



TECHNICAL MANUAL  
for  
PRECISION FREQUENCY COMPARATOR  
MODEL PFCB-1

VOL. 2

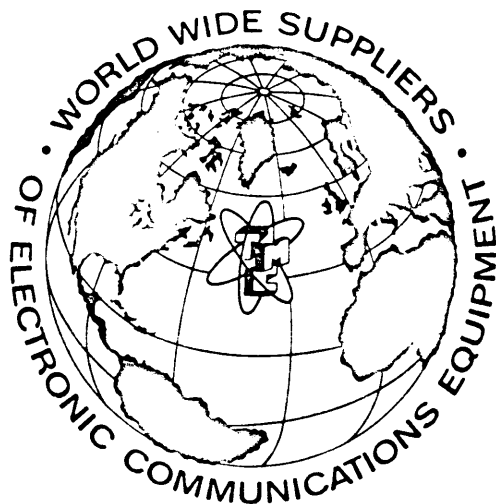


THE TECHNICAL MATERIEL CORPORATION  
MAMARONECK, N. Y. OTTAWA, CANADA





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(To be supplied)

Figure 1-1. Model PFCB, Precision Frequency Comparator

SECTION 1  
GENERAL INFORMATION

1-1. PURPOSE OF EQUIPMENT.

Precision Frequency Comparator PFCB-1 (figure 1-1), hereafter referred to as the PFCB, is a highly precise frequency comparator, capable of comparing the error in frequency between a Frequency Standard under test and that of a Frequency Standard of known accuracy, in parts as minute as 1 part in  $10^{11}$ . A front panel chart recorder provides a permanent and continuous record and visual display of the error frequency.

The basic PFCB model excludes such accessory units as a doppler corrector, an oscilloscope, or a Frequency Standard. These units are self contained and equipped with facilities for mounting into a front panel accessory compartment of the PFCB. The doppler corrector, when incorporated into the PFCB is used to correct for possible doppler effects being received by a receiving site, such as a ship moving to or from the transmitting origin. The oscilloscope and Frequency Standard accessory units are respectively used to monitor the phase angle of the difference frequencies between two externally connected Frequency Standards and to provide a \_\_\_\_\_ source, accurate to 1 part in  $10^9$ . Refer to the supplemental technical manuals regarding the above mentioned accessory units.

The PFCB can be used in conjunction with the Frequency Standards manufactured by TMC or any stable frequency source operating at frequencies of 100 kc, 200 kc, 500 kc or 1 mc at signal voltages between 0.1 and 3 volts peak-to-peak.

## 1-2. DESCRIPTION OF EQUIPMENT.

The PFCB is a compact completely transistorized unit of modular construction. It can be mounted either in a cabinet or a 19-inch rack. Tilt-slide mechanisms mounted on the sides of the main chassis, facilitates in-service troubleshooting and maintenance procedures.

The PFCB is composed of a main chassis that houses a maximum of four X10 Multiplier modules, two Input-Output modules, one X9 Multiplier module, one Mixer-amplifier module, one Output module, one Power Supply module and a chart recorder. Also included is a front panel blank that supports a printed circuit board containing a multiplier-conductor connector. The connector serves as a signal interconnect jumper, which permits operation of the PFCB when an accessory unit is not required.

The modules are plug-in printed circuit boards. All wiring in a module terminates in a multiple-conductor connector. Each connector mates with a compatible jack on the main chassis interconnecting board, when the module is properly positioned. A module card extender mounted internally alongside the chart recorder is used to connect the modules to the main chassis so that components of the modules can be expose for inspection during operation and maintenance.

All operating controls and indicating devices are located on the front panel. Three non-indicating type fuses are located on the

front panel, are parallel connected with identical jacks located on the rear panel. MAIN AC, BATTERY and REF OUT 1 MC jacks are located on the rear panel only. Power for the transistor circuits mounted on the main chassis and printed circuit boards is normally controlled by operating POWER switch S101. In the event of an a-c line power failure, the PFCB contains facilities for automatically switching over to battery power operation.

Dimensionally, the PFCB measures 5-1/4 inches high by 15-5/8 inches deep (excluding front panel controls), on a 19 inch wide front panel, weighing approximately \_\_\_\_\_ lbs. Top and bottom dust covers are also supplied.

### 1-3. ELECTRICAL CHARACTERISTICS.

#### Test and reference Inputs:

Frequency	100 kc, 200 kc, 500 kc or 1 mc.
Signal level	0.1 to 3 volts peak-to-peak.
Input impedance	50 ohms nominal.

#### Multiplication:

Difference between test and reference frequencies multiplied 1, 10, 100, 1000 and 10,000 times in five selected switch positions.

#### Minimum Measurable Error:

1 part in  $10^{11}$ .

#### Source Stability:

Short term

One order of magnitude greater than meter scale selected.

Long term

Dependent upon selected switch position of METER SCALE switch S103.

#### Outputs:

Chart recorder

$\pm 1$ , 2 or 5 parts in  $10^6$   
 $\pm 1$ , 2 or 5 parts in  $10^7$   
 $\pm 1$ , 2 or 5 parts in  $10^8$   
 $\pm 1$ , 2 or 5 parts in  $10^9$   
 $\pm 1$ , 2 or 5 parts in  $10^{10}$

Frequency

$1 \text{ mc} + n\Delta f$  where  $n$ =multiplication selected.

#### Chart recorder:

Microampere Rating  
Accuracy  
Recording time  
Chart speed  
Clamping rate  
Drive motor power

0 to 10 (dc)  
+2 percent of full scale  
31 days/recorder roll chart  
1 inch/hour  
Once every 5 seconds  
115 volts ac, 50/60 cps, single phase, 3-watts.

#### Environmental:

Temperature

Between 0 to 50 degrees C.

Humidity

Between 9 and 90 percent relative humidity.

1-3. ELECTRICAL CHARACTERISTICS (CONT)

AC Power requirements:

115/230 volts ac, 50/60 cps,  
single phase power.

DC Power requirements:  
(For emergency use only)

Except for recorder motor, unit  
capable of operating with ex-  
ternally connected 24-volt  
battery. Power consumption  
on battery operation is \_\_\_\_\_  
watts (\_\_\_\_\_ milliamperes).



1-4. TRANSISTOR AND DIODE COMPLEMENT.

Table 1-1 lists the transistors and diodes for the PFCB.

TABLE 1-1. TRANSISTOR AND DIODE COMPLEMENT

REFERENCE SYMBOL	TYPE	FUNCTION
MAIN CHASSIS (1)		
Q101	2N2143	-12-volt series regulator
Q102	2N2143	-6-volt regulator
CR106	VR101-24- S51	24-volt Zener diode
CR107	1N2976B	12-volt Zener doode
CR108	1N1819	18-volt Zener diode
POWER SUPPLY MODULE (1)		
CR101 thru CR104	2N2484	B+ bridge rectifier diodes
CR105	2N2484	In battery operation, dis- connects battery supply line from relay K101.
IN-OUT MODULES (2)		
Q201	2N396A	Amplifier-multiplier
Q202	2N396A	1 mc amplifier
Q203	2N2084	1 mc amplifier
X10 MULTIPLIER MODULES (4)		
Q301	2N396A	Buffer amplifier
Q302	2N2084	X5 Multiplier
Q303	2N2084	X2 Multitplier

TABLE 1-1. TRANSISTOR AND DIODE COMPLEMENT (CONT)

REFERENCE SYMBOL	TYPE	FUNCTION
X10 MULTIPLIER MODULES (4)(CONT)		
Q304	2N2084	9 mc buffer amplifier
Q305	2N396A	Mixer-amplifier
Q306	2N396A	1 mc amplifier
X9 MULTIPLIER MODULE (1)		
Q401	2N396A	Buffer amplifier
Q402	2N2084	X3 multiplier
Q403	2N2084	X3 multiplier
Q404	2N2084	1 mc amplifier
MIXER-AMPLIFIER MODULE (1)		
Q501, Q502	2N396A	1 mc amplifiers
Q503, Q504	2N396A	Mixer-amplifiers
Q505, Q506	2N706	Buffer amplifiers
Q507	2N706	1 mc oscillator
OUTPUT MODULE (1)		
Q601, Q603	2N706	Schmitt trigger
Q602, Q604	2N706	Schmitt trigger
Q605, Q607	2N706	Multivibrator
Q606, Q608	2N706	Multivibrator
CR601, CR602	1N34A	Schmitt trigger diodes
CR603, CR604	1N3022	12-volt Zener diode

SECTION 2  
INSTALLATION

2-1. INITIAL INSPECTION.

Each PFCB has been calibrated and tested at the factory before shipment. Upon arrival at the operating site, inspect the packaging case and its contents immediately for possible damage. Unpack the equipment carefully. Inspect all packing material for parts that may have been shipped as loose items. Also, check that all modules are properly seated in their respective connectors.

With respect to damage to the equipment for which the carrier is liable, The Technical Materiel Corporation will assist in describing methods of repair and the furnishing of replacement parts.

2-2. POWER REQUIREMENTS.

Unless otherwise specified, the PFCB is wired at the factory for 115-volts ac, 50/60 cycle, single-phase operation. For 230-volts ac operation, make the necessary wiring changes as shown in figure 2-1. Also, with 230-volt ac operation, change the ampere rating of AC fuse F101 from 1 to 1/2 ampere.

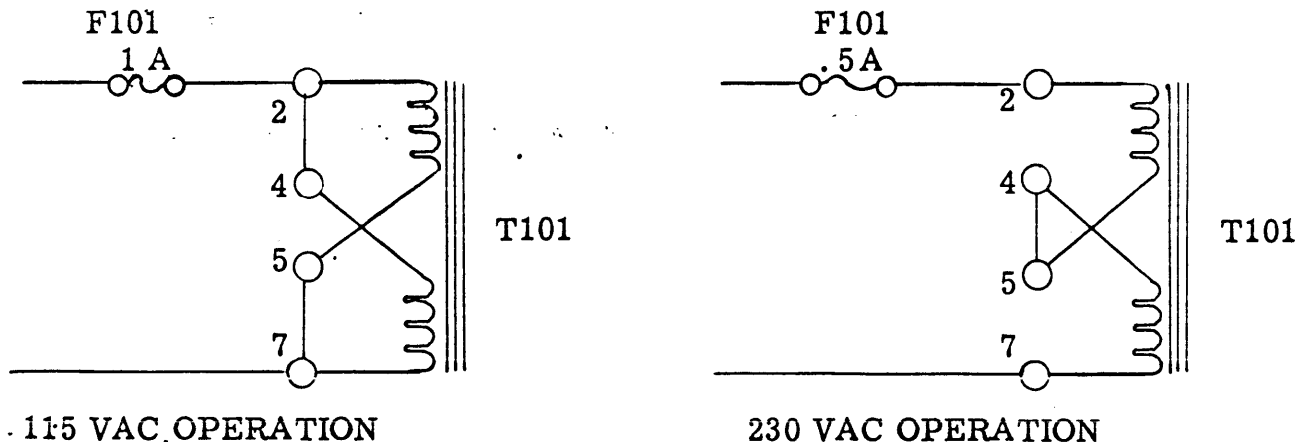


Figure 2-1. Power Supply Changeover Connections.

### 2-3. INSTALLATION.

Installation of the PFCB into a 19-inch wide equipment rack may be made by use of the dimensions given in paragraph 1-2 and performing the following steps: (See figure 2-2).

#### NOTE

The PFCB is designed for rack installation. The unit is provided with tilting slide type mechanism. The tilting slide permits the chassis to be pulled out of the equipment rack to expose the top or bottom of the chassis for greater accessibility and ease of maintenance.

- a. Install unit in rack and secure front panel to rack with four suitable bolts and washers.
- b. Set POWER switch S101 to lower (off) position.
- c. Connect a-c power cable between MAIN AC jack J108 and a-c power receptacle.

#### CAUTION

To avoid damage to components within the PFCB, observe for proper polarity when connecting battery to BATTERY jack J109.

- d. If a 24-volt db battery source is available, observe for proper polarity when connecting battery to BATTERY jack J109.
- e. With a 24-volt dc battery connected as given in step d, set BAT switch S104 to IN. If battery is not used or ready for use at this time, set BAT switch S104 to OUT.

(TO BE SUPPLIED)

Figure 2-2. PFCB, Rear View

#### 2-4. PRE-OPERATIONAL CHECK.

After installing the PFCB, a check should be performed to insure that the unit is operational. This check is performed as follows:

- a. Set POWER switch S101 and RECORDER switch S102 on to lower (off) position.
- b. Set METER SCALE switch S103 on to 5 PARTS FULL SCALE.
- c. Set MULTIPLIER switch S104 on to PARTS IN  $10^6$ .
- d. Adjust Hewlett-Packard 5245L counter or equivalent, to provide a 1 mc external frequency output.
- e. Connect coaxial cable between 1 mc external standard frequency output jack on counter and REF IN jack J102.
- f. Connect Tee-connector to \_\_\_\_\_ oscillator or equivalent. Then, connect coaxial cables between Tee-connector on oscillator and AC INPUT jack on counter and TEST IN jack J101.
- g. Adjust counter for a 10-second count.
- h. Adjust oscillator until counter indicates 1-cycle greater than 1 mc.

#### NOTE

The 1 mc plus 1 cycle indication in step h, should be exact before proceeding with remainder of check.

- f. Set POWER switch S101 and RECORDER switch S102 to ON, and observe the following:
  - (1) POWER ON indicator DS101 should go on.
  - (2) Recorder chart should move.
  - (3) Recorder pen markings on recorder chart should indicate 1 part deflection to left.

NOTE

If any of the recorder indications as given in steps i through m are abnormal, it may be necessary to re-align the PFCB. (Refer to Section 5.)

j. Set METER SCALE switch S103 to 2. Recorder pen markings on recorder chart should indicate 2-1/2 parts (1/2 scale) deflection to left.

k. Set METER SCALE switch S103 on PFCB to 1. Recorder pen markings on recorder chart should indicate full scale deflection to left.

l. Set MULTIPLIER switch S104 to PARTS IN  $10^{10}$ . Recorder pen markings on recorder chart should indicate full scale deflection to left.

m. Repeat steps a, b, c, and h through k, with oscillator adjusted for a 1 mc minus 1 count on counter and recorder pen deflecting towards right on recorder chart.

n. At completion of check, set POWER ON switch S101 and RECORDER switch S102 to lower (off) position, MULTIPLIER switch S104 to PARTS IN  $10^6$  and METER SCALE switch S103 to OFF. Then, disconnect coaxial cables connected in steps e and f.

SECTION 3  
OPERATOR'S SECTION

3-1. GENERAL.

This section contains instructions for operating the PFCB after it has been fully installed. All operating instructions assume that the unit has been checked and is in good working order.

3-2. OPERATING CONTROLS, INDICATORS AND JACKS.

Figure 3-1 shows front panel callouts with index numbers for locating the controls, indicators and jacks of the PFCB. The function of each control, indicator and jack, the locating index number, together with their nomenclature and reference designation are given in table 3-1.

3-3. OPERATING INSTRUCTIONS.

To operate the PFCB, proceed as follows:

a. Make certain that POWER switch S101 and RECORDER switch S104 are set to lower (off) position.

b. Set METER SCALE switch S103 and MULTIPLIER switch S104 to 5 PARTS FULL SCALE and PARTS IN  $10^6$ , respectively.

c. Connect Frequency Standard under test to TEST IN jack J101.

d. Connect reference Frequency Standard to REF IN jack J102.

e. Set POWER switch S101 and RECORDER switch S104 to ON and observe for the following:

(1) POWER indicator DS101 should go on.

(2) Recorder chart should move.

(3) Recorder pen should move with subsequent markings on recorder chart.



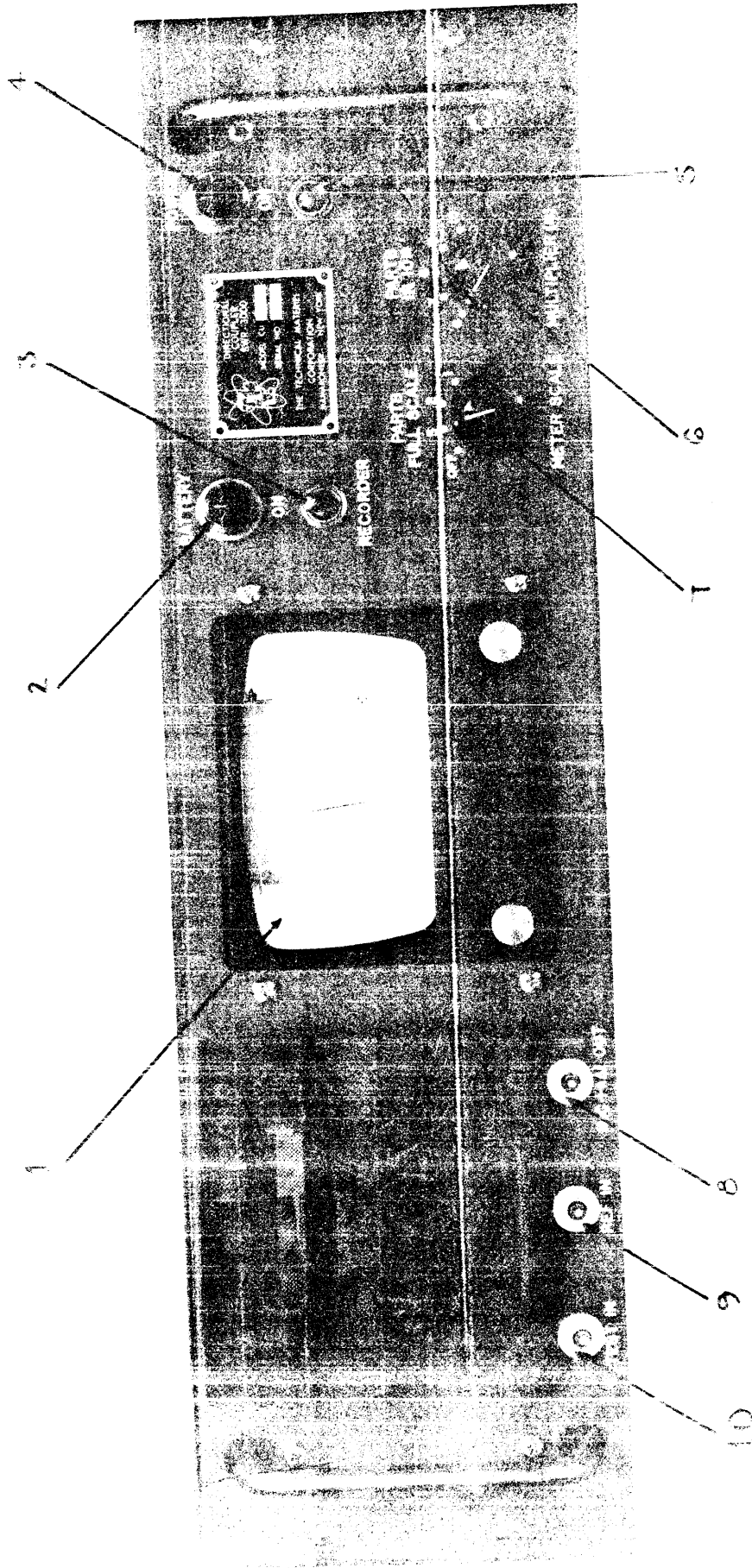


FIGURE 3-1. PFCB, Front Panel Controls, Indicators and Jacks.

TABLE 3-1. FRONT PANEL CONTROLS AND INDICATORS AND JACKS

INDEX NUMBER	CONTROL OR INDICATOR	FUNCTION
1	Recorder	Monitors and permanently records the error frequency of the Frequency Standard under test in parts as minute as 1 part in $10^{11}$ .
2	BATTERY inciator DS102	Indicates power supply circuit in-operative and unit is capable of being operated from an external battery source only.
3	RECORDER switch S102	In ON position operates in conjunction with POWER switch S101 to connect a-c power to recorder motor. When in lower (off) position, disconnects a-c power from recorder motor.
4	POWER indicator DS101	Indicates a-c power is applied to power supply circuit.
5	POWER switch S101	In ON position, connects a-c power to power supply circuit. When in the lower (off) position, disconnects a-c power from power supply circuit.
6	MULTIPLIER switch S104	A five position selector switch. The switch positions correspond to the rate at which the error frequency ( $n\Delta f$ ) is multiplied. For example, in position 6 the recorder will indicate parts in $10^6$ .
7	METER SCALE switch S103	A four position switch, the positions of which are as follows: OFF, 1, 2, and 5. The OFF position disconnects the Output module from the recorder. The remaining switch positions, select the full scale readings of the recorder. For example, in position 5, the full scale reading is +5 parts. Therefore, with the suggested setting for MULTIPLIER switch S104, a full-scale deflection indicates +5 parts in $10^6$ difference between Frequency Standards.
8	1MC+n $\Delta$ f OUT jack J103	Monitors the 1 mc+n $\Delta$ f frequency as selected by MULTIPLIER switch S104.
9	REF IN jack J102	Monitors the input frequency of the reference Frequency Standard.
10	TEST IN jack J101	Monitors the input frequency of the Frequency Standard under test.

f. Set MULTIPLIER switch S104 and METER SCALE switch S103 for convenient recorder pen deflection.

NOTE

The recorder pen (polarity) markings to the right (minus) or left (plus), indicates the frequency difference of the test frequency relative to the reference frequency. Refer to table 3-2 as a quick guide for determining in cycles the full-scale (recorder) deflection parameters for the various switching combinations of METER SCALE switch S103 and MULTIPLIER switch S104. The ± cycles as given in table 3-2 are the actual full-scale frequency deviations with respect to 1 mc.

g. Adjust Frequency Standard under test until recorder pen markings on recorder chart are centered at mid-scale.

h. Set MULTIPLIER switch S104 and METER SCALE switch S103 to the highest setting possible for convenient recorder pen deflection. Then repeat step g.

i. Allow recorder chart to run for 24 hours. If at the termination of the 24-hour period, the recorder pen indications remain centered at mid-scale, proceed to steps j. If not, repeat steps g, h and i.

NOTE

Due to the diurnal effect two major changes will be seen on recorder chart. These two major changes are normal and occur at sunrise and sunset. Also, these changes are in direct opposition to each other.

j. Set POWER switch S101 and RECORDER switch S104 to lower (off) position.

k. Disconnect Frequency Standard under test and reference Frequency Standard from TEST IN jack J101 and REF IN jack J102, respectively.

TABLE 3-2. RECORDER SWITCHING ARRANGEMENTS

METER SCALE (PARTS FULL SCALE) SWITCH S103	MULTIPLIER (PARTS IN $10^m$ ) SWITCH S104	+ CYCLES (FULL-SCALE DEFLECTION) *
5	6	5.0
2	6	2.0
1	6	1.0
5	7	0.5
2	7	0.2
1	7	0.1
5	8	0.05
2	8	0.02
1	8	0.01
5	9	0.005
2	9	0.002
1	9	0.001
5	10	0.0005
2	10	0.0002
1	10	0.0001

\*The ± cycles are with respect to 1 mc.

### 3-4. LOADING OF RECORDER ROLL CHART.

The procedures for reloading a recorder roll chart are as follows:

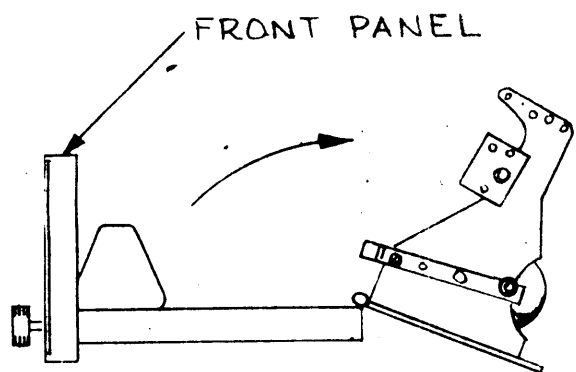
- a. Turn off power by setting POWER switch S101 to lower (off) position.
- b. Loosen knobs on front panel attaching recorder to case.
- c. Remove recorder from case by initially pulling forward on front panel knobs until sides on front panel are exposed. Then, grasp sides of front panel firmly with one hand and continue pulling recorder forward until removed from case.
- d. Lay recorder on work bench.
- e. Swing recorder open on hinge (figure 3-2A), by holding top side of front panel down while lifting up on front of frame.
- f. Noting position of guide roller assembly remove thumb nut (figure 3-2B), securing guide roller assembly to frame. Then remove guide roller assembly.
- g. Turn knurled knob on top roller in a clockwise direction until complete recorder roll chart is wound on top roller.
- h. Unlock both rollers by pivoting clamps on either side of rollers in a clockwise direction and remove top (with recorder chart) and bottom rollers from frame.
- i. Slide paper chart with cardboard sleeve off top roller.
- j. Remove cardboard sleeve from bottom roller and slip onto top roller.
- k. Place a new recorder roll chart with perforated side against disk side of bottom roller (figure 3-2C.)
- l. Replace top and bottom rollers into guide grooves on either side of frame.

- m. Lock rollers by pivoting clamps to either side of roller studs.
- n. Pull recorder roll chart on bottom roller over frame and onto cardboard sleeve on top roller. Then, tape edge of recorder chart roll squarely and neatly to cardboard sleeve on top roller.
- o. Swing recorder back to original position on hing (figure 3-2D.)
- p. Push paper chart down from top side, allowing slack between paper drive and top rollers.
- q. Reinstall guide roller assembly to frame as shown in figures 3-2D and E, and holding guide roller assembly in place, secure to frame with thumb nut removed in step f.
- r. Remove any slack from recorder roll chart by slightly turning top or bottom roller in a clockwise direction.
- s. Carefully reinstall recorder into case and secure to case by tightening front panel knobs.

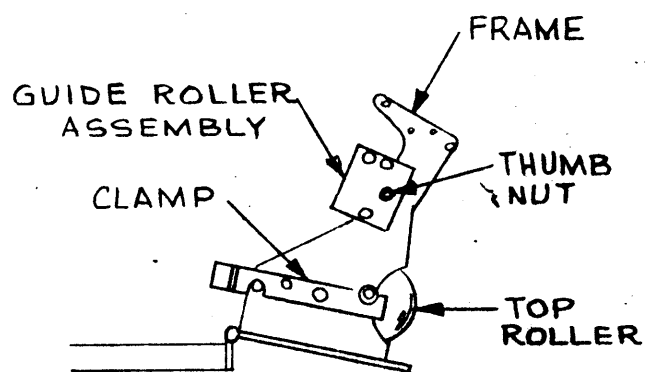
### 3-5. OPERATOR'S MAINTENANCE.

The operator may at times be required to perform operator's maintenance. This may consist of replacing a recorder chart roll, observing for unit cleanliness, condition and connection of interconnecting cables and replacement of defective fuses and indicator lamps. See figures 2-2, 3-1, 5-1 and 5-2 for identification and location of the various connectors, controls and indicators and fuses of the PFCB.

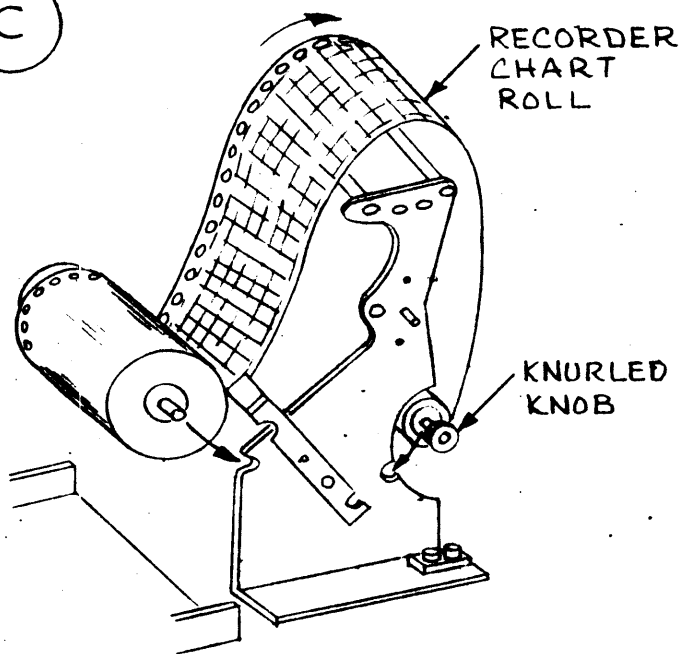
(A)



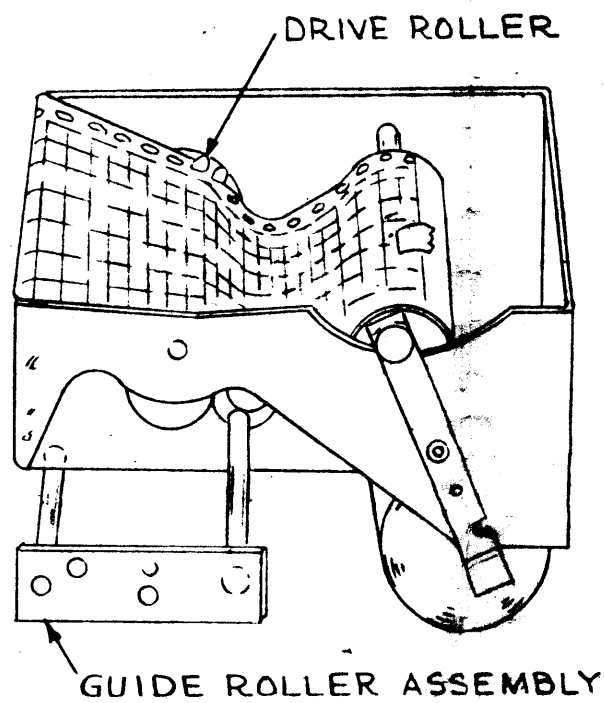
(B)



(C)



(D)



(E)

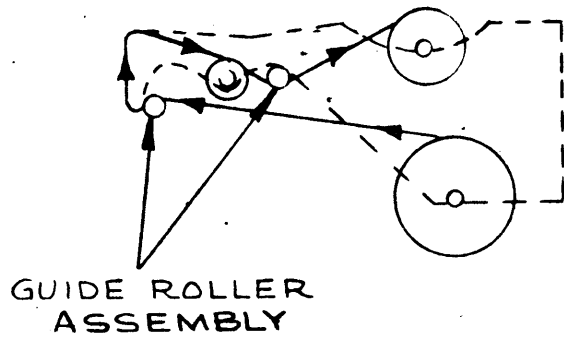


FIGURE 3-2 RECORDER ROLL CHART REPLACEMENT GUIDE

## SECTION 4

### TROUBLESHOOTING

#### 4-1. OVERALL FUNCTIONAL DESCRIPTION AND TROUBLESHOOTING OF UNIT.

a. FUNCTIONAL DESCRIPTION. - The PFCB is a precision frequency comparator which employs a heterodyning technique in conjunction with frequency multiplication, to derive an error or difference frequency between a Frequency Standard under test and that of a Frequency Standard of known accuracy. A front panel recorder operating in conjunction with front panel switching controls is used to accurately display and record the error frequency in parts in  $10^6$  to parts in  $10^{11}$ .

Figure 4-1 is a functional block diagram of the PFCB. Basically, it is a transistorized unit comprised of ten plug-in printed circuit boards or modules, with appropriate switching, calibration and recorder monitoring circuits. The printed circuit boards, (interconnected through jacks mounted on an interconnecting board) consist of four X10 Multiplier modules, two Input-Output modules, one X9 Multiplier module, one Mixer-Amplifier module and a Power Supply module. In the discussion to follow a functional description of the regulated power supply will precede those which relate to signal flow.

The regulated power supply is comprised of a power supply module, Z101 and components externally mounted on the main chassis. It also contains facilities for automatically switching over to battery operation during emergencies.

In normal operation, with POWER switch S104 in the ON position, 115-volt 50/60 cycle single phase a-c power is applied between MAIN AC jack J108 and connected through AC fuse F101 to the input side of the regulated power supply circuits. These circuits serve to produce regulated operating potentials of +12 vdc, -12 vdc and -6 vdc.



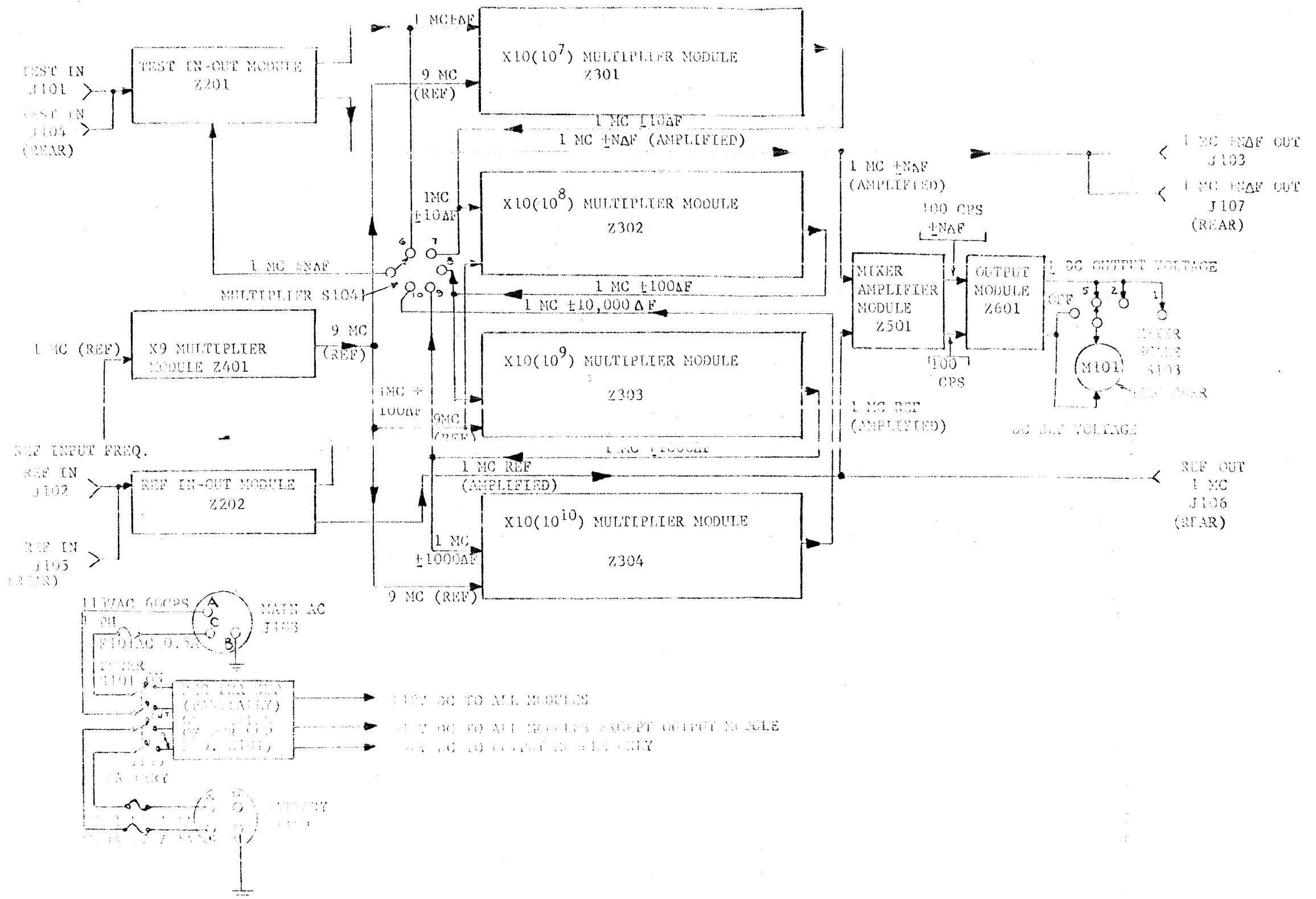


Figure 4-1. PFCB, Functional Block Diagram

In the event of an a-c power failure the regulated power supply circuits are automatically switched over to 24-volt battery operation, assuming an external 24-volt battery is connected to BATTERY jack J109 and provided BATTERY switch S105 is in the IN position. Under these conditions, 24 volts d-c is applied across -12V and +12V fuses F102 and F103 as an input to the regulated power supply.

The Reference Input-Output module functions as an amplifier or a multiplier, depending upon the input frequency of the ultra-stable Frequency Standard. Operating as a multiplier, it converts input frequencies of 100 kc, 200 kc or 500 kc to an exact frequency of 1 mc. However, with a 1 mc input, it serves as an amplifier, amplifying the incoming signal to its proper operating level. In either case, a precise 1 mc output is supplied by the Reference Input-Output module as an input to the X9 Multiplier and Mixer-Amplifier modules and as an output available at REF OUT 1 MC jack J106.

The Test Input-Output module contains identical circuits as those included in the Reference Input-Output module. It functions as an amplifier or a multiplier, depending upon the input frequency. This results in a 1 mc output which includes the  $\pm\Delta f$  or difference frequency of the Frequency Standard under test. The  $1\text{ mc} \pm \Delta f$  output is supplied by the module as one of two input frequencies to the X10 ( $10^7$ ) Multiplier module. The module also amplifies the selected X10 Multiplier frequency

$1\text{ mc} + n\Delta f$ . When amplified,  $1\text{ mc} + n\Delta f$  frequency is supplied as an output to be monitored at parallel connected  $1\text{ MC} + n\Delta f$  OUT jacks and as an input to the Mixer-Amplifier module.

The X9 Multiplier module functions as a times-nine multiplier. It multiplies the precise  $1\text{ mc}$  frequency, derived from the reference input, to a frequency of  $9\text{ mc}$ . During operation, the  $9\text{ mc}$  frequency developed by the X9 Multiplier module is supplied as a reference frequency to the X10 Multiplier modules.

There are four X10 Multiplier modules used in the PFCB. They are connected in cascade and numerically designated as the Z300 series. Effectively, each X10 Multiplier module progressively multiplies by 10 the difference frequency of the Frequency Standard under test while maintaining a stable center frequency of  $1\text{ mc}$ . In this manner, the difference frequency appears ten times larger at the output of each successive X10 Multiplier, while the center frequency remains at a nominal  $1\text{ mc}$ . Since each of the X10 Multiplier modules are similar, only the X10 ( $10^7$ ) Multiplier will be discussed.

Initially, the X10 ( $10^7$ ) Multiplier receives the  $1\text{ mc} + \Delta f$  and  $9\text{ mc}$  frequencies from the test Input-Output and X9 Multiplier modules, respectively. The  $1\text{ mc}$  input which includes the difference frequency is multiplied by 10 to a frequency of  $10\text{ mc} + 10\Delta f$ . This frequency converts back to  $1\text{ mc} + 10\Delta f$  when subtracted by the  $9\text{ mc}$  signal derived from the reference input frequency. When selected by manually controlled MULTIPLIER switch S104, the output of the X10 ( $10^7$ ) Multiplier is supplied as an input to the Test Input-Output module.

The Mixer-Amplifier module consists of two identical mixer-amplifier channels and a  $1\text{ mc} + 100\text{ cps}$  oscillator which is common to both channels. Each channel is connected to receive either the selected X10 Multiplier output ( $1\text{ mc} + n\Delta f$ ) or the  $1\text{ mc}$  frequency derived from the reference input. During operation, the two input frequencies are subtracted from the  $1\text{ mc} + 100\text{ cps}$  frequency derived from the oscillator, resulting in two output frequencies; an exact  $100\text{ cps}$  and  $100\text{ cps} + n\Delta f$ . Both outputs are channeled as inputs to the Output module, where they are further frequency compared.

The output module is essentially comprised of a two channel integrator and differential comparison circuits. Each integrator circuit receives and processes either the  $100\text{ cps}$  reference or  $100\text{ cps} + n\Delta f$  frequencies supplied by the Mixer-Amplifier module. The resultant output of each integrator circuit is a series of continuous pulses which are frequency compared in a differential comparison circuit. This circuit functions to generate a d-c comparison output voltage, whose amplitude and polarity is directly proportional to the frequency difference of the two sets of incoming pulses. The d-c resultant output voltage from the differential comparison circuit is then fed to a chart recorder which presents both the magnitude and sense of the difference frequency. A front panel METER SCALE switch S103, is used in conjunction with the front chart recorder to conveniently set the level of pen deflection on the recorder chart.

b. TROUBLESHOOTING. - When troubleshooting the PFCB, refer to table 4-1 which lists the typical voltages for the transistors that are integral to the unit. The test equipment required for troubleshooting is as follows:

- (1) Oscilloscope-Tektronix 545A, with plug-in unit and 10-megohm, 11.5 pica-farad probe or equivalent.
- (2) Frequency Counter-Hewlett-Packard 5245L or equivalent.
- (3) VTVM-Hewlett-Packard 410B or equivalent.

Faulty PFCB operation is usually apparent by the abnormal indications observed the recorder chart, such as the recorder pen pinning to either side of center-scale, or a continuous straight line display on the recorder chart in all METER SCALE switch positions. Pinning of the recorder could be associated with a defective X10 Multiplier module, an Input-Output module or an X9 Multiplier module. One method of detecting whether pinning of the recorder is due to a defective X10 Multiplier module is to first set MULTIPLIER switch S104 to PARTS IN  $10^{10}$  position. Then, successively rotate the switch towards the PARTS IN  $10^6$  position, until pinning of the recorder pen ceases. The defective X10 multiplier module would be the one before switching to the position which provides normal operation. Another method of detecting a defective X10 Multiplier module would be to connect an oscilloscope to the rotor-arm of MULTIPLIER switch S104 and monitoring each switch position corresponding to the output of each multiplier module. The oscilloscope in each switch position should indicate a peak-to-peak amplitude of 350 millivolts, approximately.

A quick method of checking for a defective Input-Output module when the recorder pen is pinning, is to switch positions of the two Input-Output modules on the interconnecting board, and observing if the recorder pen pins in the opposite direction. If the recorder pen continues to pin<sup>e</sup> in the same direction as formerly, trouble may lie in the X9 Multiplier module.

#### NOTE

It is important that 1 mc frequency source be connected to both input channels during the above mentioned checks. A 1 mc source is available at a rear panel jack on the counter.

A fault in Mixer-Amplifier or Output module usually results in a continuous straight line regardless of the setting of METER SCALE switch S103. When this occurs, check the outputs of each module with a oscilloscope and/or counter.

For ease of troubleshooting the PFCB stages, connect the counter directly to the oscilloscope. Then use the oscilloscope probe for obtaining simultaneous frequency and amplitude indications. This method of test equipment hookup also eliminates improper loading of the stage being checked.

Check transistors using the substitution method. Check fuses as necessary. A visual inspection of the unit should pinpoint burned or open parts.

When a defective component on a module (other than the power supply module), has been isolated, removed and replaced, it may be necessary to re-align the repaired module. System checks (paragraph 5-11) should first be performed in order to determine whether the repaired module requires alignment.

SECTION 5  
MAINTENANCE

5-1. GENERAL.

Maintenance may be divided into three categories: operator's maintenance, preventive maintenance and corrective maintenance. Corrective maintenance is sometimes considered as consisting of information useful in locating and diagnosing equipment troubles and maladjustments, existing and/or pending, and information necessary to remedy the equipment troubles and maladjustments. In this section, corrective maintenance procedures are those necessary to correct a trouble due to a maladjustment of a control or adjustment. By using these procedures along with the troubleshooting information presented in Section 4, a trouble may also be localized to a particular area. Operator's maintenance is included in Section 3.

The PFCB has been designed to provide long-term, trouble-free operation under continuous duty conditions. It is recommended that any necessary maintenance be done by a competent maintenance technician familiar with troubleshooting techniques. If the trouble cannot be corrected by utilizing the information presented in this section and Section 4, it is recommended that the PFCB be returned to The Technical Materiel Corporation.

5-2. PREVENTIVE MAINTENANCE.

In order to prevent failure to the equipment due to component failure, corrosion, dust or other destructive elements, it is suggested that a schedule of preventive maintenance be set up

and closely adhered to.

At periodic intervals, the PFCB should be removed from its mounting for cleaning and inspection purposes. All accessible covers should be removed and wiring and components inspected for dirt, corrosion, charring, discoloring or grease. Remove dust with a soft brush or vacuum cleaner. Remove dirt or grease from other parts with any suitable cleaning solvent. Use of carbon tetrachlorethylene or methyl chloroform may be used, providing the necessary precautions are observed.

#### WARNING

When using toxic solvents, make certain that adequate ventilation exists. Avoid prolonged or repeated breathing of the vapor. Avoid prolonged or repeated contact with skin. Flammable solvents shall not be used on energized equipment or near any equipment from which a spark may be received. Smoking, "hot work", etc. is prohibited in the immediate area.

#### CAUTION

When using trichlorethylene, avoid contact with painted surfaces, due to its paint removing effects.

### 5-3. CORRECTIVE MAINTENANCE.

#### CAUTION

The PFCB is a solid state device. Any indiscriminate resistance measurements may damage the transistors mounted on the printed circuit boards or main chassis.

The corrective maintenance procedures are essentially Technical Materiel Corporation's factory alignment procedures modified for use in the field. Refer to paragraph 5-4 and 5-5 for the test equipment and preliminary instructions for aligning and testing the PFCB, respectively. Figures 5-1 and 5-2 illustrates the location of major components of the unit.



(To be supplied)

Figure 5-1. Model PFCB, Precision Frequency Comparator, Top View.

(To be supplied)

Figure 5-2. Model pFCB, Precision Frequency Comparator, Bottom View.

5-4. SPECIAL TOOLS AND TEST EQUIPMENT.

The test equipment required to perform the corrective maintenance procedures in paragraph 5-6 through 5-11 are listed in table 5-1. There is only one special tool required for corrective maintenance. That is, TMC part number TP-129.

TABLE 5-1. TEST EQUIPMENT.

ITEM	DESCRIPTION
Frequency Counter	Hewlett-Packard 5245L, or equivalent
Oscilloscope	Tektronix 545A with L type plug-in unit, or equivalent
Crystal Oscillator	Any crystal oscillator with a long term stability of better than 1 part in $10^7$ per day. Adjustable to $\pm 5$ cycles at 1 mc.
VTVM	Hewlett-Packard 410B, or equivalent
24-volt Nickel Cadmium Battery	Sonotone 10-S103, or equivalent
A-c Power Cable	3-wire cable (connectors MS310A14S-1S and three-prong a-c plug connected on either end of cable.)
D-c Power Cable	2-wire cable (connectors MS3116A14S-2S and battery clips connected on either end of cable.)
Connector	MS3106A14S-1S
Connector	MS3116A14S-2S
Connector	3-prong a-c plug
Connector	Battery clips

## 5-5. PRELIMINARY INSTRUCTIONS.

Prior to aligning the PFCB, perform the following:

### NOTE

These instructions assume that the unit has just been repaired. Therefore, the unit should be on a work bench, with top and bottom covers removed, and all signal and power cables disconnected. This procedure also assumes that an external 24-volt d-c battery source is available for use at all times.

- a. Set POWER switch S101 and RECORDER switch S104 to lower (off) position.
- b. Set BATTERY switch S105 to IN.
- c. Connect d-c power cable between BATTERY jack J109 and battery.
- d. Set BATTERY switch S104 to ON. BATTERY indicator DS102 should go on.
- e. Connect a-c power cable between MAIN AC jack J109 and a-c source receptacle.
- f. Set POWER switch S101 to ON. BATTERY and POWER indicators DS102 and DS101 should go off and on respectively.

## 5-6. DC POWER CHECK

To perform the d-c power check, proceed as follows:

- a. Perform the preliminary instructions as given in paragraph 5-5.
- b. Set POWER switch S101 to lower (off) position.
- c. Connect VTVM between test point TP108 (emitter of transistor Q101), on interconnecting board and ground.
- d. Set POWER switch S101 to ON. POWER indicator DS101 should go on and VTVM should indicate approximately -12 volts.

- e. Disconnect VTVM from test point TP108 and connect to test point TP107 (cathode of Zener diode CR106) on interconnecting board. VTVM should indicate approximately +12 volts dc.
- f. Disconnect VTVM from test point TP107 and connect to test point TP102B (emitter of transistor Q102) on interconnecting board. VTVM should indicate approximately -6 volts dc.
- g. Disconnect VTVM connected between test point TP102B and ground.
- h. Disconnect a-c power from MAIN AC jack J108. Observe POWER indicator DS101 and BATTERY indicator DS102 should go off and on, respectively.
- i. Repeat steps d through g.
- j. Set BATTERY switch S105 to OUT.

#### 5-7. INPUT-OUTPUT MODULE ALIGNMENT.

To align the Input-Output module, proceed as follows:

- a. Perform the preliminary instructions as given in paragraph 5-5.
- b. Set MULTIPLIER (m) switch S104 to PARTS IN 10<sup>6</sup>.
- c. Adjust counter for 1 mc external standard frequency output.

Counter output should be between the limits of 0.1 to 3 volts peak-to-peak.

- d. Connect Tee-connector to external standard frequency output jack on counter. Then, connect coaxial cables between Tee-connector on counter and TEST IN and REF IN jacks J101 and J102, respectively.

- e. Set POWER switch S101 to lower (off) position.

- f. Remove Input-Output module from unit and connect module to extension card. Then, connect extension card into appropriate jack connector on interconnection board.

- g. Set POWER switch S101 to ON.

- h. Connect oscilloscope to test point TP1. Oscilloscope should indicate approximately 200 millivolts peak-to-peak with a slightly distorted sine-wave.

- i. Disconnect oscilloscope from test point TP1 and connect to test point TP2.

- j. Adjust transformer T201 until an instantaneous jump voltage is indicated on oscilloscope. Then, adjust transformer T201 one-quarter turn in a clockwise direction.

- k. Disconnect oscilloscope from test point TP2, and connect to test point TP3. Adjust capacitor C211 for a maximum signal indication on oscilloscope.

- l. Disconnect oscilloscope from test point TP3 and connect to test point TP4. Adjust control R216 fully counterclockwise.

- m. Adjust transformer T202 until an instantaneous jump voltage is indicated on oscilloscope. Then, adjust transformer T202 one-quarter turn in a clockwise direction.

n. Readjust capacitor C211 for a maximum signal indication on oscilloscope.

o. Readjust control R211 until waveform on oscilloscope indicates approximately 350 millivolts, peak-to-peak.

NOTE

When aligning the Input-Output ( $10^6$ ) module, readjust control R211 for a 2 volt peak-to-peak indication on oscilloscope.

p. Disconnect oscilloscope from test point TP4 and connect to test point TP6.

q. Adjust transformer T203 for a maximum signal indication on oscilloscope.

r. Set POWER switch S101 to lower (off) position. Disconnect coaxial leads connected between Tee-connector on counter and REF IN and TEST IN jacks J101 and J102, respectively.

s. Disconnect oscilloscope from test point TP6.

t. Remove extension card and mated module from unit. Then, disconnect extension card from module and re-install module into appropriate jack connector on interconnecting board.

#### 5-8. X9 MULTIPLIER MODULE ALIGNMENT.

To align the X9 Multiplier module, proceed as follows:

- a. Repeat steps a through e of paragraph 5-7.
- b. Remove X9 Multiplier module from unit and connect module to extension card. Then, connect extension card into appropriate jack connector on interconnection board. Set POWER switch S101 to ON.
- c. Connect oscilloscope to test point TP1. Waveform on oscilloscope should be almost sinusoidal at an amplitude of approximately 800 millivolts peak-to-peak.
- d. Disconnect oscilloscope from test point TP1 and connect to test point TP2. Adjust transformer T401 until an instantaneous jump voltage is indicated on oscilloscope. Then, adjust transformer T401 one-quarter turn in a clockwise direction. Amplitude of waveform on oscilloscope should be approximately 3.5 volts peak-to-peak.
- e. Disconnect oscilloscope from test point TP2 and connect to test point TP3. Amplitude of waveform on oscilloscope should be approximately 700 millivolts peak-to-peak (figure 5-3A.)
- f. Disconnect oscilloscope from test point TP3 and connect to test point TP4. Adjust transformer T403 until oscilloscope indicates a nine-cycle sine-wave at approximately 700 millivolts peak-to-peak (figure 5-3B.)
- g. Disconnect oscilloscope from test point TP4 and connect to test point TP5. Adjust capacitor C415 for a maximum signal indication on oscilloscope. Amplitude of waveform as indicated on oscilloscope should be approximately 100 millivolts peak-to-peak.
- h. Disconnect oscilloscope from test point TP5 and connect to test point TP6. Readjust capacitor C415 for a maximum signal indication on oscilloscope. Amplitude of waveform as indicated on oscilloscope should be 200 millivolts peak-to-peak or greater.



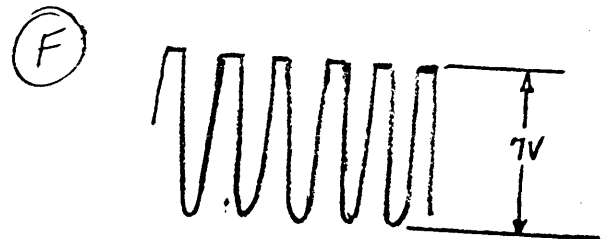
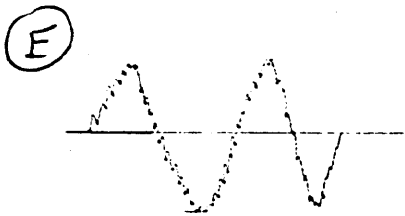
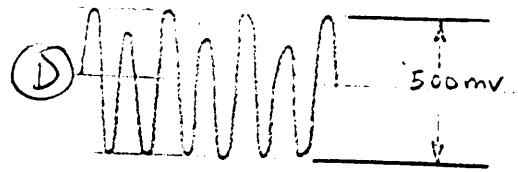
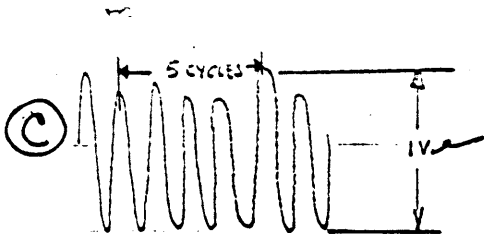
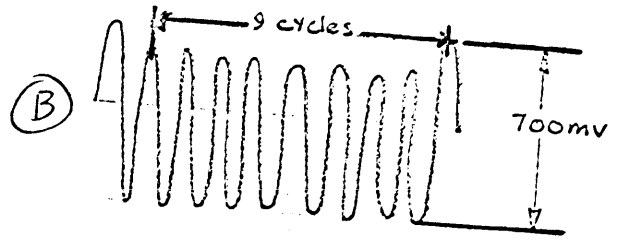
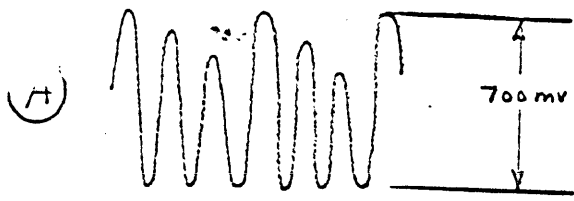


Figure 5-3. PFCB Alingment Waveforms.

i. Set POWER switch S101 lower (off) position. Disconnect coaxial leads connected between Tee-connector on counter and REF IN and TEST IN jacks J101 and J102, respectively.

j. Disconnect oscilloscope from test point TP6.

k. Remove extension card and mated module from unit. Then, disconnect extension card from module and re-install module into appropriate unit jack connector on interconnecting board.

#### 5-9. X10 MULTIPLIER MODULE ALIGNMENT.

To align the X10 Multiplier module (s), proceed as follows:

##### NOTE

All X10 Multiplier modules are aligned in the third jack position located to the right of unit. This jack position is associated with the first X10 Multiplier module nearest to the Input-Output and Power Supply modules.

- a. Repeat steps a through e of paragraph 5-7.
- b. Remove X10 Multiplier module from unit and connect module to extension card.
- c. Connect extension card into the third jack position located to the right of the unit, removing existing X10 Multiplier card, if necessary.  
Set POWER switch S101 to ON.
- d. Connect oscilloscope to test point TP1. Amplitude of waveform on oscilloscope should be approximately 200 millivolts peak-to-peak. If amplitude of signal level is low, adjust control R211 on the Input-Output module until waveform on oscilloscope is approximately 200 millivolts.

##### NOTE

Control R211 is mounted on the Input-Output module located to the right of the X10 Multiplier modules.

- e. Disconnect oscilloscope from test point TP1, and connect to test point TP2. Adjust transformer T301 until an instantaneous jump voltage is indicated on oscilloscope. Then, adjust transformer T301 one-quarter turn clockwise. Amplitude of waveform on oscilloscope should be approximately 350 millivolts peak-to-peak.
- f. Disconnect oscilloscope from test point TP2 and connect to test point TP3. Adjust inductor L301 until a five-cycle sine-wave at approximately 1 volt peak-to-peak is indicated on oscilloscope (figure 5-3C.)

g. Disconnect oscilloscope from test point TP3 and connect to test point TP4. Alternately adjust transformer T302 and inductor L301 until a perfect sinusoidal waveform at approximately 450 millivolts peak-to-peak is indicated on oscilloscope.

h. Disconnect coaxial cable from REF IN jack J102.

i. Disconnect oscilloscope from test point TP4 and connect to test point TP5. Adjust transformer T303 until waveform on oscilloscope indicates approximately 500 millivolts peak-to-peak (figure 5-3D.)

j. Disconnect coaxial cable from TEST IN jack J101 and connect to REF IN jack J102.

k. Disconnect oscilloscope from test point TP5 and connect to emitter of transistor Q305. Adjust transformer T304 until a perfect sinusoidal waveform at approximately 700 millivolts peak-to-peak is indicated on oscilloscope.

l. Reconnect coaxial cable between Tee-connector on counter and TEST IN jack J101.

m. Disconnect oscilloscope from emitter of Q305 and connect to test point TP6. Adjust transformer T304 until waveform on oscilloscope appears as shown in figure 5-4E.

n. Disconnect oscilloscope from test point TP6 and connect to test point TP7. Alternately adjust capacitor C324 and transformer T305 until amplitude of waveform on oscilloscope is peaked for a maximum indication.

o. Adjust control R232 fully clockwise.

p. Disconnect oscilloscope from test point TP7 and connect to test point TP8. Adjust transformer T306 until an instantaneous jump voltage is indicated on oscilloscope. Then, adjust transformer T306 one-quarter turn in a clockwise direction. Readjust control R232 until waveform on oscilloscope indicates approximately 350 millivolts peak-to-peak.

p. Disconnect oscilloscope from test point TP7 and connect to test point TP8. Adjust transformer T306 until an instantaneous jump voltage is indicated on oscilloscope. Then, adjust transformer T306 one-quarter turn in a clockwise direction. Readjust control R323 until waveform on oscilloscope indicates approximately 350 millivolts peak-to-peak.

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NOTE

The control setting for R323 as given in step p is applicable to all X10 Multiplier modules with the exception of the X10 Multiplier module associated with the sixth jack position to the right of the unit. For this module, (which does not contain a crystal), control R323 is adjusted for approximately 500 millivolts peak-to-peak.

- g. Set POWER switch S101 to lower (off) position. Disconnect coaxial leads between Tee-connector on counter and REF IN and TEST IN jacks J101 and J102, respectively.
- r. Disconnect oscilloscope from test point TP8.
- s. Remove extension card and mated module from unit. Then, disconnect extension card from module and re-install module into appropriate unit jack connector on interconnecting board.
- t. If necessary, replace X10 Multiplier module which may have been removed in step c.

#### 5-10. MIXER-AMPLIFIER MODULE ALIGNMENT.

To align the Mixer-Amplifier module, proceed as follows:

- a. Repeat steps a through e of paragraph 5-7.
- b. Remove Mixer-Amplifier module from unit and connect module to extension card. Then, connect extension card into appropriate jack connector on interconnection board.
- c. Make certain accessory connector is connected to accessory connector jack J111 located in rear of accessory compartment. Set POWER switch S101 to ON.
- d. Connect oscilloscope to emitter of transistor Q503 on wired side of module. Adjust transformer T502 for a maximum signal indication on oscilloscope approximately 300 millivolts peak-to-peak.
- e. Disconnect oscilloscope from emitter of transistor Q503 and connect to emitter of Q504. Adjust transformer T501 for a maximum signal indication on oscilloscope (approximately 300 millivolts peak-to-peak).
- f. Set MULTIPLIER(m) switch S102 to PARTS IN  $10^6$ .
- g. Disconnect oscilloscope from emitter of transistor Q504 and connect to emitter of Q501. Adjust capacitor C523 until frequency of waveform on oscilloscope is 100 cycles per second at approximately 7 volts peak-to-peak (figure 5-3F.)
- h. Set POWER switch S101 to lower (off) position. Disconnect coaxial leads connected between Tee-connector on counter and REF IN and TEST IN jacks J101 and J102, respectively.
- i. Disconnect oscilloscope from emitter of Q501.
- j. Remove extension card and mated module from unit. Then, disconnect extension card from module and re-install module into appropriate unit jack connector on interconnecting board.

#### 5-11. OVERALL CHECKS AND ALIGNMENT.

The overall checks and alignment procedures of the PFCB are performed to insure that the operational capabilities of the unit are within acceptable limits.

a. SIGNAL LEVEL CHECKS. - To check internal signal parameters of the PFCB are normal, proceed as follows:

- (1) Repeat steps a through e of paragraph 5-7.
- (2) Remove Mixer-Amplifier module from unit and connect module to extension card. Then connect extension card into appropriate jack connector on interconnecting board.
- (3) Connect oscilloscope to rotor arm of MULTIPLIER(m) switch S102.
- (4) (4) Set POWER switch S101 to ON.
- (5) Successively rotate MULTIPLIER(m) switch S102 to PARTS IN  $10^6$ ,  $10^7$ ,  $10^8$ ,  $10^9$ , and  $10^{10}$  in that order. Oscilloscope should indicate approximately 350 millivolts peak-to-peak in switch position PARTS IN  $10^6$ ,  $10^7$ ,  $10^8$ , and  $10^9$ . In switch position PARTS IN 10 oscilloscope should indicate approximately 500 milliwatts peak-to-peak.
- (6) Disconnect oscilloscope from rotor arm of MULTIPLIER switch S102 and connect to emitter of Q501. Oscilloscope should indicate 100 cycles per second at approximately 7 volts peak-to-peak (figure 5-3F.)
- (7) Disconnect oscilloscope from emitter of transistor Q501 and connect to emitter of transistor Q502. Oscilloscope should indicate 100 cycles per second at approximately 7 volts peak-to-peak (figure 5-3F).
- (8) Set POWER switch S101 to lower (off) position.
- (9) Disconnect oscilloscope from emitter of transistor Q502.

(10) Remove extension card and mated Mixer-Amplifier module from unit. Then, disconnect extension card from module and re-install module into appropriate unit jack connector on interconnecting board.

(11) Remove Output module from unit and connect module to extension card. Then, connect extension card into appropriate jack connector on interconnecting board.

(12) Set POWER switch S101 to ON.

(13) Connect oscilloscope to collector of transistor Q607. Oscilloscope should indicate a series of square-waves at an amplitude of between 14 and 18 volts peak-to-peak.

(14) Disconnect oscilloscope from collector of transistor Q607 and connect to transistor of collector Q608. Oscilloscope should indicate a series of square-waves at an amplitude of between 14 and 18 volts peak-to-peak.

(15) Set POWER switch S101 to lower (off) position.

(16) Disconnect oscilloscope from collector of transistor Q608.

(17) Disconnect Coaxial leads connected between Tee-connector on counter and REF IN and TEST IN jacks J101 and J102, respectively.

(18) Remove extension card and mated output module from unit. Then, disconnect extension card from module and re-install module into appropriate jack connector on interconnecting board.



b. RECORDER CALIBRATION.-After performing the signal level checks, the recorder should be calibrated as follows:

(1) Set MULTIPLIER(m) switch S102 and METER SCALE switch S103 to PARTS IN  $10^6$  and 1 PARTS FULL SCALE, respectively.

(2) Connect Tee-connector to external standard frequency output jack on counter. Then connect coaxial cables between Tee-connector on counter and TEST IN and REF IN jacks J101 and J102, respectively.

(3) Remove output module from unit and connect module to extension card. Then, connect extension card into appropriate jack connector on interconnecting board.

(4) Set POWER switch S101 and RECORDER switch S102 to ON and observe for the following indications:

(a). POWER ON indicator DS101 should go on.

(b). Recorder chart should move.

(c) Recorder pen markings on recorder chart should be centered on recorder chart.

NOTE

If necessary, adjust control R610 on Output module until recorder pen indicates center scale reading on chart.

(5) Set POWER switch S101 and RECORDER switch S102 to lower (off) position. POWER indicator DS101 should go off.

(6) Disconnect coaxial lead connected between Tee-connector on counter and TEST IN jack J101.

(7) Connect a Tee- connector to crystal oscillator. Then, connect coaxial cables between Tee-connector on crystal oscillator and TEST IN jack J101 on PFCB and input jack on counter.

- (8) Adjust counter for a 10-second count.
- (9) Adjust frequency of crystal oscillator until counter indicates exactly 5 cycles greater than 1 mc.
- (10) Set METER SCALE switch S103 to 5 PARTS FULL SCALE.
- (11) Set POWER switch S101 and RECORDER ON switch S102 to ON and observe POWER indicator DS101 should go on.
- (12) Observe recorder pen markings for full-scale deflection to left of recorder chart. If not, adjust control R609 on Output module until recorder pen markings indicate full scale deflection to left of recorder chart.
- (13) Readjust frequency of crystal oscillator until counter indicates 2 cycles greater than 1 mc.
- (14) Set METER SCALE switch S103 to 2 PARTS FULL SCALE.
- (15) Observe recorder pen markings for full-scale deflection to left of recorder chart. If not, adjust control R603 on Output module until recorder pen markings indicate full-scale deflection to left on recorder chart.
- (16) Set METER SCALE switch S103 to 1 PARTS FULL SCALE.
- (17) Observe recorder pen markings for full-scale deflection to left of recorder chart. If not, adjust control R608 on Output module until recorder pen marking indicates full-scale deflection to left of recorder chart.

(18) Repeat steps (9), (10) and (12) through (17) with oscillator frequency adjusted for a minus, rather than a plus frequency greater than 1 mc and recorder pen indicating full-scale deflection to right, rather than left on recorder chart.

NOTE

When performing step (18) do not adjust controls R603, R608 or R609. These controls have been previously adjusted in steps (11), (15) and (17) at their proper settings. If improper pen recordings are indicated, it may be necessary to readjust control R610 on the Output module for a center-scale indication on recorder chart.

## 5-12. REPAIR OF PRINTED CIRCUITS.

a. GENERAL. - Although the troubleshooting procedure for printed circuits are similar to those for conventional circuits, the repair of printed circuits requires considerably more skill and patience. The printed circuits are small and compact; thus personnel should become familiar with the special servicing techniques required.

The defective part should be pinpointed by a study of the symptoms and by careful analysis of the circuit before attempting to trace trouble on a printed circuit board. Ascertain whether the conducting strips are coated with a protective lacquer, epoxy resin, or similar substance. If so, carefully scrape it away.

Breaks in the conducting strip (foil) can cause permanent or intermittent trouble. In many instances, these breaks will be small that they cannot be detected by the naked eye. These almost invisible cracks (breaks) can be located only with the aid of a powerful hand-or stand-held magnifying glass.

b. MULTIMETER CHECKOUT. - The most common cause of an intermittent condition is a poorly soldered connection. Other causes are: broken boards, broken conducting strips, fused conducting strips, arc-over, loose terminals, etc.

To check out and locate trouble in the conducting strips of a printed circuit board, use a multimeter which does not draw current in excess of 1 ma. For making point-to-point resistance tests, use needle point multimeter probes. Ins rt

one probe into the conducting strip, close to the end of terminal, and place the other probe on the terminal or opposite end of the conducting strip. The multimeter should indicate continuity. If the multimeter indicates an open circuit move the probe along the strip (or if the conducting strip is coated, puncture the coating at intervals) until the multimeter indicates continuity. Mark this area, then using a magnifying glass locate the fault in the conductor.

#### CAUTION

Before using an ohmmeter for testing a circuit containing transistors or other voltage-sensitive semiconductors, check the current drawn under test on all ranges. Do not use a range that exceeds more than 1 ma.

c. HOW TO REPAIR THE BREAK. - If a break in the conducting strip is small, lightly scrape away any coating covering the area of the conducting strip to be repaired. Clean the area with a firm-bristle brush and approved solvent. Then repair the cracked or broken area of the conducting strip by flowing solder over the break. Considerable care must be exercised to keep the solder from flowing into an adjacent strip.

If a strip is burned out, or fused, cut and remove the damaged strip. Connect a length of insulated wire across the breach or from solder-point to solder-point.

After the repairs are completed, clean the repaired area with a stiff brush and solvent. Allow the board to dry thoroughly, and then coat the repaired area with an epoxy resin or a similar compound. This coating not only will protect the repaired area but will help to strengthen it.

NOTE

The repair techniques given above are for temporary repair only. Thus, when a board is broken, it should be replaced.

d. HOW TO CHECK FOR SHORTS AND LEAKAGE. - Printed circuit boards are frequently subject to leakage and shorts, especially if the spacing between conductors is very close, or by the careless formation of a solder bridge between the conducting strips during soldering.

CAUTION

After repairing the printed circuit board, carefully examine the board for solder droppings. This may cause possible shorts.

Frequently, a low-resistance leakage path will be created by moisture and/or dirt that has carbonized onto the phenolic board. This leakage can be detected by measuring the suspected circuit with a multimeter. To overcome this condition, thoroughly clean the carbonized area with solvent and stiff brush. If the carbon cannot be removed in this manner, use a scraping tool (spade end of a solder-aid tool or its equivalent) to remove the carbon.

or drill a hole through the leakage path to break the continuity of the leakage. When the drilling method is used, be careful not to drill into a part mounted on the reverse side of the board.

## SECTION 6 PARTS LIST

6-1. INTRODUCTION Reference designations have been assigned to identify all component parts of the equipment. They are used for marking the equipment (adjacent to the part 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 a 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 F101 is designated XF101. The parts of each major unit are grouped together. Column 1 lists the reference designations of the various parts in alphabetical and numerical order. Column 2 gives the name and description of the various parts. Column 3 lists each Technical Materiel Corporation part number.

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## PFCB-1 MODULAR COMPONENTS BREAKDOWN

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
A101	PFCB-1 SUB-ASSEMBLY	A3875
*A102	DOPPLER CORRECTOR ASSEMBLY	AX519
*A103	SCOPE	
Z101	PRINTED CIRCUIT BOARD ASSEMBLY: Power Supply.	A3785
Z102	PRINTED CIRCUIT BOARD ASSEMBLY: Test Card.	A3784
Z201	PRINTED CIRCUIT BOARD ASSEMBLY: Input-Output Module.	A3808
Z202	PRINTED CIRCUIT BOARD ASSEMBLY: Input-Output Module (REF).	A3808
Z301	PRINTED CIRCUIT BOARD ASSEMBLY: X10 Multiplier Module ( $10^7$ ).	A3786
Z302	PRINTED CIRCUIT BOARD ASSEMBLY: X10 Multiplier Module ( $10^8$ ).	A3786
Z303	PRINTED CIRCUIT BOARD ASSEMBLY: X10 Multiplier Module ( $10^9$ ).	A3786
Z304	PRINTED CIRCUIT BOARD ASSEMBLY: X10 Multiplier Module ( $10^{10}$ ) Y301 is not used.	A3786-1
Z401	PRINTED CIRCUIT BOARD ASSEMBLY: X9 Multiplier Module.	A3787
Z501	PRINTED CIRCUIT BOARD ASSEMBLY: Mixer Amplifier Module.	A3783
Z601	PRINTED CIRCUIT BOARD ASSEMBLY: Output Module.	A3809

\*Units to be shipped with PFCB-1 upon customer request only.

MAIN CHASSIS ASSEMBLY

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C101	CAPACITOR, FIXED, ELECTROLYTIC: 2,600 uf, -10% +100%; 50 WVDC; 75 volts DC surge; plain aluminum case, uninsulated.	CE112-3
CR101	SEMICONDUCTOR DEVICE, DIODE: silicon; 600 volts; max. continuous DC current .50 amp at 100°C; surge current peak 75 amps; max. operating temperature 150°C; max. forward voltage drop 1.0 V; max. reverse current 1,000 ua.	1N2484
CR102 thru CR105	Same as CR101.	
CR106	SEMICONDUCTOR DEVICE, DIODE: silicon; nom. Zener voltage 24 V; standard anode-to-stud polarity, negative-grounded application; tolerance +5%; junction storage temperature rating -65°C to +175°C; power dissipation 10 watts DC; solder terminals; hermetically sealed metal and glass case.	VR101-24S51
CR107	SEMICONDUCTOR DEVICE, DIODE: silicon; 12 volts nom., +5%; 10 watts max. dissipation at 25°C; max. current rating 210 ma; max. impedance 3.0 ohms; storage temperature 175°C.	1N2976B
CR108	SEMICONDUCTOR DEVICE, DIODE: Zener, silicon, diffused junction; reverse breakdown voltage 18 volts, +10%; max. dynamic impedance 3 ohms; DC current rated at 500 ma; max. leakage current 10 ua at 5 volts; power dissipation 10 watts; hermetically sealed metal and glass case.	1N1819
DS101	LAMP, INCANDESCENT: 28 volts; 0.04 amps; miniature bayonet base T-3-1/4 bulb.	BI101-1819
DS102	Same as DS101.	
F101	FUSE, CARTRIDGE: 1 amp; time lag; 1-1/4" lg. x 1/4" dia.; slow blow.	FU102-1
F102	Same as F101.	
F103	FUSE, CARTRIDGE: 1/2 amp; time delay; 1-1/4" lg. x 1/4" dia.; slow blow.	FU102-.5

## MAIN CHASSIS ASSEMBLY

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
J101	CONNECTOR, RECEPTACLE, BULKHEAD, ELECTRICAL: pressurized; 1-5/16" long; series BNC.	UG657/U
J102	Same as J101.	
J103	Same as J101.	
J104	CONNECTOR, RECEPTACLE, ELECTRICAL: RF; 1 round female contact, straight type; 52 ohms; series BNC as BNC.	UG625B/U
J105	Same as J104.	
J106	Same as J104.	
J107	Same as J104.	
J108	CONNECTOR, RECEPTACLE, ELECTRICAL: 3 number 16 male contacts; straight type.	MS3102A14S-1P
J109	CONNECTOR, RECEPTACLE, ELECTRICAL: 4 number 16 male contacts; straight type.	MS3102A14S-2P
J110	Same as J104.	
J111	CONNECTOR, RECEPTACLE, ELECTRICAL: 20 female, flat solid face contacts; for double sided 3/32" printed circuit board; continuous current rating 5 amps; 1800 V RMS; float bushing.	JJ293-10D
J112	Supplied as part of M101.	
J113	CONNECTOR, RECEPTACLE, ELECTRICAL: 15 female, flat solid face contacts; for single sided 3/32" printed circuit board; continuous current rating 5 amps; 1800 V RMS; float bushing; threaded insert and dipped solder terminals.	JJ293-15STD
J114 thru J122	Same as J113.	
J123	CONNECTOR, RECEPTACLE, ELECTRICAL: 30 female, flat solid face contacts; for double sided 3/32" printed circuit board; continuous current rating 5 amps; 1800 V RMS; float bushing; threaded insert and dipped solder terminals.	JJ293-15DTD

## MAIN CHASSIS ASSEMBLY

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
K101	RELAY, ARMATURE: DPDT; 700 ohms, <u>+10%</u> DC resistance; operating voltage 24 VDC; current rating 35 ma, 700 mw at 25°C; contacts rated for 5 amps at 29 VDC; clear high impact styrene dust cover case.	RL156-1
M101	MICROAMP METER: 10-0-10 DC range; 5-0-5 scale; voltage rating 110 VAC, 60 cycle; speed 1" per hour; resistance 1500 ohms, <u>+5%</u> -10%; 50 division chart paper; <u>+2%</u> accuracy, full scale; clamping rate 5 second interval; black metal case.	MR184
Q101	TRANSISTOR: germanium; PNP; collector to base and emitter voltage 45 VDC at 300 ma, 30 VDC at 500 ma; emitter base voltage 25 V; collector current 3 amps; power dissipation 62.5 watts at 25°C; junction temperature range -65°C to +100°C.	2N2143
Q102	Same as Q101.	
R101 thru R104	Refer to Power Supply Assembly A3785.	
R105	RESISTOR, FIXED, COMPOSITION: 100 ohms, <u>+5%</u> ; 1/2 watt. Part of Z103.	RC20GF101J
R106	Same as R105. Part of Z103.	
R107	Same as R105. Part of Z103.	
R108	RESISTOR, FIXED, WIREWOUND: 50 ohms; current rating 316 ma; 5 watts. (Part of Power Supply circuit. For reference see A3785)	RW107-16
R109	RESISTOR, FIXED, FILM: 1,500 ohms, <u>+1%</u> ; rated at 1/4 watt, 300 WVDC.	RN60D1501F
S101	SWITCH, TOGGLE: DPST; 2 amps rated at 250 volts; bat type handle.	ST22K
S102	SWITCH, ROTARY: 1 section, 5 positions, 30° angle of throw; non-shorting type contacts.	SW118
S103	SWITCH, ROTARY: interlock; SPDT; rated at 15 amps for 120 or 250 VAC; .2 amps resistive at 250 VDC.	SW230
S104	Same as S101.	

## MAIN CHASSIS ASSEMBLY

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
S105	Same as S101.	
T101	TRANSFORMER, POWER, ISOLATION, STEP-DOWN: primary input 105, 115, 125 or 210, 230, 250 V; frequency 50/60 cps, phase 1; secondary 28 V rated at 500 ma; 2-13/16" long x 2-11/16" wide x 2-3/8" high; hermetically sealed steel case.	TF269
TB101	TERMINAL BOARD, BARRIER: 5 terminals; 6-32 thread x 1/4" lg, binder head screws; phenolic black bakelite.	TM100-5
W101	WIRING HARNESS, BRANCHED, ELECTRICAL: consists of various lengths and sizes of MWC and LWC wire; coaxial cables RG174/U, and insulation sleeving.	CA900
XDS101	LIGHT, INDICATOR: with red frosted lens; for miniature bayonet base T-3-1/4 bulb.	TS106-1
XDS102	LIGHT, INDICATOR: with green frosted lens; for miniature bayonet base T-3-1/4 bulb.	TS106-3
XF101	FUSEHOLDER: extractor post type; accommodates cartridge fuse 1/4" dia. x 1-1/4" long; rated at 15 amps, 250 V max.; o/a length 1-3/4"; bushing mounted.	FH103
XF102	Same as XF101.	
XF103	Same as XF101.	
XK101	SOCKET, RELAY: with retainer; 6 contacts, solder type terminals; black phenolic socket.	TS171-1
XQ101	SOCKET, SEMICONDUCTOR DEVICE: 2 pin contact accommodation; consisting of one socket, TMC part number TS166-S1, one chassis insulator, TMC part number TS166-M1, polarized; one terminal grounding strap; 1-37/64" x 1" max. o/a dimensions.	TS166-1
XQ102	Same as XQ101.	
Z103	PRINTED CIRCUIT BOARD ASSEMBLY: module interconnect consists of resistors, R105, R106, R107; connectors, J113 through J122.	A3810

## POWER SUPPLY ASSEMBLY

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C101	Refer to Center Support Assembly A3881.	
C102	CAPACITOR, FIXED, ELECTROLYTIC: polarized; 500 uf; 15 VDCW; max. temperature range of 0°C to 85°C; hermetically sealed aluminum case with clear vinyl plastic sleeve.	CE116-6VN
C103	Same as C102.	
C104	Same as C102.	
C105	Same as C102.	
CR101	SEMICONDUCTOR DEVICE, DIODE: silicon; 600 volts; max. continuous DC current .50 amp at 100°C; surge current peak 75 amps; max. operating temperature 150°C; max. forward voltage drop 1.0 V; max. reverse current 1,000 ua.	1N2484
CR102	Same as CR101.	
CR103	Same as CR101.	
CR104	Same as CR101.	
CR105.	Same as CR101.	
R101	RESISTOR, FIXED, COMPOSITION: 470 ohms, $\pm 10\%$ ; 1 watt.	RC32GF471K
R102	RESISTOR, FIXED, COMPOSITION; 220 ohms, $\pm 10\%$ , 2 watts	RC42GF221K
R103	RESISTOR, FIXED, COMPOSITION: 1,000 ohms, $\pm 10\%$ 2 watts.	RC42GF221K
R104	Same as R103.	
R105 thru R107	Refer to Interconnect Board Assembly A3810.	
R108	Refer to Main Chassis Center Support Assembly A3881.	

## INPUT-OUTPUT MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C201	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 10,000 uuf; GMV; 500 WVDC.	CC100-16
C202	Same as C201.	
C203	Same as C201.	
C204	Same as C201.	
C205	Same as C201.	
C206	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 100,000 uuf, +80% -20%; 100 WVDC.	CC100-28
C207	Same as C206.	
C208	CAPACITOR, FIXED, MICA DIELECTRIC: 120 uuf, +5%; 500 WVDC; straight wire leads.	CM111F12LJ5S
C209	Same as C208.	
C210	Same as C208.	
C211	Same as C201.	
C212	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: 8-50 uuf; 500 min. Q at 1 Mc; 350 WVDC; operating temperature range -55°C to +85°C.	CV109-9
C213	CAPACITOR, FIXED, MICA DIELECTRIC: 510 uuf; +5%; 500 WVDC; straight wire leads.	CM111F51LJ5S
C214	CAPACITOR, FIXED: MICA DIELECTRIC: 47 uuf, +5%; 500 WVDC; straight wire leads.	CM111F47QJ5S
Q201	TRANSISTOR: PNP germanium, alloy junction; collector to base voltage 30 volts; collector to emitter, and emitter to base voltage 20 volts; collector current 200 ma; power dissipation 200 mw; storage temperature -65°C to +100°C; metal case.	2N396A
Q202	Same as Q201.	
Q203	TRANSISTOR: germanium, PNP; max. collector dissipation 125 mw; alpha cut-off frequency 100 mc; collector to emitter breakdown voltage, base open 20 V; max. collector current 10 ma; collector to base leakage current, emitter open 8 ma; forward current gain 100 mc.	2N2084

## INPUT-OUTPUT MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R201	NOT USED	
R202	RESISTOR, FIXED, COMPOSITION: 100 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF101K
R203	RESISTOR, FIXED, COMPOSITION: 4,700 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF472K
R204	NOT USED	
R205	RESISTOR, FIXED, COMPOSITION: 1,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF102K
R206	Same as R205.	
R207	RESISTOR, FIXED, COMPOSITION: 2,200 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF222K
R208	RESISTOR, FIXED, COMPOSITION: 10,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF103K
R209	Same as R208.	
R210	Same as R208.	
R211	RESISTOR, FIXED, COMPOSITION: 47 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF470K
R212	Same as R211.	
R213	RESISTOR, FIXED, COMPOSITION: 330 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF331K
R214	RESISTOR, FIXED, COMPOSITION: 150 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF151K
R215	Same as R214.	
R216	RESISTOR, VARIABLE, COMPOSITION: 500 ohms, $\pm 10\%$ ; 0.25 watt at 70 C; operating temperature range -55°C to +120°C; linear taper.	RV111U501A
R217	Same as R202.	
T201	TRANSFORMER, RADIO FREQUENCY: adjustable	TT248



## INPUT-OUTPUT MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
T202	TRANSFORMER, RADIO FREQUENCY; adjustable	TT251
T203	Same as T202.	
XY201	SOCKET, CRYSTAL: clip type; 2 cadmium plated contacts; 3/64" x 5/32" tail slots.	TS167-1
Y201	CRYSTAL UNIT, QUARTZ: nom. frequency range 800 - 20,000 Kc, + .005%; operating temperature range $-55^{\circ}\text{C}$ to $+90^{\circ}\text{C}$ ; xtal unit max. capacitance 7.0 uuf; load capacitance $32.0 \pm 0.5$ uuf; parallel resonance; metal case and HC-6/U holder.	CR18A/U1.000, 000

## X 10 MULTIPLIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C301	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 10,000 uuf, 500 WVDC.	CC100-16
C302	Same as C301.	
C303	Same as C301.	
C304	Same as C301.	
C305	Same as C301.	
C306	Same as C301.	
C307	Same as C301.	
C308	Same as C301.	
C309	Same as C301.	
C310	Same as C301.	
C311	Same as C301.	
C312	Same as C301.	
C313	CAPACITOR, FIXED, MICA DIELECTRIC: 120 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F121J5S
C314	CAPACITOR, FIXED, MICA DIELECTRIC: 220 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F221J5S
C315	CAPACITOR, FIXED, MICA DIELECTRIC: 82 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F820J5S
C316	CAPACITOR, FIXED, MICA DIELECTRIC: 68 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F680J5S
C317	Same as C313.	
C318	Same as C313.	
C319	Same as C314.	

## X 10 MULTIPLIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C320	CAPACITOR, FIXED, MICA DIELECTRIC: 47 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F470J5S
C321	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 100,000 uuf, $+80\%$ $-20\%$ ; 100 WVDC.	CC100-28
C322	Same as C321.	
C323	CAPACITOR, FIXED, MICA DIELECTRIC: 10 uuf, $\pm 10\%$ ; 500 WVDC; straight wire leads.	CM111C100K5S
C324	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: 8-50 uuf; 500 min. Q at 1 mc; 350 WVDC; operating temperature range $-55^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ .	CV109-6
L301	COIL, RADIO FREQUENCY: adjustable.	AC207
L302	COIL, RADIO FREQUENCY: fixed; 33 uf, $+5\%$ ; 1.2 ohms DC resistance; current rating 520 ma; molded case.	CL275-330
Q301	TRANSISTOR: PNP, germanium, alloy junction; collector to base voltage 30 volts; collector to emitter, and emitter to base voltage 20 volts; collector current 200 ma; power dissipation 200 mw; storage temperature $-65^{\circ}\text{C}$ to $+100^{\circ}\text{C}$ ; metal case.	2N396A
Q302	TRANSISTOR: PNP, germanium; max. collector dissipation 125 mw; alpha cut-off frequency 100 mc; collector to emitter breakdown voltage, base open 20 V; max. collector current 10 ma; collector to base leakage current, emitter open 8 ma; forward current gain 100 mc.	2N2084
Q303	Same as Q302.	
Q304	Same as Q302.	

## X 10 MULTIPLIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
Q305	Same as Q301.	
Q306	Same as Q301.	
R301	RESISTOR, FIXED, COMPOSITION: 120 ohms, $\pm 10\%$ , 1/2 watt.	RC20GF121K
R302	RESISTOR, FIXED, COMPOSITION: 1,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF102K
R303	Same as R302.	
R304	Same as R302.	
R305	Same as R302.	
R306	Same as R302.	
R307	Same as R302.	
R308	RESISTOR, FIXED, COMPOSITION: 3,300 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF332K
R309	RESISTOR, FIXED, COMPOSITION: 100 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF101K
R310	Same as R309.	
R311	Same as R309.	
R312	RESISTOR, FIXED, COMPOSITION: 150 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF151K
R313	Same as R312.	
R314	Same as R312.	
R315	RESISTOR, FIXED, COMPOSITION: 220 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF221K
R316	RESISTOR, FIXED, COMPOSITION: 330 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF331K
R317	RESISTOR, FIXED, COMPOSITION: 10,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF103K

## X 10 MULTIPLIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R318	Same as R317.	
R319	Same as R317.	
R320	Same as R317.	
R321	RESISTOR, FIXED, COMPOSITION: 15,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF153K
R322	RESISTOR, FIXED, COMPOSITION: 27,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF273K
R323	RESISTOR, VARIABLE, COMPOSITION: 500 ohms, $\pm 10\%$ ; power rating 0.25 watt at $70^{\circ}\text{C}$ ; operating tempera- ture $-55^{\circ}\text{C}$ to $+120^{\circ}\text{C}$ ; linear taper.	RV111U501A
R324	RESISTOR, FIXED, COMPOSITION: 47 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF470K
T301	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT251
T302	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT250
T303	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT249
T304	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT247
T305	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT248
T306	Same as T301.	
XY301	SOCKET, CRYSTAL: clip type; 2 cadmium plated con- tacts; 3/64" x 5/32" tail slots.	TS167-1
Y301	CRYSTAL UNIT, QUARTZ: nom. frequency range 800 - 20,000 Kc, $\pm 0.005\%$ ; operating temperature range $-55^{\circ}\text{C}$ to $+90^{\circ}\text{C}$ ; xtal unit max. capacitance 7.0 uuf; load capacitance $32.0 \pm 0.5$ uuf; parallel resonance; metal case and HC-6/U holder.	CR18A/U1.000, 000

## X 9 MULTIPLIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C401	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 10,000 uuf; GMV; 500 WVDC.	CC100-16
C402	Same as C401.	
C403	Same as C401.	
C404	Same as C401.	
C405	Same as C401.	
C406	Same as C401.	
C407	Same as C401.	
C408	Same as C401.	
C409	CAPACITOR, FIXED, MICA DIELECTRIC: 120 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F12LJ5S
C410	CAPACITOR, FIXED, MICA DIELECTRIC: 330 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F33LJ5S
C411	CAPACITOR, FIXED, MICA DIELECTRIC: 68 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F68QJ5S
C412	Same as C411.	
C413	CAPACITOR, FIXED, CERAMIC DIELECTRIC; 100,000 uuf, $+80\%$ $-20\%$ ; 100 WVDC.	CC100-28
C414	Same as C413.	
C415	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: 8-50 uuf; 500 min Q at 1 Mc; 350 WVDC; operating temperature range $-55^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ .	CV109-9
Q401	TRANSISTOR: PNP, germanium, alloy junction; collector to base voltage 30 volts; collector to emitter, and emitter to base voltage 20 volts; collector current 200 ma; power dissipation 200 mw; storage temperature $-65^{\circ}\text{C}$ to $+100^{\circ}\text{C}$ ; metal case.	2N396A

## X 9 MULTIPLIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
Q402	TRANSISTOR: germanium, PNP; max. collector dissipation 125 mw; alpha cut-off frequency 100 mc; collector to emitter breakdown voltage, base open 20 V; max. collector current 10 ma; collector to base leakage current, emitter open 8 ma; forward current gain 100 mc.	2N2084
Q403	Same as Q402.	
Q404	Same as Q402.	
R401	RESISTOR, FIXED, COMPOSITION: 1,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF102K
R402	Same as R401.	
R403	Same as R401.	
R404	Same as R401.	
R405	RESISTOR, FIXED, COMPOSITION: 10,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF103K
R406	Same as R405.	
R407	Same as R405.	
R408	Same as R405.	
R409	RESISTOR, FIXED, COMPOSITION: 100 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF101K
R410	Same as R409.	
R411	Same as R409.	
R412	Same as R409.	
R413	RESISTOR, FIXED, COMPOSITION: 330 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF331K
R414	RESISTOR, FIXED, COMPOSITION: 47 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF470K
R415	RESISTOR, FIXED, COMPOSITION: 120 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF121K

## X 9 MULTIPLIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R416	RESISTOR, FIXED, COMPOSITION: 150 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF151K
R417	Same as R416.	
T401	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT251
T402	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT253
T403	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT247
T404	Same as T403.	
XY401	SOCKET, CRYSTAL: clip type; 2 cadmium plated contacts; 3/64" x 5/32" tail slots.	TS167-1
Y401	CRYSTAL UNIT, QUARTZ: nom. frequency range 800-20,000 Kc, $\pm .005\%$ ; operating temperature range $-55^{\circ}\text{C}$ to $+90^{\circ}\text{C}$ ; xtal unit max. capacitance 7.0 uuf; load capacitance 32.0 $\pm 0.5$ uuf; parallel resonance; metal case and HC-6/U holder.	CR18A/U9.000, 000



## MIXER-AMPLIFIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C501	CAPACITOR, FIXED, ELECTROLYTIC: 200 uuf, -10% +150% at 120 cps, at 25°C; 15 WVDC; polarized; insulated tubular case.	CE105-200-15
C502	Same as C501.	
C503	CAPACITOR, FIXED, ELECTROLYTIC: 20 uuf, -10% +150% at 120 cps, at 25°C; 25 WVDC; polarized; insulated tubular case.	CE105-20-25
C504	Same as C503.	
C505	Same as C503.	
C506	Same as C503.	
C507	Same as C503.	
C508	Same as C503.	
C509	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 100,000 uuf, +80% -20%; 100 WVDC.	CC100-28
C510	Same as C509.	
C511	Same as C509.	
C512	Same as C509.	
C513	Same as C509.	
C514	Same as C509.	
C515	CAPACITOR, FIXED, CERAMIC DIELECTRIC: 10,000 uuf; GMV; 500 WVDC.	CC100-16
C516	Same as C515.	
C517	Same as C515.	
C518	Same as C515.	
C519	Same as C515.	
C520	Same as C515.	

## MIXER-AMPLIFIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C521	CAPACITOR, FIXED, MICA DIELECTRIC: 390 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F391J5S
C522	CAPACITOR, FIXED, MICA DIELECTRIC: 220 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111F221J5S
C523	CAPACITOR, VARIABLE, CERAMIC DIELECTRIC: 8-50 uuf; 500 min. Q at 1 Mc; 350 WVDC; operating temperature range $-55^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ .	CV109-9
C524	CAPACITOR, FIXED, MICA DIELECTRIC: 10 uuf, $\pm 5\%$ ; 500 WVDC; straight wire leads.	CM111C100K5S
C525	Same as C524.	
C526	CAPACITOR, FIXED, MICA DIELECTRIC: 1,000 uuf, $\pm 5\%$ ; 300 WVDC; straight wire leads.	CM112F102J3S
C527	Same as C526.	
C528	Same as C509.	
C529	Same as C509.	
L501	COIL, RADIO FREQUENCY: fixed; 2,200 uh, $\pm 5\%$ ; 33.7 ohms DC resistance; current rating 99 ma, molded case.	CL275-222
L502	Same as L501.	
L503	COIL, RADIO FREQUENCY: fixed; 1,000 uh, $\pm 5\%$ ; 16.0 ohms DC resistance; current rating 140 ma; molded case.	CL275-102
L504	Same as L503.	
Q501	TRANSISTOR: PNP, germanium, alloy junction; collector to base voltage 30 volts; collector to emitter, and emitter to base voltage 20 volts; collector current 200 ma; power dissipation 200 mw; storage temperature $-65^{\circ}\text{C}$ to $+100^{\circ}\text{C}$ ; metal case.	2N396A
Q502	Same as Q501.	
Q503	Same as Q501.	
Q504	Same as Q501.	

## MIXER-AMPLIFIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
Q505	TRANSISTOR: NPN diffused silicon; collector to base voltage 25 volts; collector to emitter voltage 20 volts; emitter to base voltage 3 volts; collector current 200 ma; power dissipation 1 watt at 25°C; junction temperature -65°C to +175°C; metal case.	2N706
Q506	Same as Q505.	
Q507	Same as Q505.	
R501	RESISTOR, FIXED, COMPOSITION: 47 ohms, <u>+10%</u> ; 1/2 watt.	RC20GF470K
R502	Same as R501.	
R503	Same as R501.	
R504	Same as R501.	
R505	RESISTOR, FIXED, COMPOSITION: 150 ohms, <u>+10%</u> ; 1/2 watt.	RC20GF151K
R506	Same as R505.	
R507	RESISTOR, FIXED, COMPOSITION: 1,500 ohms, <u>+10%</u> ; 1/2 watt.	RC20GF152K
R508	Same as R507.	
R509	RESISTOR, FIXED, COMPOSITION: 3,300 ohms, <u>+10%</u> ; 1/2 watt.	RC20GF332K
R510	Same as R509.	
R511	RESISTOR, FIXED, COMPOSITION: 1,000 ohms, <u>+10%</u> ; 1/2 watt.	RC20GF102K
R512	Same as R511.	
R513	RESISTOR, FIXED, COMPOSITION: 2,200 ohms, <u>+10%</u> ; 1/2 watt.	RC20GF222K
R514	Same as R513.	
R515	RESISTOR, FIXED, COMPOSITION: 4,700 ohms, <u>+10%</u> ; 1/2 watt.	RC20GF472K

## MIXER-AMPLIFIER MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R516	Same as R515.	
R517	Same as R515.	
R518	Same as R511.	
R519	Same as R511.	
R520	RESISTOR, FIXED, COMPOSITION: 10,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF103K
R521	Same as R520.	
R522	Same as R520.	
R523	Same as R520.	
R524	Same as R520.	
R525	Same as R520.	
R526	RESISTOR, FIXED, COMPOSITION: 22,000 ohms, $\pm 10\%$ ; 1/2 watt.	RC20GF223K
T501	TRANSFORMER, RADIO FREQUENCY: adjustable.	TT252
T502	Same as T501.	
XY501	SOCKET, CRYSTAL: clip type; 2 cadmium plated contacts; 3/64" x 5/32" tail slots.	TS167-1
Y501	CRYSTAL UNIT, QUARTZ: nom. frequency range 800-20,000 Kc, $\pm .002\%$ ; crystal oscillating temperature range $-55^{\circ}\text{C}$ to $+50^{\circ}\text{C}$ ; operating temperature range for $\pm .002\%$ frequency tolerance $75^{\circ}\text{C} \pm 5^{\circ}\text{C}$ ; crystal unit max. capacitance 7.0 uuf; load capacitance 32.0 $\pm 0.5$ uuf; parallel resonance; metal case with HC-6/U holder.	CR27A/U1.000, 000

## OUTPUT MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
C601	CAPACITOR, FIXED, ELECTROLYTIC: 10 uuf, -10%, +150% at 120 cps, at 25°C; 15 WVDC; polarized; insulated tubular case.	CE105-10-15
C602	Same as C601.	
C603	CAPACITOR, FIXED, MICA DIELECTRIC: 220 uuf, ±5%; 500 WVDC; straight wire leads.	CM111F221J5S
C604	Same as C603.	
C605	CAPACITOR, FIXED, ELECTROLYTIC: polarized; 2,000 uf; 12 WVDC; max. temperature range 0°C to +85°C; hermetically sealed aluminum case with vinyl plastic sleeve.	CE116-9VN
C606	Same as C605	
C607	CAPACITOR, FIXED, METALIZED PLASTIC: 1.0 uf; ±1%; 100 WVDC.	CN112A105F1
C608	Same as C607.	
CR601	SEMICONDUCTOR DEVICE, DIODE: germanium; max. peak inverse voltage 60 V; continuous average forward current 50 ma; max. peak forward current 150 ma; max. surge current 500 ma; max. inverse current 500 ua at 50 volts or 30 ua at 10 volts.	1N34A
CR602	Same as CR601.	
CR603	SEMICONDUCTOR DEVICE, DIODE: nom. Zener voltage 12 V rated at 21 ma; DC current rating 70 ma; power dissipation 1 watt; junction storage temperature rating -65°C to +175°C; polarized; hermetically sealed metal and glass case.	1N3022
CR604	Same as CR603.	
Q601	TRANSISTOR: NPN diffused silicon; collector to base voltage 25 volts; collector to emitter voltage 20 volts; emitter to base voltage 3 volts; collector current 200 ma; power dissipation 1 watt at 25°C junction temperature -65°C to +175°C; metal case.	2N706
Q602	Same as Q601.	

## OUTPUT MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
Q603	Same as Q601.	
Q604	Same as Q601.	
*Q605	TRANSISTOR: NPN diffused silicon. (Match with Q606 only)	TX102
*Q606	TRANSISTOR: NPN diffused silicon. (Match with Q605 only)	
*Q607	TRANSISTOR: NPN diffused silicon. (Match with Q608 only)	TX102
*Q608	TRANSISTOR: NPN diffused silicon. (Match with Q607 only)	
R601	RESISTOR, FIXED, COMPOSITION: 10,000 ohms, $\pm 5\%$ ; 1/2 watt.	RC20GF103J
R602	Same as R601.	
R603	RESISTOR, VARIABLE, COMPOSITION: 10,000 ohms, $\pm 10\%$ ; power rating 0.25 watt at 70°C; operating temperature -55°C to +120°C; linear taper.	RV111U103A
R604	RESISTOR, FIXED, COMPOSITION: 4,700 ohms, $\pm 5\%$ ; 1/2 watt.	RC20GF472J
R605	Same as R604.	
R606	RESISTOR, FIXED, COMPOSITION: 560 ohms, $\pm 5\%$ ; 1/2 watt.	RC20GF561J
R607	Same as R606.	
R608	RESISTOR, VARIABLE, COMPOSITION: 5,000 ohms, $\pm 10\%$ ; power rating 0.25 watt at 70°C; operating temperature -55°C to +120°C; linear taper.	RV111U502A
R609	RESISTOR, VARIABLE, COMPOSITION: 50,000 ohms, $\pm 10\%$ ; power rating 0.25 watt at 70°C; operating temperature -55°C to +120°C; linear taper.	RV111U503A

\* (Q605, Q606) and (Q607, Q608) are supplied as matched pairs, and should only be replaced as matched pairs.

## OUTPUT MODULE

REF SYMBOL	DESCRIPTION	TMC PART NUMBER
R610	RESISTOR, VARIABLE, COMPOSITION: 100 ohms, <u>+10%</u> ; power rating 0.25 watt at 70°C; operating temperature -55°C to +120°C; linear taper.	RV111U101A
R611	RESISTOR, FIXED, FILM: 1,000 ohms, <u>+1%</u> ; rated at 1/4 watt, 300 WVDC.	RN60D1001F
R612	Same as R611.	
R613	RESISTOR, FIXED, FILM: 4,700 ohms, <u>+1%</u> ; rated at 1/4 watt, 300 WVDC.	RN60D4701F
R614	Same as R613.	
R615	RESISTOR, FIXED, FILM: 10,000 ohms, <u>+1%</u> ; rated at 1/4 watt, 300 WVDC.	RN60D1002F
R616	Same as R615.	
R617	RESISTOR, FIXED, FILM: 560 ohms, <u>+1%</u> ; rated at 1/4 watt, 300 WVDC.	RN60D5600F
R618	Same as R617.	
R619	RESISTOR, FIXED, FILM: 220 ohms, <u>+1%</u> ; rated at 1/4 watt, 300 WVDC.	RN60D2200F
R620	Same as R619.	
R621	RESISTOR, FIXED, FILM: 270 ohms, <u>+1%</u> ; rated at 1/4 watt, 300 WVDC.	RN60D2700F
R622	Same as R621.	
R623	NOT USED.	
R624	RESISTOR, FIXED, COMPOSITION: 1,000 ohms, <u>+5%</u> ; 1/2 watt.	RC20GF102J
R625	Ssme as R624.	

SECTION 7

SCHEMATIC DIAGRAMS

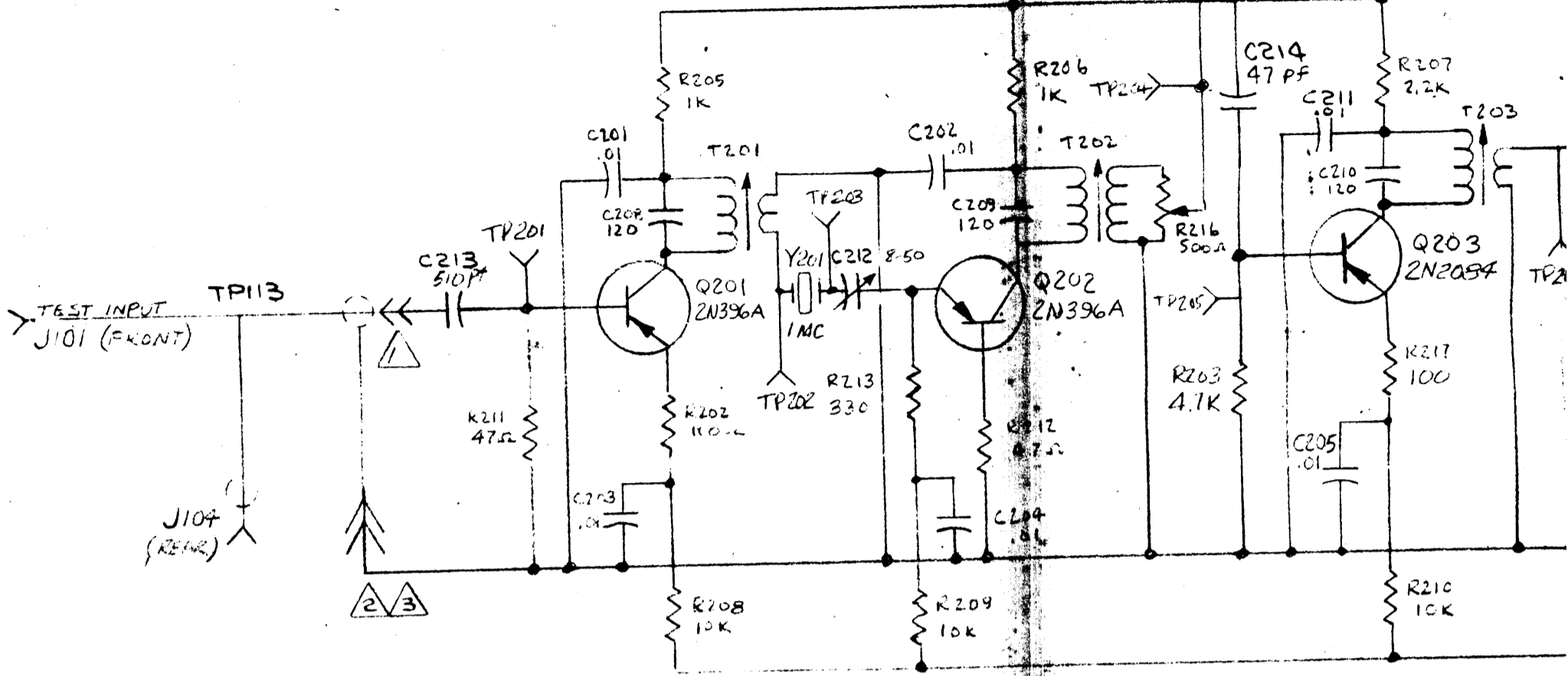


Z201  
PC166/A3808

OUTPUT AMP.

AMP/MULT.

CRYSTAL FILTER AMP.



J103 (FRONT)  
IMC + nAf OUT

J107 (REAR)

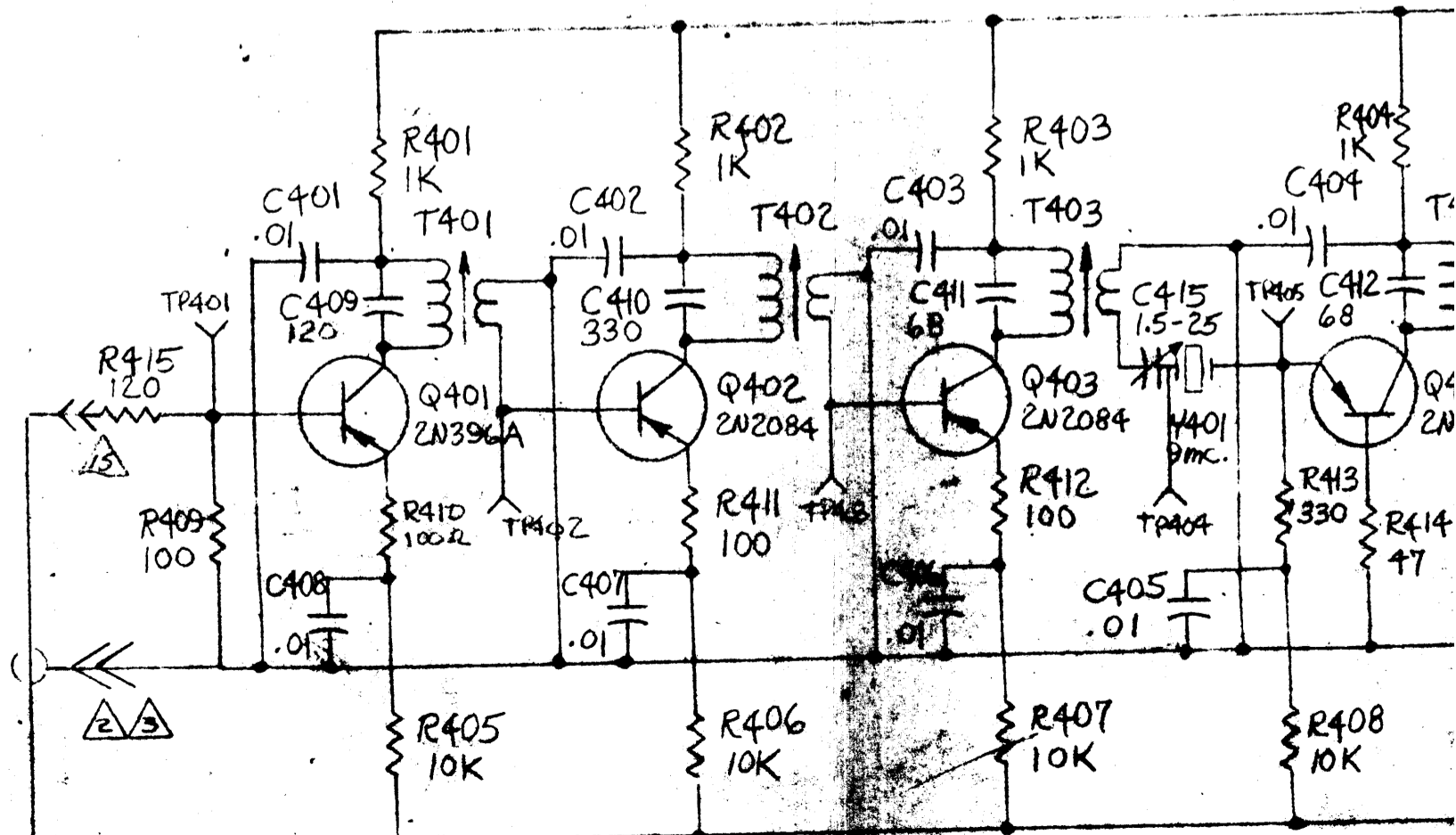
Z401  
PC153/A3787

ISOLATION AMP.

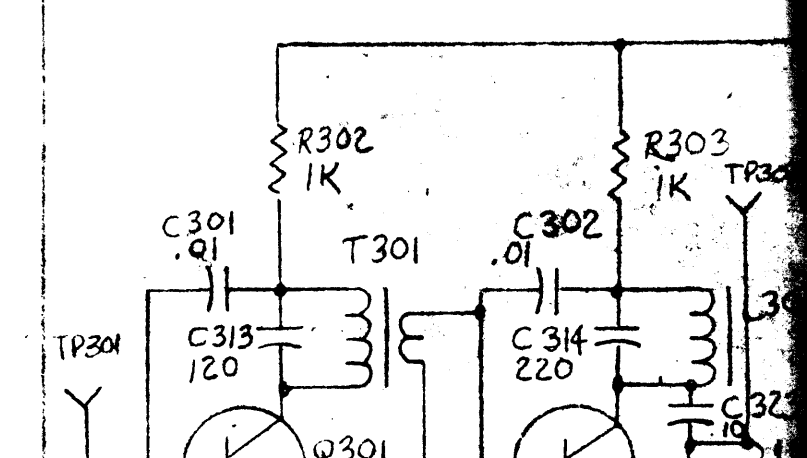
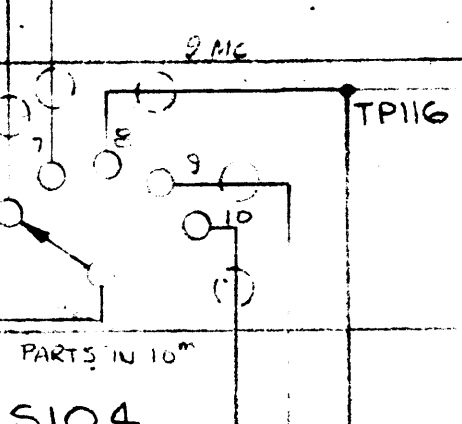
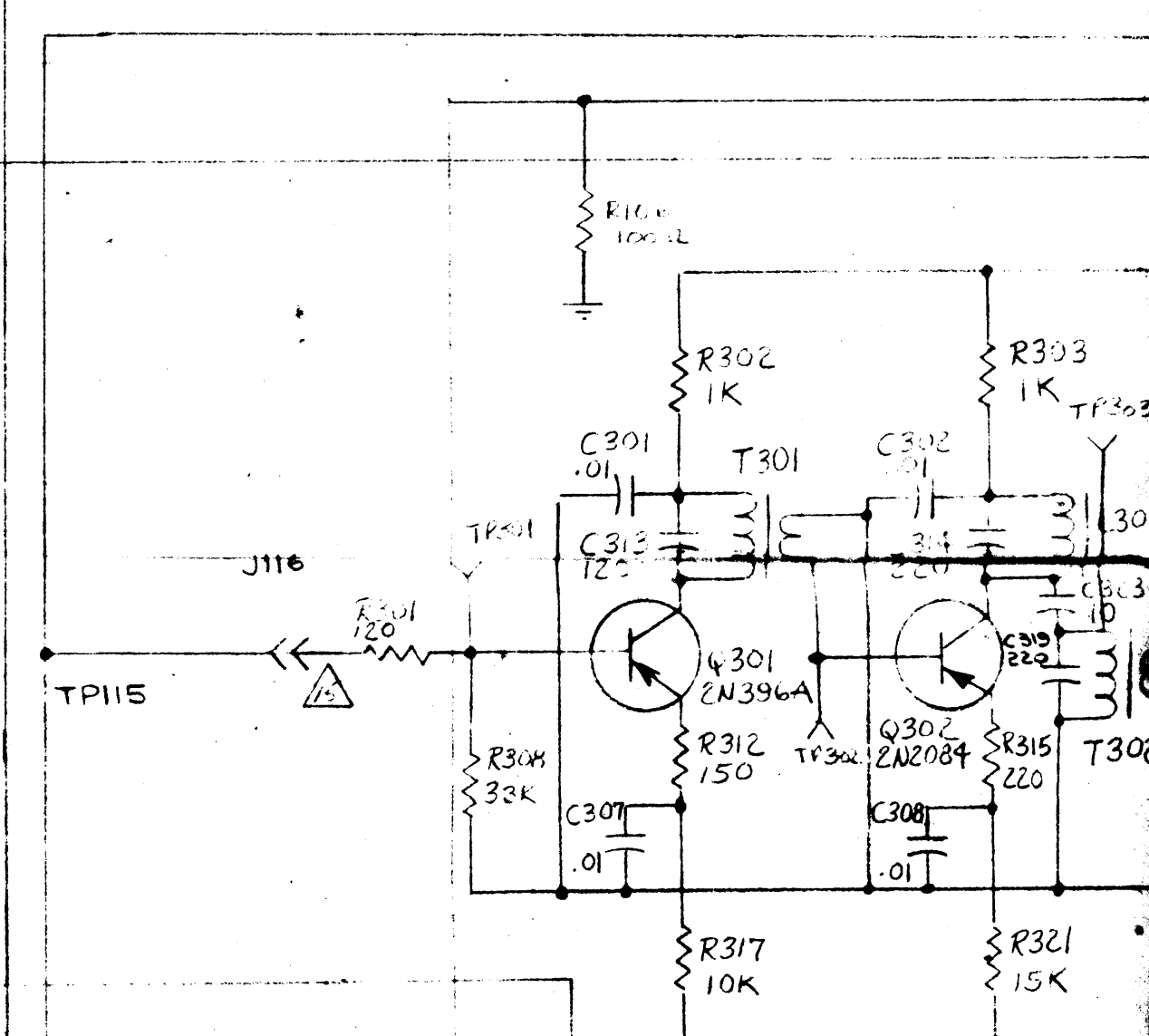
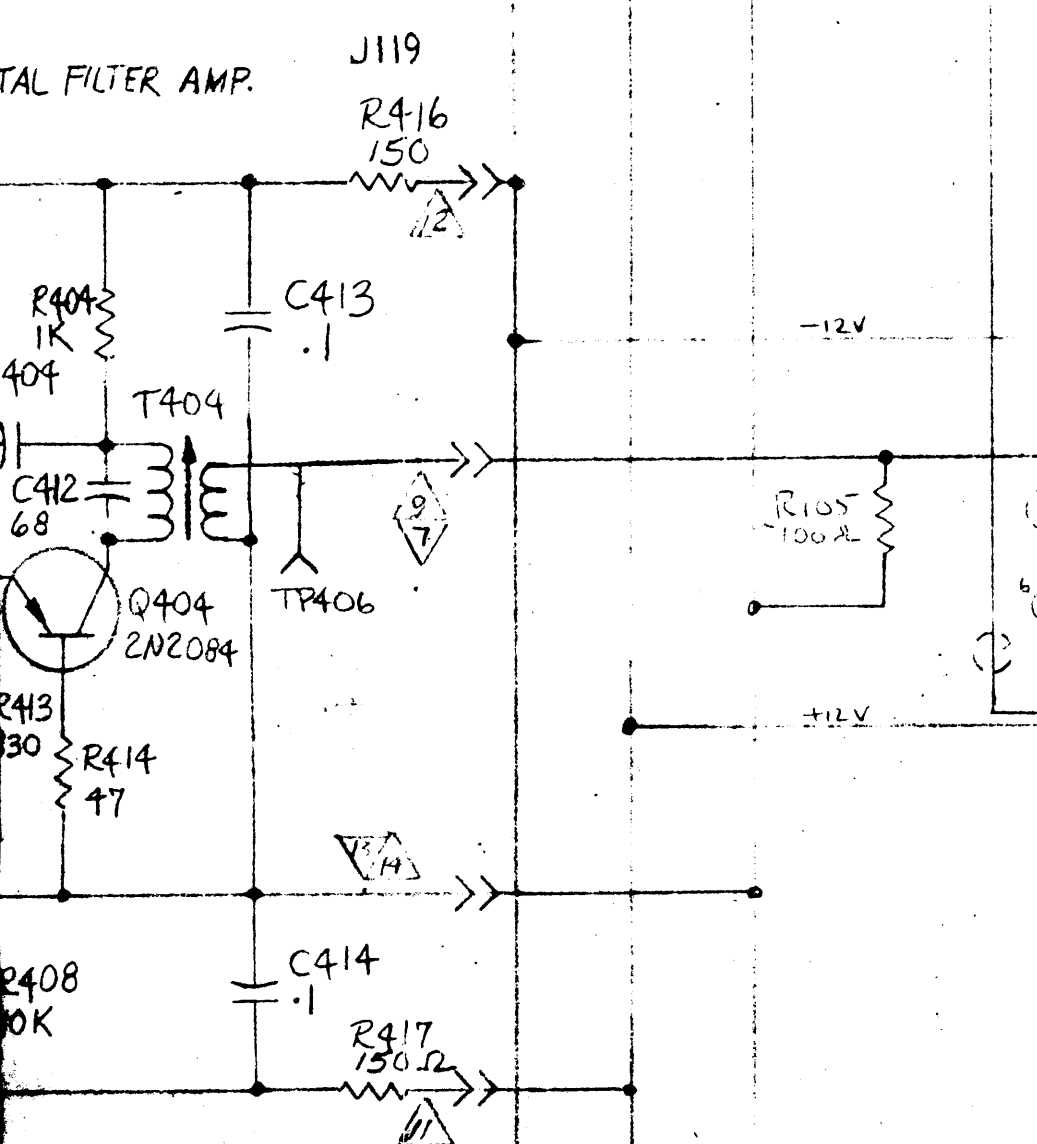
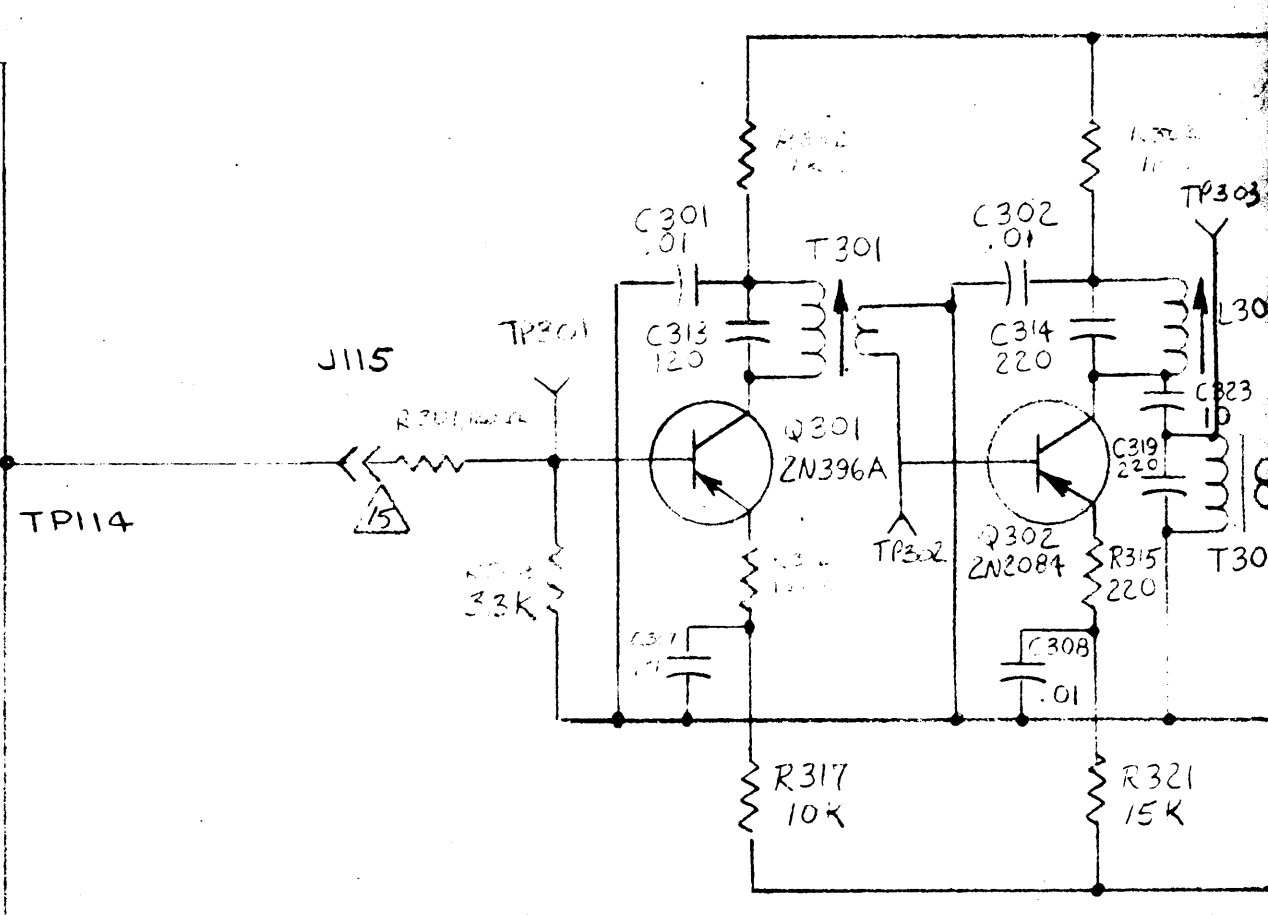
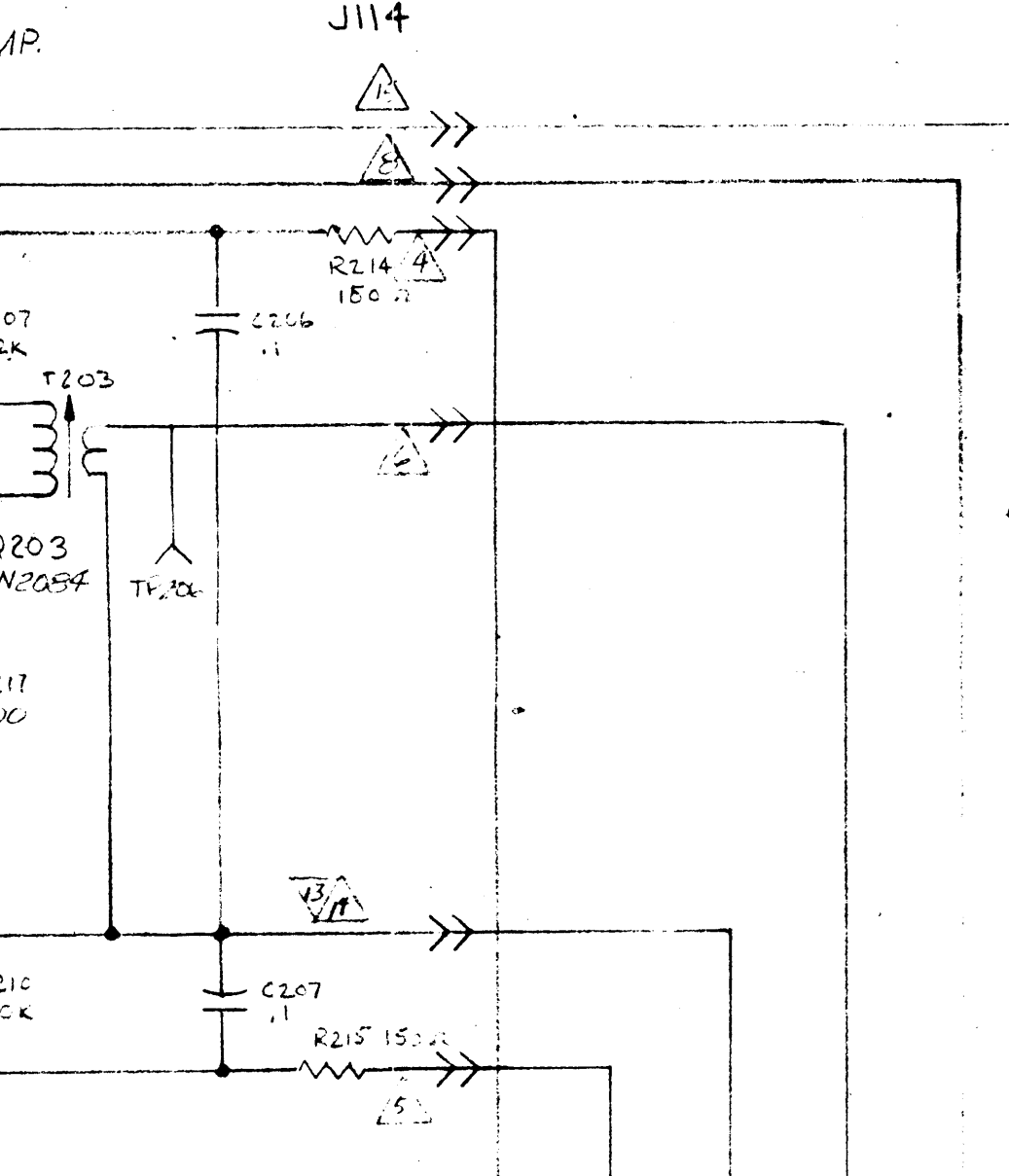
TRIPLER

TRIPLEX

CRYSTAL FILTER

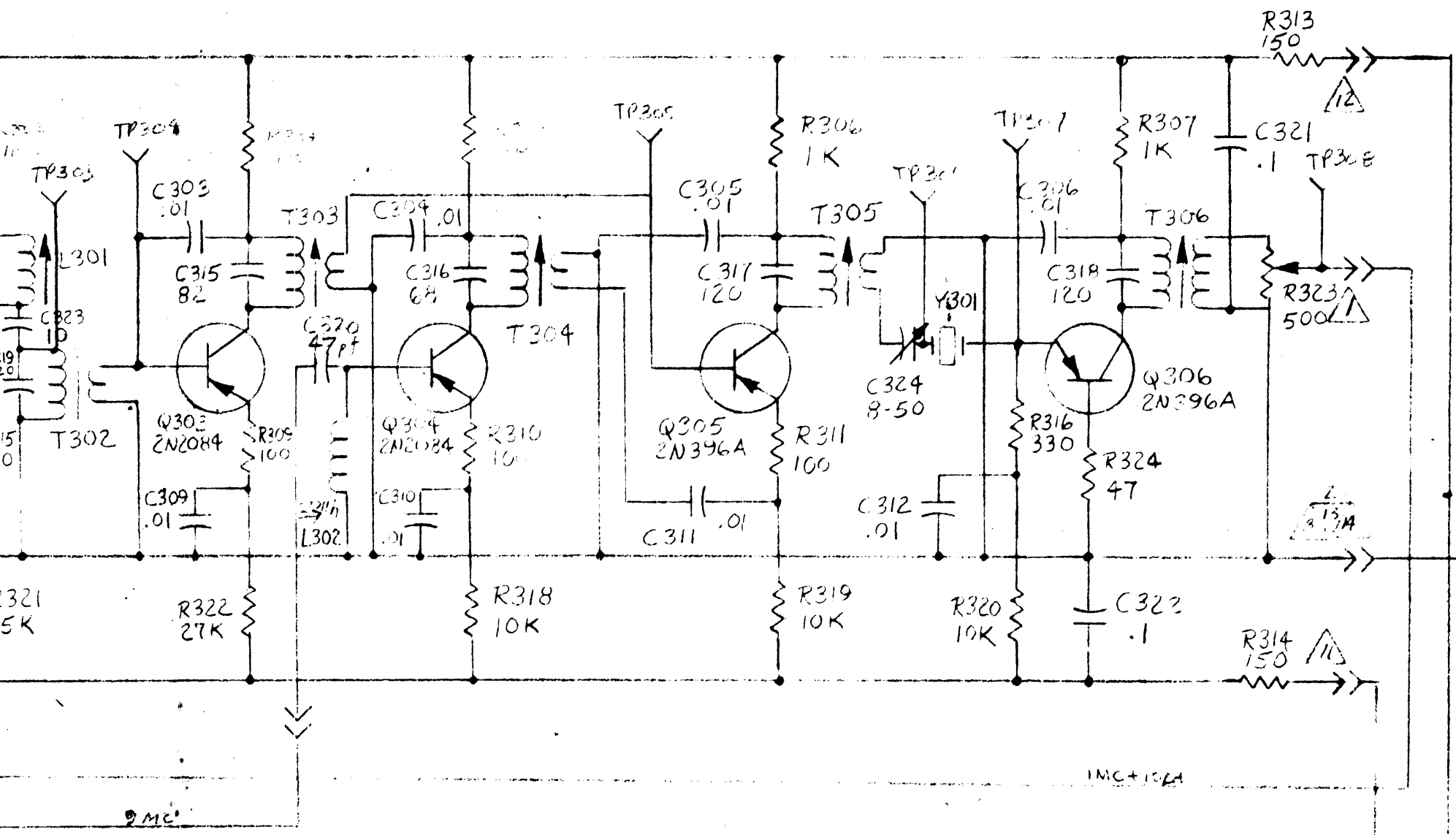


AMPLIFIER X5 MULTIPLIER

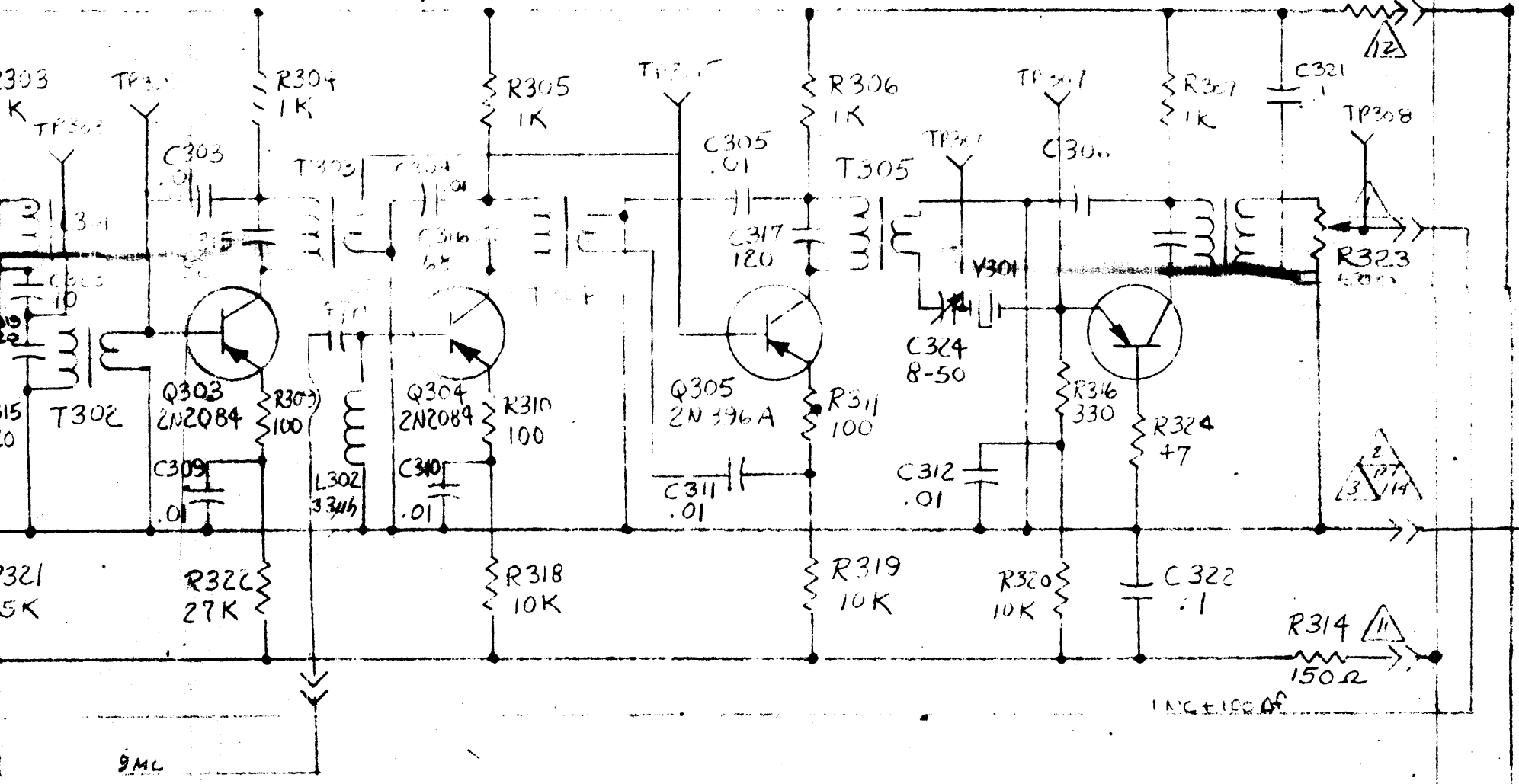


PC152/A3786  
Z301

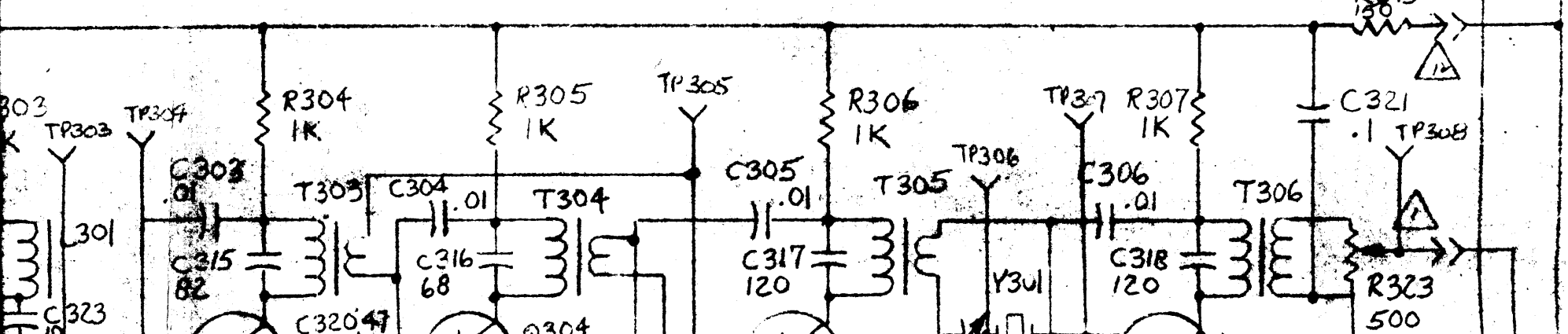
AMPLIFIER X2 MULTIPLIER 9MC BUFFER MIXER XTAL FILTER AMPLIFIER



Z302  
PC152/A3786

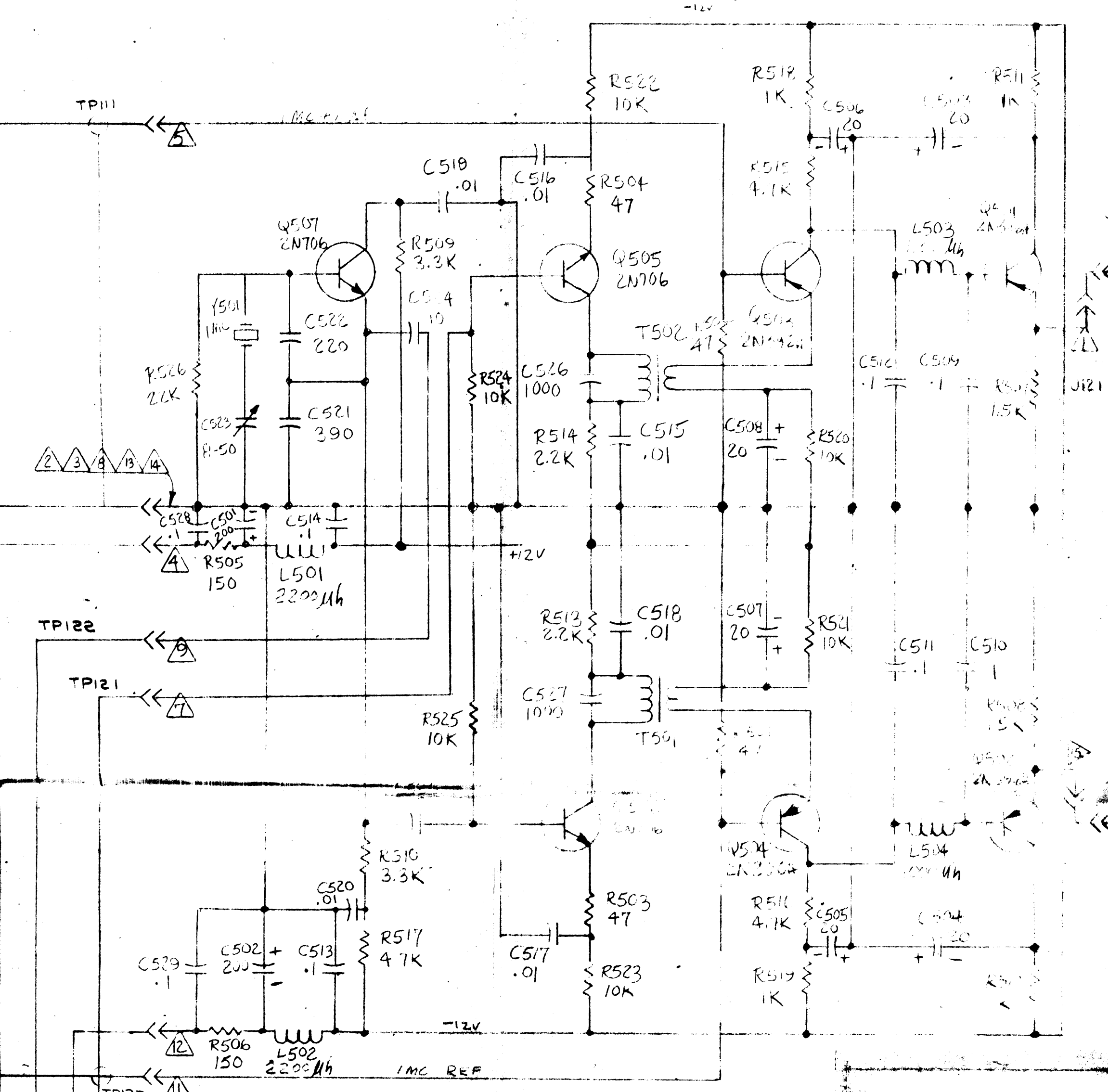


PC152/A3786  
Z303



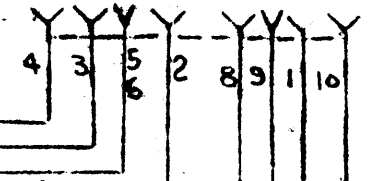
Z501  
PC149/A3783

1 MC OSCILLATOR      BUFFER      DRIVER      AMPLIFIER



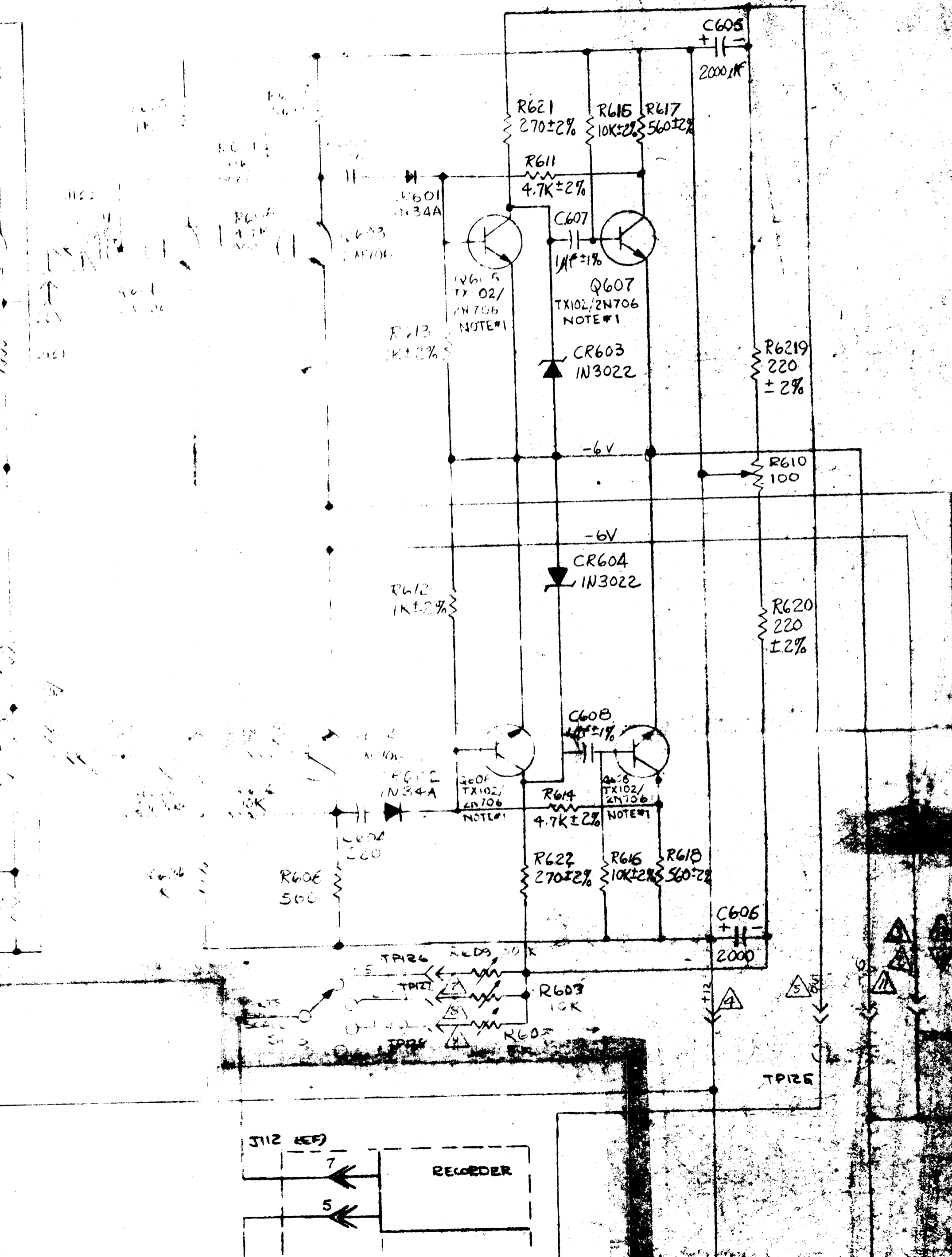
ACCESSORY JACK  
J111

JUMPER PLUG FOR NORMAL  
OPERATION SHORTS PINS  
3 AND 4



7601  
PC161/A3809

ONE SHOT MV.



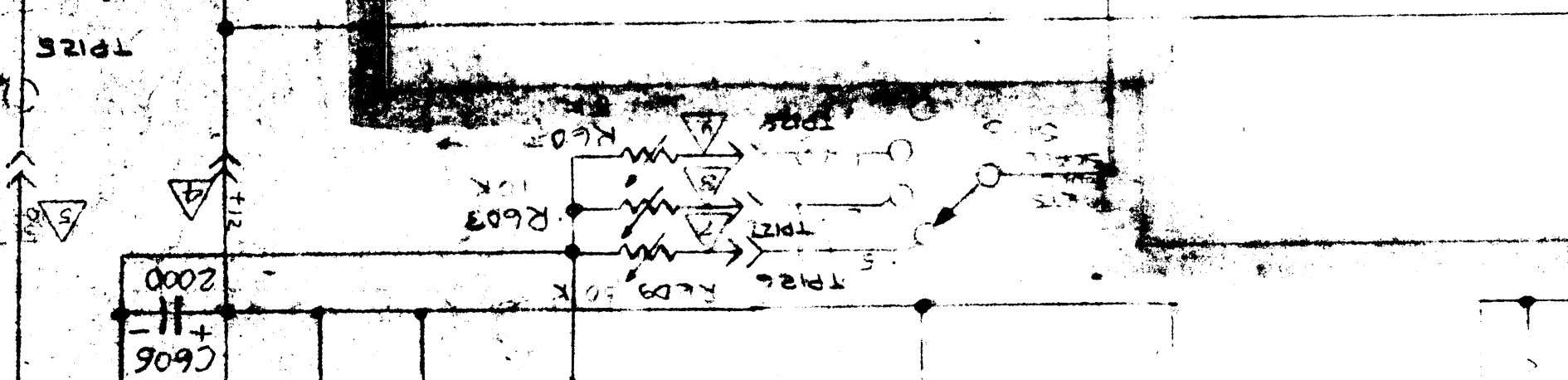
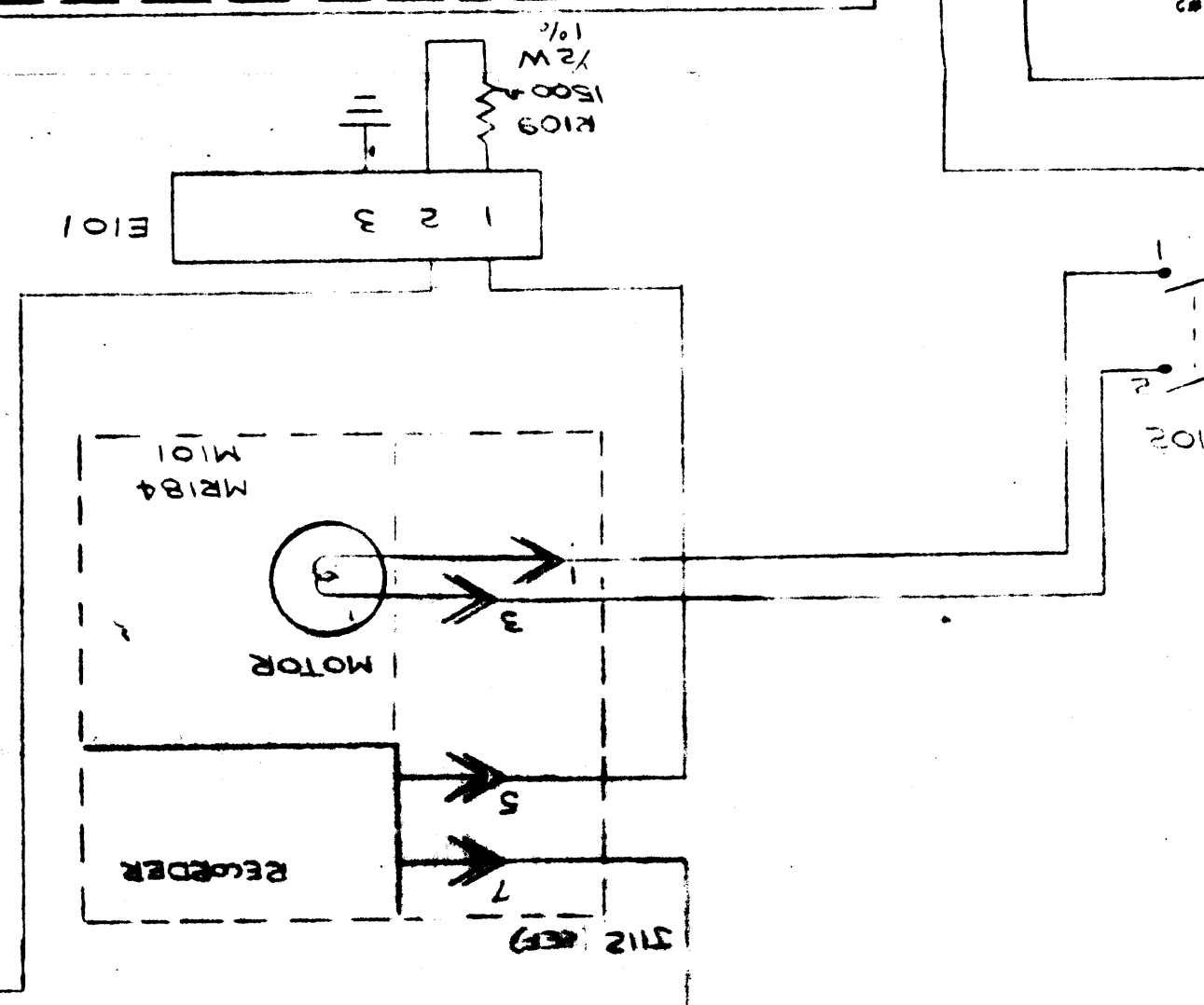
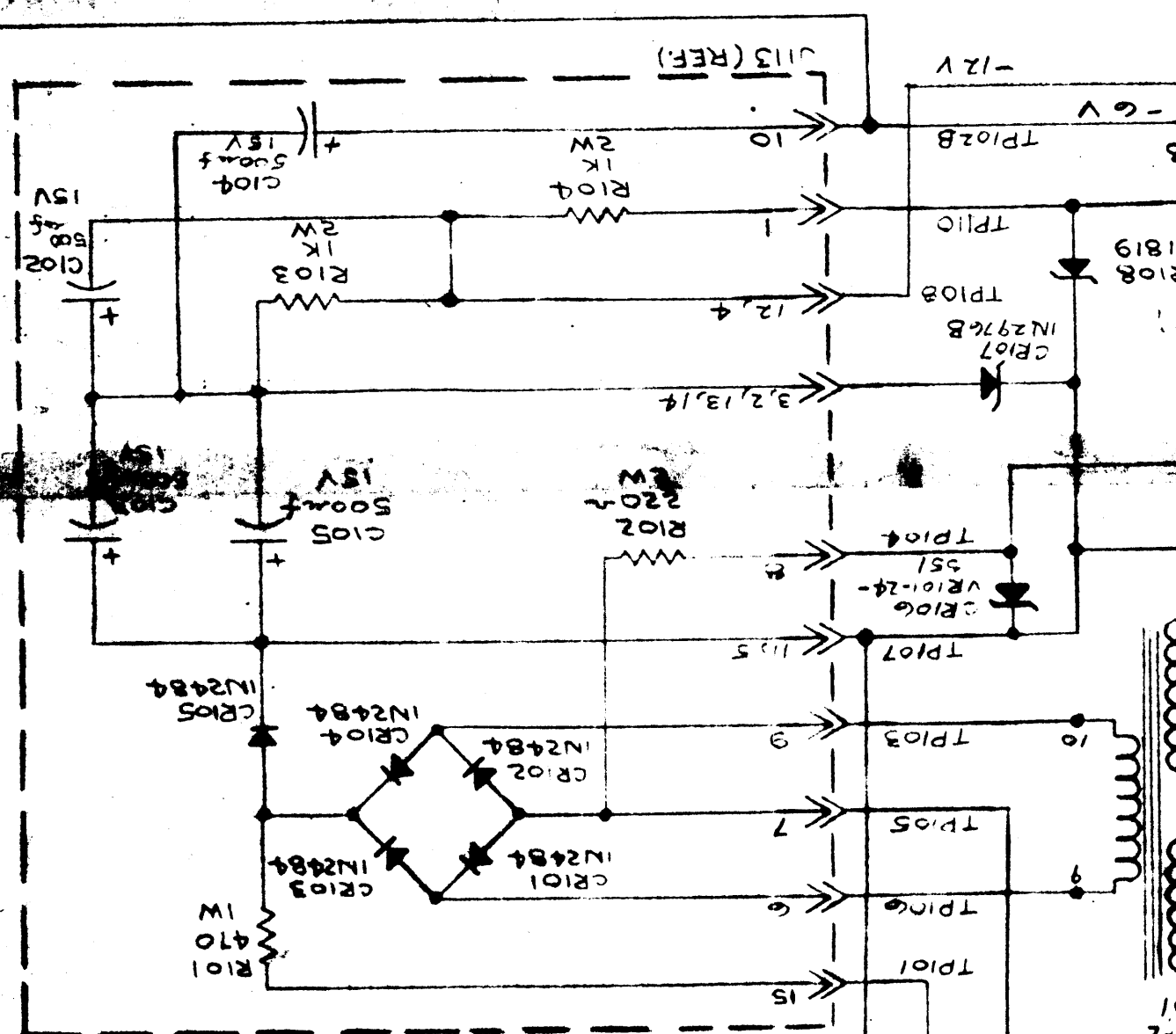
THE CONTENTS OF THIS DRAWING ARE THE EXCLUSIVE PROPERTY OF THE TECHNICAL MATERIAL GROUP. THE QUALITY OF THE REPRODUCTION IN WHOLE OR IN PART IS WHOLLY UNSURE.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND INCLUDE CHEMICALLY APPLIED OR PLATED FINISHES

DATE: 10-24-54  
 DRAWN: [Signature]  
 CHECKED: [Signature]  
 TITLE: DIAGRAM SCHEMATIC

THE TECHNICAL MATERIAL GROUP  
 HAWAIIAN, NEW YORK

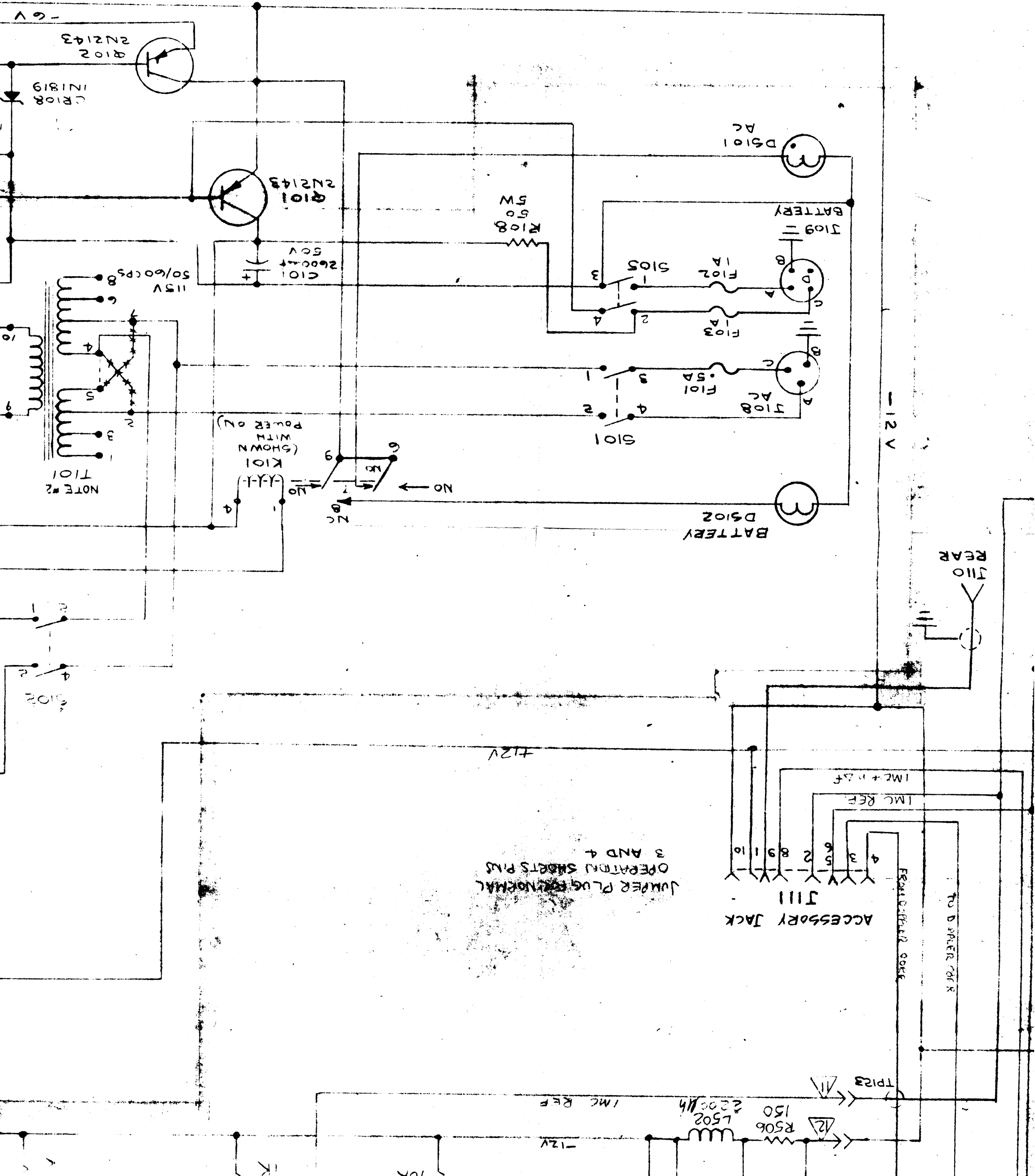
PC151/A3785  
 Z101



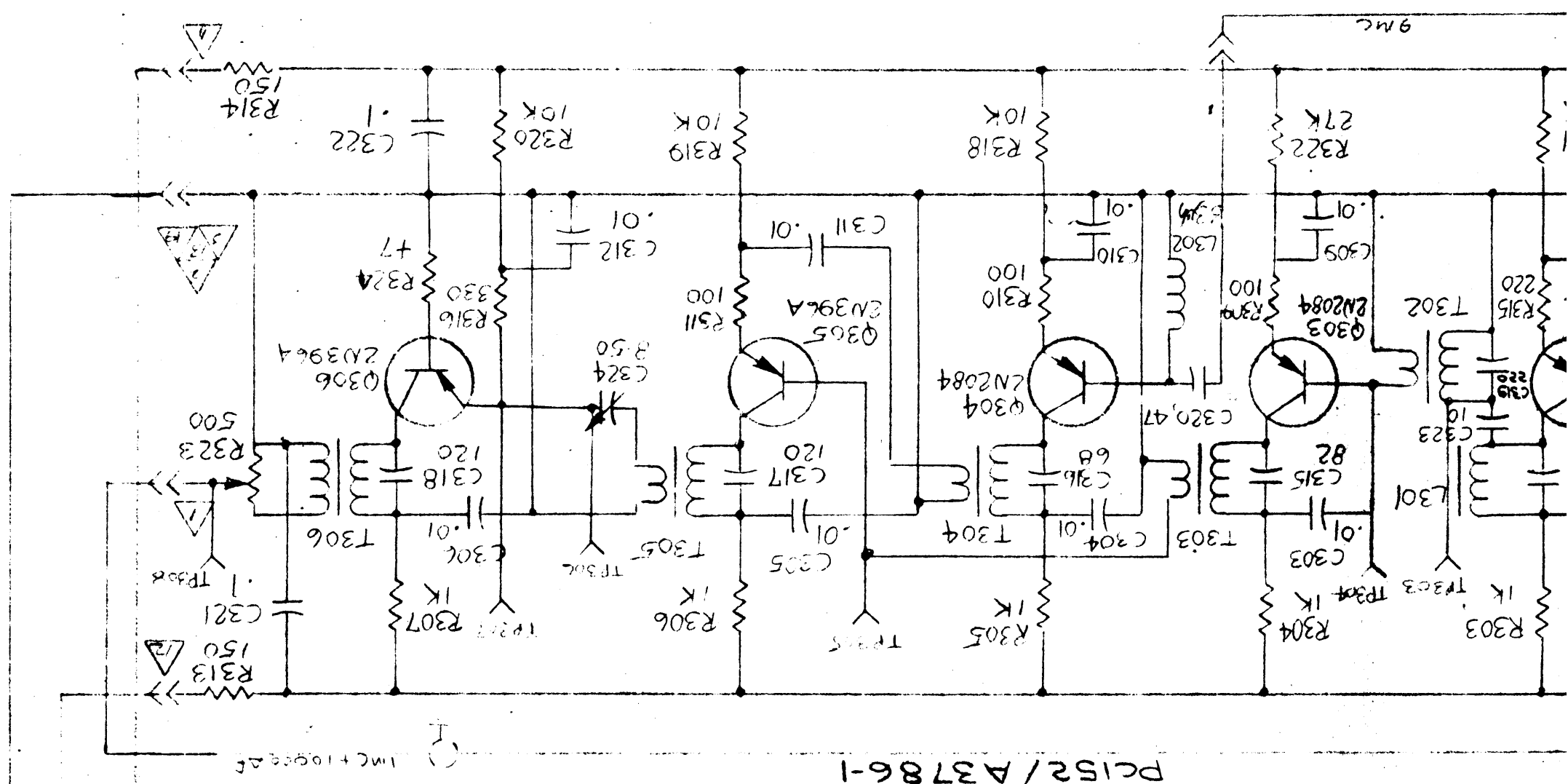
3. THE FOLLOWING RECEPTACLE SYMBOLS APPLY TO THE PC BOARDS AS FOLLOWS:  
 BOARD SYMBOL: Z101, Z201, Z202, Z301, Z302, Z303, Z304, Z401, Z501, Z601.  
 MATING CONN. SYM: J113, J114, J120, J115, J116, J117, J118, J119, J121, J122.

2. JUMPER MARKED --- JUMPER MARKED --- JUMPER MARKED --- AND ADD  
 T101 WIRING FOR 230 VOLT OPERATION REMOVE JUMPERS MARKED \*\*\* AND ADD  
 READ MUST BE REPLACED AS MATCHED PAIR (PART NO. TX102/2N705).

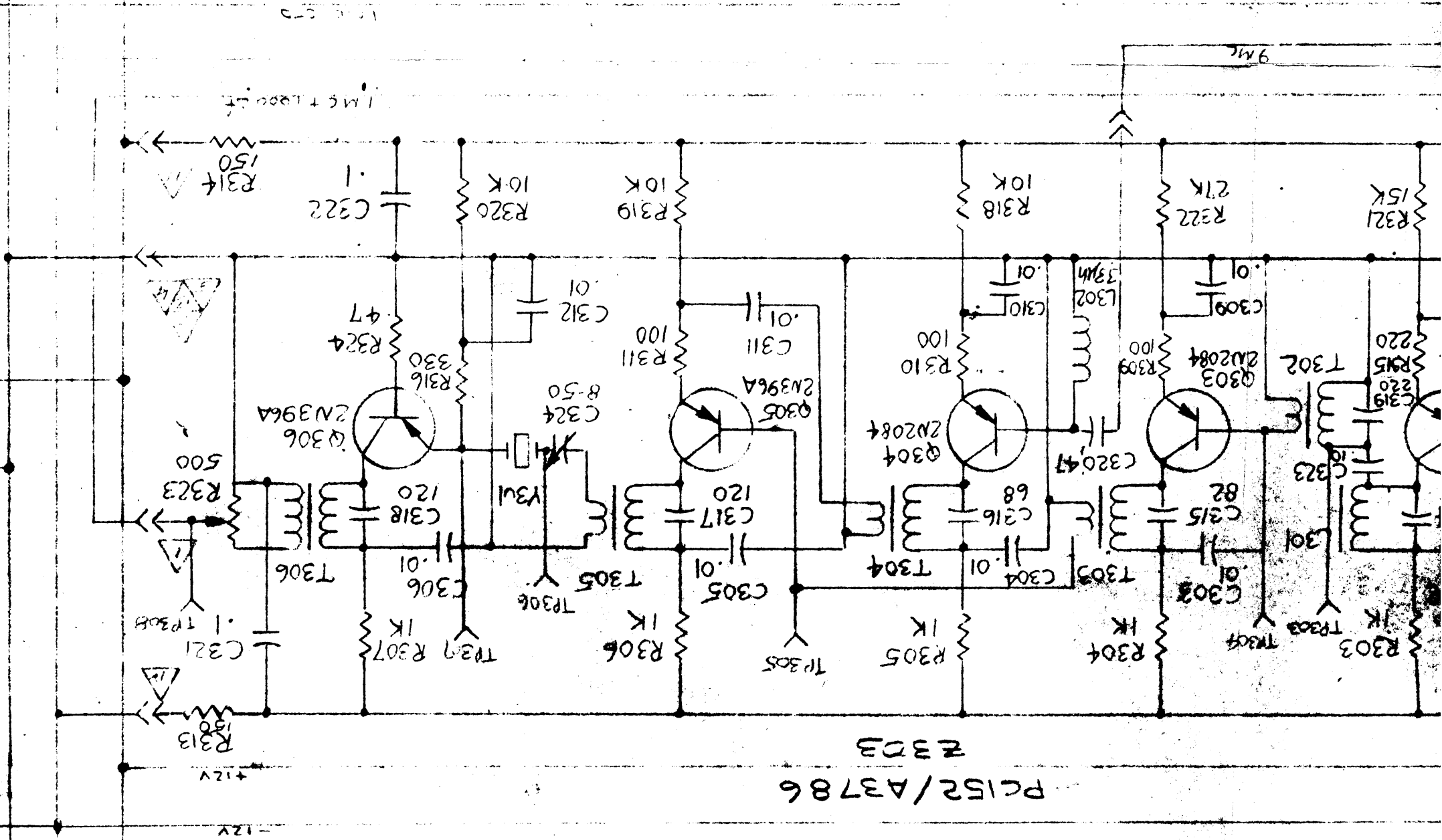
NOTES:



N



Z304  
PC152/A3786-1

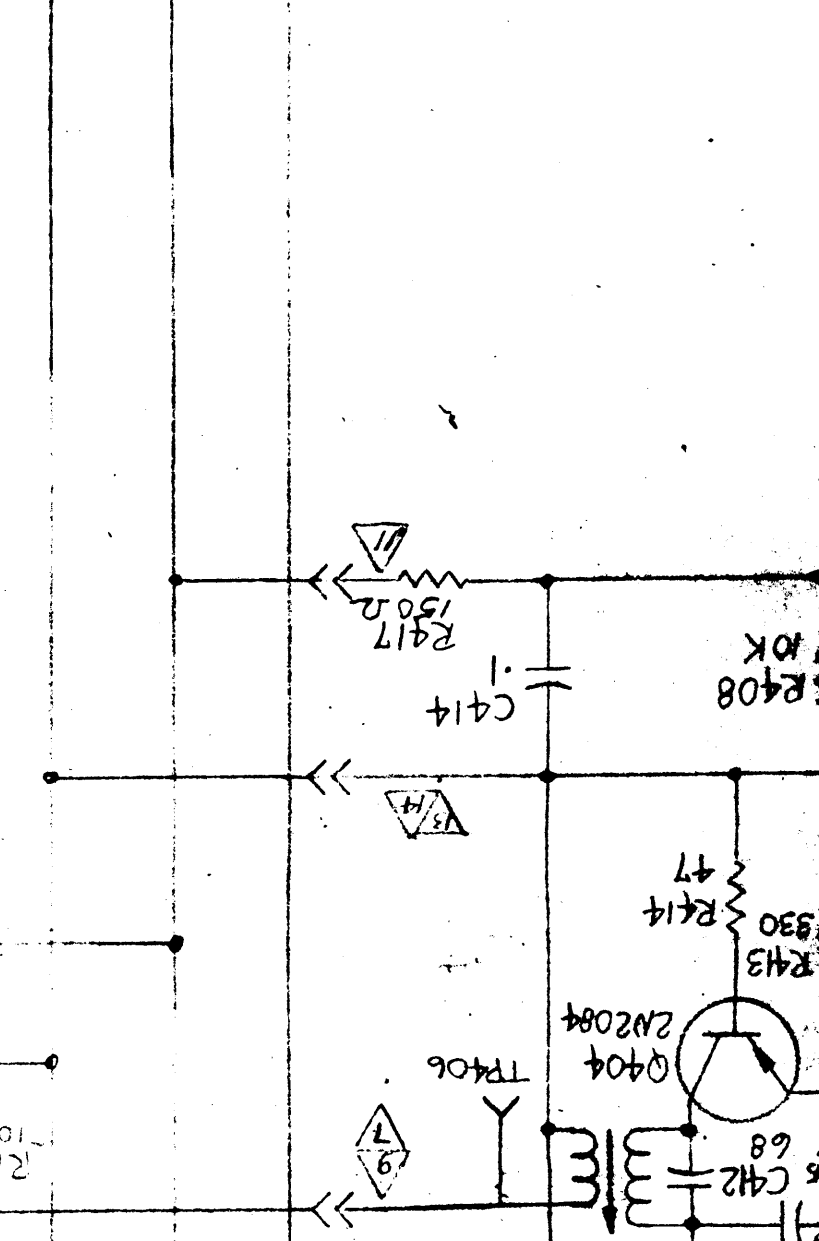
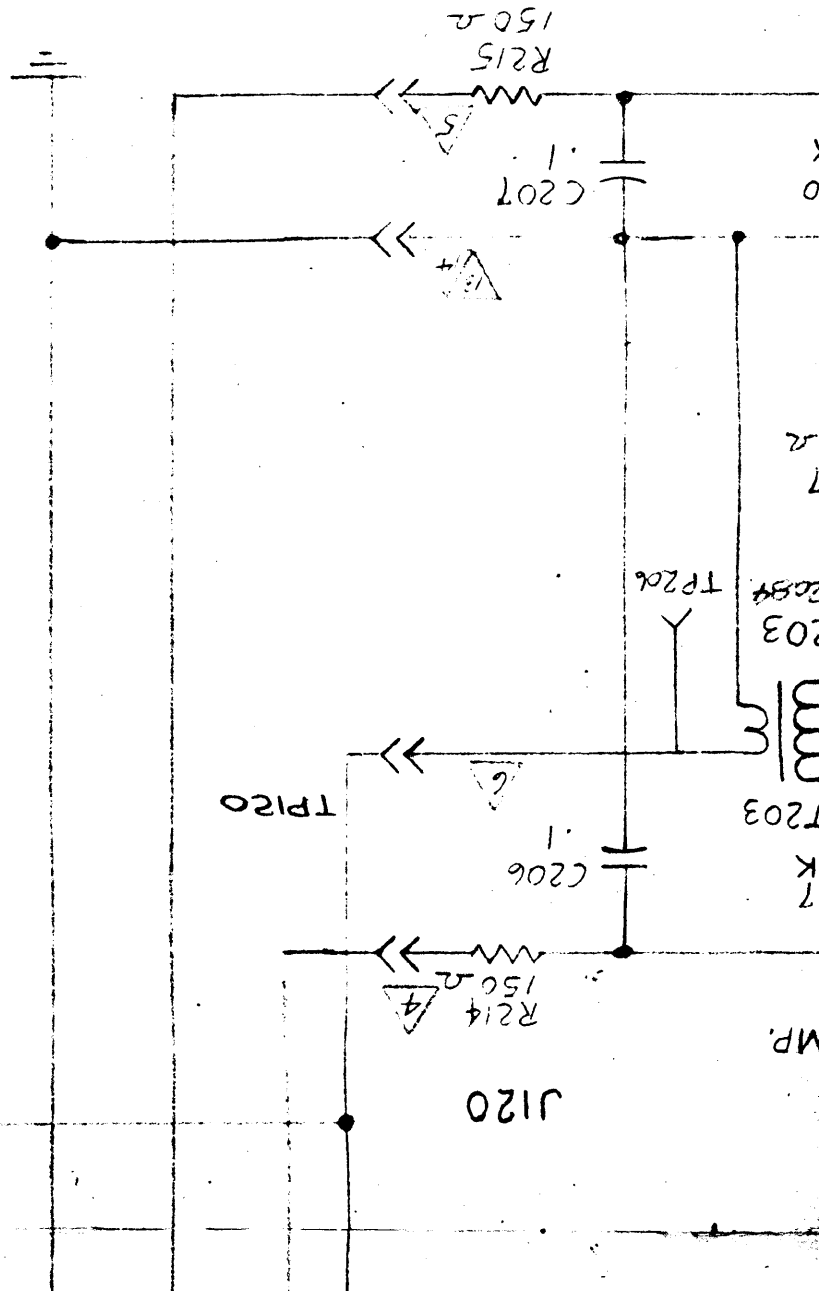
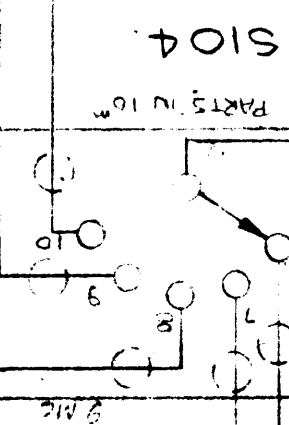
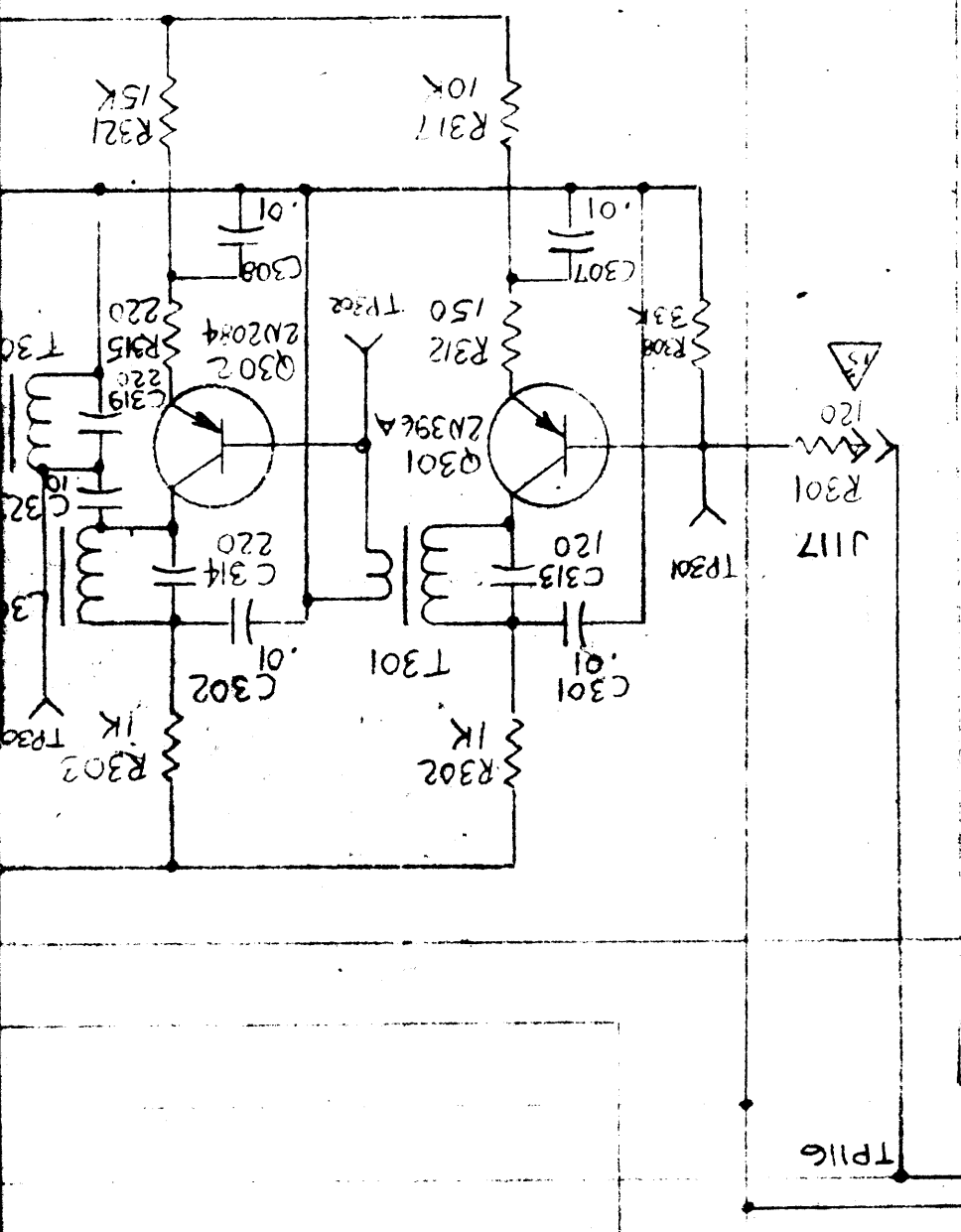
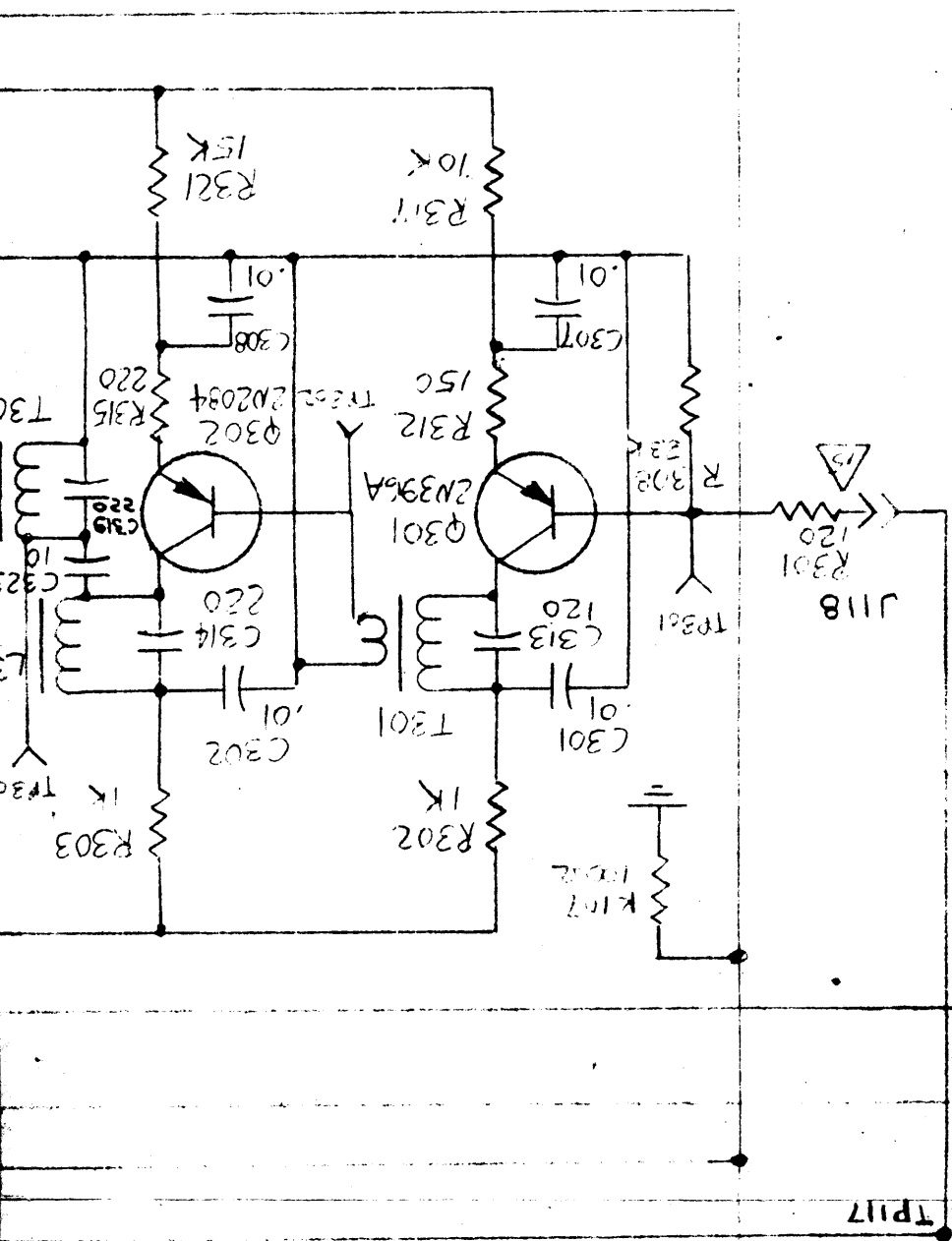


Z303  
PC152/A3786

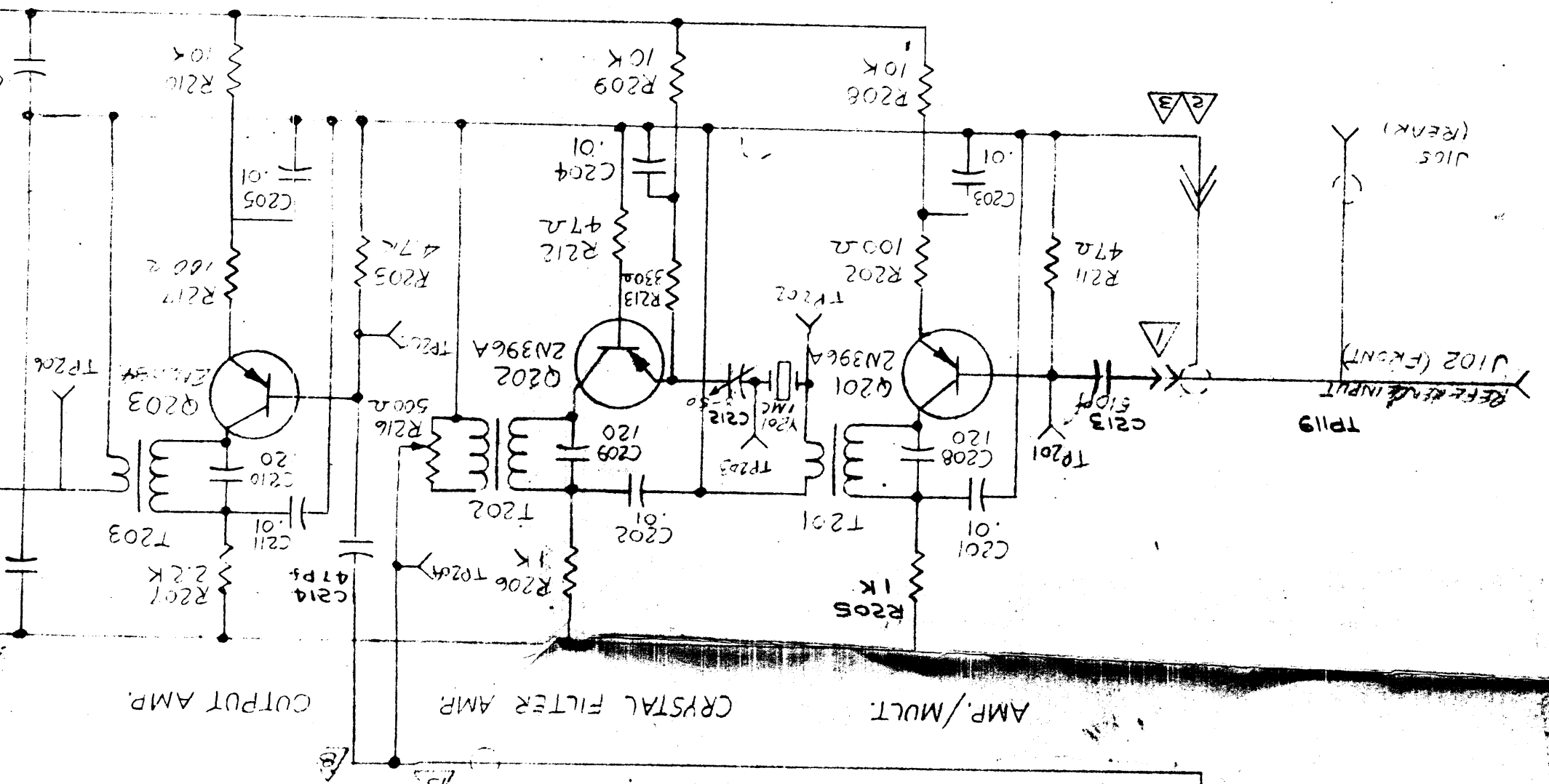
RE

1





A	UPDATED, EXTENSIVE CHANGES	11-12-64	12937	98	98
B	ORIGINAL RELEASE FOR PRODUCTION	11-5-64	98	98	98
X2	ON PC167/A3808 SYMBOLS UPDATED	11-2-64	X2	677	98
X1	POWER SUPPLY REDRAWN	10-23-64	X1	98	98



Z202  
PC166/A3808

REFERENCE OUT. INC. J106 (REAR)

REFERENCE INPUT J102 (FRONT)

