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**TECHNICAL MANUAL**

for

**POWER SUPPLY**

**MODEL TPSA-20**



**THE TECHNICAL MATERIEL CORPORATION**  
**MAMARONECK, N.Y.**

**OTTAWA, CANADA**

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MAMARONECK, N.Y. OTTAWA, CANADA

**IN 1004C**

**January 1, 1968**

## **NOTICE**

THE CONTENTS AND INFORMATION CONTAINED IN THIS INSTRUCTION MANUAL IS PROPRIETARY TO THE TECHNICAL MATERIEL CORPORATION TO BE USED AS A GUIDE TO THE OPERATION AND MAINTENANCE OF THE EQUIPMENT FOR WHICH THE MANUAL IS ISSUED AND MAY NOT BE DUPLICATED EITHER IN WHOLE OR IN PART BY ANY MEANS WHATSOEVER WITHOUT THE WRITTEN CONSENT OF THE TECHNICAL MATERIEL CORPORATION.

TECHNICAL MANUAL CHANGE NOTICE

DATE: Feb. 12/68

MANUAL AFFECTED: Power Supply Model TPSA-20

IN1004C

Page 4-1, paragraph 4-2b.

In the last sentence of 4-2b, change "at pin 17 of J903" to read across pins 16 and 17 of J903.

Figure 7-1, sheet 1

- a. Add a lead from pin 16 of J903 to the lead joining T901, pin 6, and F900.
- b. Label pin 16 of J903: PILOT LAMP
- c. Change pin 9 of J903 from +27 V REG. to + 28 V REG.
- d. Label the "INTERNAL/OFF/EXTERNAL" switch: S900, OVEN VOLTAGE.

In the bottom right corner of the sheet, change FIGURE 7-3 to FIGURE 7-1 and add page number 7-3.

Figure 7-1, sheet 2

In the bottom right corner of the sheet, change FIGURE 7-5 to FIGURE 7-1 and add page number 7-5.



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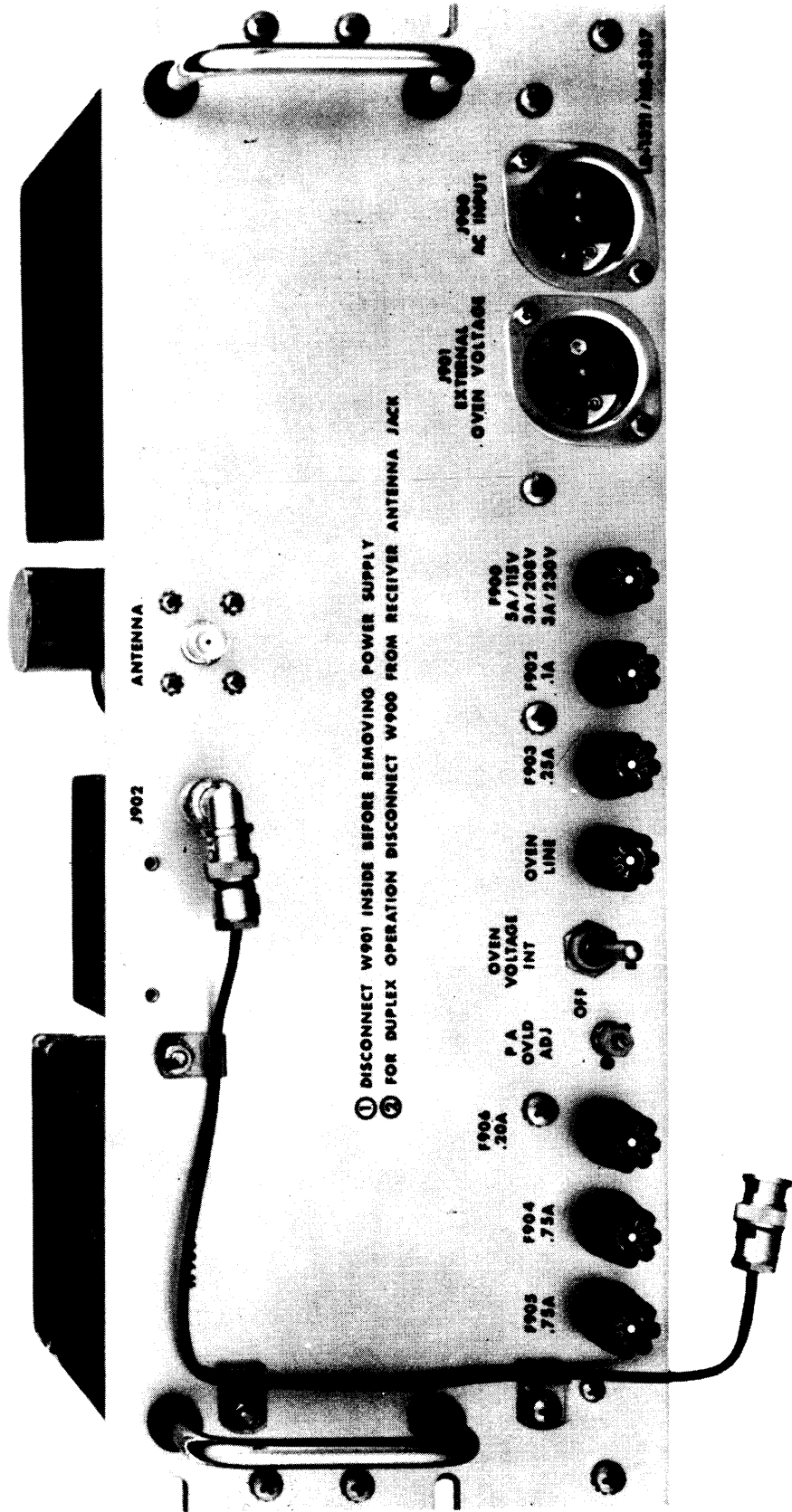


Figure 1-1. Power Supply, Model TPSA-20

## SECTION 1

### GENERAL INFORMATION

#### 1.1 DESCRIPTION

Power Supply, Model TPSA-20 (see figure 1-1), is a solid-state power supply designed to plug into TMC transmitter/receivers (such as the TTR-20) that do not have power supplies built in. The TPSA provides all operating voltages required by the associated transmitter/receiver as well as antenna switching for simplex operation of the associated transmitter/receiver. The TPSA contains:

- (1) a low-voltage power supply for operation of receiver and exciter circuits;
- (2) a filament, bias, and high-voltage power supply for operation of linear-amplifier circuits;
- (3) an antenna switching relay.

Most of the smaller components in the TPSA are located on a printed-circuit board that is mounted to the chassis; larger components are chassis mounted. All TPSA outputs are available at a connector (J903) mounted on the rear of the unit. The front panel provides jacks for connecting the TPSA to a primary-power source, to external oven power supplies, and for antenna input and output connections. All fuses for the TPSA are mounted on the front panel.

Performance specifications and other reference data (physical dimensions, weight, etc.) are given in paragraph 1-2. The semiconductor complement of the TPSA is given in table 1-1.

TABLE 1-1. SEMICONDUCTOR COMPLEMENT

Reference Designation	Type	Function
CR901 through CR904	1N547	Rectifiers
CR905 through CR908	1N3006RB	Zenner regulators
CR909	DD108-1	Bridge rectifier
CR910 and CR911	1N547	Rectifiers
CR912	1N3022B	Voltage reference
CR913 and CR914	1N547	Rectifiers
CR915	1N3022B	Voltage reference
CR916 and CR917	1N547	Rectifiers
CR918	1N3030B	Voltage reference
Q900	2N350A	+12 V series regulator
Q901	2N350A	-12 V series regulator
Q902	2N3616	+28 V series regulator



## 1-2 TECHNICAL SPECIFICATIONS

Primary power input	115/208/230 volts, 50-400 Hz single phase ac.
Oven power input	Depends upon the type of ovens used in the equipment of which the TPSA is a part.
Outputs	
1. Regulated	+12, -12, +28, -105 and +315 V dc.
2. Unregulated	+400, +800 V, and -150 V dc.
3. Oven voltage	Same as primary-power input when OVEN VOLTAGE switch is set at INT. Same as oven-power input when OVEN VOLTAGE switch is set at EXT.
4. Filament voltage	6.3 V ac.
Dimensions	Depth: 6.0 inches Width: 16.5 inches Height: 6.25 inches
Weight, uncrated	40 pounds

## SECTION 2

### INSTALLATION

#### 2-1 INITIAL INSPECTION

Each TPSA has been thoroughly checked and tested at the factory before shipment. When it arrives at the operating site, inspect the packing case and its contents immediately for possible damage. Unpack the equipment carefully; inspect all packing material for parts that have been shipped as loose items. With respect to damage to the equipment for which the carrier is liable, TMC (Canada) Limited will assist in describing methods of repair and the furnishing of replacement parts.

#### 2-2 POWER REQUIREMENT

a. MAIN POWER—The TPSA can operate with 115, 208, or 230 volts ac power; it is factory

wired for 115 volts ac unless otherwise specified on customer's order. Minor wiring changes must be made to power transformers T900 and T901 (see figure 2-1) if the TPSA is to be operated from a power source other than that for which it was originally configured. It is recommended that a 5-ampere fuse (F900) be used with 115 volts, and a 3-ampere fuse be used with 208 or 230 volts.

b. OVEN POWER—When OVEN VOLTAGE switch S900 is set at INT, primary-power input voltage is available for crystal ovens in the unit that is powered by the TPSA. If a voltage other than the primary input-voltage is required, an external oven supply must be provided. This supply must be connected to EXTERNAL OVEN VOLTAGE jack J901, and the OVEN VOLTAGE switch must be set at EXT; if no oven-supply

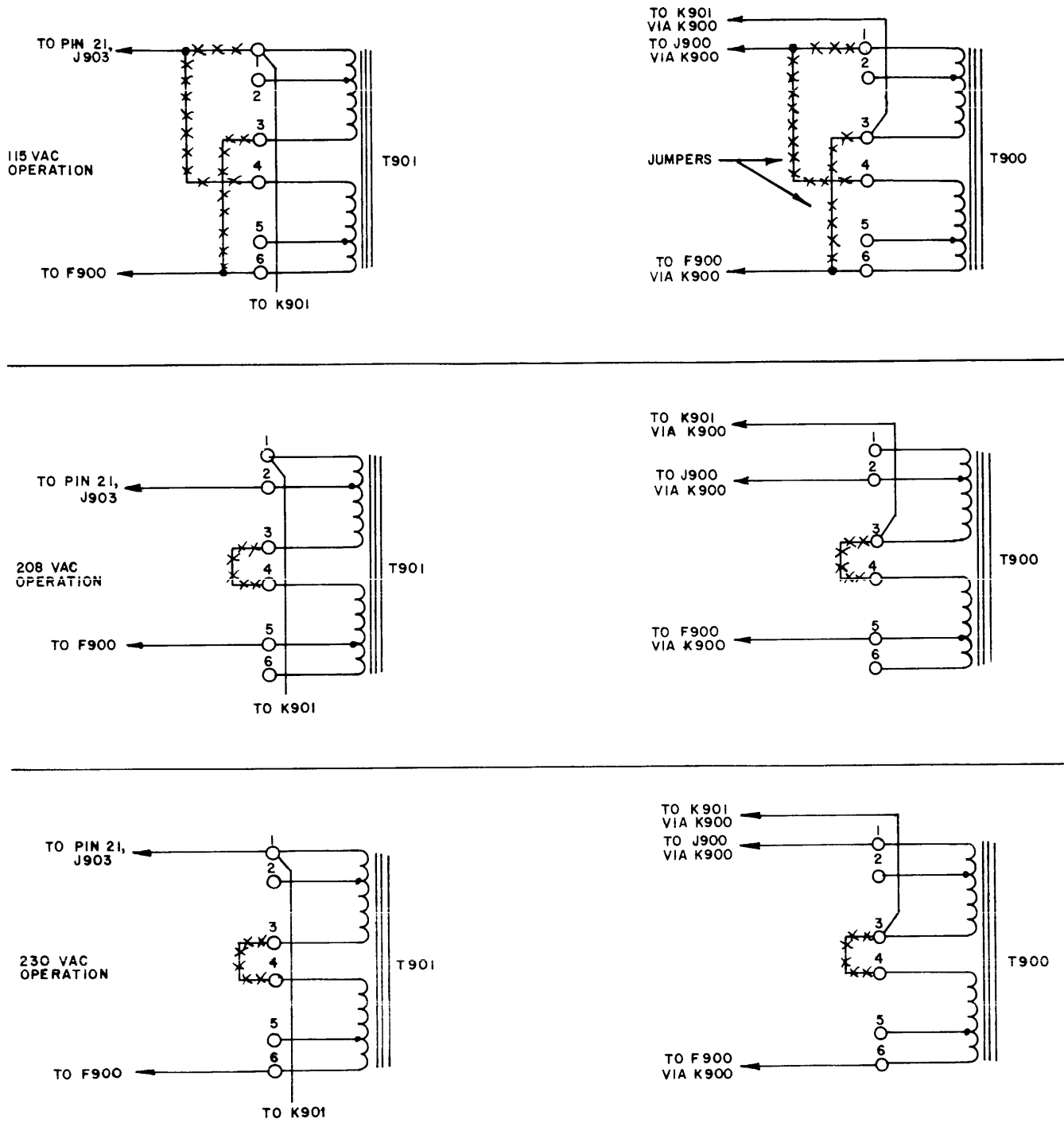


Figure 2-1. Power Transformer Wiring

voltage is required, the OVEN VOLTAGE switch should be set at OFF. The value of OVEN LINE fuse F901 depends upon the number of crystal ovens in use and upon the oven supply voltage.

### 2-3 INSTALLATION REQUIREMENTS

Any installation procedures required for the TPSA are included in the manual for the unit in which the TPSA is used.

### 2-4 PERFORMANCE CHECK

Proper operation of the TPSA is verified by satisfactory completion of the performance check for the unit in which the TPSA is used.

#### NOTE

PA OVLD ADJ R907 must be set at the time of installation. The setting will depend on the unit in which the TPSA is used.

## SECTION 3

### OPERATOR'S SECTION

The TPSA has one operator's control: the OVEN VOLTAGE switch. If the ovens in the transmitter/receiver (of which the TPSA is a part) are to be operated from the same primary power source as the power supply, set the OVEN VOLTAGE switch at INT. If the ovens in the

transmitter/receiver are to be operated from a separate power source (connected to EXTERNAL OVEN VOLTAGE jack J901), set the switch at EXT. If no oven-supply voltage is required, set the switch at OFF.

## SECTION 4

### PRINCIPLES OF OPERATION

#### 4-1 GENERAL

The TPSA, designed for use with TMC transmitter/receivers that do not have built-in power supplies, produces all operating voltages required by the associated transmitter/receiver, and also provides antenna switching for the transmitter/receiver when it is used in simplex operation. Circuit analyses for the four circuits that constitute the TPSA are given in paragraphs 4-2 a through 4-2d.

#### 4-2 CIRCUIT ANALYSES (See figure 7-1)

a. OVEN SUPPLY—The oven supply provides operating voltage for crystal ovens contained in the RF stages of the unit that the TPSA powers.

The oven-supply voltage is applied across pins 23 and 24 of J903 through OVEN VOLTAGE switch S900. If the ovens used in the associated transmitter/receiver require the same voltage as the ac input to the TPSA, S900 is set at INT. For other oven-voltage requirements, S900 is set at EXT and the oven voltage is provided by an external source connected to EXTERNAL OVEN VOLTAGE jack J901. If ovens are not used, S900 is set at OFF. The external oven supply is fused in the TPSA.

b. LOW-VOLTAGE POWER SUPPLY—The low-voltage power supply consists of three independent, separately-fused, regulated supplies: a +12 Vdc supply, a -12 Vdc supply and a +28 Vdc supply. Each supply contains a series-

regulating transistor in which the output voltage (at the emitter) is compared to a stable zener-diode reference voltage (at the base.) The conduction in the series regulator varies as its emitter voltage changes, and thus, a constant output voltage is maintained. The +12 Vdc and -12 Vdc supplies are identical, and are very similar to the +28 Vdc supply.

The ac power for the low-voltage power supply is provided by step-down transformer T901, which can be wired for operation with 115 Vac, 208 Vac, or 230 Vac. Power from AC INPUT jack J900 is supplied to the low-voltage power supply whenever pins 20 and 21 of J903 are connected together; this connection is made by the power switch of the transmitter/receiver in which the TPSA is used. Operating voltage for a pilot lamp in the associated transmitter/receiver is provided at pin 17 of J903 whenever the low-voltage power supply is energized.

c. HIGH-VOLTAGE POWER SUPPLY—The high-voltage power supply consists of a +800 Vdc unregulated supply, a +400 Vdc unregulated supply, a +315 Vdc zener-diode regulated supply, a -150 Vdc unregulated supply and a -105 Vdc zener-diode regulated supply. Each supply, except the +800 Vdc supply, is separately fused; the +800 Vdc supply is protected by a circuit breaker in the associated transmitter/receiver, whose trip point is determined by the setting of PA OVLD ADJ R907. In addition, the high-voltage supply provides a 6.3 Vac output. All of the outputs of the high-voltage supply are used for the operation of the linear amplifier in the transmitter section of the unit in which the TPSA is installed.

Both the +800 Vdc and +400 Vdc unregulated supplies receive their ac voltage from winding 9-10-11 of T900. The +800 Vdc supply is derived by the ac voltage developed across the entire-winding; this ac voltage is full-wave rectified by bridge rectifier CR909. The +400

Vdc supply is derived by the ac voltage developed across either winding 9-10 or 10-11 depending upon the instantaneous polarity of the induced voltage. This ac voltage is full-wave rectified by two of the four diodes in CR909.

Thus, at any instant, two of the four diodes are shared by both the +800 Vdc and +400 Vdc supplies, while the other two are part of the +800 Vdc supply only.

The ac power for the high-voltage power supply is provided by transformer T900, which can be wired for operation with 115, 208, or 230 Vac. Power from AC INPUT jack J900 is supplied to the high-voltage power supply whenever HV control relay K900 is energized. Relay K900 is energized by +12 Vdc from the low-voltage power supply when pin 5 of J903 is grounded through the interlock circuit in the associated transmitter.

d. ANTENNA SWITCHING CIRCUIT—Antenna relay K901 provides antenna switching for simplex operation of the transmitter/receiver in which the TPSA is used. In simplex operation, the output of the transmitter section is connected through W901 to P900; the input to the receiver section is connected from P901 through W902; the antenna is connected to the ANTENNA jack. When K901 is deenergized, the antenna is connected to the receiver section input, and the output of the transmitter section is grounded. When K901 is energized, the antenna is connected to the transmitter section output, and the input to the receiver section is grounded. In duplex operation, W902 is disconnected from K901 and a separate receiving antenna is used. The transmitter section output remains connected through the antenna relay, however.

Operating power for the antenna relay is supplied through normally open contacts of HV control relay K900, and contacts of a transmit/receive relay in the associated transmitter/receiver. The antenna relay is energized only when the transmitter section is ready for operation and the transmitter is keyed.

## SECTION 5

### MAINTENANCE

#### 5-1 PREVENTIVE MAINTENANCE

Preventive maintenance of the TPSA consists of routine visual inspection and cleaning. Cleaning is necessary because dust may accumulate on certain components and not only reduce the efficiency of the unit, but also increase component wear. Either a vacuum cleaner or a compressed air hose is the quickest and most effective method of cleaning the unit. Visually checking the TPSA at the time of cleaning can prevent downtime due to component failure. Often a deteriorating component will look bad before it actually affects the operation of the unit. Some indications of trouble are: discolored components, leaking capacitors, dirty switch and relay contacts, warped printed-circuit boards, and damaged wiring. Any components found in this condition should be replaced. In addition, all hardware should be checked for tightness. Refer to figure 5-1 for aid in locating components of the TPSA-20.

#### 5-2 TROUBLESHOOTING

The first step in troubleshooting the TPSA is to ascertain which of the supplies (oven supply, low-voltage power supply, or high-voltage power supply) is not operating properly. Check the fuse for each supply before proceeding with any extensive troubleshooting. If the problem is not a blown fuse, remove the TPSA from the associated transmitter/receiver, and bench test the unit.

#### NOTE

The TPSA must be connected to its associated transmitter/receiver when making voltage

measurements so that the on/off control circuits function.

The following are the voltage measurements for the regulating transistors in the low-voltage power supply. All of the readings are taken with respect to ground.

TRANSISTOR NO.	BASE	EMITTER	COLLECTOR
Q900	0	0	+13
Q901	-12	-12	-25
Q902	-36	-36	-65 V

#### 5-3 REPAIR

In most cases, the repair of the TPSA will consist of the replacement of an electrical component. Although no special instructions are required to accomplish this, the following hints are provided to ensure that the repairs are completed properly.

a. Always replace a defective component with its exact duplicate.

b. Always place a new component in the same position as the one it replaces. In general, never change the existing chassis layout, whether in the routing of wiring or component placement.

c. Never use a soldering iron with a power rating of more than 100 watts. Use a pair of long-nose pliers as a heat sink to protect components while soldering.

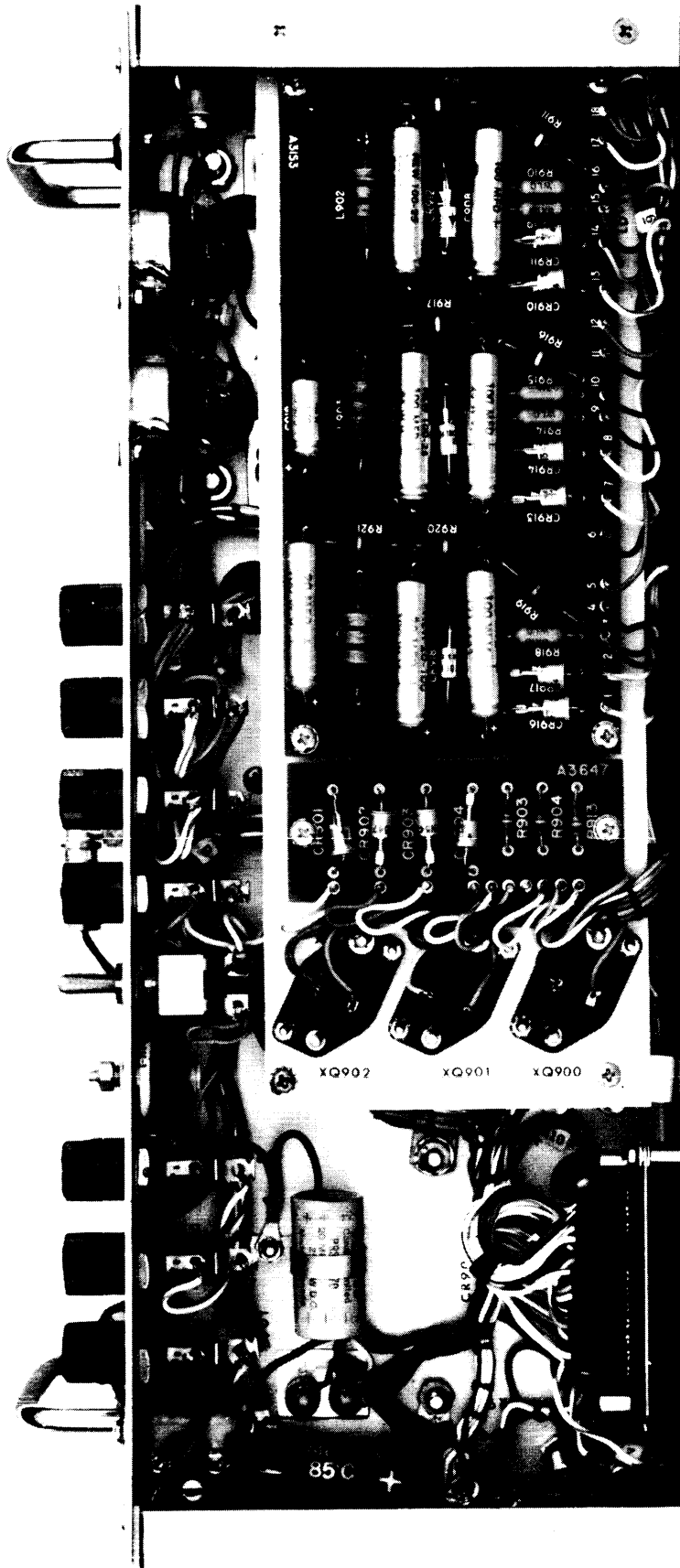


Figure 5-1. TPSA-20, Bottom View

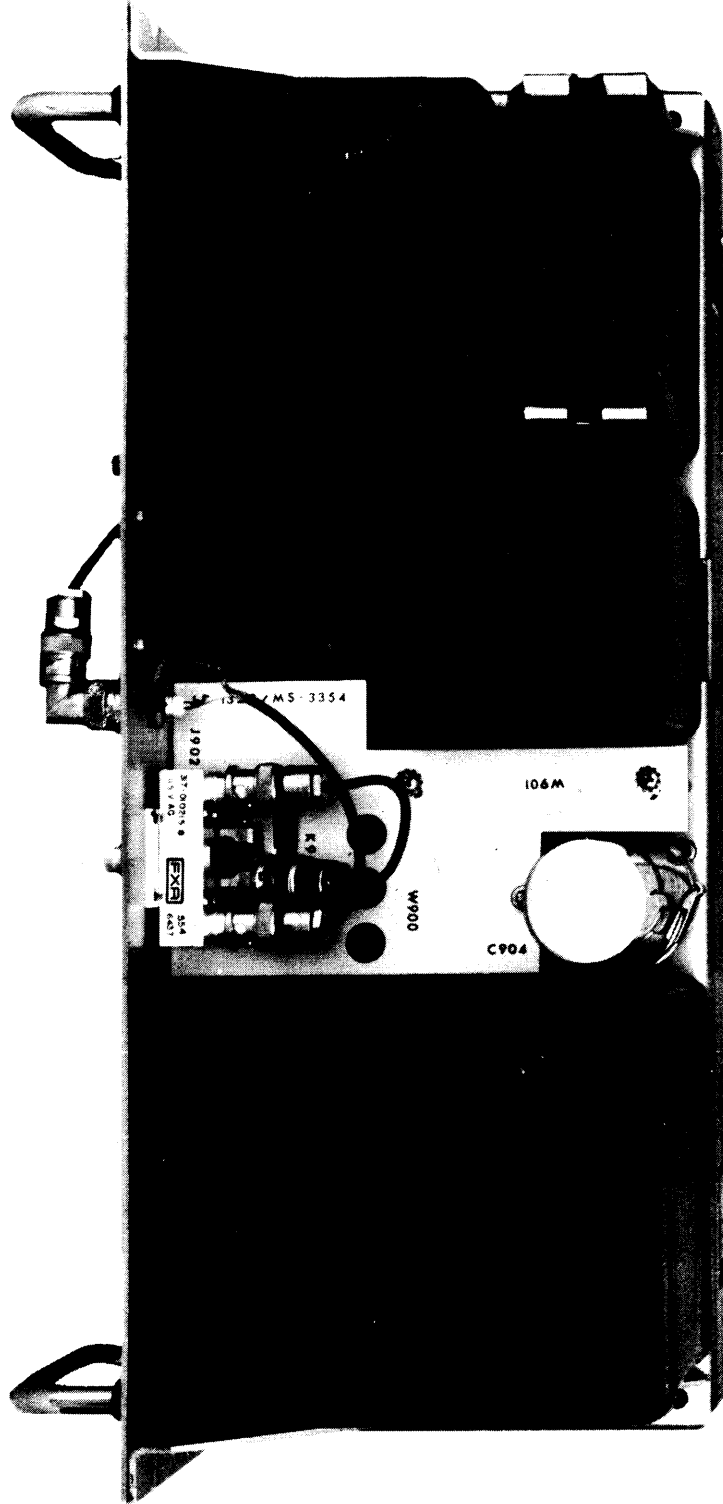


Figure 5-2. TPSA-20, Top View

## SECTION 6

### PARTS LIST

Reference designations have been assigned to identify all electrical parts of the equipment. These designations are used for marking the equipment (adjacent to the parts they identify) and are included on drawings, diagrams and the parts list. The letters of a reference designation indicate the kind of part (generic group), such as resistor, capacitor, transistor, etc. The number differentiates between parts of

the same generic group. Sockets associated with a particular plug-in device, such as transistor or fuse, are identified by a reference designation which includes the reference designation of the plug-in device. For example, the socket for fuse F900 is designated XF900. To expedite delivery when ordering replacement parts, specify the TMC part number and the model number of the equipment.



MAIN CHASSIS

Ref Symbol	Description	TMC Part Number
C900A,B	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 2 x 10,000 pF, GMV; 1,000 WVDC	CC100-23
C901A,B	Same as C900A,B	
C902	CAPACITOR, FIXED, ELECTROLYTIC: 20 uF, 250 WVDC; polarized	CE103-5
C903	Same as C902	
C904	CAPACITOR, FIXED, ELECTROLYTIC: 80 pF, 450 WVDC; polarized	CE51F800R
C905	CAPACITOR, FIXED, PAPER DIELECTRIC: 10.0 uF, ±10%; 1,000 WVDC at 40°C	CP115-1
C906	NOT USED	
C907	CAPACITOR, FIXED, ELECTROLYTIC: 2,000 uF, 25 WVDC; polarized	CE116-5VN
C910	Same as C907	
C911	Same as C907	
C914	CAPACITOR, FIXED, ELECTROLYTIC: 100 pF, 100 WVDC; polarized	CE51C101H
CP900	ADAPTER, CONNECTOR, ELECTRICAL: RF type; right angle, one male, one female coaxial contact; series BNC to BNC	UG306B/U
CR900	NOT USED	
CR901	SEMICONDUCTOR DEVICE, DIODE: silicon	1N547
CR902 thru CR904	Same as CR901	
CR905	SEMICONDUCTOR DEVICE, DIODE: Zener, silicon	1N3006RB
CR906 thru CR908	Same as CR905	

MAIN CHASSIS

Ref Symbol	Description	TMC Part Number
CR909	SEMICONDUCTOR DEVICE, DIODE: silicon	DD108-1
F900	FUSE, CARTRIDGE: 3 A, 250 volts; medium time lag; 1-1/4 in. lg. x 1/4 in dia.; hi-rating. (FOR 208/230 VAC OPERATION)	FU103-3
F900	FUSE, CARTRIDGE: 5 A, 250 volts; medium time lag; 1-1/4 in lg. x 1/4 in dia.; hi-rating. (FOR 115 VAC OPERATION)	FU103-5
F901	FUSE, CARTRIDGE: 1/8 A; time lag; 1-1/4 in lg. x 1/4 in dia.; slow blow. (USED WITH 2 OVENS)	FU102-.125
F901	FUSE, CARTRIDGE: 1/4 A; time lag; 1-1/4 in lg. x 1/4 in dia.; slow blow (USED WITH 4 OVENS)	FU102-.250
F901	FUSE, CARTRIDGE: 3/8 A; time lag; 1-1/4 in lg. x 1/4 in dia.; slow blow (USED WITH 6 OVENS)	FU102-.375
F901	FUSE, CARTRIDGE: 1/2 A; time lag; 1-1/4 in lg. x 1/4 in dia.; slow blow (USED WITH 8 OVENS)	FU102-.5
F902	FUSE, CARTRIDGE: 1/10 A; time lag; 1-1/4 in lg. x 1/4 in dia.; slow blow	FU102-.1
F903	Same as F902	
F904	FUSE, CARTRIDGE: 3/4 A; time lag: 1-1/4 in lg. x 1/4 in dia.; slow blow.	FU102-.750
F905	Same as F904	
F906	FUSE, CARTRIDGE: 2/10 A; time lag; 1-1/4 in lg. x 1/4 in dia.; slow blow.	FU102-.2
J900	CONNECTOR, RECEPTACLE, ELECTRICAL: male; ac power; 2 contacts: 250 V at 10 A, 125 V at 15 A; polarized; twist lock	JJ175
J901	Same as J900	
J902	CONNECTOR, RECEPTACLE, ELECTRICAL: RF; 1 round female contact; straight type; 52 ohms; series BNC to BNC	UG625/U

MAIN CHASSIS

Ref Symbol	Description	TMC Part Number
J903	CONNECTOR, RECEPTACLE, ELECTRICAL: 24 flat female contacts, rated at 5 A, 750 WVDC; polarized. Part of W903	JJ295-1
K900	RELAY, ARMATURE: 3PDT	RL144-2
K901	RELAY, ARMATURE, COAXIAL: RF	RL157-1
L900	REACTOR: inductance, 8 H at 160 mAdc at 120 Hz; max. dc current 160 mA; 180 ohms nom. dc resistance	TF5017
L901	REACTOR: 50 H at 15 mA dc and 10 H at 200 mA dc	TF5018
P900	CONNECTOR, PLUG, ELECTRICAL: RF; BNC type. Part of W901	PL169
P901	Same as P900. Part of W902	
P902	Same as P900. Part of W900	
P903	Same as P900. Part of W900	
P904	Same as P900. Part of W901	
Q900	TRANSISTOR: germanium	2N350A
Q901	Same as Q900	
Q902	Transistor	2N3616
R900	RESISTOR, FIXED, WIREWOUND: 2,250 ohms; current rating 47 mA; 5 watts	RW107-41
R901	Same as R900	
R902	RESISTOR, FIXED, WIREWOUND: 1,000 ohms; current rating 100 mA; 10 watts	RW109-24
R903	RESISTOR, FIXED, COMPOSITION: 15,000 ohms, $\pm 5\%$ ; 1/2 watt	RC20GF153J
R904	Same as R903	
R905	RESISTOR, FIXED, WIREWOUND: 2,000 ohms; current rating 100 mA; 25 watts	RW111-24

MAIN CHASSIS

Ref Symbol	Description	TMC Part Number
R906	RESISTOR, FIXED, WIREWOUND: 50,000 ohms; current rating 8 mA; 25 watts	RW111-40
R907	RESISTOR, VARIABLE, WIREWOUND: 350 ohms, $\pm 10\%$ ; 12.5 watts; linear taper A.	RP100XH351K
R908	RESISTOR, FIXED, WIREWOUND: 2,000 ohms; current rating 70 mA; 10 watts	RW109-28
R913	RESISTOR, FIXED, COMPOSITION: 82,000 ohms, $\pm 5\%$ ; 1/2 watt	RC20GF823J
R922	RESISTOR, FIXED, WIREWOUND: 30 ohms, $\pm 5\%$ ; current rating 408 mA; 5 watts	RW107-13
S900	SWITCH, TOGGLE: DPDT	ST50P
T900	TRANSFORMER, POWER, STEP-DOWN, STEP-UP	TF265
T901	TRANSFORMER, POWER, STEP-DOWN	TF264
W900	CABLE ASSEMBLY, ELECTRICAL: RF; two cable connectors, P902, P903.	CA480-3-14
W901	CABLE ASSEMBLY, ELECTRICAL: RF; two cable connectors, P900, P904	CA480-3-5
W902	CABLE ASSEMBLY, ELECTRICAL: RF; one cable connector, P901	CA480-96-5
W903	WIRING HARNESS, BRANCHED, ELECTRICAL: one cable connector, J903	CA10501

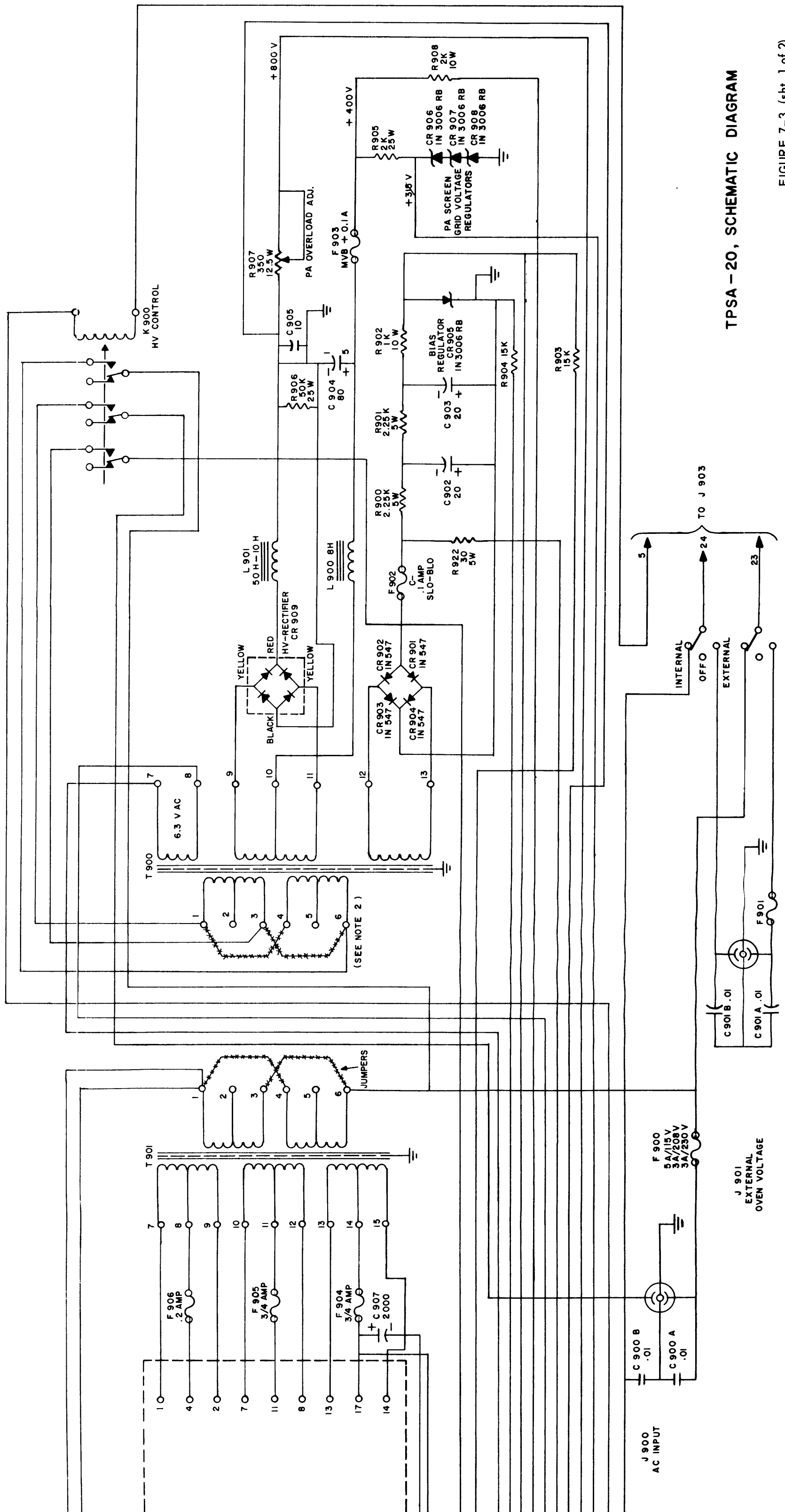
POWER SUPPLY BOARD  
A10545-7

Ref Symbol	Description	TMC Part Number
C908	CAPACITOR, FIXED, ELECTROLYTIC: 100 uf, -10%, +150% at 120 Hz at 25°C; 25 WVDC; polarized	CE105-100-25
C909	Same as C908	
C912	Same as C908	
C913	Same as C908	
C915	CAPACITOR, FIXED, ELECTROLYTIC: 20 uf, -10% +150% at 120 Hz at 25°C; 100 WVDC; polarized	CE105-20-100
C916	Same as C915	
C917	Same as C915	
C918	CAPACITOR, FIXED, ELECTROLYTIC: 25 uf, -10%, +150% at 120 Hz at 25°C; 50 WVDC; polarized	CE105-25-50
CR910	SEMICONDUCTOR DEVICE, DIODE: silicon	1N547
CR911	Same as CR910	
CR912	SEMICONDUCTOR DEVICE, DIODE: silicon	1N3022B
CR913	Same as CR910	
CR914	Same as CR910	
CR915	Same as CR912	
CR916	Same as CR910	
CR917	Same as CR910	
CR918	SEMICONDUCTOR DEVICE, DIODE: Zener	1N3030B
L902	COIL, RF: fixed; 1 mH	CL101-2
L903	Same as L902	
L904	Same as L902	
R909	RESISTOR, FIXED, WIREWOUND: 10 ohms ±5%; 3 watts	RW123-100J
R910	Same as R909	

POWER SUPPLY BOARD  
A10545-7

Ref Symbol	Description	TMC Part Number
R911	RESISTOR, FIXED, COMPOSITION: 100 ohms $\pm 5\%$ ; 1 watt	RC32GF101J
R912	Same as R911	
R914	Same as R909	
R915	Same as R909	
R916	Same as R911	
R917	Same as R911	
R918	Same as R909	
R919	RESISTOR, FIXED, COMPOSITION: 1,000 ohms $\pm 5\%$ ; 1 watt	RC32GF102J
R920	Same as R919	
R921	Same as R919	

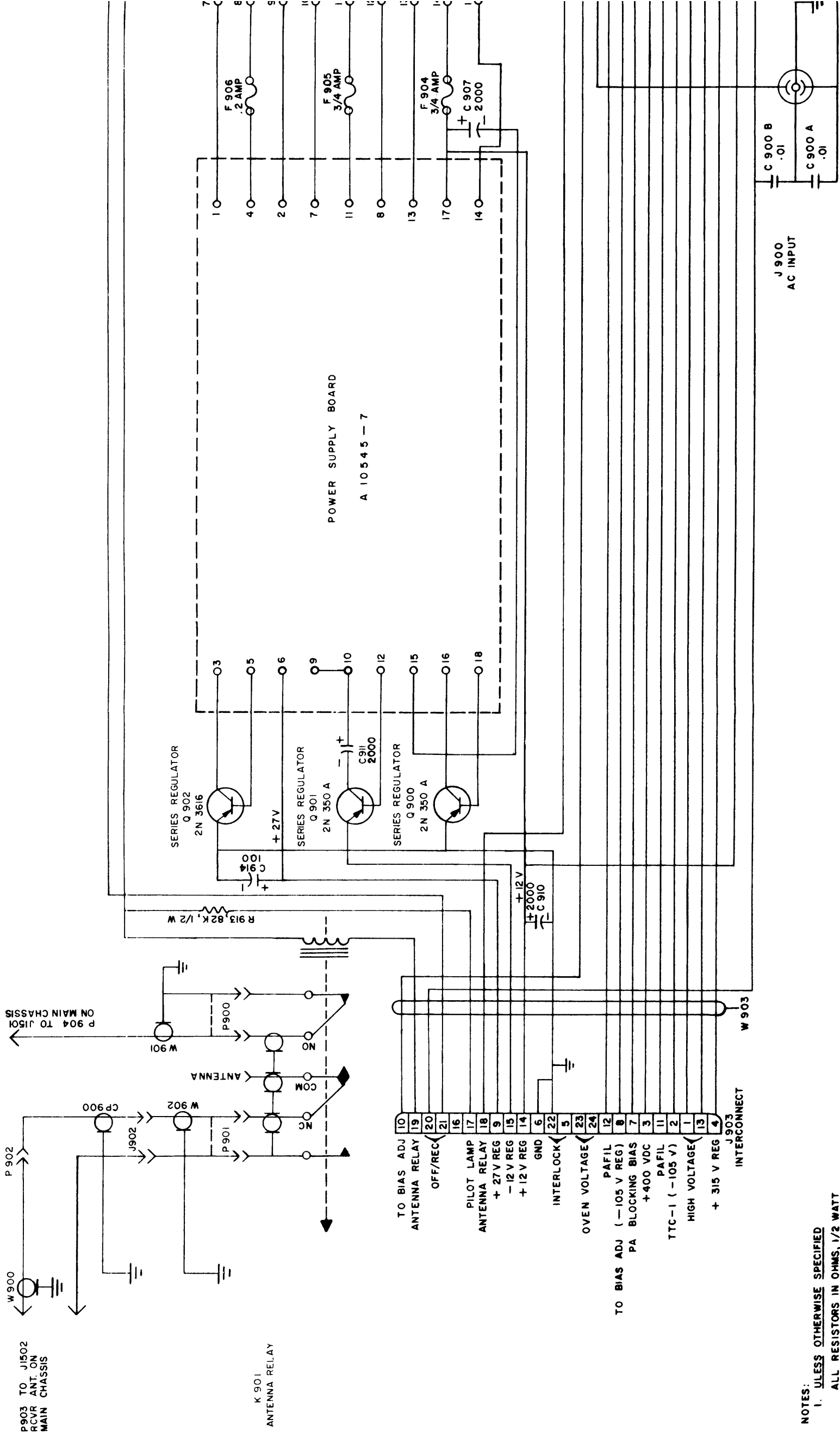
**SECTION 7**  
**SCHEMATIC DIAGRAMS**



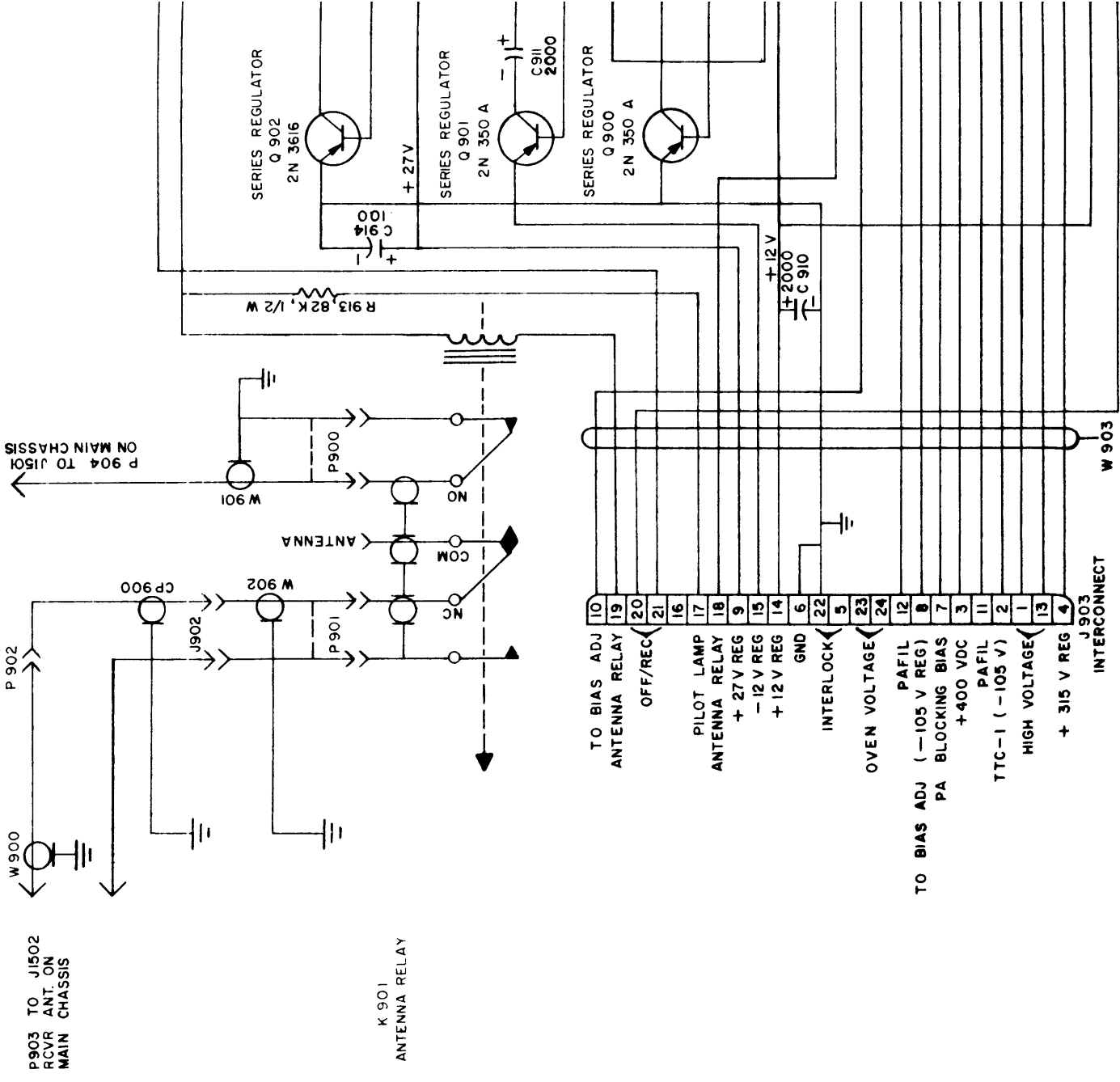
TPSA - 20, SCHEMATIC DIAGRAM

FIGURE 7-3, (sht. 1 of 2)



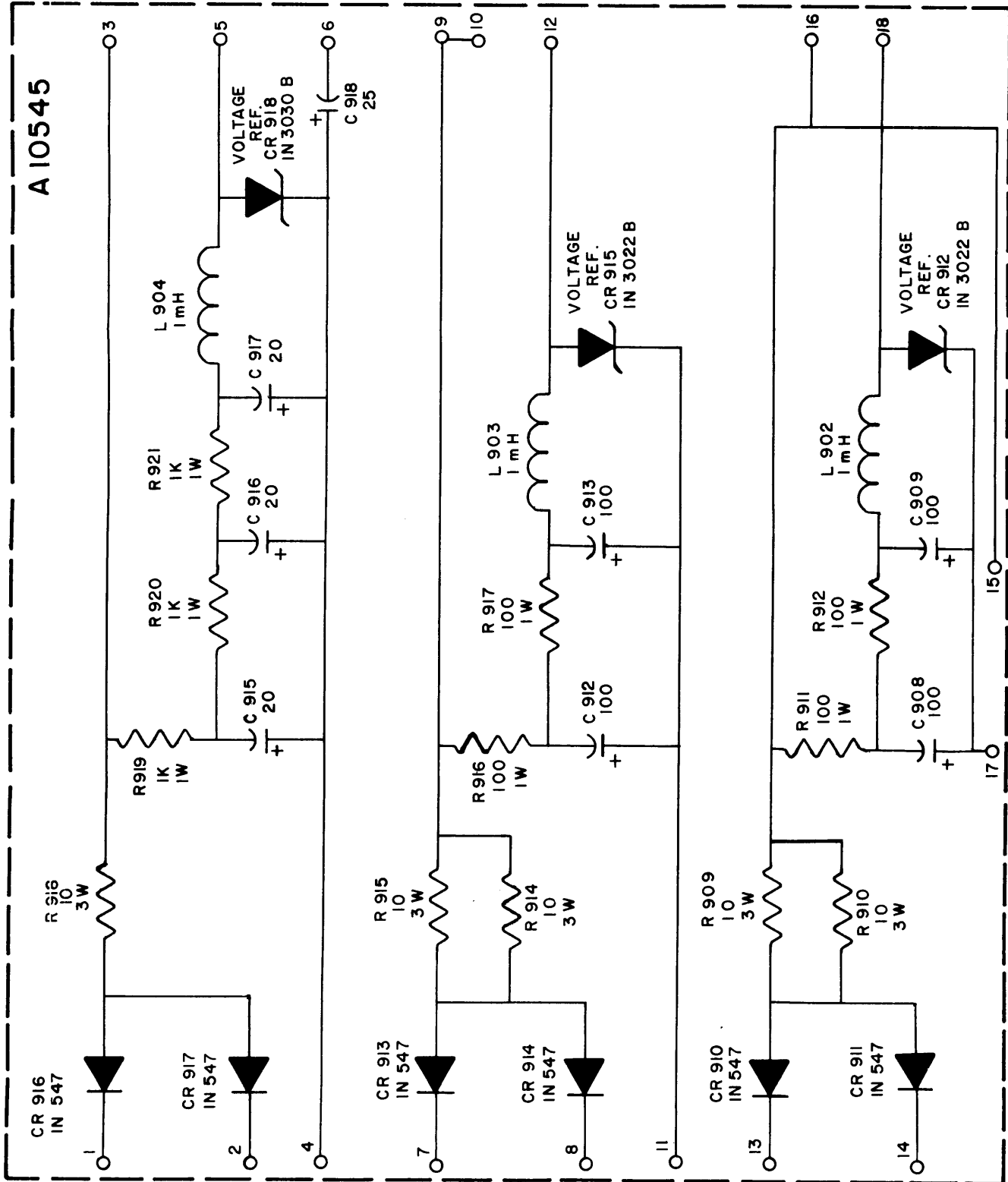


- NOTES:**
1. UNLESS OTHERWISE SPECIFIED  
 ALL RESISTORS IN OHMS, 1/2 WATT  
 ALL CAPACITORS IN  $\mu$ F  
 ALL RELAYS SHOWN DE-ENERGIZED  
 ALL VOLTAGES AT NO. LOAD WITH UNIT DISCONNECTED FROM MAIN CHASSIS  
 AND JUMPERS BETWEEN 20 AND 21 AND BETWEEN 5 AND 6 ON J 903.  
 AND JUMPERS BETWEEN 20 AND 21 AND BETWEEN 5 AND 6 ON J 903.
  2. T 901 AND T 902 SHOWN WIRED FOR 115 V AC. FOR 208 AND 230 V AC,  
 CONNECT JUMPERS AS SHOWN IN FIGURE 2-1.



- NOTES:
1. UNLESS OTHERWISE SPECIFIED  
 ALL RESISTORS IN OHMS, 1/2 WATT  
 ALL CAPACITORS IN  $\mu$ F  
 ALL RELAYS SHOWN DE-ENERGIZED  
 ALL VOLTAGES AT NO. LOAD WITH UNIT DISCONNECTED FROM MAIN CHASSIS  
 AND JUMPERS BETWEEN 20 AND 21 AND BETWEEN 5 AND 6 ON J 903.
  2. T 901 AND T 902 SHOWN WIRED FOR 115 VAC. FOR 208 AND 230 V AC,  
 CONNECT JUMPERS AS SHOWN IN FIGURE 2-1.

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UNLESS OTHERWISE SPECIFIED :

ALL RESISTOR VALUES ARE IN OHMS, 1/2 WATT  
 ALL CAPACITOR VALUES ARE IN MICROFARADS .