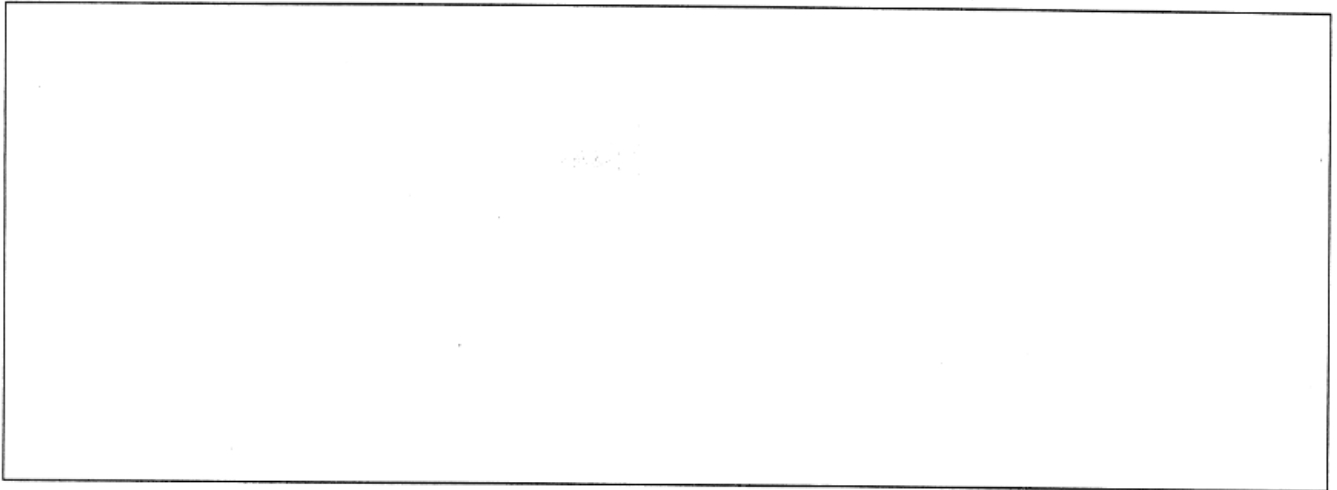




INSTRUCTION MANUAL
PDT
Pulse Duration Transmitter

Form 606-701-00B

June 1971



1.1 SCOPE OF MANUAL

This manual contains a description, installation and operating instructions, and maintenance instructions for the Pulse Duration Transmitter. To support any maintenance that might be required, a description of the theory of operation is also included, and a list of replaceable parts is given. A list of recommended spares is also included.

1.2 PURPOSE OF EQUIPMENT

The Pulse Duration Transmitter (PDT) is used in process control systems to convert a process signal input into an output pulse or relay closure with a duration or "on time" that is linearly proportional to the amplitude of the input signal. The input may be any standard process DC current or voltage proportional to the on time of the output pulses. With the unit connected in the reversed-output option, the off time (instead of the on time) is linearly proportional to the input amplitude, thus making the on time a maximum with minimum input. In either case, the pulse duration on any given range is adjustable over a 5-to-1 ratio and the total range of pulse duration is from 0.2 to 100 seconds in four ranges.

1.3 GENERAL DESCRIPTION

The unit compares the amplitude of the input signal with that of an internally-generated ramp signal. The ramp has a constant frequency and a constant maximum amplitude. As a result, a comparator changes state each time the amplitude of the ramp crosses (either rising or falling) the amplitude of the input signal, thus producing pulses. With the standard configuration, the circuit is arranged so the duration of a given state (corresponding to the "on" time) of each pulse is proportional to the time the amplitude of the ramp is below that of the input signal, thus making this duration directly proportional to the amplitude of the input signal. The unit then amplifies the pulses, and the output may be in the form of voltage pulses for driving an external relay, or an internal relay may be provided as an option.

1.4 PHYSICAL DESCRIPTION

The PDT is available in several different physical configurations. In general, the unit consists of two circuit boards, with one small board mounted on a main board. The small board contains voltage regulators and a rectifier, and the main board contains all the signal-processing and signal-generating circuits. The boards are enclosed in a protective housing, and the entire assembly may be installed in a number of ways. A bracket (supplied when specified in order) may be used to mount the assembly. For hazardous environments, an explosion-proof housing with a base containing up to four threaded hubs for wiring can

be supplied. Also available are an enclosure that is oil-tight and dust-tight and another that is water-tight. Although the printed-circuit board assembly is electrically identical regardless of the physical configuration and mounting method, the external electrical connections may be made to different terminals on the terminal block or PC receptacle in the various versions of the unit. Specific details for making electrical connections are given in Section 2, Installation Information.

1.5 SPECIFICATIONS

The specifications of the PDT are given in Table 1-1.

TABLE 1-1. PDT SPECIFICATIONS

INPUT:

CURRENT: 1-5 mA DC, 4-20 mA DC, 10-50 mA DC

VOLTAGE: 0-5 VDC, 1-5 VDC standard, other voltages optional

INPUT IMPEDANCE:

CURRENT: 1-5 mA into 200 ohms
4-20 mA into 50 ohms
10-50 mA into 20 ohms

VOLTAGE: 10 megohms

SPAN AND ZERO:

Adjustable with multiturn potentiometer

SPAN: Adjusts output to 100% pulse width with an input of full scale $\pm 50\%$ of span

ZERO: Adjusts output to 0% pulse width with an input of 0% $\pm 25\%$ of span

PULSE DURATION:

Adjustable over the indicated interval on each preselected range

ISOLATION:

Power-supply isolation is maintained on both AC- and DC-powered models. Input-to-output isolation may be achieved by using the relay-output option.

OUTPUT: 24-volt pulse with a width proportional to the amplitude of the input signal. The 50-mA maximum pulse current may be used for driving an external power relay. Optional relay contact closure with 1-ampere 28-VDC non-inductive rating is available

OUTPUT PULSE REPETITION PERIODS:

RANGE A:	0.2-1 sec
RANGE B:	1-5 sec
RANGE C:	5-25 sec
RANGE D:	25-100 sec

LINEARITY: $\pm 0.1\%$ maximum deviation from straight line

AMBIENT TEMPERATURE RANGE: 0°F to +140°F (-18°C to +60°C)

AMBIENT TEMPERATURE EFFECT: $\pm 0.01\%/^{\circ}\text{F}$ over above range

POWER INPUT: 24 VDC standard, maximum optional 70 VDC.
117 VAC 50/60 Hz or 220 VAC 50/60 Hz optional
5 watts maximum
Other supply voltages available
Line voltage effect $\pm 0.005\%/volt$

1.6 MODEL NUMBERING SYSTEM

Model Numbers describe an instrument's type, functional range, and features. If all accompanying documentation of a unit should be missing, one can still "translate" the Model Number back into a working description of the unit by using the information in this paragraph as a reference.

BASIC EXAMPLE:

PDT/4-20MA/C/AC/RR

PDT, 4-20 mA input, range C
output, 117 VAC power, internal
relay output option

BASIC INSTRUMENT TYPE:

PDT indicates Pulse Duration
Transmitter

INPUT RANGE:

Numbers: Minimum and maximum nominal
input range, generally an
industry standard

SC: Selectable Current (i.e.,
input current range selectable
with one of several resistors
supplied for this purpose)

OUTPUT RANGE:

Letter indicates range of output pulse repetition
periods listed in Table 1-1

POWER INPUT:

DC: DC power, 24 VDC $\pm 10\%$ unless
stated otherwise, e.g., 45 VDC

AC: AC power, 117 VAC $\pm 10\%$ unless
stated otherwise, e.g., 220 VAC

OPTIONS:

Letters indicate options. See Table 1-2 for explanation
of letters.

INPUT AND OUTPUT ABBREVIATIONS:

MA = milliamperes V = volts

Table 1-2 lists the option letters in the model number and explains their meanings. Although Table 1-2 lists all the option letters currently used in MII model numbers, it should be noted that not all options are necessarily applicable to all units.

TABLE 1-2. EXPLANATION OF OPTION LETTERS IN MODEL NUMBER

-AC ^{**}	117 VAC Power Operation
-AD	Adjustable Deadband (Alarm Units)
-AL	Integral Alarm Light (Alarm Units)
-AR	Factory Set Response Time Delay (Alarm Units)
-BU	AC/Battery Backup Option (Isolated Units)
-DD	Downscale TC Burnout Drive
-DL	Off Lamp (Indicates When Relay Is Deenergized)
-EL	On Lamp (Indicates When Relay Is Energized)
-HS	Hermetically Sealed Relay Output (Alarm Units)
-IS	Input Summing (SCT Units Only)
-KO	Constant "K" Internal Drive For Computing Units
-LD	Low Signal Select Option (ADM Unit Only)
-LNN	Linearizing Option (RBT Units Only) <u>Standard Nickel</u>
-LNP	Linearizing Option (RBT Units Only) <u>Standard Platinum</u>
-LO	Adjustable Output Limiting (SCT Unit Only)
-LOA	Adjustable Output Limiting and Alarm Output (SCT Unit Only)
-LSA	Lower Spans (2-5 mV)
-LSB	Lower Spans (0.75-2 mV)
-MR	Manual Reset - External Pushbutton (Alarm Units)
-PR	Solid-State Power Relay Including Socket (PDT and Alarms)*
-RO	Reversed Output
-RR	Internal Output Relay
-SCR ^{**}	Selectable Current Range
-TT	Precision 10-Turn Dial (Alarm and Computing Units)

* Must be used in separate enclosure (-GP, etc.)

** Not supplied in plug-in units

INSTALLATION INFORMATION

2.1 GENERAL INSTALLATION INFORMATION

Installation, in general, consists of calibration (when required), mechanical mounting, and making the electrical connections to the unit. The following paragraphs describe the necessary procedures.

2.2 CALIBRATION

Units are calibrated and checked for proper performance at the factory before they are shipped. However, unless calibration was requested to a specific set of input-output values, the unit should be calibrated by the user before the unit is placed in service.

NOTE

Adjustments should not be made in the field on units that are calibrated to values specified in the purchase order. Units that are calibrated at the factory to customer's specifications have protective caps over the SPAN and ZERO potentiometers; do NOT remove these caps.

An adjustable input signal source and input monitoring device are required for calibration. Also required is a means of determining the total pulse period and duration of the "on time" of the output pulses. An electronic counter is the preferred instrument for this purpose. However, for the longer pulse periods (Range B and longer), a high-impedance voltmeter and stop watch may be used if an electronic counter is not available. The input monitoring device must have an accuracy within $\pm 0.01\%$ or better. MII Test Set PTS-770 may be used to supply and monitor the input signal.

NOTE

Refer to paragraph 1.6 for information on how to use the model number to determine the input signal range and range of output full scale pulse repetition period.

To calibrate a unit, proceed as follows:

- a. Connect unit and test equipment as shown in Figure 2-1.
- b. Apply power input to the unit.

INSTALLATION INFORMATION

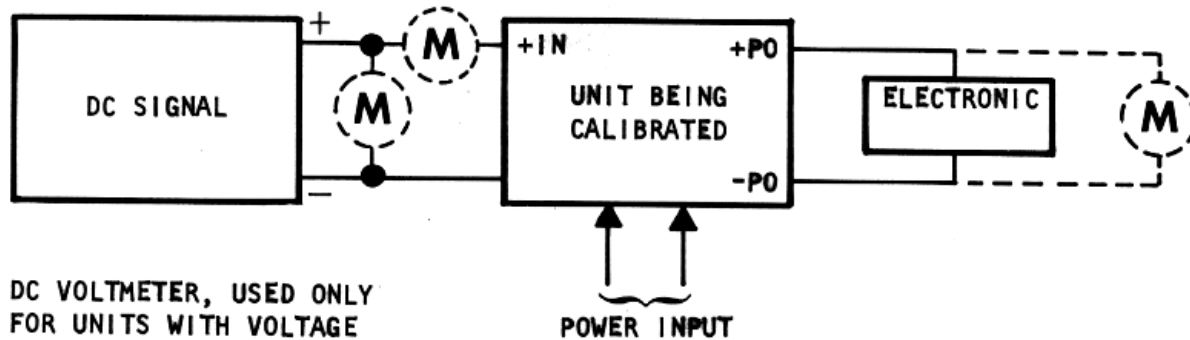
- c. Adjust the input signal source to an output of the minimum signal plus 50% of the span for the unit. For example, for a 4- to 20-mA input, the span is 16 mA and 50% of this is 8 mA. For this range, therefore, the input signal would be adjusted to 4 plus 8, or 12 mA. This adjustment need not be too exact, since the only purpose of it is to avoid the extremes (0% and 100%) of the input signal and allow the pulse repetition period to be adjusted to the desired value.
- d. Adjust the potentiometer that is accessible through the hole in the lower right side of the case to obtain the desired pulse repetition period. If the pulse repetition period of the unit is Range B or longer and if an electronic counter is not available, the pulse repetition period may be determined by using a stop watch to time the interval between the start of one indication on a voltmeter connected to the output and the start of the next indication. Alternatively, the number of pulses in a convenient time period may be counted and then divided into the period to obtain the period per pulse.
- e. Adjust the input signal source to an output of 0% input plus 25% of the span for the unit.
- f. Determine the pulse width duration ("on time") as a percent of the pulse repetition period. If no electronic counter is available, this may be done in a manner similar to that described in step (d) except that, for the pulse width determination, the time interval between the start of a voltmeter indication and its return to zero is the time required. Dividing this into the total pulse repetition period and multiplying by 100 will give the percent pulse width.
- g. Adjust the ZERO potentiometer and repeat step (f) as required to obtain a pulse width duration that is 25% of the total pulse repetition period.
- h. Adjust the input signal source to an output of 0% signal plus 75% of the span for the unit.
- i. Repeat step (f). Adjust the SPAN potentiometer and repeat step (f) as required to obtain a pulse width duration that is 75% of the total pulse repetition period.

SECTION 2

INSTALLATION INFORMATION

DC MILLIAMMETER, USED ONLY FOR UNITS WITH CURRENT INPUT (SEE NOTES 1 & 2)

OPTIONAL VOLTMETER (24V RANGE) (MAY BE USED ONLY ON LONG REPETITION PERIOD, RANGES B AND LONGER)



DC VOLTMETER, USED ONLY FOR UNITS WITH VOLTAGE INPUT (SEE NOTES 1 & 2)

NOTES:

1. INPUT MONITORING DEVICE MUST BE ACCURATE TO WITHIN $\pm 0.01\%$
2. M.I.I. TEST SET PTS-770 MAY BE USED FOR INPUT SIGNAL SOURCE
3. ELECTRONIC COUNTER, H-P MODEL 523D, OR EQUIVALENT

Figure 2-1. Test Equipment Setup For Calibration Of Unit

INSTALLATION INFORMATION

- j. Repeat steps (e) through (i) as required to obtain 25% and 75% pulse width duration with input signals applied as in steps (e) and (h), until no further adjustment of either the ZERO or SPAN potentiometer is required.
- k. Apply 0% input and then increase the input until the pulse width duration just increases from 0%. Note that only a very slight increase in input signal (generally less than 1%) above 0% is required to obtain a pulse width duration greater than 0%.
- i. Apply 0% input plus 25%, 50%, and 75% of the span successively, and check that the pulse width is linearly proportional (within $\pm 0.1\%$).
- m. Gradually approach 0% input plus 100% of the span (maximum input signal for the unit). Check that the output of the unit remains in the on state ("on time" 100%) when the applied signal equals the maximum for the unit.
- n. After step (m) has been successfully completed, remove the input signal source and then turn off the power input to the unit.

2.3 MECHANICAL INSTALLATION

As mentioned in Section 1, the unit may be obtained in various physical configurations and/or case sizes. Figure 2-2 shows the outline dimensions and other installation requirements for the particular configuration supplied. Be sure to observe the applicable special procedures and precautions given with the illustration. Although the units are designed to operate in free air at quite a high ambient temperature, it is advisable if possible to mount the unit on a surface made of material that can serve as a heat sink. For a plug-in unit mounted in a rack, be sure that the rack has adequate ventilation.

2.4 ELECTRICAL CONNECTIONS

Except on plug-in units, all electrical connections are made to the terminal blocks in the unit. On plug-in units, the electrical connections are made to terminals on the mating connector for the unit. The terminals to be used for the electrical connections are indicated in Figure 2-3. The following paragraphs provide additional information on wiring the unit.

2.4.1 General Wiring Techniques

No special wire or cable is required for signal connections to the unit. To avoid transients and stray pickup, it is recommended that twisted conductors be used where they are run close to other services (such as power wiring).

On open units supplied with a snap-off cover, dress all wiring up through the opening in the bottom of the cover. Spade-lug connectors are recommended for all wire terminals. All terminals are supplied with 6-32 screws long enough to easily accept three spade-lug connectors.

2.4.2 Power Connections

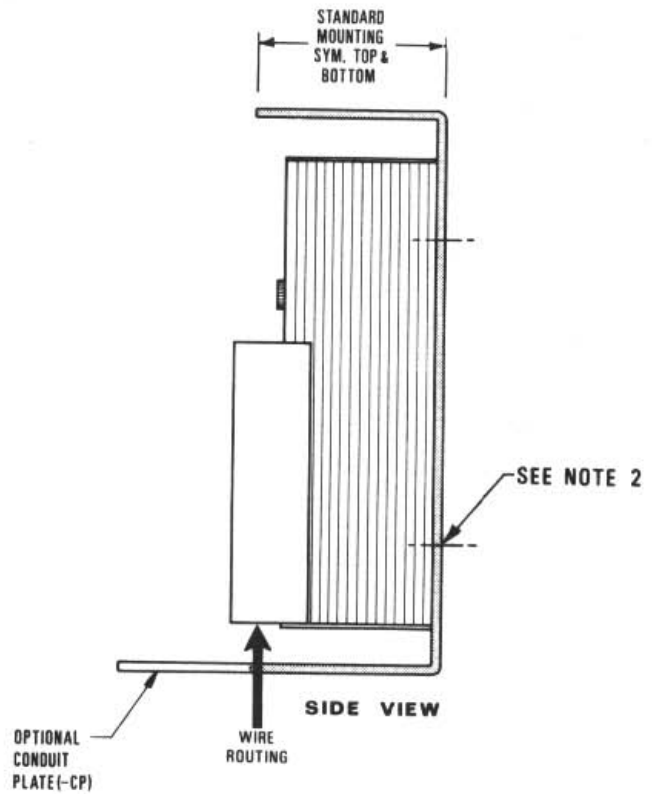
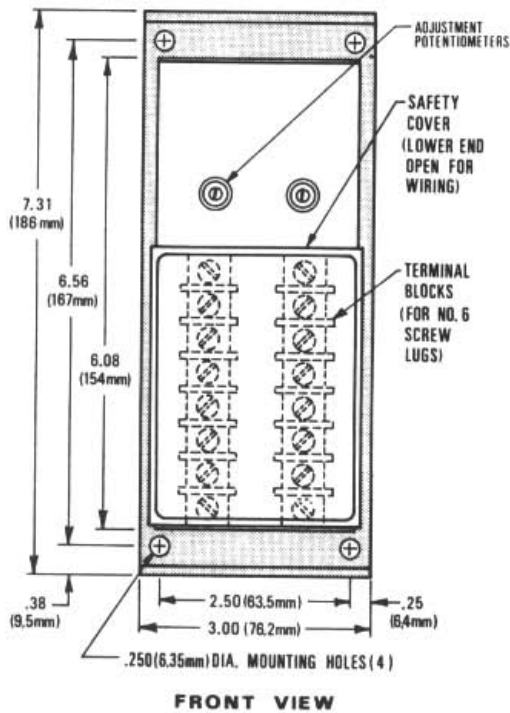
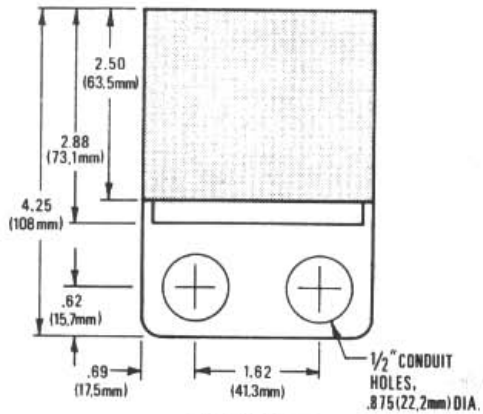
A given unit is designed to be operated from either a DC power source or an AC power source. Refer to paragraph 1.6 for information on how to use the model number to determine the type of power required.

On DC-powered units, the DC terminal is connected to the + (positive) side of the source, and the DCC terminal is connected to the - (negative) side. The DC source should be regulated to within $\pm 10\%$ of the nominal voltage and should be capable of delivering 5 watts.

On AC-powered units, 117 volts AC $\pm 10\%$, 50/60 Hz, 5 VA nominal power is required. The AC terminal should be connected to the ungrounded or "hot" side of the supply, if possible, and the ACC terminal is connected to the common or neutral. The GND terminal is the mechanical case connection.

2.4.3 Connections On Units With SCR Input Option

On units with the SCR (selectable current resistor) input option, connect the resistor to the +IN and -IN terminals. The current range is marked on the body of each resistor. If provided, the selectable current resistor for a plug-in unit is mounted externally either at the terminal block or soldered to the appropriate terminals on the PC connector.



NOTES:

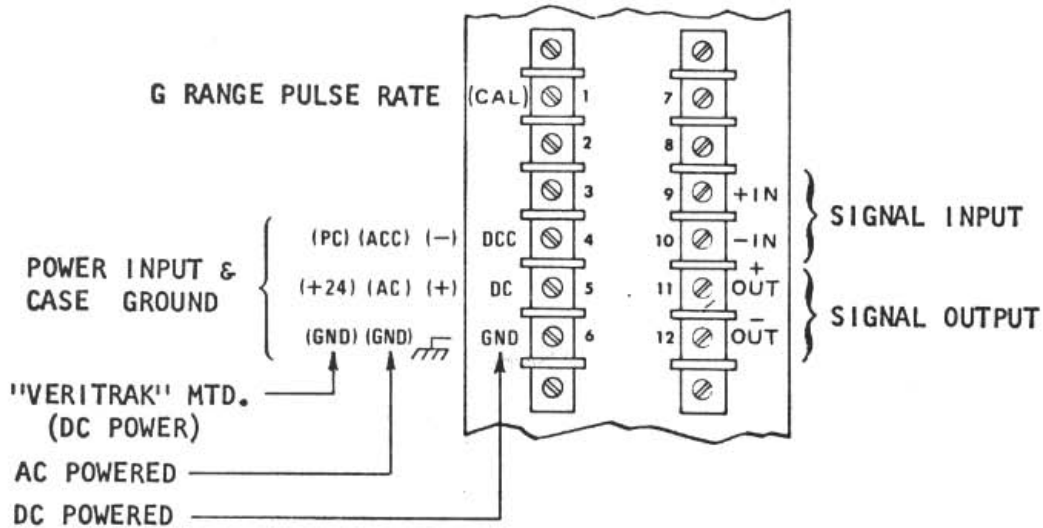
1. Complete Model No. and Serial No. are permanently marked on the identification plate located at the upper end of the terminal blocks.
2. When extra-compact mounting is required for rack or portable installation, the C-shaped mounting bracket may be removed and the two threaded inserts (located 4.00 inches apart) may be used for mounting, using 6-32 NC machine screws.

CAUTION

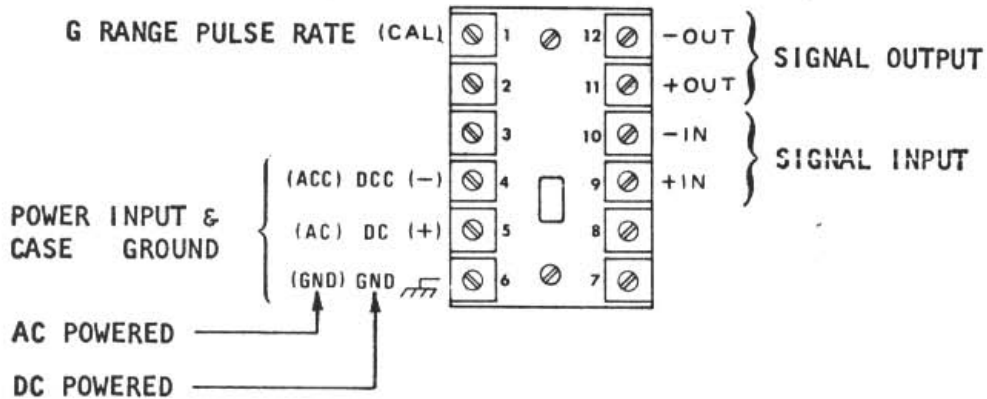
WHEN THE REAR INSERTS ARE USED FOR MOUNTING, BE SURE THAT THE MOUNTING SCREWS DO NOT PROTRUDE MORE THAN 1/8 INCH INTO THE UNIT.

Figure 2-2. Outline and Installation

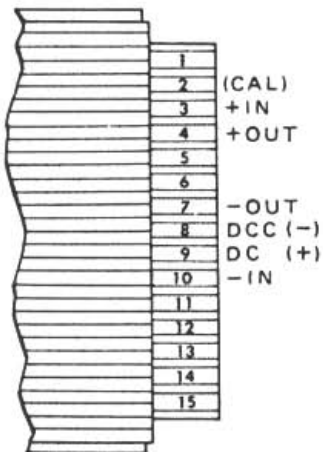
A. STANDARD, PANEL-MOUNTED AND "VERITRAK" MOUNTED UNIT



B. EXPLOSION-PROOF HOUSING MOUNTED, SINGLE UNIT



C. PLUG-IN UNIT



PIN NO	DESIG.	FUNCTION
3	+IN	SIGNAL INPUT
10	-IN	
4	+OUT	SIGNAL OUTPUT
7	-OUT	
8	DCC	DC POWER INPUT
9	DC	
2	(CAL)	G RANGE PULSE RATE

Figure 2-3. Electrical Connections For Unit

3.1 OPERATING PROCEDURE

Once calibrated and installed, the unit may be operated unattended. The only controls on the outside of the unit are the SPAN and ZERO potentiometers which, after initial adjustment, need no further attention. One or two indicator lamps may be included on the unit as an option. If present, these lamps inform the operator when the relay is energized and/or when it is deenergized. There are no other indicators on the unit. Because the circuit uses highly reliable solid-state components (with the exception of those units that include the optional output relay and/or indicator lamp(s)), the unit should operate virtually maintenance-free for a long period of time. However, if a malfunction should occur, refer to Section 5 for maintenance information.

A unit may become warm during operation, especially where the ambient temperature is rather high. This is perfectly normal and should not be a cause for alarm unless a malfunction is also observed.

In some DC-operated units, a high-pitched sound may be audible, either initially or after the unit has been in use for some time. This sound is normal and is caused by inherent characteristics of the cup core in the inverter transformer. A transformer of different design is used in later versions of the unit to eliminate this noise.

4.1 INTRODUCTION

This section describes the theory of operation of the unit. The description is made at two levels. First, a block-diagram description of each function of the unit is presented to provide information on the overall operation of the unit. The circuits are then described in more detail to provide maintenance personnel with a thorough understanding of how each circuit operates so malfunctions can be located and corrected as rapidly as possible.

4.2 FUNCTIONAL DESCRIPTION

Figure 4-1 is a functional diagram of the unit, with both the AC-operated power supply and the DC-operated power inverter indicated. It should be noted, however, that a given unit will have either the power supply or the inverter, but not both. In the following functional description, which is based on Figure 4-1, simply disregard those elements of Figure 4-1 and the corresponding text that do not apply.

4.2.1 Functional Description Of AC Power Supply

When AC power input is applied, the power supply produces AC voltages of two different amplitudes (with respect to ground). These are applied to the rectifier and regulator, which develop regulated and unregulated DC outputs that are used as operating voltages for the unit.

4.2.2 Functional Description Of Power Inverter

The power inverter accepts DC power input and produces two square-wave outputs. These square-wave outputs, instead of outputs from the AC power supply, are then applied to the rectifier and regulator, which function in the usual manner. A diode in the DC (positive) lead will prevent damage to components in the power inverter if the DC power source is accidentally connected with incorrect polarity.

4.2.3 Functional Description Of Rectifiers And Voltage Regulators

The main rectifier accepts the output from either the AC power supply or the power inverter and produces unregulated positive and negative voltages (of equal value with respect to ground). Two regulators on the same assembly reduce these voltages to the required operating values and regulate them against changes with load or line-voltage variations. Another rectifier, physically on the same assembly with the two voltage regulators, produces a higher unregulated output that is used as operating voltage for the relay driver.

4.2.4 Functional Description Of Ramp Generator

The ramp generator produces an output that periodically increases at a constant rate to a specific maximum positive value and then decreases at the same rate to zero. The frequency, and hence the rate of rise and fall, of the ramp output is adjustable to produce an adjustable pulse rate from the output of the unit.

The main elements of the ramp generator are a ramp comparator, switch, and integrator. Assume that the comparator output is initially at a fixed negative value. The switch is now off and a constant positive voltage is applied to one input of the comparator. Under these conditions, the integrator output begins to increase and this rising signal is applied to the other input of the comparator. When the integrator output that is applied to the side of the comparator just equals the fixed positive voltage applied to the other side, the comparator output rapidly switches to a fixed positive value and turns on the switch. When it is on, the switch grounds the comparator input terminal to which the fixed positive voltage was previously applied, thereby allowing the integrator output alone to govern the behavior of the comparator. With a positive output from the comparator applied to the integrator, the output of the integrator begins to decrease from its maximum value and the drive to the comparator likewise begins to decrease. When the drive from the integrator to the comparator becomes practically zero, the comparator output turns off the switch, thus again allowing the fixed positive voltage to be applied to the comparator input and thereby initiating another cycle. The frequency at which the switch is turned on and off, and thus the frequency of the ramp output from the integrator, is determined by the signal applied from the comparator to the integrator input. This, in turn, is established by the ramp frequency adjust potentiometer.

The ramp comparator and integrator operate from the +V_I and -V_I voltages. The positive voltage applied to the comparator input is derived from the +V_I voltage.

4.2.5 Functional Description Of Input Network And Zero Adjust Circuit

The input network provides the input signal with the proper termination and combines this signal with the voltage from the zero adjust circuit. The zero adjust circuit, which operates from +V_I and -V_I, adds an adjustable voltage of the proper polarity to cancel the live zero of the basic input signal. With the minimum input signal applied, the zero adjust circuit is adjusted so the voltage added to the applied input signal results in a pulse width that is 0% of the total pulse period (i.e., no positive output at all). Because the zero adjust voltage is added in the negative leg of the basic input signal, the positive side of the input signal is connected to the input of the active low-pass filter.

4.2.6 Functional Description Of Active Low-Pass Filter

The low-pass filter removes noise, transients, and other high-frequency signal components from one input to the output comparator, leaving only an essentially DC signal proportional to the input signal applied to the unit. Removing high-frequency signal components assures reliable pulse output and prevents pulses from being produced by a false trigger such as noise spike. The filter consists of an operational amplifier with feedback and a filter arranged to produce the required low-pass characteristics. The output of the stage is applied to one input of the comparator. The active low-pass filter operates from the +V1 and -V1 voltages.

4.2.7 Functional Description Of Output Comparator

The output comparator compares the amplitude of the filtered composite signal (applied input signal plus the zero adjust voltage) at the output of the low-pass filter with that of the ramp signal. The span adjust potentiometer controls the amplitude of the ramp signal (from the output of the integrator in the ramp generator) that is applied to the output comparator. As long as the amplitude of the ramp signal applied to one input of the comparator is less than that of the signal applied to the other input, the comparator produces a positive output. When the ramp amplitude becomes greater than the input signal, the comparator output rapidly changes to a negative value and remains at this value until the amplitude of the ramp signal again falls below that of the ramp. The comparator thus generates the proper pulses for application to the relay driver. The +V1 and -V1 voltages are used to operate the comparator.

4.2.8 Functional Description Of Relay Driver

The output comparator produces pulses at a relatively low power level. To drive a relay, the power of these pulses must be increased. A single transistor is used to produce output pulses with enough power to operate a relay (either the external relay or the optional internal relay). Although not indicated in Figure 4-1, an amplifier driven from the output comparator is used to drive an "off" lamp if the unit includes that option. The relay driver operates from the +V2 voltage, and the off lamp driver, if used, operates from the -V1 voltage.

4.3 CIRCUIT DESCRIPTION

The following paragraphs describe the operation of the various circuits in sufficient detail so troubleshooting, if required, can be carried out intelligently and rapidly. Except where otherwise indicated, refer to drawing 606-401-00, the main schematic diagram near the end of this manual, when reading these paragraphs.

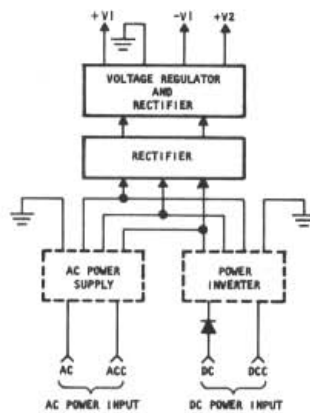
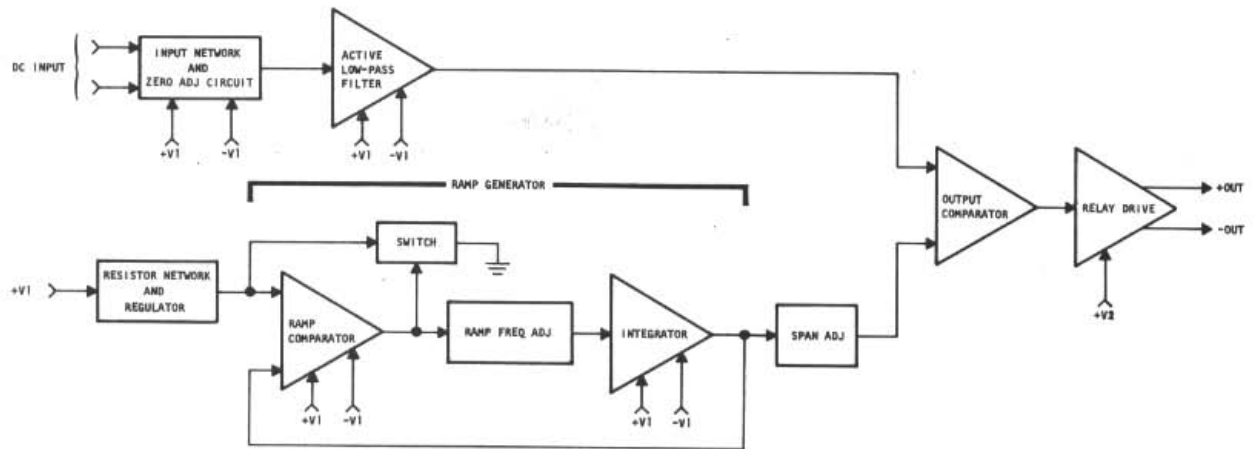


FIGURE 4-1. FUNCTIONAL DIAGRAM OF TRANSMITTER

4.3.1 Description Of AC Power Supply Circuit

The AC power supply circuit consists basically of a power transformer that produces two different AC outputs. Referring to the main schematic diagram, it is seen that the AC power is filtered by L2-C6 and L1-C5 and applied to the primary of power transformer T1. The filter elements serve to prevent line noise or spikes from getting into the unit. Each half of the center-tapped secondary of T1 puts out 18 volts, and the other secondary produces 36 volts. The voltage from the center-tapped secondary is applied to CR9, and that from the other secondary is applied to PC2.

4.3.2 Description Of Power Inverter Circuit

Drawing 400-404-00 is the schematic diagram of the power inverter (PCA). When the unit is ordered for use with DC power, the power inverter is used instead of the AC source (T1) shown on the main schematic diagram. The DC applied to the power inverter is converted to a square wave of approximately 3 KHz by Q1, Q2, and the primaries of T1 (PCA schematic), functioning as a DC-to-AC inverter. Filter L1-C1 on PCA prevents the 3-KHz signal from getting back into the external DC source. CR1 provides protection against damage from inadvertent application of DC of incorrect polarity. The square-wave output from center-tapped secondary 8-13 is applied to CR9, and that from secondary 17-16 is applied to PC2.

4.3.3 Description Of Rectifier And Regulator Circuit

CR9 (main schematic diagram) consists of two sets of full-wave rectifiers arranged to produce both positive and negative DC outputs (with respect to the grounded center tap of the winding that feeds the rectifier). The positive and negative outputs from CR9 are applied to pins 6 and 5 of power supply regulator PC2 (drawing 400-402-00). PC2 consists of two filters and voltage regulators (one each for the positive and negative outputs from CR9) and a half-wave rectifier and filter. The unfiltered positive output from CR9 is filtered by C3 and then regulated to +12 volts by CR3. Similar action to produce -12 volts output is accomplished by C2, Q1, and CR2. Half-wave rectifier CR1 and filter C1 produce a higher unregulated positive voltage from the transformer winding that is not center-tapped. This higher voltage is used by the relay driver.

4.3.4 Description Of Ramp Generator Circuit

In the ramp generator, IC4 and associated components from the comparator, and IC3 and its associated components act as the integrator. Q1 serves as the switch, with a very low voltage drop between its collector and emitter when it is on. CR3, fed from the +12-volt source through R12, produces a regulated +6.2 volts, and this is applied through R11 to pin 2 (the inverting input) of IC4. The output of IC3 is applied through R9 to pin 3 (the non-inverting input) of IC4. Thus, when Q1 is off, the output of IC4 is the result of the difference between the fixed positive voltage from CR3 and the instantaneous value of the ramp output from IC3.

THEORY OF OPERATION

To begin the explanation of circuit action, we will assume, arbitrarily, that the output of IC4 is negative initially and thus Q1 is turned off. The negative output from IC4 is applied through R22 to CR6, which clamps the voltage at this point to -6.2 volts. R23 and potentiometer R24 act as a voltage divider across this voltage. A portion of this voltage, determined by the setting of R24, is applied through R21 to pin 2 (the inverting input) of IC3. Under the influence of the negative signal applied to the inverting input, IC3 produces an output that begins to rise from zero. The action of C3 (and C4, if present) in the feedback path causes this rise in output to occur at a constant rate, and the actual rate is determined by the adjustment of R24 and the value of C3 (and C4, if used).

When the rising voltage from IC3 applied to pin 3 of IC4 becomes greater than the +6.2 volts applied to pin 2, the output of IC4 rapidly changes to a positive value, thereby turning on Q1, which places pin 2 of IC4 at essentially ground potential. Now CR7 clamps the voltage at the junction of it and R22 to +6.2 volts, and a portion of this voltage is applied to pin 2 of IC3. Since the signal applied to the inverting input of IC3 is now positive, the output of IC3 begins to decrease toward zero at the same rate it originally increased from zero to its maximum positive value. When the output of IC3 reaches zero, the positive voltage applied to pin 2 of IC4 from CR3 causes the output of IC4 to become negative again, turning off Q1 and initiating a new ramp cycle.

R10 limits the base current of Q1 resulting from a positive output at IC4, and CR2 limits the negative voltage at the base of Q1 to approximately 0.6 volt. Both IC4 and IC3 operate from +12 volts and -12 volts.

4.3.5 Description Of Input Network And Zero Adjust Circuit

With current input, R13 provides the proper termination for the input signal source connected to the +IN and -IN terminals. The zero adjust circuit is connected across plus and minus 6.2 volts, derived from the plus and minus 12-volt outputs of the power supply regulator through R18 and R6 and regulated by CR5 and CR1. The ZERO potentiometer is arranged so the voltage at its wiper can be of either polarity, and this voltage is combined directly with that at -IN terminal. With an applied input signal of 0%, the ZERO potentiometer is adjusted so the voltage at its wiper just cancels the voltage at the -IN terminal with respect to ground. Because no signal current flows in R19, this adjustment also cancels the voltage at the +IN terminal with respect to ground, and results in a pulse output of 0%. The composite signal (applied input signal plus the voltage added by the ZERO potentiometer) is applied to the input of the active low-pass filter.

4.3.6 Description Of Active Low-Pass Filter

The active low-pass filter consists of operational amplifier IC2 and associated components. The composite input signal is applied through R4 to pin 3 (the non-inverting input) of IC2. Direct feedback from the output is applied to pin 2 (the inverting input). C1 and low-pass filter R4-C2, in the input signal lead to IC2, produce a feedback signal to pin 3 that changes in phase with increasing frequency in such a way that the stage exhibits the desired overall low-pass characteristic. The output of IC2 drives one input of the comparator. IC2 operates from +12 volts and -12 volts.

4.3.7 Description Of Output Comparator Circuit

The output comparator consists of IC1 and associated components. A voltage divider consisting of R8, the SPAN potentiometer, and R5 is connected across the output from the ramp generator. The desired portion of this ramp signal, as determined by the adjustment of the SPAN potentiometer, is applied through R16 to pin 2 (the inverting input) of IC1, and the filtered composite input signal is applied through R15 to pin 3 (the non-inverting input) of IC1. As long as the amplitude of the ramp signal applied to pin 2 is less than the input signal applied to pin 3, IC1 produces a positive output. When the ramp signal rises above the input signal, the output from IC1 rapidly changes to a negative value and remains at this value until the ramp signal again falls below the input signal. Since the SPAN potentiometer determines the maximum amplitude of the ramp signal applied to IC1, this potentiometer also establishes the amplitude at which the ramp signal and the input signal will equal each other. It therefore determines the input signal required to produce 100% pulse width. R1 provides feedback to keep IC1 in a given state until the inequality between the two signals applied to this stage reverses.

The previous explanation was based on the normal configuration, which produces pulses with the "on time" proportional to the amplitude of the input signal. If pins of IC1 to which the ramp and input signals are applied are reversed (reverse output option) by using jumpers J2 and J4 instead of J1 and J3, the output of IC1 will be negative while the ramp signal is below the input signal, and will change to positive when the ramp signal becomes greater than the input signal. This results in output pulses with the "off time" proportional to the amplitude of the input signal.

IC1 operates from +12 volts and -12 volts.

4.3.8 Description Of Relay Driver Circuit

The relay driver circuit consists of Q3 and associated components. The output from IC1 is applied through R12 to the base of Q3. With a positive signal from IC1, Q3 turns on and essentially grounds the -OUT terminal if an external relay is used or grounds the -R terminal of the internal relay if the unit was ordered with the "RR" option. The basic operating voltage for this stage comes from the higher unregulated power-supply output (approximately +38 volts), and this is reduced by R25 and regulated to 24 volts by CR8. CR4 suppresses the high back voltage that would otherwise develop when the relay drops out. An optional "ON" lamp can be connected across the relay coil to come on and inform the operator when the relay (either external or internal) is energized.

4.3.9 Description Of Optional "OFF" Lamp Driver Circuit

When the unit is equipped with the optional "OFF" lamp, Q2 is used as the "OFF" lamp driver. The base of Q2 receives its drive through R2 from IC1. When the output of IC1 is negative, Q2 turns on and completes the circuit from pin 2 of the lamp to ground, thus turning the lamp on when the relay is not energized. If present, Q2 operates from -12 volts.

5.1 INTRODUCTION

This section contains information on maintenance of the unit. General troubleshooting procedures are given, using conventional signal-tracing techniques. Precautions and special techniques used to replace components are also described.

5.2 PERIODIC MAINTENANCE

It is suggested that the calibration of the unit be checked approximately every 6 months as described in Section 2. No other periodic maintenance is required.

5.3 CORRECTIVE MAINTENANCE

The following paragraphs provide information on corrective maintenance of the unit. Corrective maintenance should be carried out only by qualified personnel who have read and thoroughly understand the description of circuit operation given in Section 4.

5.3.1 Disassembly

To troubleshoot the unit, it is first necessary to disassemble it so the circuit board is exposed. The physical configuration of the unit determines the steps to be followed in disassembly and are described in the following paragraphs. In all cases, disconnect the input signal and turn off power input before disassembling the unit.

5.3.1.1 Disassembly Of Standard And -CP Units

To disassemble a standard or -CP unit, remove the unit from its installed position. If the mounting bracket is used, separate it from the unit by removing the two countersunk screws at the rear of the unit. After the unit has been removed from its installed position, disassemble the unit as follows to gain access to the circuit board:

- a. Remove the two front Phillips-head screws at the top of the unit.
- b. Remove the four Phillips-head screws at the bottom of the unit.

MAINTENANCE INFORMATION

- c. Slide the front panel (with the circuit board still attached) down and free of the sides of the case. Points on the circuit board may now be reached for troubleshooting. It is suggested that the case be used as a container for storing the removed hardware.

5.3.1.2 Disassembly Of A Plug-In Unit With A -PC Housing

To remove the cover of a plug-in unit with a -PC housing, proceed as follows:

- a. Gently spread the forward locking feet and lift the front of the cover NO MORE THAN 1/4 INCH. Excessive force applied to the cover may break the rear retaining clips.
- b. With the front of the cover raised, slide the cover to the rear to disengage it from the plug-in card.

If it is desired to test a plug-in unit in the operating position, a circuit-board extender (part no. 350-206-00 or equivalent) is required to bring the unit forward so the components on the circuit board are accessible for troubleshooting.

5.3.1.3 Disassembly Of A Plug-In Unit In A Housing

To disassemble a plug-in unit in an explosion-proof or other type of housing or enclosure (in addition to the case), proceed as follows:

- a. Use a bar wrench to loosen the housing cover from the base, then unscrew and remove the housing cover to expose the unit.
- b. If required, remove the unit from the socket by rocking the unit slightly while pulling upward until it is free of the socket. The socket and terminal card are keyed to eliminate error when the unit is reinstalled.

5.3.2 Troubleshooting

The schematic diagrams include flagged numbers (or letters) at various points in the circuit. Table 5-1 gives the voltages and waveforms at these points for specified input-signal conditions. The assembly drawings show the physical location of the parts on the circuit board. Bear in mind that the circuit

board is protected with a moisture-resistant coating. Therefore, it may be necessary to use a needle-point probe and exert a fair amount of pressure to break through the coating when it is desired to observe the signal or voltage at a specific point. When connecting a probe to a component on the circuit board, exercise care to make sure the probe does not short-circuit to an adjacent component. In general, troubleshooting is carried out by tracing the signal with an oscilloscope and referring to the schematic diagrams to determine what component might be causing an observed abnormal indication. If the original symptom was a complete failure of the unit to operate, the most logical components to suspect are those associated with the power supply (including any voltage regulators). If the unit was producing an incorrect (but not zero) output, check the outputs from the voltage regulator board and, if these are normal, apply a standard input signal and trace the resulting signal through the unit.

5.3.3 Component Replacement Techniques And General Precautions

Replace all defective components with identical parts. Refer to the assembly drawings for a list of replacement parts. The letter S and a number, all enclosed in a circle, appear after the description of certain parts in this list. The number indicates the number of spares recommended to be kept on hand for that part, per unit, for up to ten units of the same type. For more than ten units, a spares complement of 10% on the indicated parts should be used.

Most parts used in the unit are quite small and are located in a confined area. Therefore, small hand tools are a necessity when servicing the unit. The following is a summary of the general techniques and precautions that should be observed to prevent damage to components in the unit:

- a. Use a transformer-operated low-voltage soldering iron with a grounded tip and rated at not more than 50 watts. A temperature-controlled tip is desirable.
- b. Use extreme care when unsoldering the leads to any component. Do not keep the soldering iron on a point for more than a few seconds at a time. Use a suction-type solder-removing tool (solder sucker) as an aid in unsoldering transistors and integrated circuits. The protective coating on the unit may be removed with trichlorethane or equivalent. Be sure adequate ventilation is provided when using this or any other chemical.

MAINTENANCE INFORMATION

NOTE

Unused connections on integrated circuits are left unsoldered to aid in removal. Refer to the assembly drawing for more complete information.

- c. Do not excessively bend or twist the leads of small components; they break easily.
- d. Before removing a component, observe the lead dress. Be sure that the lead dress of the replacement is the same as that of the original.
- e. Remove all flux from soldered joints with trichlorethane or equivalent.

NOTE

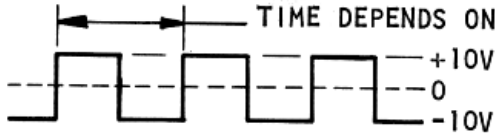
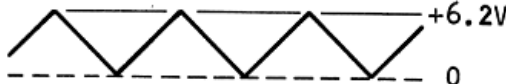
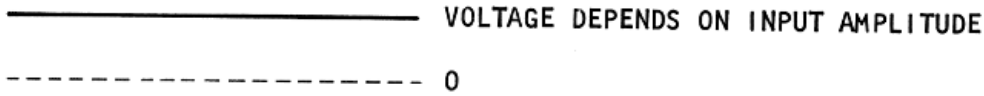
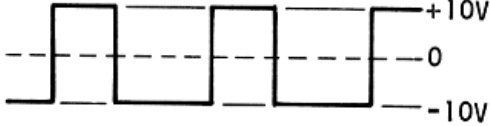
Units that were calibrated at the factory to customer's specifications have protective caps over the SPAN and ZERO potentiometers. These caps must be removed so the unit can be recalibrated. LIFT, DO NOT TWIST, the caps off, using a screwdriver tip as a prying tool. Snap the caps back in place, WITHOUT TWISTING, when recalibration has been completed.

- f. Test the unit for proper operation and, if necessary, recalibrate by the procedure given in Section 2. When the performance of the unit is known to be satisfactory, apply clear acrylic to reseal the unit where required.
- g. Check that all leads are clear of the board edge before reinstalling the board into its case.
- h. When reinstalling the unit onto the mounting bracket, be sure to use the same screws (or screws of the same size) as the ones removed. Longer screws will damage the unit.

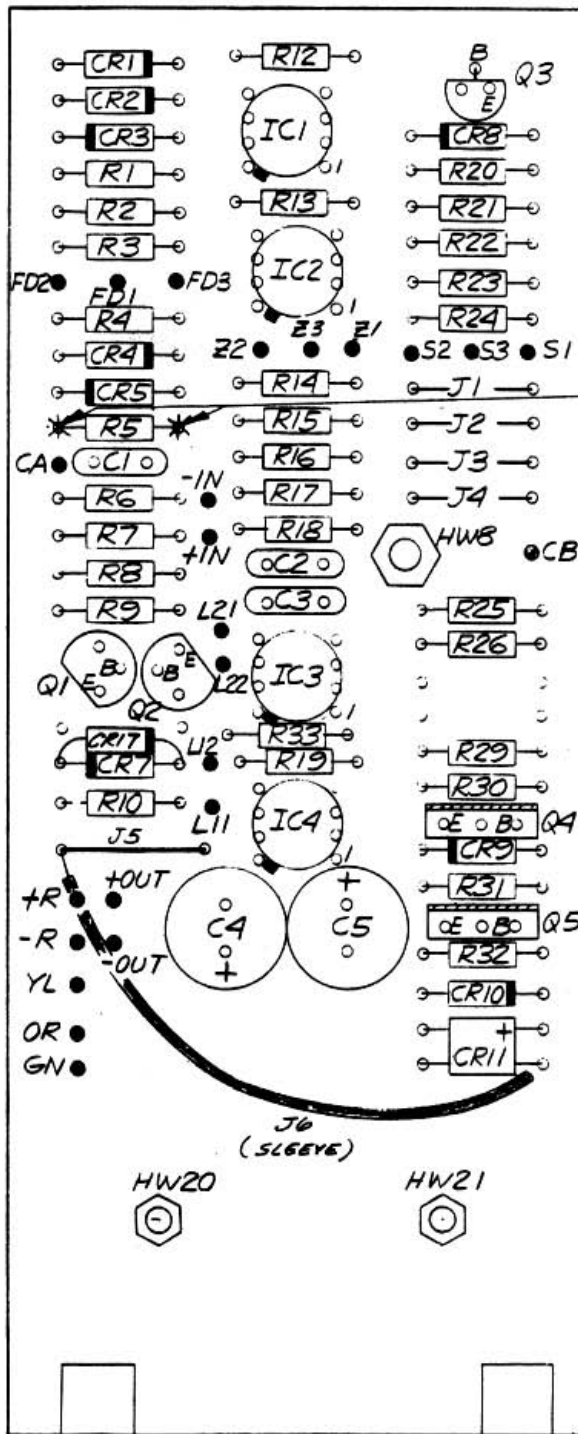
SECTION 5

MAINTENANCE INFORMATION

TABLE 5-1. WAVE FORMS AND VOLTAGES

TEST POINT(S)	WAVE FORM AND AMPLITUDE OR VOLTAGE LEVEL
1	
2	
3	
4	

1. SWAGE MOUNTING BLOCKS TO P.C. BOARD BEFORE ADDING COMPONENTS. SEE TRAVELER FOR CASE ASSY & ASSEMBLY OF MOUNTING BLOCKS.
 2. C6 LEADS GO TO PADS "CA" & "CB".
 3. METAL SIDE OF Q4 & Q5.
 4. ON UNITS WITH "SC" OPTION ATTACH R101-1 & R101-2 TO JOB TRAVELER.
 5. SEE PG. 2 FOR ADDITIONAL COMP. LOCATIONS.
 6. ALL JUMPERS ARE 22 AWG BUSS, TEFLON SLEEVED AS REQ'D.
 7. ALL LEADS & TERMINALS MUST BE SOLDERED TO PADS.
- NOTES: UNLESS OTHERWISE SPECIFIED



CR15 BANDED END DOWN

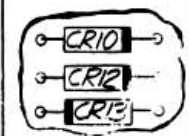


CR16 BANDED END UP

BUSS FEED-THRU WHEN R5 IS NOT USED



MOUNTING OF C7



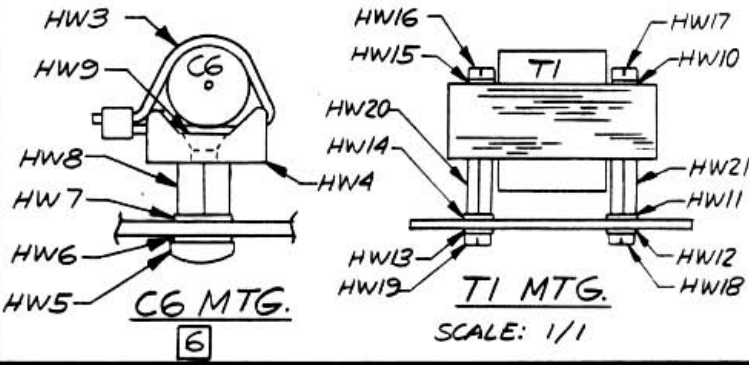
NO.	ITEM	PART NUMBER	PART NAME	MANUFACTURER	REFERENCE DESIGNATION
LIST OF MATERIALS					
1					

DASH NO.	NEXT ASSEMBLY
FINISH	PROT. ENGR.
CUSTR.	

DO NOT SCALE DRAWING
SCALE 2/1 & NOTED
JOB NO. 606

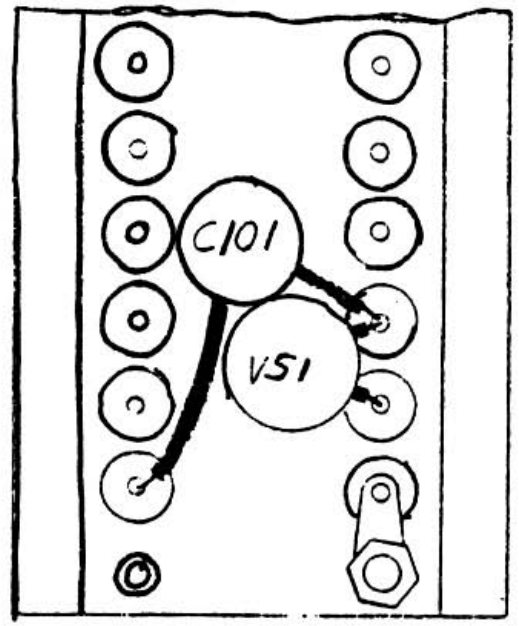
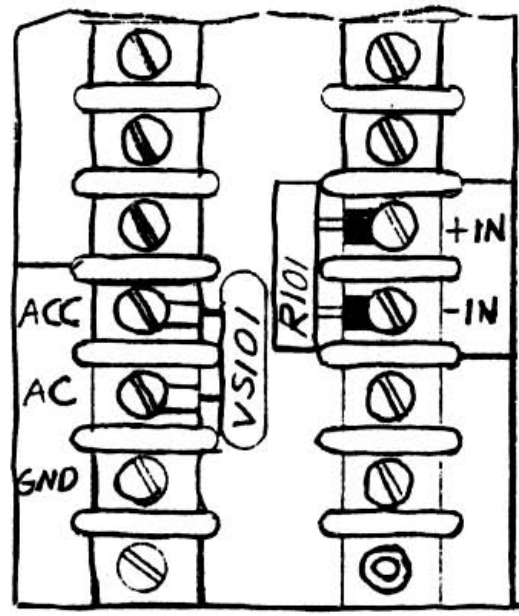
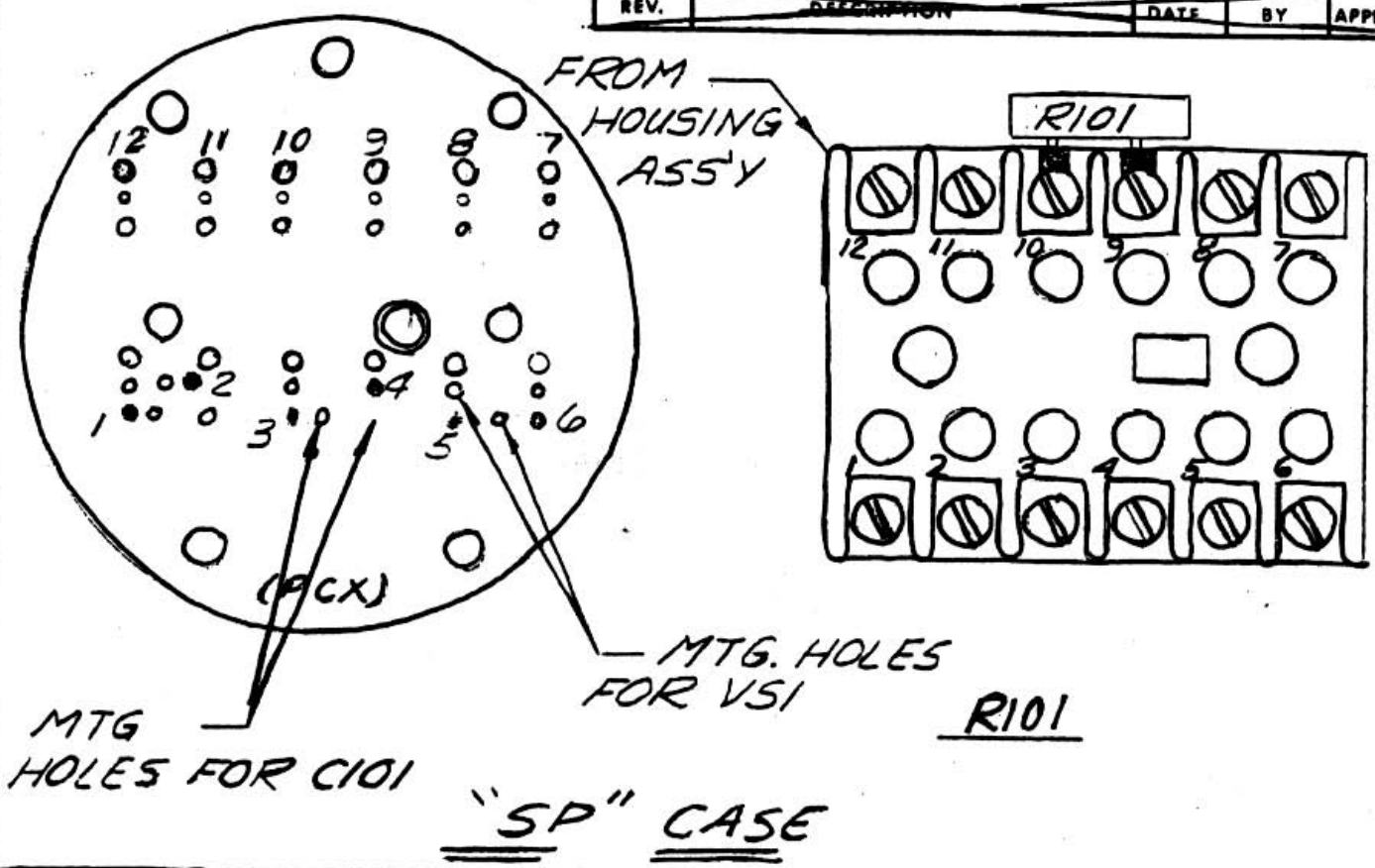
P.C. BD. ASSY,
STANDARD
PDT

606-501-00C
Pg. 1 OF 2



REV.	DESCRIPTION	DATE	BY	APPV.
C	ECO 1800/1913, 2259, 2528	10/18	JUN	

REV.	DESCRIPTION	DATE	BY	APPROV.



"SR & CH" CASE SLEEVE LEADS

DIMENSIONS ARE IN INCHES UNLESS NOTED OTHERWISE

TOLS. UNLESS NOTED:

.X = ±.10

.XX = ±.030

.XXX = ±.010

ANGLES = ± 30'

DO NOT SCALE DRAWING

SCALE: 1/1

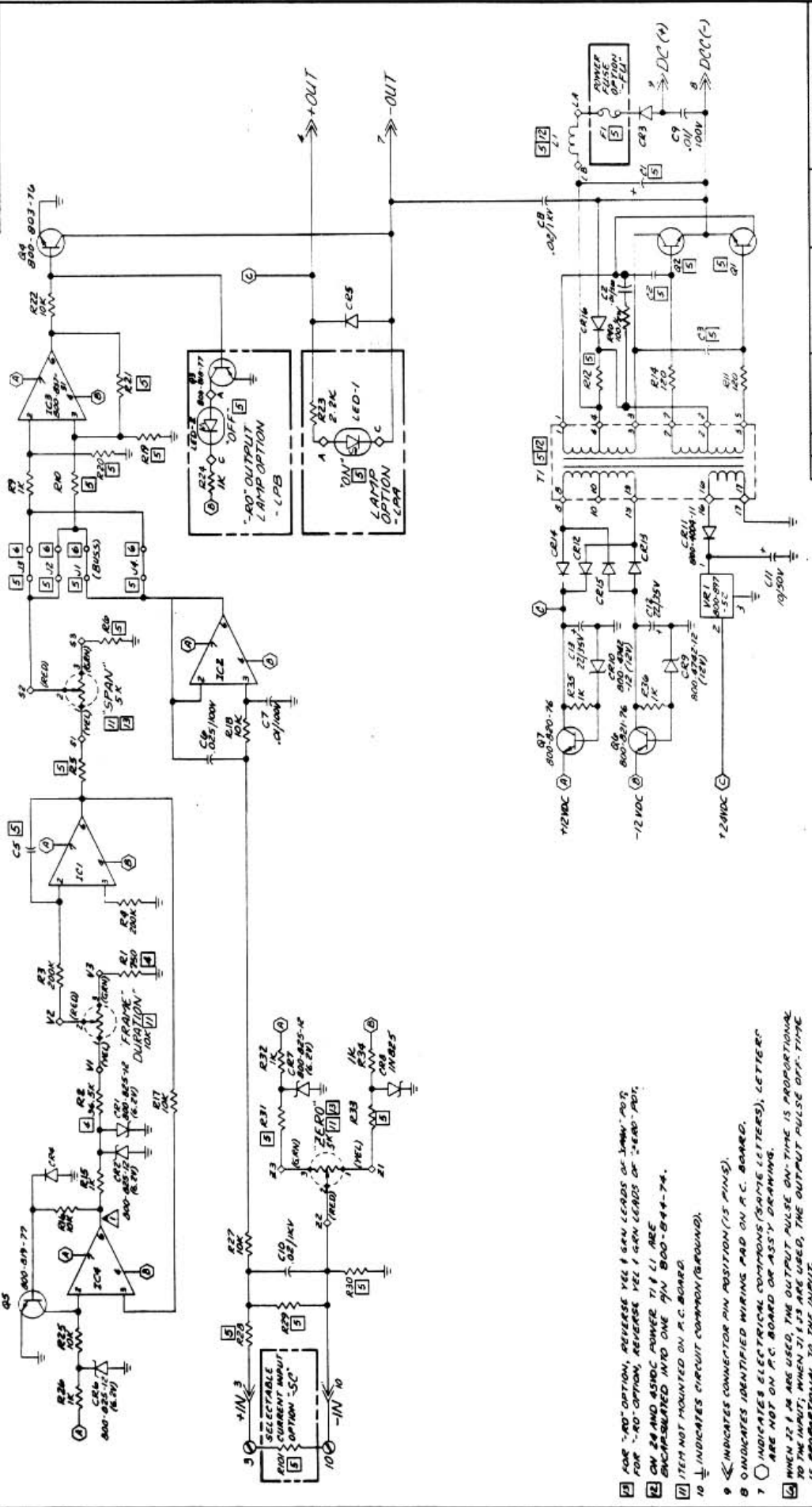
DRAWN	<u>L. J. JENSEN</u>	<u>2/7/5</u>
CHECKED		
PROJ. ENGR.	<u>J. JENSEN</u>	<u>1/2/5</u>
CUSTOMR.		

MOORE INDUSTRIES INC.
VAN NUYS CA.

**ADDITIONAL PARTS LOC'N,
STANDARD PDT**

DWG. NO. 606-501-00 Pg. 2 of 2

REV. C



REV.	DATE	BY	CHK.	APP.
1	10/74			
2				
3				
4				
5				
6				
7				
8				
9				
10				

SCHEMATIC
PDT
 88 BJT BUILT BARRIER
 6006-451-000

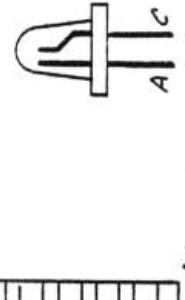
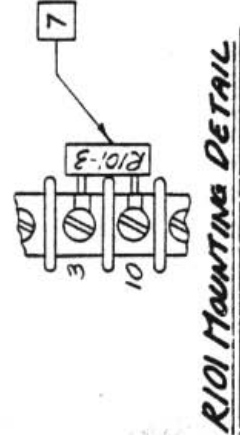
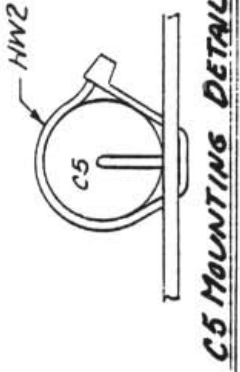
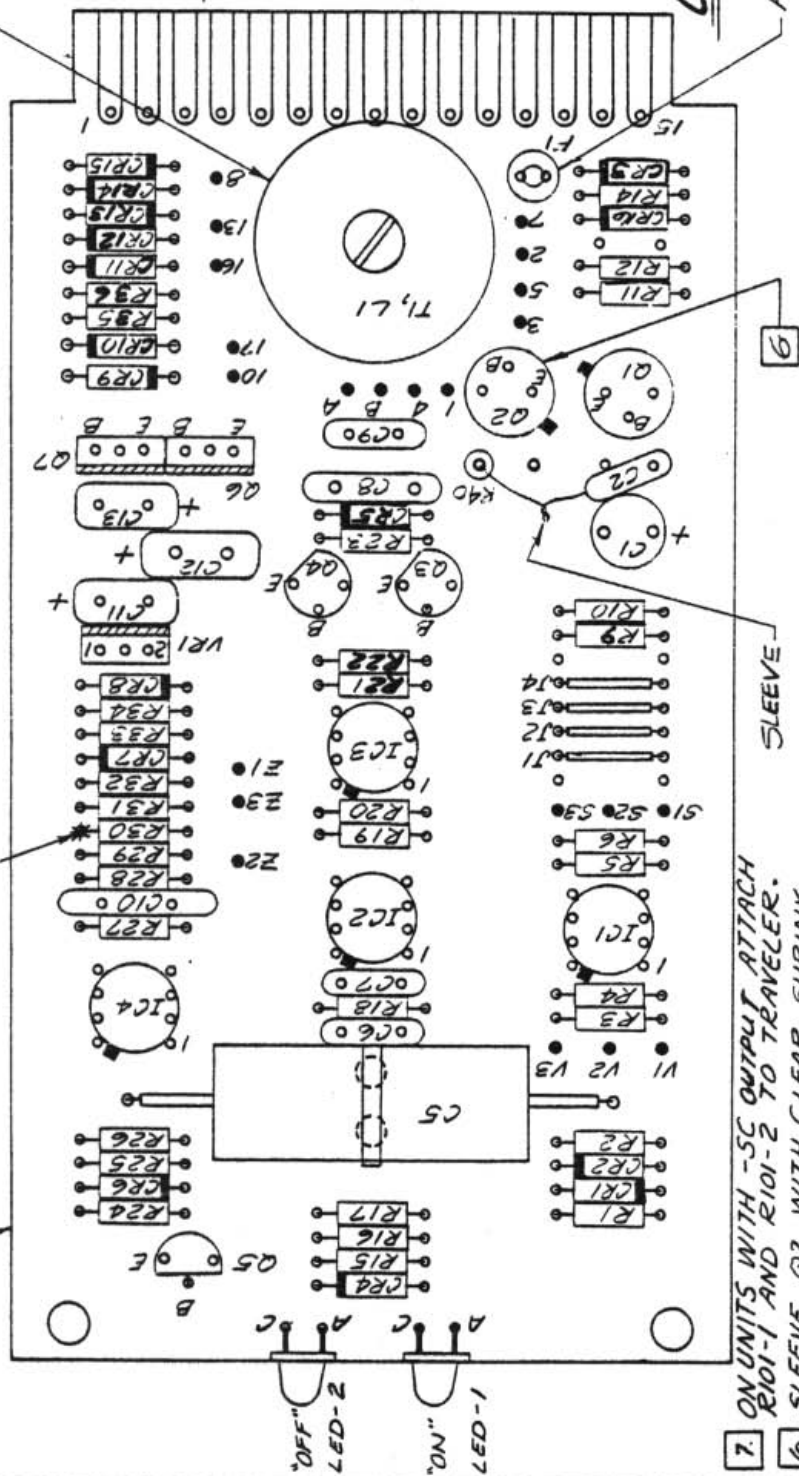
1. FOR "-AD" OPTION, REVERSE YEL 1 GRN LEADS OF 300MVA-AD. FOR "-AD" OPTION, REVERSE YEL 1 GRN LEADS OF 300MVA-AD. ENCASED INTO ONE 741N 800-844-74.
2. ON 24 AND 45VDC POWER T1 & L1 ARE ENCASED INTO ONE 741N 800-844-74.
3. ITEM NOT MOUNTED ON A.C. BOARD
4. INDICATES CIRCUIT COMMON (GROUND).
5. INDICATES CONNECTOR PIN POSITION (15 PINS).
6. INDICATES IDENTIFIED WIRING PAD ON A.C. BOARD.
7. INDICATES ELECTRICAL COMMONS (SAME LETTERS), LETTERS ARE NOT ON P.C. BOARD OR ASSY DRAWING.
8. WHEN 24V ARE USED, THE OUTPUT PULSE ON-TIME IS PROPORTIONAL TO THE INPUT PULSE ON-TIME. WHEN 12V ARE USED, THE OUTPUT PULSE OFF-TIME IS PROPORTIONAL TO THE INPUT.
9. SEE LIST OF MATERIALS FOR VALUE, PART NO. AND/OR USE
10. METAL FILM RESISTORS, 1%.
 11. ALL POTENTIOMETERS INCREASE C. M. FROM 1 TO 3.
 12. ALL INTD. CRTS ARE FULL RN 800-852-31, DIODES ARE 800-640-11, RESISTORS ARE CARB COMB, 1/2 WATT, ±10%.
 13. RESISTANCE VALUES ARE IN OHMS; CAPACITANCE VALUES ARE IN MICROFARADS.
 14. UNLESS OTHERWISE SPECIFIED

REV.	DESCRIPTION	DATE	BY	APPROV
D	REV PER ECO 3761, 3771	11/28/64	JAD	JMC

SEE DWG 200-237-00 FOR TI/LI MFG. DETAIL

FEED THRU, BUSS WHEN R30 IS NOT USED

PCI



- ON UNITS WITH -SC OUTPUT ATTACH R101-1 AND R101-2 TO TRAVELER.
- SLEEVE Q2 WITH CLEAR SHRINK TUBING.

- INDICATES METAL SIDE OF VR1, Q6 & Q7.
- ALL JUMPERS ARE 22 AWG BUSS, TEFLON SLEEVED.
-
-
- SOLDER ALL LEADS TO PADS.

NOTES: UNLESS OTHERWISE SPECIFIED

ITEM NO.	PART NUMBER	PART NAME	MANUFACTURER	REFERENCE DESIGNATION
1				

LIST OF MATERIALS	
DRAWN	F. Kelly
CHECK	A. J. [unclear]
PROJ. ENG.	[unclear]
CUST.	

P.C. BOARD ASSEMBLY PLUG-IN PDT	
MOORE INDUSTRIES INC. VAN NUYS • CALIF.	
606-551-00 D	

DO NOT SCALE DRAWING	JOB NO 606
SCALE 2/1	

RETURN PROCEDURES

To return equipment to Moore Industries for repair, follow these four steps:

1. Call Moore Industries and request a Returned Material Authorization (RMA) number.

Warranty Repair –

If you are unsure if your unit is still under warranty, we can use the unit's serial number to verify the warranty status for you over the phone. Be sure to include the RMA number on all documentation.

Non-Warranty Repair –

If your unit is out of warranty, be prepared to give us a Purchase Order number when you call. In most cases, we will be able to quote you the repair costs at that time. The repair price you are quoted will be a "Not To Exceed" price, which means that the actual repair costs may be less than the quote. Be sure to include the RMA number on all documentation.

2. Provide us with the following documentation:
 - a) A note listing the symptoms that indicate the unit needs repair
 - b) Complete shipping information for return of the equipment after repair
 - c) The name and phone number of the person to contact if questions arise at the factory
3. Use sufficient packing material and carefully pack the equipment in a sturdy shipping container.
4. Ship the equipment to the Moore Industries location nearest you.

The returned equipment will be inspected and tested at the factory. A Moore Industries representative will contact the person designated on your documentation if more information is needed. The repaired equipment, or its replacement, will be returned to you in accordance with the shipping instructions furnished in your documentation.

WARRANTY DISCLAIMER

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ANY BUYER OF GOODS OR SERVICES FROM THE COMPANY AGREES WITH THE COMPANY THAT THE SOLE AND EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONCERNING THE GOODS OR SERVICES SHALL BE FOR THE COMPANY, AT ITS OPTION, TO REPAIR OR REPLACE THE GOODS OR SERVICES OR REFUND THE PURCHASE PRICE. THE COMPANY SHALL IN NO EVENT BE LIABLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES EVEN IF THE COMPANY FAILS IN ANY ATTEMPT TO REMEDY DEFECTS IN THE GOODS OR SERVICES. BUT IN SUCH CASE THE BUYER SHALL BE ENTITLED TO NO MORE THAN A REFUND OF ALL MONIES PAID TO THE COMPANY BY THE BUYER FOR PURCHASE OF THE GOODS OR SERVICES.

ANY CAUSE OF ACTION FOR BREACH OF ANY WARRANTY BY THE COMPANY SHALL BE BARRED UNLESS THE COMPANY RECEIVES FROM THE BUYER A WRITTEN NOTICE OF THE ALLEGED DEFECT OR BREACH WITHIN TEN DAYS FROM THE EARLIEST DATE ON WHICH THE BUYER COULD REASONABLY HAVE DISCOVERED THE ALLEGED DEFECT OR BREACH, AND NO ACTION FOR THE BREACH OF ANY WARRANTY SHALL BE COMMENCED BY THE BUYER ANY LATER THAN TWELVE MONTHS FROM THE EARLIEST DATE ON WHICH THE BUYER COULD REASONABLY HAVE DISCOVERED THE ALLEGED DEFECT OR BREACH.

RETURN POLICY

For a period of thirty-six (36) months from the date of shipment, and under normal conditions of use and service, Moore Industries ("The Company") will at its option replace, repair or refund the purchase price for any of its manufactured products found, upon return to the Company (transportation charges prepaid and otherwise in accordance with the return procedures established by The Company), to be defective in material or workmanship. This policy extends to the original Buyer only and not to Buyer's customers or the users of Buyer's products, unless Buyer is an engineering contractor in which case the policy shall extend to Buyer's immediate customer only. This policy shall not apply if the product has been subject to alteration, misuse, accident, neglect or improper application, installation, or operation. THE COMPANY SHALL IN NO EVENT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.



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