

November 1983

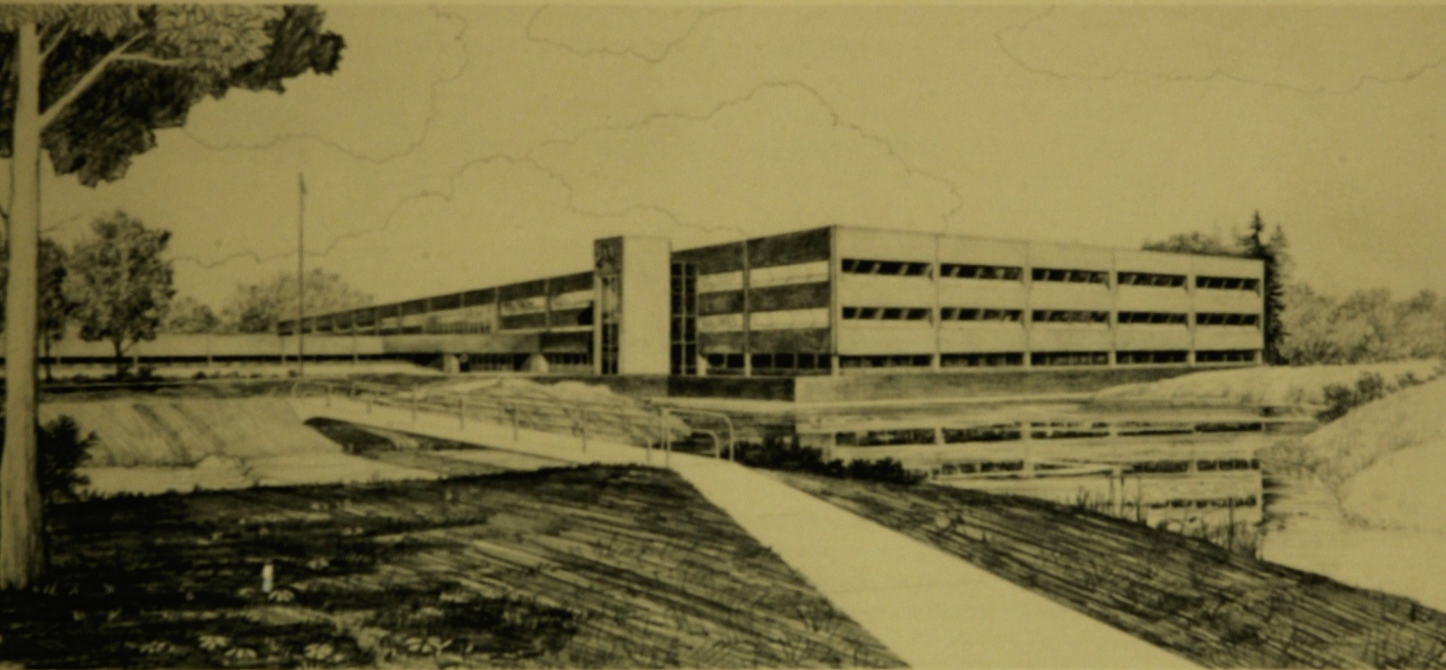
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TMI CABLE TRACER OPERATION AND MAINTENANCE  
MANUAL FOR ASSEMBLY 417910

R. L. Sumstine

**Idaho National Engineering Laboratory**

Operated by the U.S. Department of Energy



This is an informal report intended for use as a preliminary or working document

Prepared for the  
U.S. DEPARTMENT OF ENERGY  
Idaho Operations Office  
Under DOE Contract No. DE-AC07-76ID01570



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Idaho Falls, Idaho 83415

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## ABSTRACT

This manual provides technical information and instructions to operate and maintain the cable tracer designed for the Three Mile Island (TMI) Unit 2 Reactor Building.

The TMI cable tracer was developed to allow TMI personnel to trace cables in cable trays that may be tested or sectioned for destructive examination.



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TMI CABLE TRACER OPERATION AND MAINTENANCE  
MANUAL FOR ASSEMBLY 417910

1. GENERAL INFORMATION

1.1 Scope of Manual. This manual contains specifications, theory of operation, circuit checkout, drawings and spare parts list for the Three Mile Island (TMI) cable tracer, assembly 417910.

1.2 Purpose of Equipment. The TMI cable tracer is needed to identify a cable in a cable tray or bundle that is unmarked and among many cables. Access to each end of the cable is accessible and is connected to the cable tracer for identifying the cable that may be tested or sectioned for destructive examination.

1.3 Description of Equipment. The TMI cable tracer has a portable transmitter unit for frequency current excitation of the cable (Figure 2-1). A separate receiver with a clamp-on cable probe (Figures 2-2 and 2-3) is used to pick up the identification current signal in the cable of interest.

2. SPECIFICATIONS

2.1 TMI Cable Tracer Transmitter. The following specifications are for the TMI cable tracer transmitter, Figure 2-1:

Power requirement--+12 V, 600 mA-h battery pack

Recharge rate--0.06 A for 10 h

Power drain--50 mA-h

Signal output--21.5 kHz,  $\pm 100$  Hz at 10 mA rms with a 1.05-kHz modulation at 40 to 60% modulation.

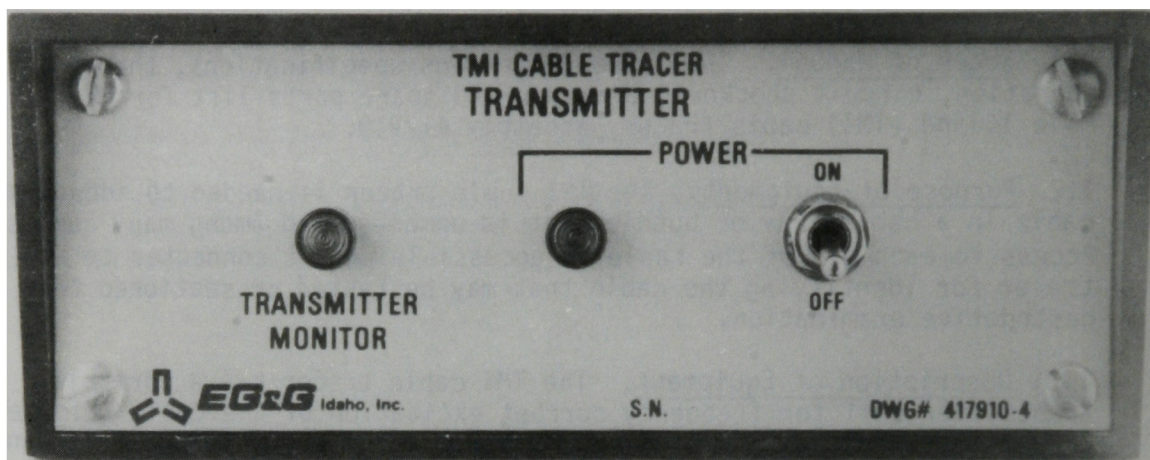
Maximum load impedance--1K ohms

Drive isolation-- $1 \times 10^6$  ohms or greater

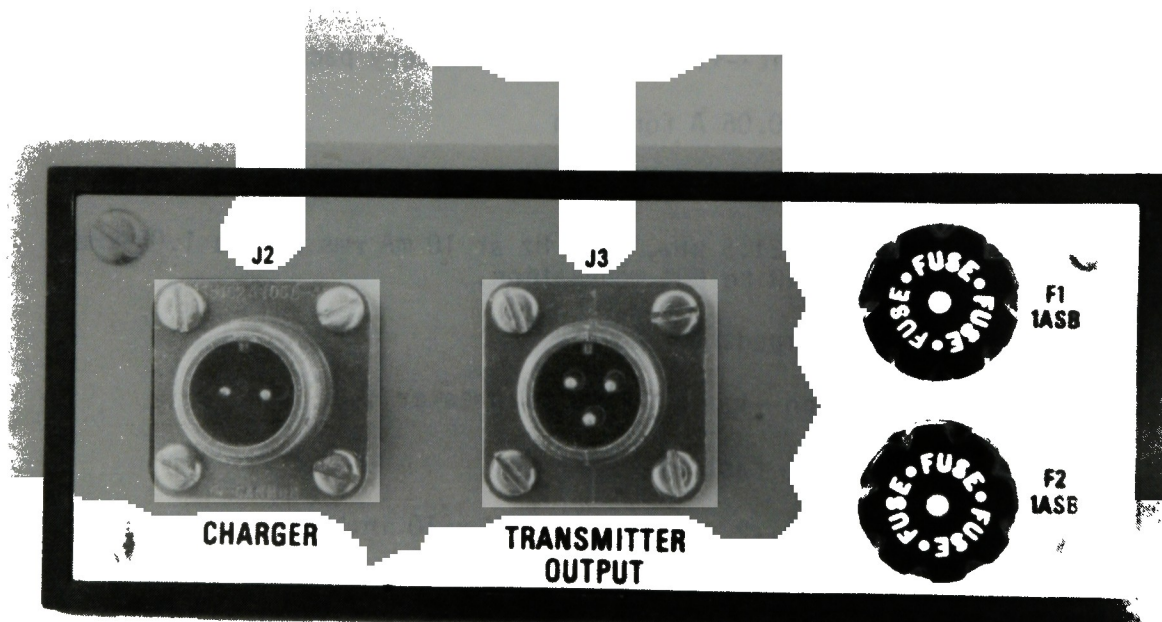
Drive fuse--1 A fast blow

Case dimensions--2 in. H x 5 in. W x 10 in. L

Weight--3.8 lb



Front Panel



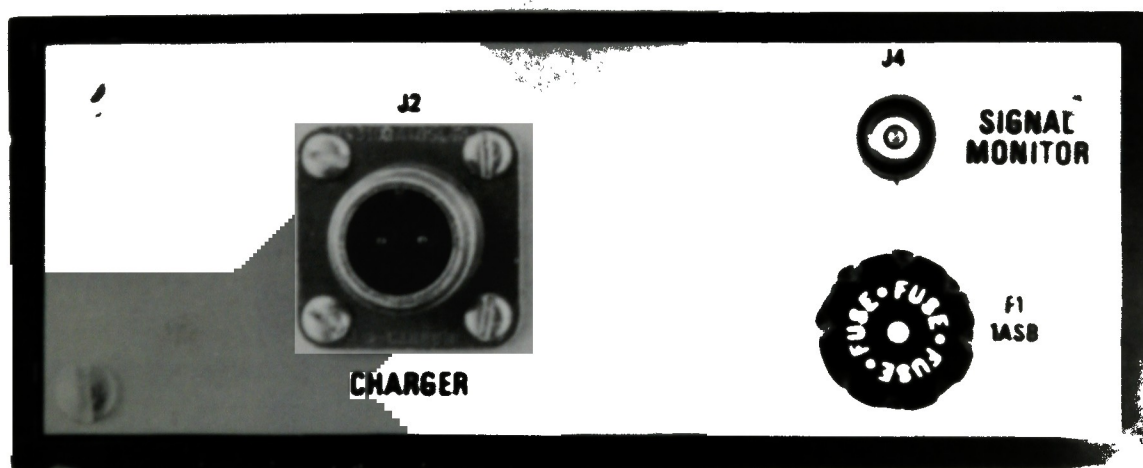
Back Panel

Figure 2-1. TMI cable tracer transmitter.





Front Panel



Back Panel

Figure 2-2. TMI cable tracer receiver.



Figure 2-3. TMI cable tracer receiver clamp-on probe.

**2.2 TMI Cable Tracer Receiver.** The following specifications are for the TMI cable tracer receiver, which is shown in Figure 2-2:

Power requirement-- $\pm 12$  V at 600 mA-h

Recharge rate--0.06 A for 10 h

Power drain--50 mA-h

Input band pass--21.5 kHz--3 dB  $\pm$  2 kHz

Input dc isolation-- $1 \times 10^6$  ohm or greater

Accepted carrier--21.5 kHz carrier  $\pm$  100 Hz

Accepted signal level--5 mA rms to 10 mA rms

Case dimensions--2 in. H x 5 in. W x 10 in. L

Weight--3.8 lb

**2.3 Battery Charger.** The following specifications are for the battery charger:

Power requirement--115 Vac  $\pm$  10%

Charge rate--0.06 A

Recharge voltage--24 Vac  $\pm$  10%

Case dimensions--4.25 in. H x 3.0 in. W x 5.12 in. L

Weight--2.3 lb

### 3. THEORY OF OPERATION

3.1 Cable Tracer Transmitter. Figure 3-1 shows the TMI cable tracer transmitter block diagram of the major portions of the transmitter. The transmitter excites the cable with a 21.5-kHz current carrier of 10-mA rms with a 1.05-kHz modulation. The carrier oscillator, 5U1, feeds a signal to 5Q5 of the differential transmitter. The current in the differential transmitter is controlled by current source 5Q3. The 1.05-kHz modulator oscillator, 5U2, feeds a signal to 5Q3, which turns the current source up and down and causes the carrier to be modulated 40 to 60%. The 1-Hz oscillator, 5U3, turns the transmitter on and off. When receiving the signal, a blinking alarm light is a firm confirmation and is desired over steady-state "on lights." The transmitter indicator light is controlled by 5Q4, which senses that there is current in the transmitter circuit. The battery power is monitored by 5U4 and 5Q7 and will blink the "Power On" light, 4DS1, when the battery is +10 Vdc or lower.

3.2 Cable Tracer Receiver. Figure 3-2 is a TMI cable tracer receiver block diagram for the major portions of the receiver. The clamp-on probe (Figure 2-3), is a modified AMPROBE instrument ac current probe. A preamplifier, 6Q1 and 6Q2, was installed inside of the probe body along with three LED lights that will turn on when a 21.5-kHz current carrier with a 1.05-kHz modulation is received with enough amplitude to trigger the receiver circuits. The preamplifier signal is fed to a 21.5-kHz band pass buffer amplifier, 7Q1 and 7Q2, which accepts the 21.5 kHz and feeds a sample 0.2 V rms to the 21.5-kHz tone decoder, 7U1. 7Q3 and 7Q4 are used as modulation demodulators and a 1.05-kHz sample of 0.2 V rms is supplied to the 1.05-kHz tone decoder, 7U3. Level detector, 7Q5,



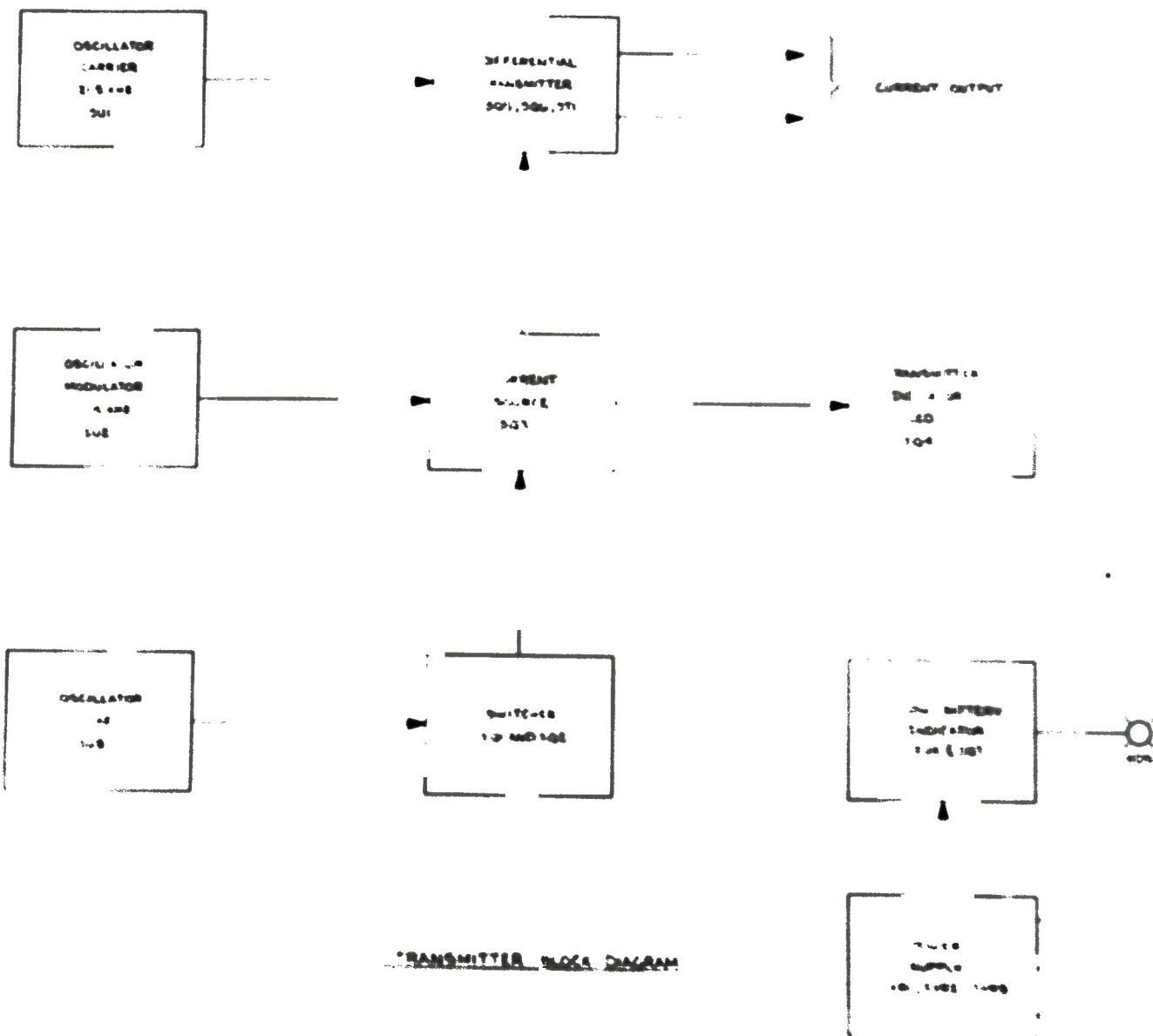
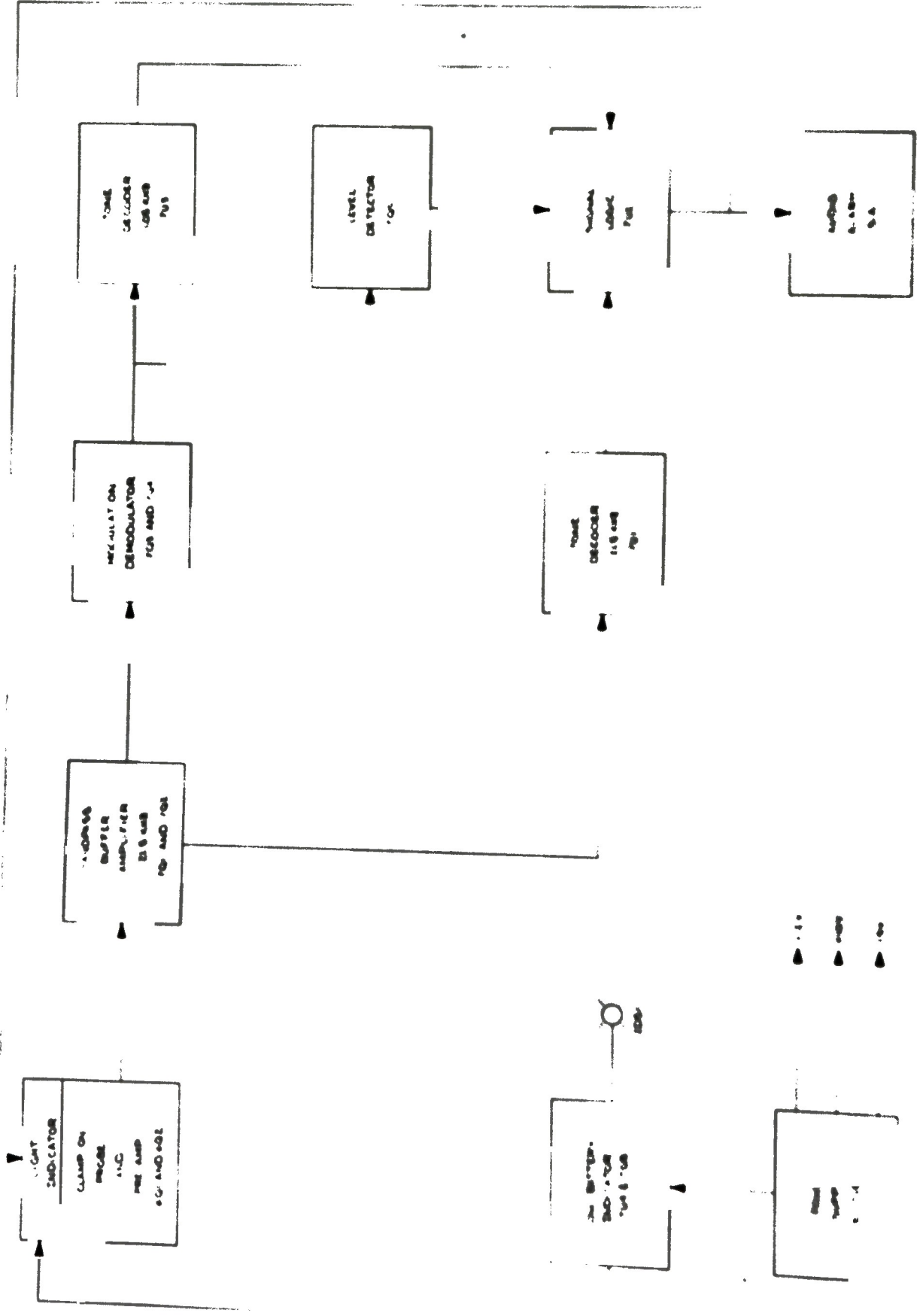


Figure 3-1. TM1 cable transmitter block diagram.





NOT AMP AND SIGNALS ARE IN THE SAME

Figure 3-2. Cable tracer receiver block diagram.

detects a positive dc voltage at the output of 7Q3 and 7Q4 and sends a logic signal (low true) to logic 7U2. When the tone decoders have also sent a signal to logic 7U2 (low true), the logic circuit will turn both the Sona-Lert audio transducer and LED lights on once per second, which indicates that the probe head is clamped on the excited cable. The battery power is monitored by 7U4 and 7Q8 and will blink the "Power On" light, 2DS1, and also will blink light 6DS4 in the clamp-on probe receiver head when the battery power is +10 Vdc or lower.

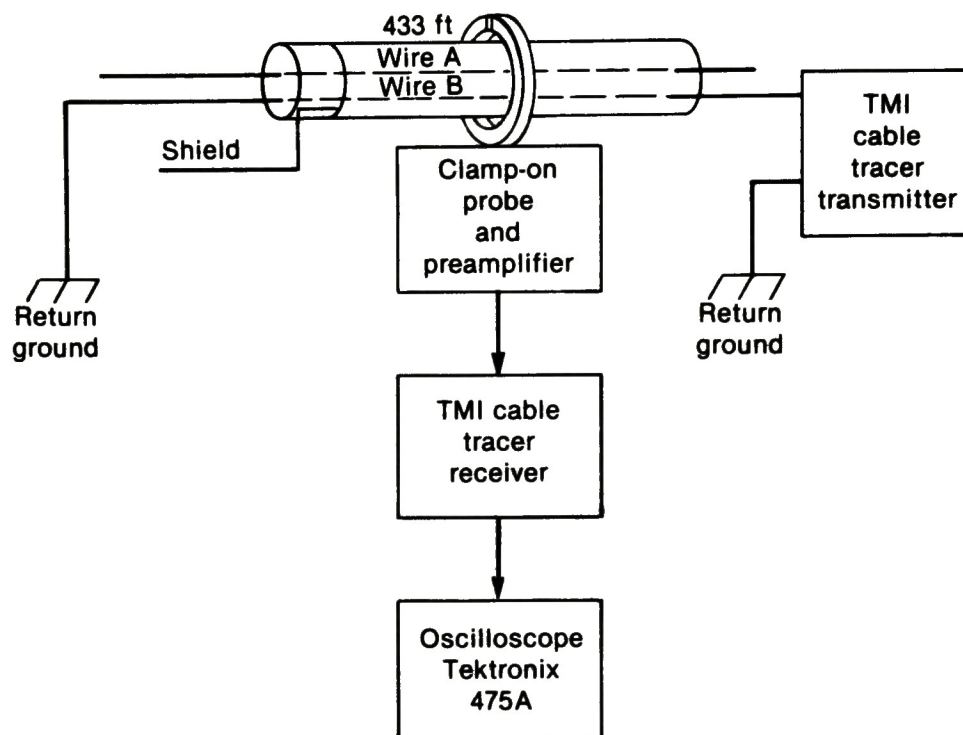
**3.3 Battery Charger.** The battery charger provides 24 Vac to the receiver or transmitter when connected to the battery charger connector. The 24 Vac is fed through current limiting resistors and a diode located in the unit being charged. The charge rate is 0.06 A-h, which can charge the unit in 10 h. Also, the unit can run from the charger with low batteries if charged for 5 min.

**3.4 TMI Cable Tracer Operation.** Figure 3-3 shows the different connections for signal excitation of a cable.

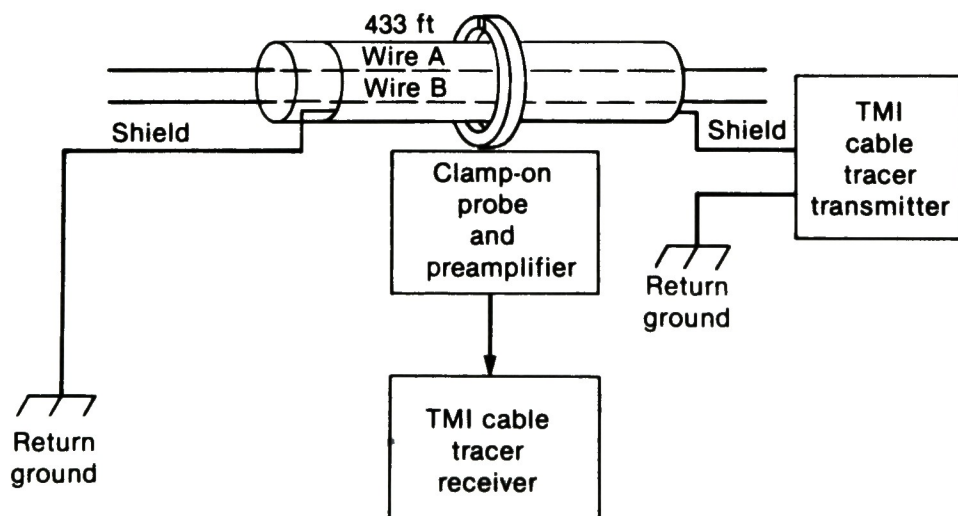
**Warning**--The cable to be traced should not have ac voltage or dc voltage between leads or to plant ground. Check cable leads with a volt-ohm meter.

1. The TMI cable tracer transmitter should be connected to facility ground and to a lead or shield isolated from facility ground on the cable.
2. The other end of the cable should have the same cable lead connected to facility ground. If necessary an isolated single return wire could be substituted for facility ground.





Test condition 1



Test condition 2

INEL 3 1269

Figure 3-3. TMI cable tracer test connections.

Note: The cable to be inspected cannot be traced if the cable has both the sender wire and return wire inside of the cable. The magnetic fields will cancel and a signal cannot be detected.

3. Clamp the clamp-on receiver probe on the cable near the transmitter for checkout. The TMI cable tracer receiver should alarm and the clamp-on probe LED lights should blink on and off.
4. Temporarily disconnect the transmitter facility ground lead, with receiver probe still connected to cable. The alarm should disappear. Reconnect facility ground and the TMI cable tracer receiver will alarm. The cable tracer set-up has been confirmed to operate only on a cable with the ac current signal and will reject a cable with an ac signal "VOLTAGE."
5. Take the TMI cable tracer to the bundle in question and locate the cable that is to be traced. For absolute confirmation it is necessary to check every cable in a bundle, and only one cable should alarm the cable tracer receiver. For best results lift cable from bundle, approximately 6 in., when tracing cable.
6. If signal levels are to be recorded, a portable oscilloscope can be connected to a signal connector on the back of the receiver. A confirmation signal will alarm the receiver and should be 3 V rms or greater. Cables next to activated cable should have 0.03 V rms or less, and will not alarm cable tracer receiver.

If the cable trace clamp-on probe is laid on the excited cable but not clamped on, the signal will be approximately 0.1 V rms and will not alarm the cable tracer receiver.

Note: This is the reason why it is better to lift the cable to be inspected from the bundle of cables for optimum performance.

#### 4. CALIBRATION, ACCEPTANCE TEST, AND SERVICING

Calibration is required after fabrication, servicing, or every six-month period. The "Calibration/Acceptance Test Procedure for the TMI Cable Tracer Transmitter and Receiver" in Appendix A is to be used to calibrate the cable tracer. This procedure requires an appropriate facility quality assurance person for verification. To service the cable tracer, review Section 3, Theory of Operation, and refer to Appendixes B and C for schematics and case construction.

##### 4.1 Required Instruments

The following instruments are required to service and calibrate the TMI cable tracer:

1. Fluke digital multimeter, model 80248 or equivalent
2. Fluke frequency counter, model 1953A or equivalent
3. Tektronix oscilloscope, model 475A or equivalent.

#### 5. SPARE PARTS LIST

The following parts are provided for servicing the TMI cable tracer. Refer to EG&G Drawing 417910, sheet 5, for suppliers of the spare parts.

<u>Drawing Item #</u>	<u>Description</u>	<u>Required</u>
2B1, 4B1	Battery, 12 V Gould MP202t, 600 mA-h	1
5U1	I.C., LM566CN	1
5VR2	I.C., LM555CN	1
5U4	I.C., LM567CN	1

7U1	I.C., LM567CN	1
7U2	I.C., SN7402N	1
4DS1	LED 556-R	2
7Q6	Transistor 2N3906	2
7Q7	Transistor 2N3904	4
6Q1	Transistor 2N3819	2





## APPENDIX A

### CALIBRATION/ACCEPTANCE TEST PROCEDURE FOR THE TMI CABLE TRACER TRANSMITTER AND RECEIVER

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Calibration/Acceptance Test Procedure  
for the  
TMI Cable Tracer Transmitter and Receiver

CTTP-1

Serial No.: \_\_\_\_\_

Reference Drawing: 417910

Prepared By: \_\_\_\_\_ Date: \_\_\_\_\_

Requester: \_\_\_\_\_ Date: \_\_\_\_\_

Design Engineer: \_\_\_\_\_ Date: \_\_\_\_\_

Quality: \_\_\_\_\_ Date: \_\_\_\_\_

General:

This procedure provides instructions for performing the acceptance test and Level II Qualification of the TMI cable tracer transmitter, receiver, and battery charger. Each unit will be checked for functional operation. Each unit will be covered in a separate section.

Prerequisites:

1. Test instrumentation calibration must be current, as evident by an attached calibration tag and serial number (S/N) or ID number. This information shall be recorded in the equipment section.
2. Verify that all work has been completed per approved drawings and integrated planning.
3. Verify that all quality discrepancy reports have been resolved.

Equipment:

1. Oscilloscope (Tektronix 465) or equivalent S/N \_\_\_\_\_
2. Frequency counter (Fluke 1953A) or equivalent S/N \_\_\_\_\_
3. Digital multimeter (Fluke 8050A) or equivalent S/N \_\_\_\_\_
4. Other  
\_\_\_\_\_, S/N \_\_\_\_\_  
\_\_\_\_\_, S/N \_\_\_\_\_

Precautions:

1. Before applying power to transmitter and receiver, measure for shorts at battery inputs on printed circuit boards.

Tech

- \_\_\_\_\_ 1. Transmitter TP6 and TP7
- \_\_\_\_\_ 2. Receiver TP1 and TP2

Procedure:

Verify that prerequisites have been performed.

Tech \_\_\_\_\_ QA \_\_\_\_\_

Section 1: Battery Charger

1. Connect a battery charger to the transmitter charger input connector. Place transmitter power switch in "OFF" position.
2. Apply ac power to battery charger.



3. Measure dc voltage across 5R27.

\_\_\_\_ a. Voltage across 5R27\_\_\_\_, should be between 1.4 and 1.6 Vdc.

4. Allow transmitter unit to charge for a minimum of 10 h.

5. Connect the second battery charger to the receiver charger input connector. Place receiver power switch in "OFF" position.

6. Apply ac power to battery charger.

7. Measure dc voltage across 7R30.

\_\_\_\_ a. Voltage across 7R30\_\_\_\_, should be from 1.4 Vdc to 1.6 Vdc.

8. Allow receiver unit to charger for a minimum of 10 h.

## Section 2: Transmitter

1. Apply battery power with on/off switch to the transmitter.

2. Verify input voltages at:

\_\_\_\_\_ A. TP6 to TP7, +12 V to +14.5 V.

\_\_\_\_\_ B. TP5 to TP7 +10 V +0.20 V

\_\_\_\_\_ C. TP4 to TP7 +5 V +0.10 V

3. Using a Tektronix 465 oscilloscope (or equivalent) with a Fluke 1953A frequency counter (or equivalent), observe wave forms, measure, and record frequency at the following test points. Note: Ensure that oscilloscope is dc coupled.

- \_\_\_\_\_ A. TP1-21.5 kHz (triangle wave) \_\_\_\_\_  
adjust 5 R4 to 21.5 kHz  $\pm$  100Hz.
- \_\_\_\_\_ B. TP2-1.05 kHz (triangle wave) \_\_\_\_\_  
adjust 5 R4 to 1.05 kHz  $\pm$  10 Hz.
- \_\_\_\_\_ C. TP3-1 Hz (square wave) \_\_\_\_\_  
(limits 1-2 Hz).

NOTE: Verify that carrier light blinks at the above frequency.

4. Attach a 100-ohm resistor across the transmitter output (J3. A and B), observe output.

\_\_\_\_\_ A. Calculate and record ac rms current output.

\_\_\_\_\_

\_\_\_\_\_ B. Remove 100-ohm resistor.

5. Attach adjustable dc power supply to TP-6 and TP-7. Ensure that transmitter power switch is in the "OFF" position. Apply power to supply and adjust for +12 Vdc. Adjust power supply output slowly down until 4DS1 begins to blink. Record that voltage:

\_\_\_\_\_.

NOTE: The voltage at which the 4DS1 begins to blink should be no less than +10 Vdc. Disconnect dc power supply.

### Section 3: Receiver

1. Connect clamp-on probe to receiver and apply battery power with on/off switch.

2. Verify voltage at:

\_\_\_\_\_ A. TP1 to TP2, +12 V to +14.5 V.

\_\_\_\_\_ B. TP3 to TP2, +5 V  $\pm$  0.10 V.

3. Ensure that there is no signal to receiver.

4. Attach a Tektronix (or equivalent) 10X isolated scope probe to frequency counter input and measure frequency at the following:

\_\_\_\_\_ A. "PIN 6 7U1," adjust 7R23 until frequency is 21.5 kHz  $\pm$  100 Hz.

\_\_\_\_\_ B. "PIN 6 7U3," adjust 7R17 until frequency is 1.05 kHz  $\pm$  10 Hz.

5. Attach a 6-ft length of 20 AWG wire to the transmitter at connect J3 pins A and B, loop wire outside transmitter.

6. Apply battery power to transmitter with on/off switch. \_\_\_\_\_

7. Clamp search probe around the 20 AWG wire. \_\_\_\_\_

8. Using a Tektronix 465 (or equivalent) oscilloscope, observe modulated input wave form as follows:

\_\_\_\_\_ A. TP4 to ground, 5-7.5 V rms

\_\_\_\_\_ B. TP5 to ground, 5-7.5 V rms

9. Verify that Sona-Lert and LEDs are working on search probe. \_\_\_\_\_

10. Attach adjustable dc power supply to TP-1 and TP-2. Ensure receiver power switch is in the "OFF" position. Apply power to supply and adjust to +12 V. Adjust power supply output slowly down until 2DS1 and 6DS4 begin to blink. Record this voltage: \_\_\_\_\_.

NOTE: The above recorded voltage should be no less than +10 Vdc. Disconnect dc power supply.

### Section 3: Acceptance

After quality verification and inspection of the TMI cable tracer receiver and the TMI cable tracer transmitter using EG&G Drawing 417910 and completing the acceptance test procedure for the TMI cable tracer units, a green tag for each unit is to be issued for Quality Level II, and a signed calibration sticker is to be attached to the front panels.

QD Verify: \_\_\_\_\_.

APPENDIX B

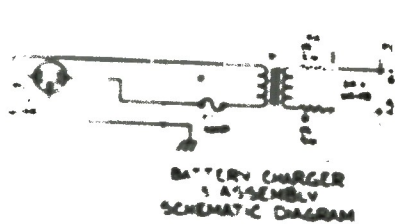
TMI CABLE TRACER  
EG&G DRAWING 417910





ATTN-1  
PRE AMP PC BOARD

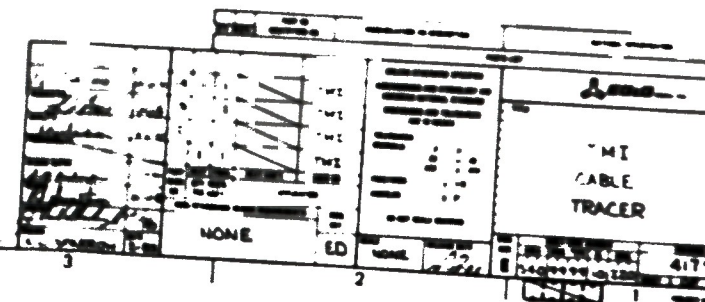
PRE AMP 1 ASSEMBLY  
SCHEMATIC DIAGRAM



417910-7  
RECEIVER PC BOARD

RECEIVER 2 ASSEMBLY  
SCHEMATIC DIAGRAM

TOP VIEW BT1 & BT2  
BT1





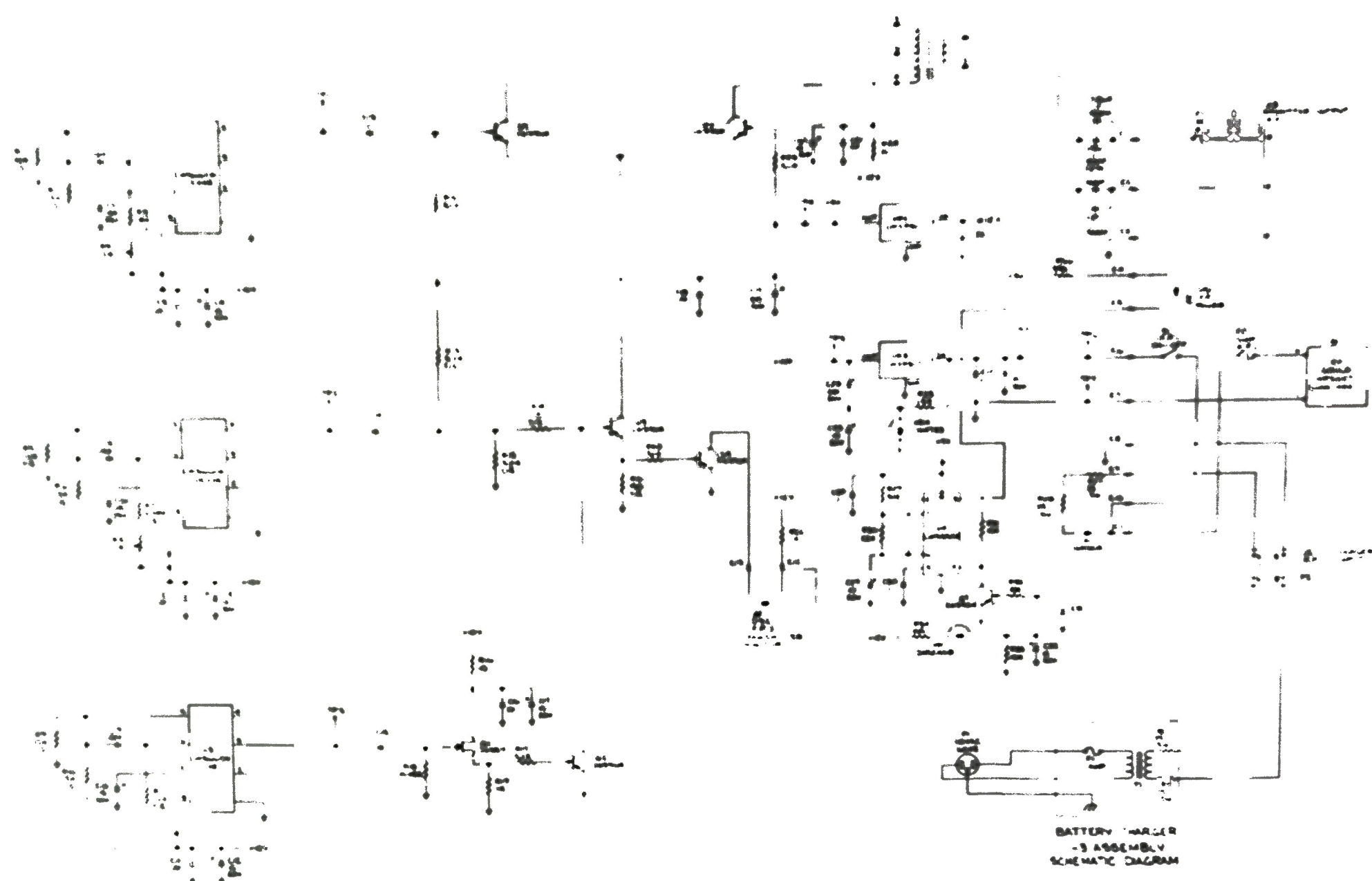












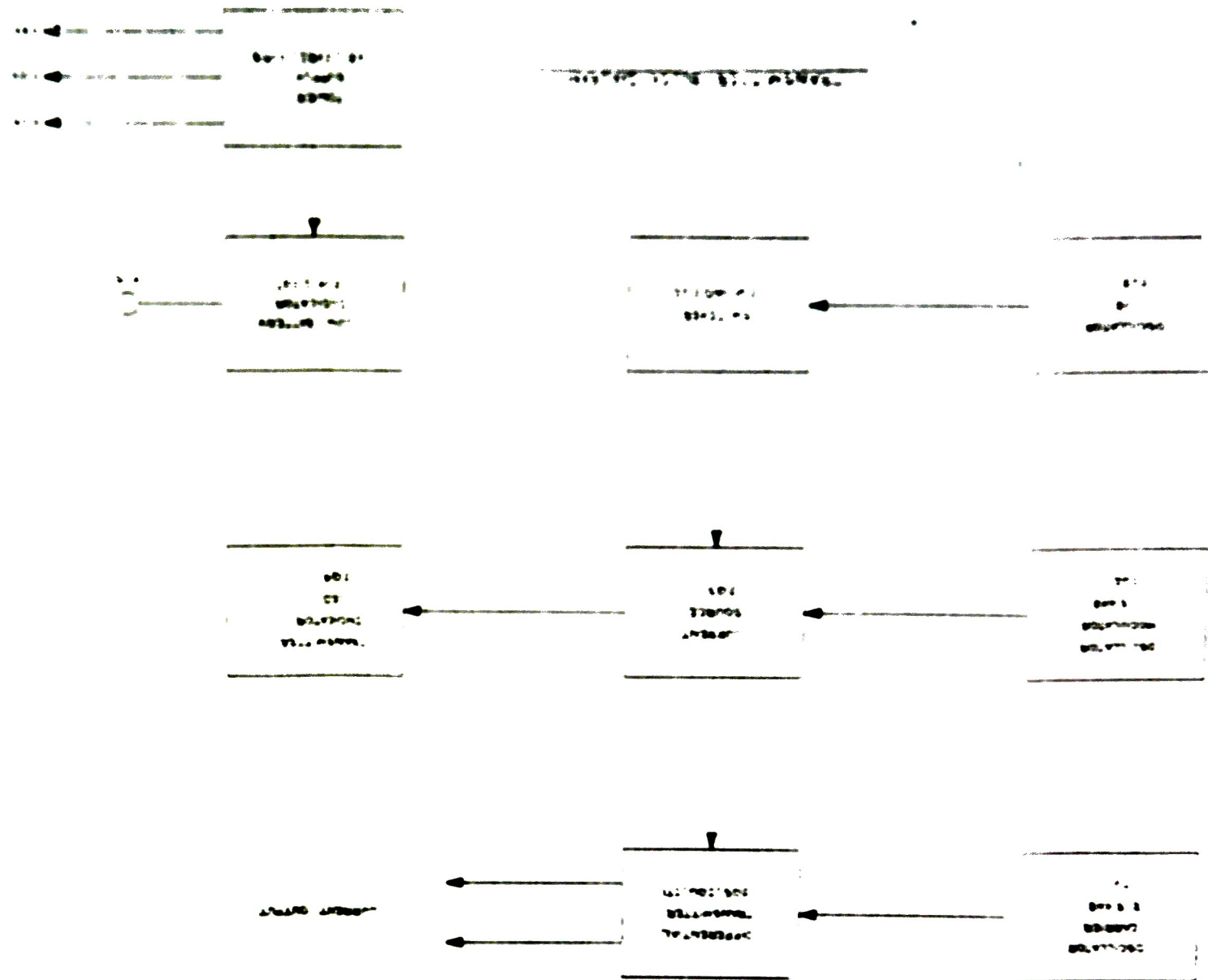
417910-5  
TRANSMITTER PC BOARD

TRANSMITTER - 4 ASSEMBLY  
SCHEMATIC DIAGRAM



BATTERY CHARGER  
- 3 ASSEMBLY  
SCHEMATIC DIAGRAM







1	10:00	10:15	Arrival	10/10/50	10:00	Arrived at office
2	10:15	10:30	Meeting	10/10/50	10:15	Met with Mr. Smith
3	10:30	10:45	Work	10/10/50	10:30	Working on report
4	10:45	11:00	Work	10/10/50	10:45	Continued work
5	11:00	11:15	Work	10/10/50	11:00	Working on report
6	11:15	11:30	Work	10/10/50	11:15	Continued work
7	11:30	11:45	Work	10/10/50	11:30	Working on report
8	11:45	12:00	Work	10/10/50	11:45	Continued work
9	12:00	12:15	Work	10/10/50	12:00	Working on report
10	12:15	12:30	Work	10/10/50	12:15	Continued work
11	12:30	12:45	Work	10/10/50	12:30	Working on report
12	12:45	1:00	Work	10/10/50	12:45	Continued work
13	1:00	1:15	Work	10/10/50	1:00	Working on report
14	1:15	1:30	Work	10/10/50	1:15	Continued work
15	1:30	1:45	Work	10/10/50	1:30	Working on report
16	1:45	2:00	Work	10/10/50	1:45	Continued work
17	2:00	2:15	Work	10/10/50	2:00	Working on report
18	2:15	2:30	Work	10/10/50	2:15	Continued work
19	2:30	2:45	Work	10/10/50	2:30	Working on report
20	2:45	3:00	Work	10/10/50	2:45	Continued work
21	3:00	3:15	Work	10/10/50	3:00	Working on report
22	3:15	3:30	Work	10/10/50	3:15	Continued work
23	3:30	3:45	Work	10/10/50	3:30	Working on report
24	3:45	4:00	Work	10/10/50	3:45	Continued work
25	4:00	4:15	Work	10/10/50	4:00	Working on report
26	4:15	4:30	Work	10/10/50	4:15	Continued work
27	4:30	4:45	Work	10/10/50	4:30	Working on report
28	4:45	5:00	Work	10/10/50	4:45	Continued work
29	5:00	5:15	Work	10/10/50	5:00	Working on report
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36	6:45	7:00	Work	10/10/50	6:45	Continued work
37	7:00	7:15	Work	10/10/50	7:00	Working on report
38	7:15	7:30	Work	10/10/50	7:15	Continued work
39	7:30	7:45	Work	10/10/50	7:30	Working on report
40	7:45	8:00	Work	10/10/50	7:45	Continued work
41	8:00	8:15	Work	10/10/50	8:00	Working on report
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47	9:30	9:45	Work	10/10/50	9:30	Working on report
48	9:45	10:00	Work	10/10/50	9:45	Continued work
49	10:00	10:15	Work	10/10/50	10:00	Working on report
50	10:15	10:30	Work	10/10/50	10:15	Continued work
51	10:30	10:45	Work	10/10/50	10:30	Working on report
52	10:45	11:00	Work	10/10/50	10:45	Continued work
53	11:00	11:15	Work	10/10/50	11:00	Working on report

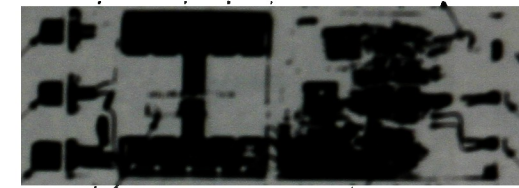
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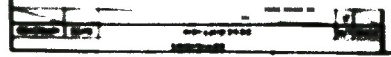
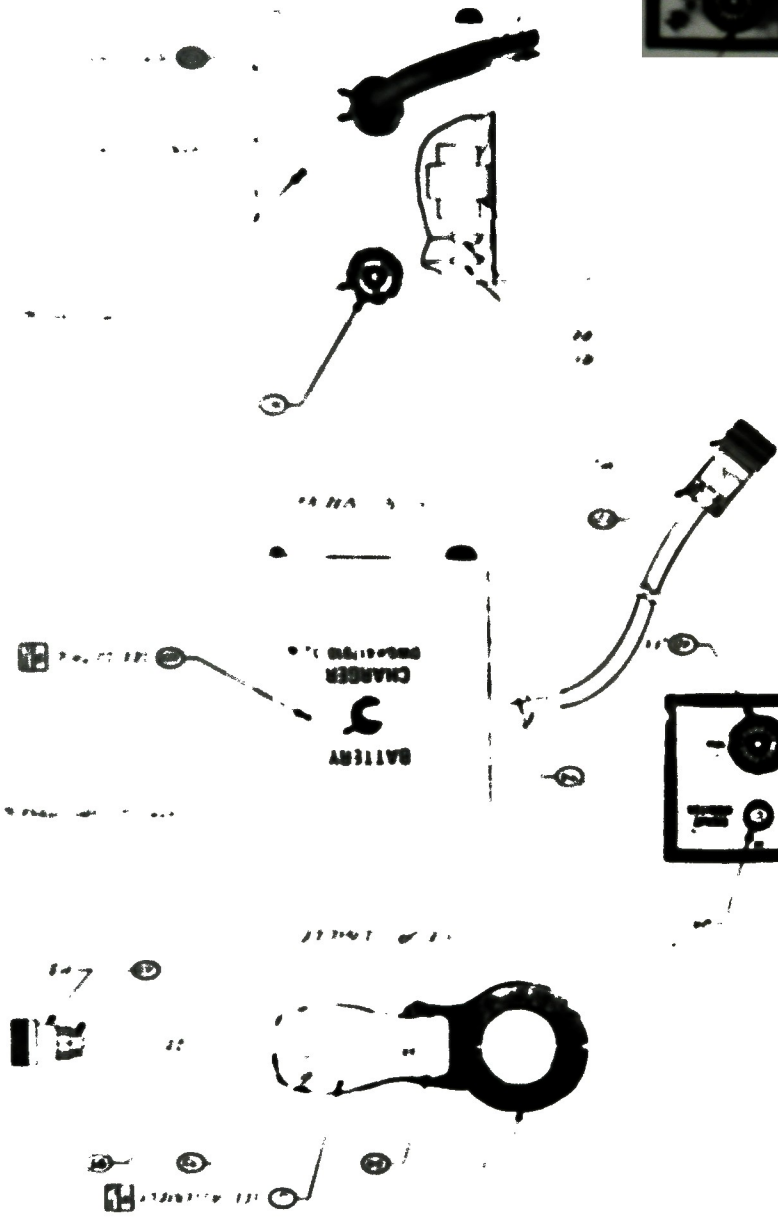
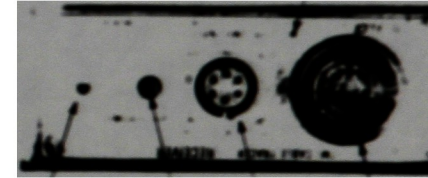
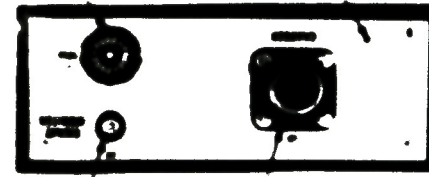


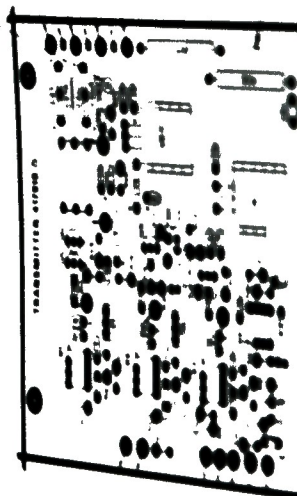
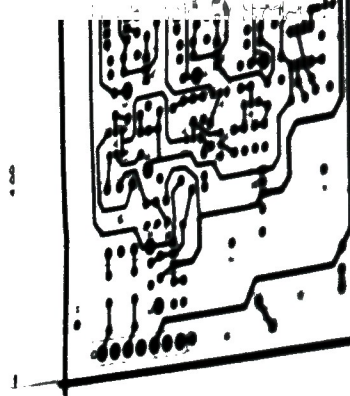
DO NOT TOUCH



1

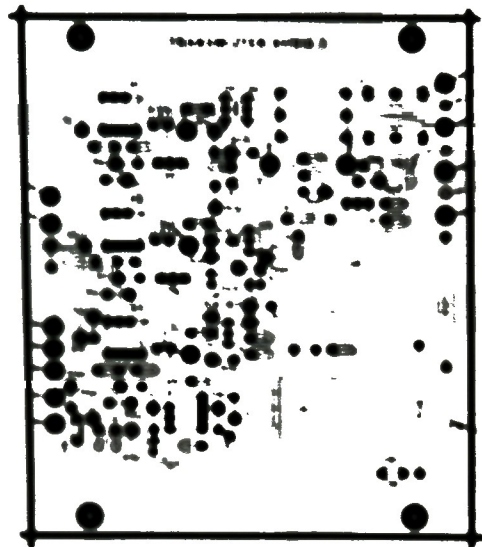
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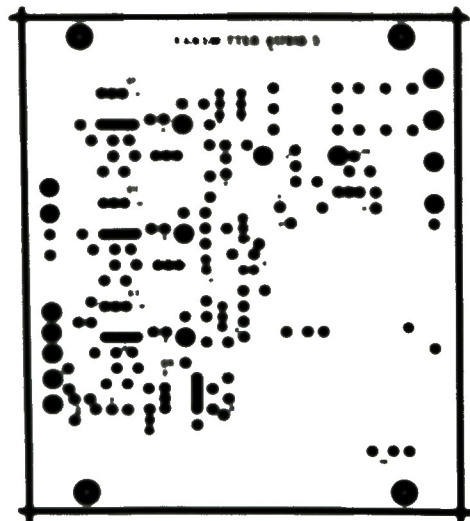
3 4 5 6 7 8

1 2 3 4 5 6 7 8



TOP TRACE OF BOARD 1

COMPONENT SIDE ARTWORK  
SCALE 1/8"

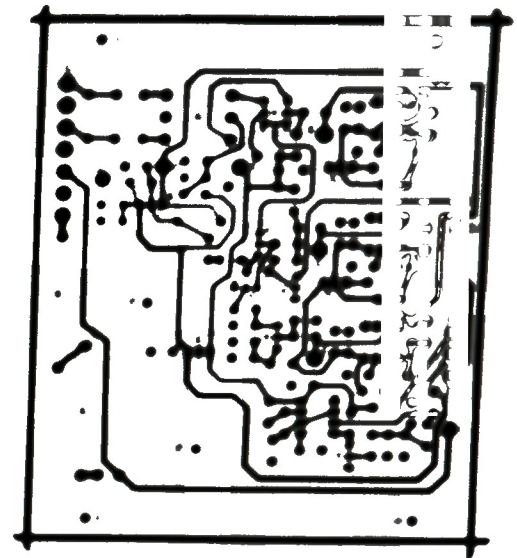


BOTTOM TRACE OF BOARD 1

COMPONENT SIDE ARTWORK  
SCALE 1/8"  
TO BE USED AS A TEMPLATE TO FABRICATE  
COMPONENT SIDE OF THIS BOARD

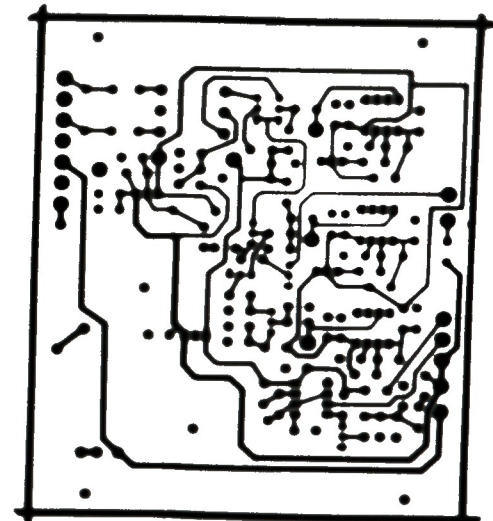
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100

1/8" (25.4mm)



TOP TRACE OF BOARD 2

COMPONENT SIDE ARTWORK  
SCALE 1/8"



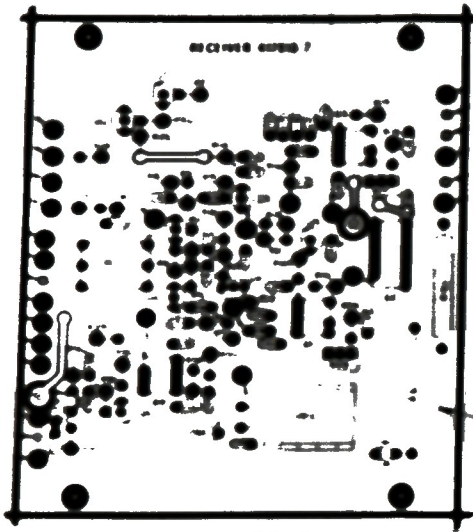
BOTTOM TRACE OF BOARD 2

CIRCUIT SIDE ARTWORK  
SCALE 1/8"  
TO BE USED AS A TEMPLATE TO FABRICATE  
CIRCUIT SIDE OF THIS BOARD

HOLE SCHEDULE

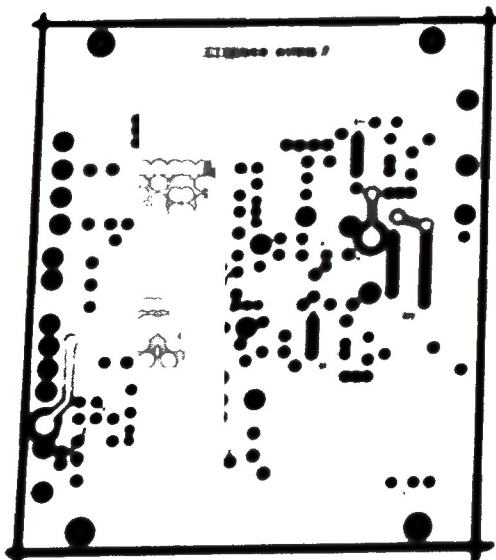
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7	0.063	0.500
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9	0.063	0.500
10	0.063	0.500
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100	0.063	0.500





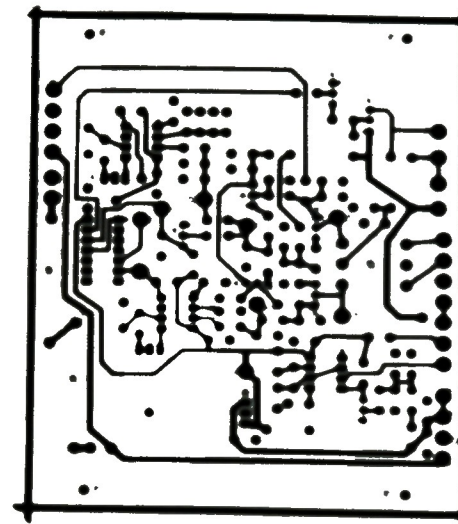
TOP VIEW OF BOARD

NOT TO SCALE  
 PREPARED BY: [illegible]  
 DATE: 1



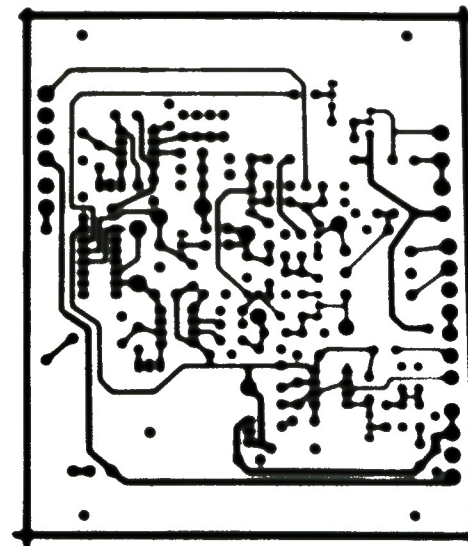
BOTTOM VIEW OF BOARD

NOT TO SCALE  
 PREPARED BY: [illegible]  
 DATE: 1



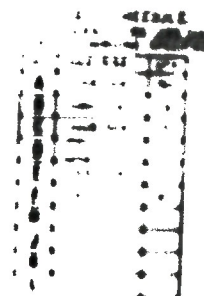
TOP VIEW OF BOARD

NOT TO SCALE  
 PREPARED BY: [illegible]  
 DATE: 1



BOTTOM VIEW OF BOARD

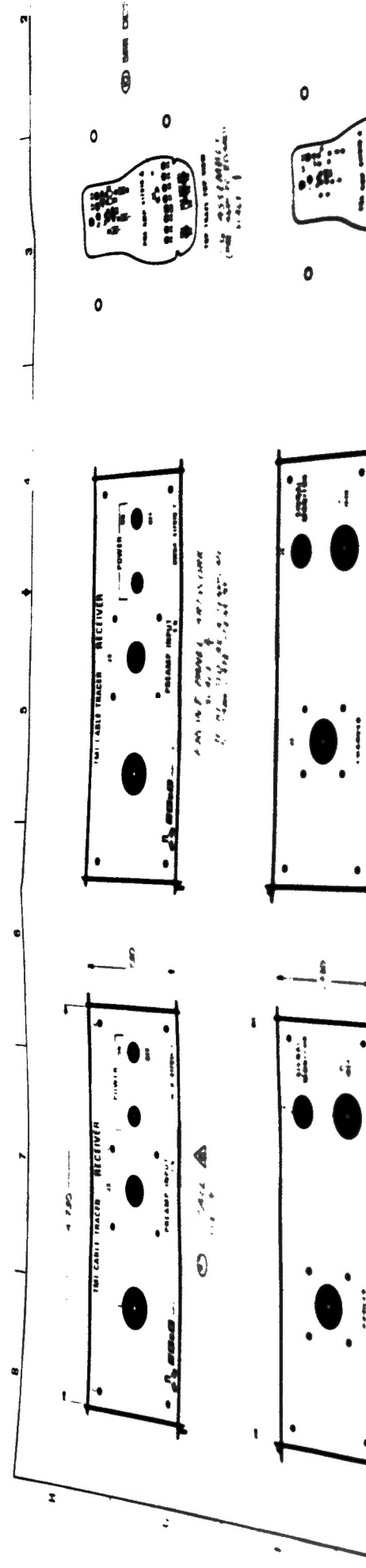
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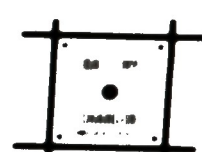
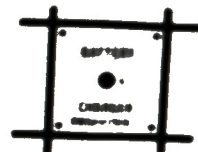
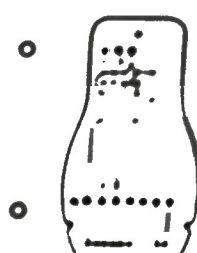
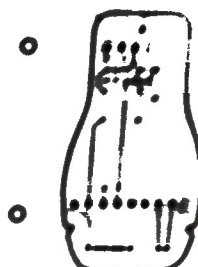
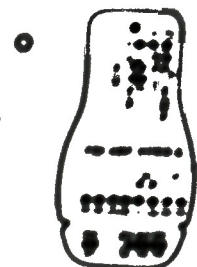
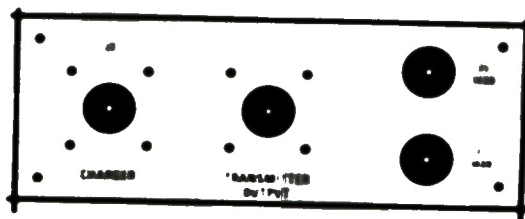
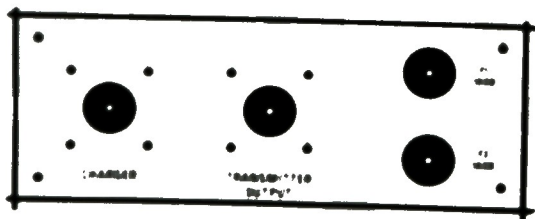
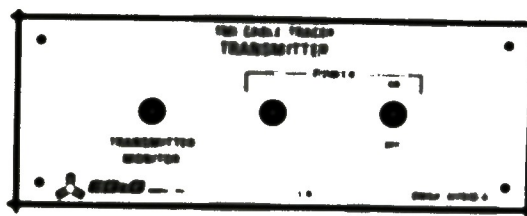
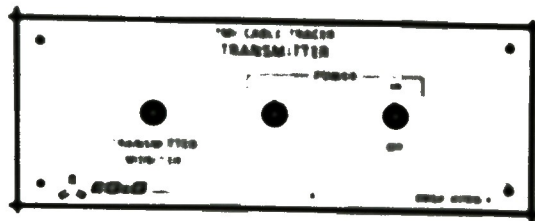
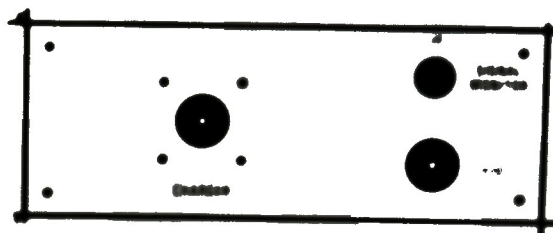
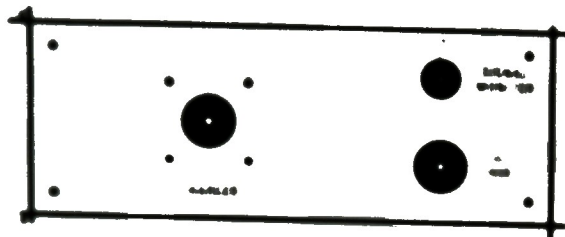
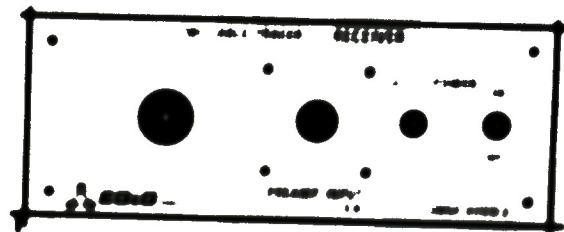
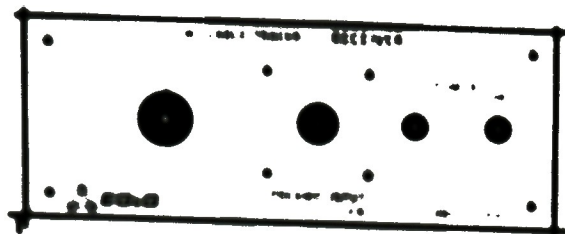


DETAIL

NOT TO SCALE  
 PREPARED BY: [illegible]  
 DATE: 1







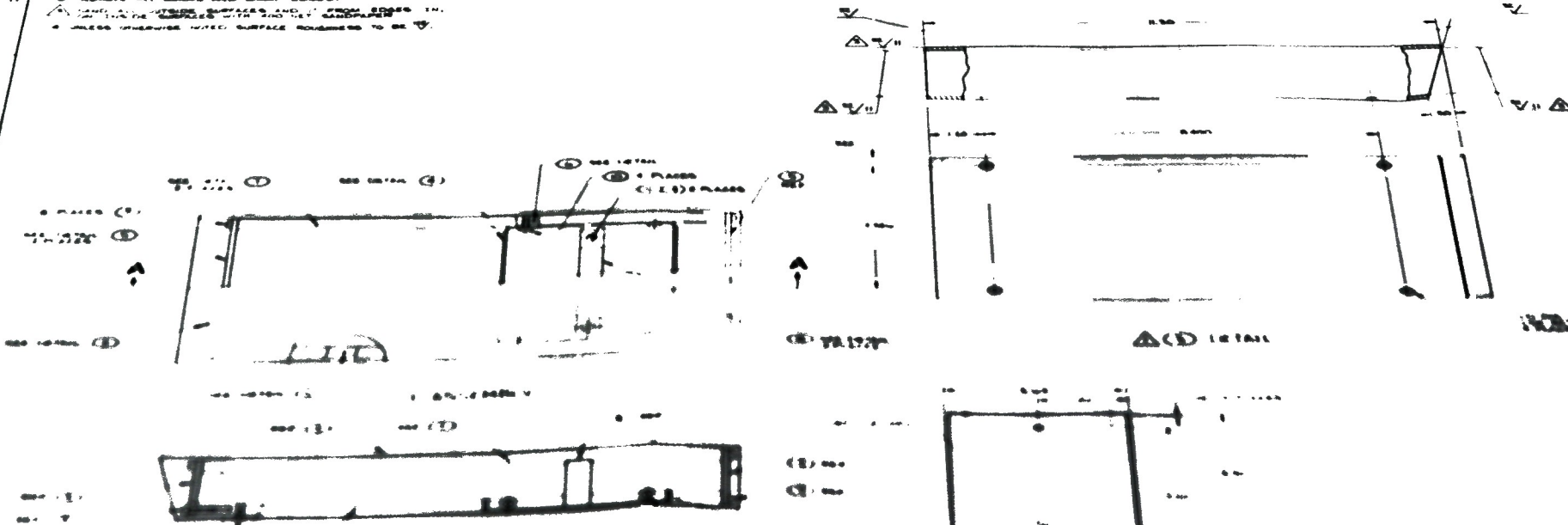
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100	RECEIVER	1	

NEAR PANEL NETWORK  
SCALE +  
TO BE USED AS A TEMPLATE  
TO FABRICATE "EM 100"

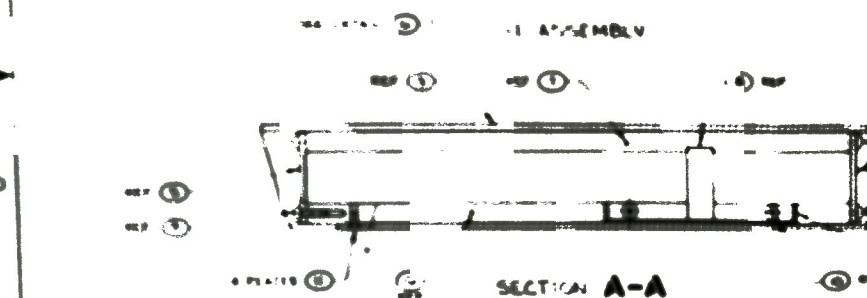
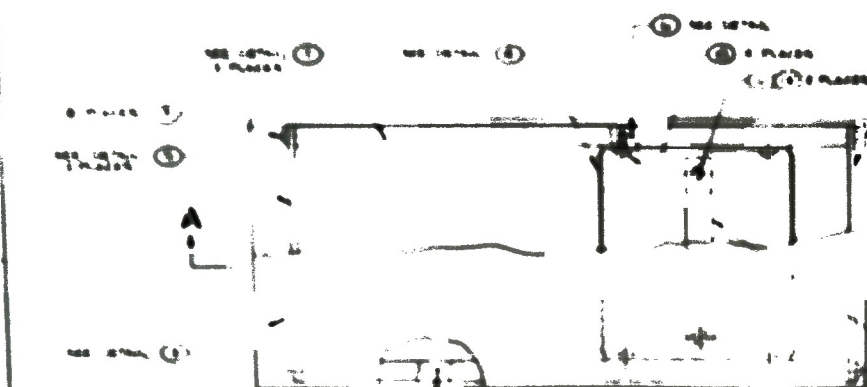


APPENDIX C

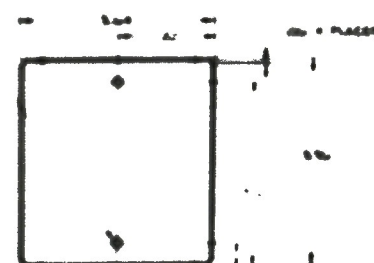
PORTABLE INSTRUMENT CASE  
EG&G DRAWING 417911



1. The first group of people who are interested in the results of the study are the researchers themselves. They want to know if the study was successful in achieving its objectives and if the data collected is reliable and valid. They also want to know if the study has contributed to the existing knowledge in the field and if it has any practical implications.



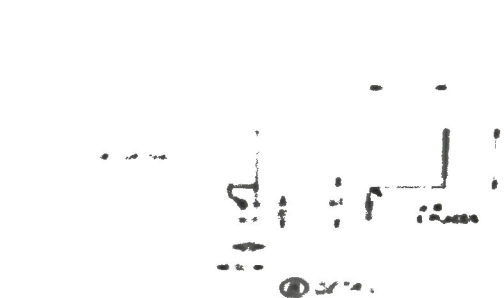
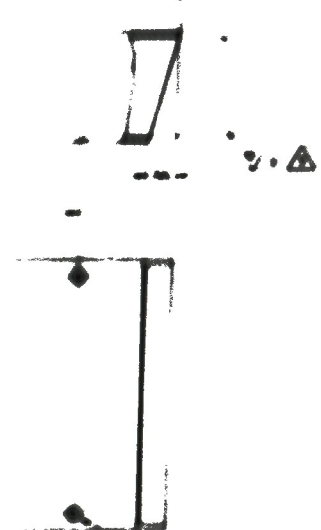
• DETAIL AS SHOWN  
⑦ DETAIL



△◎ DETAIL



⑤ DETAIL



3

2





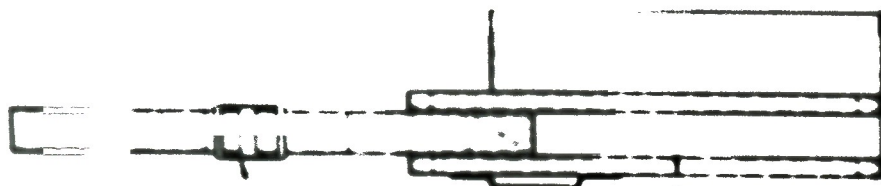
APPENDIX D

TMI CABLE TRACER CARRYING CASE  
EG&G DRAWING 418619



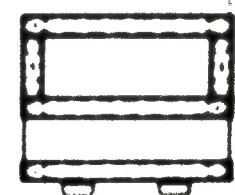
8 7 6 5 4 3 2

TO BE MADE IN THE  
TO BE MADE IN THE

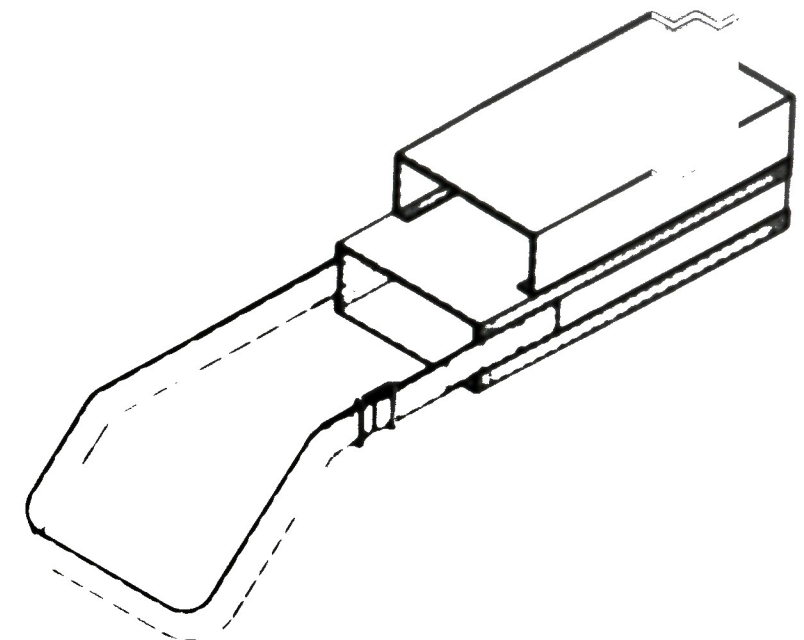


ADJUSTABLE BUCKLE

2" PAGES



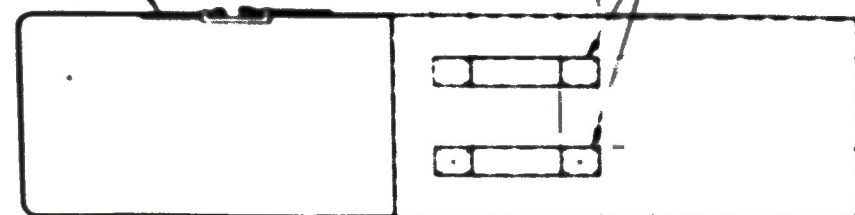
2" 2"



1" STRAP  
W/ON WEAVING

2" 2" 1"

BELT LOOPS  
W/ON WEAVING



2"

ENVELOPE DRAWING

NO. OF ENVELOPES IN SET 1		NO. OF ENVELOPES IN SET 1		NO. OF ENVELOPES IN SET 1	
NAME K. L. SPARROW		TITLE N/A		DATE 10/1/77	
PROJECT TMI		DRAWING NO. 540 9999 0 222		SCALE NONE	
DESCRIPTION TMI CABLE TRACE CARRYING CAS		MATERIALS NONE		OTHER NONE	

8 7 6 5 4 3 2





