

## DIGITAL SIGNAL RECORDING AND PLAYBACK USING A PULSE TRANSMITTER/RECEIVER DESCRIPTION, APPLICATION, AND CONSTRUCTION

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### 1. GENERAL

**1.01** This section describes a method of recording and playback of digital data signals for later analyzation. This method of recording and comparing transmitted data is intended for evaluation of abnormal data problems which cannot be solved by normal test procedures or equipment. Equipment needed to perform this data recording is a tape recorder, test adapter (described in Section 107-180-100), and a Pulse Transmitter/Receiver (PTR) described in this section.

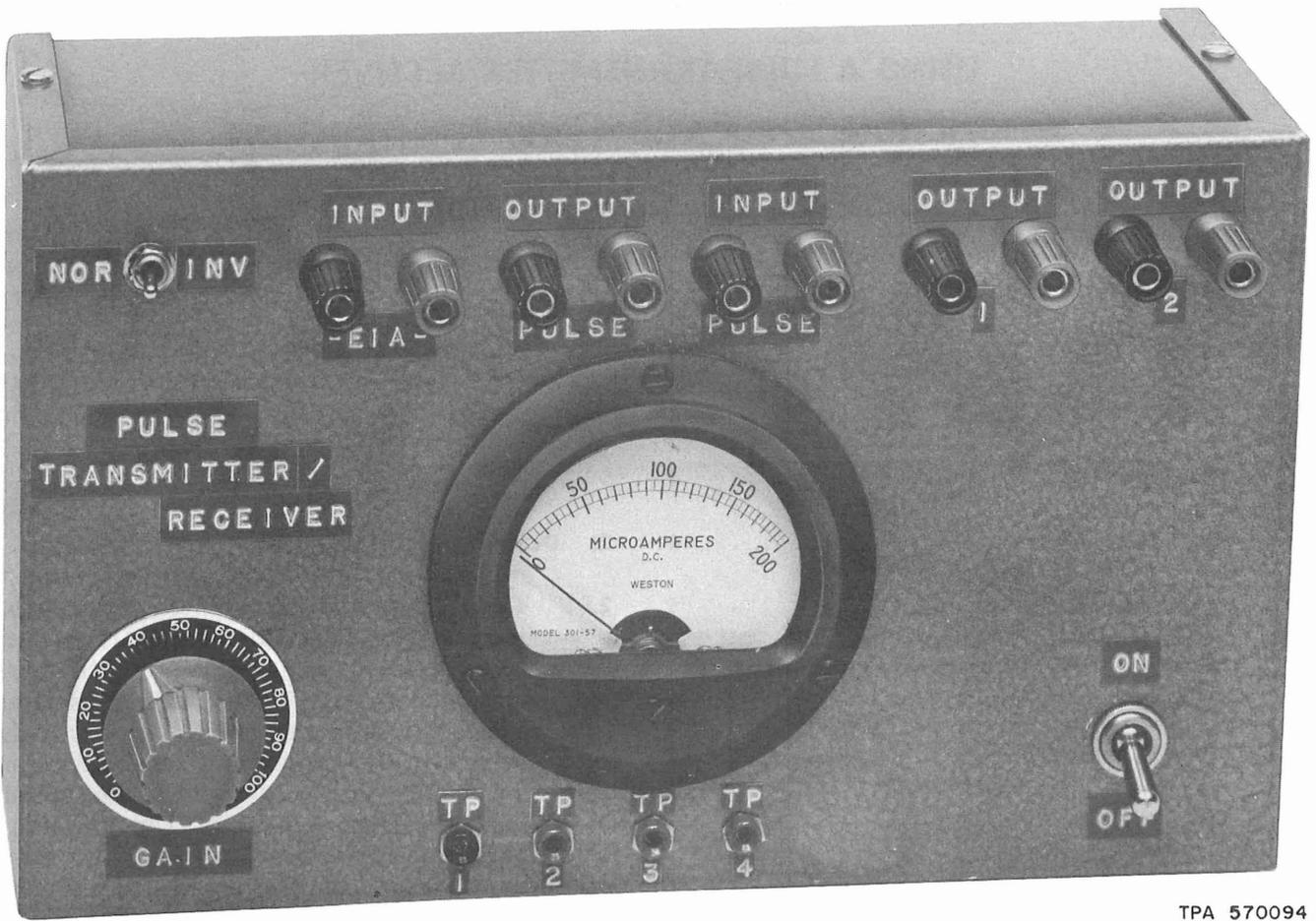
**1.02** The pulse transmitter shapes EIA interface data signals into a form suitable for recording

on a tape recorder, such as the Wollensack model 6200 stereo recorder. The pulse receiver shapes output signals from a tape recorder to a form suitable for input to an oscilloscope, data test set, or oscillograph. The PTR is not an orderable item; therefore, detailed information is given in this section so the PTR may be constructed locally. A prototype model of the PTR is shown in Fig. 1.

### 2. DESCRIPTION

**2.01** The PTR consists of two sections: a pulse transmitter and a pulse receiver. Binary data pulses are shaped into narrow pulses by a passive R-C circuit located in the pulse transmitter. This enables the tape recorder to reproduce the recorded polar pulses with more reliability. The PTR will operate with data transmission speeds up to 4800 bits per second (bps). Output voltage of the pulse transmitter is approximately 6 percent of the input. For example, an EIA signal level of 10 volts peak-to-peak will result in a polar pulse output of 0.6 volt peak-to-peak. If the level of output voltage of the PTR overloads the input circuitry of the recorder used, resulting in distortion, a shunt resistor may be placed in parallel with the output. A shunt of 270 ohms will reduce the output by a factor of 10.

**2.02** The pulse receiver will convert polar pulses to binary pulses. The input pulse amplitude, which is adjustable by the GAIN potentiometer (R1), must exceed 0.04 volt peak. Test point TP2 provides access to the input signal for high-impedance test equipment, such as an oscilloscope. The input signal should be pulses as shown in Fig. 2. Output signal is unipolar at OUTPUT 1 and polar through a coupling capacitor at OUTPUT 2. A 914B Data Test Set (DTS) may be operated from OUTPUT 2.



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Fig. 1—Pulse Transmitter/Receiver

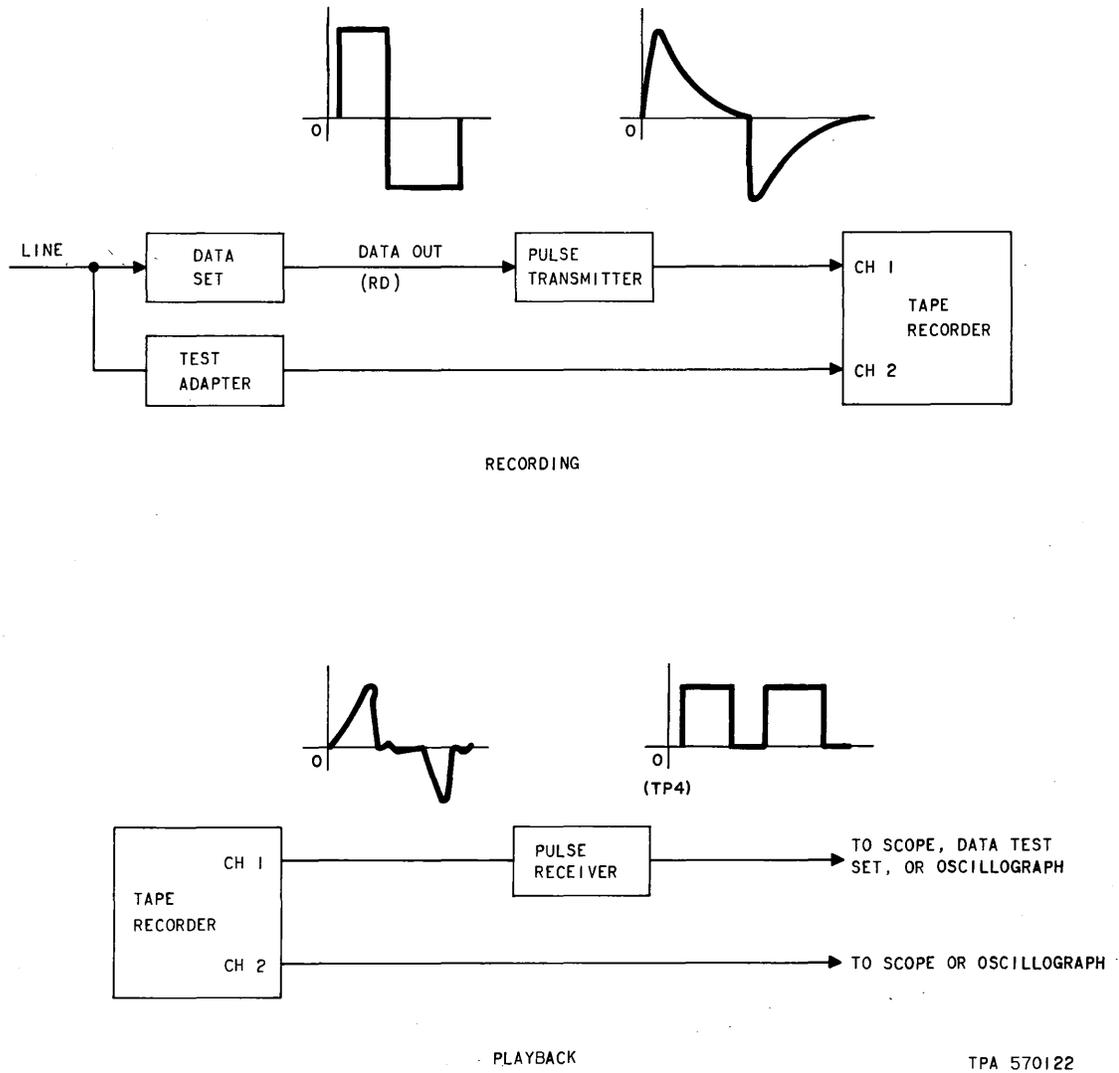


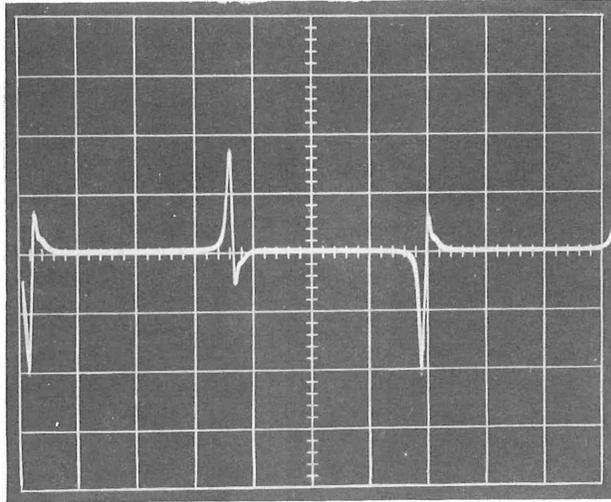
Fig. 2—Application of Pulse Transmitter/Receiver

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### 3. THEORY OF OPERATION

#### TRANSMITTER

**3.01** The shape of the pulse transmitted to a tape recorder is critical, depending upon the input characteristics of the tape recorder with which the pulse transmitter is used. Coupling capacitor C2 may be changed in value to match the R-C time constant with the input requirements of the tape recorder. If C2 is too small, the output of the recorder during playback may have an undesirable overshoot as shown in Fig. 3A. If C2 is too large, the pulses will be stretched out as indicated in Fig. 3B, thus reducing the maximum bit rate.



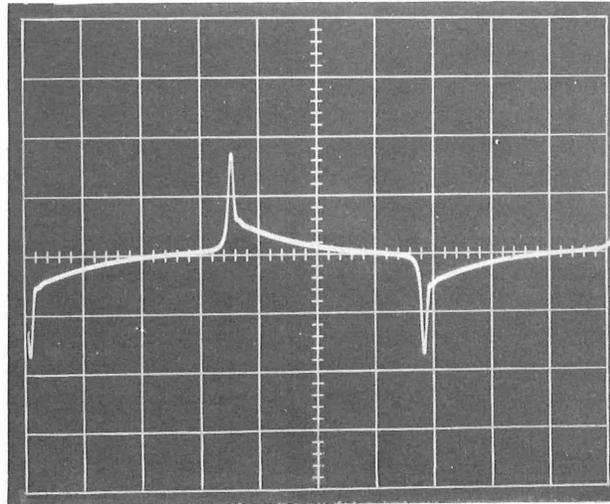
A.

#### RECEIVER

**3.02** The pulse receiver consists of three stages: an amplifier, a flip-flop, and a buffer. Transistor Q1 operates as an amplifier to input pulses. The operating point of Q1 is set to maximize its undistorted voltage amplification. If the correct operating point is set, clipping both positive and negative pulses will occur at the same input level. When a 9-volt power supply is used, the correct average voltage (dc) at the collector of Q1 is approximately 3.8 volts. If the operating point is incorrect, the value of base bias resistor R3 may be changed to correct the bias voltage.

**3.03** An alternate method of establishing the correct operating point of transistor Q1 is to replace R3 with a 15K-ohm resistor in series with a 50K-ohm potentiometer. The potentiometer can be adjusted to provide the correct operating point for Q1. Since this adjustment need be performed only during construction, the potentiometer can be a screwdriver adjustable type.

**3.04** The minimum signal required at the amplifier output is approximately 1 volt peak. With a 9-volt power supply, the maximum amplifier output, without clipping, is about 3 volts peak. During normal operation, the level is adjusted by



B.

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**Fig. 3—Output of Tape Recorder When: (A) Input Pulses Are Too Narrow, (B) Input Pulses Are Too Wide**

the GAIN control to about 2.5 volts peak. This signal appears on test point TP3. An incorrect GAIN setting will overload the amplifier, resulting in a distorted output as shown in Fig. 4.

**3.05** Transistors Q2 and Q3 form a flip-flop circuit which is set each time a positive pulse is applied and reset with each negative pulse. Thus, the outputs of the flip-flop circuit are reconstituted binary pulses.

**3.06** The buffer stage consists of transistor Q4 and serves to isolate the load from the flip-flop circuit. Since some tape recorders invert recorded pulses, a polarity-reversing switch, S1, is necessary at the input to the buffer. Output of the buffer appears at two terminals: OUTPUT 1 and OUTPUT 2. Capacitor C3 increases the output signal rise time on TP4 for reproduction by an oscilloscope. The signal at this point will be pulses as shown in Fig. 2.

**3.07** Meter M1 monitors the output signal. The correct value of current-limiting resistor R17 depends upon power supply voltage. The resistance value should be selected to give an almost full scale indication on the meter when Q4 is off. The table in Fig. 5 contains power supply voltages and corresponding resistor values.

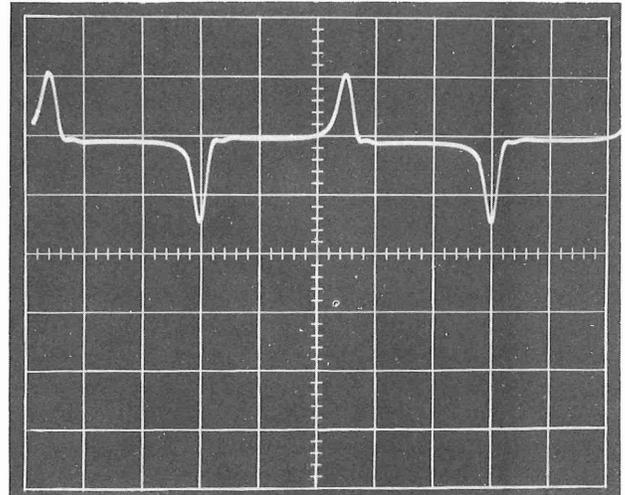
#### POWER SUPPLY

**3.08** The pulse transmitter does not require a power supply. The pulse receiver will operate on a supply voltage between 9 and 18 volts. The lower limit is determined by two factors: output of Q1 must be higher than 1 volt peak and the output of Q4 must be high enough to drive a test set or recording device. The upper limit is set to avoid unnecessary power consumption. Total current drain at 9 volts is approximately 25 mA.

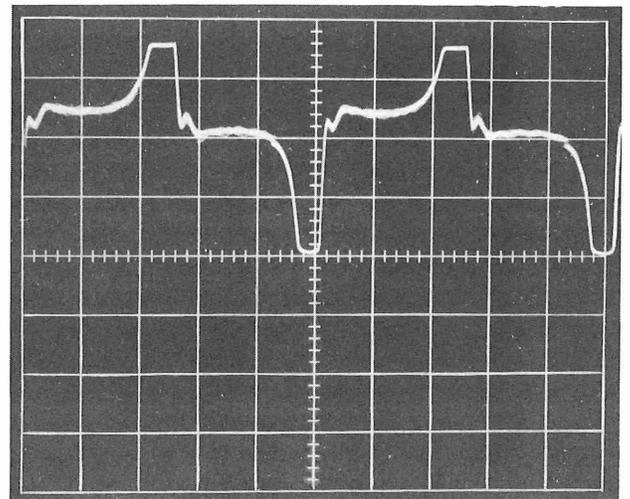
#### 4. PULSE TRANSMITTER/RECEIVER OPERATIONAL TESTING

**4.01** Static testing of the PTR can be done without using a tape recorder. A data source, such as a 914B Data Test Set, can be used to simulate dynamic conditions. The following procedure should be performed upon completion of

initial construction to insure correct operation of the PTR.



NORMAL



OVERLOADED

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**Fig. 4—Test Signal at TP3 Showing Results of Incorrect GAIN Setting; Vertical Deflection is 2V/CM and Horizontal Sweep is 0.2 MSEC/CM**

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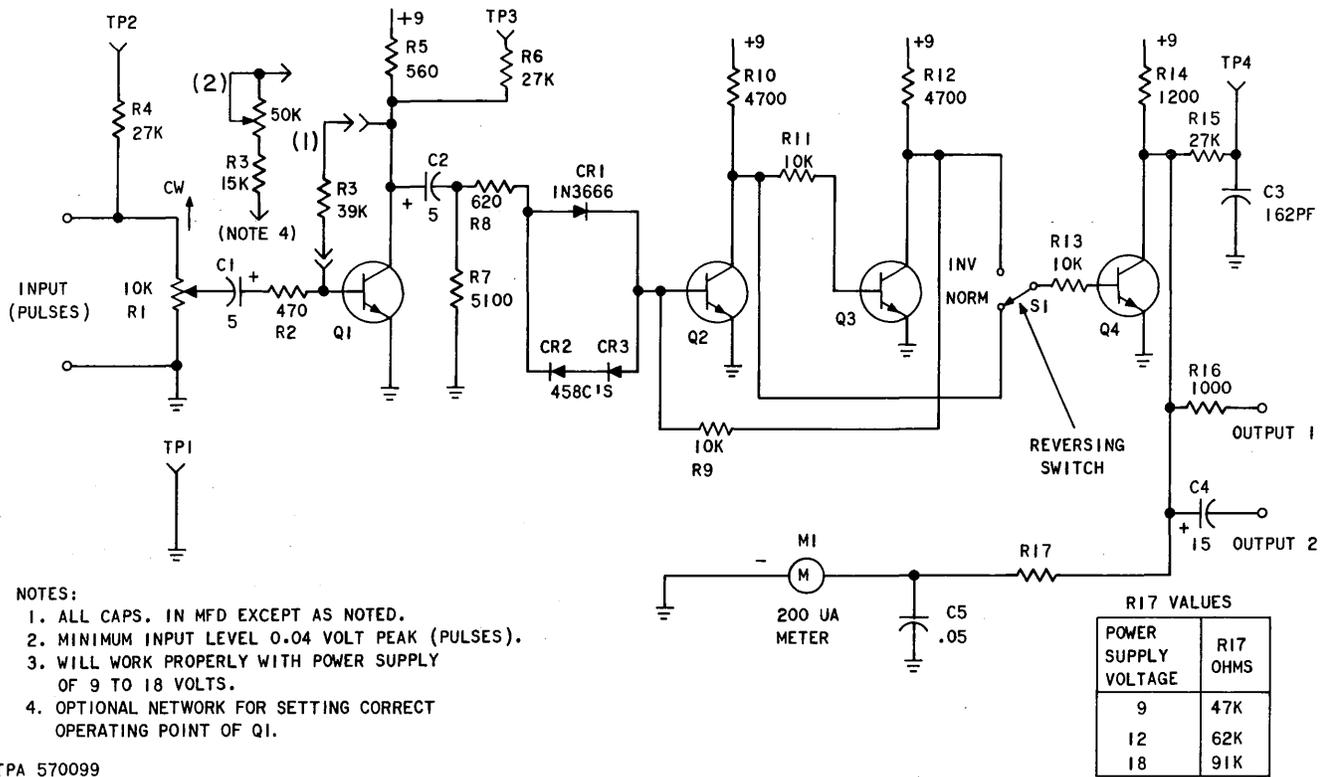


Fig. 5—Pulse Receiver—Schematic Diagram

Procedure

STEP	PROCEDURE
1	Connect the ground terminal of the 914B DTS to one of the ground terminals of the PTR.
2	Connect the DATA OUT jack of the 914 DTS to the EIA INPUT jack of the PTR.
3	At the PTR, connect the OUTPUT PULSE jack to the INPUT PULSE jack.
4	Connect OUTPUT 2 of the PTR to the center terminal of AB interface selector switch 3 of the 914B DTS and insert a shorting pin into the program matrix, row RD column 3.

STEP	PROCEDURE																
5	<p>At the 914B DTS, position switches as follows:</p> <table border="0" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">SWITCH</th> <th style="text-align: center;">SETTING</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">TEST SET MODE</td> <td style="text-align: center;">RCV SER</td> </tr> <tr> <td style="text-align: center;">COUNTER</td> <td style="text-align: center;">BIT ERRORS</td> </tr> <tr> <td style="text-align: center;">WORD LENGTH</td> <td style="text-align: center;">63</td> </tr> <tr> <td style="text-align: center;">BIT RATE</td> <td style="text-align: center;">2400</td> </tr> <tr> <td style="text-align: center;">SAMPLE WIDTH</td> <td style="text-align: center;">.5 <math>\mu</math>S</td> </tr> <tr> <td style="text-align: center;">WORD SYNC</td> <td style="text-align: center;">MANUAL</td> </tr> <tr> <td style="text-align: center;">POWER</td> <td style="text-align: center;">ON</td> </tr> </tbody> </table>	SWITCH	SETTING	TEST SET MODE	RCV SER	COUNTER	BIT ERRORS	WORD LENGTH	63	BIT RATE	2400	SAMPLE WIDTH	.5 $\mu$ S	WORD SYNC	MANUAL	POWER	ON
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SAMPLE WIDTH	.5 $\mu$ S																
WORD SYNC	MANUAL																
POWER	ON																
6	At the PTR, position the ON-OFF switch to ON and the NOR-INV switch to NOR.																
7	Rotate the GAIN control of the PTR full clockwise.																
8	At the 914 DTS, momentarily depress the RESET switch and repeat at intervals to observe error count on the counter display.																

**4.02** If the PTR is functioning properly, the meter will indicate between zero and full scale and the 914 DTS error readout will be zero. If the PTR is not operating correctly, the meter will indicate zero or full scale, and a check of components and circuitry must be made.

**4.03** When the GAIN control is turned counterclockwise, a point will be reached where the meter will indicate no signal and the output will disappear. This point will be when there is approximately 0.8 volt peak on TP3.

## 5. APPLICATION

### RECORDING

**5.01** The functional block diagram for a method of recording is shown in Fig. 2. The RD lead of the data set under test is connected to the EIA INPUT jack of the PTR. Connect channel 1 of a stereo tape recorder to the OUTPUT PULSE

jack of the PTR. The data line is bridged to channel 2 of the tape recorder by a test adapter. Information concerning construction and application of this device is found in Section 107-180-100. Adjust the recorder input level to a level that will not overload the tape recorder.



***A tape free from splices must be used. Splices may cause an error indication when played back. In addition, the tape should be a type which will not stretch, such as a tensilized mylar base.***

### PLAYBACK

**5.02** The functional block diagram for a method of playback is also shown in Fig. 2. Channel 1 of the tape recorder output is connected to the INPUT PULSE jack of the PTR. Channel 2 is fed directly to an oscilloscope or oscillograph. The polar signal which appears at OUTPUT 1 of the

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PTR is connected to either an oscilloscope or oscillograph. The polar signal which appears at OUTPUT 2 of the PTR will drive a 914B DTS in addition to the oscilloscope or oscillograph.

**5.03** To determine the optimum setting for the PTR GAIN control with the recorder operating, position the PTR GAIN control fully counterclockwise. The meter will indicate no data (either 0 or full scale). By rotating the GAIN control clockwise, a point is reached where the meter will indicate pulses are being received by oscillating about a point which is approximately midscale. Call this point A. By rotating the GAIN control still further clockwise, a point is reached where the meter changes its average position which indicates overloading of the PTR input circuits (Fig. 4). Call this point B. A normal operating position is determined by setting the GAIN control one-third of the distance from point A to point B.

**5.04** If an oscilloscope is available, the correct operating position of the GAIN control may be determined more precisely. Monitor TP3 with the oscilloscope and adjust the PTR GAIN control until the pulse peaks are just clipped. Correct settings for the GAIN control and the tape recorder input controls should be recorded for later use since these should remain constant for a particular recorder.

**5.05** When the GAIN control is properly positioned, the PTR output may be analyzed with the 914B Data Test Set. A zero error rate should be indicated if the recording was made from an error-free data signal. The inverting switch is provided to compensate for tape recorders which invert recorded signals.

**5.06** Test equipment needed to analyze the recorded digital data, in addition to the PTR, is an oscilloscope, 914B Data Test Set, or oscillograph. To accommodate high-speed modems operating at up to 4800 bps, an oscillograph must have sufficient frequency response and paper-chart speed to provide good resolution of the interface signals. In addition, it must be reasonably portable for field use.

Several manufacturers supply oscillographs which may be used. The Honeywell Test Instruments Division model 1508A Visicorder\* which can be equipped with seven M13000 galvanometers, for example, will meet these requirements. Option A (.15 to 120 in./sec chart speed) should be specified in order to obtain sufficient resolution on modems of 2400 bps and above. In addition, the Honeywell Accudata 117\* equipped with seven channel amplifiers will provide the required impedance matching, sensitivity adjustment, and galvanometer overload protection.

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**5.07** Customer permission to record transmitted data should be obtained by Telco personnel and, in cases where any uncertainty exists, permission should be detailed and confirmed in writing with the signature of a customer management employee. Unless further need for the recording exists, Telco personnel should erase the recorded tape in the presence of customer personnel. If a recording is to be retained for future use, customer permission should also be obtained. Detailed information concerning the legality of recording procedures can be found in Section 107-180-100.

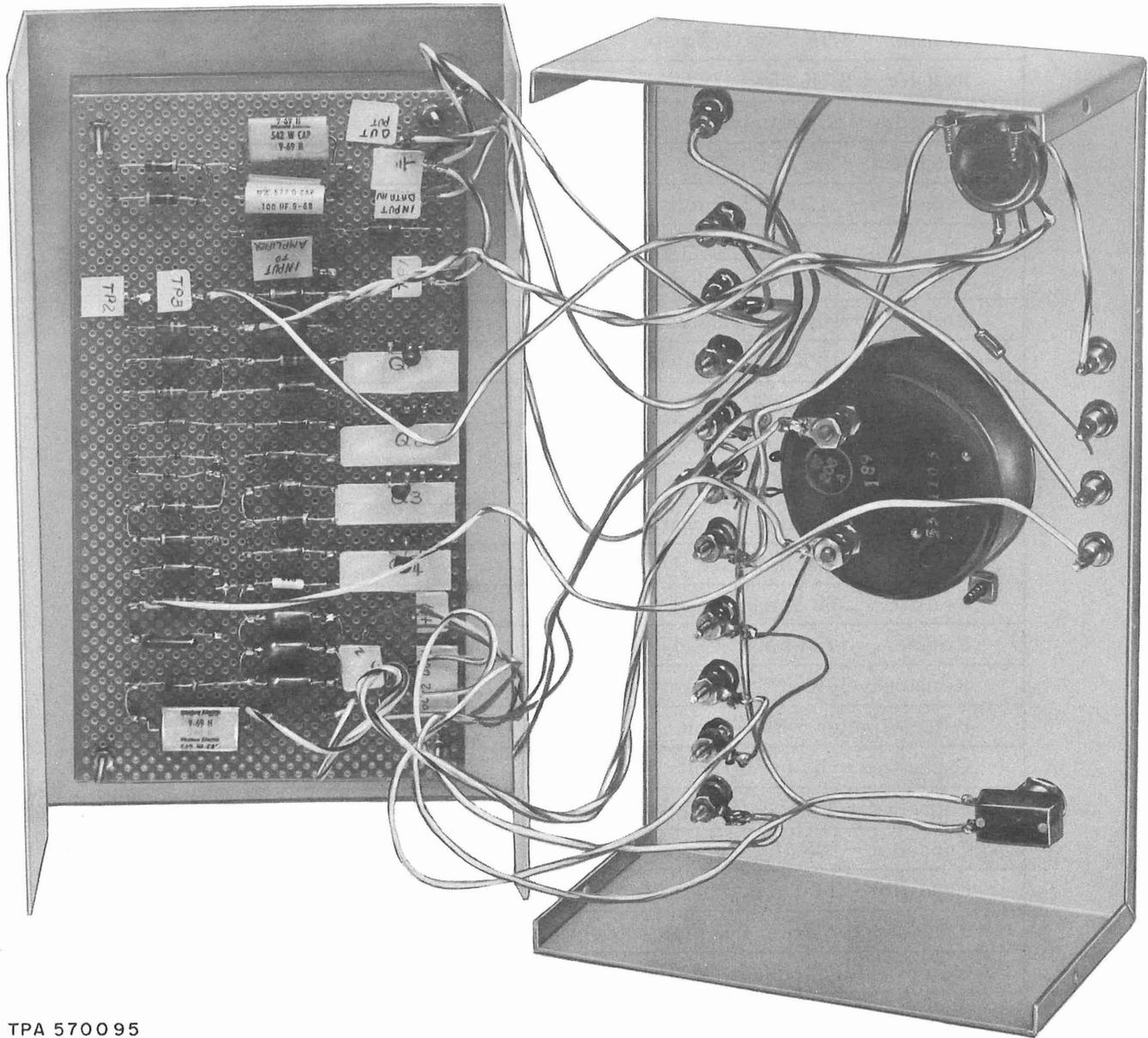
## 6. CONSTRUCTION

**6.01** Components needed for construction of the PTR are available either as standard commercial or WECO-coded components. A recommended parts list is given in Table A. Equivalent components can be substituted in cases where those listed are not locally available.

**6.02** All circuit components can be placed on a standard 4-3/4" by 8-1/2" vector board. The components are placed as shown in Fig. 6 and are wired in accordance with Fig. 5 and 7. The vector board, meter, and controls will fit into a 3-1/2" by 6" by 10" mini-box. The completed circuit board may be mounted into the mini-box housing by the same four screws which mount the rubber feet. A 9-volt battery to serve as a power supply can also be included. The housing is custom cut and drilled as shown in the mechanical layout of Fig. 8.

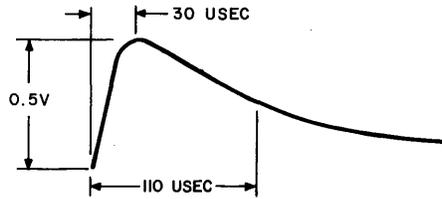
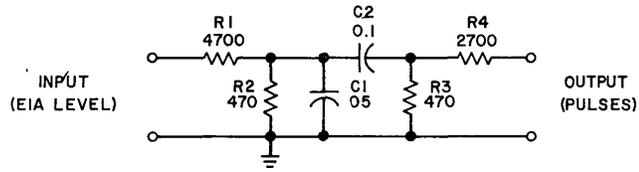
TABLE A  
PTR COMPONENT LIST

TRANSMITTER COMPONENTS	QUANTITY
Resistor — 4.7K $\pm$ 5%, 1/2 watt	1
Resistor — 2.7K $\pm$ 5%, 1/2 watt	1
Resistors — 470 ohm $\pm$ 5%, 1/2 watt	2
Capacitor — .05 $\mu$ f @ 200 volts	1
Capacitor — .1 $\mu$ f @ 200 volts	1
RECEIVER COMPONENTS	
Resistors — 27K $\pm$ 5%, 1/2 watt	3
Resistors — 10K $\pm$ 5%, 1/2 watt	3
Resistors — 4.7K $\pm$ 5%, 1/2 watt	2
Resistor — 5.1K $\pm$ 5%, 1/2 watt	1
Resistor — 1.2K $\pm$ 5%, 1/2 watt	1
Resistor — 1K $\pm$ 5%, 1/2 watt	1
Resistor — 39K $\pm$ 5%, 1/2 watt	1
Resistor — 620 ohms $\pm$ 5%, 1/2 watt	1
Resistor — 560 ohms $\pm$ 5%, 1/2 watt	1
Resistor — 470 ohms $\pm$ 5%, 1/2 watt	1
Resistor — 47K $\pm$ 5%, 1/2 watt (See Fig. 5)	1
Potentiometer — 10K ohms	1
Capacitors — 5 $\mu$ f @ 20 volts, WECO 601A	2
Capacitor — 15 $\mu$ f @ 20 volts	1
Capacitor — .05 $\mu$ f @ 200 volts, WECO 542W	1
Capacitor — 160 — 200 pf, mica	1
Transistors — WECO 66J or equivalent	4
Meter — 200 $\mu$ A meter, Weston 301-57 or equivalent	1
Switch — S.P.D.T. Toggle	1
Switch — S.P.S.T. Toggle	1
Vector board — 4-3/4" x 8-1/2"	1
Mini-box — 3-1/2" x 6" x 10"	1
Battery — 9-18 Volts (See Fig. 5)	1
Terminals	10
Pin Jack — Black, KS-14523-L3	1
Pin Jacks — Red, KS-14523-L2	3
Rubber Feet	4
Miscellaneous Mounting Hardware, Wire, and Labels	



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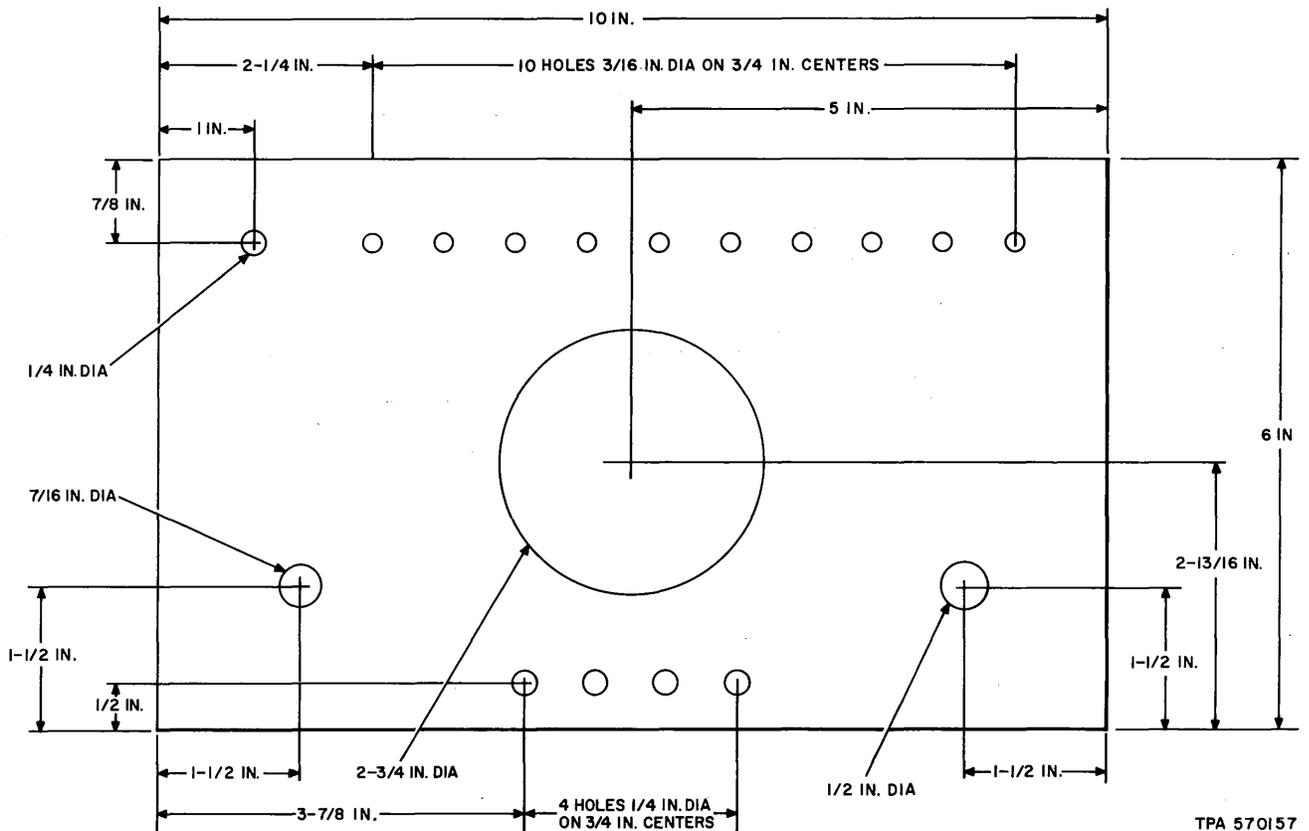
Fig. 6—Pulse Transmitter/Receiver—Inside View



TYPICAL OUTPUT (NO LOAD, 8V PEAK INPUT)

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Fig. 7—Pulse Transmitter—Schematic Diagram



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Fig. 8—Mechanical Layout