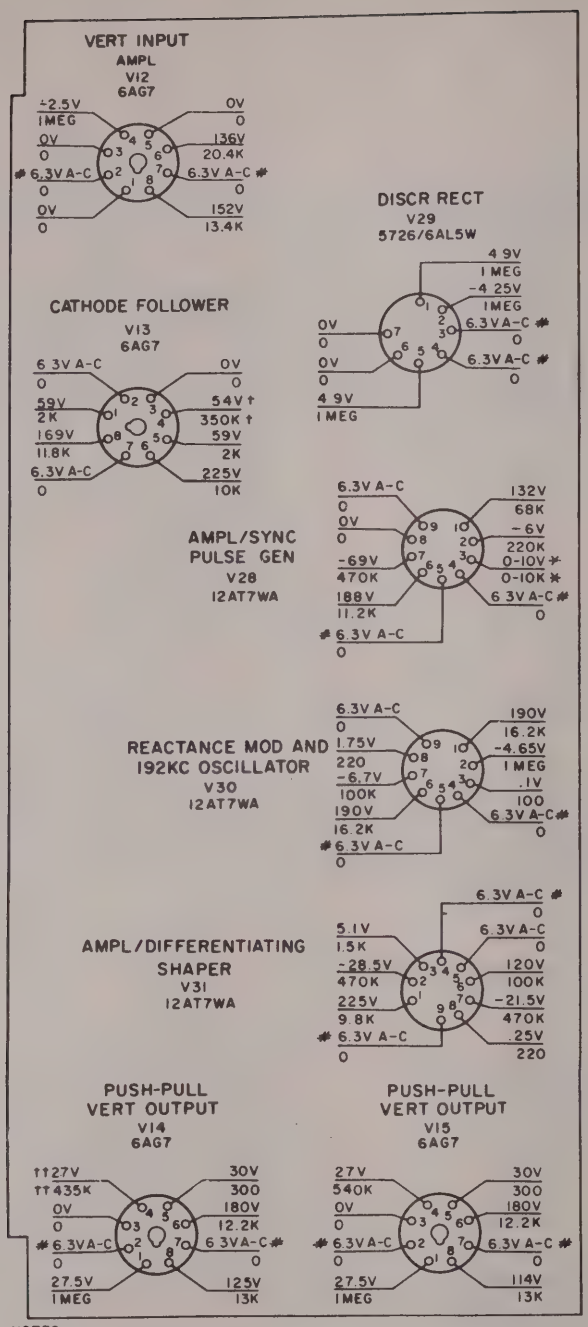


NOTES:

1. UNLESS OTHERWISE SHOWN, VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER.
2. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS
   * INDICATES READING DEPENDS ON SETTING OF R102
   ** INDICATES READING DEPENDS ON SETTING OF R110
   † INDICATES READING DEPENDS ON SETTING OF R116
   †† INDICATES READING DEPENDS ON SETTING OF R130

TM5091-757

Figure 342. Oscilloscope, bottom right section, tube socket voltage and resistance diagram.



NOTES

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A VACUUM TUBE VOLTMETER.

2 NC INDICATES NO CONNECTION

3 # INDICATES FILAMENT READING BETWEEN FILAMENT PINS
* INDICATES READING DEPENDS ON SETTING OF R150. VOLTAGE ALSO DEPENDS ON SYNC INPUT: WITHOUT SYNC, VOLTAGE 0-4V; WITH SYNC, VOLTAGE 0-10V.
† INDICATES READING DEPENDS ON SETTING OF R59
†† INDICATES READING DEPENDS ON SETTING OF R71

TM5091-758

Figure 343. Oscilloscope, bottom left section, tube socket voltage and resistance diagram.

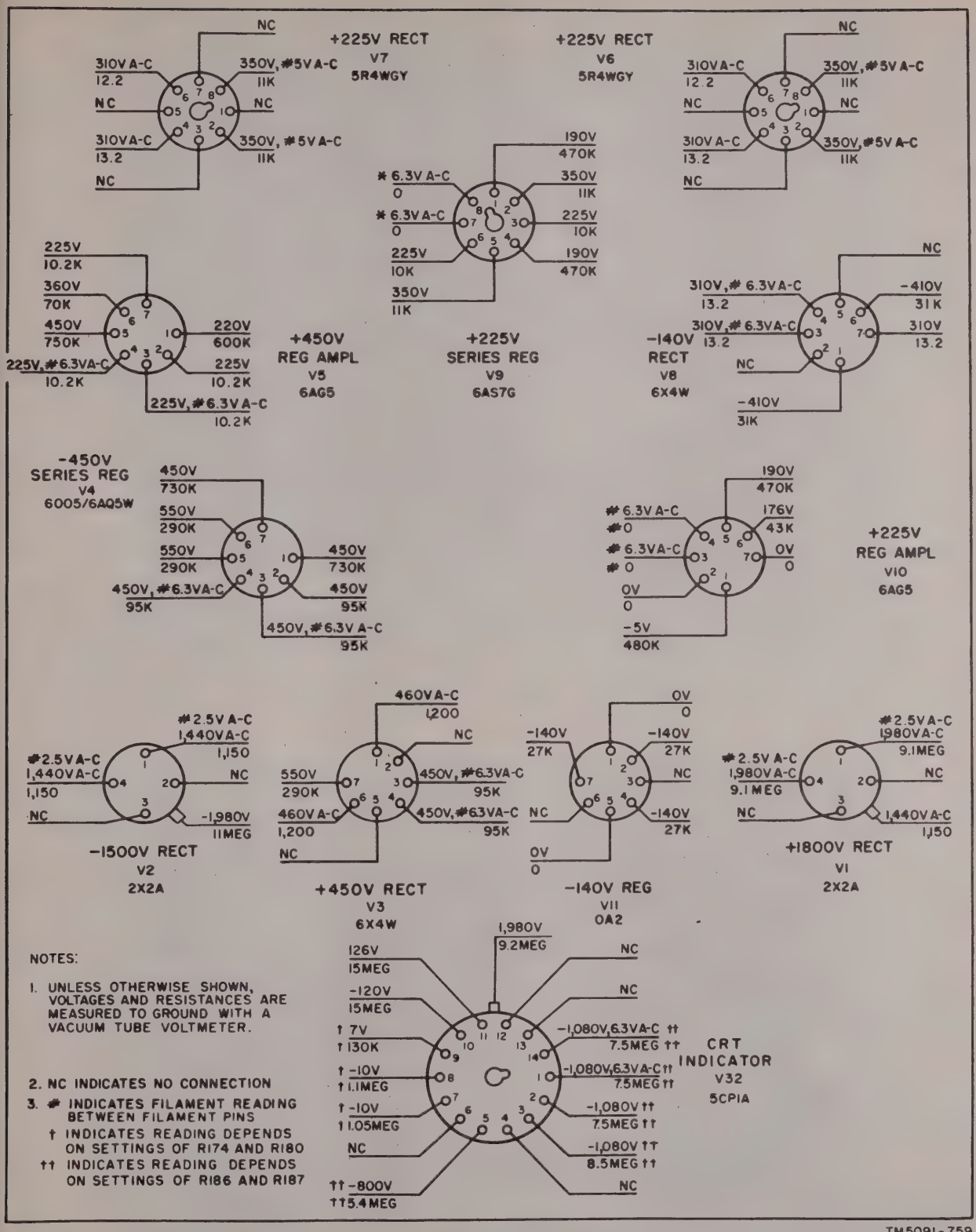


Figure 344. Oscilloscope, bottom center section, tube socket voltage and resistance diagram.

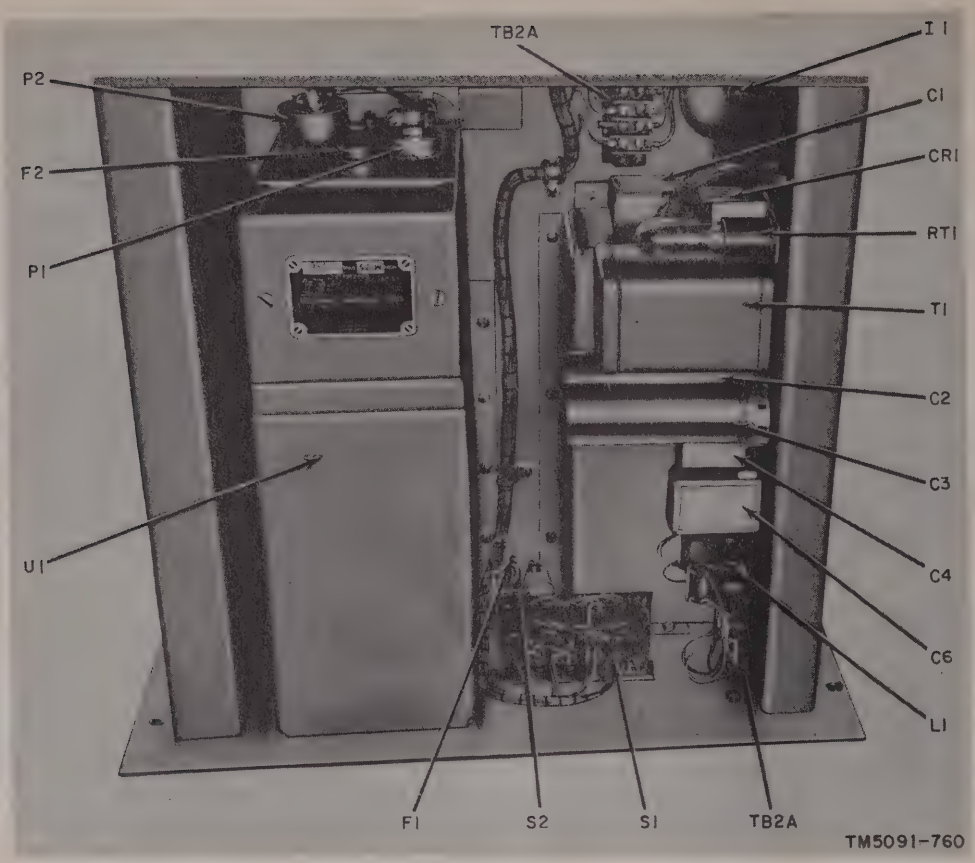


Figure 345. Control monitor, top view.

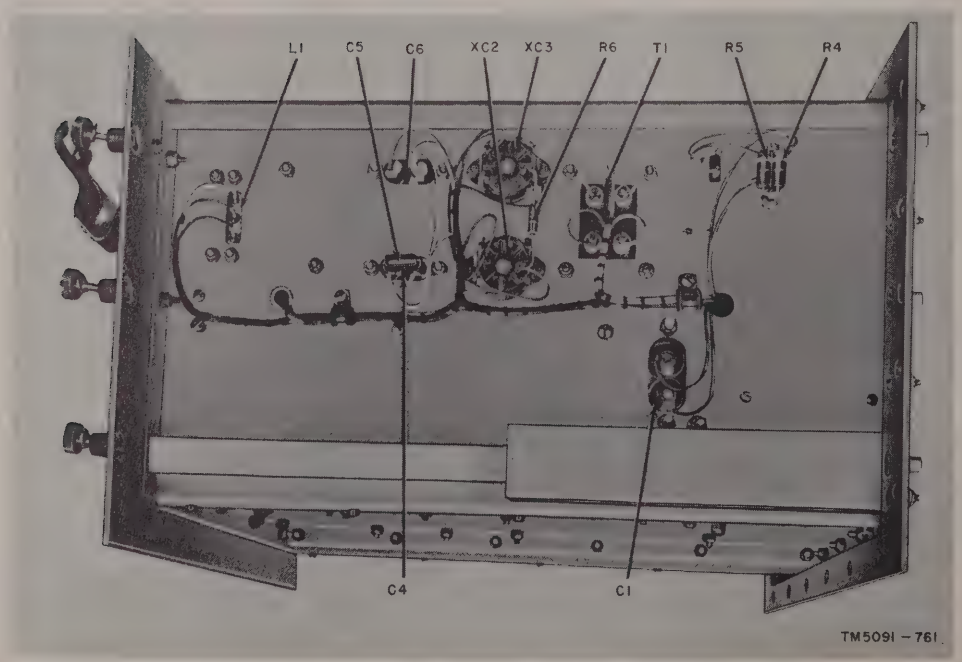


Figure 346. Control monitor, side view.

357. Control Monitor Trouble-shooting Data

The following data will assist maintenance personnel when trouble shooting the control monitor.

Fig. No.	Description
382	Control Monitor C–1151/TC, over-all schematic diagram.
405	Control Monitor C–1151/TC, over-all wiring diagram.
345	Control Monitor, top view.
346	Control Monitor, side view.

358. Test Equipment Required for Control Monitor

The following test equipment is required fully to check the control monitor.

Item	Common name	Technical manual
Telephone EE–8–B	Field telephone	TM 11–333
Multimeter TS–352B/U	Multimeter	TM11–5527A
Spectrum Analyzer TS–723/U	Spectrum analyzer	
Signal Generator SG–71/FCC	Signal generator	TM 11–5088
Oscilloscope OS–25/G or Oscilloscope AN/USM–50	Oscilloscope	

359. Control Monitor Trouble-shooting Procedure

The test panel is best serviced by taking voltage and resistance measurements. The most common source of trouble in the test panel is the microphone current supply to the telephone. Other sources of trouble are the push-button switches. The tests below may be made when trouble shooting the control monitor. First, place a 115-volt ac source across terminals C and D of J3.

a. Ringer Circuit.

(1) Measure the 20-cps ringing voltage across terminals E and F of J2 with the wave analyzer. There should be 100 volts ±10 per cent rms of 20-cps ringing voltage. This is the open-circuited voltage.

(2) Place a variable resistance of about 2,000 ohms across J2–E and J2–F. Slowly decrease this resistance until the output voltage drops to 75 volts rms. Measure the resistance and then determine the output power. It should be at least 7.5 watts. Temporarily short the output. Lamp RT1, which gives short-circuit protection, should begin to glow.

(3) The maximum 20-cps ringing voltage distortion should be 20 per cent. This should be checked with the wave analyzer at 60 cps and 120 cps in particular. Compare the values at 60 cps and 120 cps with the value at 20 cps and compute the percentage.

(4) The ringing voltage fundamental should be 20 cps ±20 per cent. This may be checked by Lissajous patterns with the output of Audio Oscillator TS–382A/U connected to the horizontal input of the oscilloscope and the ringing voltage connected to the vertical input terminals. Adjust the frequency of the audio oscillator until a circle is seen on the oscilloscope; the frequency of the ringing voltage is equal to the value on the audio oscillator.

b. Telephone Circuit.

(1) Place the panel switch in the TEL SET position and connect Field Telephone EE–8–B across terminals A and B of J2. Crank the ringing handle on the field telephone. This should ring the bell in the control monitor.

(2) Now place the field telephone across terminals C and D of J2. It should be possible to converse between the field telephone and the control monitor headset.

c. Panel Ring Switch. With the field telephone still connected across terminals C and D of J2, press the panel RING switch. The field telephone bell should ring.

d. Panel Selector Switch. Make a dc check on the panel switch. Do this by using an ohmmeter and checking against the schematic diagram to be sure that terminals A, B, C, and D of J2 connect properly through the switch in all the

switch positions. This testing can be performed readily by following the procedure below.

(1) *Order wire (J2–A and J2–B).*

Switch position	Check for continuity				Resistance (ohms)
	From		To		
	Jack	Terminal	Switch	Terminal	
REC	J2	A	S2	2 (TB1A–8)	100
SEND	J2	B	S2	5 (TB1A–6)	100
NORMAL					
TEL SET	J2	A	S2	2 (TB1A–8)	
	J2	B	S2	5 (TB1A–6)	

(2) *Test Pair (J2–C and J2–D).*

Switch position	Check for continuity				Resistance (ohms)
	From		To		
	Jack	Terminal	Jack or switch	Terminal	
REC	J2	C	J4	B	0
	J2	D	J4	A	0
SEND	J2	C	J1	B	0
	J2	D	J1	A	0
TEL SET	J2	C	S2	2 (TB1A–8)	0
	J2	D	S2	5 (TB1A06)	0
NORMAL	J2	C	J2	D	620

360. Control Monitor Trouble-shooting Chart

The following chart is supplied as an aid in locating trouble in the control monitor.

Sympton	Probable trouble	Correction
1. No 20-caps ringing voltage at pins C and D (test pair when test switch is in TEL SET and RING switch S2 depressed).	1. Faulty U1 (20-cps ringing generator).	1. Replace U1.
	Faulty RING switch S2.	Replace S2.
	Faulty test switch S1.	Replace S1.
	No ac to ringing generator.	Check ac input.
2. Order wire inoperative.	2. Faulty CR1.	2. Replace CR1.
	Faulty C2 and C3.	Replace C2 and C3.
	Faulty T1.	Replace T1.
	Faulty HS1 (handset)	Replace HS1.
	Faulty L1.	Replace L1.
3. Unable to modulate pulse out.	3. Faulty S1. Faulty test set.	3. Replace S1. Repair test set.
4. Unable to receive tone from demodulator.	4. Faulty S1. Faulty test set.	4. Replace S1. Replace test set.

361. Control Monitor Dc Resistance of Transformer and Coils

The dc resistance of transformer and coil windings are listed below. An asterisk (*) indicates a reading of less than 1 ohm.

Coil or transformer	Terminals	Ohms	Coil or transformer	Terminals	Ohms
T1		1,300		1–4	335
L1	1–2	13	T1	1–2	12
	2–3	2		3–4	*
	3–4	320			

362. Audio Test Set Trouble-shooting Data

a. General. The following data will aid maintenance personnel in trouble shooting the test set.

Fig. No.	Description
381	Audio Test Set TS–762/TC, schematic diagram.
407	Audio Test Set TS–762/TC, wiring diagram.
347	Audio Test Set, top view.
348	Audio Test Set, bottom view.
349	Audio Test Set, tube socket voltage and resistance diagram.

Note. Figure 349 shows the normal voltages as indicated by a vacuum-tube voltmeter. The values given are typical for normal operation and may vary by ±10 per cent. The B+ supply is +238 volts, +150 volts, and +14 volts. The diagram also shows the normal resistance between each tube socket terminal and the chassis ground as calculated. For long drift capacitive circuits, sufficient time was allowed for the readings to be stabilized.

b. Test Equipment Required for the Audio Test Set.

The following test equipment is required to trouble shoot the test set:

Item	Common name	Technical manual
Decade Resistor TS–679/U	Resistance box	TM 11–5520
Decibel Meter ME–22/PCM	VTVM	TM 11–2096
Frequency Meter FR–67/U		TM 11–2698
Spectrum Analyzer	Analyzer	
Attenuator TS–402/U	Attenuator	
Signal Generator SG–71/FCC	Signal generator	TM 11–5088
Multimeter TS–352B/U	Multimeter	TM 11–5527A
Voltmeter ME–30A/U	Electronic multimeter	
Double-pole, double-throw switch	Switch	
Resistors, 600 ohms ±1% (4)		

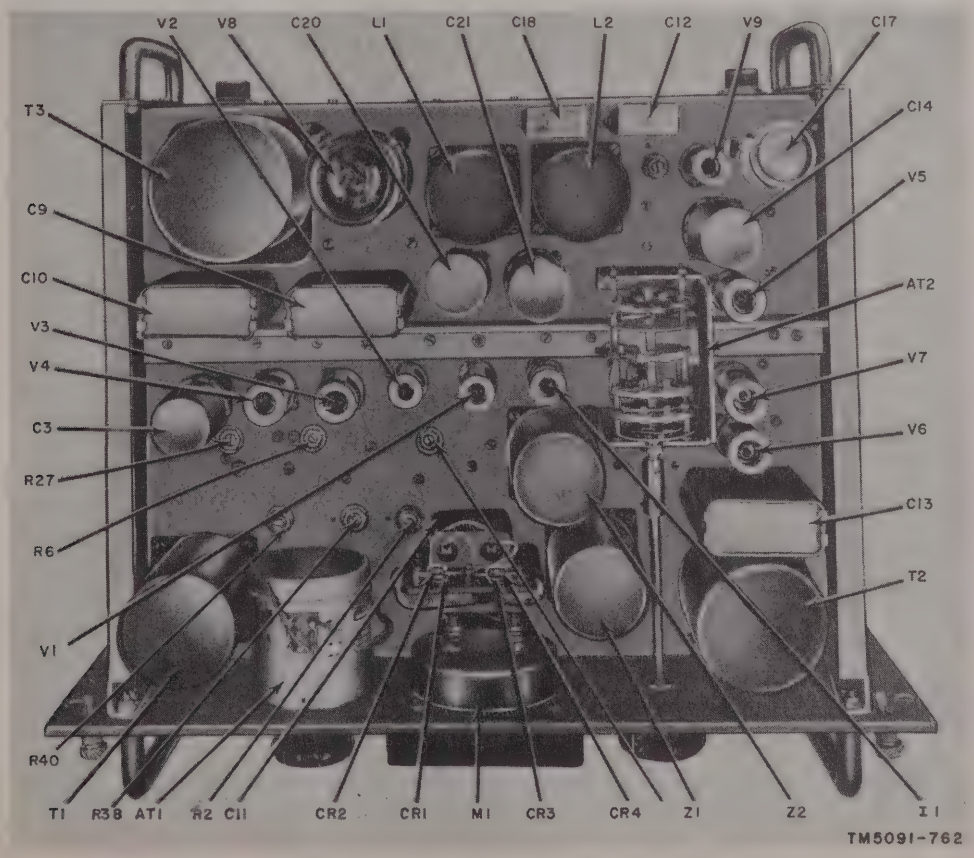


Figure 347. Audio test set, top view.

363. Audio Test Set Trouble-shooting Chart

The following chart will assist maintenance personnel in trouble shooting the test set.

Symptom	Probable trouble	Correction
1. No 1,000-cycle tone.	1. Faulty T1.	1. Replace T1.
	Faulty J1, J2, and/or J3.	Replace J1, J2, and/or J3.
	Open R27.	Replace R27.
	Open R18.	Replace R18.
	Failure to oscillate.	Check V1 and V2, voltages and resistances.
2. No reading on meter.	2. Faulty meter.	2. Replace meter.
	Faulty diodes CR1 through CR4.	Replace faulty diode.
	Faulty S1.	Replace S1.
	Faulty T2.	Replace T2.
	Faulty J4, J5, or J6.	Replace J4, J5, or J6.
	Faulty Z1.	Replace Z1.
3. Incorrect or not able to calibrate both send and receive.	3. Faulty S1.	3. Repair or replace S1.
	Faulty R38.	Replace R38.
	Faulty R40.	Replace R40.
	Faulty M1.	Replace M1.
4. Cannot measure distortion.	4. Faulty Z2.	4. Replace Z2.
	S1 faulty.	Replace S1.
	M1 faulty.	Replace M1.
	CR1 through CR4 faulty.	Replace faulty CR1 through CR4.



Figure 348. Audio test set, bottom view.

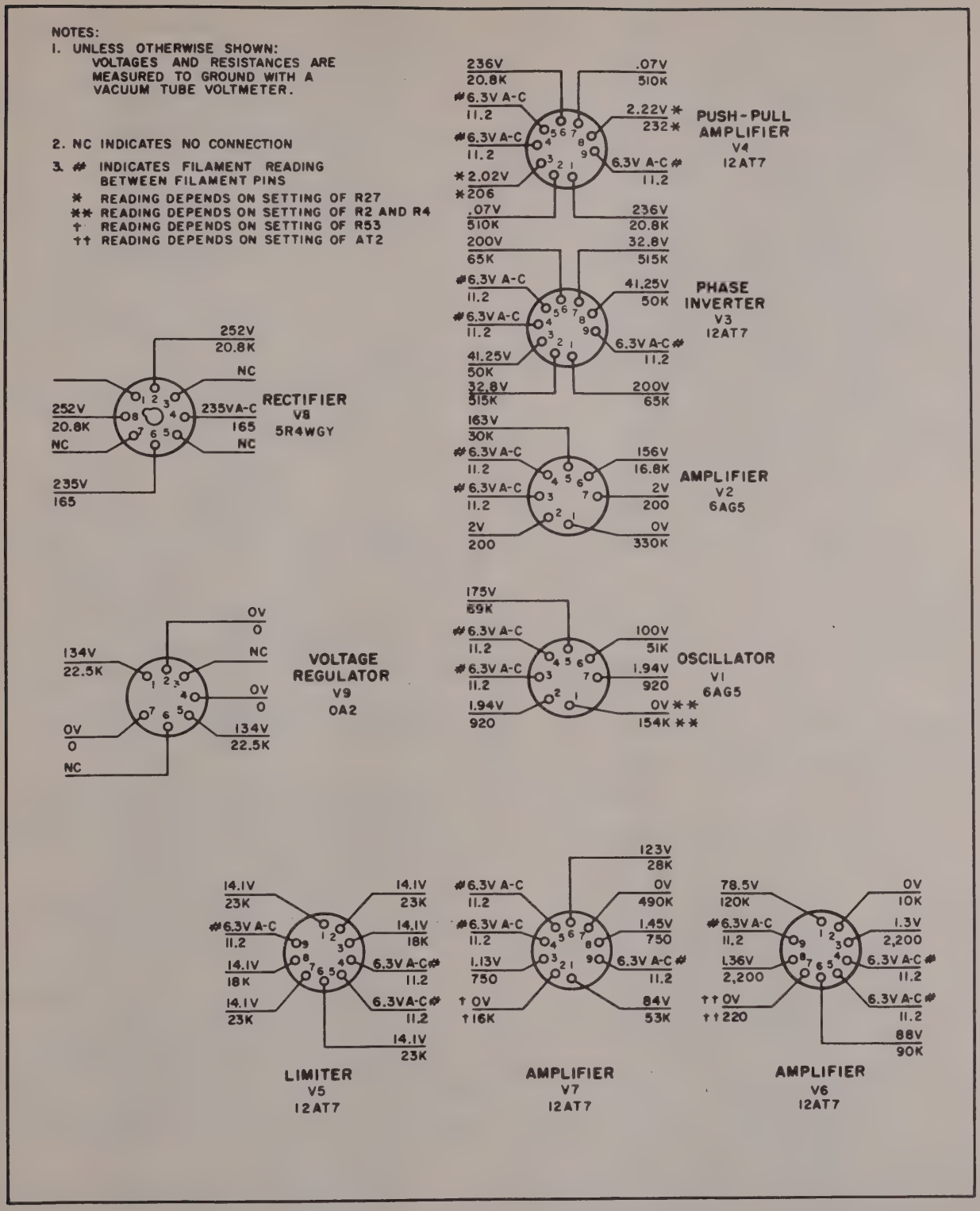


Figure 349. Audio test set, tube socket voltage and resistance diagram.

364. Audio Test Set Tests

The following tests will be used as a reference and test procedure after major repairs.

a. Send Oscillator Frequency Range.

(1) Connect the audio test set to the frequency meter as indicated in figure 350.

(2) Turn on the audio test set and frequency meter.

(3) Depress the MEASURE F1A button.

(4) Use audio test set chassis FREQUENCY control R4 (fig. 347) to adjust the frequency over the range of at least 970 to 1,030 cps. The frequency range should be continuous and the output amplitude should be relatively constant.

(5) After completing the above check, the frequency should be readjusted to 1,000 cps (par. 365).

Note. Frequencies may be determined by reading Frequency Meter FR–67/U.

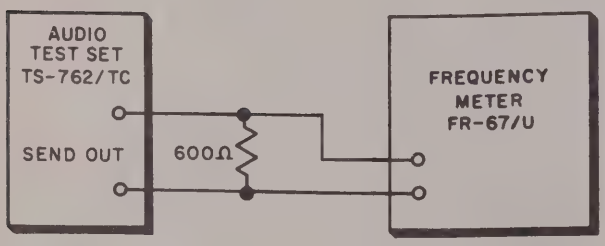


Figure 350. Send oscillator frequency range, test setup.

b. Send Oscillator Distortion Control.

(1) Connect the equipment as indicated below and in figure 351.

(*a*) Connect a 600-ohm resistor across the SEND OUT binding posts of the audio test set.

(*b*) Connect the audio test set SEND OUT terminals to the AF INPUT binding posts of Spectrum Analyzer TS–723/U.

(*c*) Connect a vtvm (ME–22/PCM or equivalent) across AF INPUT binding posts of Spectrum Analyzer TS–723/U.

(2) Turn on the equipment.

(3) Press the audio test set MEASURE F1A button.

(4) Adjust the output level of the audio test set for +10 dbm.

(5) Measure the distortion with the spectrum analyzer at 1,000 cps, 2,000 cps, 3,000 cps, and 4,000 cps.

(6) Compute the distortion as follows:

$$D = \sqrt{D_1^2 + D_2^2 + D_3^2}$$

Where: D_1 = distortion reading at 2,000 cps

D_2 = distortion reading at 3,000 cps

D_3 = distortion reading at 4,000 cps

(7) The ratio of the distortion, D, to the distortion reading at 1,000 cps should be less than 1 per cent.

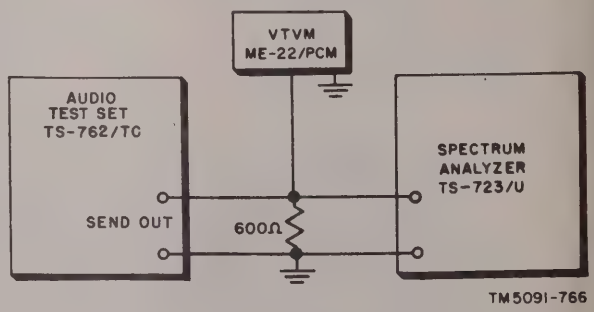


Figure 351. Send oscillator distortion control, test setup.

c. Send Attenuator Calibration Accuracy.

(1) Connect the equipment as shown in figure 352.

(2) Turn on the audio test set.

(3) Calibrate the send section (par. 46).

(4) Adjust the SEND-DBM knob for +10 dbm.

(5) Insert 50 db of external attenuation with Attenuator TS–402/U.

(6) Set the RECEIVE-DBM dial to —40.

(7) Depress the MEASURE F1A button.

(8) Use the REC ADJ knob, and set the meter pointer to the reference mark (red line).

(9) Reduce the SEND-DBM attenuator by 1 db and add 1 db to the external attenuator.

(10) Any variation from the reference mark represents an error.

(11) Repeat the procedures given in (8) and (9) above for each step of the attenuator.

(12) Error should not exceed +.3 db per step and .6 db over-all.

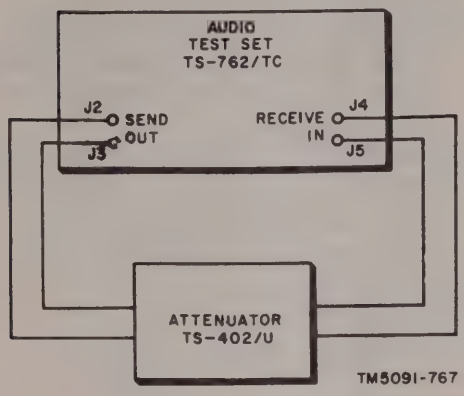


Figure 352. Send attenuator calibration accuracy, test setup.

d. Send Output Impedance at 1 Kc.

(1) Connect the equipment as shown in figure 353.

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button to connect the internal oscillator section to the output jacks.

(4) Disable the internal oscillator by unscrewing the 3-watt bulb (I 1) to measure the output impedance alone.

(5) Switch from position 1 to position 2 while adjusting the resistance box until the meter indicates equal voltage for either switch position.

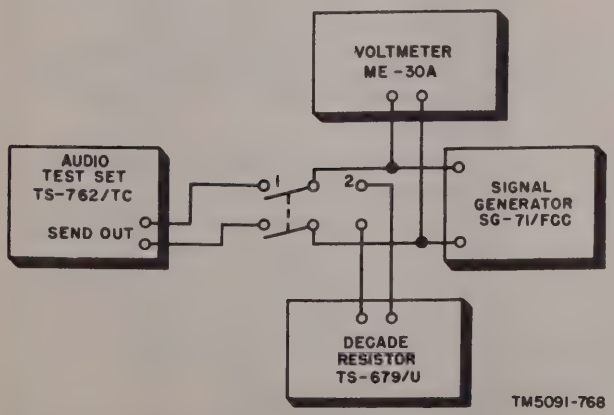


Figure 353. Send output impedance at 1 kc, test setup.

(6) The reading of the resistance box is equal to the output impedance of the audio test set.

(7) The impedance should be 600 ohms +10 per cent.

Caution: The output of SG–71/FCC must be kept below +10 dbm.

e. Send Output Balance to Ground.

(1) Connect the equipment as shown in figure 354.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button and adjust the output for a level of +10 dbm. This value will give the poorest condition of output balance to ground.

(4) Read the voltage on the vtvm.

(5) The meter reading indicates longitudinal unbalance and should not exceed 40 db down from +10 dbm. The vtvm reading should be 24 millivolts or less.

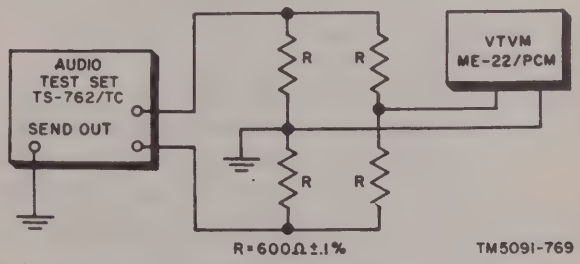


Figure 354. Send output balance to ground, test setup.

f. Receive Attenuator Accuracy.

(1) Connect the equipment as shown in figure 355.

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button to connect the internal oscillator section to the output jacks.

(4) Adjust the oscillator for a level of +10 dbm.

(5) Insert 70 db of external attenuation with Attenuator TS–402/U.

(6) Set the RECEIVE-DBM dial to the —60 position (minimum attenuation).

(7) Use the REC ADJ knob, and set a convenient reference point (the red line).

(8) Rotate the RECEIVE-DBM dial to the —50 position and decrease the exter-

nal attenuation by 10 db.

(9) Any variation from the reference point determined in (7) above represents a deviation from the standard.

(10) Repeat the procedure in (8) above for all positions of the RECEIVE-DBM dial.

(11) The error should not exceed +.3 db per step and +.6 db over-all.

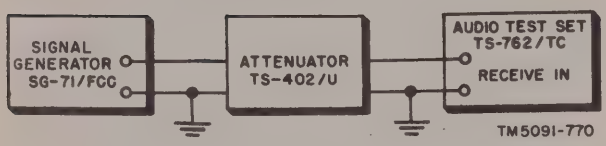


Figure 355. Receive attenuator accuracy, test setup.

g. Meter Calibration Accuracy.

(1) Connect the equipment as shown in figure 352.

(2) Turn on the audio test set.

(3) Calibrate the send section (par. 46).

(4) Depress the MEASURE F1A button.

(5) Place the SEND-DBM dial at +10.

(6) Place the RECEIVE-DBM dial at +10.

(7) Set the meter to the 0 position; use the REC ADJ control.

(8) Add 1 db of attenuation; use Attenuator TS–402/U.

(9) Note the reading on the meter scale.

(10) Repeat the procedure given in (8) and (9) above for the values of attenuation listed below:

Attenuation	Limit (db)
1	+ .15
2	+ .3
3	+ .5
4	+ .6
5	+ .8
7	+1.2
10	+1.5
20	+3.0

(11) The meter scale readings should be within the limits indicated above.

h. Receive Input Impedance at 1 Kc.

(1) Connect the equipment as shown in figure 356.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button.

(4) Adjust the oscillator to +10 dbm, with the SEND-DBM knob.

(5) Switch from position 1 to position 2 while adjusting the resistance box until equal voltage readings are indicated on the vtvm.

(6) The value of R as read from the resistance box is equal to the receive input impedance of the test set.

(7) The impedance should be 600 ohms +10 per cent.

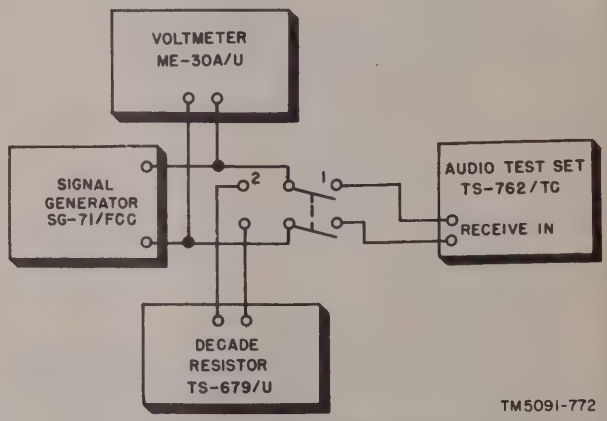


Figure 356. Receive input impedance at 1 kc, test setup.

i. Receive Input Balance to Ground.

(1) Connect the equipment as shown in figure 357.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button.

(4) Adjust Signal Generator SG–71/FCC for an output of +10 dbm.

(5) Rotate the RECEIVE-DBM dial until a readable indication is noted on the meter.

(6) The degree of receive longitudinal input unbalance is equal to the sum of the meter reading plus the RECEIVE-DBM dial setting.

(7) Input unbalance should not exceed 40 db down from +10 dbm. The meter reading should be —30 dbm, or less.

j. F1A Network Response.

(1) Connect Signal Generator SG–71/FCC output binding posts to the RE-

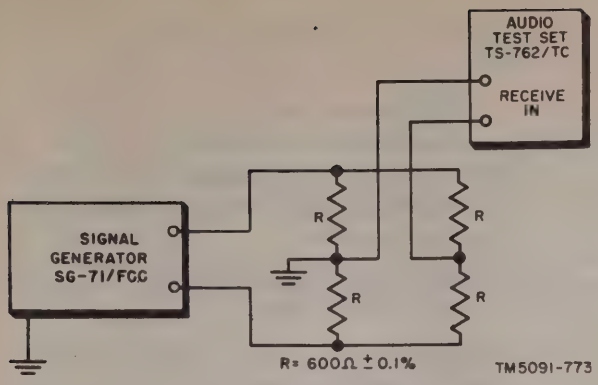


Figure 357. Receive input balance to ground test setup.

CEIVE-IN binding posts of the audio test set. Connect Decibel Meter ME–22/PCM across the RECEIVE IN binding posts of the audio test set (fig. 358).

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button.

(4) Adjust the signal generator for an output of approximately +10 dbm at 1 kc.

(5) Set the RECEIVE-DBM dial to the +10 position.

(6) Use the REC ADJ control to set a convenient reference point (red line).

(7) Maintain the voltage from the signal generator at the level indicated in (4) above (at vtvm ME–22/PCM), then adjust the signal generator to the frequencies indicated in the chart below. Response should be within the limits indicated.

Frequency	Attenuation (db down)	
	Maximum	Minimum
200	—24.0	—30
400	—7.5	—11.5
1,000	Reference	
3,000	—7.0	—13.0
5,000	—26 or greater	

Note. Read the values of attenuation on the audio test set meter. Use the RECEIVE-DBM knob. Turn the knob until a readable value is obtained. The total value is the sum of the meter reading and knob setting.

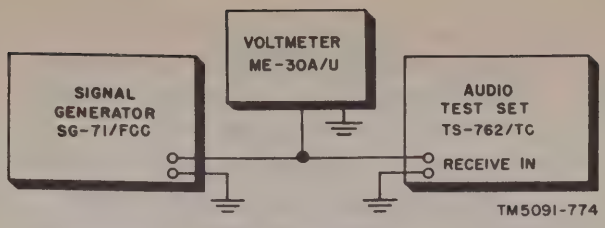


Figure 358. F1A network response test setup.

k. F1A Noise Reading. Perform the test as indicated in paragraph *j* above. Use the following chart in place of the one indicated.

Frequency	Attenuation (db down)	
	Maximum	Minimum
200	—27	—33
400	—7.5	—11.5
1,000	Reference	Reference
3,000	—7	—13
5,000	—26 or greater	
8,000	—25 or greater	

l. Distortion Network Reading at 970 and 1,030 Cycles.

(1) Connect the audio oscillator to the audio test set as shown in figure 359. Connect the vtvm (ME–22/PCM) across the RECEIVE IN binding posts of the test set.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button.

(4) Adjust the audio oscillator for an output of +10 dbm at 1 kc.

(5) Set the RECEIVE-DBM dial to +10.

(6) Vary the REC ADJ knob until the meter reads 0.

(7) Push the DIST AT 1,000 ∽ button. Turn the RECEIVE-DBM knob until a readable value is obtained. Total distortion is the sum of the meter reading and the RECEIVE-DBM dial.

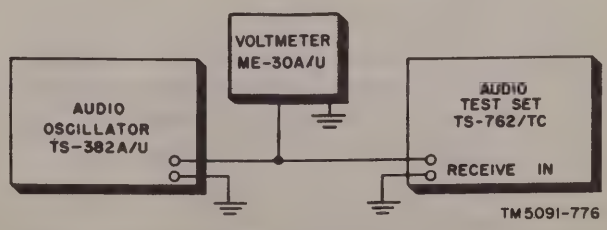


Figure 359. Distortion network reading at 970 and 1,030 cycles, test setup.

(8) Adjust the audio oscillator for the same voltage output as indicated in (4) above at a frequency of 970 cps, and measure the distortion.

(9) Repeat the procedure given in (8) above at a frequency of 1,030 cps.

(10) The distortion reading should be at least 40 dbm down at all three above frequencies.

365. Adjustment of Internal Controls

Normally, these adjustments are set at the factory and need no readjustment. However, if the tests given in paragraph 364 indicate that these controls are not set properly, proceed as follows:

a. FREQUENCY Potentiometer (R4A and R4B). Adjustment of potentiometer R4 varies the frequency of oscillator V1. The output frequency of the oscillator should be 1,000 cps ±3 cycles.

(1) Connect the audio test set to Frequency Meter FR–67/U (fig. 350), and turn on the equipment.

(2) Depress the MEASURE F1A button, on the front panel of the audio test set.

(3) Turn FREQUENCY control potentiometers R4A and R4B so that the frequency meter indicates 1,000 cps ±3 cps.

b. BRIDGE BALANCE Potentiometer R2.

(1) Connect the audio test set to the frequency meter as indicated in figure 350.

(2) Turn on the equipment.

(3) Depress the MEASURE F1A button on the audio test set.

(4) Adjust the FREQUENCY control potentiometer to approximately 1,000 cycles.

(5) Turn off the equipment.

(6) With Multimeter TS–352/U, measure the resistance between the junction of R4A and R8 and the junction of R5 and C1. Record this reading.

(7) Transfer the multimeter leads to ground and pin 1 of V1.

(8) Adjust BRIDGE BALANCE potentiometer R2 so that the resistance measured in (7) above is the same as that recorded in (6) above.

Caution: Always check the oscillator frequency after adjusting BRIDGE BALANCE potentiometer R2. The oscillator output frequency may have been disturbed.

c. DISTORTION Potentiometer R6 and OUTPUT BALANCE R27.

(1) Connect the equipment as indicated below and in figure 351.

(*a*) Connect a 600-ohm resistor to the SEND OUT binding posts of Audio Test Set TS–762/TC.

(*b*) Connect the SEND OUT binding posts of the audio test set to the AF INPUT binding posts of Spectrum Analyzer TS–723/U.

(*c*) Connect a vtvm (ME–22/PCM, or equivalent) across the AF INPUT binding post of the spectrum analyzer.

(2) Turn on the equipment.

(3) Press the MEASURE F1A button on the audio test set.

(4) Place the SEND-DBM attenuator to +10.

(5) Use the ADJ SEND control (R18 of the audio test set) and set the output level to approximately +10 dbm.

(6) Adjust OUTPUT BALANCE potentiometer R27 for lowest distortion output as read on the spectrum analyzer.

(7) Adjust the DISTORTION control, R6, until the level of distortion has reached the minimum value consistent with the requirements given in (10) below.

(8) Repeat procedure given in (6) above.

(9) Rotate ADJ SEND control R18 to its maximum clockwise position.

(10) Measure the total output; it should be at least +13 dbm.

(11) Set the output level of the audio test set to +10 dbm. Use ADJ SEND control R18.

(12) The total distortion as read on the spectrum analyzer should not exceed 1 per cent.

Note. To measure distortion, refer to *c* above.

d. HUM ADJ Potentiometer R66.

(1) Turn on Audio Test Set TS–762/TC.

(2) Calibrate the receive and send sections (par. 46).

(3) Terminate the SEND OUT and the RECEIVE IN terminals in 600-ohm resistance.

(4) Place SEND-DBM attenuator AT1 in the +10 dbm position.

(5) Press the MEASURE F1A button.

(6) Rotate RECEIVE-DBM attenuator AT2 until a readable indication is observed on the test set meter.

(7) Rotate HUM ADJ control R66 for minimum reading on the meter.

e. RECEIVE MTR ADJ R38.

(1) Connect Signal Generator SG–71/FCC to the RECEIVE IN binding posts of Audio Test Set TS–762/TC. The signal generator should be set for an output of 1,000 cycles at 2.45 volts.

(2) Turn on the equipment.

(3) Calibrate the test set receive section.

(4) Adjust the output of the test set to +10 dbm.

(5) Turn the RECEIVE-DBM attenuator, AT2, to the +10 dbm position.

(6) Depress the MEASURE F1A button.

(7) Rotate the ADJ REC control, R53, until the meter pointer reaches the red line at the meter zero db position.

(8) Depress the CALIBRATE-REC button.

(9) Rotate the RECEIVE MTR ADJ, R38, until the meter pointer reaches the red line at the meter zero db position.

(10) Depress the MEASURE F1A button and make sure that the meter pointer is at the red line.

f. SEND MTR ADJ Potentiometer R40.

(1) Connect a 600-ohm resistor to the SEND OUT terminals of the audio test set, and connect a vtvm across the resistor.

(2) Turn on the audio test set.

(3) Calibrate the send section (par. 46).

(4) Place the SEND-DBM attenuator, AT1, to the +10 position.

(5) Adjust the output to a level of +10 dbm by pressing the MEASURE F1A and using the SEND ADJ control, R18.

(6) Depress the MEASURE F1A button and rotate the ADJ SEND control, R18, for a reading of 2.45 volts on the vtvm.

(7) Press the CALIBRATE-SEND button and adjust the SEND MTR ADJ, R40, until the meter pointer reaches the red line at the meter zero db position.

(8) Depress the MEASURE F1A button and be sure the output is still 2.45 volts.

366. Audio Test Set Dc Resistances of Transformers and Coils

The dc resistance of transformers and coil windings are given below. An asterisk (*) indicates a reading of less than 1 ohm.

Transformer or coils	Terminals	Ohms
L1, L2		100
T1	1–2	180
	3–4	180
	1–4	360
	4–5	16
T2	1–2	13
	4–5	340
	3–7	13
T3	1–2	5.2
	3–4	150
	4–5	150
	3–5	300
	6–7	*
	8–9	*

367. Switch Box Trouble-shooting Data

The following trouble-shooting data will assist maintenance personnel in trouble shooting the switch box.

Fig. No.	Description
385	Switch box, schematic diagram.
21	Switch box, front and rear view.

368. Test Equipment Required and Trouble-shooting Procedure

a. Test Equipment. The only test equipment required to trouble shoot the switch box is a Multimeter TS–352/U.

b. Tests To Be Made. The following tests must be made to trouble shoot the switch box.

(1) Visual mechanical inspection.

(2) Continuity check.

c. Visual Mechanical Inspection. Remove the switch box cover. Be *sure* that all solder connections on J1, J2, J3, and J4 are properly made and that all nuts are on tight.

d. Continuity Check.

(1) With the INPUT SELECTOR SWITCH in position 1, the following points should have short circuits between them:

(*a*) Pin B on J1, J2, J3, J4 to GND CONN terminal.

(*b*) Pin E on J1 to pin E on J3.

(*c*) Pin D on J1 to pin D on J3.

(*d*) Pin D on J1 to pin D on J2.

(*e*) Pin E on J1 to pin E on J2.

(2) With the INPUT SELECTOR SWITCH in position 1, the following points should have open circuits between them:

(*a*) Pin E on J2 to pin E on J4.

(*b*) Pin D on J2 to pin D on J4.

(3) With the INPUT SELECTOR SWITCH in position 2, the following points should have short circuits between them:

(*a*) Pin B on J1, J2, J3, J4 to GND CONN terminal.

(*b*) Pin E on J2 to pin E on J4.

(*c*) Pin D on J2 to pin D on J4.

(*d*) Pin E on J1 to pin E on J2.

(*e*) Pin D on J1 to pin D on J2.

(4) With the INPUT SELECTOR SWITCH in position 2, the following points should have open circuits between them:

(*a*) Pin E on J1 to pin E on J3.

(*b*) Pin D on J1 to pin E on J3.

369. Switch Box Trouble-shooting Chart

The following chart will assist maintenance personnel in trouble shooting the switch box.

Symptom	Probable trouble	Correction
1. No 115/230 v ac output.	1. Faulty S1.	Replace.
	2. No 115/230 v ac input.	Check power source.
	3. Faulty connectors.	Replace.

370. General

Most of the parts in the AN/TCC–13, AN/TCA–1, and AN/TRA–10 can be reached and replaced easily if found to be faulty. If the part requires replacement, carefully mark the wires connected to it with tags or other devices to avoid misconnection when the new part is installed. Follow this practice whenever replacement requires the disconnection of numerous wires. Where identification of capacitors or resistors is required, the capacitor and resistor color code charts (fig. 361 and 362) will provide the color code identification.

371. Replacement of Parts and Removal of Units

a. Common Unit. The common unit multiplexer is mounted on a sliding drawer (fig. 40), which pulls out from the front of the rack. All parts can be unsoldered and removed easily. All parts are readily available and no special precautions are necessary.

b. Video Restorer. The video restorer is mounted in a sliding drawer, which pulls out from the front of the rack, similar to the common unit. All parts can be unsoldered and removed. All parts can be easily reached and no special precautions are necessary.

c. Modem. Each modem slides out from the mounting rack completely, and all parts are available.

d. Power Supply. The power supply may be removed from the rack by removing the screws that hold it in the rack, and pulling it out from the front. When it is out, all of the parts may be removed. An access door is also provided at the top front of the unit through which most of the smaller components may be reached. This is held closely by three captive screws. Fuses may be replaced from the front of the panel.

e. Multiplexer Subassembly. The multiplexer subassembly is removed by unscrewing the panel mounting screws, which hold it in the rack, and sliding it out. Wiring between the rack and the terminal boards on the subassembly must be removed. However, filters for the blower may be replaced by removing the filter panel held on with captive screws. Some of the smaller parts also may be reached through this panel. Major repairs or overhaul necessitates removal of the complete subassembly from the rack.

f. Voltage Regulator. The voltage regulator is removed by unscrewing the panel mounting screws. The cover over the control amplifier also must be removed to permit servicing.

g. Oscilloscope. All parts in the oscilloscope, with the exception of those mounted on the rear of the front panel, can be reached after the unit is removed from the rack. The front panel must be removed to service the units behind the panel. This can be done after removing knobs and mounting nuts on the various switches and the crt mask and four screws that hold the crt shield. The switches remain on the chassis, while all other components remain on the panel. All parts are then available for removal (fig. 316).

h. Control Monitor. The control monitor is mounted on slides and may be pulled forward in the rack. When this is done, all parts are available for removal.

i. Audio Test Set. The test set may be removed from the rack by disconnecting all cables at the front and rear of the unit, loosening the four captive screws that hold the audio test set in place, and pulling the unit forward by the handles. When this is done, all parts are available for inspection, testing, or replacement.

j. Delay Line. The delay line is available from the rear of the rack. The delay line is serviced only in extremely rare cases, and then in a place where it may be completely disassembled.

CHAPTER 11

ALIGNMENT, ADJUSTMENT, AND FINAL TESTING

Section I. ALIGNMENT, ADJUSTMENT AND FINAL TESTING OF MULTIPLEXER SET AN/TCC–13

372. Reference Data

The following reference may assist maintenance personnel during alignment, adjustment, and final testing.

Fig. No.	Description
363	Multiplexer Set AN/TCC–13, over-all schematic diagram.
387	Multiplexer Set AN/TCC–13, over-all wiring diagram.

373. Test Equipment Required

The following test equipment is required for alignment, adjustment, and final testing:

a. Multiplexer Set AN/TCC–13 (a terminal that has already been checked).

b. Electronic Multimeter TS–505/U.

c. Telephone EE–8–B (two).

d. Multimeter TS–352/U.

e. Telephone terminal to test set adapter.

374. Test Procedure

a. General. It is assumed that all components have been tested separately and that they have been interconnected to form a complete terminal. The complete terminal is now ready for alignment and system checks. Do this by connecting the terminal to be tested back to back with a test terminal with all modems set for four-wire operation and the remote keying units in NORMAL position.

b. Initial Connections.

(1) Connect the test terminal and the terminal to be tested back to back (par. 44).

(2) Bypass the multiplexer and demultiplexer filters in both terminals.

(3) Set all modem 2W–4W switches to 4W position.

(4) Place both remote keying units in NORMAL position.

(5) Switch on the filament voltage of the test terminal.

(6) Wait a few minutes, and then turn on the B+. Do the same for the terminal to be tested.

Caution: If there is any smoke or burning smell when the filaments or B+ is switched on, quickly switch them off.

c. Tests to be Made.

(1) B+ voltage.

(2) Filament voltage.

(3) Fan rotation.

(4) Multiplexer test point wave forms.

(5) PPM test point wave forms.

(6) Pulse train alignment.

(7) Modulator delay line integration.

(8) Demultiplexer test point wave forms.

(9) PWM test point waveforms.

(10) Demodulator delay line integration.

(11) Switching functions.

(12) Telephone circuits.

(13) Ringing circuits.

(14) Alarm circuit.

(15) Remote keying circuit.

(16) Signal to noise.

(17) Cross talk.

(18) 45-channel operation.

(19) Power consumption.

375. Preliminary Tests

a. B+ Voltage. With a vtvm, check B+ voltage on the multiplexer and demultiplexer. The voltage from both sides of the fuse to ground should be 250 ±10 volts dc.

b. Filament Voltage. With a vtvm, measure the filament voltage on the multiplexer (at TB1A–1 and TB1A–2) and the demultiplexer (at TB1A–3 and TB1A–4) filament fuses. It should be 6.3 ±.3 volts ac.

c. Fan Rotation. Check the fan in the multiplexer subassembly. It should be turning to blow air up into the modem rack.

376. Common Unit Multiplexer Test Points

The wave forms available at the front panel of the common unit and modems should be observed on the oscilloscope and should not vary by more than 20 per cent in width and amplitude from the figures listed.

Test point	Description	Fig. reference
J8, J9	PULSE TRAIN OUTPUT	69
E5	MIXED PULSE TRAIN	68
E4	MODEM CHAN PULSES	67
E3	MTPX GATE OUTPUT	66
E1	45 CHAN SYNC	65
E2	8KC OSC	64
J1	PPM[a]	87

[a]Test each modem.

377. Pulse Train Alignment

Follow the procedure below to align the pulse train:

a. Observe the pulse train at the PULSE TRAIN OUTPUT (on the multiplexer panel) with the oscilloscope.

b. Adjust the sweep speed so that there is one complete pulse train (that is, 1 marker pulse and 23 channel pulses) across 10 cm on the oscilloscope.

c. Switch on the timing pips and adjust the TIMING PIP PHASE control until the leading edge of the second marker pulse is aligned with a timing pip.

d. Adjust each modem PULSE POSITION control until each channel pulse is aligned with its respective timing pip.

378. Modulator Delay Line Intergration

To insure proper modem modulation sensitivity, adjust the delay line as follows:

a. Set the oscilloscope so that 2 cm (two boxes) are equal to 20 volts in amplitude.

b. Observe the sawtooth input to each modulator on the oscilloscope by removing the delay line cover and placing the probe on the proper variable integrating capacitor (fig. 289 and 400). The sawtooth should be 20 volts in amplitude.

Note. Be sure that the delay line input meets specified requirements.

c. If correction is necessary, turn the capacitor trimmers on the delay line until each sawtooth is 20 volts in amplitude (that is, two boxes on the oscilloscope).

d. If any adjustments were made (*c* above), realign the pulse train as described in paragraph 376.

e. Use the scope timing pips and adjust the COARSE and FINE controls so that the sweep is 1 microsecond per cm.

f. Observe the modulator sawtooth on the scope and adjust the vertical gain so that the center of the sawtooth slope crosses the center of the graticule.

g. Observe the channel pulse at the OUTPUT PULSE TRAIN test point. The channel pulse leading edge should fall within .3 microsecond ahead (in time) or .8 microsecond behind the center of the sawtooth slope for minimum distortion. If the pulse does not fall as specified above, proceed as instructed in *h* below.

h. If the pulse occurs sooner than .3 microsecond in time with respect to the sawtooth center, the tap from the delay line to the delay line integrating circuit should be moved up the delay line one coil section (½ a delay line section) (fig. 168 and 400). This will make the sawtooth occur approximately 1 microsecond earlier than it did. If the pulse occurs later in time than .8 microsecond, the tap should be moved down the line.

Note. After the tap has been moved, realign the pulse in the pulse train and repeat the procedures in *e* through *g* above.

379. Common Unit Demultiplexer Test Points

The wave forms available at the front panel of the common unit demultiplexer and modems should be observed on the oscilloscope and

should not vary by more than 20 per cent in width and amplitude from the figures listed.

Test point	Description	Fig. ref	Note
J21	MASTER INPUT FROM RF	63	
J20, J22	PULSE TRAIN INPUT	91	
E12	MODEM PULSE TRAIN	92	
E13	DEMTPX GATE	93	
J2	PWM test point	104	If the width is variable, integrate the demodulator delay line (par. 379).

380. Demodulator Delay Line Integration

Follow the procedure below to integrate the demodulator delay line:

a. Be sure that the pulse train coming into the demultiplexer is aligned correctly (par. 376).

b. Be sure that the delay line input is within its tolerance. Compare the wave form at the DEMTPX GATE test point with that in figure 93.

c. Observe the sawtooth input to the demodulator on each channel (this is conveniently observed on the back of the delay line on the integrating capacitors). This pulse should be at least 30 volts in amplitude and may be as high as 80 volts.

d. Now observe each modem PWM test point. Adjust each respective trimmer on the delay demodulator line until each pwm wave shape is 1.8 ±.8 microseconds across the flattop. If this tolerance cannot be obtained with the trimmer, the lead connecting the delay line to the integrating network on the back of the delay line will have to be moved. If the pwm is too narrow, the lead should be moved one tap up the delay line. The leading edge of the pwm will now occur at approximately 1 microsecond earlier. If the pwm is too wide, the lead should be moved down one tap.

Note. Before continuing with the following tests, reconnect both multiplexers and demultiplexers through their filters.

381. Power Consumption

Switch off the audio test set, the oscilloscope, and anything plugged into the convenience outlets, and connect the terminal to the ac source through Electronic Multimeter TS–505/U. The current drawn by the unit, with the audio test set and oscilloscope off, should not be greater than 7.4 amperes (850 watts) at 115 volts ac. The power taken by the audio test set and the oscilloscope may be measured separately in the same way. The audio test set should take no more than .35 ±.087 ampere (40 watts) and the oscilloscope should take no more than 2.6 ±.2 amperes (300 watts) at 115 volts ac.

Note. Power consumption in watts can be calculated by using the formula $P = EI$, where E is the input voltage (115 volts) and I is the current as measured with Multimeter TS–352/U.

382. Miscellaneous Circuits

a. Switching Functions. The switching functions should be checked as described in paragraph 118*a*.

b. Telephone Circuit. The telephone circuit should be checked as described in paragraph 118*b*.

c. Ringing Circuits. Each modem should be checked for ringing as described in paragraph 119.

d. Alarm Circuit. Remove the pulse train input cable from the demultiplexer. The alarm should sound and the ALARM indicator on the multiplexer subassembly should light.

e. Remote Keying Circuits. The remote keying circuits should be checked as described in paragraph 120.

f. Signal to Noise. The signal-to-noise ratio should be checked as described in paragraph 121*a*.

g. Cross Talk. Cross talk should be checked as described in paragraph 121*b*.

h. 45-channel Operation. 45-channel operation should be checked as described in paragraph 122.

Section II. ALIGNMENT, ADJUSTMENT AND FINAL TESTING OF MULTIPLEXER GROUP AN/TCA-1 AND PULSE FORM RESTORER GROUP AN/TRA-10

Note. The alignment, adjustment, and final testing instructions for Multiplexer Group AN/TCA–1 and Pulse Form Restorer Group AN/TRA–10 are similar. Therefore, only the multiplexer group will be covered unless otherwise specified. When checking the pulse form restorer group, disregard all procedures for channels 3 through 8 at a repeater.

383. Reference Data

The following reference may assist maintenance personnel during alignment, adjustment, and final testing.

a. Multiplexer Group.

Fig. No.	Description
363	Multiplexer Group AN/TCA–1, over-all schematic diagram.
393	Multiplexer Group AN/TCA–1, over-all wiring diagram.

b. Pulse Form Restorer Group.

Fig. No.	Description
365	Pulse Form Restorer Group AN/TRA–10, over-all schematic diagram.
394	Pulse Form Restorer Group AN/TRA–10, over-all wiring diagram.

384. Test Equipment Required

The following test equipment is required for alignment, adjustment, and final testing:

a. Four Multiplexer Sets AN/TCC–13 (terminals which have been checked and can be used as test equipment).

b. One Electronic Multimeter TS–505/U.

c. Three field Telephones EE–8–B.

d. One Multimeter TS–352/U.

e. Decade Resistor TS–679/U.

385. Tests Required

a. 23-channel Operation.

(1) Fan rotation.
(2) Filament voltage.
(3) B+ voltage.
(4) Power consumption.
(5) Pulse form restorer wave forms.
(6) PPM wave forms.
(7) Blanking gate alignment.
(8) PWM test point wave form.
(9) Demodulator (DEMTPX) delay line integration.
(10) Modulator (MTPX) delay line integration.
(11) Pulse train alignment.
(12) Switching circuits.
(13) Impedance of party-line terminals.
(14) Telephone circuit and order-wire circuits.
(15) Ringing circuit.
(16) Remote keying circuits.
(17) Audio levels.
(18) Alarm circuit.
(19) Signal-to-noise ratio.
(20) Channel cross talk.

b. 45-channel Operation.

(1) Symmetry control.
(2) Channel cross talk.
(3) Channel signal-to-noise ratio.

386. Test Procedure

It is assumed that all components have been tested separately and that they have been interconnected to form a complete terminal. Align and check the complete terminal by connecting the terminal to be tested back to back with a test terminal, with all modems set for four-wire operation and the remote keying units in the normal position.

a. Preliminary Adjustments. Connect the AN/TCA–1 or AN/TRA–10 to the two AN/TCC–13 terminals as shown in figure 275 or 276 respectively. Switch on the power to the terminals. Align the output pulse train of each terminal and set the output pulse train amplitude of each to .5 volt from base line to peak. The pulse width should be a maximum of .8 usec at 50 per cent amplitude. Set the 23 CHAN-45 CHAN switch on the video restorer to the 23 CHAN position and the P.T. OUT AMPL switch to the LOW position. Whenever an alignment or integration of the delay lines is to be made, check the AN/TCA–1 for any obvious defects which could throw the alignment of integration off.

Note. When observing a wave form in a video restorer, be sure the oscilloscope is being synchronized from the associated video sync jack.

b. Fan Rotation. Turn on the power supply FILAMENT switch of the AN/TCA–1. The fan in the video restorer should start turning immediately. If it does not, quickly throw the FILAMENT switch to OFF. The fan should be rotating in the direction that sucks air into the front and out of the rear of the video restorer.

Note. The fan on the filament supply of multiplexer group should also operate. If it does not, turn off power immediately.

c. Filament Voltage. With a vtvm, measure the filament voltage between E51 and E53 (ground) in both video restorers. It should be 6.3 +.4 volts.

d. B+ Voltage. Switch on the power supply +250V circuit breaker of the AN/TCA–1. With a vtvm, measure the B+ voltage at the B+ fuse of both video restorers on the reshaper side of the fuse. It should be 250 ±10 volts. When B+ has been turned on, the video restorer ALARM light on both reshapers should go out.

387. Power Consumption

a. Multiplexer Group AN/TCA–1. Switch the power supply +250V and the FILAMENT circuit breakers to OFF. Connect the AN/TCA–1 to the ac source through Multimeter TS–352/U. The current drawn by the AN/TCA–1 with Oscilloscope OS–25/G and Audio Test Set TS–762/TC off should not be greater than 6.74 amperes (775 watts) and not less than 6.3 amperes (725 watts) at 115 volts ac. The oscilloscope should take no more than 2.6 ±.2 amperes (300 ±25 watts) at 115 volts ac. The audio test set should take no more than .35 ±.087 amperes (40 ±10 watts) at 115 volts ac.

Note. Power consumption in watts can be calculated by using the formula P = EI, where E is the input voltage (115 volts ac) and I is the current as measured with the Multimeter TS–352/U.

b. Pulse Form Restorer Group AN/TRA–10. The pulse form restorer group with the oscilloscope off should not be greater than 4.44 amperes (510 watts) and not less than 4 amperes (460 watts) at 115 volts ac.

388. Pulse Form Restorer Wave Forms

The wave forms available at the front panel of the video restorer should be observed on the oscilloscope and should not vary by more than 20 per cent in width and amplitude from the figures listed, except as indicated.

Test point	Description	Figure reference	Note
E1	INPUT FROM EASTFACING REC INPUT FROM WESTFACING REC	119	.25 v. p-p, .8 usec max at 50 per cent amplitude (.5 v p-p with P.T. OUT AMPL switch in HIGH).
E5	DEMTPX GATE (eastgoing) DEMTPX GATE (westgoing)	120	125 to 155 v p-p, 3.8 to 4.3 usec at 50 per cent amplitude.
E4	Blanking GATE (eastgoing) Blanking GATE (westgoing)	121	24 to 55 v p-p, 8-12 v p-p pulses, 4.3 ±1.2 usec at 50 per cent amplitude.
E6	MTPX GATE (eastgoing) MTPX GATE (westgoing)	122	102 to 112 v p-p, 8 ±1 usec at 50 per cent amplitude.
E3	MODEM CHAN PULSES (eastgoing) (westgoing)	123	3.5 to 7.5 v p-p, .2 to .4 usec at 50 per cent amplitude.
E2	OUTPUT TO EASTFACING XMTR OUTPUT TO WESTFACING XMTR	125	Set SYM ADJ to .25 volt base line to peak, .48 to .58 usec at 50 per cent amplitude.

389. PPM Test Point Wave Forms

The PPM test point wave form should be measured at each modem. It should not vary by more than 20 per cent in width and amplitude from that shown in figure 87.

390. Blanking Gate Alignment

Follow the procedure below to align the blanking gates at both video restorers.

Note. Be sure that there are no obvious defects that might throw the alignment off.

a. Have all modems plugged in.

b. Have all remote keying units in NORMAL OPERATION position.

c. Place all D&I-THRU switches in D&I position.

d. Observe DEMTPX GATE and MTPX GATE test points E5 and E6 on the oscilloscope. The DEMTPX GATE should be 125 to 155 volts and 3.8 to 4.3 usec at the 50 per cent amplitude point. The MTPX GATE should be 102 to 112 volts in amplitude and 8 ±1 usec wide at 50 per cent amplitude.

e. Place channel 1 in D&I and the remaining channels in the THRU position.

Note. The D&I-THRU plugs and the associated video restorer are on the same side of the rack. Observe the wave form at pin 7 of V13. The amplitude should be between 6.8 and 8.5 volts peak to peak. Repeat the procedure in *a* through *e* above with channel 2 in the D&I position and all others in the THRU position.

f. Repeat the procedure in *e* above until all eight channels have been measured individually.

g. When all the blanking gates at pin 7 of V13 are the proper amplitude, the blanking gate timing may be aligned as follows:

(1) Align the incoming train at the terminal.

(2) Observe the blanking gates at BLANKING GATE test point E4.

(3) Place channel 1 in the D&I position, channel 2 in the THRU position, and channels 3 through 8 in the D&I position.

(4) Center the channel 1 blanking gate on the scope face; place channel 1 in the THRU position. The channel 1 pulse of the incoming pulse train will be seen. Record the time in usec from the center of channel 1 pulse to the 50 per cent amplitude point of the leading and trailing edges (two readings) of the channel 1 blanking gate. (The leading edge of the blanking gate should occur before the channel pulse.) If there is a difference between the two readings of greater than 1 usec, then move the lead on the DEMTPX delay line connecting the blanking pulse to channel 1 so that the *difference* is 1 usec or less.

Note. The associated video restorer and the DEMTPX delay line are on the same side.

h. Place channel 2 in the D&I position and channel 1 in the THRU position. Place channel 3 in the THRU position and the remainder in the D&I position. Repeat the same measurement as described in *g*(4) above

i. Repeat the procedure in *a* through *h* above for all eight channels. In each case, leave the two channels adjacent to the one under test in the THRU position, and all others in the D&I position. When doing channel 8, only channel 7 need be in the THRU position.

j. When properly aligned, all blanking gates should be between 3.1 and 5.5 usec at 50 per cent amplitude and the amplitudes may vary from 28 to 55 volts peak to peak.

391. PWM Test Point Wave Forms

The pulse-width modulated wave form as seen at the PWM test point should not vary more than 20 per cent in amplitude from that shown in figure 104. Check each modem. The pwm wave form widths will be variable until the demodulator delay line is integrated properly.

392. Demultiplexer Delay Line Integration

Follow the procedure below to integrate the demultiplexer lines.

Note. The associated modem, demodulator delay line, and video restorer for this test are on the same side of the rack.

a. At the terminals, be sure the incoming pulse train is at the terminal.

b. Place all D&I-THRU plugs in D&I position and the remote keying units in NORMAL OPERATION position.

c. Observe the demultiplexer gate at E5. It should be 125 to 155 volts and 4.0 ±.5 usec at 50 per cent amplitude.

d. Observe the sawtooth input to the demodulator on each channel (on the back of the delay line).

e. Observe each modem PWM test point and adjust each respective trimmer on the demodulator delay line until each pwm wave form is 1.8 ±.8 usec across the flattop (fig. 104). If the tolerance given in *c* above cannot be obtained with the trimmer, the lead that connects the delay line to the integrating network on the

side of the line should be moved. If the pwm pulse is too narrow, the lead should be moved up the delay line, and if the pwm pulse is too wide the lead should be moved down the line. Moving this lead one tap will cause a change of 1 microsecond in the pwm pulse.

393. Multiplexer Delay Line Integration

Follow the procedure below to integrate the two multiplexer delay lines.

Note. For this procedure, the associated video restorer and multiplexer delay line are on the same side but the modem is on the opposite side.

a. Place all D&I-THRU plugs in the D&I position.

b. Place the remote keying units in NORMAL OPERATION position.

c. Observe the inserted channel pulse at the MODEM CHAN PULSES test point, E3. These should be eight channel pulses, and they may vary from 3.5 to 7.5 volts peak to peak.

Note. If any of the inserted pulses do not appear, the modem, remote keying unit, D&I-THRU switches and/or delay line connections may be faulty.

d. Observe the pulse train at OUTPUT TO WESTFACING (EASTFACING) XMTR test point E2. The inserted pulses, channel 1 through 8, should appear in the pulse train. To be sure that channels 1 through 8 are the inserted pulses and not the terminal pulses, vary the PULSE POSITION control of each modem. The respective channel pulse should move.

Note. The associated modems and video restorer are on opposite sides for this test.

e. Now observe the multiplexer gate on the same video restorer as the output pulse train was observed in *d* above. It should be 102 to 112 volts in amplitude and 8 ± 1 usec wide at the 50 per cent amplitude point.

f. Set the oscilloscope so that 2 cm (two boxes) are equal to 20 volts in amplitude.

g. Observe the sawtooth input to each modem on the oscilloscope (on the back of the multiplexer delay line trimmers).

h. Adjust the respective capacitor trimmers on the multiplexer delay line until each sawtooth is 20 ± 2 volts in amplitude (that is, two boxes on the oscilloscope).

i. Observe the pulse train at OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 and align channels 1, 2, and 3 through 8. This is done as follows:

(1) Adjust the sweep speed so that there is one complete pulse train across 10 cm of the scope face (that is, 2 marker pulses and 23 channel pulses).

(2) Switch on the timing pips and adjust the TIMING PIP PHASE control until the leading edge of the second marker pulse is aligned with a timing pip.

(3) Adjust the PULSE POSITION control of each modem until the respective channel pulse is aligned with leading edge of its respective timing pip.

j. Use the timing pips (5.2 usec apart) and adjust the scope sweep so that 1 cm equals 1 usec (that is, 1 usec per centimeter).

k. Observe each modulator sawtooth on the scope and adjust the vertical gain for a deflection of 2 centimeters. With the SWEEP PHASE control, move the sawtooth so that the center of the leading edge crosses the center of the graticule of the oscilloscope.

l. Without touching the SWEEP PHASE control, observe the respective channel pulse at the MODEM CHAN PULSES test point, E3. Adjust the VERTICAL GAIN until a channel pulse can be readily seen. The point where the channel pulse leading edge leaves the base line should fall within .5 usec before or .8 usec later than the center of the sawtooth slope. If the pulse does not fall within the above specification, proceed to *m* below. If it does, consider that channel completed.

m. If the pulse occurs sooner than .5 usec with respect to the sawtooth center, the lead from the delay line to the integrating circuit should be moved up the line. If the pulse occurs later than .8 usec, the lead should be moved down the line. One tap will move the sawtooth 1 usec.

Note. After a lead has been moved as above, the procedures outlined in *i* through *m* above should be repeated.

394. Pulse Train Alignment

Align the output pulse train as directed in paragraphs 70 and 71.

395. Switching Functions (AN/TCA–1 Only)

Both directions of the AN/TCA–1 are similar in operation; therefore, this procedure may be used to check both directions. Check the switching functions as follows:

a. Place the D&I-THRU switches in the D&I position, 2W–4W switches in the 4W position, and the PARTY LINE-PRIV switches in the PRIV position.

b. Turn on the audio test set and allow it to warm up.

c. Calibrate the audio test set (par. 46).

d. Set the SEND-DBM for —4 dbm output and RECEIVE-DBM for 0 dbm.

e. Adjust the sweep speed on the oscilloscope for 1 usec per cm.

f. Observe OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 with the oscilloscope.

g. Place the control monitor panel switch in the SEND position.

h. Turn each modem selector switch to SR, one at a time, and with the scope, check to see that each channel pulse is modulating approximately ±.5 usec.

i. Connect the 4W REC terminals to the audio test set REC jacks and place the modem selector switch in the SL position. The test set should read —4 dbm (same as it is sending out), and the channel pulse that is associated with the 4W REC terminals should not be modulated. Each channel in both directions should be tested similarly.

j. Modulate the channel pulses from one of the test terminals, one at a time, with a —4 dbm input (*a* through *h* above). Place the control monitor switch on the AN/TCA–1 in the REC position. Turn the modem selector switch of each respective channel in the AN/TCA–1 being tested to the RR position and adjust the AUDIO OUTPUT GAIN control on the modem until the audio test set reads zero dbm output. The same procedure applies for the other test terminal and its associated modems.

k. Connect an adapter from the 4W SEND terminals to the audio test set SEND jacks and place the modem selector switch in the RL position. The test set should read —4 dbm and the channel pulse associated with the 4W SEND terminals should not be modulated.

396. Impedance of Party-line Terminals

a. Place the 2W–4W switches in 4W on channels 1 and 2 (both directions).

b. Turn the OUTPUT AUDIO GAIN control fully counterclockwise on channels 1 and 2 modems (both directions).

c. Place the PARTY LINE-PRIV switches in PARTY LINE operation.

d. Connect the test equipment as shown in figure 360.

e. Connect channel 1 PARTY LINE terminals E9 and E10 to the test equipment.

f. Set the decade box to 300 ohms.

g. Adjust the audio oscillator to 1,000 cps and its output for a .2-volt ac reading on the vtvm with the switch in position 1.

h. Adjust the decade box so that the vtvm reads the same in switch positions 1 and 2.

i. Record the decade box reading. The reading should be 320 to 400 ohms.

j. Disconnect the input terminals from channel 1 PARTY LINE terminals and connect them to channel 2 PARTY LINE terminals.

k. Repeat the procedures in *a* through *i* above for channel 2.

l. Disconnect the test equipment.

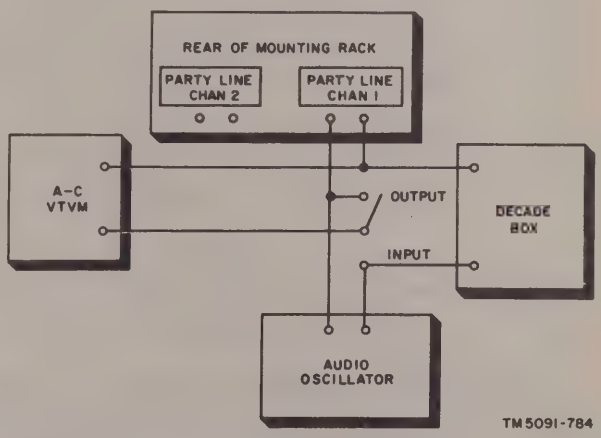


Figure 360. Impedance of party-line terminals, test setup.

397. Telephone, Order-wire, and Ringing Circuits

a. Telephone and Order-wire Circuits (AN/TCA–1 Only).

(1) Place the control monitor switches S1 of both east and west terminals and the AN/TCA–1 being tested in NORMAL position.

(2) Place channel 1 of both terminals in two-wire operation.
(3) Place the D&I-THRU switch in D&I, the PARTY LINE-PRIV switch in PARTY LINE, the 2W–4W switch in 4W, and the remote keying units in NORMAL OPERATION positions.
(4) Press the RING switch at each terminal separately. The bell at both terminals and at the AN/TCA–1 should ring.
(5) Press the RING switch at the AN/TCA–1. Its own bell and the bell at each terminal should ring.
(6) It should be possible to converse between terminal and terminal, and between either terminal and the AN/TCA–1 over channel 1 by using the handset provided with the control monitor.
(7) Place channels 3 through 8 of both terminals and the AN/TCA–1 in two-wire operation. Place the control monitor switches S1 of both terminals and the AN/TCA–1 in TEL SET position.
(8) Place the east terminal modem selector switch in either the RR or SR position. Place the eastfacing modem selector switch at the AN/TCA–1 in either the SR or RR position. By using the handset, it should be possible to conserve between the east terminal and AN/TCA–1, but not the west terminal. Do each channel 3 through 8 individually.
(9) Repeat the procedures in (7) and (8) above for the west terminal modems and the westfacing modem at the AN/TCA–1.
(10) Return channels 1 through 8 of both terminals and the AN/TCA–1 to four-wire operation, and push all control monitor NORMAL switches.

b. Ringing Circuits

(1) *Private-line connection.*
(*a*) Place all remote keying units in NORMAL OPERATION position.
(*b*) Place all D&I-THRU switches in D&I position.
(*c*) Place all PARTY LINE-PRIV switches in PRIV position.
(*d*) Place all the 4W–2W modem switches in the AN/TCA–1 and both AN/TCC–13 terminals in the 2W position.
(*e*) By using field Telephone EE–8–B, it should be possible to ring *between* the following modem two-wire lines of each channel:

Terminal	Repeater
West terminal modem channels	Westfacing modem channels
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
East terminal modem channels	Eastfacing modem channels
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8

(2) *Party-line connection.*
(*a*) Place all 4W–2W modem switches at the repeater in 4W position.
(*b*) Place all PARTY LINE-PRIV switches in PARTY LINE position.
(*c*) Place an EE–8–B on the party-line connection of mounting rack terminals E9 and E10.
(*d*) Ringing at the repeater local line should ring the corresponding channel at *both* terminals.
(*e*) Ringing at a terminal should cause ringing at the repeater local line and also at the far terminal.
(*f*) Repeat the procedures in *a* through *e* above for channel 2; use party-line terminals E141 and E142.

398. Remote Keying Circuits

Check both remote keying circuits as follows:

a. Place channels 1 and 2 of the repeater and both terminals in remote keying operation. At

the repeater, all channels should be set for drop and insert and party line operation.

(1) There should be no channel 1 and 2 pulses arriving at the repeater from the terminals. This can be checked at the INPUT FROM EASTFACING (WESTFACING) REC test point E1 of both video restorers.

(2) There should be no ringing at the repeater. This can be checked by placing a field telephone on the local PARTY LINE terminals of both channels.

(3) There should be no repeater inserted pulses. This can be checked at MODEM CHAN PULSES test point E3 of both video restorers.

(4) At the AN/TCA–1, there should be an open circuit across E1 and E2 and also across E11 and E12 on the mounting rack. At the AN/TRA–10, there should be an open circuit across E16 and E17 also across E27 and E28 on the mounting rack.

b. At the repeater, place a short circuit across E13 and E14 (E12 and E13 of the AN/TRA–10).

Caution: There are 40 volts dc on these terminals.

(1) This should insert channel 1 in both directions. This can be checked at OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 of both video restorers.

(2) At the multiplexer group, terminals E11 and E12 should still be open-circuited. At the pulse form restorer group, terminals E16 and E17 should still be open-circuited.

c. At the repeater. place a short circuit across E3 and E4 (E23 and E24 of the AN/TRA–10).

(1) This should insert channel 2 in both directions.

(2) There should still be an open circuit across E1 and E2 (E27 and E28 of the AN/TRA–10) at the repeater.

d. Place a short circuit across E13 and E14 of either terminal. Do both, one at a time. This should short-circuit E11 and E12 (E16 and E17 of the AN/TRA–10) at the repeater.

Caution: There are 40 volts dc on these terminals.

e. Place a short circuit across E3 and E4 of the west terminal. This should short circuit E1 and E2 (E27 and E28 of the AN/TRA–10) at the repeater. Repeat the procedure for the east terminal.

Caution: There are 40 volts dc on these terminals.

f. Place the remote keying units in the NORMAL OPERATION position at both terminals and at the repeater. Channels 1 and 2 should now be present at the terminals and at the repeater.

398. Audio Levels

a. Bypass the repeater by switching off the power supply +250V circuit breaker. The terminals should be in four-wire operation.

b. Set the terminal audio levels as follows:

(1) Inject —4 dbm into the 4W TRANS terminals of the west terminal channels.

(2) Set the modem OUTPUT AUDIO GAIN control of the corresponding demodulator in the east terminal for zero dbm output.

(3) Repeat this procedure on all channels, then modulate the east terminal and adjust the OUTPUT AUDIO GAIN of the west terminal modem demodulators.

c. Switch on B+ at the repeater and place the PARTY LINE-PRIV switches in PRIV position. The repeater modems should still be in four-wire operation.

d. Modulate channel 1 of the west terminal with —4 dbm, and monitor the westfacing channel 1 of the repeater at the 4W REC terminals. Adjust the modem OUTPUT AUDIO GAIN for zero dbm (.78 volts rms) output. Repeat for channel 2 of the pulse form restorer group and for channels 2 through 8 of the multiplexer groups.

e. Repeat the procedure in *d* above for the east terminal and the eastfacing modems of the repeater.

f. Place channels 1 and 2 PARTY LINE-PRIV switches in PARTY LINE position.

g. Modulate channel 1 at the east terminal with —4 dbm. Monitor the output at the channel 1 PARTY LINE terminals at the repeater.

There should be —8 ±1 dbm across 600 ohms. Also monitor the channel 1 4W REC terminals at the west terminal. This should be zero dbm.

Note. Repeat the procedure in *g* above for channel 2.

h. Now repeat the procedure in *g* above, modulating at the west terminal and listening at the east terminal and the repeater.

i. Modulate channel 1 at the repeater with zero dbm into the PARTY LINE terminals. Monitor the output of channel 1 of both terminals. This should be —8 ±1 dbm. Repeat for channel 2.

j. At the AN/TCA–1 only, place the east and west terminals and channels 3 through 8 at the repeater in two-wire operation.

k. Place an EE–8–B on the channel 1 2W terminals of both the east and west terminals and also on the PARTY LINE connections of channel 1 at the repeater. It should be possible to converse between all three phones simultaneously. Repeat for channel 2.

l. Place channels 1 and 2 PARTY LINE-PRIV switches in PRIV, and 2W–4W switches in 2W operation.

m. Place an EE–8–B on the 2W LINE terminals of the eastfacing channel 1 modem. It should be possible to converse with the east terminal channel 1 but not the west terminal.

n. Place an EE–8–B on the 2W LINE terminals of the westfacing channel 1 modem. It should be possible to converse with the west terminal channel 1 but not the east terminal.

o. Connect an EE–8–B on the channel 2 2W LINE terminals at the east terminal and the 2W LINE terminals of the eastfacing channel 2. It should be possible to converse between the east terminal and the repeater, but not the west terminal.

p. At the AN/TCA–1, repeat the procedure in *o* for channels 3 through 8.

q. Repeat the procedure in *e* above for the west terminal and the westfacing channels at the repeater.

400. Alarm Circuit

The alarm circuit should permit ringing disabling and should bypass the input pulse train to the output terminal if any of the following conditions take place: the input pulse train at E1 falling below an amplitude of .22 volt peak; failure of any tube in the positive pulse train section of the video restorer (V6 through V12); failure of any tube in the marker separator-shaping section of the video restorer (V19 through V26); high noise input to the video restorer.

Note. The output pulse train at E2 will be attenuated by a 6-db pad.

a. Place the D&I-THRU switches in D&I position, 2W–4W switches in 4W position, and PARTY LINE-PRIV switches in PARTY LINE position.

b. Connect a field Telephone EE–8–B across terminals at E9 and E10, PARTY LINE, channel 1.

c. Simulate all four conditions listed above. The telephone should not ring.

d. In simulating the four conditions above, the ALARM indicator located on both the video restorer and the multiplexer subassembly should light. The ALARM buzzer should sound. Press the AUDIBLE ALARM DISCONNECT switch on the multiplexer subassembly front panel. The ALARM buzzer should no longer sound but the alarm indicator lights remain on. When everything is connected normally, the ALARM lights should extinguish.

401. Signal-to-noise Ratio, Two-wire

a. Place all the PARTY LINE-PRIV switches in PRIV position.

b. Measure the signal-to-noise ratio at the 2W LINE terminals of channels 1 through 10, 17, and 22 of both terminals and at the 2W LINE terminals of repeater channels 1 and 2 (1 through 8 for the AN/TCA–1), under the following conditions:

(1) All channels in THRU operation. (Do not measure the channels at the repeater in this condition.)

(2) All channels in D&I operation.

Note. No reading should be greater than —55 dbm.

402. Cross Talk, 23-channel

Terminate channels 1-3, 5, 6, 8-11, 17, 18, 22, and 23 with 600 ohms at the east and west terminals.

a. Be sure that all D&I-THRU switches are in THRU position. All modems at the repeaters should be connected for two-wire operation.

b. At the west AN/TCC–13 terminal, press SEND button on control monitor, adjust SEND-DBM on the test set to 0.

c. At the west terminal, turn the channel 1 modem selector switches to SR.

d. At the east AN/TCC–13 terminal, press the REC button on the control monitor and F1A button on the test set.

e. Turn the channel 2 modem selector switch to RR at the east terminal and read meter on the audio test set. The allowable cross-talk reading is —48 dbm.

f. Return the selector switches on both modems to OPER.

g. Repeat the procedures in *e* through *f* above for the following channels (the allowable cross-talk reading is —48 dbm maximum) :

Modulate (0 dbm)	Receive
West terminal channel into	East terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
22	23
East terminal channel into	West terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
22	23

h. Set all repeater channels for D&I operation. PARTY LINE-PRIV switches should be in PRIV operation.

i. On AN/TCC–13 terminals and AN/TCA–1 repeater, modulate by pressing SEND button on control monitor, adjusting SEND-DBM to 0, and turning the modem selector switch to SR. Receive by pressing REC button on control monitor, pushing F1A button on the audio test set, and turning modem selector switch to RR.

j. Terminate channels 1, 2, 3, 5, 6, 8, and 9 with 600 ohms at both terminals and repeater. Take the following cross-talk readings (allowable cross talk is —48 dbm maximum) :

Modulate (0 dbm)		Receive (by turning modem switch to RR)			
West terminal channel	East terminal channel	Westfacing repeater channel		Eastfacing repeater channel	
		AN/TCA–1	AN/TRA–10	AN/TCA–1	AN/TRA–10
1	1, 2	2	2	1, 2	1, 2
2	2, 3	3	—	2, 3	2
5	5, 6	6	—	5, 6	—
8	8, 9	—	—	8	—
East terminal channel	West terminal channel	Eastfacing repeater channel		Westfacing repeater channel	
		AN/TCA–1	AN/TRA–10	AN/TCA–1	AN/TRA–10
1	1, 2	2	2	1, 2	1, 2
2	2, 3	3	—	2, 3	2
5	5, 6	6	—	5, 6	—
8	8, 9	—	—	8	—

Westfacing repeater channel		West terminal channel	Eastfacing repeater channel		East terminal channel
AN/TCA–1	AN/TRA–10		AN/TCA–1	AN/TRA–10	
1	1	2	1, 2	1, 2	1,2
2	2	3	2, 3	2	2, 3
5	—	6	5, 6	—	5, 6
8	—	9	8	—	8,9
Eastfacing repeater channel		East terminal channel	Westfacing repeater channel		West terminal channel
AN/TCA–1	AN/TRA–10		AN/TCA–1	AN/TRA–10	
1	1	2	1, 2	1, 2	1,2
2	2	3	2, 3	2	2, 3
5	—	6	5, 6	—	5, 6
8	—	9	8	—	8, 9

403. Operation, 45-channel

Connect the terminals for 45-channel operation. Connect the MASTER OUTPUTS TO RF (J5) of the master terminals to each of the pulse train inputs of the video restorer as in the 23-channel connection. The input pulse train consists of a positive 23-channel pulse train and a negative 23-channel pulse train, each being .5 volt from base line to peak, or 1 volt over-all peak to peak. The width of the pulses should be a maximum of .8 usec measured at the 50 per cent amplitude point. The spacing between the second positive marker pulse and the second negative marker pulse should be 2.6 ±.1 usec. Switches S1 of the video restorers should be placed in the 45 CHAN position. This will energize the filaments of V1 through V5 and permit the video restorer to accept the 45-channel pulse train.

a. Symmetry Control. Observe OUTPUT TO EASTFACING (WESTFACING) XMTR test point E2 with the oscilloscope. Adjust the SYM ADJ control until both positive and negative pulse trains are of equal amplitude. Meas-

ure the output pulse train. It shall be .4 to .6 volt peak to peak.

b. Channel Signal-to-noise Ratio.

(1) Bypass the repeater by turning off the +250V circuit breaker on the power supply.

(2) Set up correct audio levels by placing all 2W–4W switches of the test channels on the terminals in 2W. Modulate the 2W LINE terminals of both directions, one at a time, with 0 dbm. Adjust the corresponding modem OUTPUT AUDIO GAIN controls for —3 dbm output.

(3) Place all PARTY LINE-PRIV switches in PRIV position.

(4) Turn on the +250 volts at the repeaters.

(5) Measure the signal-to-noise ratio at the 4W REC terminals of channels 1 through 9 of all terminals (master and slave AN/TCC–13's), and at the 4W REC terminals of all channels at the repeater under the following conditions:

(*a*) All channels in THRU operation. (Do not measure channels 1 through 8 at the repeater in this condition.)

(*b*) All channels in D&I operation.

(6) No reading should be greater than —48 dbm.

404. Channel Cross Talk (Two-wire 45-channel)

a. At the terminals and AN/TCA–1, press the SEND button on the control monitor, adjust the SEND-DBM switch on the audio test set to 0, and turn the modem selector switch to SR. To receive, press the REC button on the control monitor, press the F1A button on the audio test set, and turn the modem selector switch to RR.

Note. After each check, return the modem selector switch to OPER.

b. Place all repeater D&I-THRU switches in THRU. Allowable cross talk in all cases is —38 dbm maximum.

(1) Terminate channels 1, 2, 3, 5, 6, 8, 9, 10, 11, 17, 18, 22, and 23 of both master terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West master terminal channel into	East master terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
22	23

(2) Terminate channels 1, 2, 3, 5, 6, 8, 9, 10, 11, 17, 18, 22, and 23 of the west master and east slave terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West master terminal channel into	East slave terminal channel
1	1
2	2
5	5
8	8
10	10
17	17
22	22

(3) Terminate chanels 1-3, 5, 6, 8-11, 17, 18, 21, and 22 at the west slave and east master terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West slave terminal channel into	East master terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
21	22

(4) Terminate channels 1-3, 5, 6, 8-11, 18, 21, 22 at both slave terminals with 600 ohms. Take the following cross-talk readings:

Modulate (0 dbm)	Receive
West slave terminal channel into	East master terminal channel
1	2
2	3
5	6
8	9
10	11
17	18
21	22

c. Repeat the procedures described in (*b*) above by modulating the east terminal and receiving on the west terminal. No reading should be greater than —38 dbm.

d. Place all D&I THRU switches in each channel of the AN/TCA–1 in D&I position.

(1) Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the west master, east master, east slave terminals and at the repeater. Take the following cross-talk readings (no reading should be greater than —38 dbm) :

Modulate (0 dbm)	Receive					
West master terminal	Westfacing repeater channel		Eastfacing repeater channel		East master terminal	East slave terminal
	AN/TCA–1	AN/TRA–10	AN/TCA–1	AN/TRA–10		
1	2	2	1, 2	1,2	1, 2	1
2	3	—	2, 3	2	2, 3	2
5	6	—	5, 6	—	5, 6	5
8	—	—	8	—	8, 9	8

(2) Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the west slave, east master and slave terminals and at the repeater. Take the following cross-talk readings (no reading should be greater than —38 dbm) :

Modulate (0 dbm)	Receive					
West slave terminal	Westfacing repeater channel		Eastfacing repeater channel		East master terminal	East slave terminal
	AN/TCA–1	AN/TRA–10	AN/TCA–1	AN/TRA–10		
1	1, 2	1, 2	1, 2	1, 2	2	2
2	2, 3	2	2, 3	2	3	3
5	5, 6	—	5, 6	—	6	6
8	8	—	8	—	9	9

(3) Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the east master, west master and slave terminals and at the repeater. Take the following cross-talk readings (no reading should be greater than —38 dbm) :

Modulate (0 dbm)	Receive					
East master terminal	Eastfacing repeater channel		Westfacing repeater channel		West master terminal	West slave terminal
	AN/TCA–1	AN/TRA–10	AN/TCA–1	AN/TRA–10		
1	2	2	1, 2	1, 2	1, 2	1, 2
2	3	—	2, 3	2	2, 3	2, 3
5	6	—	5, 6	—	5, 6	5, 6
8	—	—	8	—	8, 9	8, 9

(4) Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the east slave west master and slave terminals and at the repeater. Take the following cross-talk readings (no reading should be greater than —38 dbm) :

Modulate (0 dbm)	Receive					
East slave terminal	Eastfacing repeater channel		Westfacing repeater channel		West master terminal	West slave terminal
	AN/TCA–1	AN/TRA–10	AN/TCA–1	AN/TRA–10		
1	1, 2	2	1, 2	1, 2	2	2
2	2, 3	—	2, 3	2	3	3
5	5, 6	—	5, 6	—	6	6
8	8	—	8	—	9	9

(5) Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the west master and slave and east master and slave terminals and at the repeaters. Take the following cross-talk readings (no reading should be greater than —38 dbm) :

Modulate (0 dbm)		Receive					
Westfacing repeater channel		West master terminal	West slave terminal	East master terminal	East slave terminal	Eastfacing repeater channel	
AN/ TCA–1	AN/ TRA–10					AN/ TCA–1	AN/ TRA–10
1	1	2	1	1, 2	1	1, 2	1, 2
2	2	3	2	2, 3	2	2, 3	2
5	—	6	5	5, 6	5	5, 6	—
8	—	9	8	8, 9	8	8	—

(6) Terminate channels 1-3, 5, 6, 8, and 9 with 600 ohms at the east master and slave and west master and slave terminals and at the repeaters. Take the following cross-talk readings (no reading should be greater than —38 dbm) :

Modulate (0 dbm)		Receive					
Eastfacing repeater channel		East master terminal	East slave terminal	West master terminal	West slave terminal	Westfacing repeater channel	
AN/ TCA–1	AN/ TRA–10					AN/ TCA–1	AN/ TRA–10
1	1	2	1	1, 2	1	1, 2	1, 2
2	2	3	2	2, 3	2	2, 3	2
5	—	6	5	5, 6	5	5, 6	—
8	—	9	8	8, 9	8	8	—

CHAPTER 12

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

405. Disassembly of Equipment

The following disassembly instructions are supplied as a guide for preparing the multiplexer set, multiplexer group, and pulse form restorer group for shipment. The instructions apply to each of the equipments.

a. Be sure all power switches are in the OFF position.

b. Disconnect all telephone lines from the binding posts alongside the delay line.

c. Disconnect all interconnecting power and signal cables, coil the cords and cables, and store them in their respective chests.

d. Replace all protective caps.

e. Disconnect the oscilloscope probe and store it in the oscilloscope probe compartment.

f. Store the multiplexer set and multiplexer group handsets in the control monitor TEL SET compartment. Disconnect and store the pulse form restorer group operators handset.

g. Tighten all captive screws securely with a screw driver

h. Tighten all rack mounting screws securely.

i. Attach the front and rear covers of the transit case to the rack.

j. Attach the front cover of the voltage regulator to its transit case.

k. Wind up the 150-foot length of Electrical Power Cable Assembly CX–2440/U on Reel RC–405/TR.

406. Repackaging

Package the multiplexer set as follows:

a. Technical Literature. Package each manual within a close-fitting bag fabricated of waterproof barrier material. Seal seams with water-resistant, pressure-sensitive taps. Place the packaged manuals in the pouches on the inside of the accessories case cover.

b. Electrical Spare Part Items and Accessories. Package each item individually. Follow the procedures in *b* above.

c. Chest CY–250/U, With Components. Stow the items, as specified in *a* and *b* above, within the applicable compartments of each Chest CY–250/U. Fill all the voids with flexible corrugated paper to prevent shifting. Close the lid of the case and secure all fastenings. Place the case, with the contents, within a snug conforming wrap of single-faced, flexible corrugated paper. Secure all closures by means of water-resistant, pressure-sensitive tape.

d. Multiplexer Rack or Pulse Form Restorer Rack. Package the multiplexer rack as follows:

(1) Block and brace components within the rack by means of suitably cushioned wood blocks or pads fabricated of single-faced, flexible corrugated paper.

(2) Close the front and rear access covers and properly secure them in place.

(3) Construct the components of a wooden box (fig. 26), modified to include a skid-type base and interior diagonal bracing. The sheathing, parallel to the skids, should run vertically to permit nailing into the skids. Maintain a minimum of 2-inch clearance between the barrier and side ends of the box.

(4) Construct a wooden mounting base with a minimum of six bolt holes to receive the mounting bolts.

(5) Secure the rack to the mounting base with metal strapping.

(6) Drill matching bolt holes through the skids and base of the box to match the bolts of the mounting base.

(7) Insert suitable style and size bolts through the box skids and base.

(8) Assemble in order (over the mounting base) a pad of single-faced, flexible corrugated paper to extend beneath all points of contact between the item and boxbase, a waterproof barrier, and a cushioning shroud of flexible corrugated paper.

(9) Place a suitable waterproof cement around the bolts at each application.

(10) Position the mounted items over the mounting bolts.

(11) Place lock washers and nuts over the bolts and turn down bolt nuts firmly.

(12) Close the waterproof barrier and seal with pressure-sensitive tape.

e. Test Equipment Rack. Package the test equipment rack as described in *d* above.

f. Reel RC–405/TR and Electrical Power Cable Assembly CX–2440/U.

(1) Wind the power cable evenly on the reel provided. Secure the free end of the cable, either by tying or taping, to prevent movement.

(2) Apply a sheet of flexible corrugated paper between the inside flanges of the reel and secure it in place by means of two metal straps equidistantly spaced.

g. Voltage Regulator CN–236/G.

(1) Block and brace components within the voltage regulator by means of wooden blocking or pads fabricated of single-faced, flexible corrugated fiberboard to prevent movement and shearing stress on the mountings.

(2) Close the access doors and secure the fastenings.

(3) Cushion all sharp edges and corners of the units by means of pads, fabricated of single-faced, flexible corrugated fiberboard.

(4) Secure the cushioning with gummed paper tape.

407. Field Repacking, Strapping, and Marking

a. Repacking.

(1) Place each packaged unit on a skid; fit the unit with a sealed waterproof liner.

(2) Nail the two ends to the bottom and skid.

(3) Nail the two sides to the bottom and skid.

(4) Nail the top to the ends and bottom.

b. Strapping. Strap the shipping box for intertheater shipment only. The strapping should run parallel to the skids.

c. Marking. Mark the shipping containers in accordance with the requirements of SR–55–720–1, Section II, Transportation and Travel, Preparation for Ovearsea Movement of Units (POM).

408. Authority for Demolition

The demolition procedures outlined in paragraph 409 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

409. Methods of Destruction

Use any of the following methods to destroy the equipment.

a. Smash. Smash the crystal, controls, tubes, coils, switches, capacitors, transformers, and headsets; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. Cut. Cut cords, headsets, and wiring; use axes, handaxes, or machetes.

c. Burn. Burn cords, resistors, capacitors, coils, wiring, and technical manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

d. Bend. Bend panels, cabinet, and chassis.

e. Explosives. If explosives are necessary, use firearms, grenades, or TNT.

f. Disposal. Bury or scatter the destroyed parts in slit trenches, fox holes, or other holes, or throw them into streams.

APPENDIX I

TABLE OF COMPONENTS

1. Multiplexer Set AN/TCC-13

a. Multiplexer Rack.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY-1280/U containing:	1	26½	27	60	24.9	535
Multiplexer TD-60/TCC-13	1	19	19	8¾		
Electrical Equipment Rack MT-1165/TCC-13	1	19	19	31½		
Delay line	1	5	5¼	31		
Telephone Modem MD-179/TC	23[a]	16	2½	8½		
Multiplexer Subassembly MX-1442/TC containing:	1	19	17¼	8½		
Remote Switching Control C-1509/TC	2	4½	2¾	5½		

[a]There are 24 modems installed in the multiplexer rack; one is supplied as a spare.

b. Test Equipment Rack.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY-1280/U containing:	1	26½	27	60	24.9	534
Oscilloscope OS-25/G	1	19	19	13		
Audio Test Set TS-762/TC	1	19	19	7		
Control Monitor C-1151/TC	1	19	19	10½		
Accessories Case CY-1334/G containing:	1	19	19	11¾		
Tube puller	2					
Pin straightener	2					
Wrenches	2					
Power Supply PP-691/G	1	19	19	12		

c. Accessories.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Voltage Regulator CN-236/G	1	23	17½	19½	5.31	215
Reel RC-405/TR with Electrical Power Cable Assembly CX-2440/U (150 ft 0 in.)	1	28 dia		12	4.27	108

d. Running Spares and Accessories Case I.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250B/U, containing:	1	27	21¼	20	6.56	127
Manual	2					
Electron tube OA2	2					
Electron tube OA3	1					
Electron tube OB2	1					
Electron tube 2X2A	1					
Electron tube 5CP1A	1					
Electron tube 5R4WGY	2					
Electron tube 6AG5	5					
Electron tube 6AG7	7					
Electron tube 6AS7G	2					
Electron tube 6AU6	1					
Electron tube 6X4W	1					
Electron tube 12AT7	2					
Electron tube 12AT7WA	17					
Electron tube 5726/6AL5W	3					
Electron tube 5727/2D21W	1					
Electron tube 6005/6AQ5W	1					
Incandescent lamp, G. E. #356–125 (3 watt)	1					
Thermal resistor	1					
Book of schematics	1					
Technical order file case	1					
Electron tube extractor	1					

e. Running Spares and Accessories Case II.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250B/U, containing:	1	27	21¼	20	6.56	126
Switch Box SA–357/G	1	6	11	5		
Electrical Connector Assembly J–535/G	1	30½	8¾	9		
Spare parts box containing:		7½	13½	2 7/32		
Electrical Contact Brush Assembly Type S373P	1					
Crystal rectifier 1N34A	1					
Crystal rectifier 1N38A	14					
Cartridge fuse, 1/10 amp, 125 volts	6					
Cartridge fuse, 3/10 amp, 125 volts	6					
Cartridge fuse, 3/10 amp, 250 volts	42					
Cartridge fuse, 1 amp, 125 volts	6					
Cartridge fuse 1.5 amp, 125 volts	6					
Cartridge fuse, 2 amp, 125 volts	30					
Cartridge fuse, 3 amp, 125 volts	12					
Cartridge fuse, 4 amp, 125 volts	12					
Cartridge fuse, 5 amp, 125 volts	12					
Cartridge fuse, 8 amp, 125 volts	6					
Cartridge fuse, 10 amp, 32 volts	12					
Glow lamp, type NE–51	8					
Cord CG–409C/U (25 ft 0 in.)	2	300				
Radio Frequency Cable Assembly CG–1040A/U (15 ft 3 in.)	2	183				
Radio Frequency Cable Assembly CG–1040A/U (25 ft 3 in.)	1	303				
Electrical Power Cable Assembly CX–2272/U (3 ft 5 in.)	1	41				
Electrical Power Cable Assembly CX–2273/U (10 ft 4 in.)	1	124				

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Power Cable Assembly CX–2275/U (8 ft 4 in.)	1	100				
Electrical Power Cable Assembly CX–2276/U (6 ft 4 in.)	1	76				
Electrical Power Cable Assembly CX–2277/U (8 ft 4 in.)	1	100				
Electrical Power Cable Assembly CX–2240/U (15 ft 0 in.)	1	180				
Electrical Power Cable Assembly CX–2441/U (8 ft 4 in.)	2	101				
Electrical Power Cable Assembly CX–2242/U (10 ft 0 in.)	2	120				
Electrical Power Cable Assembly CX–2682/U (3 ft 3 in.)	1	39				
Electrical Lead CZ–2683/U (20 ft 0 in.)	1	240				

2. Multiplexer Group AN/TCA–1

a. Multiplexer Rack.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY–1280/U, containing:	1	26½	27	60	24.9	515
Pulse Form Restorer TD–68/G	1	19	19			
Electrical Equipment Rack MT–1433/TCA–1	1	19	19			
Delay line	1	5	5¼			
Telephone Modem MD–179/TC	16	16	2½	8½		
Multiplexer Subassembly MX–1442/TC including:	1	19	17¼	8½		
Remote Switching Control C–1509/TC	2	4½	2¾	5½		

b. Test Equipment Rack.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY–1280/U, containing:	1	26½	27	60	24.9	534
Oscilloscope OS–25/G	1	19	19	13		
Audio Test SET TS–762/TC	1	19	19	7		
Control Monitor C–1151/TC	1	19	19	10½		
Accessories Case CY–1334/G which includes:	1	19	19	11¾		
Tube puller	2					
Pin straightener	2					
Wrench	2					
Power Supply PP–691/G	1	19	19	12		

c. Accessories.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Voltage Regulator CN–236/G	1	23	17½	19½	5.31	215
Reel RC–405/TR with Electrical Power Cable Assembly CX–2440/U (150 ft)	1	28 dia		12	4.27	108

d. Running Spares and Accessories Case I.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250/U, containing:	1	27	21¼	20	6.56	126
Manual	2					
Electron tube OA2	2					
Electron tube OA3	1					
Electron tube OA2	1					
Electron tube 2X2A	1					
Electron tube 5CP1A	1					
Electron tube 5R4WGY	2					
Electron tube 6AG5	7					
Electron tube 6AG7	9					
Electron tube 6AS7G	1					
Electron tube 6AU6	1					
Electron tube 6X4W	1					
Electron tube 12AT7	2					
Electron tube 12AT7WA	12					
Electron tube 5726/6AL5W	5					
Electron tube 5727/2D21W	1					
Electron tube 6005/6AQ5W	1					
Incandescent lamp, 3 watts, GE No. 356–125 (3 watt)	1					
Thermal resistor	1					
Electron tube extractor	1					
Book of schematics	1					
Technical order file case	1					

e. Running Spares and Accessories Case II.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250/U, containing:	1	27	21¼	20	6.56	150
Switch Box SA–357/G	1	6	11	5		
Electrical Connector Assembly J–535/G	1	30½	8¾	9		
Spare parts box containing:		7 7/16	13½	2 3/32		
Electrical contact brush assembly type S373P	1					
Crystal rectifier, JAN 1N34A	1					
Crystal rectifier, JAN 1N38A	12					
Cartridge fuse, 1/10 amp, 125 volts	6					
Cartridge fuse, 1/10 amp, 250 volts	6					
Cartridge fuse, 3/10 amp, 125 volts	6					
Cartridge fuse, 3/10 amp, 250 volts	24					
Cartridge fuse, 6/10 amp, 250 volts	12					
Cartridge fuse, 1 amp, 125 volts	6					
Cartridge fuse, 1½ amp, 125 volts	6					
Cartridge fuse, 2 amp, 125 volts	30					
Cartridge fuse, 3 amp, 125 volts	12					
Cartridge fuse, 4 amp, 125 volts	12					
Cartridge fuse, 5 amp, 125 volts	12					
Cartridge fuse, 8 amp, 125 volts	6					
Glow lamp, type NE–51	8					
Lightning arrestor	4					
Cord CG–409C/U	4	300				
Radio Frequency Cable Assembly CG–1040A/U (15 ft 3 in.)	2	183				
Electrical Power Cable Assembly CX–2272/U (3 ft 5 in.)	1	41				
Electrical Power Cable Assembly CX–2273/U (10 ft 4 in.)	1	124				

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Power Cable Assembly CX–2275/U (8 ft 4 in.)	1	100				
Electrical Power Cable Assembly CX–2276/U (6 ft 4 in.)	1	76				
Electrical Power Cable Assembly CX–2277/U (8 ft 4 in.)	1	100				
Electrical Power Cable Assembly CX–2440/U (15 ft 0 in.)	1	180				
Electrical Power Cable Assembly CX–2441/U (8 ft 4 in.)	2	100				
Electrical Power Cable Assembly CX–2442/U (10 ft 0 in.)	2	120				
Electrical Power Cable Assembly CX–2682/U (3 ft 3 in.)	1	39				
Electrical Lead CX–2683/U (20 ft 0 in.)	1	240				

3. Pulse Form Restorer Group AN/TRA–10

a. Pulse Form Restorer Rack.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Component Case CY–1719/G containing:	1	26½	27	60	24.9	595
Oscilloscope OS–25/G	1	19	19	12	2.5	84
Pulse Form Restorer TD–68/G	1	22¾	19	15⅝	3.8	
Electrical Equipment Rack MT–1434/TRA–10	1	20¾	19	24⅜	5.5	
Telephone Modem MD–179/TC	4	16	2½	8½	.19	5½
Delay line	1	5	4⅞	21⅝	.3	
Remote Switching Control C–1509/TC	2	4½	2⅜	5½	.03	
Power Supply PP–691/G	1	19	19	12	2.5	123

b. Accessories.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Voltage Regulator CN–236/G	1	23¼	18	22¼	5.31	215
Reel RC–405/TR with Electrical Power Cable Assembly CX–2440–U (150 ft 0 in.)	1		28 dia x 12		4.27	108

c. Running Spares and Accessories Case I.

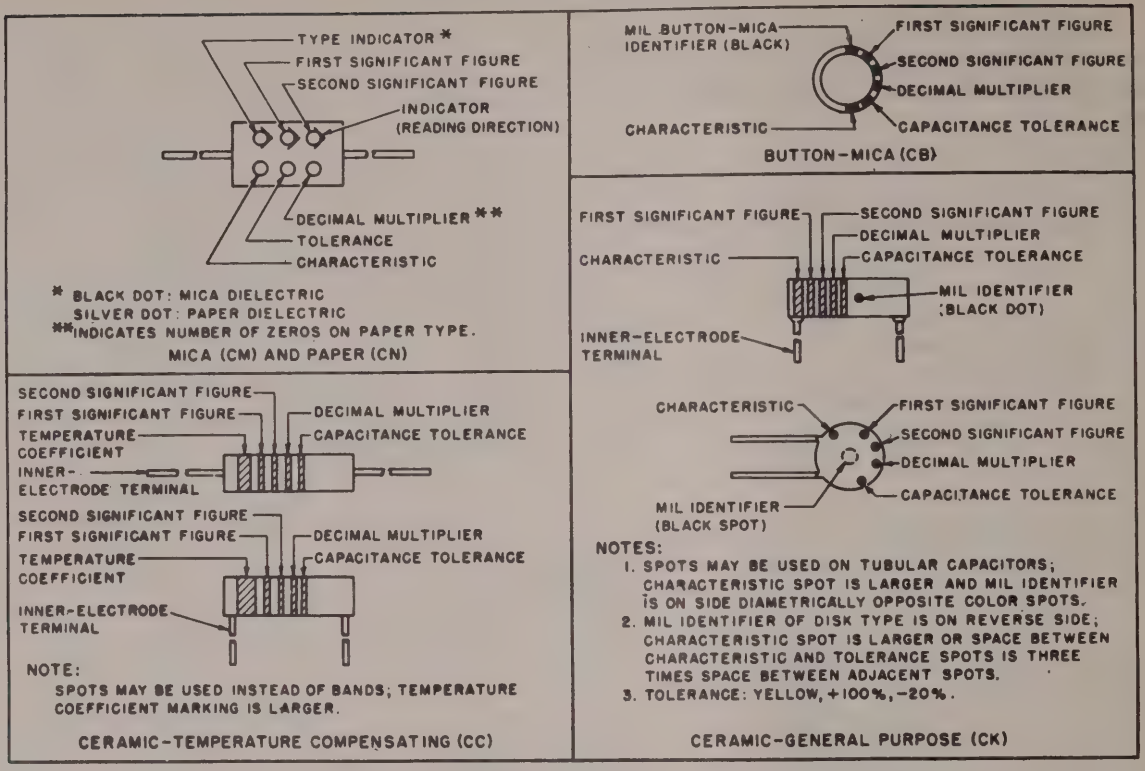
Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250/U, containing:	1	27	21¼	20	6.56	127
Manual	2					
Electron tube OA2	2					
Electron tube OA3	1					
Electron tube OB2	1					
Electron tube 2X2A	1					
Electron tube 5CP1A	1					
Electron tube 5R4WGY	1					
Electron tube 6AG5	6					
Electron tube 6AG7	9					
Electron tube 6AS7G	2					
Electron tube 6AU6	1					
Electron tube 6X4W	1					

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electron tube 12AT7WA	9					
Electron tube 5726/6AL5W	5					
Electron tube 5727/2D21W	1					
Electron tube 6005/6AQ5W	1					
Incandescent lamp, G. E. #365–125 (3 watt)	1					
Thermal resistor	1					
Book of schematics	1					
Tube extractor	1					

d. Running Spares and Accessories, Case II.

Component	Required No.	Depth (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Chest CY–250/U, containing:	1	27	21¼	20	6.56	126
Switch Box SA–357/G	1	6	11	5		
Electrical Connector Assembly J–535/G	1	30½	8¾	9		
Spare parts case containing:		7 7/16	13½	2 7/32		
Electrical Contact Brush Assembly type S373P	1					
Crystal rectifier 1N34A	1					
Crystal rectifier 1N38A	5					
Cartridge fuse, 1/10 amp, 250 volts	18					
Cartridge fuse, 3/10 amp, 125 volts	6					
Cartridge fuse, 6/10 amp, 250 volts	12					
Cartridge fuse, 15/100 amp, 250 volts	6					
Cartridge fuse, 2 amp, 125 volts	12					
Cartridge fuse, 3 amp, 250 volts	12					
Cartridge fuse, 4 amp, 250 volts	12					
Cartridge fuse, 5 amp, 250 volts	12					
Cartridge fuse, 8 amp, 250 volts	6					
Glow lamp, Type NE–51	7					
Lightning arrestor	2					
Cord CG–409C/U (25 ft 0 in.)	4	300				
Radio Frequency Cable Assembly CG–1040A/U (15 ft 3 in.)	2	183				
Electrical Power Cable Assembly CX–2276/U (2 ft 0 in.)	1	12				
Electrical Power Cable Assembly CX–2440/U (15 ft 0 in.)	1	180				
Electrical Power Cable Assembly CX–2241/U (8 ft 4 in.)	2	100				
Electrical Power Cable Assembly CX–2242/U (10 ft 0 in.)	2	120				
Electrical Power Cable Assembly CX–2682/U (3 ft 3 in.)	1	39				
Electrical Lead CX–2683/U (20 ft 0 in.)	1	240				

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



CAPACITOR COLOR CODE

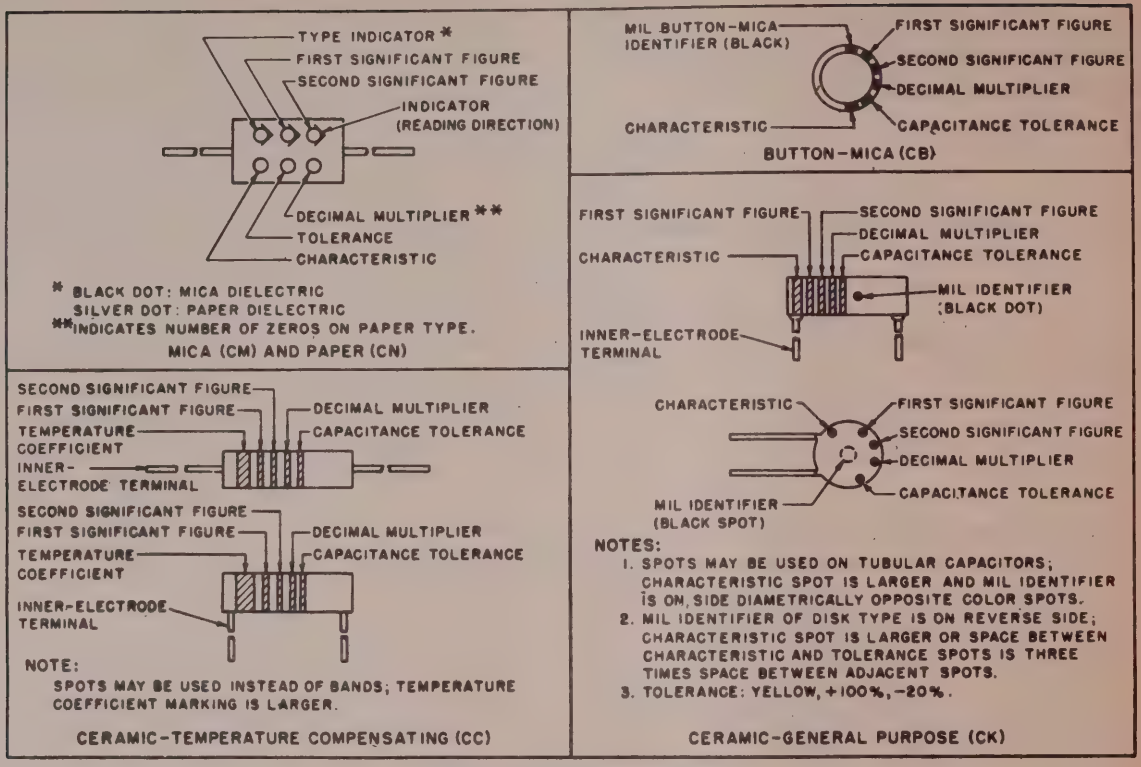
COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE[2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC.		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-CI

Figure 361. MIL–STD capacitor color codes.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE[2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC. OVER 10UUF	CC. 10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-CI

Figure 361. MIL–STD capacitor color codes.

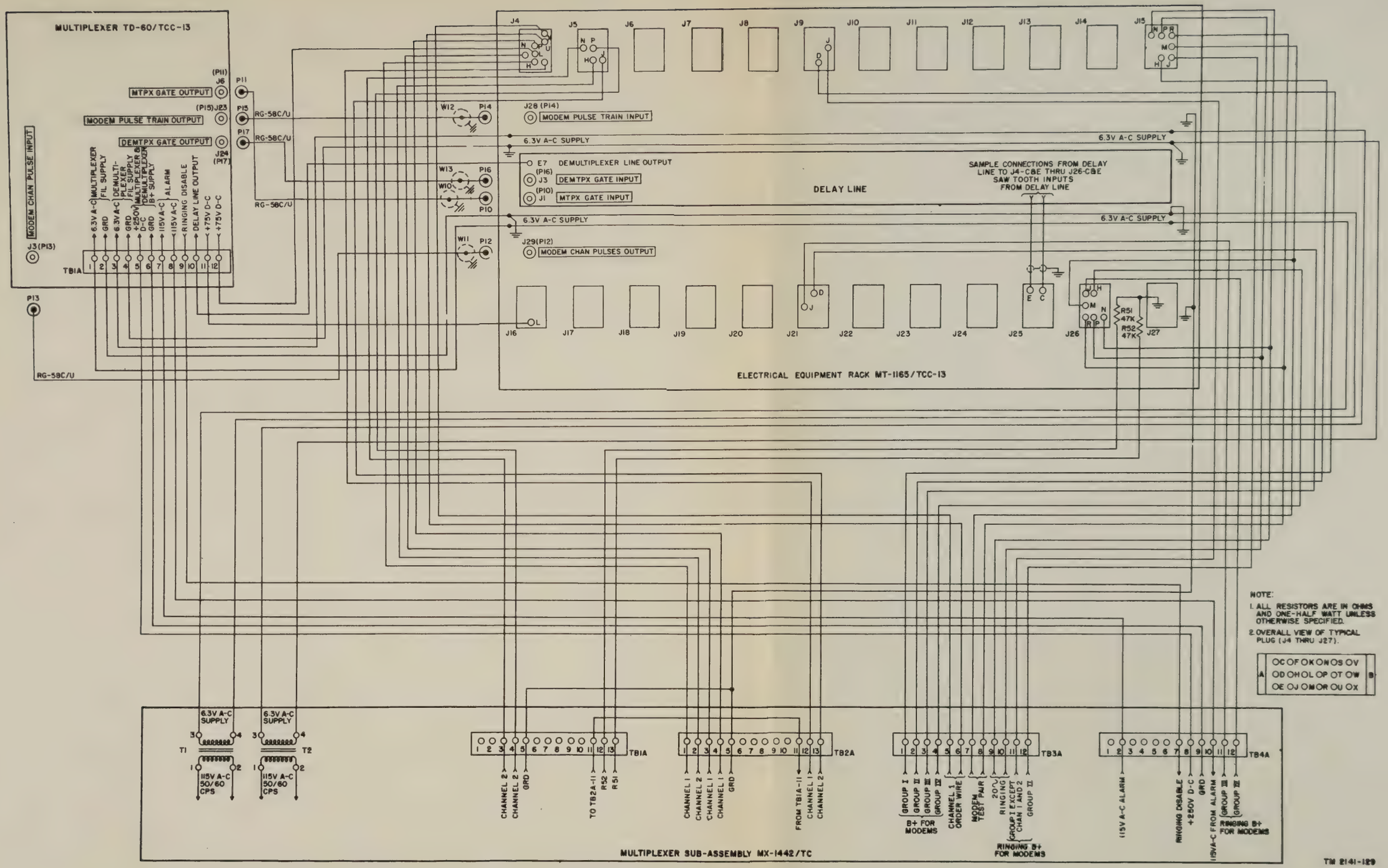


Figure 363. Multiplexer Set AN/TCC–13, multiplexer rack, over-all schematic diagram.

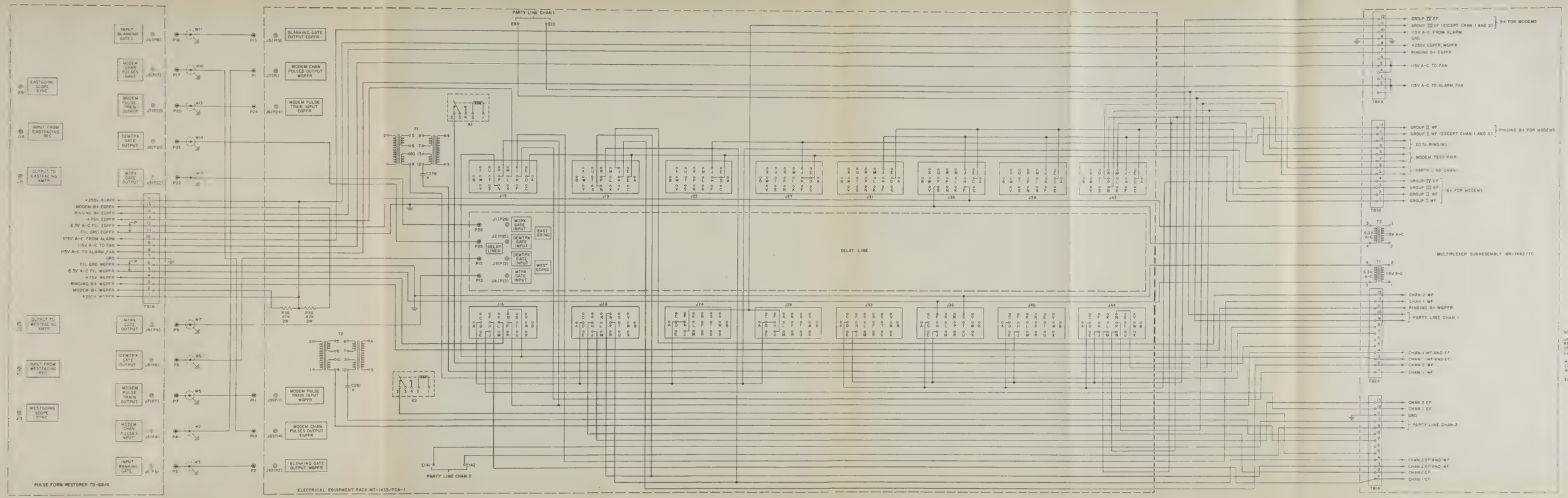
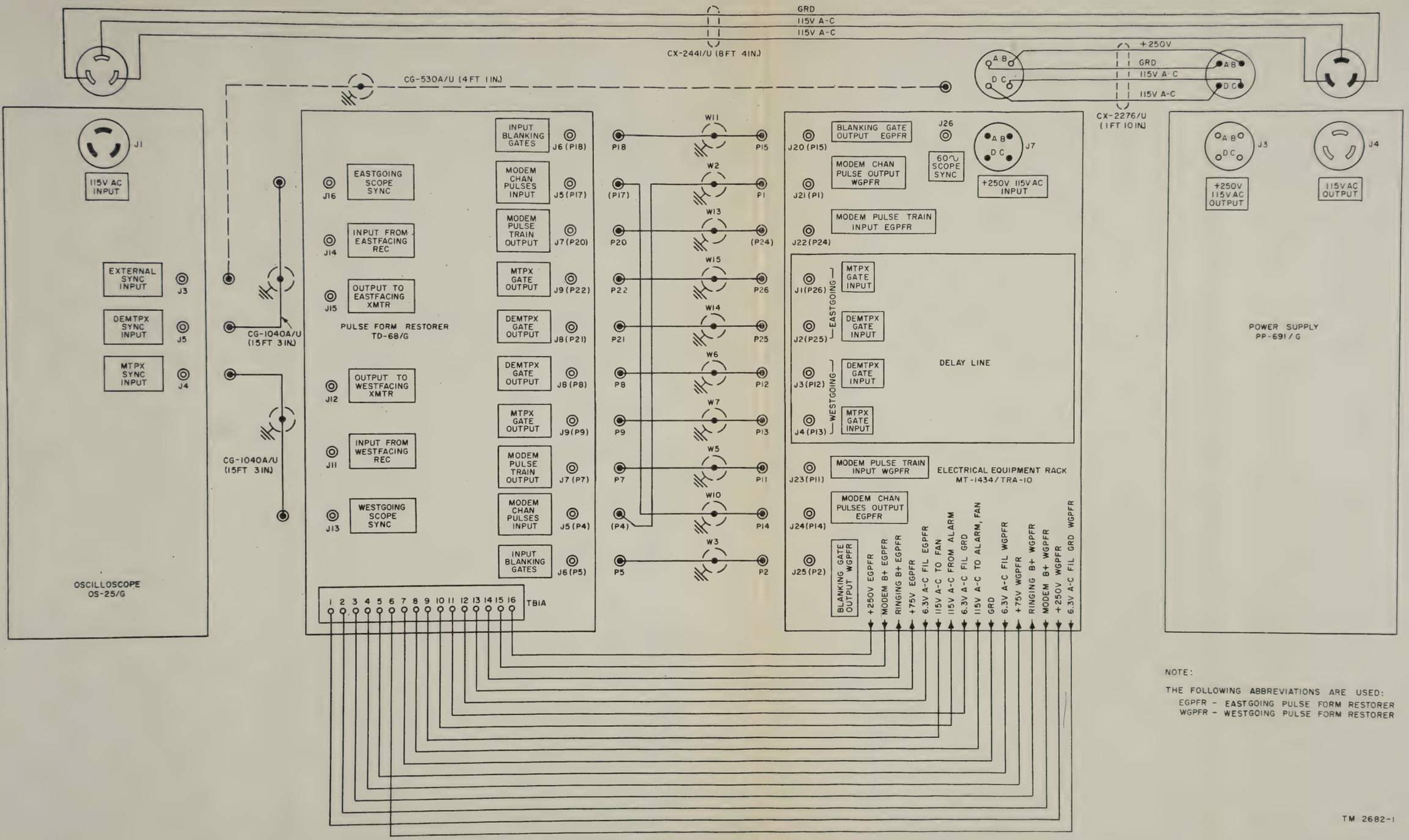


Figure 364. Multiplexer Group AN/TCA-1, multiplexer rack, over-all schematic diagram.

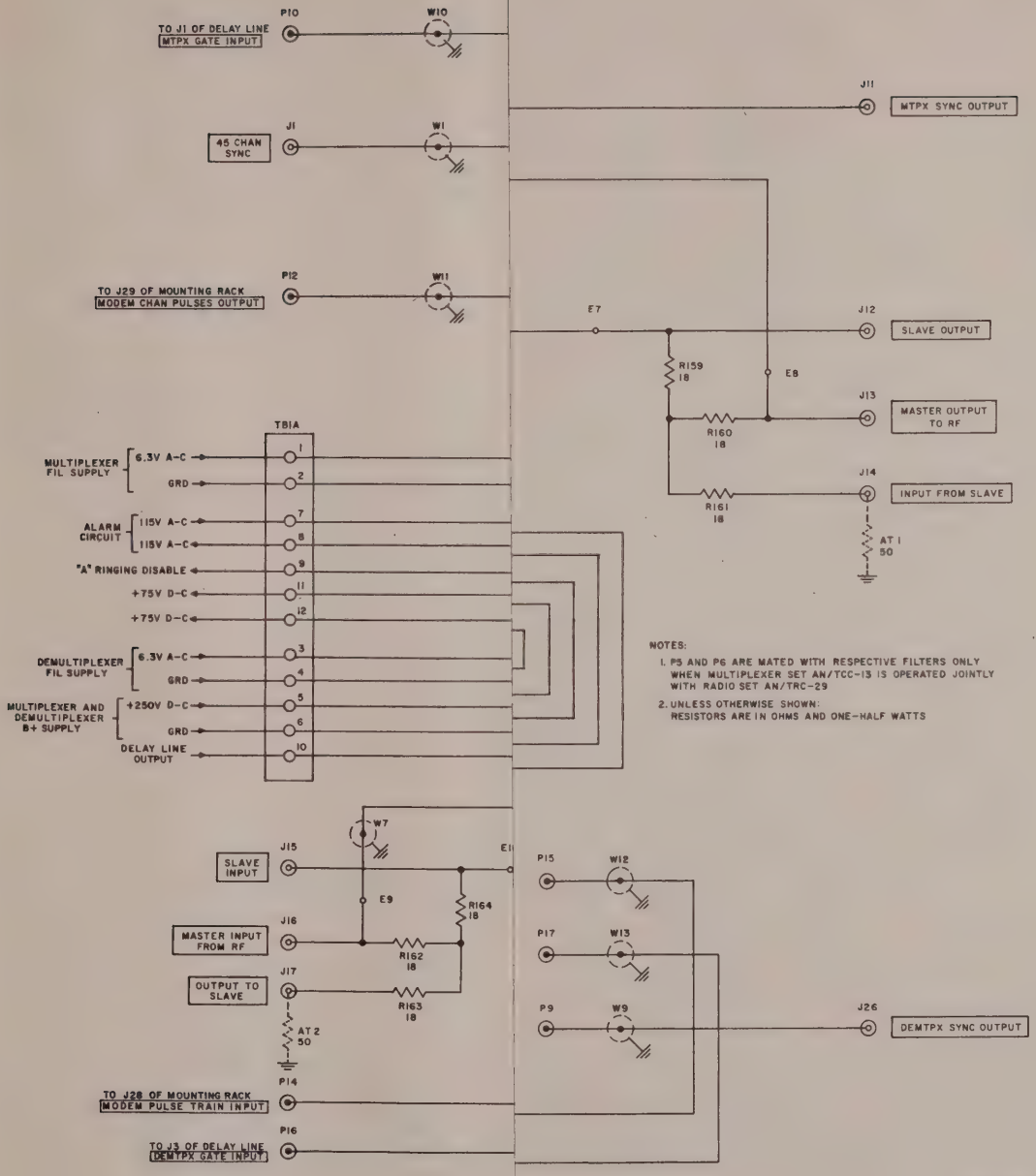


NOTE:

THE FOLLOWING ABBREVIATIONS ARE USED:
EGPFR - EASTGOING PULSE FORM RESTORER
WGPFR - WESTGOING PULSE FORM RESTORER

TM 2682-1

Figure 365. Pulse Form Restorer Group AN/TRA–10, over-all schematic diagram.


TO J1 OF DELAY LINE
MTPX GATE INPUT
P10
W10
J11
MTPX SYNC OUTPUT
45 CHAN SYNC
J1
W1
TO J29 OF MOUNTING RACK
MODEM CHAN PULSES OUTPUT
P12
W11
E7
J12
SLAVE OUTPUT
R159
18
E8
J13
MASTER OUTPUT TO RF
R160
18
J14
INPUT FROM SLAVE
R161
18
AT 1
50
TB1A
MULTIPLEXER FIL SUPPLY
6.3V A-C
GRD
ALARM CIRCUIT
115V A-C
115V A-C
"A" RINGING DISABLE
+75V D-C
+75V D-C
DEMULTIPLEXER FIL SUPPLY
6.3V A-C
GRD
MULTIPLEXER AND DEMULTIPLEXER B+ SUPPLY
+250V D-C
GRD
DELAY LINE OUTPUT
1
2
7
8
9
11
12
3
4
5
6
10
NOTES:
1. P5 AND P6 ARE MATED WITH RESPECTIVE FILTERS ONLY WHEN MULTIPLEXER SET AN/TCC-13 IS OPERATED JOINTLY WITH RADIO SET AN/TRC-29
2. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS AND ONE-HALF WATTS
W7
J15
SLAVE INPUT
E9
E1
R164
18
J16
MASTER INPUT FROM RF
R162
18
J17
OUTPUT TO SLAVE
R163
18
AT 2
50
P15
W12
P17
W13
P9
W9
J26
DEMTPX SYNC OUTPUT
P14
TO J28 OF MOUNTING RACK
MODEM PULSE TRAIN INPUT
P16
TO J3 OF DELAY LINE
DEMTPX GATE INPUT
TM2141-120

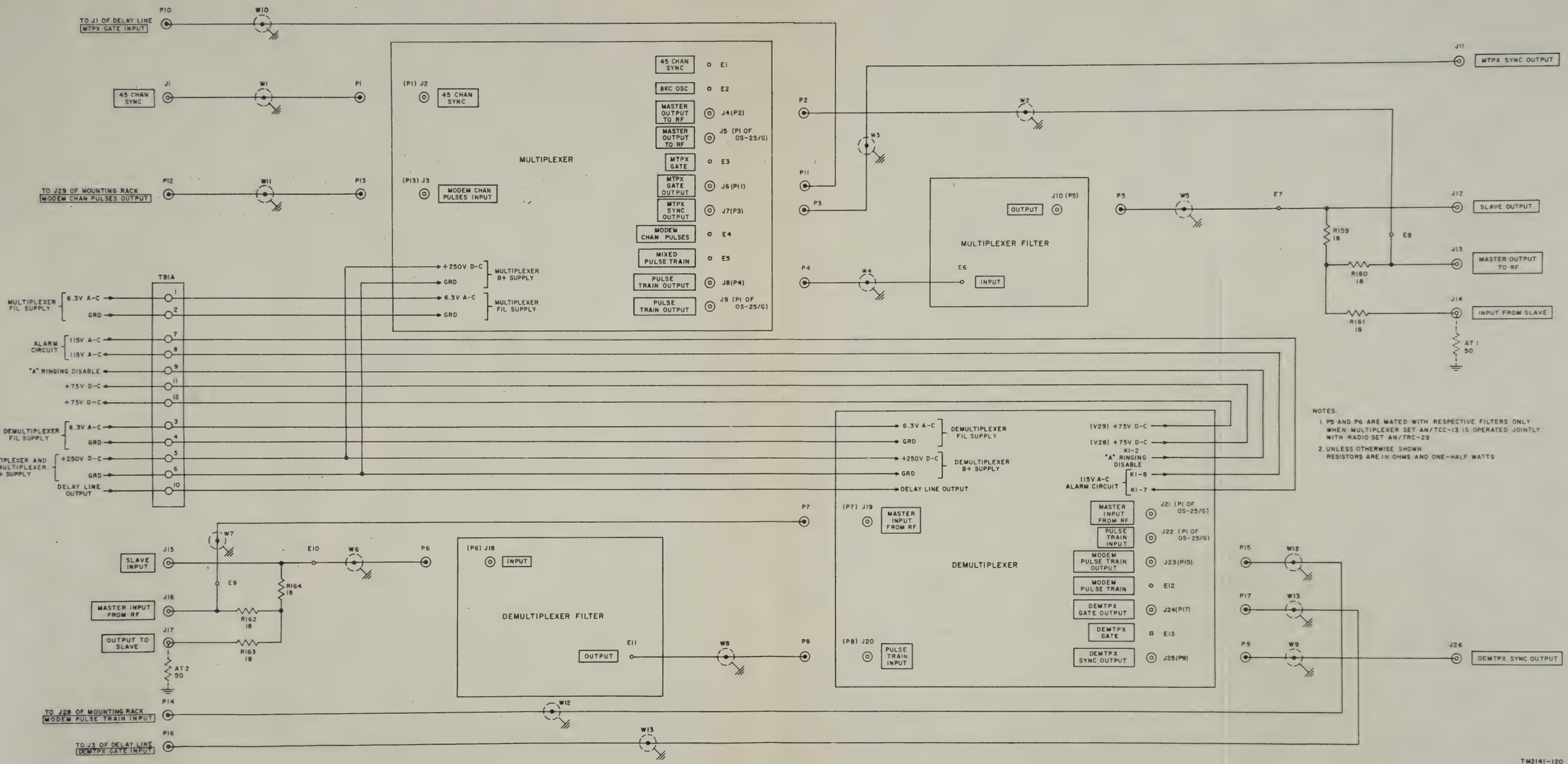


Figure 366. Multiplexer TD-60/TCC-13, over-all schematic diagram.

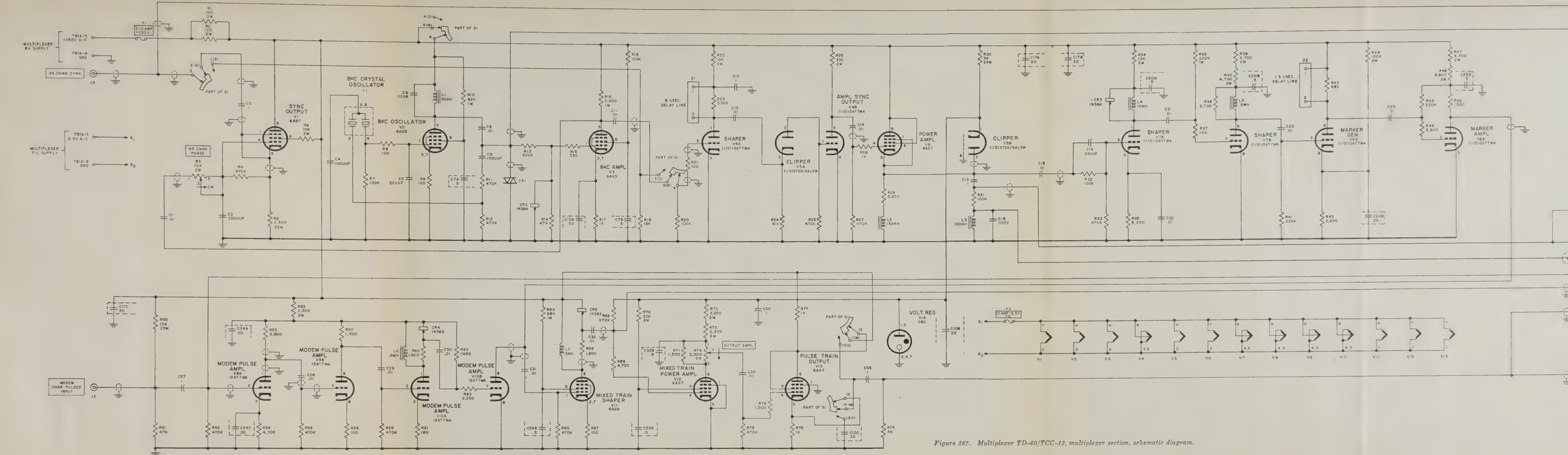
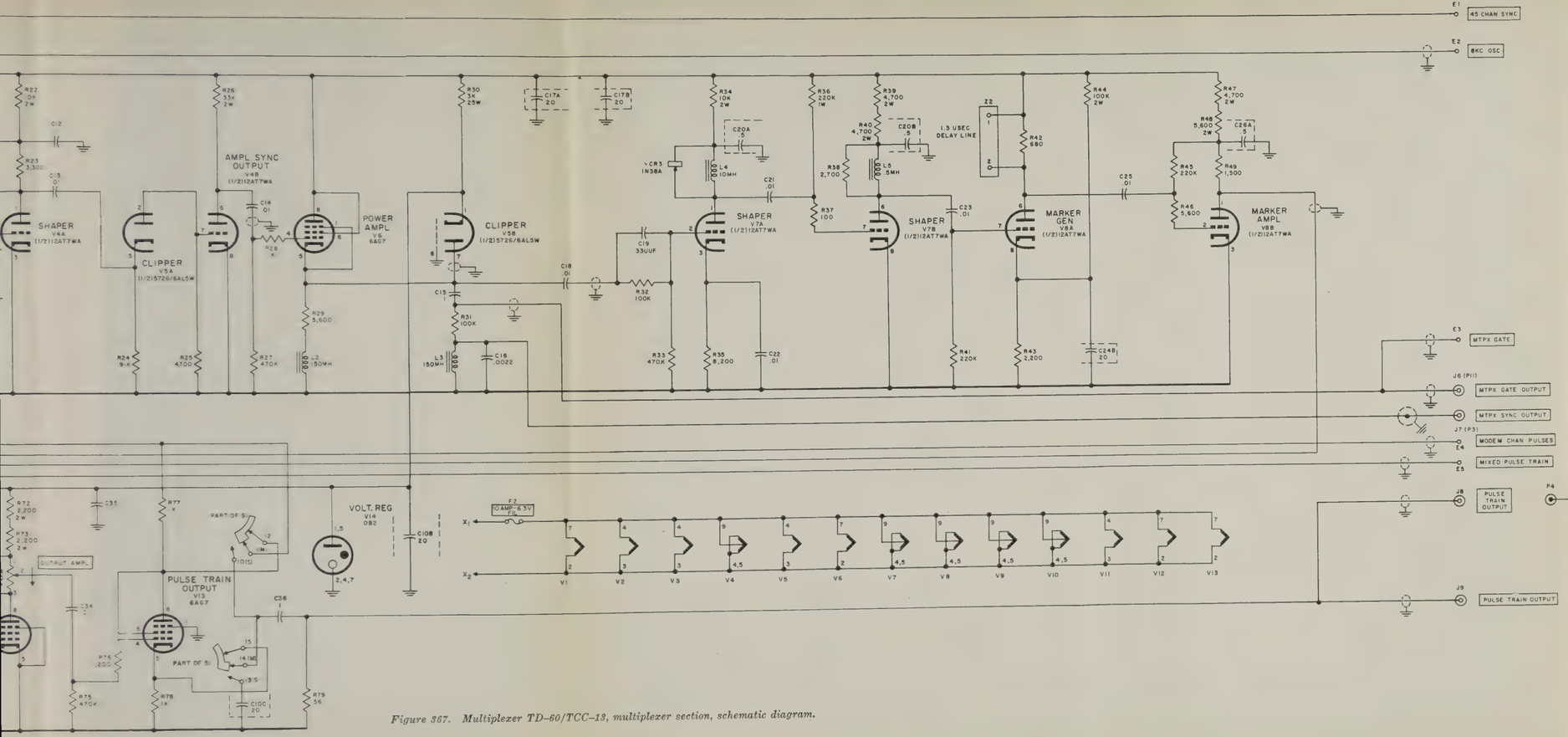


Figure 367. Multiplexer TD–60/TCC–13, multiplexer section, schematic diagram.



NOTES
1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS AND ONE HALF WATT CAPACITORS ARE IN UF.

2. S1 LEGEND

FUNCTION	POSITIONS
SLAVE	1, 4, 7, 10, 13
MASTER	2, 5, 8, 11, 14

ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB

TM 2141-121

Figure 367. Multiplexer TD–60/TCC–13, multiplexer section, schematic diagram.

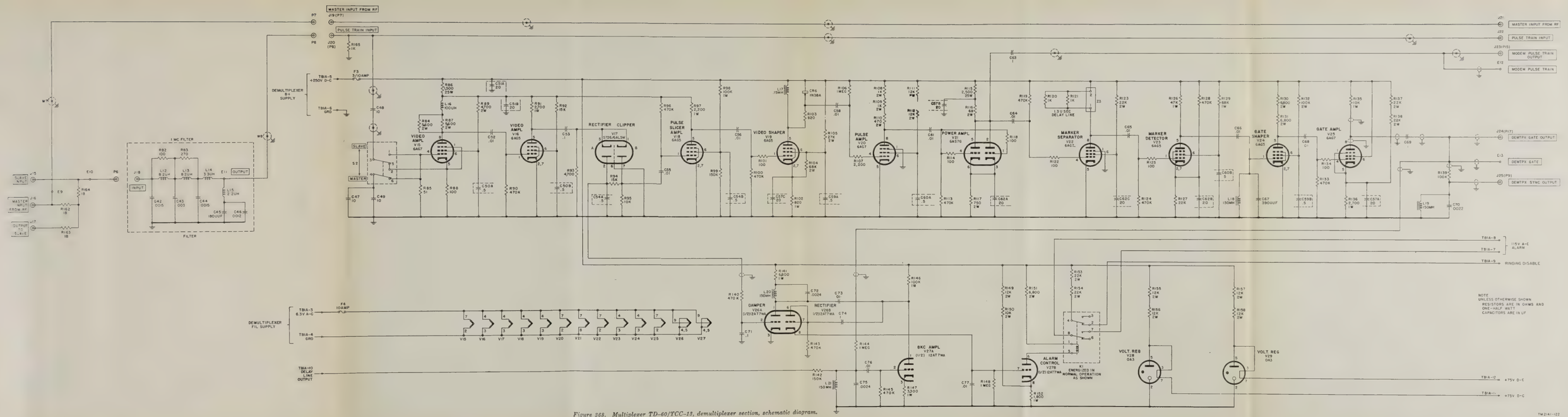
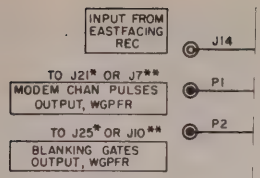
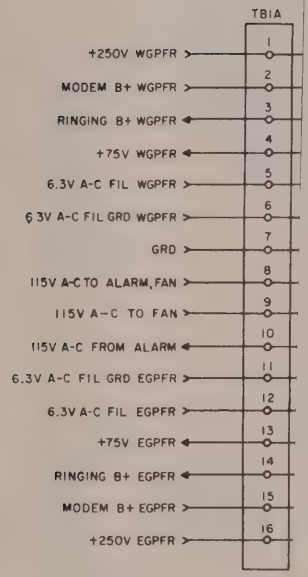
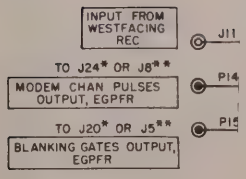


Figure 368. Multiplexer TD–60/TCC–13, demultiplexer section, schematic diagram.


INPUT FROM EASTFACING REC
J14
TO J21* OR J7**
MODEM CHAN PULSES OUTPUT, WGPFR
P1
TO J25* OR J10**
BLANKING GATES OUTPUT, WGPFR
P2


TBIA
1
+250V WGPFR
2
MODEM B+ WGPFR
3
RINGING B+ WGPFR
4
+75V WGPFR
5
6.3V A-C FIL WGPFR
6
6.3V A-C FIL GRD WGPFR
7
GRD
8
115V A-C TO ALARM, FAN
9
115V A-C TO FAN
10
115V A-C FROM ALARM
11
6.3V A-C FIL GRD EGPFR
12
6.3V A-C FIL EGPFR
13
+75V EGPFR
14
RINGING B+ EGPFR
15
MODEM B+ EGPFR
16
+250V EGPFR


INPUT FROM WESTFACING REC
J11
TO J24* OR J8**
MODEM CHAN PULSES OUTPUT, EGPFR
P14
TO J20* OR J5**
BLANKING GATES OUTPUT, EGPFR
P15

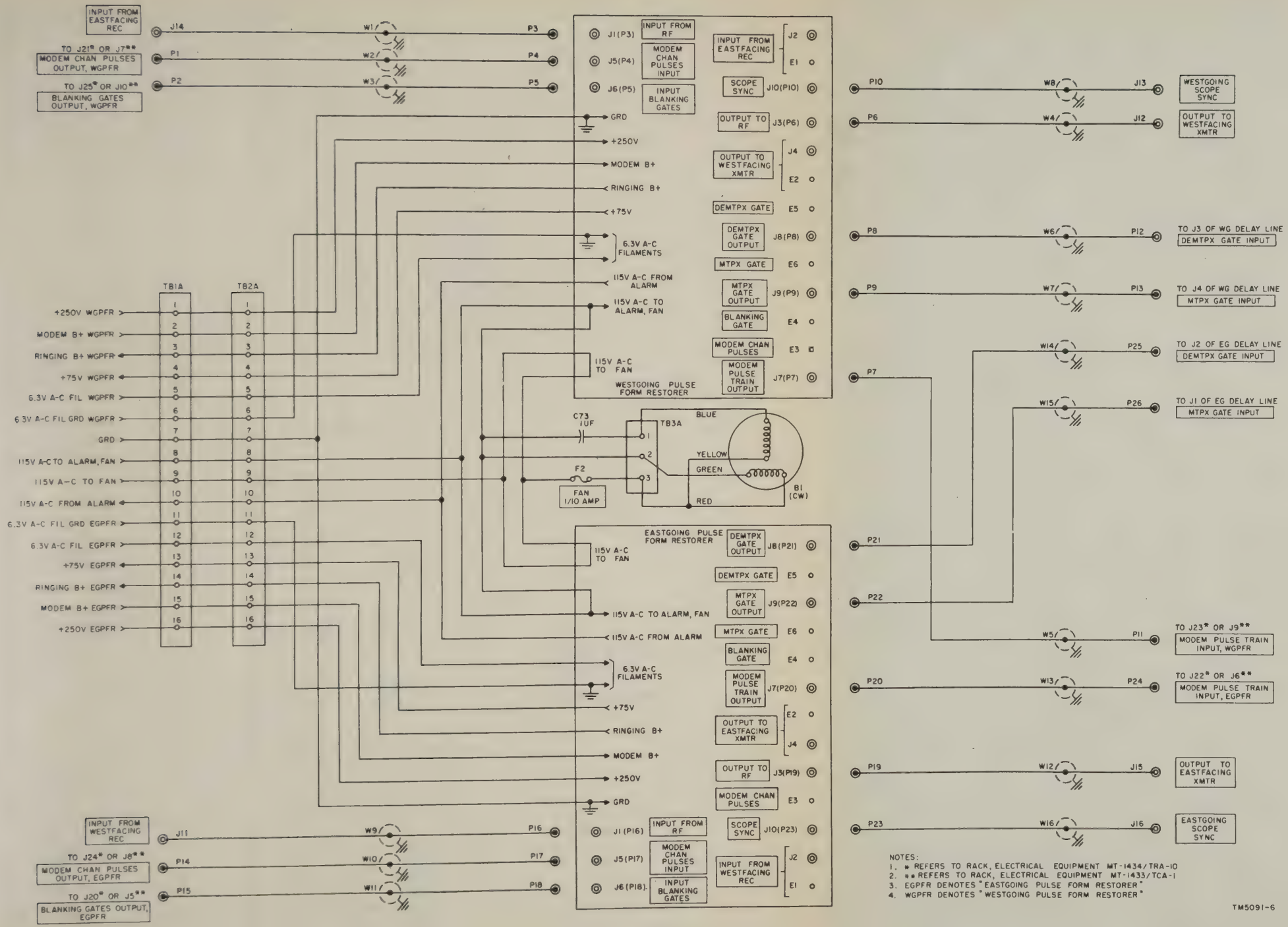
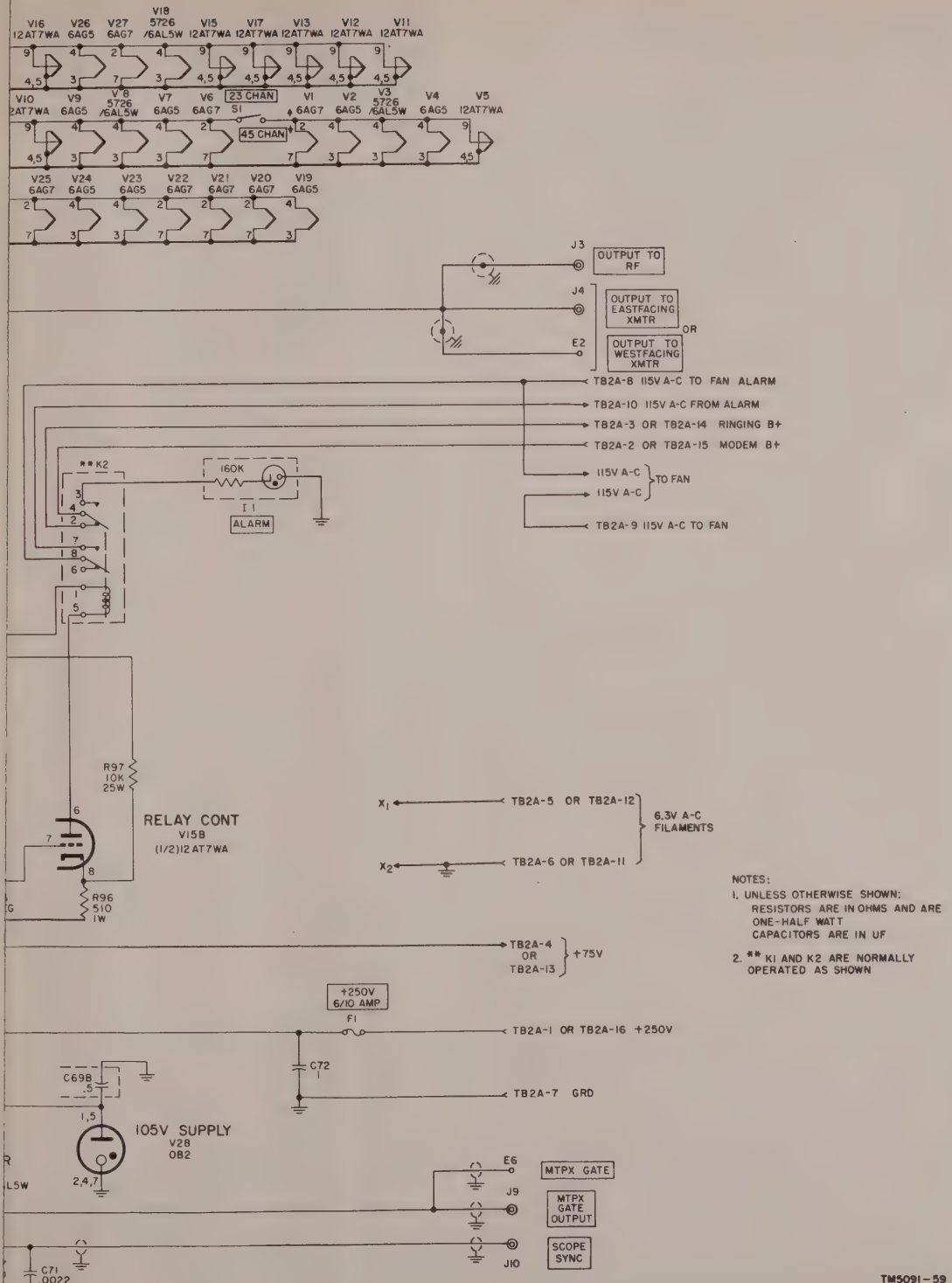


Figure 369. Pulse Form Restorer TD–68/G, over-all schematic diagram.



NOTES:

1. UNLESS OTHERWISE SHOWN:
   RESISTORS ARE IN OHMS AND ARE ONE-HALF WATT
   CAPACITORS ARE IN UF
2. ** K1 AND K2 ARE NORMALLY OPERATED AS SHOWN

TM5091-59

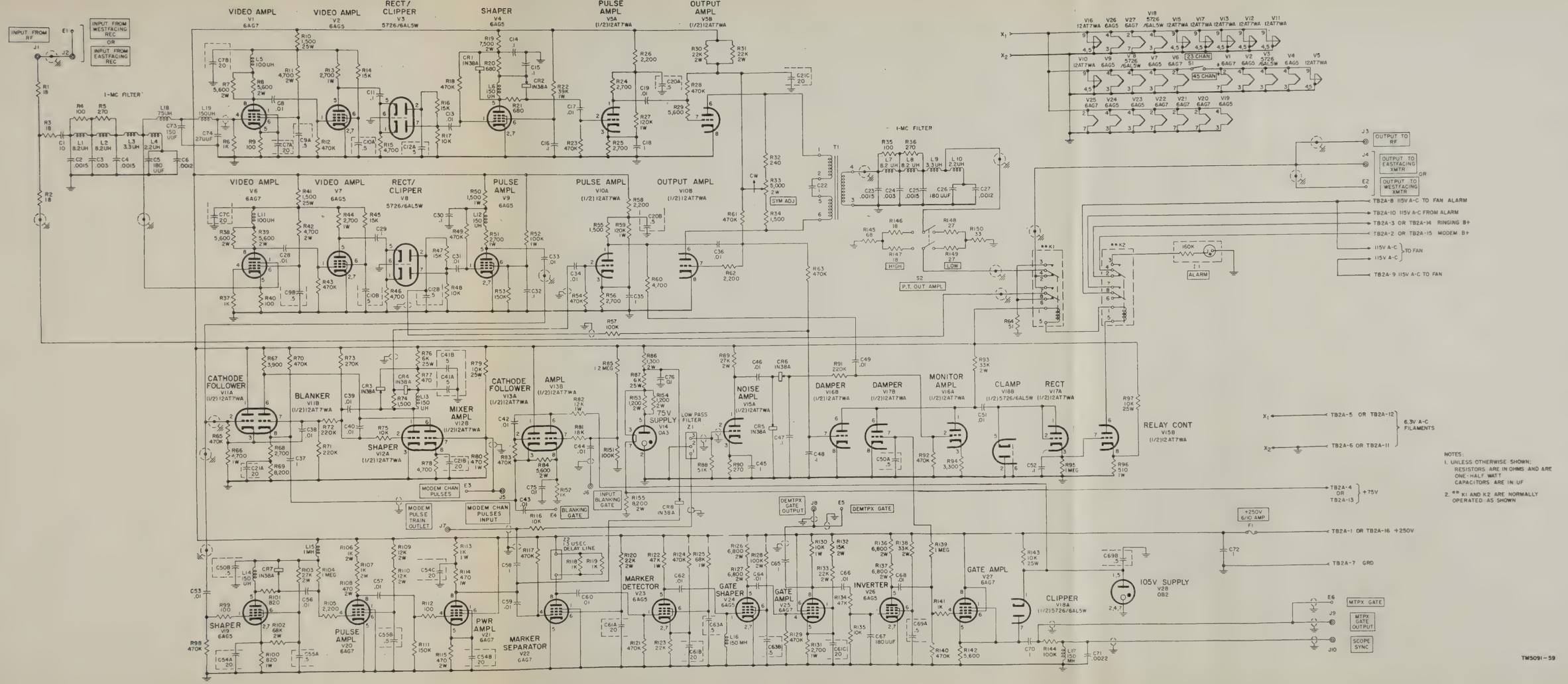


Figure 370. Video restorer, schematic diagram.

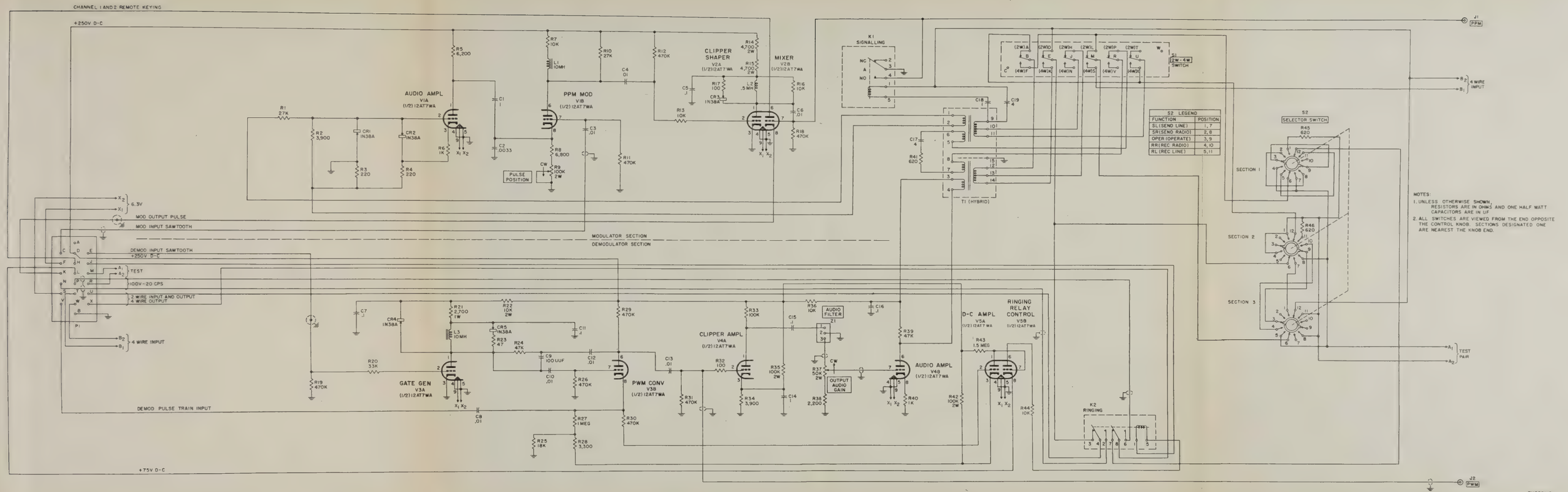


Figure 371. Telephone Modem MD-179/TC, schematic diagram.

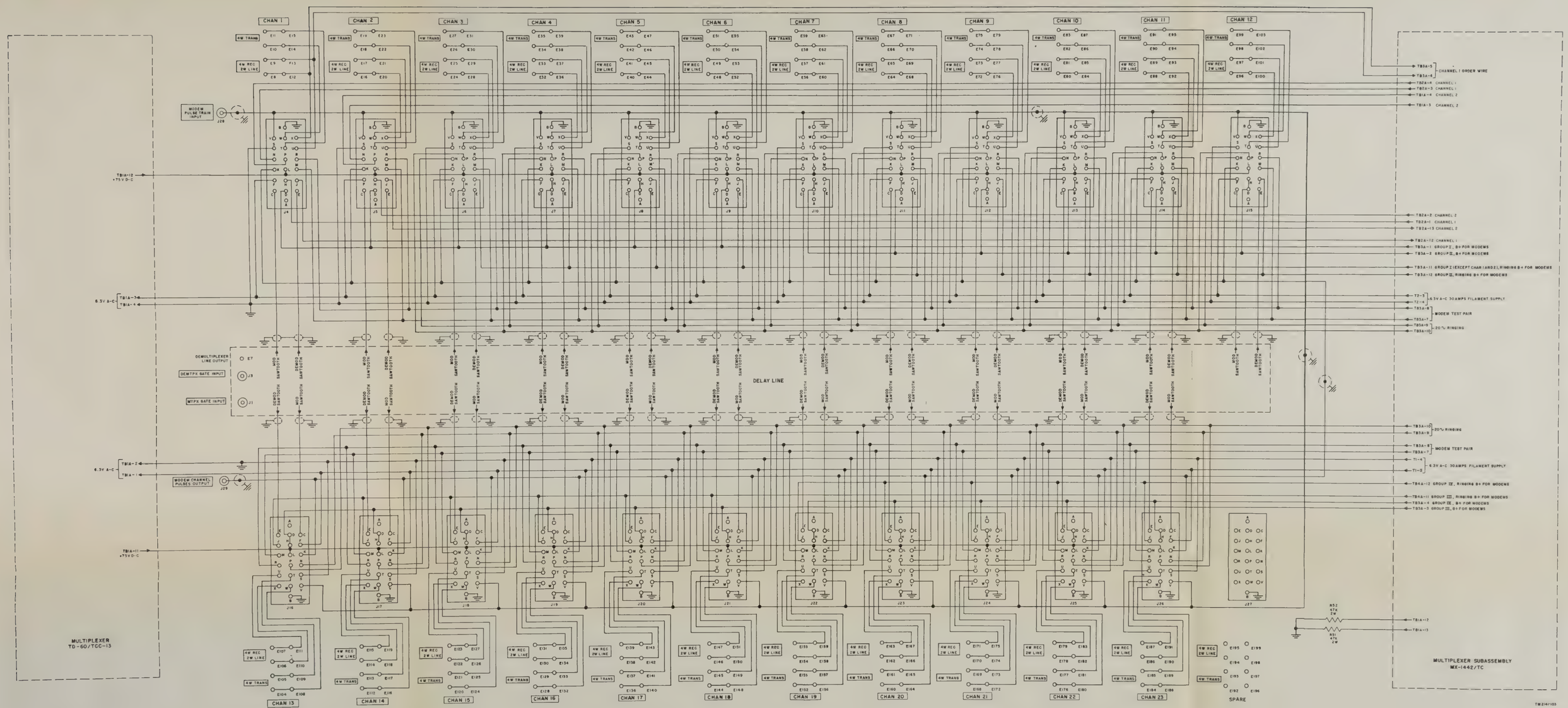


Figure 372. Electrical Equipment Rack MT–1165/TCC–13, over-all schematic diagram.

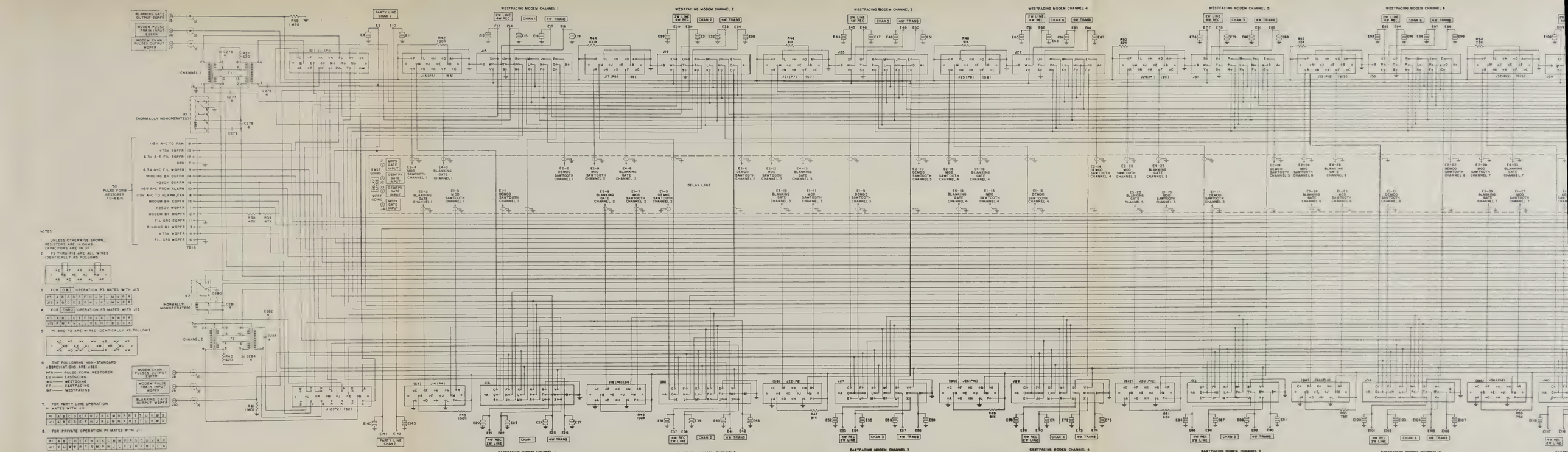


Figure 373. Electrical Equipment Rack MT-1433/TCA-1, over-all schematic diagram.

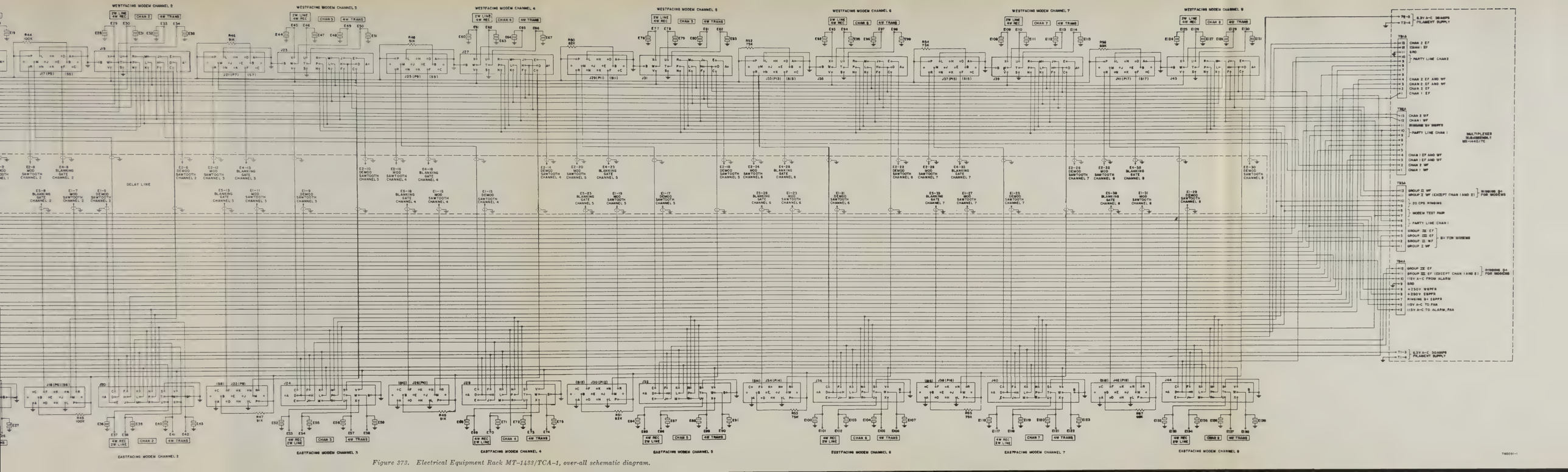


Figure 373. Electrical Equipment Rack MT-1433/TCA-1, over-all schematic diagram.

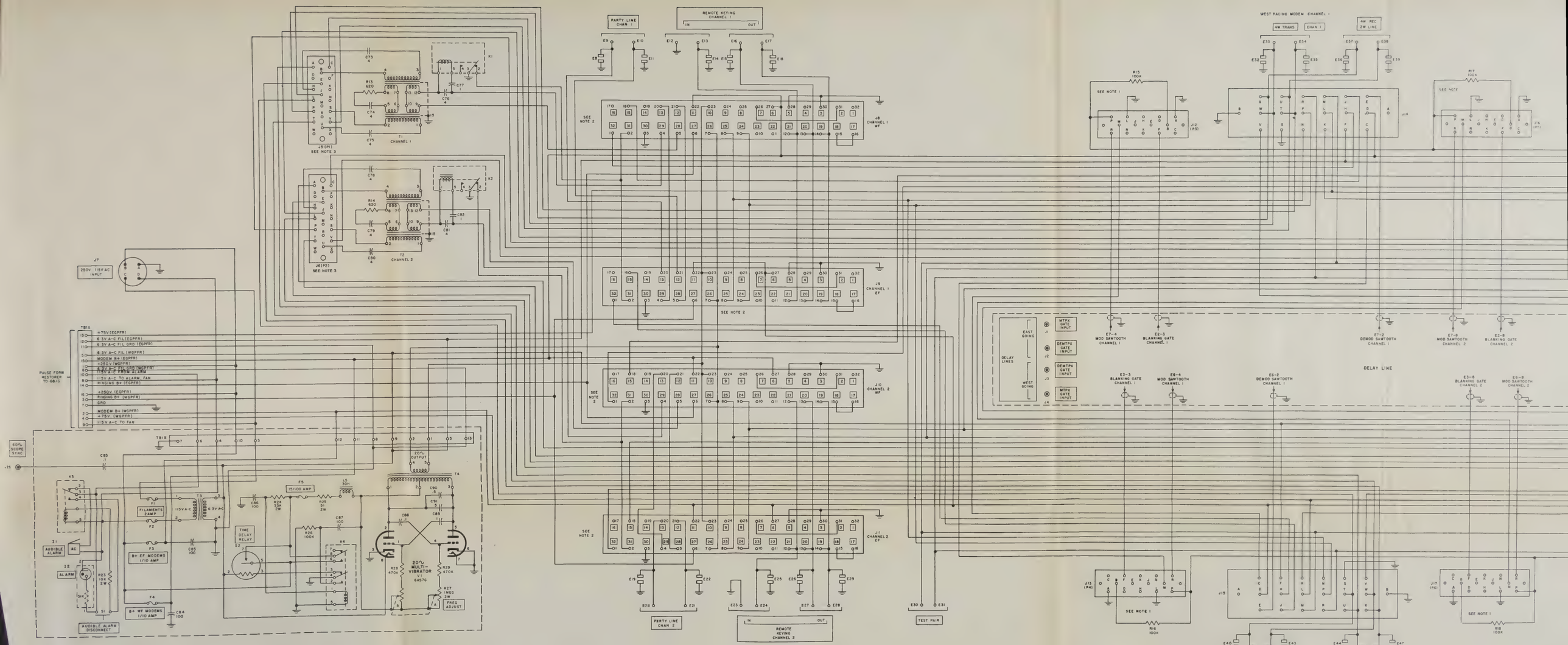


Figure 374. Electrical Equipment Rack MT-1134/TRA-10, over-all schematic diagram.

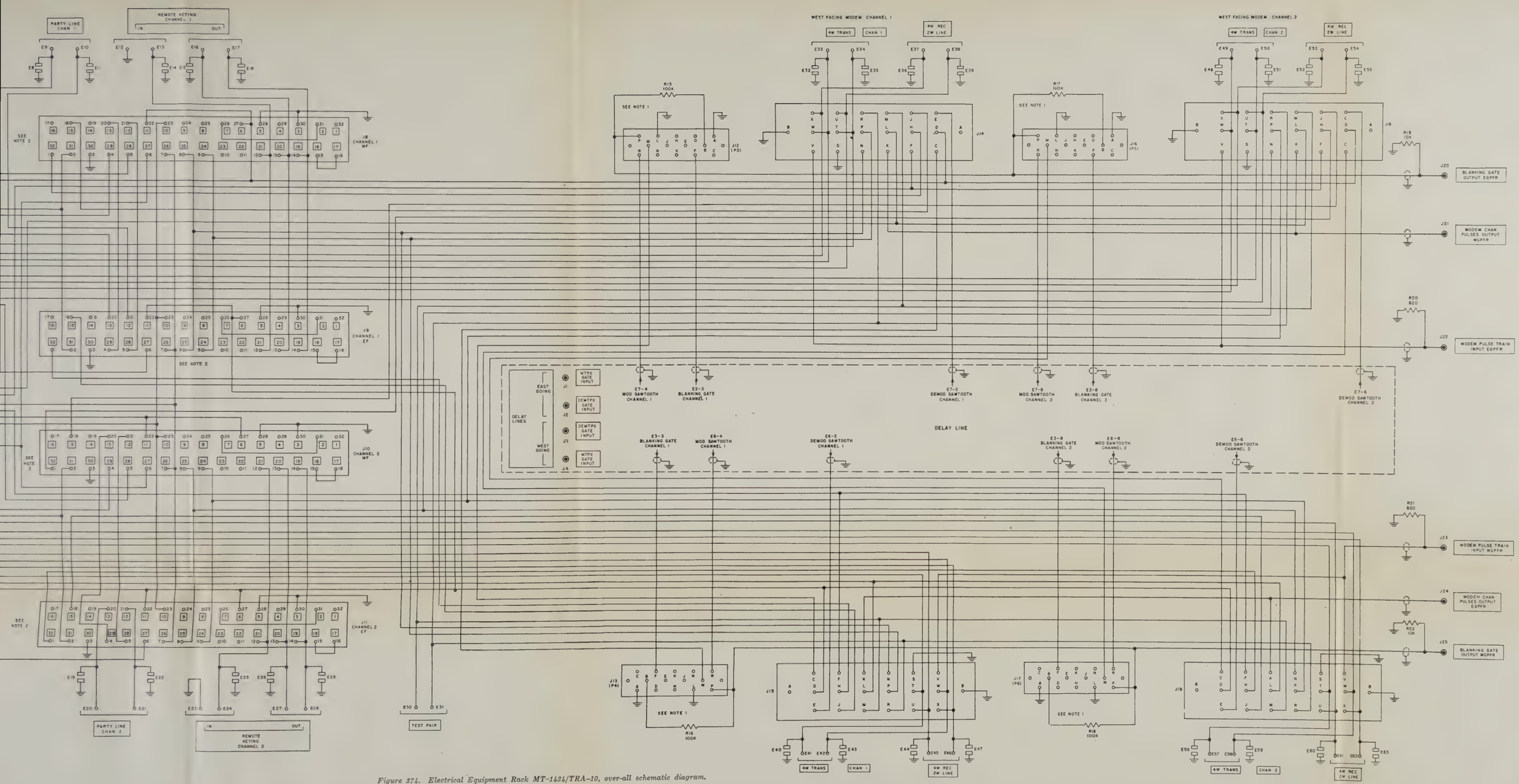


Figure 374. Electrical Equipment Rack MT-1434/TRA-10, over-all schematic diagram.

NOTES

1. P3, P4, P5 AND P6 ARE ALL WIRED IDENTICALLY AS FOLLOWS



FOR [D AND I] OPERATION, P3 MATES WITH J12

P3	A	B	C	D	E	F	H	J	K	L	M	N	P	R
J12	A	B	C	D	E	F	H	J	K	L	M	N	P	R

FOR [THRU] OPERATION, P3 MATES WITH J12

P3	A	B	C	D	E	F	H	J	K	L	M	N	P	R
J12	P	M	P	N	J	L	K	E	H	F	B	D	C	A

2. NUMBERS IN SQUARES ON J8, J9, J10 AND J11 ARE FOR REFERENCE ONLY, AND DO NOT EXIST PHYSICALLY.
   A. FOR REMOTE OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J8, J9, J10 AND J11 MATE WITH CORRESPONDING TERMINAL NUMBERS OF P1 AND P2 ON THE SCHEMATIC DIAGRAM OF CONTROL, REMOTE SWITCHING C-1509/TC
   B. FOR NORMAL OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J8, J9, J10 AND J11 MATE WITH NUMBERS OF P1 AND P2, WHICH ARE REFERENCED CORRESPONDINGLY IN THE SQUARES ALONGSIDE THE CIRCLES ON J8, J9, J10 AND J11
   FOR EXAMPLE
   [32] ON J10 INDICATES THAT FOR NORMAL OPERATION TERMINAL 1 OF J10 MATES WITH TERMINAL 32 OF P1 OR P2
   C. FOR REMOTE OPERATION:
   J8 MATES WITH P2 } CHANNEL 1
   J9 MATES WITH P1 }
   J10 MATES WITH P1 } CHANNEL 2
   J11 MATES WITH P2 }
   FOR NORMAL OPERATION
   J8 MATES WITH P1 } CHANNEL 1
   J9 MATES WITH P2 }
   J10 MATES WITH P2 } CHANNEL 2
   J11 MATES WITH P1 }
3. P1 AND P2 ARE WIRED IDENTICALLY AS FOLLOWS



FOR PARTY LINE OPERATION, P1 MATES WITH J5

P1	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X
J5	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X

FOR PRIVATE OPERATION P1 MATES WITH J5

P1	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X
J5	X	U	W	V	R	T	S	M	P	N	J	L	K	E	H	F	B	D	C	A

4. THE FOLLOWING ABBREVIATIONS ARE USED
   EG AND WG DENOTES EASTBOING OR WESTBOING
   EF AND WF DENOTES EASTFACING OR WESTFACING
   PFR DENOTES PULSE FORM RESTORER
5. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS AND ONE HALF WATT CAPACITORS ARE IN UF.

TM 2682-4

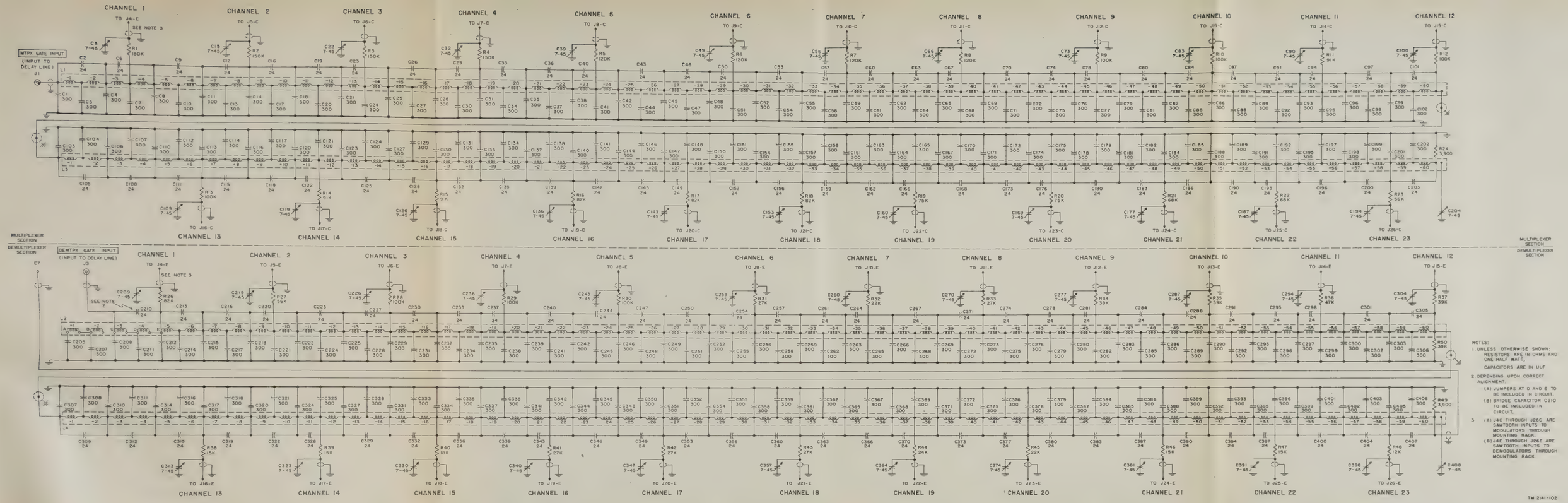
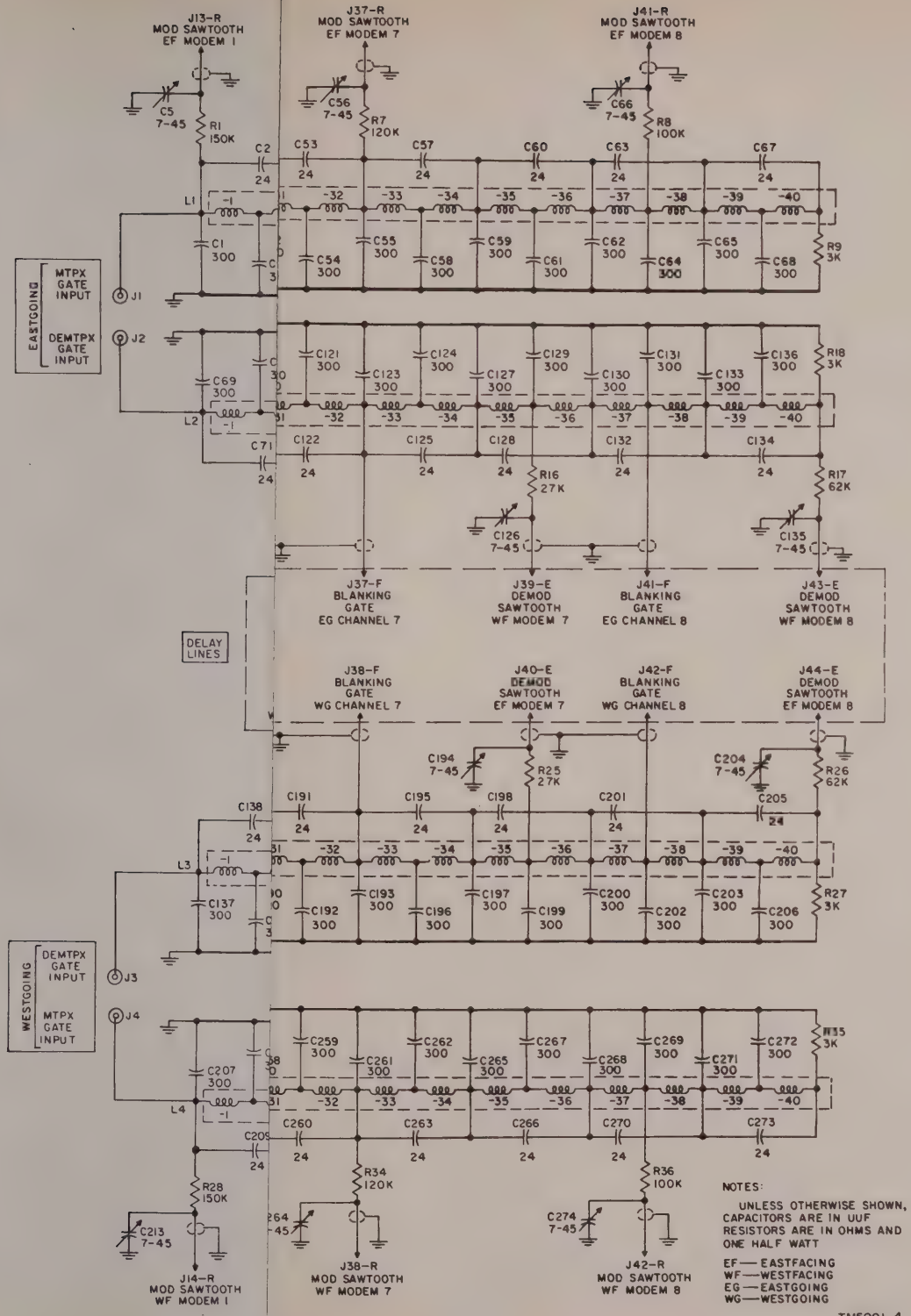


Figure 375. Multiplexer Set AN/TCC–13, delay line, schematic diagram.

NOTES:
1. UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS AND ONE HALF WATT, CAPACITORS ARE IN UUF
2. DEPENDING UPON CORRECT ALIGNMENT:
   (A) JUMPERS AT D AND E TO BE INCLUDED IN CIRCUIT.
   (B) BRIDGE CAPACITOR C210 TO BE INCLUDED IN CIRCUIT.
3. (A) J4C THROUGH J26C ARE SAWTOOTH INPUTS TO MODULATORS THROUGH MOUNTING RACK.
   (B) J4E THROUGH J26E ARE SAWTOOTH INPUTS TO DEMODULATORS THROUGH MOUNTING RACK.

TM 2141-102



NOTES:

UNLESS OTHERWISE SHOWN, CAPACITORS ARE IN UUF RESISTORS ARE IN OHMS AND ONE HALF WATT

EF — EASTFACING
WF — WESTFACING
EG — EASTGOING
WG — WESTGOING

TM5091-4

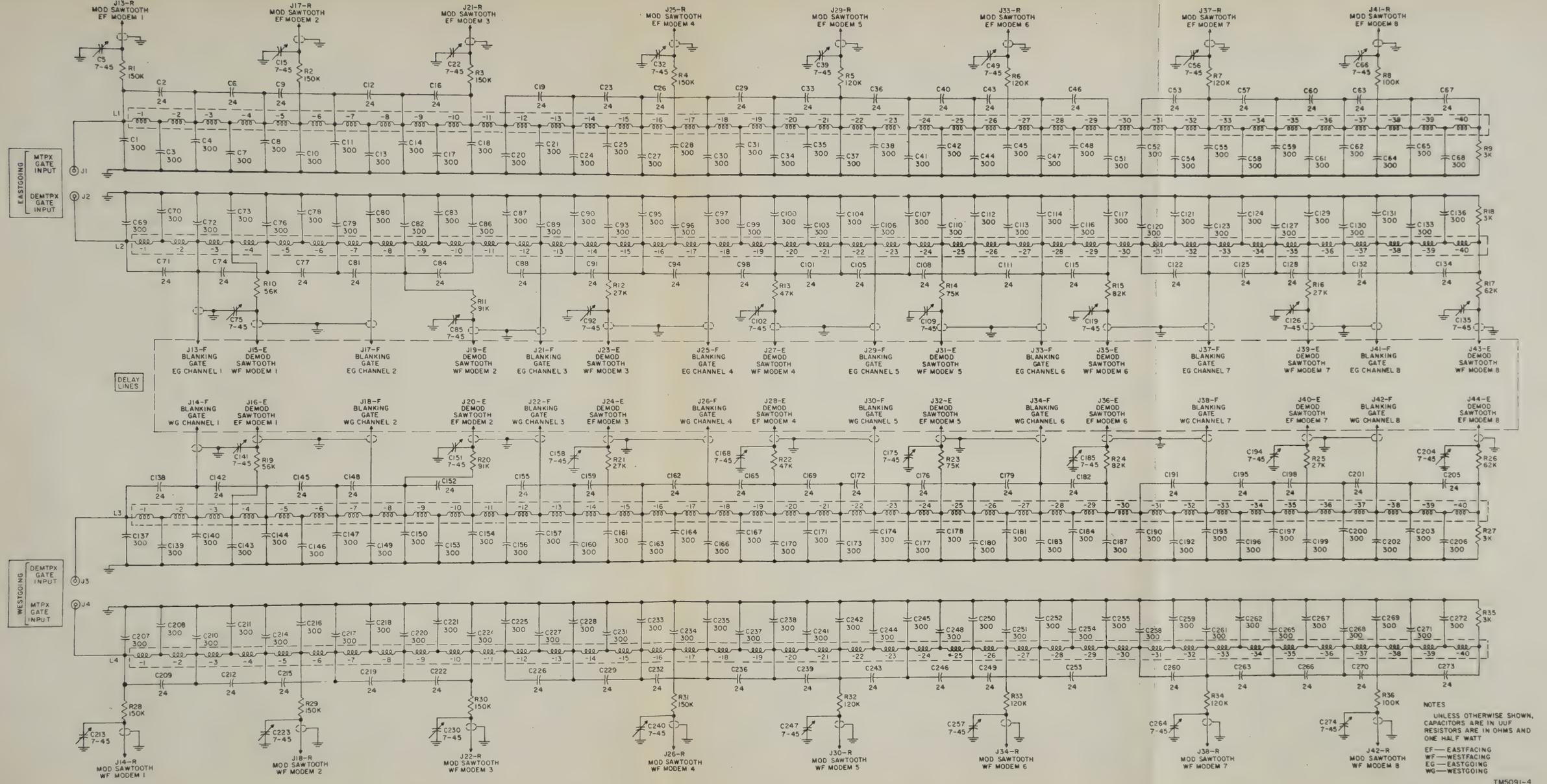
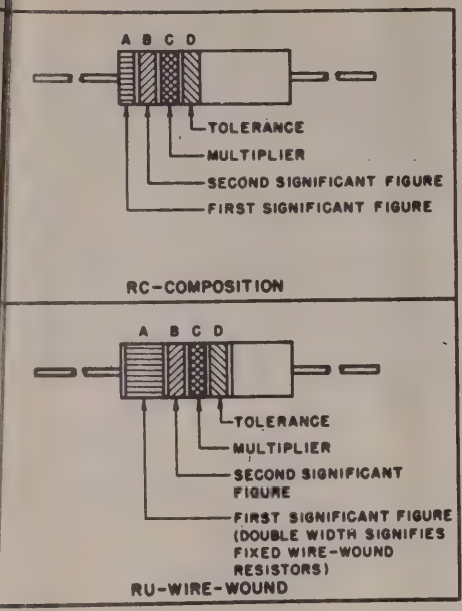


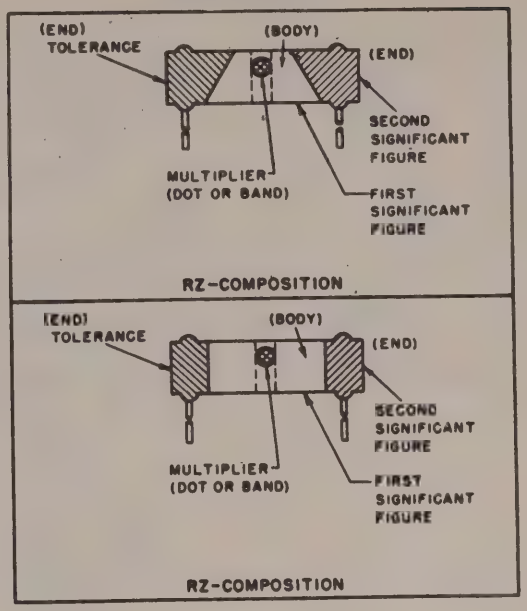
Figure 376. Multiplexer Group AN/TCA–1, delay line, schematic diagram.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)



RADIAL-LEAD RESISTORS (UNINSULATED)



RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

R WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH.
EN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR,
E COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

MPLES (BAND MARKING):
OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B;
LACK BAND C; NO BAND D.
7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B;
OLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-R1

Figure 362. MIL–STD resistor color codes.

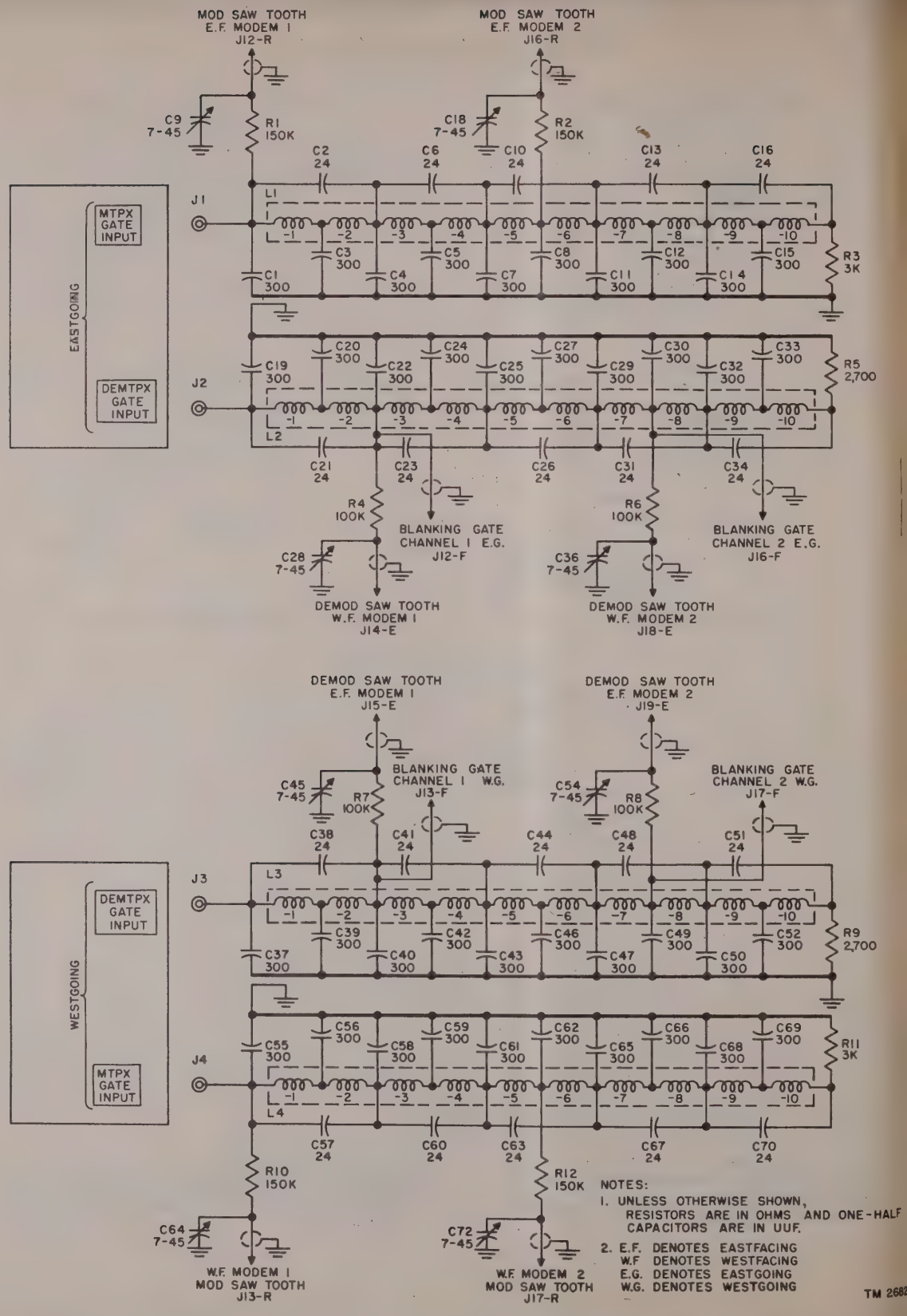


Figure 377. Pulse Form Restorer Group AN/TRA–10, delay line, schematic diagram.

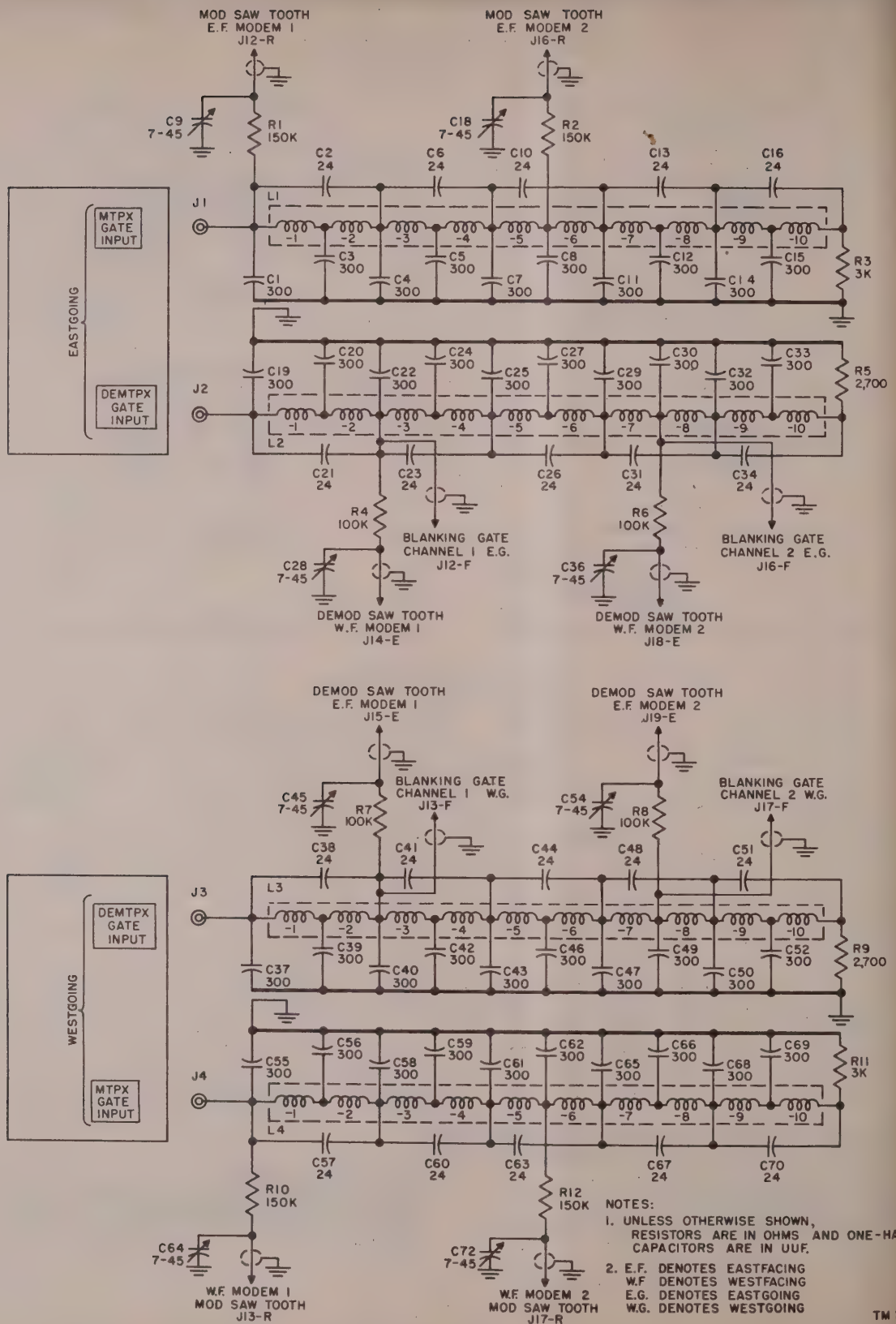
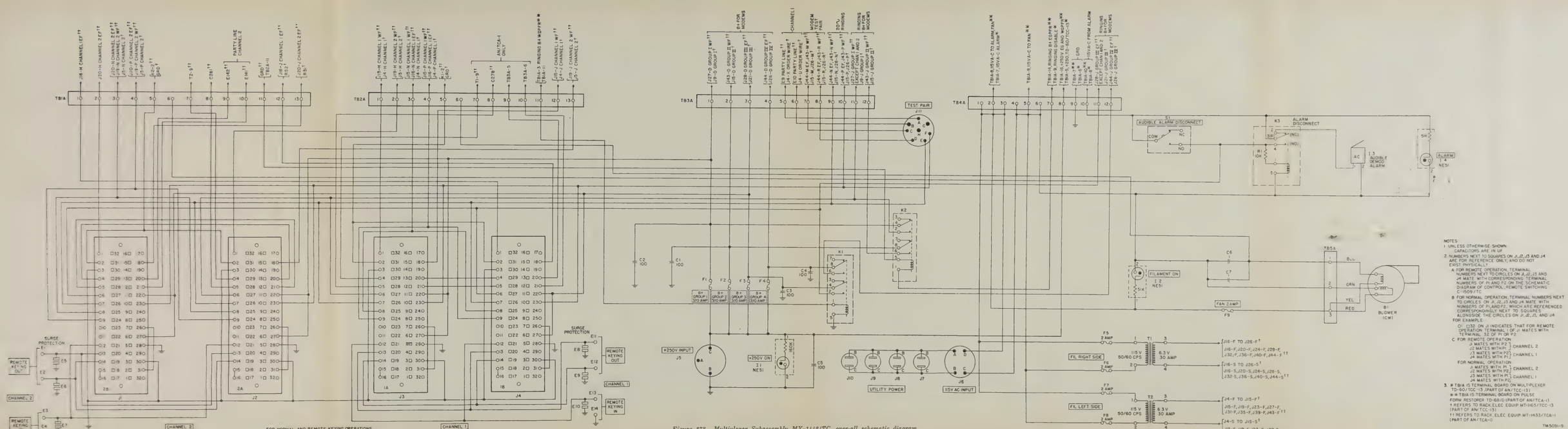


Figure 377. Pulse Form Restorer Group AN/TRA–10, delay line, schematic diagram.



NOTES:

1. UNLESS OTHERWISE SHOWN CAPACITORS ARE IN UF.
2. NUMBERS NEXT TO SQUARES ON J1,J2,J3 AND J4 ARE FOR REFERENCE ONLY, AND DO NOT EXIST PHYSICALLY.
   - A. FOR REMOTE OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J1,J2,J3 AND J4 MATE WITH CORRESPONDING TERMINAL NUMBERS OF P1 AND P2 ON THE SCHEMATIC DIAGRAM OF CONTROL, REMOTE SWITCHING C-1509/TC.
   - B. FOR NORMAL OPERATION, TERMINAL NUMBERS NEXT TO CIRCLES ON J1,J2,J3 AND J4 MATE WITH NUMBERS OF P1 AND P2, WHICH ARE REFERENCED CORRESPONDINGLY NEXT TO SQUARES ALONGSIDE THE CIRCLES ON J1,J2,J3, AND J4.

   FOR EXAMPLE
   - O 032 ON J1 INDICATES THAT FOR REMOTE OPERATION TERMINAL 1 OF J1 MATES WITH TERMINAL 32 OF P1 OR P2.
   - C. FOR REMOTE OPERATION:
     - J1 MATES WITH P2 } CHANNEL 2
     - J2 MATES WITH P1
     - J3 MATES WITH P2 } CHANNEL 1
     - J4 MATES WITH P1

     FOR NORMAL OPERATION:
     - J1 MATES WITH P1 } CHANNEL 2
     - J2 MATES WITH P2
     - J3 MATES WITH P1 } CHANNEL 1
     - J4 MATES WITH P2
3. # TB1A IS TERMINAL BOARD ON MULTIPLEXER TD-60/TCC-13 (PART OF AN/TCC-13)
   ## = # TB1A IS TERMINAL BOARD ON PULSE FORM RESTORER TD-68/G (PART OF AN/TCA-1)
   † REFERS TO RACK, ELEC EQUIP MT-1653/TCC-13 (PART OF AN/TCC-13)
   †† REFERS TO RACK, ELEC EQUIP MT-1633/TCA-1 (PART OF AN/TCA-1)

TM 5091-9

Figure 378. Multiplexer Subassembly MX-1442/TC, over-all schematic diagram.

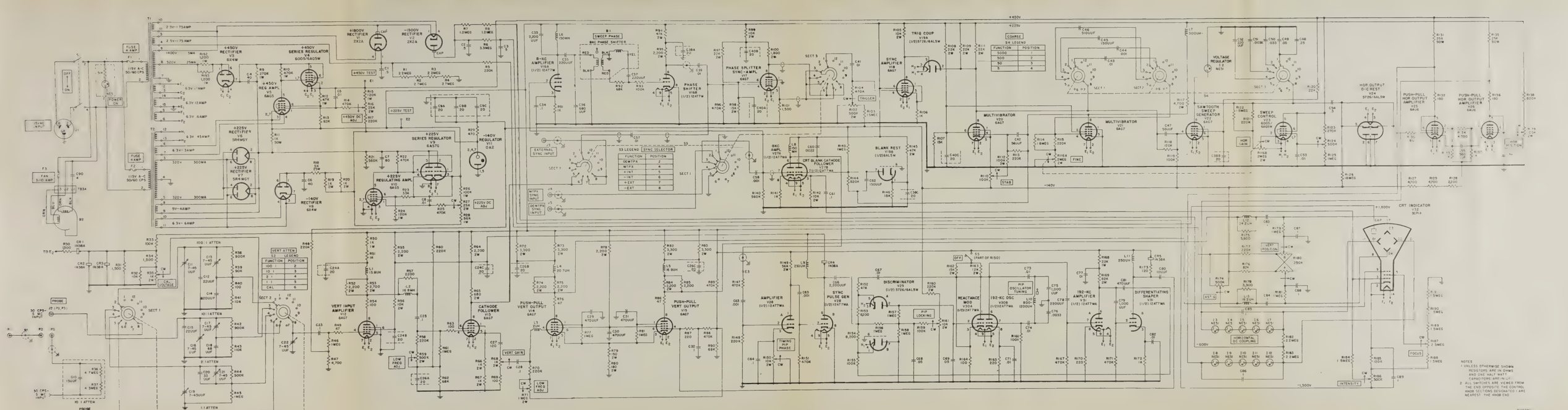


Figure 380. Oscilloscope OS-25/G, schematic diagram.

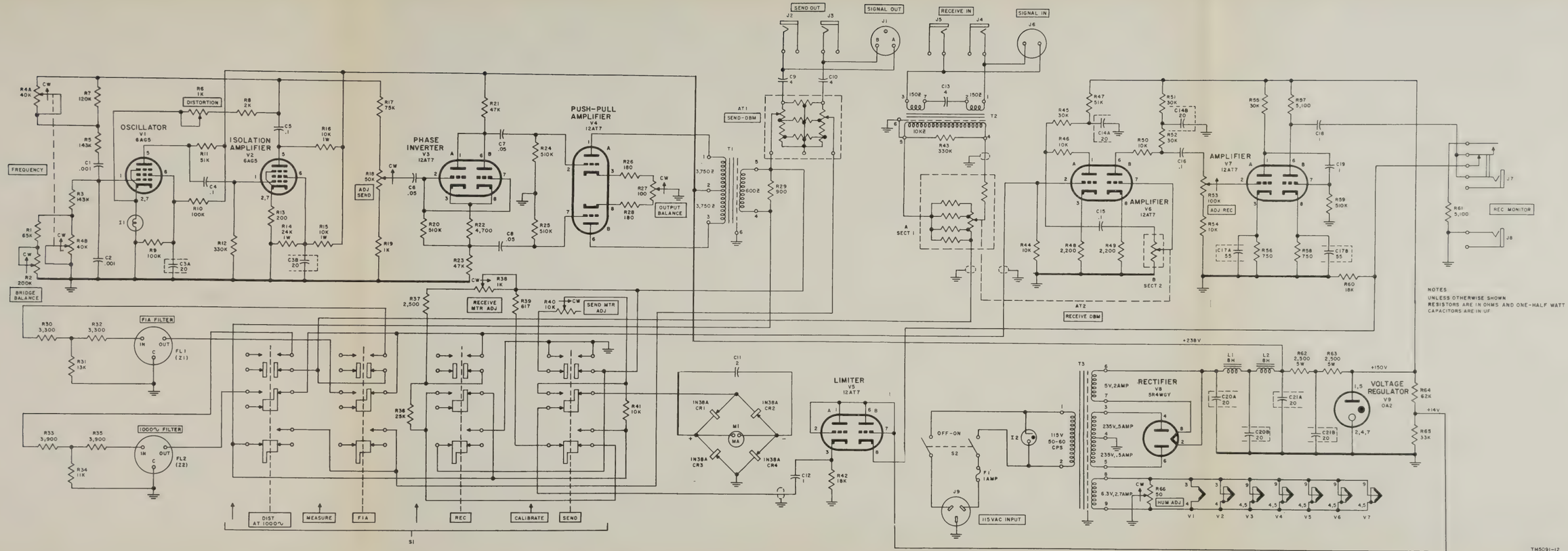
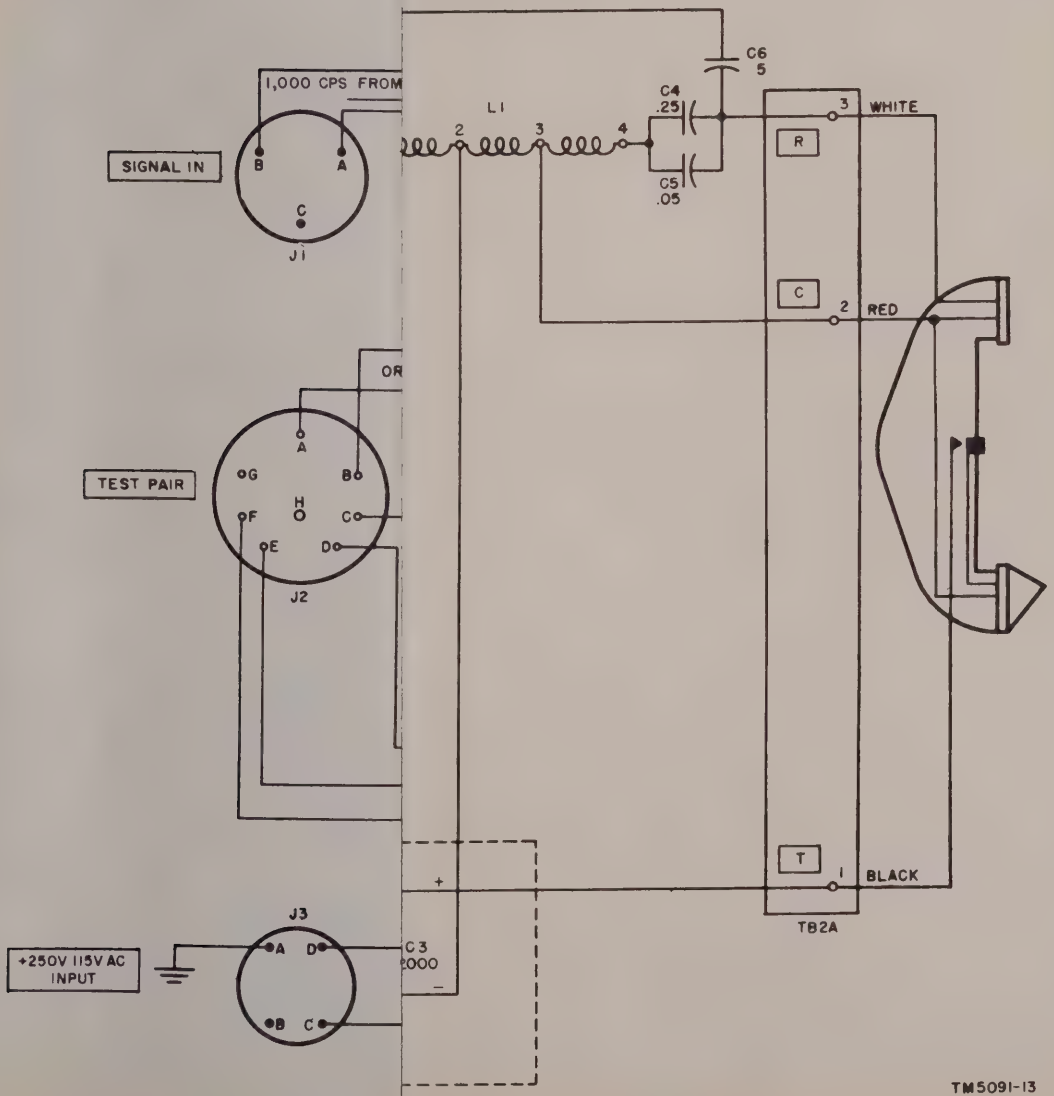


Figure 381. Audio Test Set TS–762/TC, schematic diagram.

NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS AND ONE-HALF WATT
CAPACITORS ARE IN UF



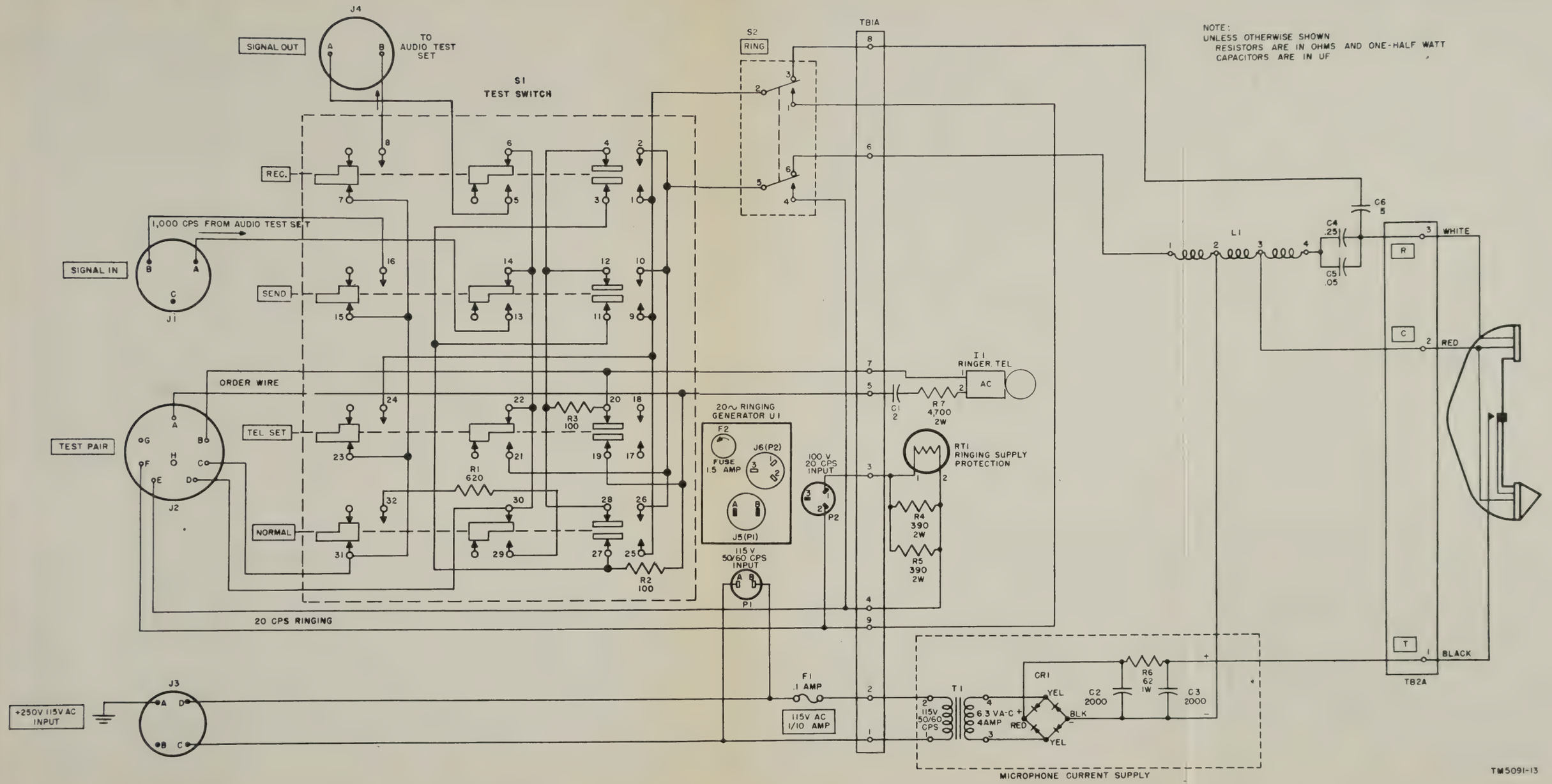


Figure 382. Control Monitor C–1151/TC, schematic diagram.

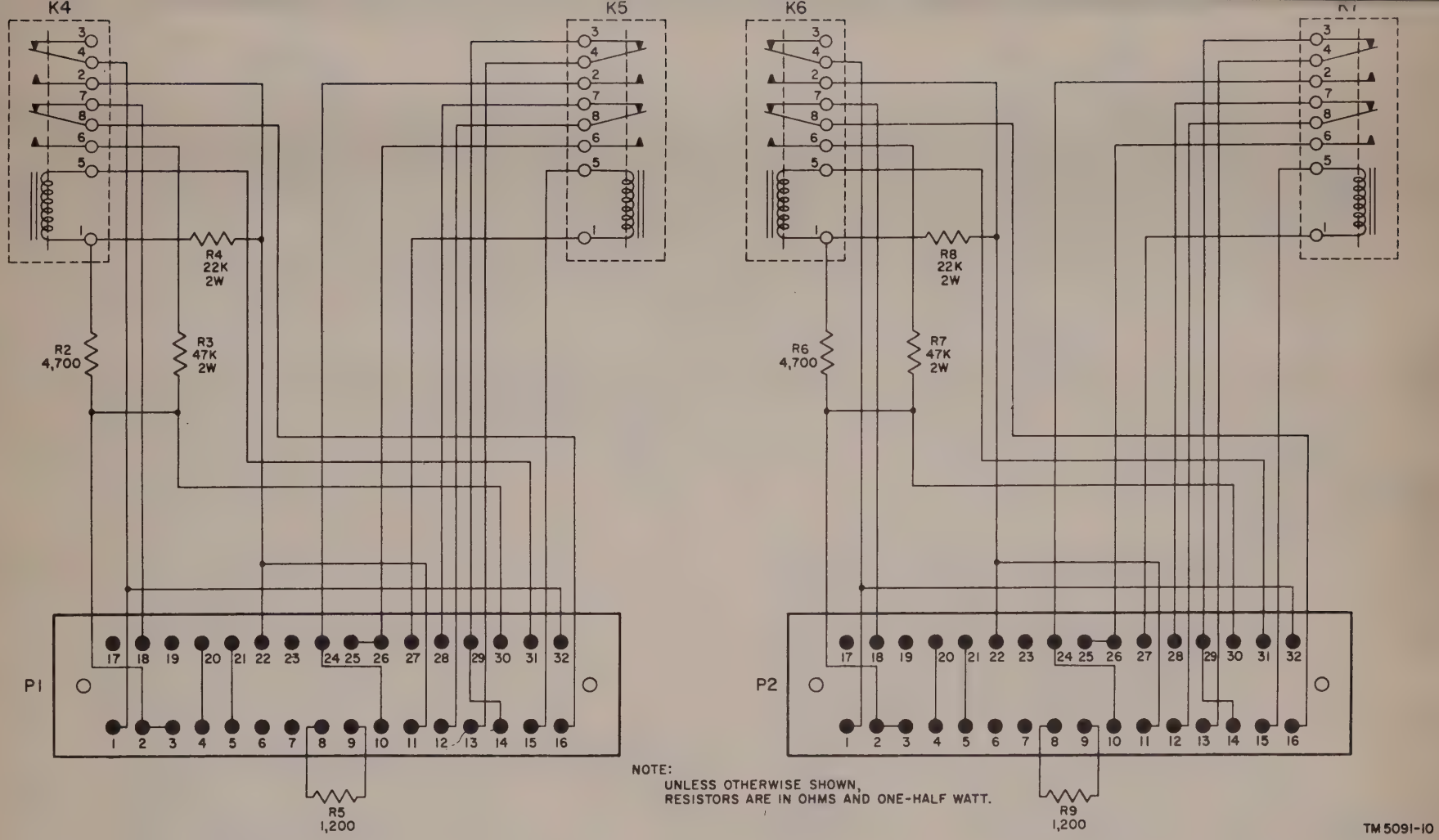


Figure 379. Remote Switching Control C–1509/TC, schematic diagram.

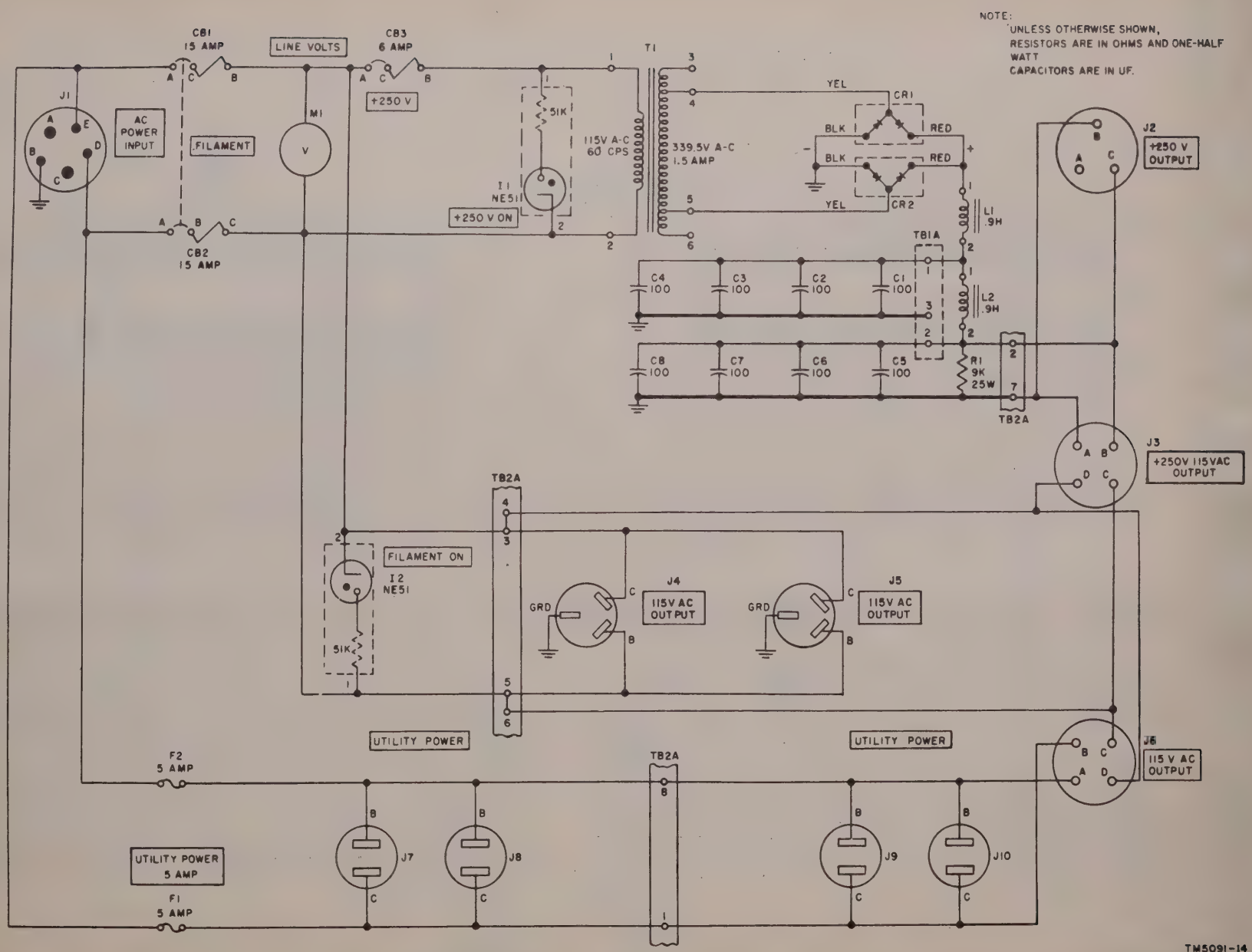
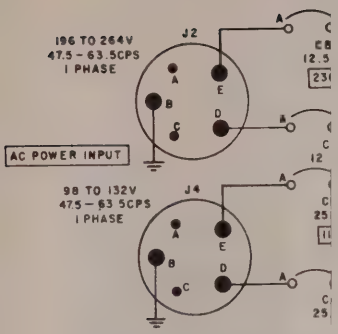
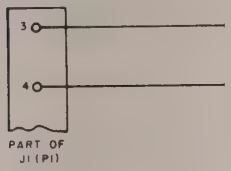
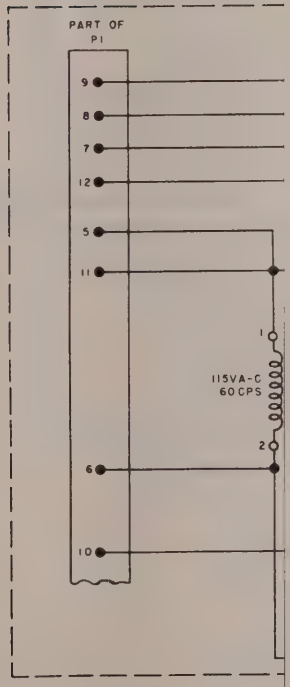


Figure 383. Power Supply PP-691/G, schematic diagram.


196 TO 264V
47.5 - 63.5CPS
1 PHASE
J2
A
B
C
D
E
AC POWER INPUT
98 TO 132V
47.5 - 63.5CPS
1 PHASE
J4


3
4
PART OF
J1 (P1)


PART OF
P1
9
8
7
12
5
11
1
115VA-C
60CPS
2
6
10

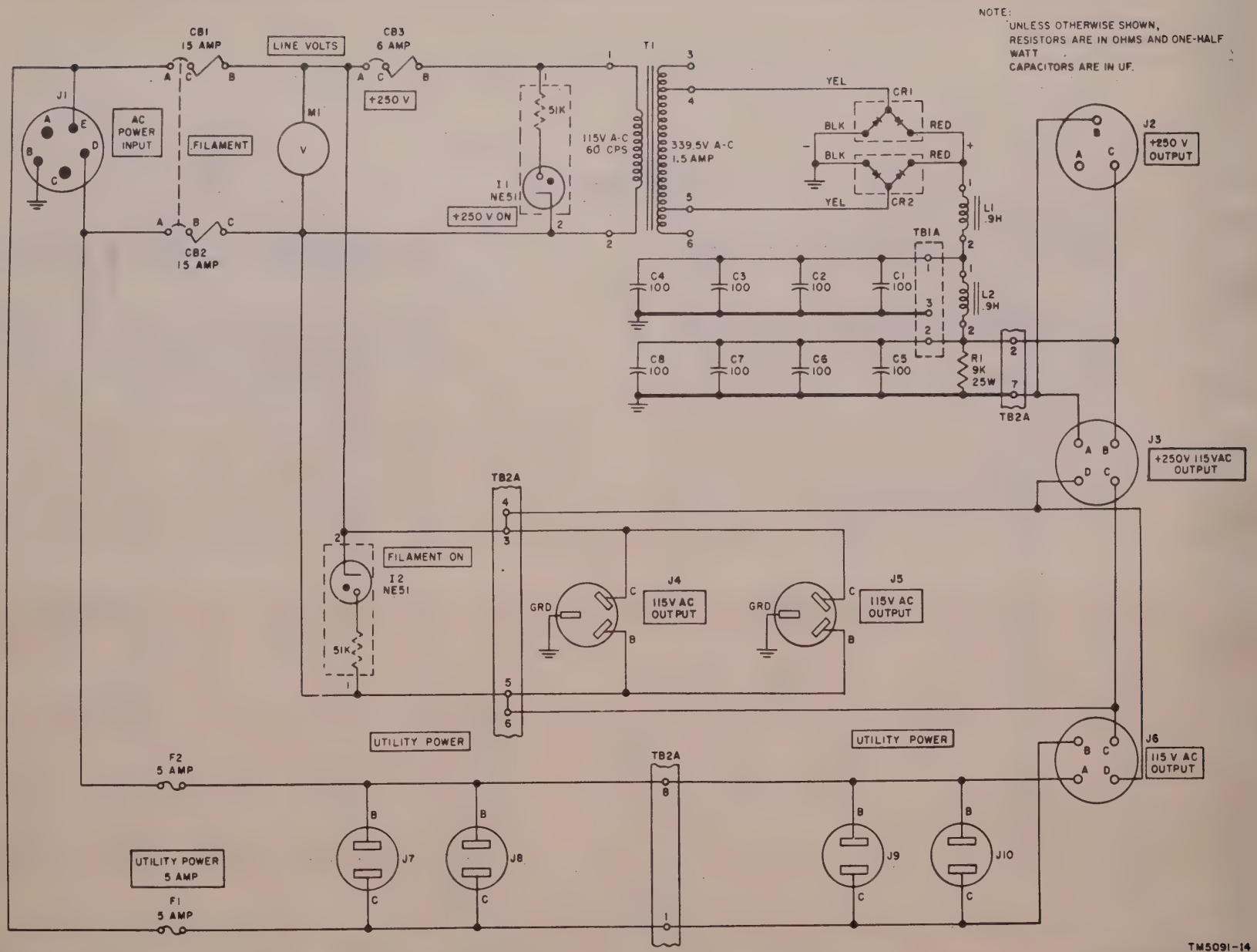


Figure 383. Power Supply PP–691/G, schematic diagram.

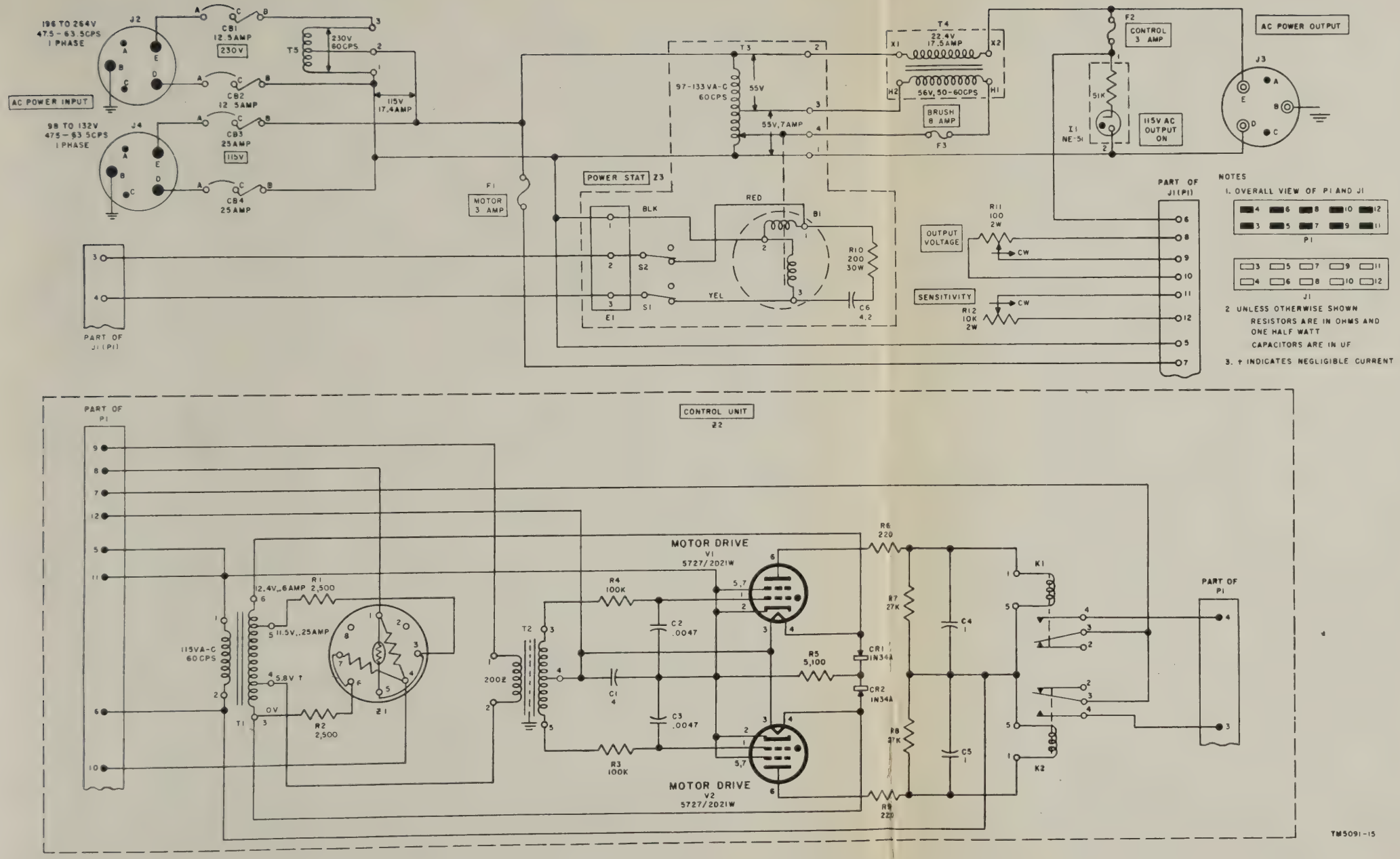
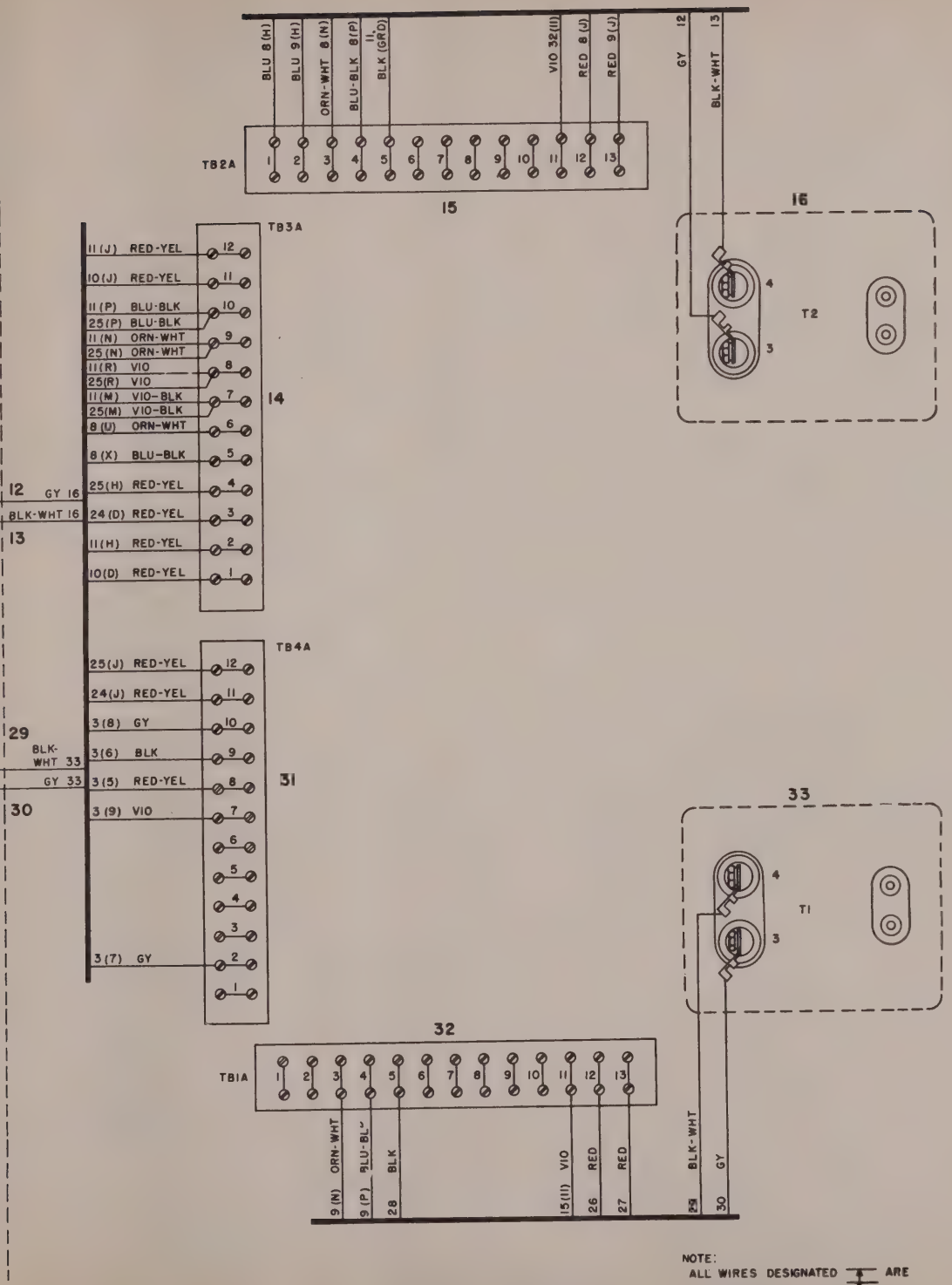


Figure 384. Voltage Regulator CN-236/G, schematic diagram.



NOTE:
ALL WIRES DESIGNATED P ARE TWISTED PAIRS.

MULTIPLEXER SUB-ASSEMBLY
MX-1442/TC

TM 2141-130

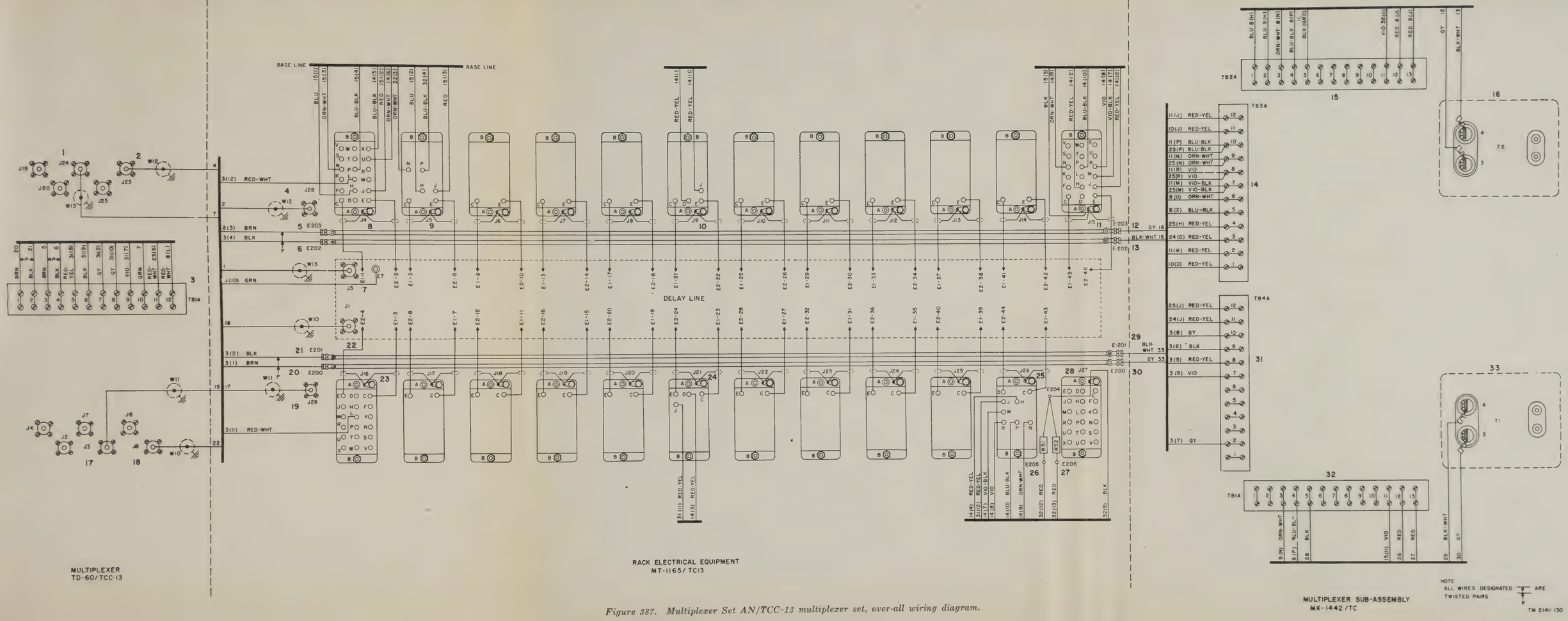
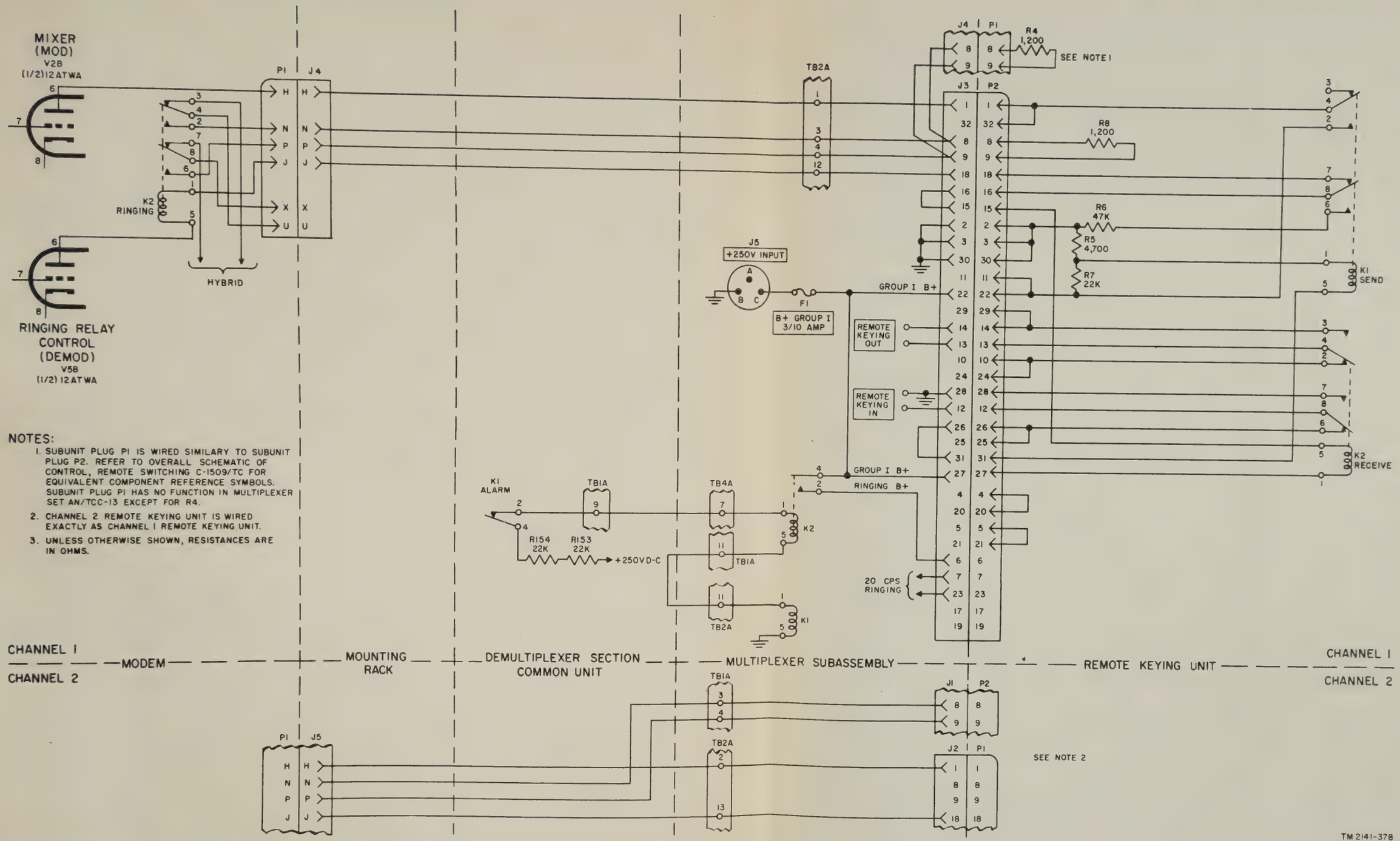


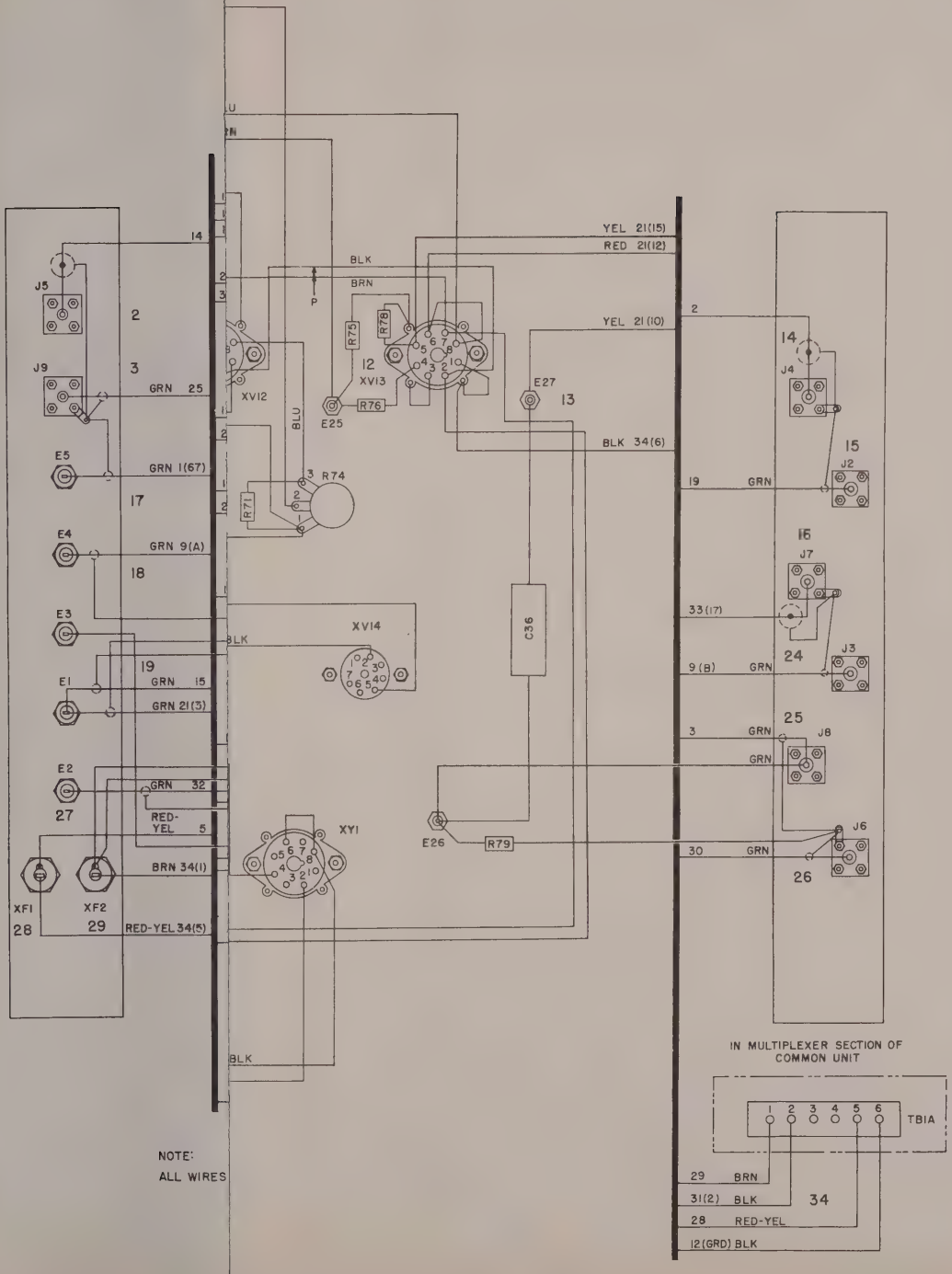
Figure 337. Multiplexer Set AN/TCC-13 multiplexer set, over-all wiring diagram.



NOTES:

1. SUBUNIT PLUG P1 IS WIRED SIMILARY TO SUBUNIT PLUG P2. REFER TO OVERALL SCHEMATIC OF CONTROL, REMOTE SWITCHING C-1509/TC FOR EQUIVALENT COMPONENT REFERENCE SYMBOLS. SUBUNIT PLUG P1 HAS NO FUNCTION IN MULTIPLEXER SET AN/TCC-13 EXCEPT FOR R4.
2. CHANNEL 2 REMOTE KEYING UNIT IS WIRED EXACTLY AS CHANNEL 1 REMOTE KEYING UNIT.
3. UNLESS OTHERWISE SHOWN, RESISTANCES ARE IN OHMS.

Figure 388. Multiplexer TD–60/TCC–13, over-all wiring diagram.


J5
J9
E5
E4
E3
E1
E2
XF1
XF2
XV12
XV13
XV14
XY1
E25
E26
E27
R71
R74
R75
R76
R78
R79
C36
BLU
BLK
BRN
YEL 21(15)
RED 21(12)
YEL 21(10)
BLK 34(6)
GRN 25
GRN 1(67)
GRN 9(A)
GRN 15
GRN 21(3)
GRN 32
RED-YEL 5
BRN 34(1)
RED-YEL 34(5)
33(17)
9(B) GRN
3 GRN
GRN
30 GRN
19 GRN
J4
J2
J7
J3
J8
J6
IN MULTIPLEXER SECTION OF COMMON UNIT
TBIA
29 BRN
31(2) BLK
28 RED-YEL
12(GRD) BLK
NOTE:
ALL WIRES

TM 2141-125

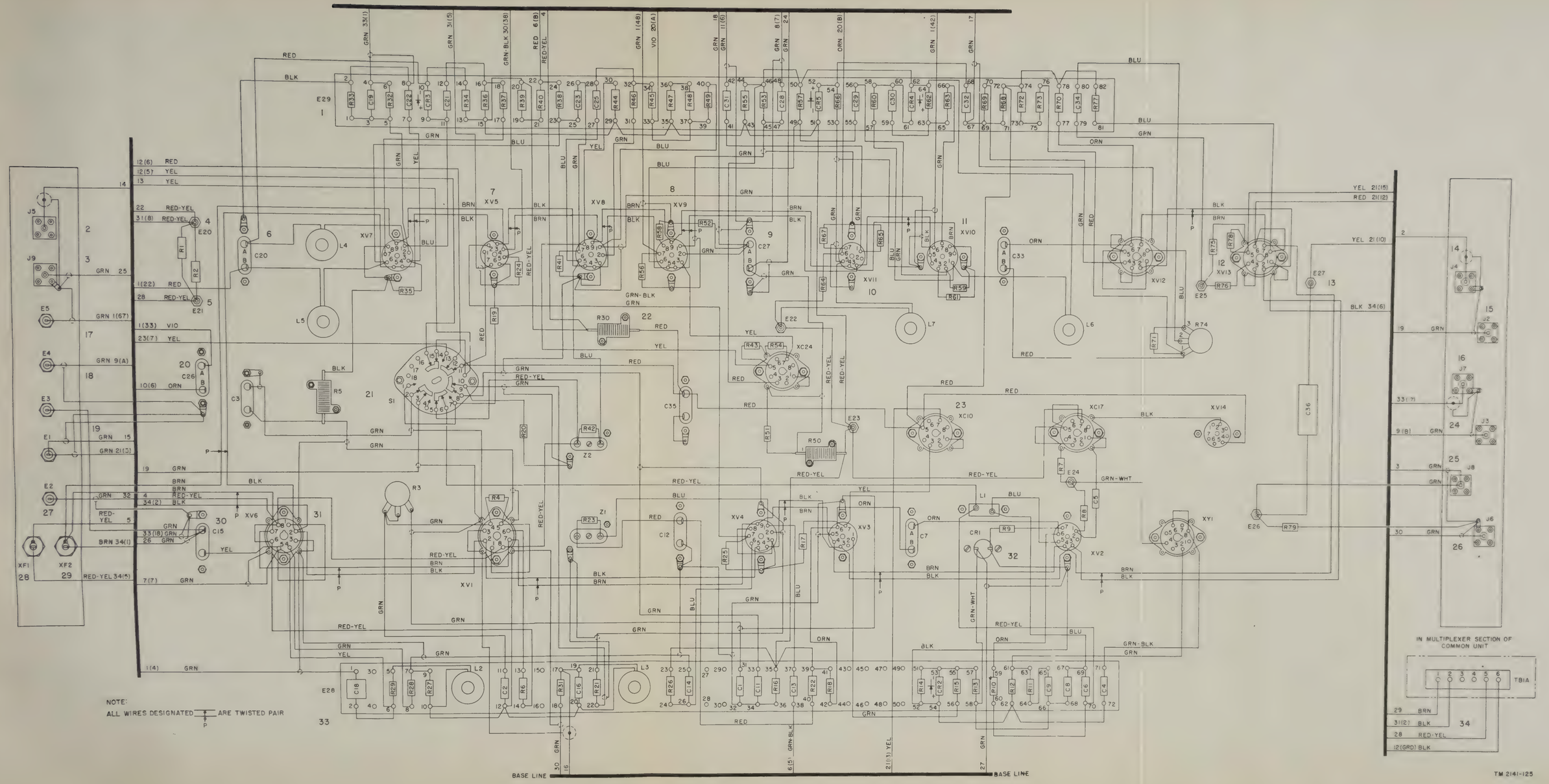


Figure 389. Multiplexer TD-60/TCC-13, multiplexer section, wiring diagram.

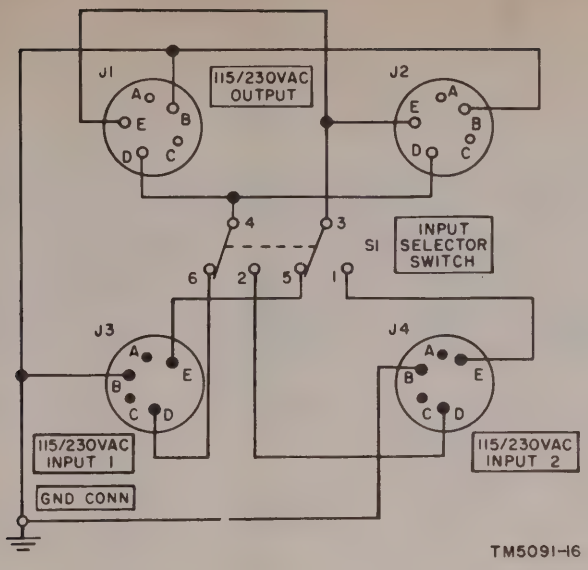


Figure 385. Switch Box SA–357/G, schematic diagram.

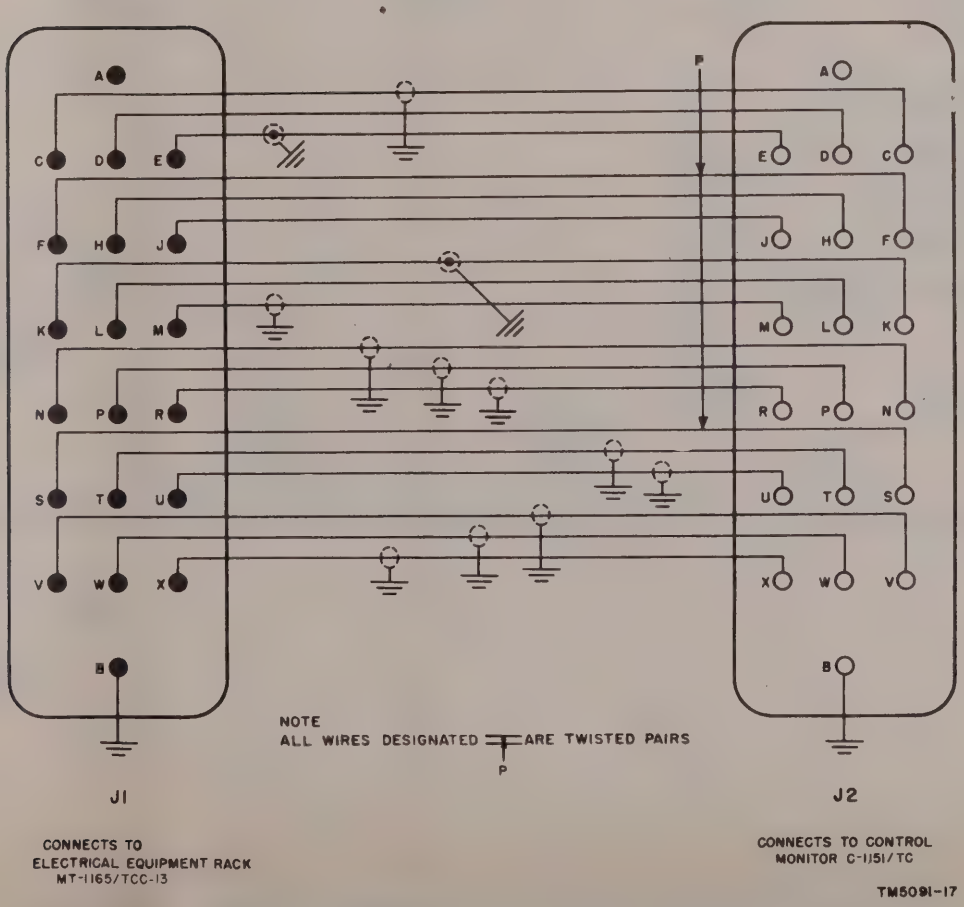


Figure 386. Electrical Connector Assembly J–535/G, schematic diagram.

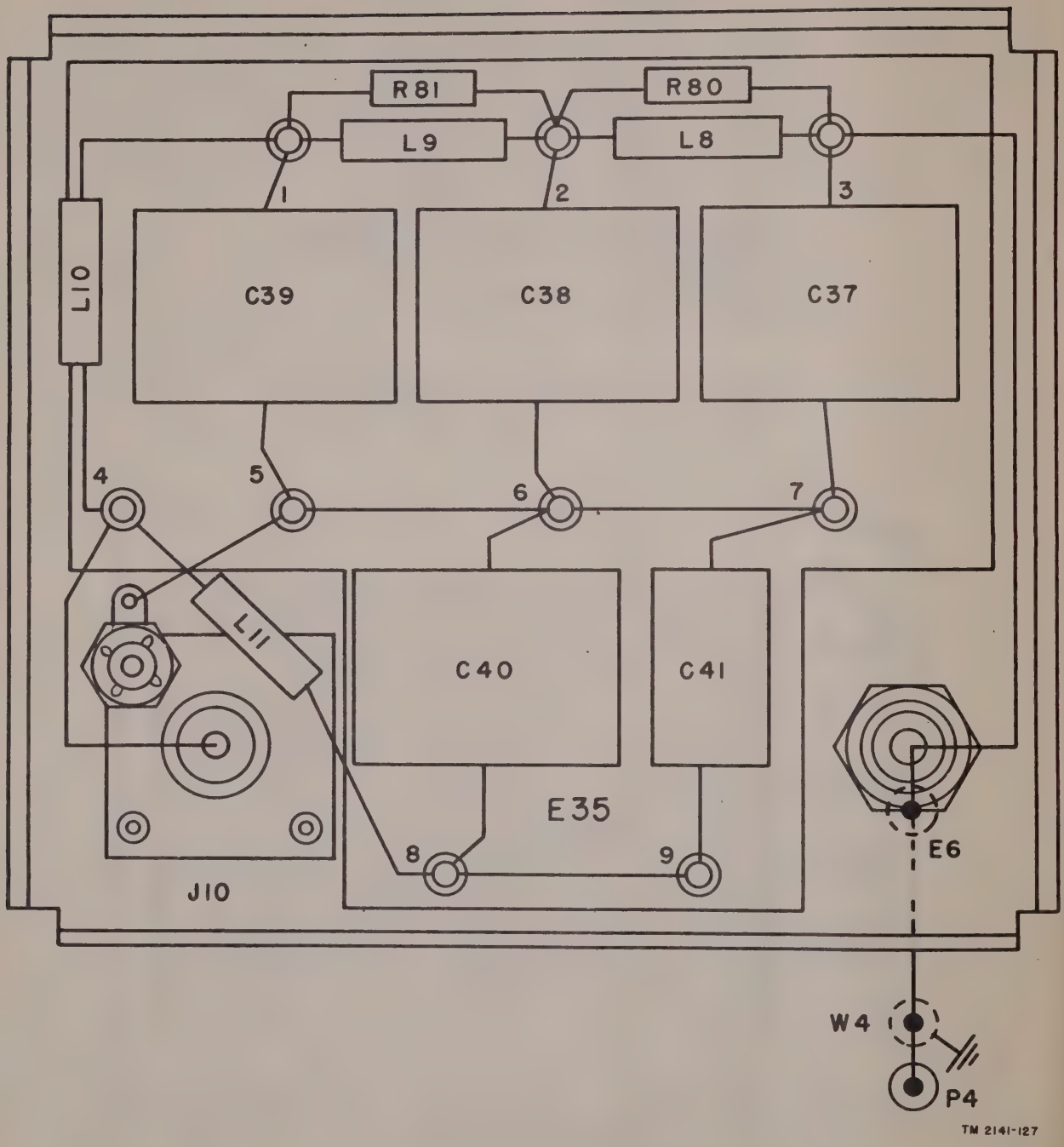


Figure 390. Multiplexer TD–60/TCC–13, multiplexer section filter, wiring diagram.

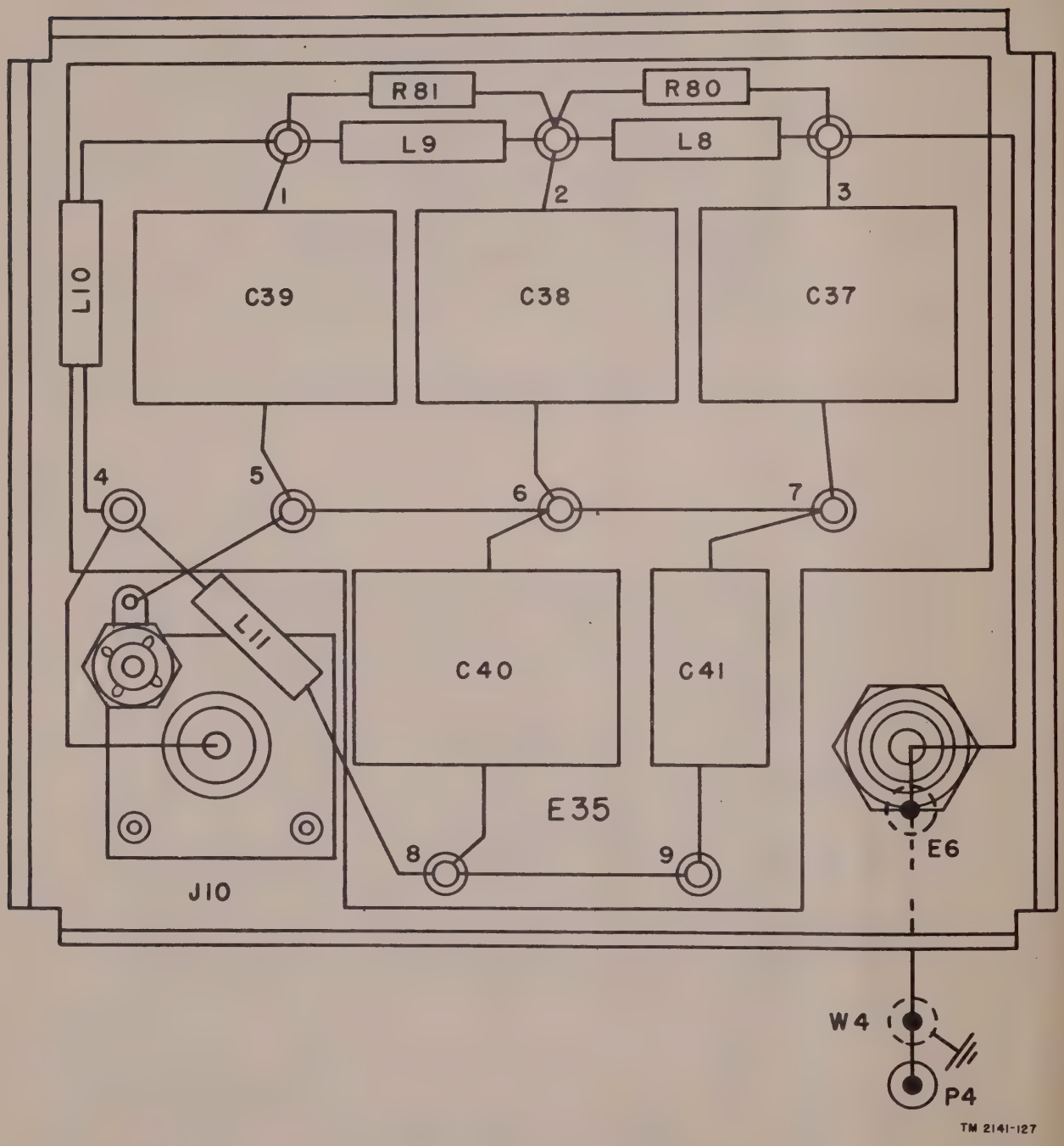


Figure 390. Multiplexer TD–60/TCC–13, multiplexer section filter, wiring diagram.

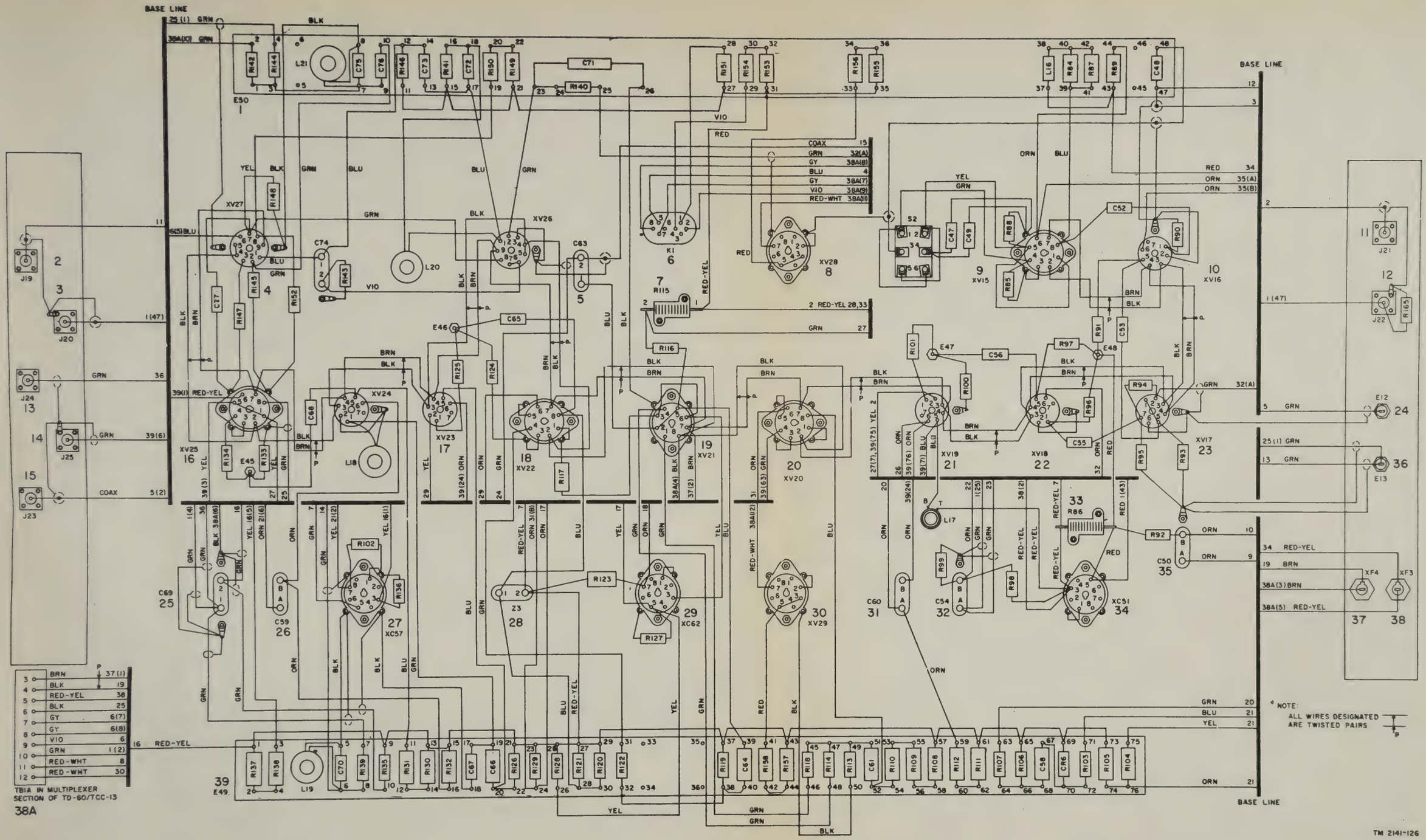
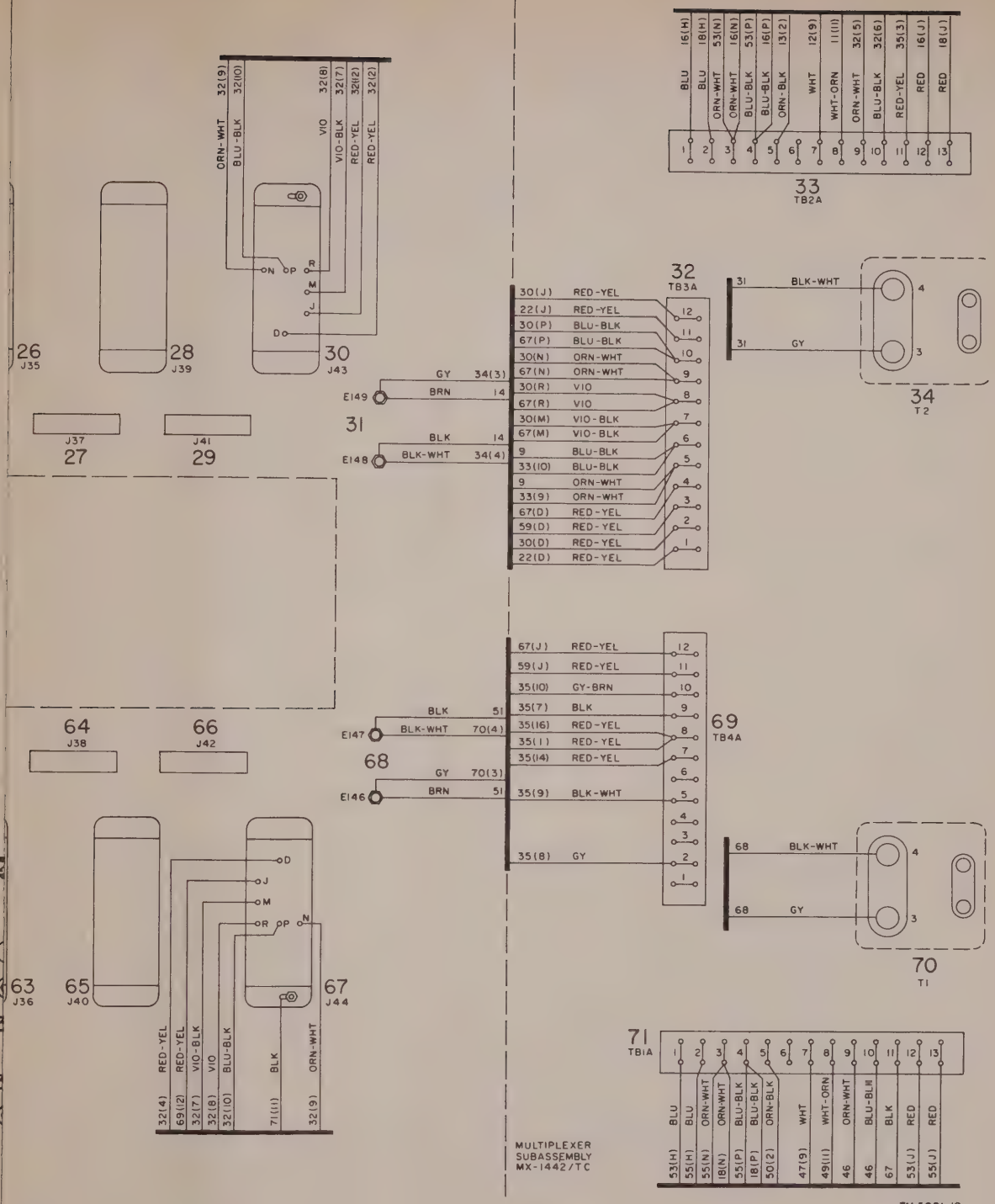


Figure 391. Multiplexer TD–60/TCC–13, demultiplexer section, wiring diagram.


33
TB2A
32
TB3A
34
T2
31
69
TB4A
68
70
T1
71
TB1A
26
J35
28
J39
30
J43
27
J37
29
J41
64
J38
66
J42
63
J36
65
J40
67
J44
E149
E148
E147
E146
MULTIPLEXER
SUBASSEMBLY
MX-1442/TC
TM 5091-18

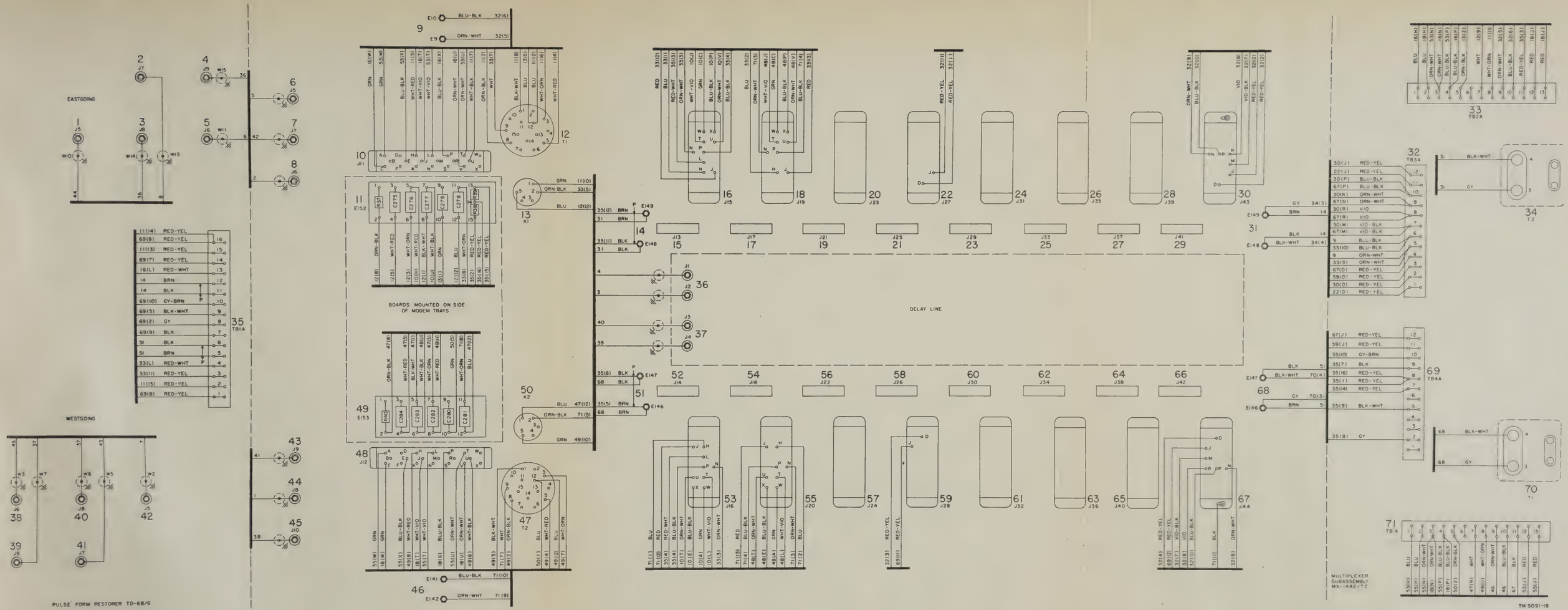
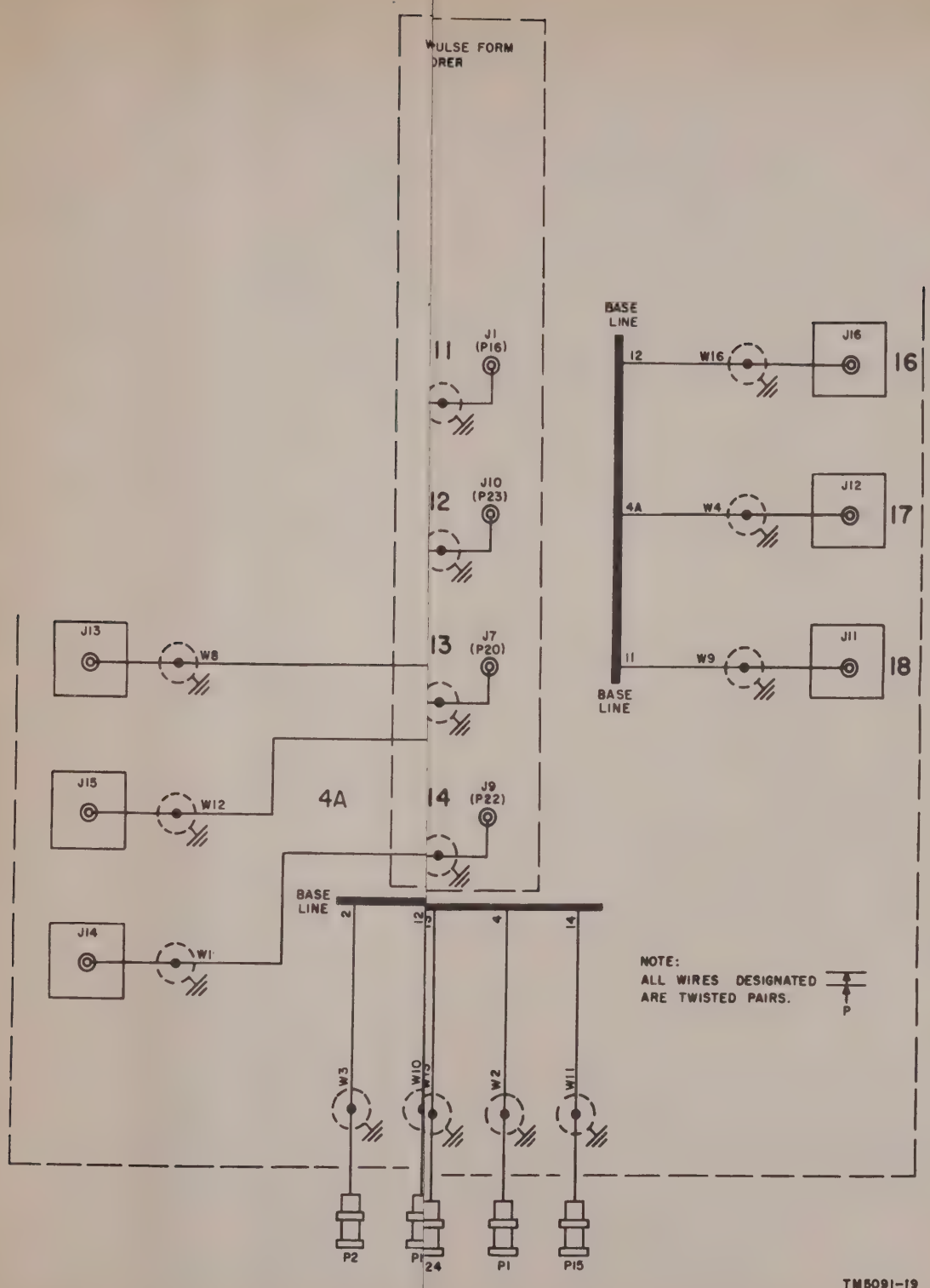


Figure 393. Multiplexer Group AN/TCA–1, multiplexer rack, over-all wiring diagram.


PULSE FORM
ORER
11
J1
(P16)
12
J10
(P23)
13
J7
(P20)
14
J9
(P22)
4A
J13
W8
J15
W12
J14
W1
BASE
LINE
2
12
4
14
W3
W10
W12
W2
W11
P2
P1
24
P1
P15
BASE
LINE
12
W16
J16
16
4A
W4
J12
17
11
W9
J11
18
NOTE:
ALL WIRES DESIGNATED
ARE TWISTED PAIRS.
P
TM5091-19

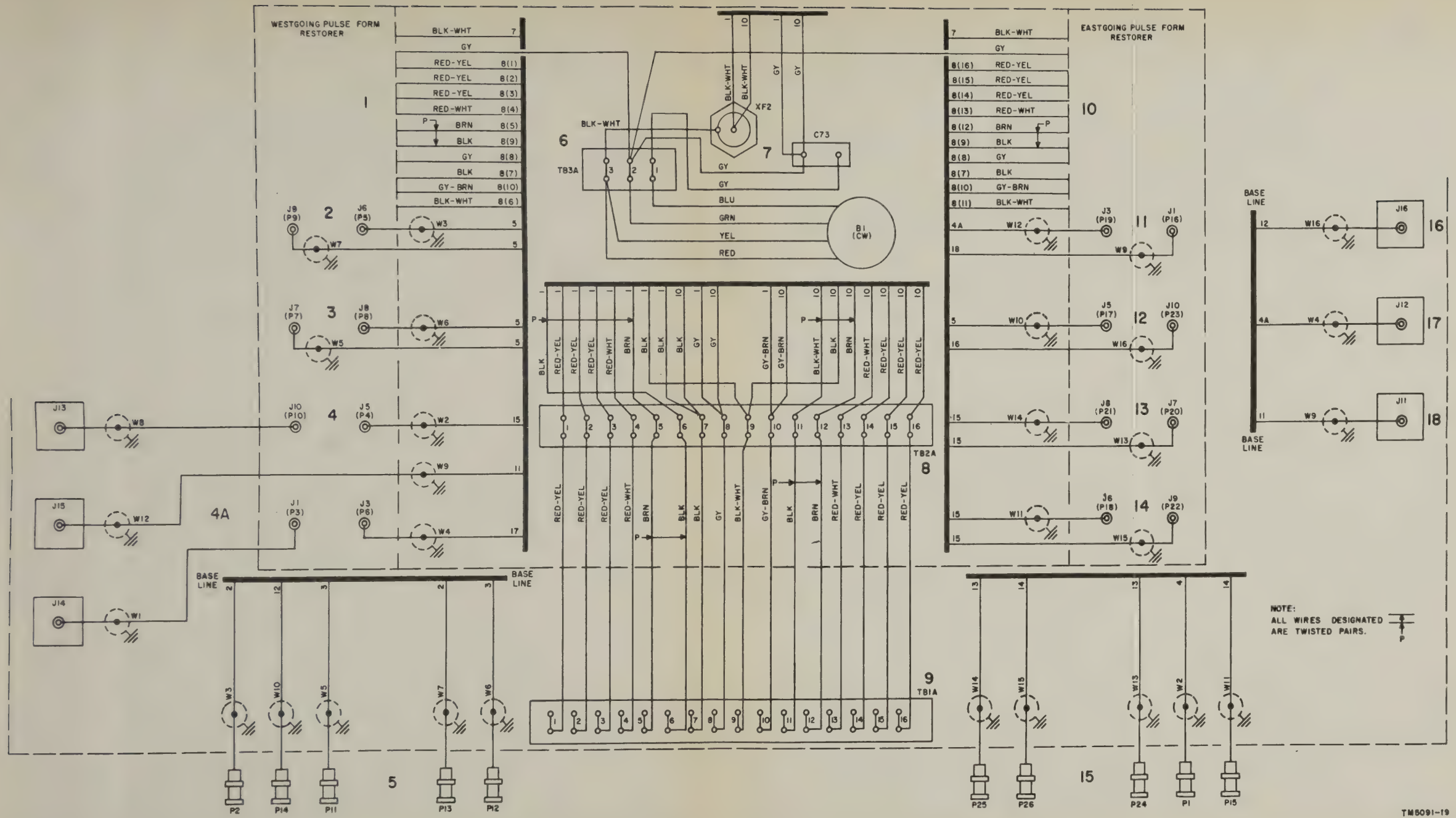


Figure 394. Pulse Form Restorer Group AN/TRA–10, over-all wiring diagram.

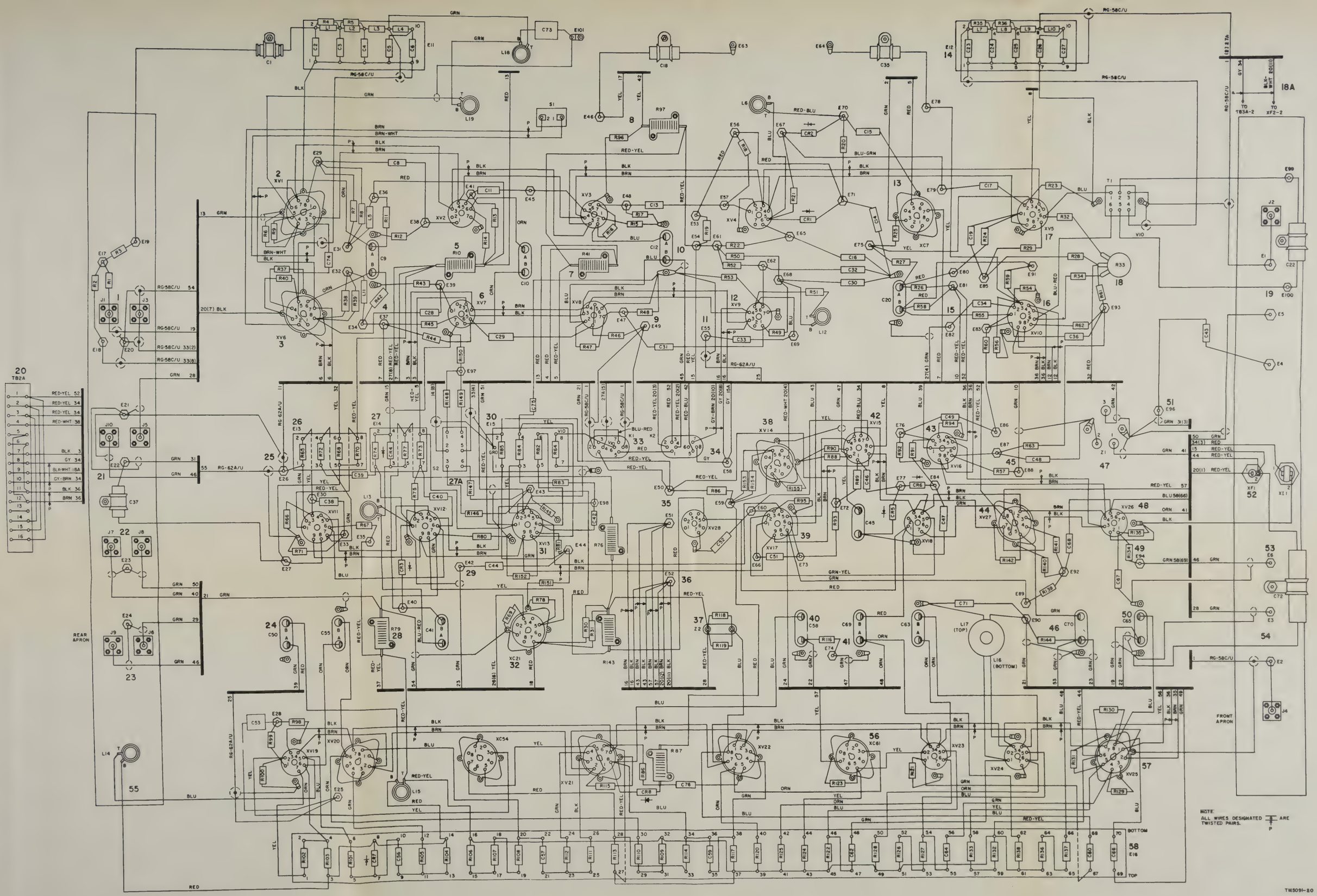
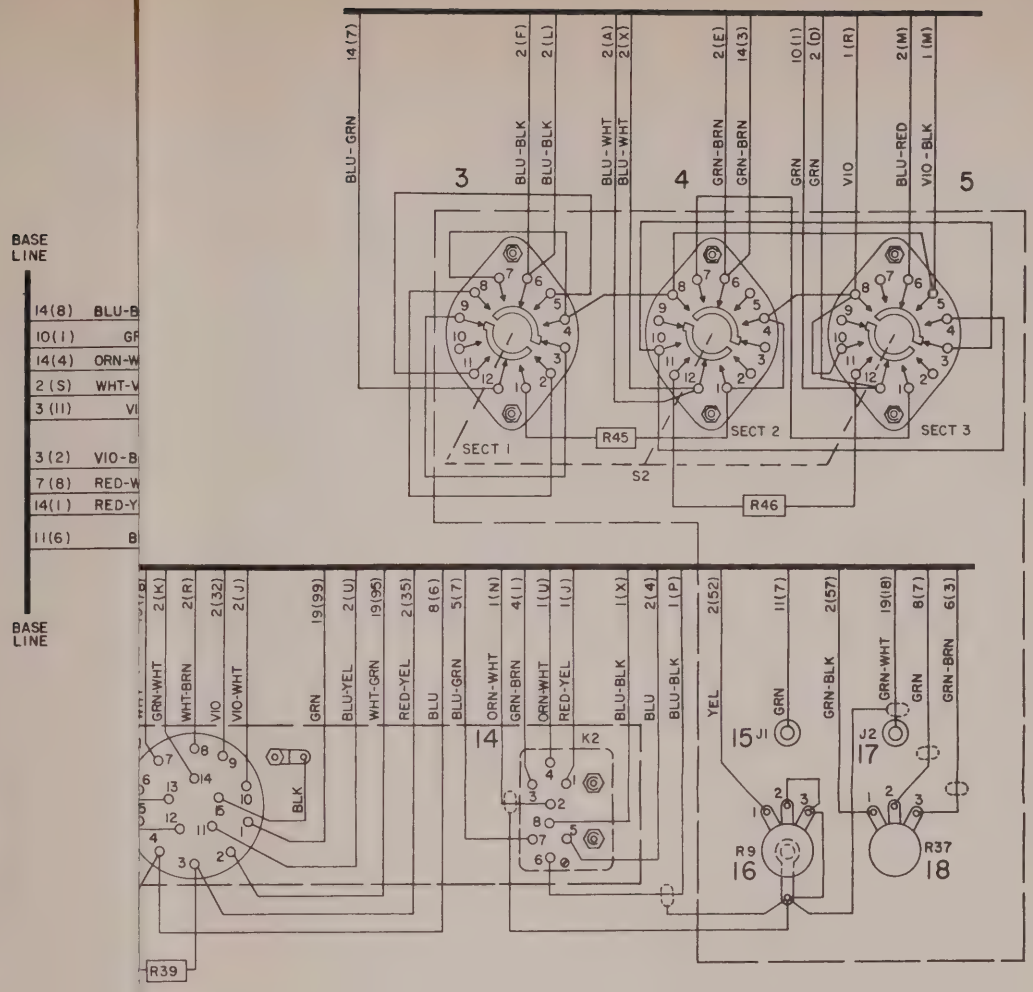
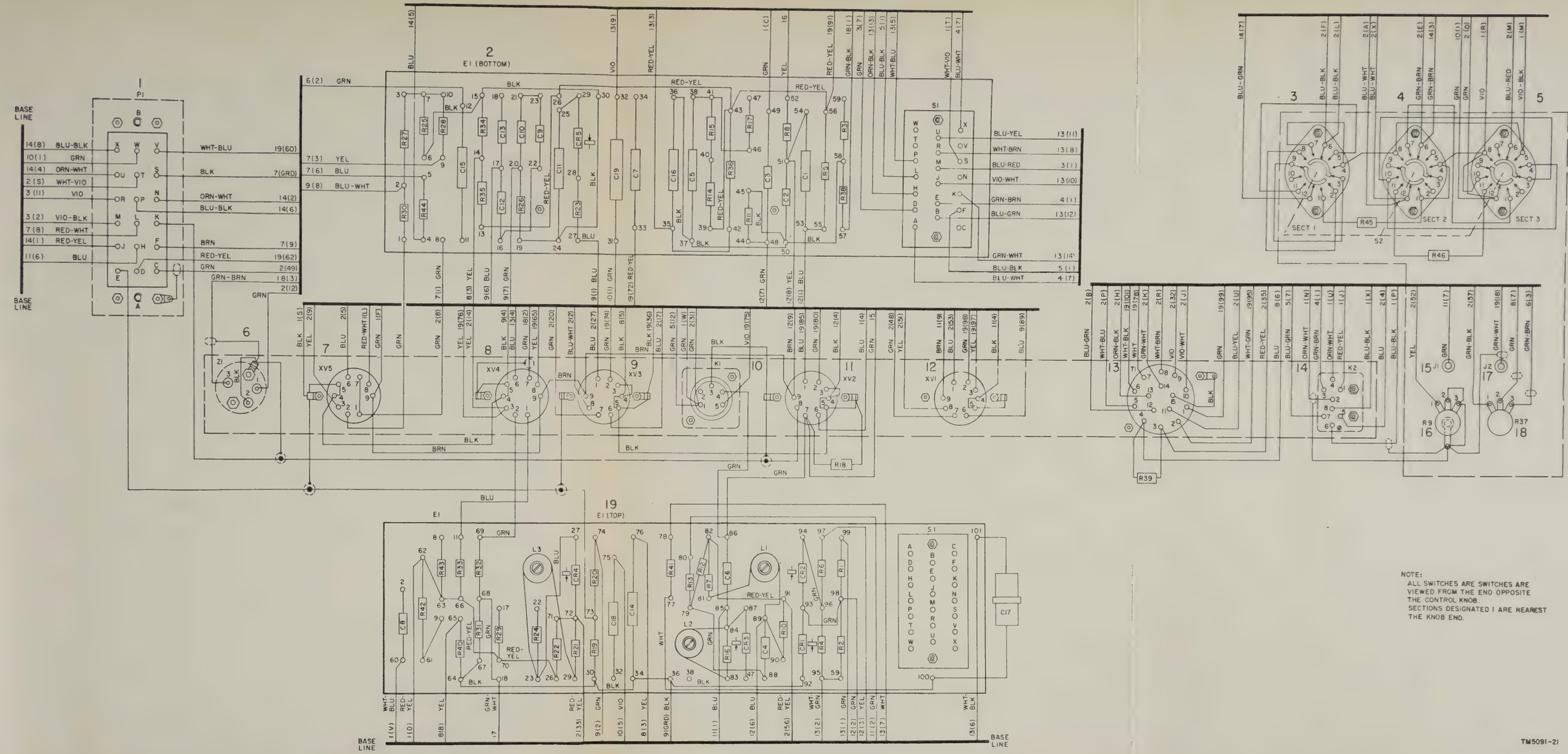


Figure 395. Video restorer, wiring diagram.



NOTE:
ALL SWITCHES ARE SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB.
SECTIONS DESIGNATED 1 ARE NEAREST THE KNOB END.



NOTE:
ALL SWITCHES ARE SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB.
SECTIONS DESIGNATED 1 ARE NEAREST THE KNOB END.

Figure 396. Telephone Modem MD–179/TC, wiring diagram.

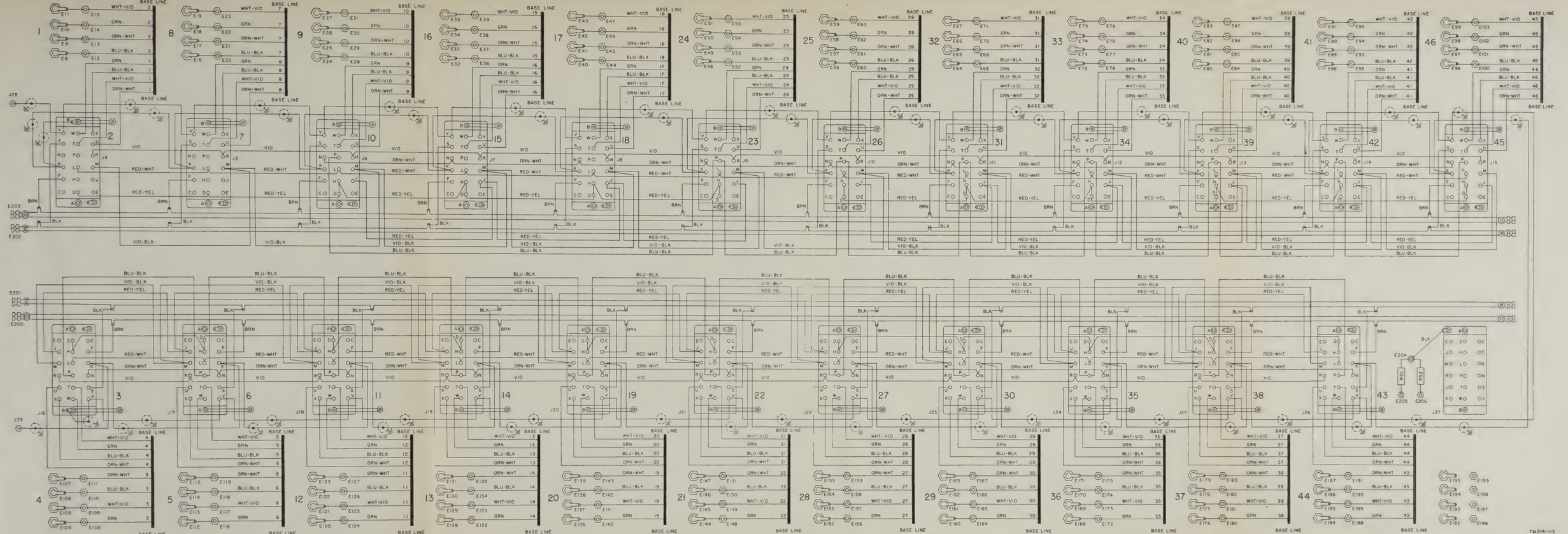
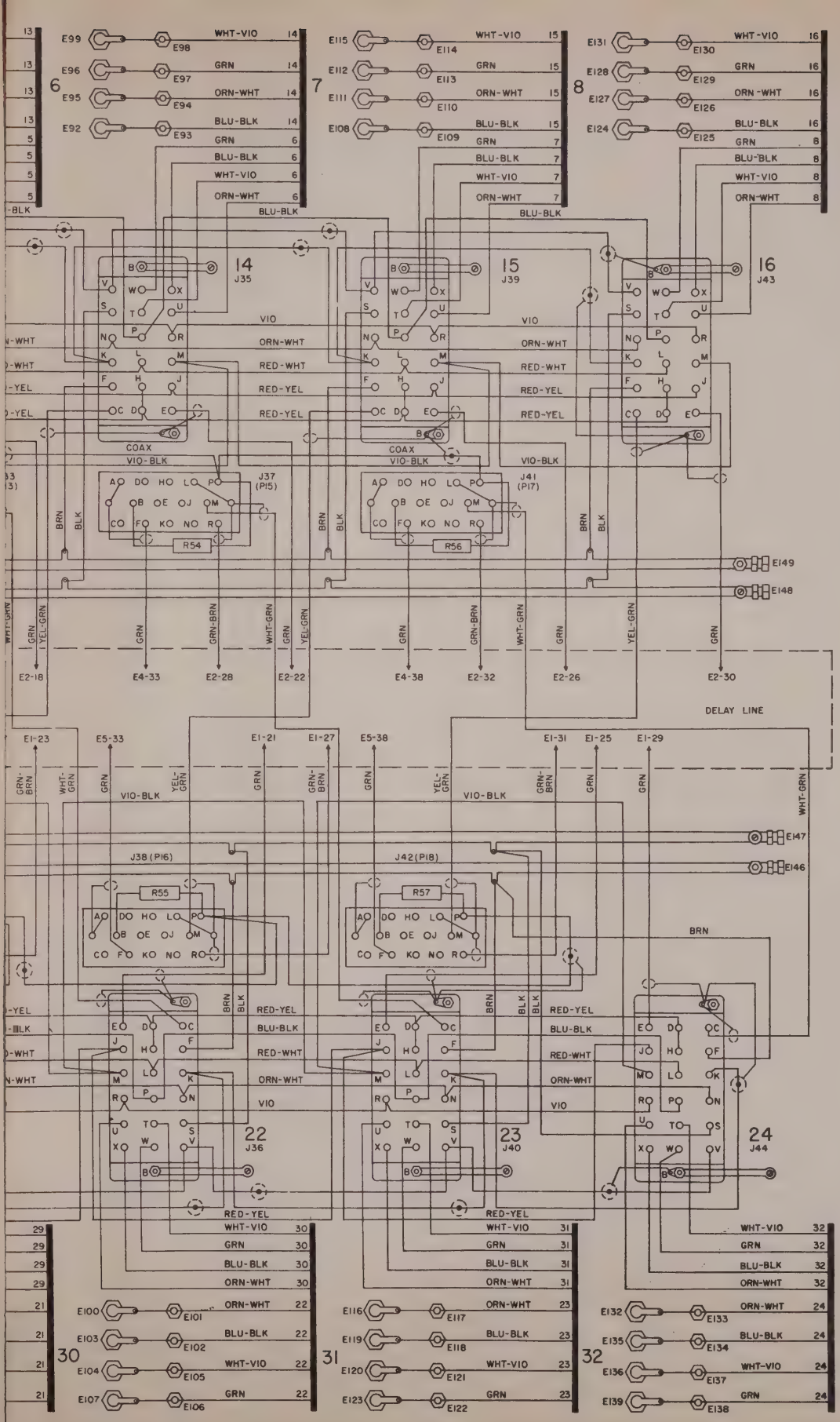


Figure 397. Electrical Equipment Rack MT-1165/TCC-13, over-all wiring diagram.


6
7
8
14
J35
15
J39
16
J43
J37 (P15)
J41 (P17)
R54
R56
J38 (P16)
J42 (P18)
R55
R57
22
J36
23
J40
24
J44
30
31
32
DELAY LINE
COAX
VIO-BLK
E2-18
E4-33
E2-28
E2-22
E4-38
E2-32
E2-26
E2-30
E1-23
E5-33
E1-21
E1-27
E5-38
E1-31
E1-25
E1-29
E149
E148
E147
E146
TM 5091-3

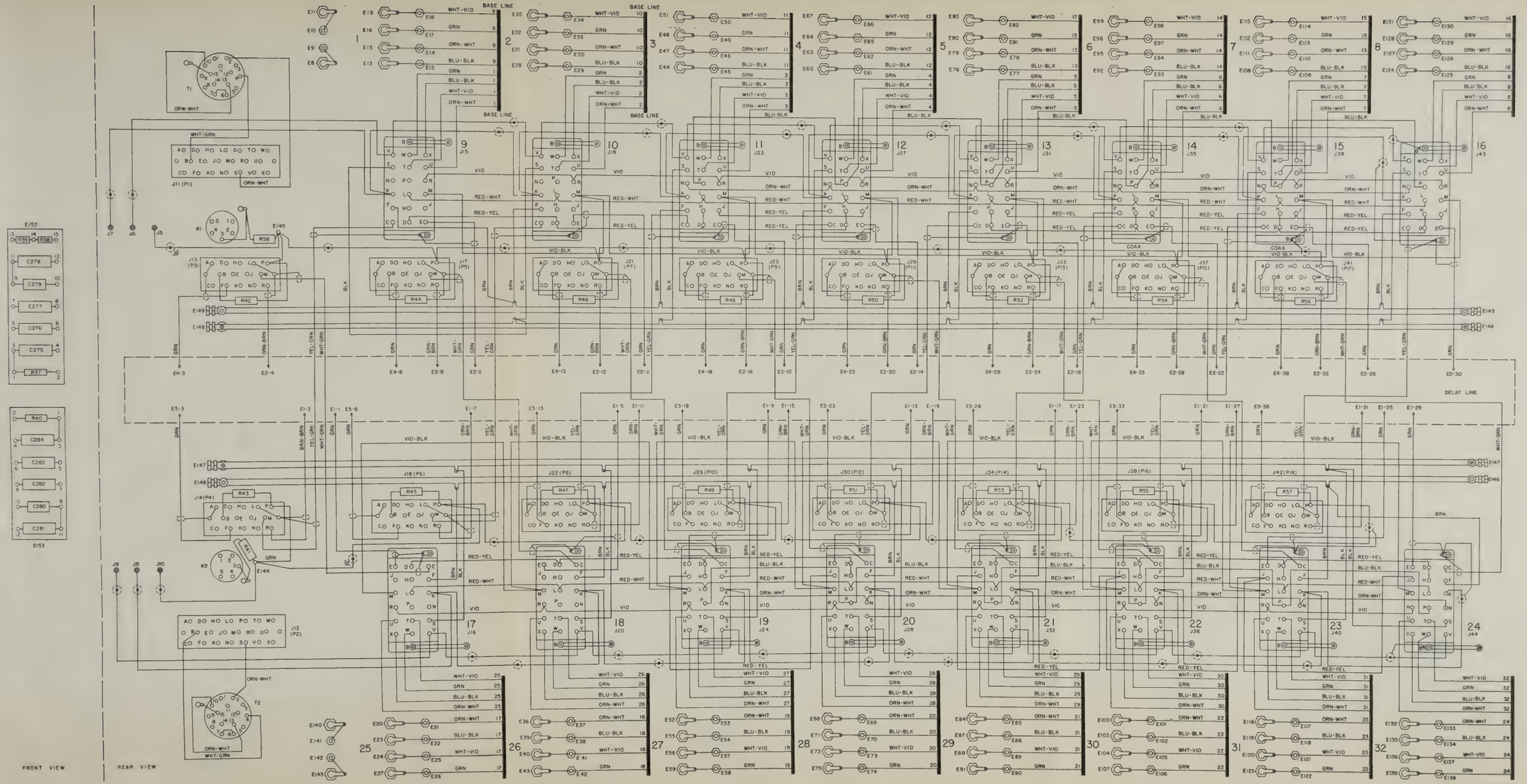
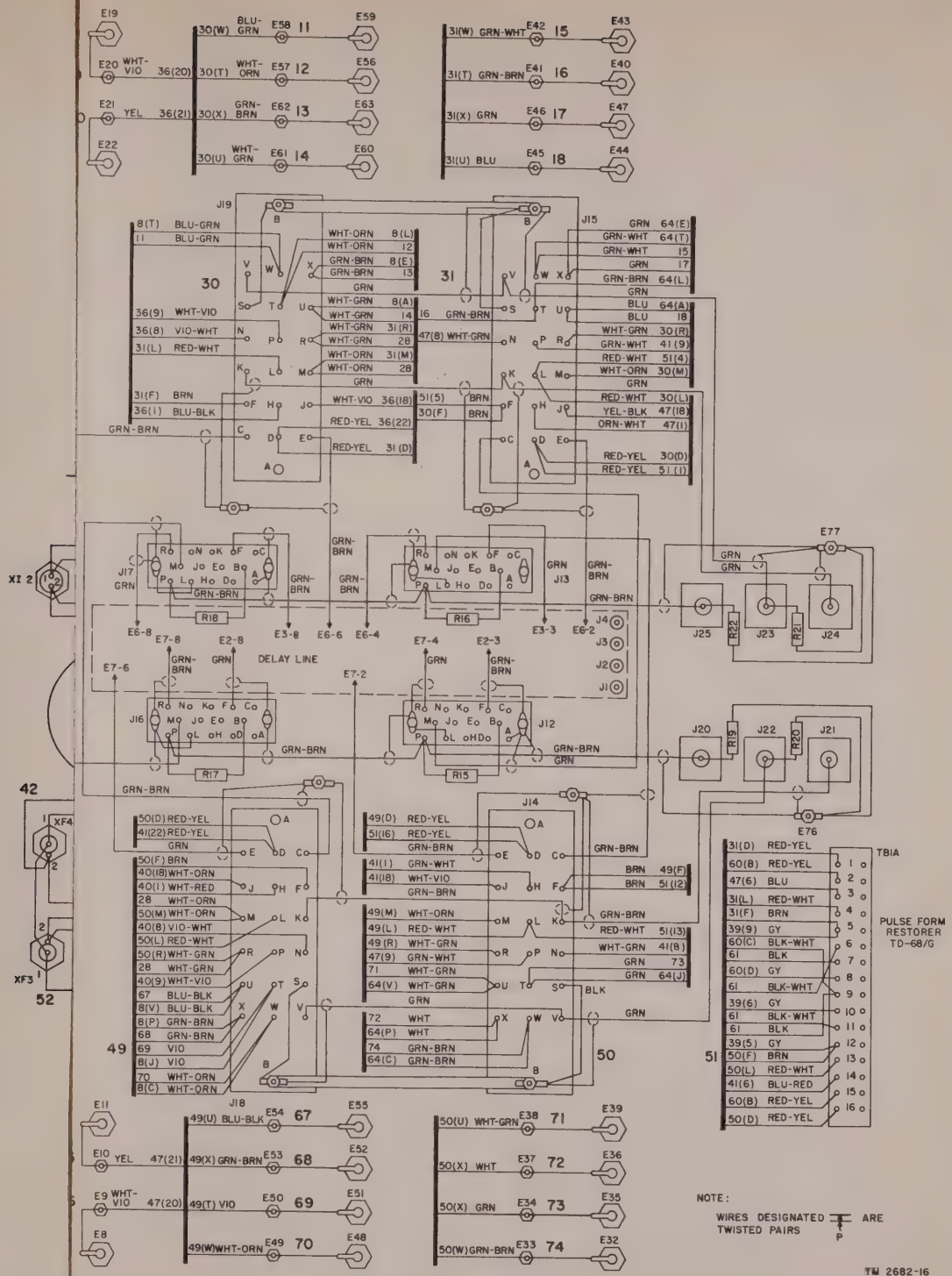


Figure 398. Electrical Equipment Rack MT–1433/TCA–1, over-all wiring diagram.


E19
E20 WHT-VIO 36(20)
E21 YEL 36(21)
E22
30(W) BLU-GRN E58 11 E59
30(T) WHT-ORN E57 12 E56
30(X) GRN-BRN E62 13 E63
30(U) WHT-GRN E61 14 E60
31(W) GRN-WHT E42 15 E43
31(T) GRN-BRN E41 16 E40
31(X) GRN E46 17 E47
31(U) BLU E45 18 E44
J19
J15
30
31
J17
J13
J16
J12
J14
J18
R18
R16
R17
R15
R19
R20
R21
R22
J20
J21
J22
J23
J24
J25
E76
E77
XI 2
XF4
XF3
42
52
49
50
51
TBIA
PULSE FORM RESTORER TD-68/G
E11
E10 YEL 47(21)
E9 WHT-VIO 47(20)
E8
49(U) BLU-BLK E54 67 E55
49(X) GRN-BRN E53 68 E52
49(T) VIO E50 69 E51
49(W) WHT-ORN E49 70 E48
50(U) WHT-GRN E38 71 E39
50(X) WHT E37 72 E36
50(X) GRN E34 73 E35
50(W) GRN-BRN E33 74 E32
DELAY LINE
NOTE:
WIRES DESIGNATED P ARE TWISTED PAIRS
TM 2682-16

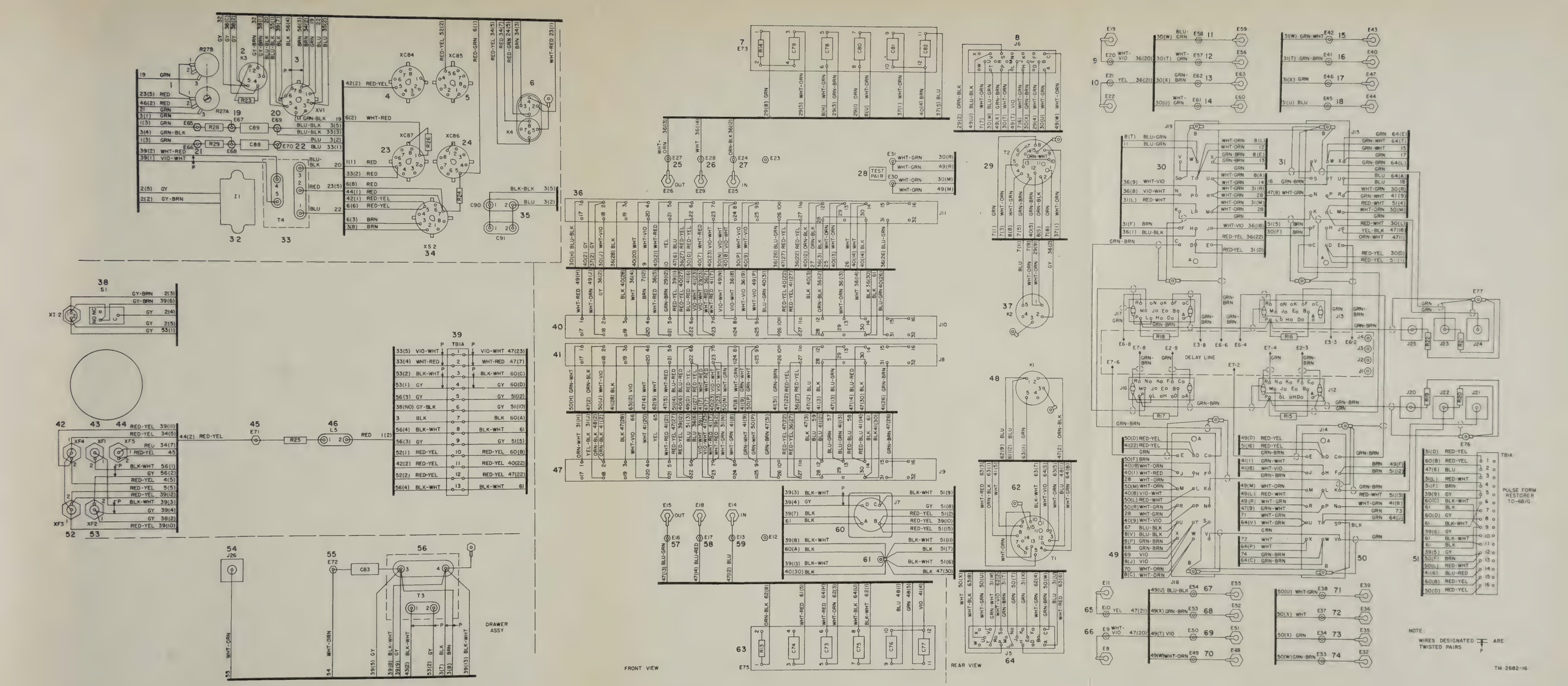


Figure 399. Electrical Equipment Rack MT–1434/TRA–10, over-all wiring diagram.

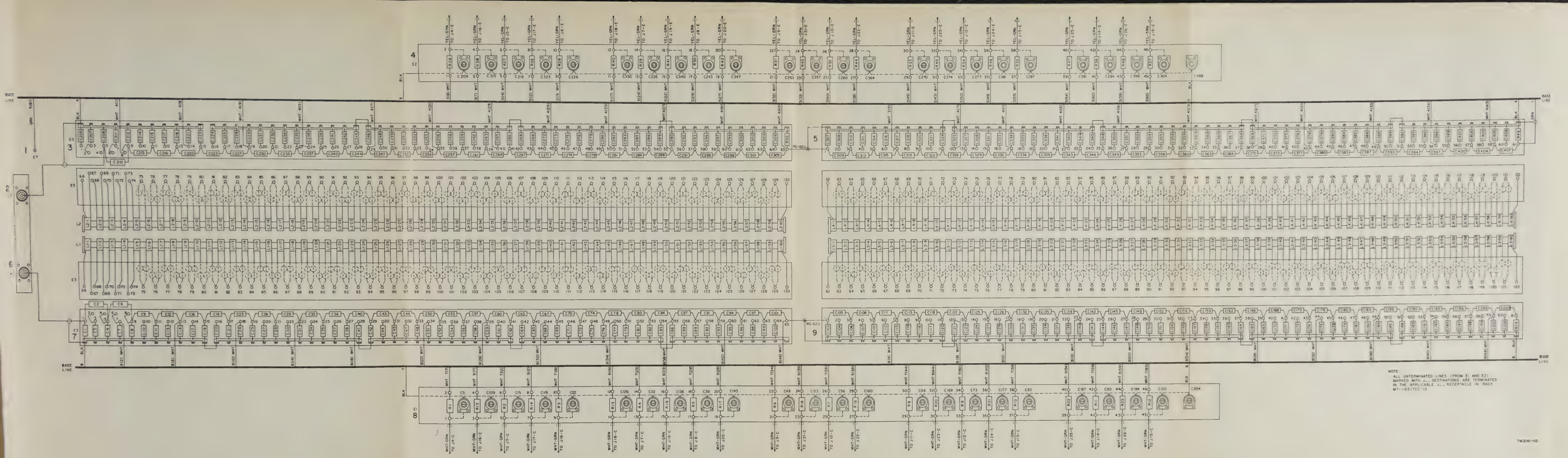
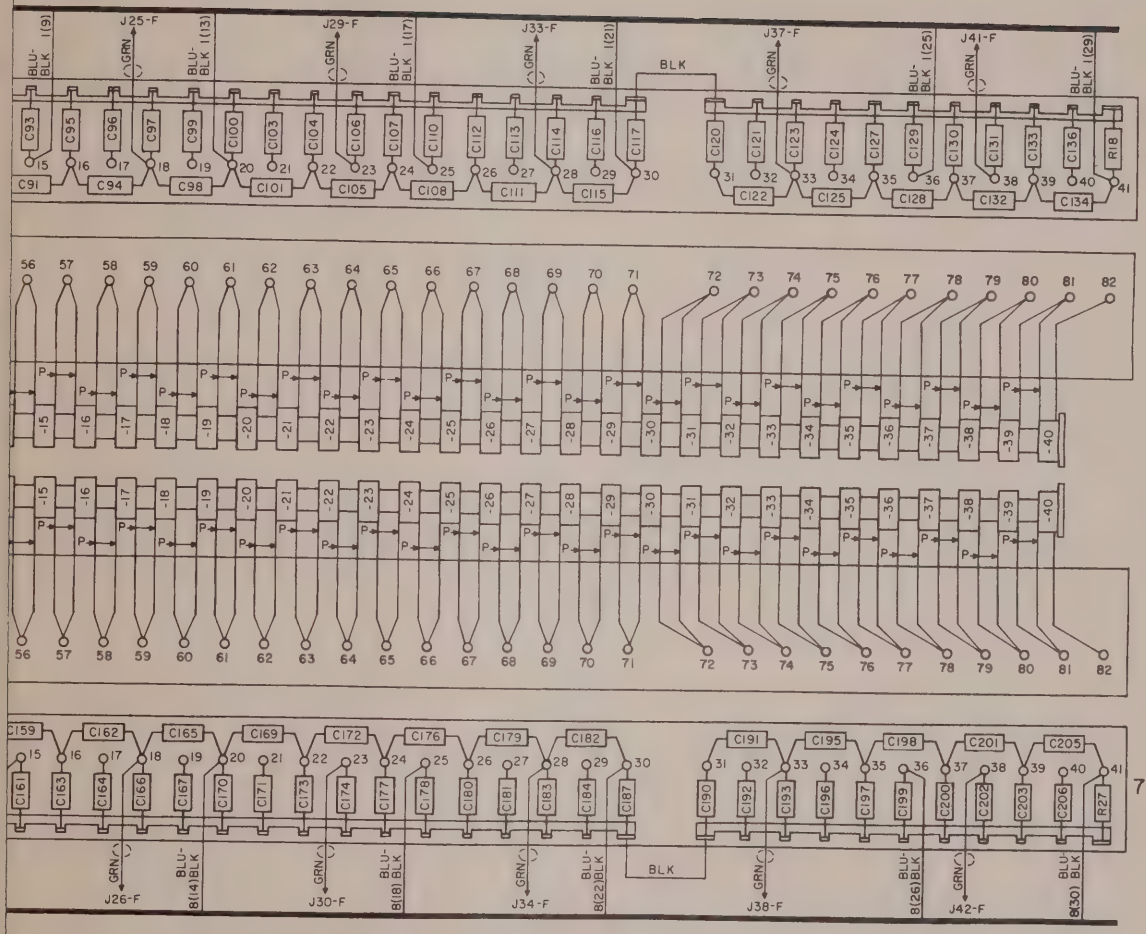


Figure 400. Multiplexer Set AN/TCC-13, delay line, wiring diagram.



NOTES:

1. ALL WIRES DESIGNATED $\frac{}{P}$ ARE TWISTED PAIRS
2. FOR WIRING OF J13 THRU J44 SEE ELECTRICAL EQUIPMENT RACK MT-1133/TCA-1
3. NUMBERS IN PARENTHESIS ON E1 AND E2 DESIGNATE TERMINAL AND CONNECTIONS ON REVERSE SIDE OF BOARD

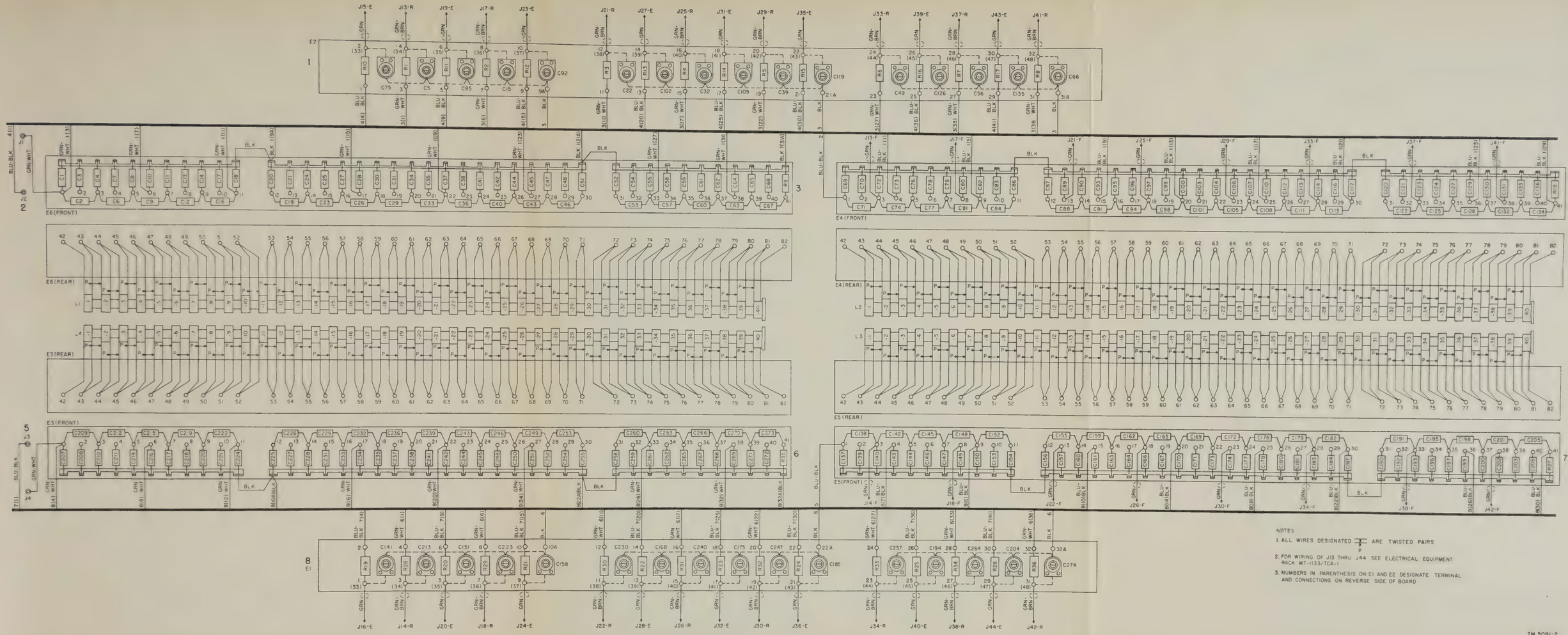
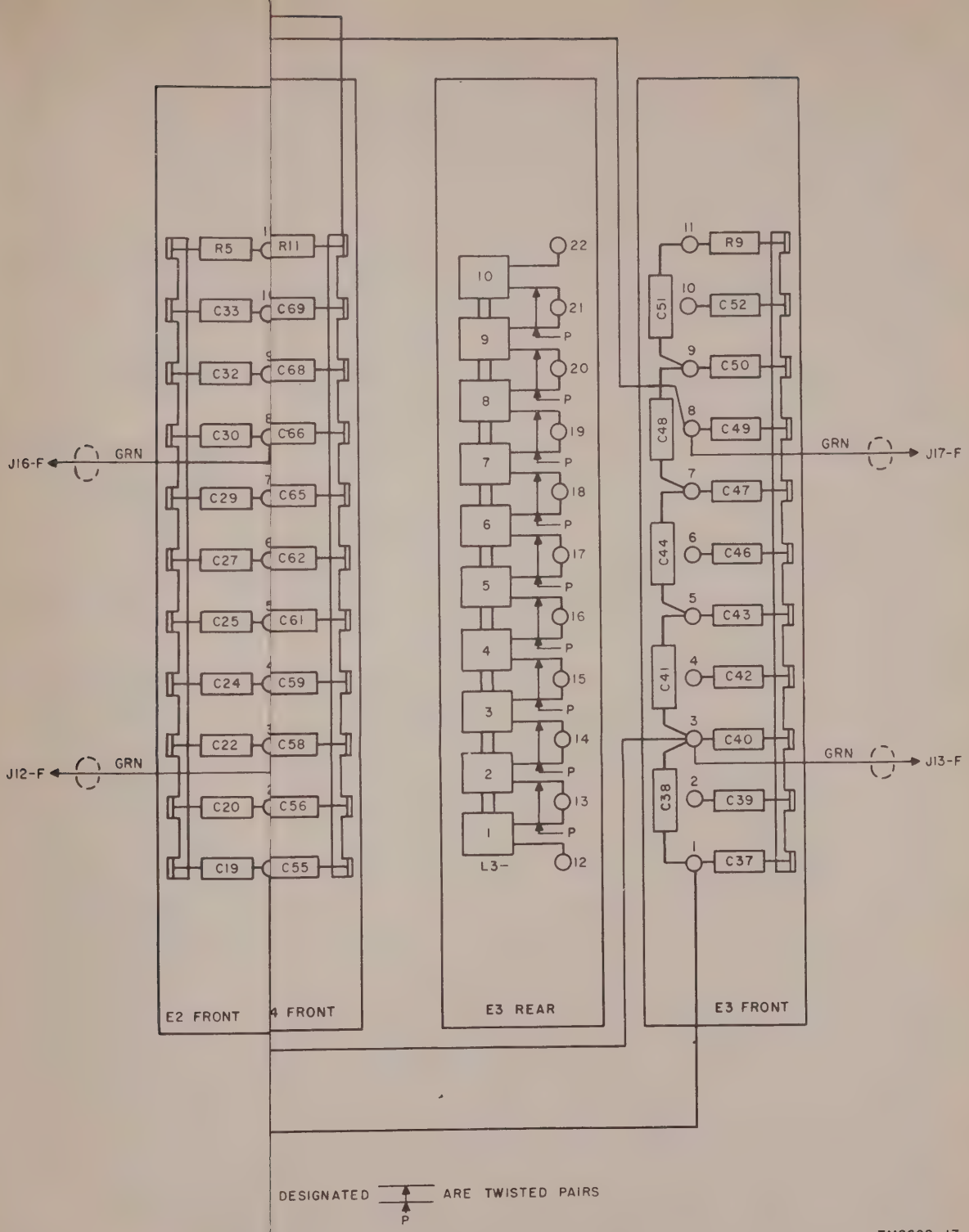


Figure 401. Multiplexer Group AN/TCA–1, delay line, wiring diagram.


R5
R11
C33
C69
C32
C68
C30
C66
C29
C65
C27
C62
C25
C61
C24
C59
C22
C58
C20
C56
C19
C55
J16-F
GRN
J12-F
GRN
E2 FRONT
4 FRONT
22
10
21
9
20
8
19
7
18
6
17
5
16
4
15
3
14
2
13
1
12
L3-
E3 REAR
11
R9
C51
10
C52
9
C50
C48
8
C49
GRN
J17-F
7
C47
C44
6
C46
5
C43
C41
4
C42
3
C40
GRN
J13-F
C38
2
C39
1
C37
E3 FRONT
DESIGNATED
P
ARE TWISTED PAIRS
TM2682-17

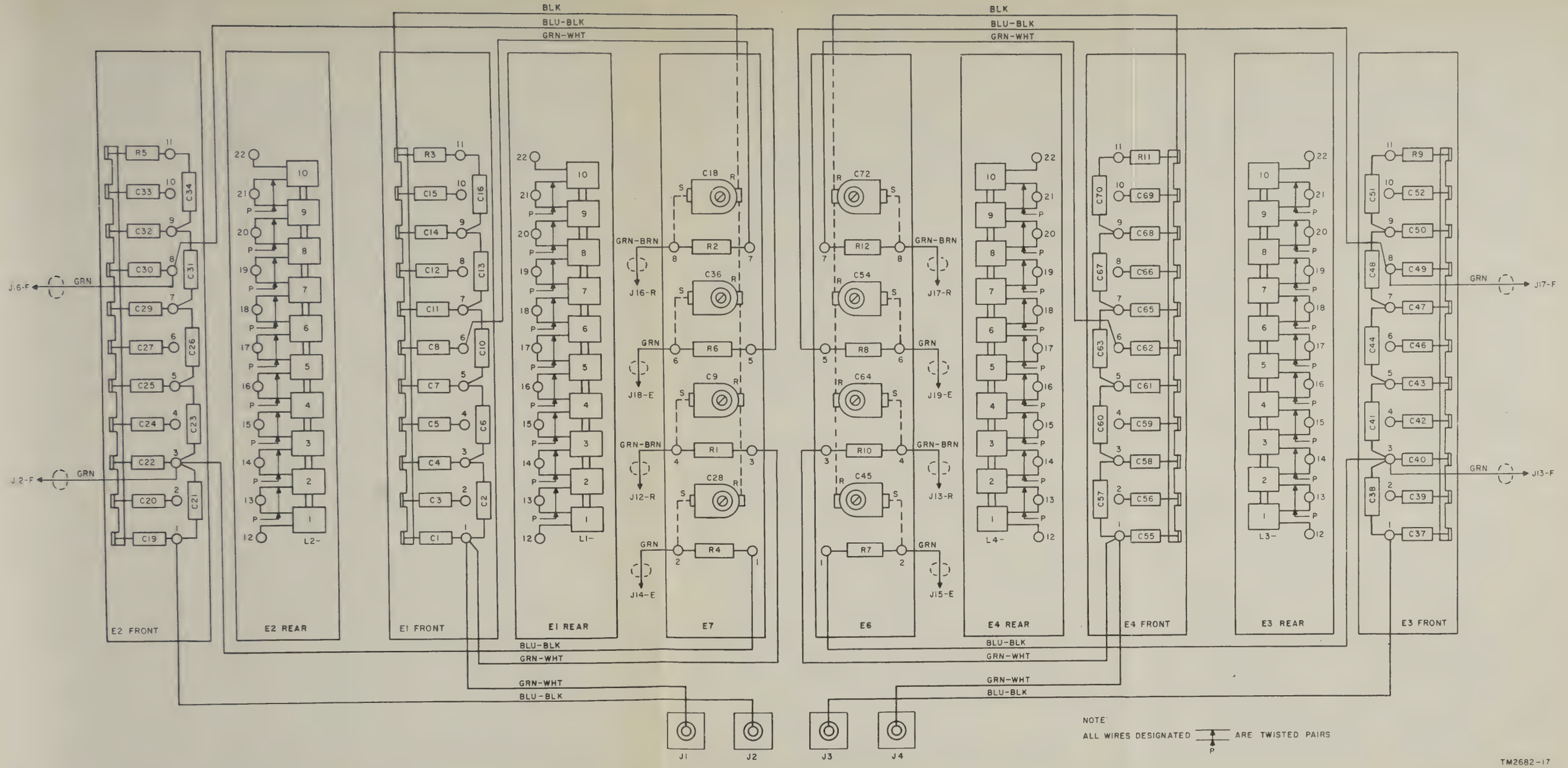
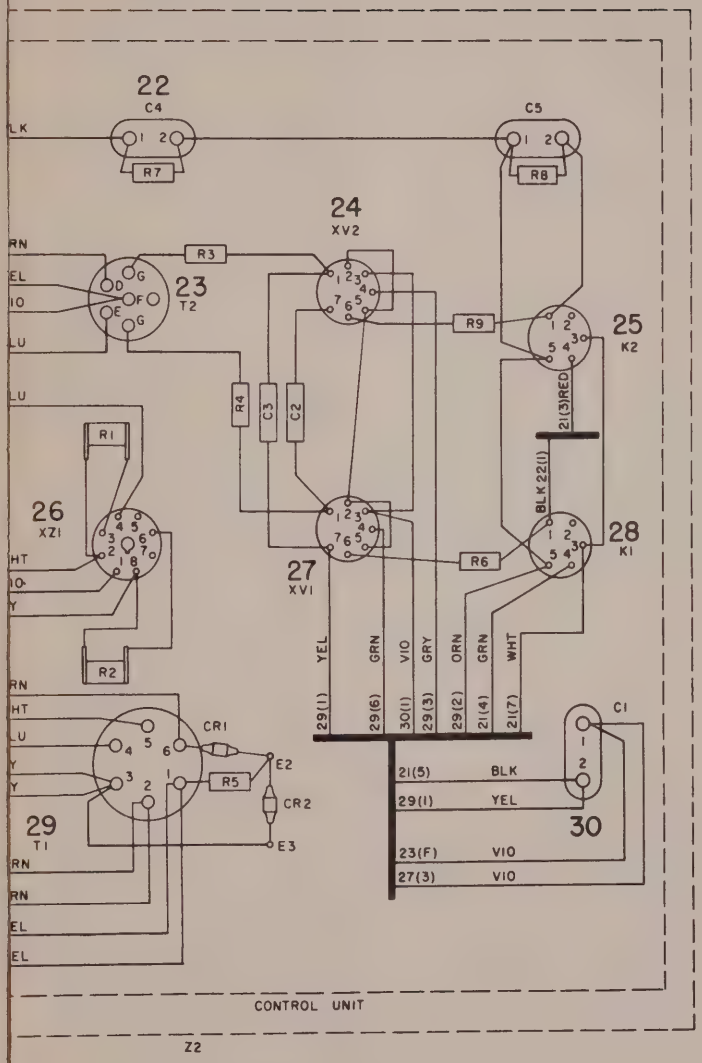


Figure 402. Pulse Form Restorer Group AN/TRA–10, delay line, wiring diagram.


22
C4
C5
R7
R8
24
XV2
R3
23
T2
R9
25
K2
R4
C3
C2
21(3)RED
BLK 22(1)
R1
26
XZ1
27
XV1
28
K1
R6
R2
YEL
GRN
VIO
GRY
ORN
GRN
WHT
29(1)
29(6)
30(1)
29(3)
29(2)
21(4)
21(7)
C1
CR1
E2
R5
CR2
E3
29
T1
21(5) BLK
29(1) YEL
30
23(F) VIO
27(3) VIO
CONTROL UNIT
Z2

TM5091-28

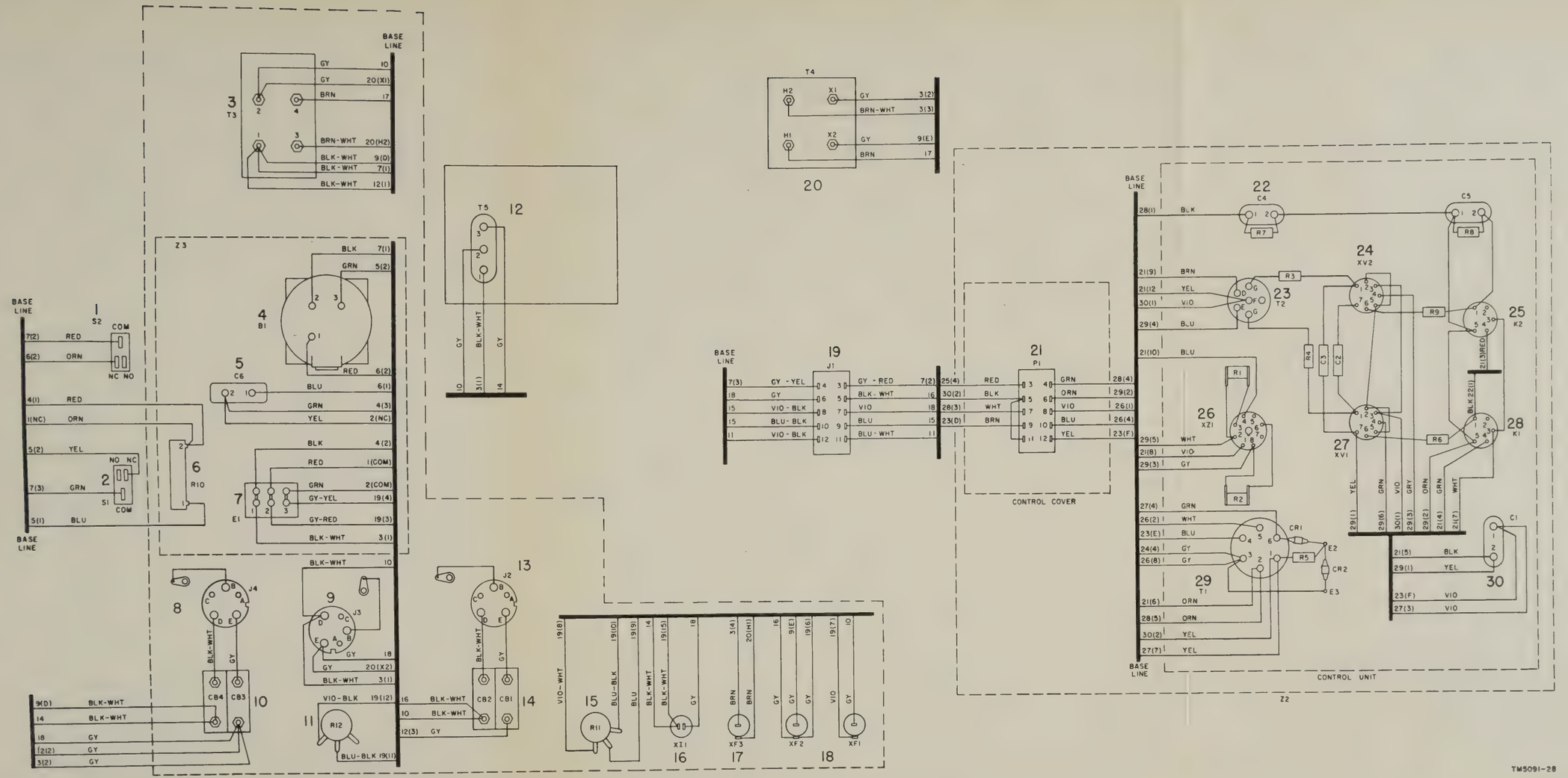
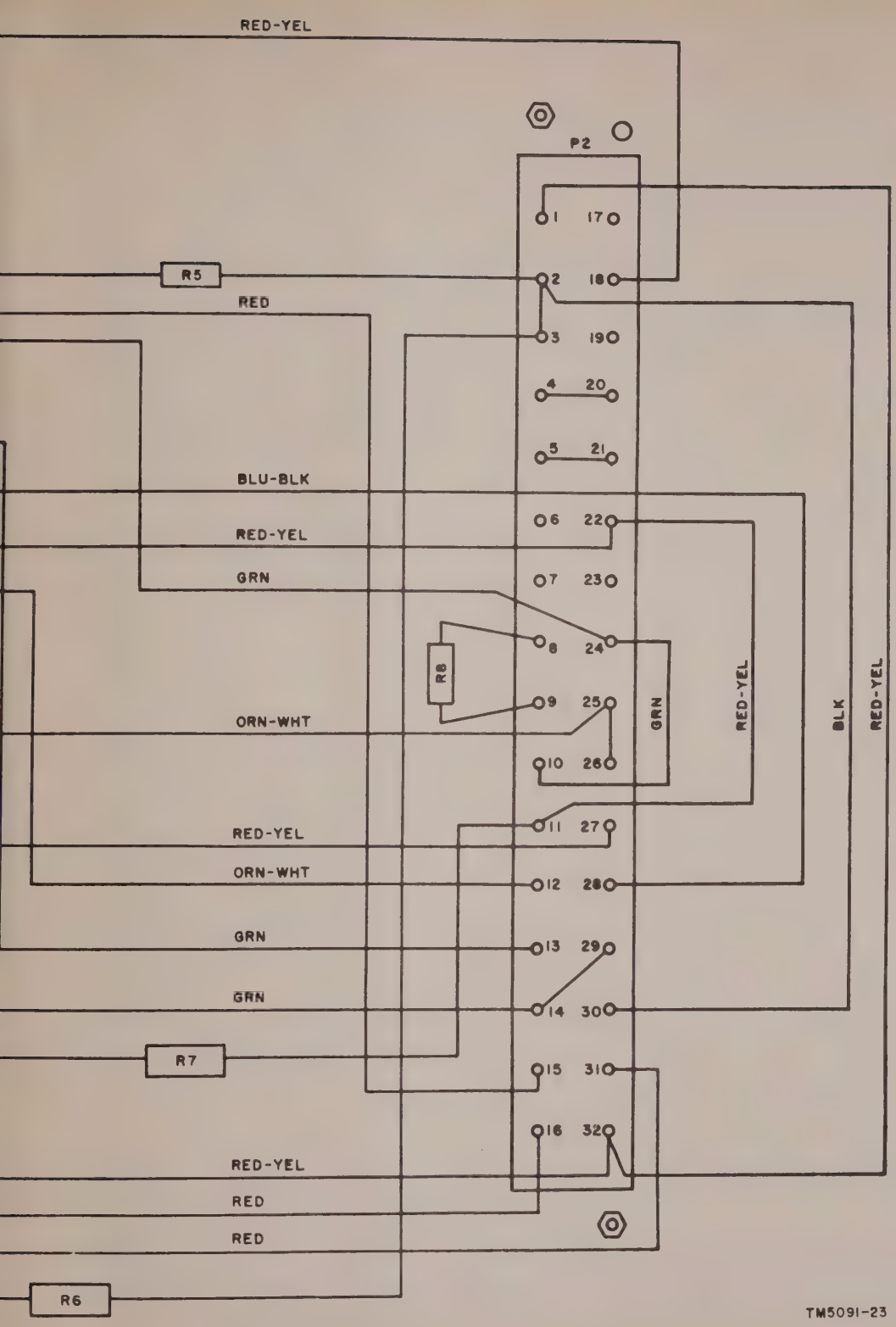


Figure 403. Multiplexer Subassembly MX-1442/TC, over-all wiring diagram.


RED-YEL
P2
1
17
R5
2
18
RED
3
19
4
20
5
21
BLU-BLK
6
22
RED-YEL
GRN
7
23
8
24
R8
9
25
ORN-WHT
10
26
GRN
RED-YEL
BLK
RED-YEL
11
27
RED-YEL
ORN-WHT
12
28
GRN
13
29
GRN
14
30
R7
15
31
16
32
RED-YEL
RED
RED
R6
TM5091-23

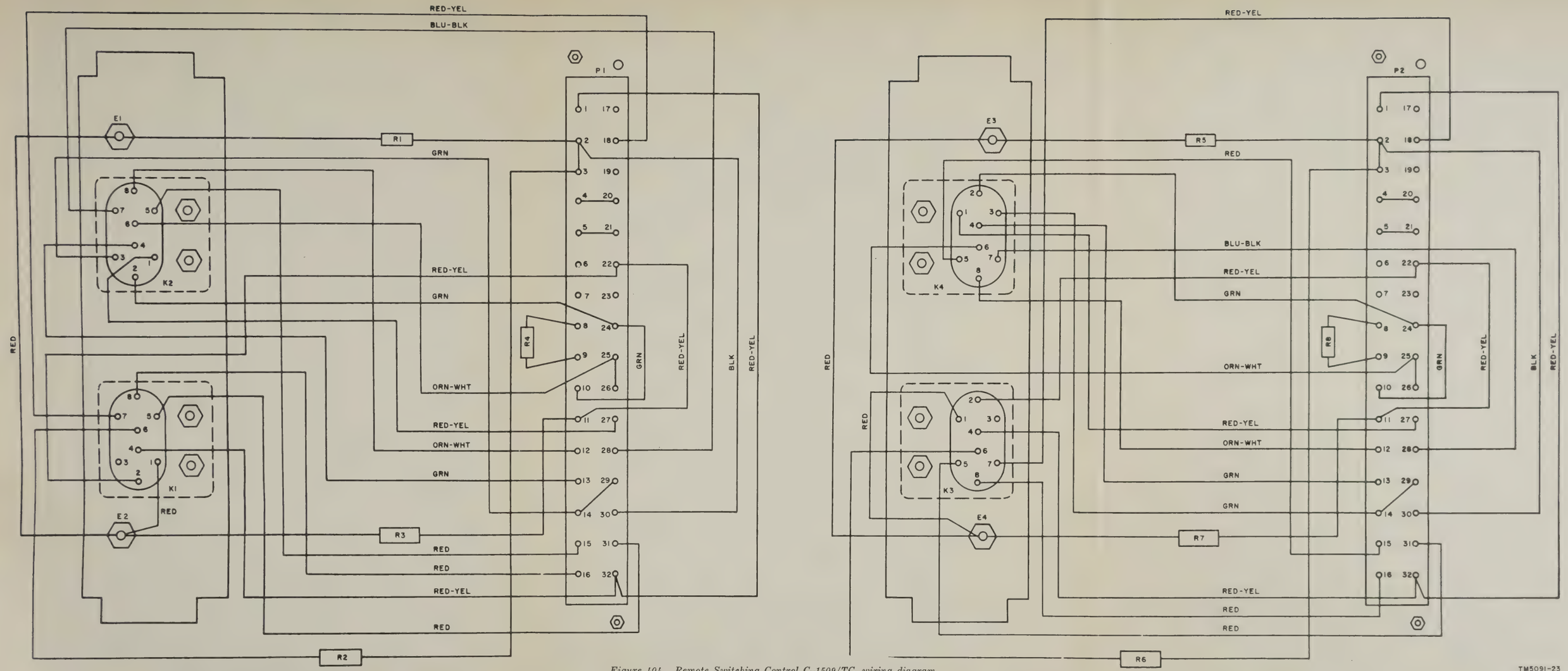
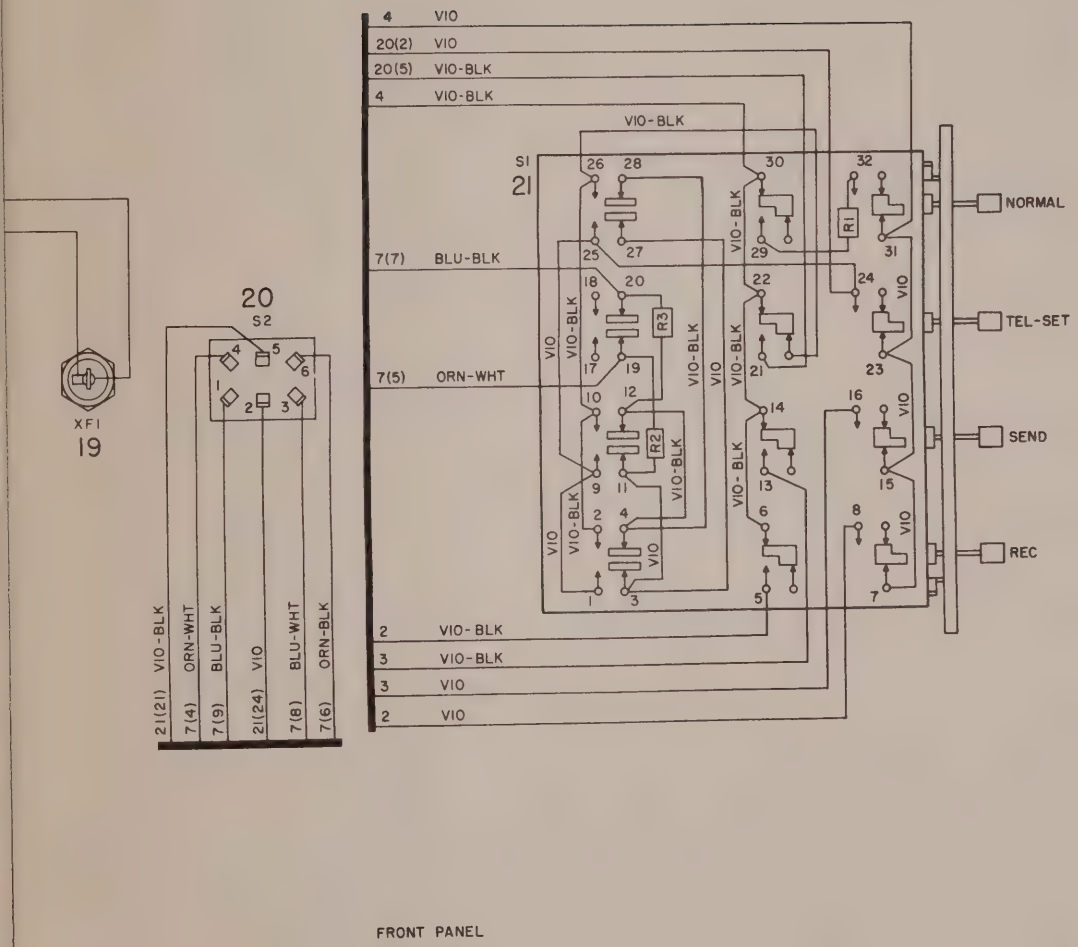


Figure 404. Remote Switching Control C–1509/TC, wiring diagram.

TM5091-23



FRONT PANEL

TM5091-26

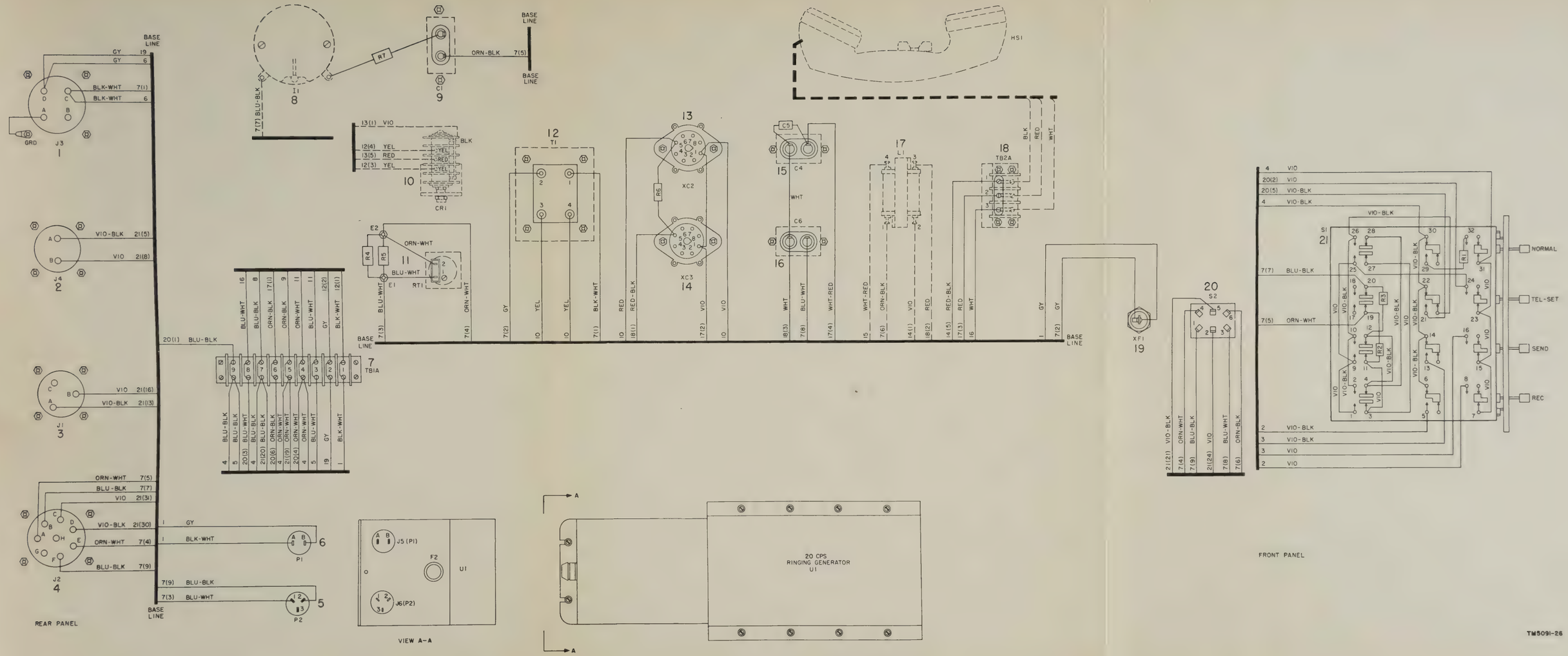


Figure 405. Control Monitor C–1151/TC, wiring diagram.

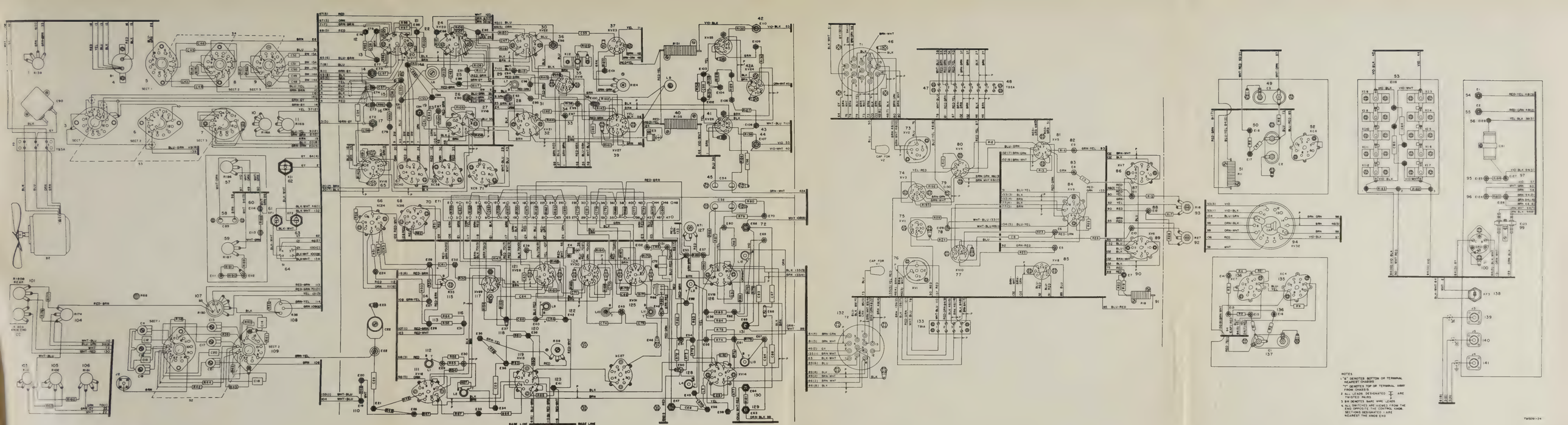
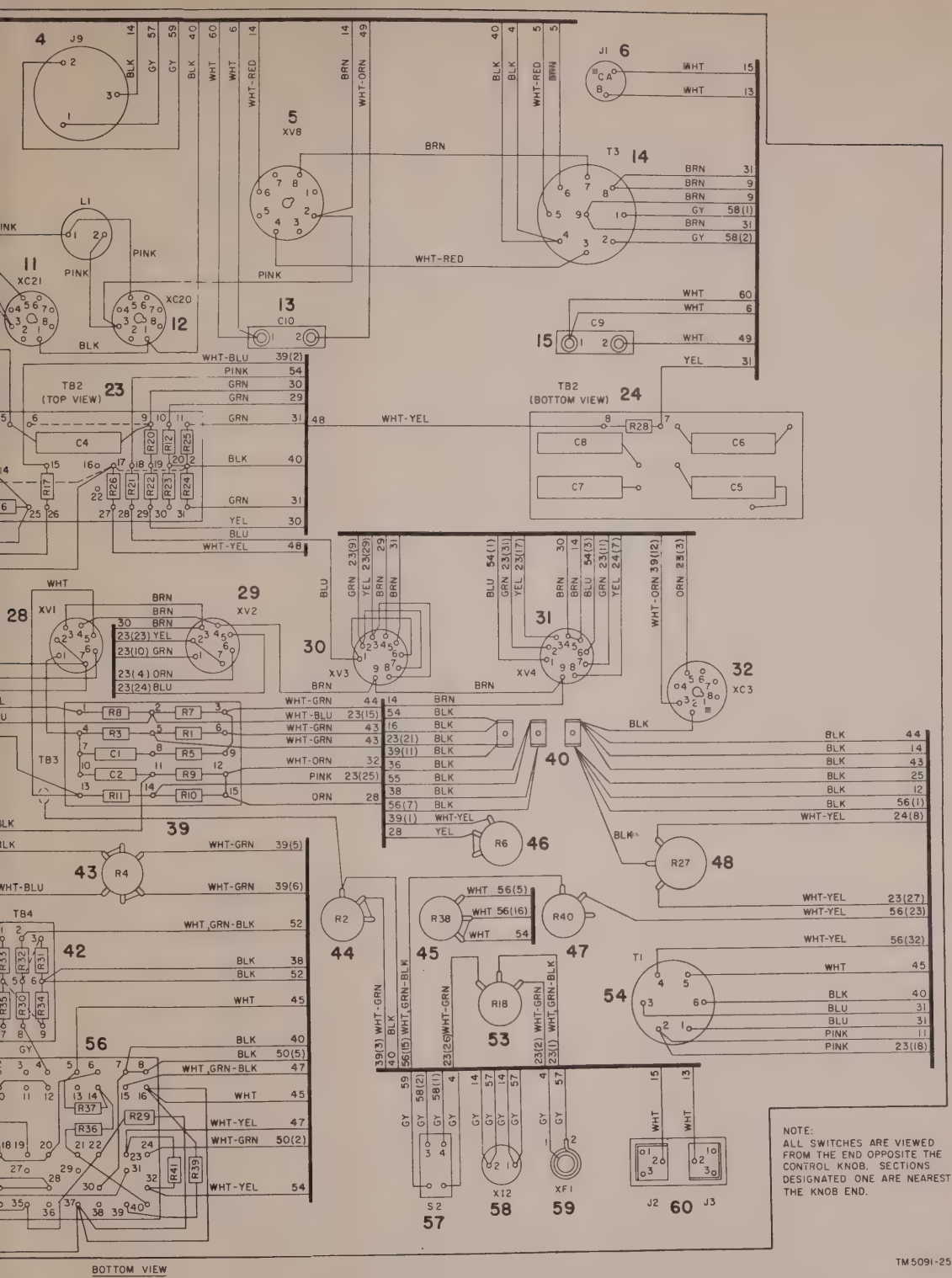


Figure 406. Oscilloscope OS-25/G, wiring diagram.


4
J9
5
XV8
T3
14
J1
6
LI
PINK
11
XC21
XC20
12
BLK
13
C10
15
C9
TB2
(TOP VIEW)
23
TB2
(BOTTOM VIEW)
24
C4
C8
C6
C7
C5
R28
R20
R12
R25
R17
R26
R21
R22
R23
R24
WHT-YEL
28
XV1
29
XV2
30
XV3
31
XV4
32
XC3
TB3
R8
R7
R3
R1
C1
R5
C2
R9
R11
R10
39
43
R4
TB4
42
56
R37
R29
R36
R41
R39
40
R6
46
R27
48
R2
44
R38
45
R40
47
R18
53
54
T1
S2
57
X12
58
XF1
59
J2
60
J3
BOTTOM VIEW
NOTE:
ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB. SECTIONS DESIGNATED ONE ARE NEAREST THE KNOB END.
TM 5091-25

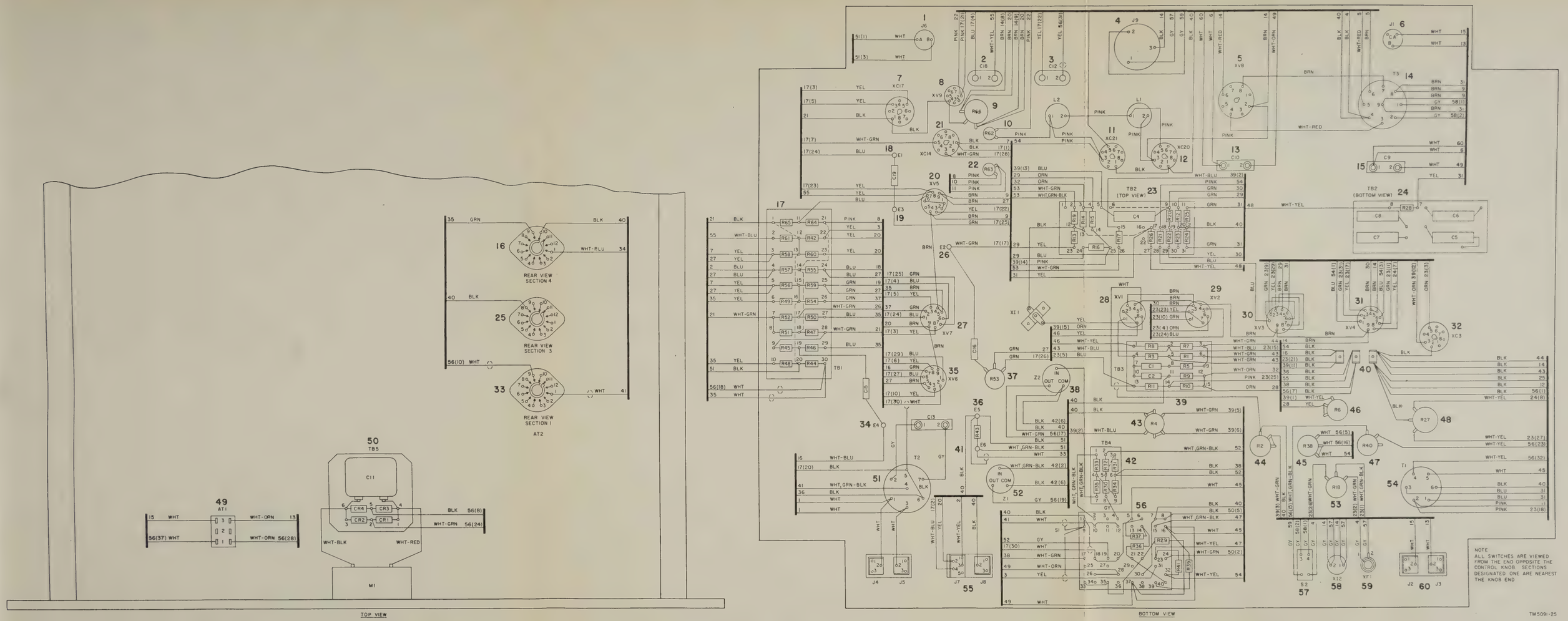
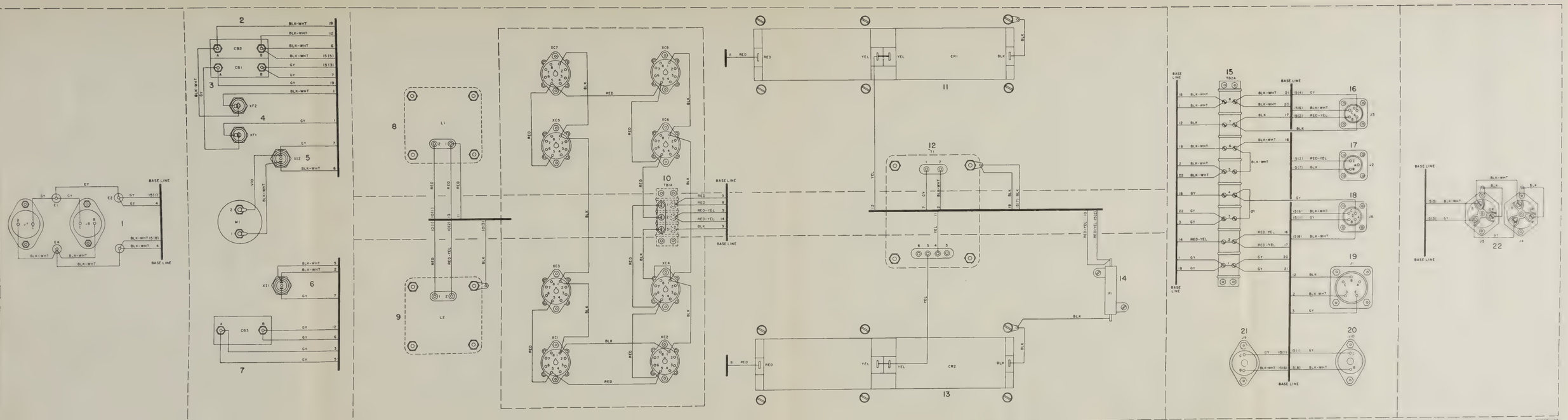
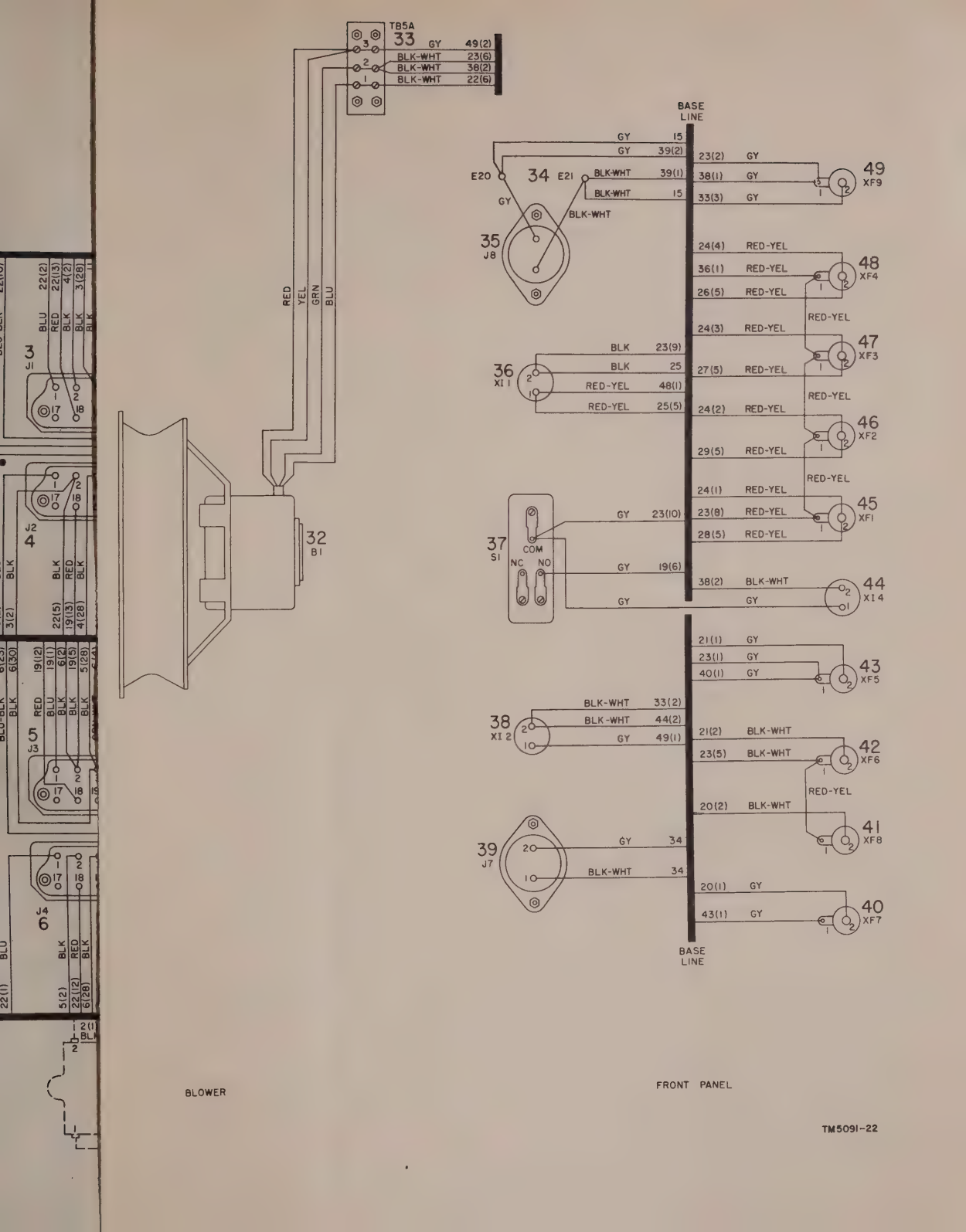


Figure 407. Audio Test Set TS-762/TC, wiring diagram.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
BASE LINE
BLK-WHT
GY
RED
YEL
BLK
RED-YEL
CB1
CB2
CB3
XF1
XF2
XI1
XI2
M1
L1
L2
XC1
XC2
XC3
XC4
XC5
XC6
XC7
XC8
TB1A
TB2A
CR1
CR2
T1
R1
E1
E2
E3
E4
J1
J2
J3
J4
J5
J6
J7
J8


TB5A
33
GY 49(2)
BLK-WHT 23(6)
BLK-WHT 38(2)
BLK-WHT 22(6)
RED
YEL
GRN
BLU
32
B1
BASE LINE
GY 15
GY 39(2)
E20
34
E21
BLK-WHT 39(1)
BLK-WHT 15
GY
BLK-WHT
35
J8
23(2) GY
38(1) GY
33(3) GY
49
XF9
24(4) RED-YEL
36(1) RED-YEL
26(5) RED-YEL
48
XF4
RED-YEL
24(3) RED-YEL
47
XF3
BLK 23(9)
BLK 25
36
XI1
RED-YEL 48(1)
RED-YEL 25(5)
27(5) RED-YEL
RED-YEL
24(2) RED-YEL
46
XF2
29(5) RED-YEL
RED-YEL
24(1) RED-YEL
23(8) RED-YEL
45
XF1
28(5) RED-YEL
GY 23(10)
37
S1
COM
NC
NO
GY 19(6)
GY
38(2) BLK-WHT
GY
44
XI4
21(1) GY
23(1) GY
40(1) GY
43
XF5
BLK-WHT 33(2)
BLK-WHT 44(2)
38
XI2
GY 49(1)
21(2) BLK-WHT
23(5) BLK-WHT
42
XF6
RED-YEL
20(2) BLK-WHT
41
XF8
GY 34
39
J7
BLK-WHT 34
20(1) GY
43(1) GY
40
XF7
BASE LINE
BLOWER
FRONT PANEL
TM5091-22

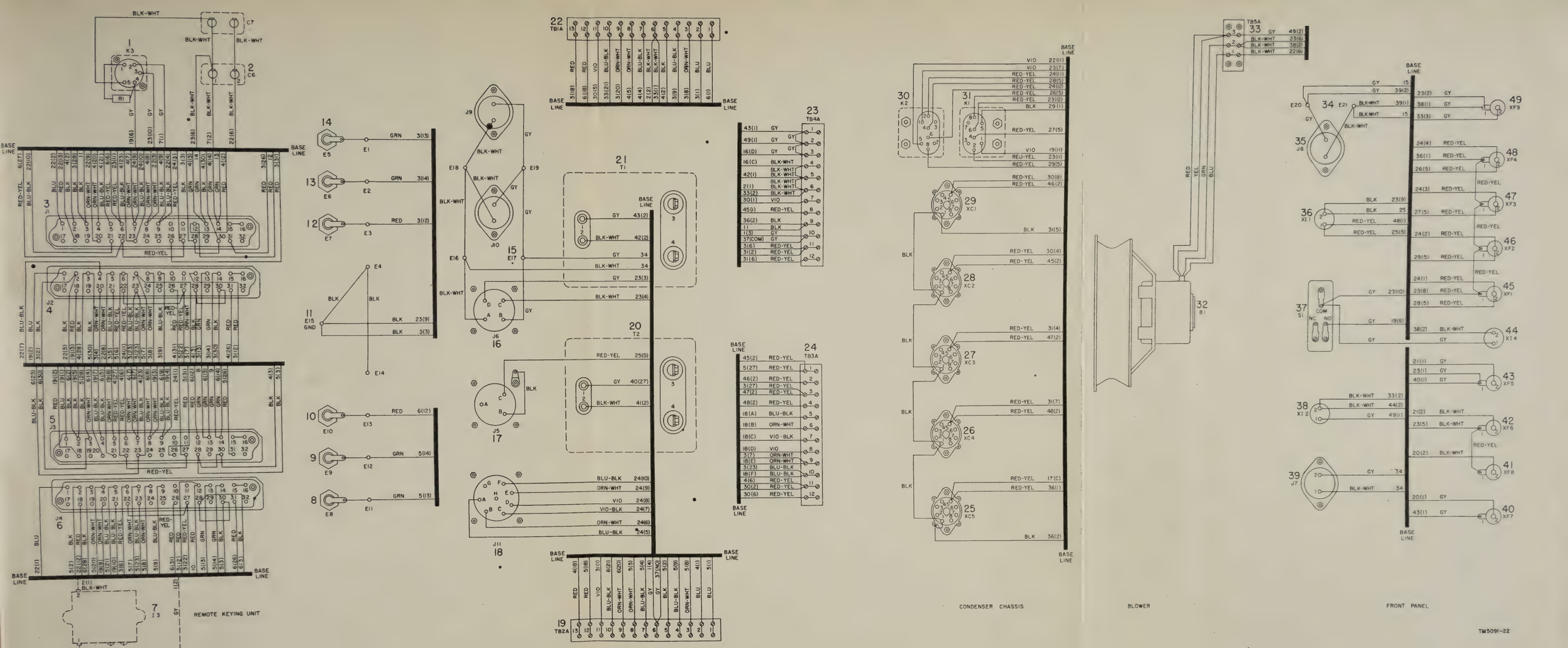


Figure 409. Voltage Regulator CN–236/G, wiring diagram.

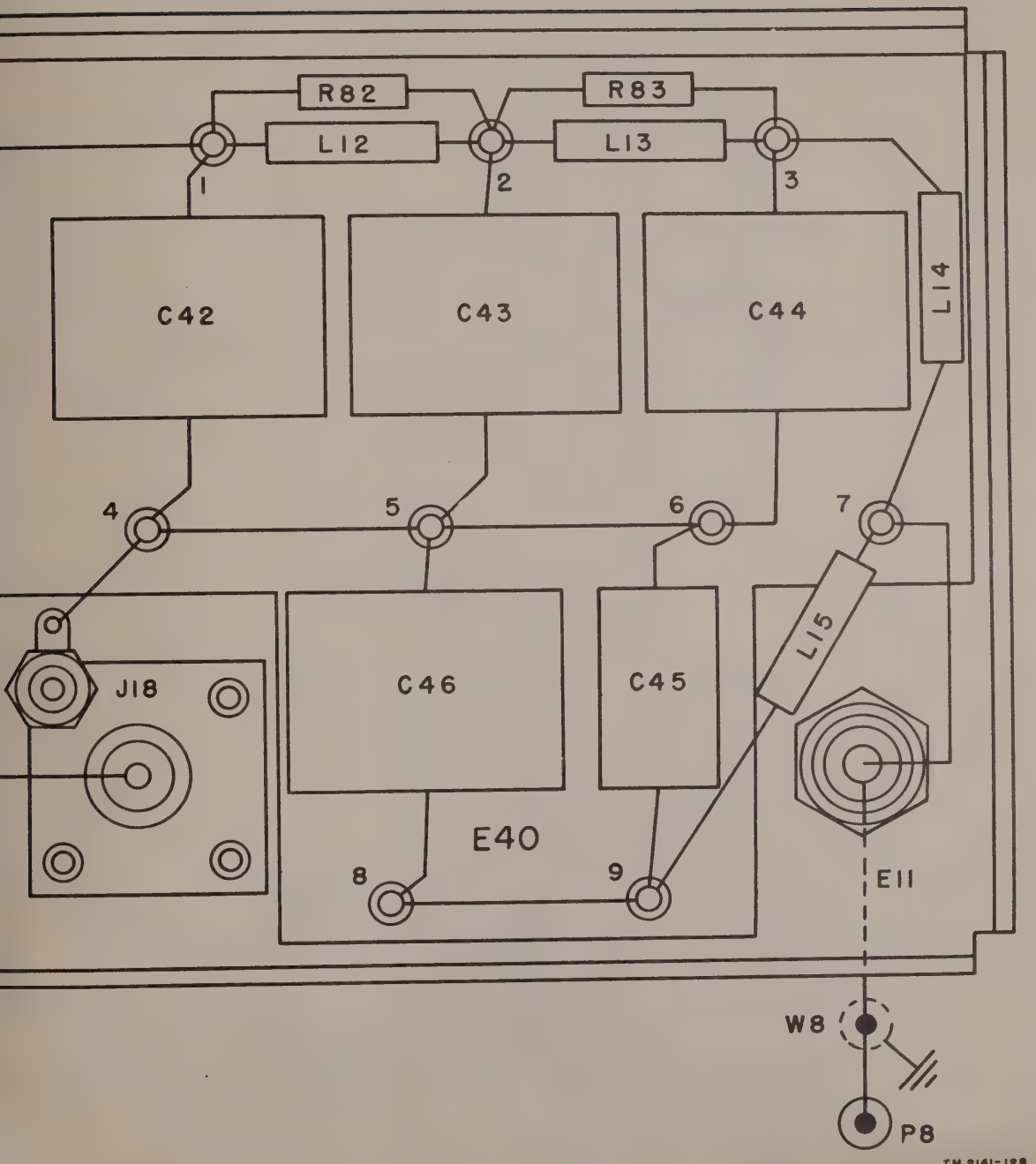


Figure 392. Multiplexer TD–60/TCC–13, demultiplexer section filter, wiring diagram.

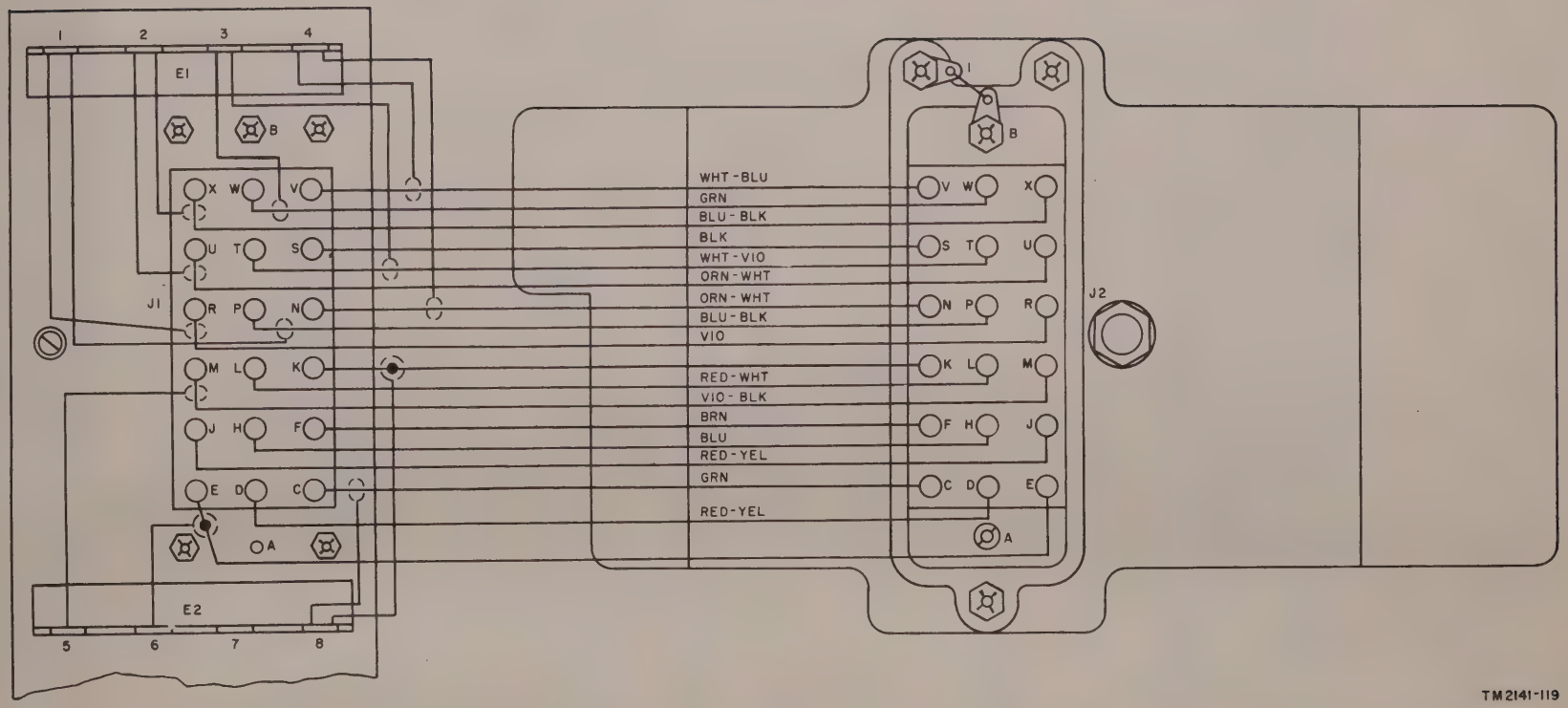


Figure 410. Electrical Connector Assembly J–535/G, wiring diagram.

INDEX

	Paragraph	Page
A		
Accessories case, description	21	25
Additional equipment required	33	33
Alarm circuit:		
Multiplexer Group AN/TCA–1	227-229	206-207
Multiplexer Set AN/TCC–13	186, 224	174-203
Pulse Form Restorer Group AN/TRA–10	227-229	206-207
Alignment, installation procedures (AN/TCA–1 and AN/TRA–10):		
Audio levels	75	70
Four-wire operation	66	62
General	65	62
Initial checks	66	62
Pulse train	70, 71	67-68
Two-wire operation	78*a*	72
Video levels	74	68
Alignment, installation procedures (AN/TCC–13):		
Audio levels	50	50
Four-wire operation	43	44
General	42	44
Initial checks	43, 55	44-52
Pulse train	47, 56	48-52
Two-wire operation	52, 58	51-54
Video levels	48	49
Application, system	4	6
Arctic climates, operation	100	86
Audio output level:		
AN/TCA–1 and AN/TRA–10	75	70
AN/TCC–13	50	50
Audio termination	226	205
Auxiliary equipment, general	137	139
B		
Back-to-back operation	44	47
Basic principles	148-152	146-148
Blanking and insert circuits	202	191
Blanking gate alignment	390	338
C		
Cable connections:		
AN/TCA–1	63*a*	56
AN/TCC–13:		
45 channels	39, 40	41-44
23 channels	39	41
AN/TRA–10	63*b*	57
Cables, description	30	28
Calibrating audio test set	46	48
Calibrator, voltage, oscilloscope, checking	45	48
Case, CY–1280/U, standardized, description	11	19
Channel pulses, modulation	151	148
Characteristics, technical	5	8
Charts, tube trouble-shooting	127, 135	116-137
Checking:		
Alarm circuit	119*b*	111
Cross talk (AN/TCC–13)	121*b*	112
Power supplies	123	113
Remote keying circuits	120	111
Signal-to-noise ratio	121	112
Tubes	127	116
Wave form	116	94
Check list, equipment performance:		
AN/TCA–1 and AN/TRA–10	132	128
AN/TCC–13	117	96
Audio test set	125	115
Oscilloscope	124	113
Use	116, 125	94-115
Checks and adjustment, initial	43, 55, 66	44-52-62
Chest CY–250/U, description	29	28
Circuit AN/TCA–1 and AN/TRA–10:		
Alarm	227	206
Demultiplexing and demodulating	200	189
Modulating and multiplexing	201	189
Order wire	95	83
Remote keying	232	208
Circuit AN/TCC–13:		
Alarm		
Demultiplexing and demodulating (23-channel)	156, 197	152-184
Demultiplexing and demodulating switching (45-channel)	194	181
Multiplexing and modulating (23-channel)	155, 179	151-168

	Paragraph	Page
Circuit AN/TCC–13—*Continued*		
Multiplexing and modulating switching (45-channel)	194	181
Order wire	95	83
Remote keying circuits	195, 197	182-184
Common names	7	10
Common unit controls	80	73
Common unit demultiplexer:		
Checking filament and B+ circuits	288	214
Dc resistance of transformers and coils	296	249
Description	15	23
Detailed theory	179-191	168-178
Repairs	371	333
Sectionalizing trouble	114	93
Test equipment required	298	251
Tests	301	253
Trouble-shooting:		
Chart	300	253
Data	297	251
Procedure	299	251
Tube replacement data	136	138
Tube socket voltages and resistances	289	244
Tube trouble-shooting chart	135	137
Common unit multiplexer:		
Checking filament and B+ circuits	288	244
Dc resistance of transformers and coils	296	249
Detailed theory	159-178	154-167
Repairs	371	333
Sectionalizing trouble	114	93
Test equipment required	292	244
Tests	295	247
Trouble-shooting:		
Chart	294	245
Data	291	244
Tube replacement data	136	138
Tube socket voltages and resistances	289	244
Tube trouble-shooting chart	135	137
Comparison of wave forms	116*c* and *d*	94-95
Components of multiplexer set, arrangement	9	12
Components, table	8	10
Connections, cable:		
AN/TCA–1	63*a*	56
AN/TCC–13	39	41
AN/TCC–13, back-to-back operation	44	47
AN/TRA–10	63*b*	57
Connector assembly, description	28	28
Control monitor:		
Controls	88	79
Dc resistance of transformers and coils	361	322
Description	25	26
Detailed theory	269-272	238-239
General theory	268	238
Sectionalizing trouble	118	111
Test equipment required	358	321
Trouble-shooting:		
Chart	360	322
Data	357	321
Precedure	359	321
Controls:		
Audio test set	87	78
Control monitor	88	79
Electrical Equipment Rack MT/1433–TCA–1	84	76
Electrical Equipment Rack MT–1434/TRA–10	85	76
Modem	82	74
Multiplexer subassembly	83	74
Oscilloscope	86	76
Power supply	89	79
Pulse form restorer (video restorer)	81	73
Switch box	91	81
Voltage regulator	90	81
Cross talk, checking	121*b*	112
Crystals, testing	287	243

D

Data:		
Packaging	6	9
Trouble shooting	279	241
Delay line:		
Description	18	24
Detailed theory	172	163
Repairs	371	333
Test equipment required	319	273
Test procedure	320	273
Trouble-shooting chart	321	276
Trouble-shooting data	318	273
Demodulating and demultiplexing circuit (AN/TCC–13, AN/TCA–1, AN/TRA–10)	156, 200	152-189
Demolition of materiel	408	349
Demultiplexer section, functional description (AN/TCC–13)	156	152
Demultiplexer switching (AN/TCC–13)	194	181
Demultiplexing and demodulating circuit	156, 200	152-189
Description:		
Accessories case	21	25
Audio test set	24	26
Cables	30	28
Case CY–1280/U	11	19
Chest CY–250/U	11	19
Common unit	12	20
Connector assembly	28	28
Control monitor	25	26
Delay line	18	24
Electrical equipment rack, AN/TCA–1	13	20

	Paragraph	Page
Description—*Continued*		
Electrical equipment rack, AN/TCC–13	12	20
Electrical equipment rack, AN/TRA–10	14	23
Filament supply	19	24
Modem	17	24
Modem test extension	28	28
Multiplexer rack	10	13
Oscilloscope	23	26
Power supply	22	26
Pulse form restorer	16	23
Remote keying unit	20	25
Switch box	27	28
Test rack	10	13
Voltage regulator	26	27
Desert climates, operation	102	87
Destruction of materiel	409	349
Disassembly	370	333
Drop-and-insert operation	202	191
E		
Electrical connector assembly	28	28
Electrical power requirements	32	33
Emergency stopping procedure	98	86
Equipment:		
Auxiliary, general	137	139
New, uncrating, unpacking, and checking	35, 61	35-55
Performance check list:		
AN/TCA–1	132	128
AN/TCC–13	117	96
AN/TRA–10	132	128
Use	116	94
Used or reconditioned, service upon receipt	41, 64	44-62
F		
Filament supply:		
Controls	83	74
Description	19	24
Detailed theory	234	213
Repairs	371	333
Test equipment required	335	213
Tests	338	215
Trouble-shooting:		
Chart	337	214
Data	334	288
Procedure	336	289
Forms and records	2	1
Forms, preventive maintenance:		
DA–238	108	89
DA–239	109	89
Forty-five channel operation:		
Checks	122	112
Demultiplexer switching	194	181
General	192	179
Multiplexer switching	193	181
Four-wire operation, installation alignment procedures	42-51	44-51
G		
Gate shaping circuit	213	197
I		
Initial checks and adjustments:		
AN/TCA–1, AN/TRA–10	66	62
AN–TCC/13, 23-channel operation	43	44
AN/TCC–13, 45-channel operation	55	52
Inspection, visual	115	94
Installation alignment procedures:		
Four-wire operation	42-51, 58	44-51-54
General	42, 54, 65	44-52-62
Remote keying operation	53, 59, 77	51-54-72
Two-wire	52, 58	51-54
Installation instructions detailed, AN/TCC–13:		
45-channel	54-59	52-54
General	54	52
23-channel	51, 52	51
Interconnection:		
AN/TCA–1	63	56
AN/TCC–13	63	56
AN/TCC–13, 23-channel	39	41
AN/TCC–13, 45-channel	40	44
L		
Link	138	139
Lubrication	110	89
M		
Maintenance, organizational:		
Tools and materials required	104	88
Trouble shooting, extent of instructions	113	93
Marker separator circuit	184, 214	172-198
Measurement:		
Resistance	284	243
Voltage	280	242
Voltmeter loading	282	242
Mechanical checks, initial:		
AN/TCA–1, AN/TRA–10	66*a*	62
AN/TCC–13, 23-channel operation	43*a*	44
AN/TCC–13, 45-channel operation	55*a*	52
Modem controls	82	74
Modem demodulator:		
Dc resistance of transformers and coils	317	273
Detailed theory	188-191	175-178
Repairs	371	333
Sectionalizing trouble	116, 131	94-125
Test equipment required	310	265
Tests	315, 316	270-272

	Paragraph	Page
Modem demodulator—*Continued*		
Trouble-shooting:		
Chart	312	267
Data	309	265
Procedure	311	267
Tube replacement information	135, 136	137-138
Tube socket voltages and resistances	289	244
Modem, description	17	24
Modem modulator:		
Dc resistance of transformers and coils	317	273
Detailed theory	173, 178	164-167
Repairs	371	333
Sectionalizing trouble	116, 131	94-125
Test equipment required	310	265
Tests	314	270
Trouble-shooting:		
Chart	312	267
Data	304	257
Procedure	311	267
Tube replacement information	135, 136	137-138
Tube socket voltages and resistances	289	244
Tube trouble-shooting chart	135	137
Modem test extension, description	28	28
Modulating and multiplexing circuit:		
AN/TCA–1, AN/TRA–10, detailed theory	218, 222	200-203
AN/TCC–13, detailed theory	159, 178	154-167
Modulation, pulse-position	150	147
Mounting rack (MT–1433/TCA–1):		
Description	13	20
Test equipment required	326	279
Test procedure	326	279
Trouble-shooting data	325	279
Mounting rack MT–1434/TRA–10):		
Alarm circuit test	330	283
Continuity checks	333	287
Controls	85	76
Description	148	146
Test equipment required	328	283
Test procedure	330, 332	283-285
Trouble-shooting data	327	283
Twenty-cycle ringing supply	331	283
Mounting rack (MT–1165/TCC–13):		
Description	12	20
Trouble-shooting data	323	277
Trouble-shooting procedure	324	277
Multiplexer delay line, detailed theory	172, 217	163-200
Multiplexer section functional, description	155	151
Multiplexer subassembly:		
Controls	80	73
General theory	234	213
Trouble shooting	334, 339	289-293
Multiplexer switching, 45-channel operation	55, 80, 193	52-73-181
Multiplexing and modulating circuit:		
AN/TCA–1	201	189
AN/TCC–13	155	151
AN/TRA–10	201	189

N

Names, common usage	7	10
Negative reshaping circuit	206	193
New equipment, uncrating, unpacking, and checking	35, 61	35-55
Nomenclature assignments	7	10

O

Ohmmeter, correct use	285	243
Operation:		
Arctic climates	100	86
Desert climates	102	87
Forty-five channel	54-59	52-54
Order-wire channel	95	83
Time-division multiplexing	149	146
Tropical climates	101	87
Order wire channel, operation	95	83
Organizational maintenance:		
Tools and materials required	104	88
Trouble shooting, extent of instructions	113	93
Oscilloscope:		
Calibrating	45	48
Checking filament and B+ circuits	288	244
Controls	86	76
Dc resistance of transformers and coils	356	312
Description	23	26
Detailed theory	237-262	214-231
Equipment performance check list	124	113
General theory	158	153
Repairs	371	333
Sectionalizing trouble	124	113
Test equipment required	352	302
Tests	355	304
Trouble-shooting:		
Chart	354	303
Data	351	302
Tube replacement information	127, 128	116-118
Tube socket voltages and resistances	353	302
Tube trouble-shooting chart	127	116
Output pulse train, checking alignment:		
AN/TCA–1, AN/TRA–10	70, 71, 394	67-68-340
AN/TCC–13	47, 56, 377	48-52-335

	Paragraph	Page
P		
Packaging data	6	9
Parts replacement	371	333
Power application:		
AN/TCA–1	66*b*	62
AN/TCC–13	43*b*, 55*b*	45-52
AN/TRA–10	66*b*	62
Power requirements:		
AN/TCA–1	5, 387	8-338
AN/TCC–13	5, 381	8-336
AN/TRA–10	5, 387	8-338
Power supplies circuit theory	236	214
Power supply:		
Controls	89	79
Dc resistance of transformers and coils	339	293
Description	22	26
Detailed theory	236	214
Repairs	371	333
Test equipment required	335	289
Trouble-shooting:		
Chart	337	290
Data	334	289
Procedure	336	289
Ppm-tdm system, principles	148-152	146-148
Precautions, high-voltage	281	242
Preliminary adjustments	43, 55, 67	44-52-64
Preventive maintenance:		
Definition	106	89
Forms, preventive maintenance	108, 109	89
Performing	110	89
Principles:		
Pulse-position modulation	150	147
Time-division multiplexing	149	146
Pulse Form Restorer TD–68/G (*See also* video restorer)	16	23
Pulse-position modulation:		
General	148	146
Principles	150	147
Pulses, channel, modulation	49, 76	49-71
Pulse train output: :		
Checking alignment	47, 56, 70	48-52-67
	71, 377, 394	68-335-340
Checking amplitude	48, 57	49-54
	72, 73	68
Purpose and use	3	1
R		
Rack, description	12-14	20-23
Radio-frequency link	138	139
Reconditioned equipment, service upon receipt	41, 64	44-62
Records, forms and	2	1
Reference data, alignment, adjustment, and testing:		
AN/TCA–1, AN/TRA–10	383	337
AN/TCC–13	372	334
Remote keying unit:		
Consideration	141	141
Description	20	25
Operation	53, 59, 577	51-54-68
Organizational trouble-shooting check	120	111
Test procedures	332, 398	285-342
Theory	195-197	182-184
Repacking for shipment	406	348
Repairs:		
Common unit	371	333
Control monitor	371	333
Delay line	371	333
Modem	371	333
Multiplexer subassembly	371	333
Oscilloscope	371	333
Power supply	371	333
Test set	371	333
Video restorer	371	333
Voltage regulator	371	333
Replacement information, tube	128, 136	118-138
Replacement of parts	370, 371	333
Requirements, power	5, 123	8-113
	381, 387	336-338
Reshaping circuit:		
Description	153, 199	149-187
Negative, theory	206	193
Positive theory	212	196
Reshaping wave form	153	227
Resistance, dc transformers, coils, and relays:		
Audio test set	366	331
Common unit	296	249
Control monitor	361	322
Delay line	322	276
Filament supply	339	293
Oscilloscope	356	312
Power supply	344	222
Video restorer	308	265
Voltage regulator	350	299
Resistance measurements	283, 285, 289	243-244
Ringing circuit checks	119, 133, 134	111-136
Ringing circuit, 20-cycle	273-276, 331	239-240-283
Running spares	31	32
S		
Scope	1	1
Sectionalizing trouble:		
Component	131	125
Drop-and-insert repeater	130	124
Terminal	114	93
Signal-to-noise ratio	121	212
Siting	34, 60	35-55
Spares running	31	32
Starting procedure:		
AN/TCA–1, AN/TRA–10	66	62
AN/TCC–13	43, 55	44-52
Stopping procedure:		
AN/TCA–1, AN/TRA–10	78	72
AN/TCC–13	51	51
Switch box:		
Controls	91	81
Description	27	28

	Paragraph	Page
System alignment of audio levels	142	141
System application	4	6
T		
Table of components	8	10
Technical characteristics	5	8
Termination audio	226	205
Test equipment, general theory	204	191
Test equipment required:		
Alignment, adjustment, and final testing	373, 384	334-337
Audio test set	362	323
Common unit demultiplexer	299	251
Common unit multiplexer	292	244
Control monitor	358	321
Delay line	319	273
Filament supply	335	289
Modem	310	265
Mounting rack	324, 326, 328	277-279-283
Oscilloscope	352	302
Power supply	341	294
Video restorer	303	257
Voltage regulator	347	298
Testing:		
Crystals and rectifiers	287	243
Final, test equipment required	373, 384	334-337
Final, test procedure	374, 386	334-337
Test procedure:		
Alignment, adjustment, and final testing	374, 384	334-337
Delay line	320	273
General	278	241
Test rack, description	9	12
Tests:		
Audio test set	362-366	323-331
Common unit demultiplexer	297-301	251-253
Common unit multiplexer	291-296	244-249
Delay line	318-322	273-276
Filament supply	334-339	289-293
Modem	309-317	265-273
Oscilloscope	351-356	302-312
Video restorer	302-308	257-265
Test set, audio:		
Calibrating	46	48
Controls	87	78
Description	24	26
Detailed theory	264-267	233-237
General theory	263	233
Test equipment required	362	323
Tests	364	326
Trouble-shooting chart	363	324
Trouble-shooting data	362	323
Tube socket voltages and resistances	289	244
Tube trouble-shooting chart	127, 128	116-118
Theory:		
AN/TCA–1 and AN/TRA–10	198-204	186-191
AN/TCC 13	154-158	151-153
Time-division:		
Multiplex, general	148	146
Multiplexing, principles	149	146
Tools and materials required, organizational maintenance	104, 105	88
Train, output pulse, alignment checking	47, 56	48-52
	70, 71	67-68
Tropical climates, operation	101	87
Trouble, sectionalization, to component	131	125
Trouble-shooting chart:		
Audio test set	363	324
Common unit demultiplexer	300	253
Common unit multiplexer	294	245
Control monitor	360	322
Delay line	321	276
Filament supply	337	290
Modem	312	267
Oscilloscope	354	303
Power supply	343	297
Switch box	369	332
Tube	127, 135	116-137
Video restorer	305	261
Voltage regulator	346	298
Trouble-shooting data:		
Audio test set	362	323
Common unit demultiplexer	297	251
Common unit multiplexer	291	244
Control monitor	357	321
Delay line	318	273
Filament supply	334	289
Modem	309	265
Mounting rack	323, 325, 327	277-279-283
Oscilloscope	351	302
Power supply	340	294
Switch box	367	332
Video restorer	302	257
Voltage regulator	345	298
Alarm circuit (AN/TRA–10)	330	283
Common unit demultiplexer	299	251
Common unit multiplexer	293	244
Control monitor	359	321
Delay line	320	273
Filament supply	336	289
Modem	311	267
Power supply	342	295
Remote keying (AN/TRA–10)	332	285
Video restorer	304	257
Voltage regulator	348	298
Trouble-shooting with equipment performance check list:		
AN/TCA–1, AN/TRA–10	132	128
AN/TCC–13	116	94
Audio test set	126	115
Oscilloscope	124	113
Tube checking	127	116

	Paragraph	Page
Tube replacement information	128, 136	118-138
Tube socket voltages and resistances	289	244
Tube trouble-shooting charts	127, 135	116-137
Two-wire, installation adjustment procedures	52, 58	51-54
U		
Uncrating and unpacking new equipment	35, 61	33-55
Used equipment, service upon receipt	41, 64	44-62
Use, purpose and	3	1
V		
Video restorer:		
Block diagram	205	192
Dc resistance of transformers or coils	308	265
Controls	81	73
Description	16	23
Detailed theory	205-212	192-196
	214, 215	198-199
	218-221	200-201
	223-225	203-204
	228-231	206-207
Repairing	370, 371	333
Test equipment required	303	257
Tests	306	264
Trouble-shooting:		
Chart	305	261
Data	302	257
Procedure	304	257
Tube data	136	138
Tube replacement chart	135	137
Visual inspection	115	94
Voltage calibrator, oscilloscope, checking	45	48
Voltage measurements	280	242
Voltage regulator:		
Controls	90	81
Description	26	27
Detailed theory	233	209
General theory	157	153
Repairs	371	333
Test equipment required	347	298
Trouble-shooting:		
Chart	346	298
Data	345	298
Procedure	348	298
Tube replacement information	128	118
Tube trouble-shooting chart	127	116
Voltmeter loading	282	242
W		
Wave form:		
Checking	116*c*	94
Comparison	116*d*	95
Weatherproofing	112	93

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *14 March 1956*

TM 11–2141 is published for the use of all concerned.

By Order of *Wilber M. Brucker,* Secretary of the Army:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

Official:

JOHN A. KLEIN
Major General, United States Army,
The Adjutant General.

DISTRIBUTION:

Active Army:

CNGB (1)
Tec Svc, DA (1) except CSIGO (30)
Tec Svc Bd (1)
Hq CONARC (5)
CONARC Bd (Incl ea Test Sec) (1)
Army AA Comd (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
MDW (1)
Armies (5)
Corps (2)
Tng Div (2)
Ft & Cp (2)
Gen & Br Svc Sch (5) except
Sig Sch (25)
Gen Depots (2) except
Atlanta Gen Depot (None)
Sig Sec, Gen Depots (10)
Sig Depots (20)
Trans Terminal Comd (2)
Army Terminals (2)
OS Sup Agencies (2)
Sig Fld Maint Shops (3)
Sig Lab (5)
Mil Dist (1)
Units organized under following TOE:
11–7R, Sig Co, Inf Div (2)
11–16R, Hq & Hq Co, Sig Bn, Corps or
Abn Corps (2)
11–57R, Armd Sig Co (2)
11–127R, Sig Rep Co (2)
11–128R, Sig Depot Co (2)
11–500R (AA-AE), Sig Svc Org (2)
11–557C, Abn Sig Co (2)
11–587R, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2)
11–597R, Sig Base Depot Co (2)

NG: State AG (6); units—same as Active Army except allowance is one copy per unit.
USAR: None.
For explanation of abbreviation used, see SR 320–50–1.

☆U. S. GOVERNMENT PRINTING OFFICE 1956:—362524—8—A